TDS5TR-1

Oil Filter Trailer

Installation and Operating Instructions

Serial Number:

____

Date Manufactured:

____

Velcon Systems®

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REVISION A

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DESCRIPTION

Scope

The Velcon Filters, Inc. model TDS5TR is designed to dehydrate wet transformers while the transformer remains on-line and energized. The system removes dissolved water from mineral based transformer oils using patented SuperDri™ cartridge technology. The unit is capable of reduction of total water content of transformer oil to levels of 10 parts per million or less in a single pass while flowing at a rate of 5 gallons per minute. The unit reduces the moisture content of the cellulose insulation in the transformer by using heat generated by the transformer under load to transfer moisture from the wet insulation into the dried oil.

General

The TDS5TR is mounted onto a drip pan base with 4 inch drip lip. All valves are accessible from the front of the unit. The unit is painted with oven-cured, high corrosion resistant, polyester polyurethane powder coat paint.

Design

The Transformer Dehydration System is designed for connection to an energized transformer and is capable of continuous operation. The unit pumps transformer oil from the bottom of the transformer, through the system where it is dehydrated, then pumped back into the top of the transformer. Dehydration is accomplished by use of dissolved water removal cartridge filters. No external heat or vacuum is required to complete the dehydration process. No moving parts, other than the pump and motor, are required to dehydrate the transformer. The unit is also capable of transferring oil without filtration. Following are descriptions of the major system components:

Suction Strainer

A Y-type strainer, ¾", 20 mesh, is installed on the inlet line upstream of the pump. Strainer mesh size is sufficient to protect the pump from damage by dirt, debris and other foreign matter. The strainer is properly sized for rated 5 GPM capacity of the pump.

Oil Pump

The pump (Viking SG-40514-GOV) is a positive displacement gear pump with mechanical seal. Pump output is not less than 5 gpm flow rate at 75 psi output pressure. An internal adjustable pressure relief bypass mechanism capable of relieving full pump flow without exceeding rated pressure of system piping and filter housing protects the system from excessive pressure. The pump is designed for continuous service.

Filter Housing

The filter housing is of vertical welded carbon steel construction built in accordance with ASME Sec. VIII for a maximum operating pressure of 100 psi. The housing accepts four (4) each 11 inch diameter by 7 inch overall length dissolved water removal cartridges. There is a manual air vent at the top of the housing and a manual oil drain at the bottom of the housing. No special tools or wrenches are required to open the top cover. A replaceable buna gasket seals the top cover under all pressure conditions.

Vacuum Pump
The system incorporates a vacuum pump with minimum of 3 cfm, displacement, 2 stage. The vacuum pump is piped so that the entire system can be evacuated through a connection at the top of the filter housing.

Sight Glass
A clear sight glass visibly indicates that oil is present at the outlet from the system.

Flowmeter/Totalizer
A digital electronic battery powered flow meter, 1” 0-30 gpm is used to display rate of flow in gallons per minute, total throughput in gallons, and batch throughput in gallons. Batch throughput is re-settable. The unit turns on automatically when fluid flow starts and turns off a few minutes after flow has stopped. A display button can also be used to manually turn on the meter, and a mode button selects the display between rate of flow, total throughput, and batch throughput. The meter is mounted in the oil piping so that all flow from the system passes through it.

Gauges
All gauges are liquid filled and accurate to ± 1.5% of full scale reading. Gauge tubing is 304 stainless steel tubing with JIC hydraulic connections. The following gauges are mounted to the system:

- One (1) each 4” 2-1/2LF, ¼” BTM MT. pressure gauge with range from 0 to 100 psi to indicate pressure immediately downstream of the pump (and before the filter housing).

- One (1) each vacuum gauge with range from -30 to +30 LF BTM in Hg to indicate vacuum between the filter housing and the vacuum pump.

- One (1) each temperature gauge with range from 0 to 250 degrees Fahrenheit, ½ MPT, to indicate oil temperature at the discharge from the unit.

Piping
Piping is 304 stainless steel tubing with JIC hydraulic fittings where possible. Tubing is sized for the maximum rated flow of the system, and is bent with smooth radius bends where possible to minimize the use of threaded or welded fittings. No galvanized fittings are used.

Co-Axial Hoses with Oil Level Alarm
Two (2) co-axial hose assemblies are provided. Each assembly includes an inner oil flow hose (3/4” single braid SAE 100R1AT 1250 PSI), outer containment hose (2” PVC, 1 clear green, 1 clear white), and normally closed hose end solenoid valves 3/4” (with latching relay and remote alarm connection mounted in control box). Standard length of hose is 25 ft (other lengths are available as optional lengths). The solenoid valve on the discharge line is the slow closing type and there is a flow directional check valve mounted downstream of the discharge solenoid. In addition to the co-axial hoses, a float switch (with control relay mounted in the control box) is installed at the bottom of the system enclosure. Oil leaking from the inner flow hose is contained by the outer containment hose and shall run back into the system enclosure. If oil accumulates in the bottom of the enclosure either due to leakage of an oil flow hose or other leak in the system, the float switch shall signal the unit to shut off. The hose end solenoid valves is wired to open when the system is turned on and to shut when either the unit is turned off or an alarm condition shuts the unit off. A red alarm light is mounted to the control box door to indicate that the unit has shut off due to high oil level at the bottom of the enclosure.

Powered Filter Housing Drain

The powered filter housing drain allows oil in the filter housing to be safely pumped back into the transformer using the system pump during cartridge changes. A 1/4-turn 3-way ball valve is installed at the inlet to the pump to select flow from the transformer or from the filter housing.

Sample Ports

Stainless steel gooseneck style valved sample ports are provided. There is one (1) sample port with capability to sample oil entering the filter housing, and one (1) sample port with capability to sample the oil leaving the system.

Valves

- All flow/isolation valves are full port, 1/4-turn type ball valves and are sized appropriately to prevent restriction at the maximum rated flow of the system. There is one (1) system isolation valve at the inlet to the system and one (1) isolation valve at the outlet from the system.

- Housing vent and drain valves, and sample valves are of the 1/4-turn ball type. 1/4-turn ball valves are also used to isolate the vacuum pump from the filter housing and to connect the piping downstream of the bypass check valve to the filter housing during evacuation of air from the system.

- One (1) each 1/4-turn ball type 3-way valve ¾", is used between the pump and filter housing to select between flow through the filter housing and flow bypassing the filter housing.

- A swing type check valve (3/4" poppet, viton seal bronze NPT) is installed between the filter housing outlet and the filter bypass line connection point. This valve allows oil to flow out from the filter housing but prevents any oil (such as from the filter bypass line) from flowing opposite to normal direction of flow back into the filter housing.

Connections

Inlet and outlet connections to the unit are via 3/4 inch male npt connections.

Electrical

All wiring conforms to the current revision of the National Electrical Code. Wires are sized for the appropriate voltage and amperage load and are of insulated stranded copper. Liquid tight flexible conduit protects all exposed wiring between the control box and motor. All wiring is made in a neat and orderly fashion and ends in terminal connections. All electrical components are electrically bonded and grounded.

Power

The unit runs on single phase, 120 volt AC, 60 hertz power. Full load current does not exceed 12 amperes. A 25 foot power cord with standard 3-prong plug is provided for connection to a power source.

Motors

- **Oil Pump Motor**
  The oil pump motor is sized (1/2 HP, 1∅ 120/230 volts) to provide adequate power to drive the pump at rated capacity. The motor runs at 1750 rpm and is of the totally enclosed fan cooled design.

- **Vacuum Pump Motor**
  The vacuum pump motor is close coupled to the vacuum pump and sized to provide adequate power to operate the vacuum pump at rated capacity (3cfm, 2 stage). The motor is of the total enclosed fan cooled design.

Control Box

Electrical control components are mounted inside a NEMA 4 enclosure. The components consist of:

- Magnetic motor starter with manual reset and overload protection.
- Programmable logic controller to control system run functions, high pressure shut-off function, low flow shut-off function, and low oil level shut-off function.
- Fuse appropriately sized to protect motor circuit. Fuse appropriately sized to protect control circuit.
- Pushbutton start/stop mounted to door of control box.
- Three (3) each red alarm lights mounted to door of control box indicating that unit has shut off due to low flow, high pump pressure, or low oil level in the transformer.
- Reset button mounted to control box door to reset unit if shutdown occurs.
- Hour meter that indicates the total run time of the unit mounted to the door of the control box.
- On-off switch to turn vacuum pump on or off mounted to door of control box.

Low Flow Switch

A low flow switch is mounted to the discharge line from the filter housing. The switch is wired in conjunction with the programmable logic controller to shut the unit off after a set amount of time if flow rate drops below 0.5 gallons per minute.

Dry Contact Relay

A dry contact relay is provided in the control box that can accept a signal from the transformer low oil level alarm circuitry. In event of low oil level in the transformer, the unit shuts down. A red alarm light is mounted on the control box door to indicate that the unit has shut down due to low oil level in the transformer.

Moisture Sensor

A Doble Domino moisture sensor, model #165, is incorporated to provide direct readings of moisture content of the oil in parts per million or in percent saturation. The sensing probe is installed in the outlet line from the unit and is able to sense moisture content of the effluent oil and influent oil when the filter bypass valve is turned to the bypass position. The sensor provides a continuous reading with a digital display. In addition to ppm and percent saturation, the display also shows oil temperature in degrees Fahrenheit or centigrade. The sensor has an alarm feature that illuminates a "change filter" light on the control box when the moisture content exceeds a pre-set value. Contacts are provided for activation of a remote customer installed alarm. Two analog outputs can be connected to a serial bus via the RS-232C interface. A second Doble Domino Moisture Sensor is available as an option to be installed on the influent oil line to continuously monitor inlet oil moisture content.

Detachable Hose Connections

Fittings are installed on the inlet and outlet hoses to allow removal of the hoses from the system for remote storage. There are also electrical plugs to disconnect the hose power lines.

Additive Injection Port

An additive injection port is located on the suction side of the pump between the pump and the oil inlet valve. There is a ¼ inch ball valve installed at the port to regulate the flow of additive into the system. The additive injection port can also be used to introduce make-up oil into the transformer.

Process Overview

The on-line dry-out process is designed for safe, unattended, 24 hour operation. The system is connected to a transformer that has been identified as wet using the transformers bottom fill connection as supply to the system and oil is returned by the system to a top fill connection valve. The number of cartridge change-outs required to dry the transformer insulation to an acceptable level will vary according to how wet the transformer is. The time at which the cartridges will require changing will vary with the rate at which the transformer insulation sheds its moisture to the oil. One set of SuperDri cartridges has a theoretical capacity to remove 1.9 gallons of dissolved water from oil. The Doble Domino on-line moisture sensor provides continuous read-out of oil moisture content in parts per million. Comparison of the influent oil moisture content and the effluent oil moisture content will determine when the cartridges are spent (no longer removing moisture) and need to be changed out.

General Conditions and Guidelines

During a transformer dry-out, periodic moisture readings should be taken to determine the progress of the dry-out. Data sheets are provided in the manual to log this information. Inlet moisture content can easily be checked by turning the filter/bypass valve 004 to the filter bypass position (turn valve handle full counterclockwise to the down position). After a minute or so, the moisture reading on the Doble Domino will stabilize. The valve can then be returned back to the filter position. The amount of water removed from the transformer can be determined by using the following formula:

Total amount of water removed from the beginning of an elapsed time period to the end of an elapsed time period equals:

$$\frac{((\text{start in ppm} - \text{start out ppm}) + (\text{end in ppm} - \text{end out ppm})) \times (\text{end gals} - \text{start gals})}{(2 \times 1{,}000{,}000)}$$

In the following example, the oil was sampled at 10:00 am with the following data taken:

Inlet ppm:	50 ppm
Outlet ppm:	0 ppm
Gals on totalizer:	5,500 gals

Oil was again sampled at 2:00 pm with the following data taken:

Inlet ppm:	50 ppm
Outlet ppm:	5 ppm
Gals on totalizer:	6,740 gals

Plug the data into the formula:

$$\frac{((50 - 0) + (50 - 5)) \times (6{,}740 - 5{,}500)}{(2 \times 1{,}000{,}000)} = \frac{(50 + 45) \times 1{,}240}{2{,}000{,}000} = .0589 \text{ gallons removed}$$

$$.0589 \text{ gallons removed in 4 hours} = \frac{.0589 \times 24}{4} = 0.3534 \text{ gallons of water removed per day}$$

Since each set of cartridge can remove from 1.5 – 1.9 gals of water, the cartridges in this example will have to be changed in approximately 5 days.

When it appears that the oil is dry and the dry-out is finished, the unit should be shut off for at least 1 full day, then restarted and the inlet oil moisture level checked. If moisture still remains in the transformer insulation, the inlet reading will have jumped up while the unit was off. This indicated that the unit is removing moisture faster than the moisture can transfer from the paper insulation to the oil and further processing is required.

Installation

Power Connection
Position TDS system as close to transformer drain and fill valves as possible. Connect 120 vac power source to junction located on the left side of the system. If the low oil level gauge of the transformer is to be used to shutdown the TDS system, it can be wired to the leads in the junction box at this time.

Ground Connection
It is recommended to electrically bond and ground the system directly to the transformer ground.

Cartridge installation
To install (4) SD-1107 SuperDri cartridges, open top of system enclosure and open vessel lid by loosening and unlatching eye bolts. Position valve handles on the top of the vessel to be in the open position (parallel with the back of the enclosure) so that the vessel lid is allowed to open more than 90 degrees. Unscrew cartridge end plate from vessel stand pipe. Remove cartridges from aluminum barrier bag and place in vessel allowing the cartridges to slide over the stand pipe. When all (4) cartridges are installed replace end plate snugly (do not over tighten). Close vessel lid making sure that the gasket is in the groove, tighten eye-bolts hand tight plus ½ turn using a crescent wrench or pipe.

Hose Connections
Install the TDS-5 suction line (green line - tagged “inlet”) to the transformer bottom fill (or drain) valve. Install the TDS-5 discharge line (white line - tagged “outlet”) to the transformer top fill valve. Make sure location of top fill remains below oil level. Hose end connections are 3/4" female JIC swivel connectors, included are 3/4" male by male pipe thread adapters. Use pipe dope or Teflon tape on threaded connections to secure the seal. Make sure transformer valves are sized a minimum of 3/4" to avoid restriction of flow. Support hoses at transformer.

System Evacuation

This procedure documents the steps required to evacuate air from the system and hoses. It is particularly critical if the system is being installed on a transformer that is energized.

Valve Position
(Refer to highlighted flow schematic, valve table, and valve diagrams attached). Open system isolation valves 001 and 002. Position 003 valve handle full clockwise (pointing to the front) to the flow position. Position 004 valve handle full counter-clockwise (pointing up) to the flow position. Open 006 and 007 vacuum line valves located at the top of the vessel. All remaining valves should be closed (solenoid valves at hose ends are closed when the motor is not running). The valves on the transformer should be closed as well.

Evacuating the system
Turn on the vacuum pump. Monitor vacuum gauge on vacuum pump. Allow vacuum pump to operate for at least thirty minutes. The final inches of vacuum that can be obtained will vary depending on altitude. A minimum of 22 inches Hg should be achieved, and 25-26 inches Hg is good. If 22" Hg is not achieved, tighten vessel lid eye-bolts and recheck all valve positions. When thirty minute time period is up, close 006 and 007 and turn off vacuum pump. Do not turn off vacuum pump before closing these valves.

Summarized Evacuation Steps

1. Install suction hose at transformer bottom fill valve.

2. Install discharge hose at transformer top fill valve.

3. Keep transformer bottom drain valve and top fill valve closed.

4. Open TDS-5 valve numbers 001, 002, 006, and 007. Turn 003 handle to front and 004 handle up to flow positions. Valves 005, 008, and 009 are closed.

5. Start vacuum pump (run pump for a minimum of ½ hour). (Make sure that the inlet valve on the vacuum pump is open.)

6. Close valves 006 and 007 to vacuum pump.

7. Turn Vacuum pump off.

Priming the System

The TDS system will consume about 25 gallons of oil from the transformer but this should not have much affect on transformer oil level. Open transformer bottom drain valve (the transformer top fill valve remains closed.) Press the start button on the TDS control panel to engage the pump and motor. The valve positions should be the same as they were at the end of the evacuation procedure with 006 and 007 closed, 001 and 002 open, and 003 valve handle pointing to the front and 004 valve handle pointing up. The time delay relay will trip the unit off every sixty seconds during this filling operation until flow is sensed by the flow switch at the vessel outlet. Press the reset button and restart the system during this time (this should have to be done approximately 3 or 4 times). Monitor the flow sight glass for oil flow. When the system, housing, and hoses are completely filled with oil, the high pressure alarm will trip at 30 psi as pressure builds at the transformer fill valve. When the high pressure alarm trips, press the reset button. Crack open 005 and carefully bleed remaining air from the top of the vessel (in some instances the pump may need to be restarted to accomplish this), and close 005 when oil appears. The system should be fully primed at this point. Open the transformer top fill valve and start system.

Summarized Priming Steps

1. Valves should be in the following position from the preceding evacuation process: Transformer fill & drain valves closed, 001 and 002 open, 003 handle to front, 004 handle up, 005, 006, 007, 008, and 009 closed.
2. Open transformer bottom drain valve.
3. Start system (solenoid valves will open allowing oil to flow).
4. The system will automatically shut down in 60 seconds.
5. Reset system and restart - repeat until system shuts down from high pressure.
6. Wait 2-3 minutes.
7. Open valve 005 slowly (bleed off residual air).
8. Close valve 005 when oil appears.
9. Repeat steps 5 thru 8 until only oil appears (typically 2 times is enough).
10. Open transformer top fill valve.
11. Turn system on.

Cartridge Change-out Procedure

Drain Vessel and Change Cartridges
Take inlet and outlet samples per the sampling procedures before changing cartridges. With the system still running in the filter mode, turn valve 003 full counterclockwise (handle pointing right) to the vessel drain position, then ***slowly*** turn valve 004 handle full clockwise (handle pointing back) to the bypass position. This allows oil from the housing to be pumped back into the transformer. Open vent valve 005 at the top of the housing. Run the system until the vessel is less than half full of oil (about 1 minute). (In the event that the high pressure shut-off switch trips and prevents the system from running, turn 004 to filter position, start pump, then turn 004 back to bypass position.). CAUTION: Do not drain the vessel completely. Turn the unit off, close valves 005, and 002. Unbolt and swing up the vessel lid. Unscrew the t-handle cartridge hold down and remove the old cartridges. Verify that all cartridge gaskets have been removed from the vessel, especially the bottom cartridge gasket. Install the new cartridges and screw the t-handle hold down until snug (NOTE: At this point, a maximum of three gallons of oil may be reintroduced into the system, if required, by pouring into the vessel to a level lower than the bottom of the top cartridge). Close the housing lid and tighten the eye bolts.

Evacuate, Prime, and Restart the System
Return valves 003 and 004 to the flow positions (003 handle full CW pointing front, and 004 handle full CCW pointing up. Open 006 and 007 and turn on the vacuum pump. Transformer fill and drain valves are still open, and 005, 008 and 009 are closed. Run the vacuum pump for 15 minutes. Vacuum should be a minimum of 20 inches of mercury. Close valves 006 and 007, and shut the vacuum pump off. Open valve 001 and start the unit. The time delay relay will trip the unit off every sixty seconds during this filling operation until flow is sensed by the flow switch at the vessel outlet. Press the reset button and restart the system during this time (this should have to be done approximately 1 or 2 times). Monitor the flow sight glass for oil flow. When the system, housing, and hoses are completely filled with oil, the high pressure alarm will trip as pressure builds at valve 002. When the high pressure alarm trips, press the reset button. Crack open 005 and carefully bleed remaining air from the top of the vessel (in some instances the pump may need to be restarted to accomplish this), and close 005 when oil appears. The system should be fully primed at this point. Open valve 002 and start the system. Check for leaks around the vessel cover. After running for approximately 15 minutes, take inlet and outlet samples per the sampling procedure.

Summarized Change-out Steps

1. Sample the oil.

2. Close valve 001.

3. Turn valve 003 handle right, and ***slowly*** turn 004 handle back.

4. Turn unit on and open 005 vent.

5. Run system for approximately 1 minute.

6. Turn the unit off and close valves 005 and 002.
7. Open vessel, change cartridges, introduce make-up oil if required, and close vessel.
8. Turn 003 handle front and 004 handle up to flow positions.
9. Open 006 and 007 and turn on vacuum pump.
10. Run vacuum pump for 15 minutes.
11. Close 006 and 007 and shut off vacuum pump.
12. Open valve 001.
13. Restart unit. The system will automatically shut off in 60 seconds by time delay.
14. Reset and restart. Repeat until unit shuts down from high pressure.
15. Wait 2-3 minutes.
16. Open 005 slowly to bleed off residual air. Close when oil appears.
17. Repeat steps 13-16 until only oil appears.
18. Open valve 002.
19. Reset and restart unit.
20. After 15 minutes, take inlet and outlet samples.

Removal

This procedure documents the steps required to remove the system from the transformer. It is particularly critical if the system is installed on a transformer that is energized.

Shut Down the System
Take inlet and outlet samples per the sampling procedures. Turn the unit off. The solenoid valves at the end of the hoses will automatically close. Close the transformer bottom drain valve.

Drain System
Turn valve 003 full counterclockwise (handle pointing right) to the vessel drain position, turn valve 004 full clockwise (handle pointing back) to the bypass position. This allows oil from the housing to be pumped back into the transformer. Turn the unit on and open vent valve 005. (In the event that the high pressure shut-off switch trips and prevents the system from running, turn 004 to filter position, start pump, then turn 004 ***slowly*** back to bypass position.) Run the system for approximately 1 minute (the vessel should be less than half full of oil at this time). Close the transformer top fill valve. Disconnect and remove the outlet hose from the transformer top fill valve, place the end of the hose into a suitable container. Restart the unit to empty the system of remaining oil. When empty, close valves 001, 002 and 005. Disconnect and remove the inlet hose from the transformer bottom drain valve.

Summarized Removal Steps

1. Sample the oil
2. Turn unit off
3. Close transformer bottom fill valve.
4. Turn 003 handle front.
5. Turn unit on and ***slowly*** turn 004 handle back to bypass position. Open 005 vent.
6. Run system for approximately 1 minute.
7. Close transformer top fill valve.
8. Disconnect discharge hose from transformer top fill valve.
9. Place hose end in suitable container with a minimum of 20 gallons storage.
10. Start system.
11. Run system until it is empty of oil.
12. Turn system off.
13. Close valves 001, 002 and 005.
14. Disconnect/remove hose from transformer bottom drain valve.

Sampling Procedures

Routine Bottle Samples

1. Fill in all filter system and transformer readings on data log sheet.

2. Wipe end of sample tube and place sample bottle under sampling tube.

3. Open valve (inlet sample is 008 , outlet sample is 009).

4. Flush into sample bottle until bottle is 3/4 full. Close valve.

5. Cap sample bottle, shake up, and dump out.

6. Repeat steps 4 & 5.

7. Open sample valve and slowly fill sample bottle 3/4 full. Flow against inside of bottle wall to avoid agitation and introduction of air. Cap tightly.

Silver Bullet Samples

1. Fill in all filter system and transformer readings on data log sheet.

2. Get small diameter inlet hose to connect end of sampling tube to barb on silver bullet. Get second drain hose and connect to barb on opposite end of silver bullet.

3. Connect inlet hose to end of sampling tube and place other end of hose into a bucket.

4. Open sample valve and flush sampling hose for a minimum of two minutes.

5. Close sample valve.

6. Connect free end of inlet hose to barb on silver bullet. Connect second drain hose to barb on opposite end of silver bullet. Place free end of drain hose in bucket.

7. Open silver bullet outlet valve, silver bullet inlet valve, and then open sample valve slightly.

8. Hold silver bullet upright with drain hose on top and shake slightly to remove trapped air.

9. Allow oil to flow through hoses and silver bullet for a minimum of 2 minutes to flush container.

10. Close sample valve, silver bullet inlet valve, and silver bullet outlet valve.

VALVE DESCRIPTION

Transformer Bottom Drain Valve	Valve at transformer bottom drain connection. Should be sized a minimum of 3/4" to avoid flow restriction.
Transformer Top Fill Valve	Valve at transformer top fill connection. Should be sized a minimum of 3/4" to avoid flow restriction. Location of valve should be below oil level in transformer.
Inlet/Outlet Solenoid Valves	Valves installed on ends of TDS-5 hoses. The solenoid valves are normally closed valves that open only when the TDS-5 unit is turned on.
001	TDS-5 system oil inlet valve. This is a full port ball valve with 1/4-turn handle. Position valve handle parallel to valve body to open valve, position handle perpendicular to valve body to close valve.
002	TDS-5 system oil outlet valve. This is a full port ball valve with 1/4-turn handle. Position valve handle parallel to valve body to open valve, position handle perpendicular to valve body to close valve.
003	3-way inlet valve. This valve is a 3-way ball valve with 1/4-turn handle. This valve selects either oil from the transformer or oil from the vessel drain to the inlet of the pump. Position the valve handle pointing to the front (turn full clockwise) for normal flow from transformer, or position the handle pointing right (turn full counterclockwise) to drain the vessel.
004	3-way bypass valve. This valve is a 3-way ball valve with 1/4-turn handle. This valve directs oil from the pump to either flow into the filter vessel or to bypass the filter vessel. Position the valve handle pointing up (turn full counterclockwise) for normal flow into the filter vessel, or position the handle pointing back (turn full clockwise) to direct flow to bypass the filter vessel.
005	TDS-5 filter vessel manual top vent valve. This is a standard port ball valve with 1/4-turn handle. Position valve handle parallel to valve body to open valve, position handle perpendicular to valve body to close valve. This valve is used to manually vent air from the vessel during priming, or to vent air into the vessel during draining.

006	Vacuum pump valve. This is a full port ball valve with 1/4-turn handle. Position valve handle parallel to valve body to open valve, position handle perpendicular to valve body to close valve. This valve allows vacuum from the vacuum pump to evacuate the TDS-5 system.
007	Auxiliary vacuum line valve. This is a full port ball valve with 1/4-turn handle. Position valve handle parallel to valve body to open valve, position handle perpendicular to valve body to close valve. This valve allows connects the outlet hose (downstream of the outlet check valve) to the rest of the TDS-5 system during vacuum evacuation.
008	Inlet oil sample valve. This is a full port ball valve with 1/4-turn handle. Position valve handle parallel to valve body to open valve, position handle perpendicular to valve body to close valve. This valve is used to draw oil samples from the inlet of the filter vessel.
009	Outlet oil sample valve. This is a full port ball valve with 1/4-turn handle. Position valve handle parallel to valve body to open valve, position handle perpendicular to valve body to close valve. This valve is used to draw oil samples from the outlet of the filter vessel.
010	Filter housing manual drain valve. This is a full port ball valve with 1/4-turn handle. Position valve handle parallel to valve body to open valve, position handle perpendicular to valve body to close valve. This valve is used to manually drain oil from the filter housing.
011	Additive injection port valve. This is a ball valve with ¼-turn handle. Position valve handle parallel to valve body to open valve, position handle perpendicular to valve body to close valve. This valve is used to introduce oil additive into the oil. It can also be used to introduce make-up oil back into the transformer to adjust fluid level higher. The inlet isolation valve 001 may have to be throttled to allow the pump to pull oil through the additive injection port.

TDS5TR VALVE TABLE

PROCESS DESCRIPTION	SUM-MARIZED STEP #	TRANSFORMER BOTTOM OUT	TRANSFORMER TOP IN	TDS-5 VALVES V1	V2	V3	V4	V5	V6	V7	V8	V9	REMARKS
SYSTEM EVACUATION	1-5	CLOSED	CLOSED	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	OPEN	OPEN	CLOSED	CLOSED	EVACUATE SYSTEM WITH VACUUM PUMP. HOLD VACUUM 30 MINUTES MINIMUM.
	6-7	CLOSED	CLOSED	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSE V6 & V7 AFTER EVACUATION. TURN OFF VACUUM PUMP.
PRIMING THE SYSTEM	1-6	OPEN	CLOSED	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	TURN UNIT ON - RUN UNTIL TDR SHUTS UNIT OFF. RESET/RESTART UNTIL HIGH PRESSURE SWITCH SHUTS OFF UNIT.
	7-9	OPEN	CLOSED	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	OPEN BLEED	CLOSED	CLOSED	CLOSED	CLOSED	CRACK OPEN V5 TO BLEED AIR FROM HOUSING, THEN CLOSE V5.
	10 (RUN)	OPEN	OPEN	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	TURN UNIT ON.
SAMPLE	INLET	OPEN	OPEN	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	OPEN	CLOSED	
	OUTLET	OPEN	OPEN	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	OPEN	
CHANGE CARTRIDGES	(RUN)	OPEN	OPEN	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	SAMPLE, THEN SHUT OFF PUMP.
	2-3	OPEN	OPEN	CLOSED	OPEN	CCW-RIGHT (DRAIN)	CW-BACK (BYPASS)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	
	4-6	OPEN	OPEN	CLOSED	OPEN	CCW-RIGHT (DRAIN)	CW-BACK (BYPASS)	OPEN	CLOSED	CLOSED	CLOSED	CLOSED	START PUMP TO DRAIN VESSEL. RUN FOR APPROXIMATELY 1 MINUTE. VESSEL SHOULD BE ½ EMPTY (DO NOT DRAIN COMPLETELY). STOP PUMP.
	6-8	OPEN	OPEN	CLOSED	CLOSED	CCW-RIGHT (DRAIN)	CW-BACK (BYPASS)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	OPEN VESSEL & CHANGE CARTRIDGES. ADD OIL, CLOSE VESSEL.
	8-10	OPEN	OPEN	CLOSED	CLOSED	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	OPEN	OPEN	CLOSED	CLOSED	TURN ON VACUUM PUMP. RUN 15 MINUTES.
	11	OPEN	OPEN	CLOSED	CLOSED	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	SHUT OFF VACUUM PUMP.
	12-14	OPEN	OPEN	OPEN	CLOSED	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	TURN UNIT ON - RUN UNTIL TDR SHUTS UNIT OFF. RESET/RESTART UNTIL HIGH PRESSURE SWITCH SHUTS OFF UNIT. WAIT 2-3 MINUTES.
	15-16	OPEN	OPEN	OPEN	CLOSED	CW-FRONT (FLOW)	CCW-UP (FLOW)	OPEN BLEED	CLOSED	CLOSED	CLOSED	CLOSED	BLEED AIR FROM VESSEL. REPEAT.
	17-19 (RUN)	OPEN	OPEN	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	TURN UNIT ON. AFTER 15 MINUTES, TAKE SAMPLES
REMOVE SYSTEM	1-2 RUN	OPEN	OPEN	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	SAMPLE, THEN SHUT OFF PUMP.
	3-6	CLOSED	OPEN	OPEN	OPEN	CCW-RIGHT (DRAIN)	CW-BACK (BYPASS)	OPEN	CLOSED	CLOSED	CLOSED	CLOSED	START PUMP TO DRAIN VESSEL. RUN FOR APPROXIMATELY 1 MINUTE.
	7-13	CLOSED	CLOSED	OPEN	OPEN	CCW-RIGHT (DRAIN)	CW-BACK (BYPASS)	OPEN	CLOSED	CLOSED	CLOSED	CLOSED	DISCONNECT HOSE FROM TRANSFORMER TOP FILL AND PLACE END IN CONTAINER. START PUMP AND RUN UNTIL SYSTEM IS EMPTY. TURN SYSTEM OFF.
	14-15	CLOSED DISCONN	DISCONN	CLOSED	CLOSED	CCW-RIGHT (DRAIN)	CW-BACK (BYPASS)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	DISCONNECT HOSE FROM TRANSFORMER BOTTOM DRAIN VALVE.

VALVE NUMBER	TYPE	OPEN POSITION	CLOSED POSITION
V1, V2, V5, V6, V7 V8, V9, V10, V11	BALL VALVE	HANDLE PARALLEL WITH FLOW	HANDLE PERPENDICULAR TO FLOW

VALVE NUMBER	TYPE	FLOW POSITION	DRAIN POSITION
V3	3-WAY BALL VALVE	HANDLE TURNED FULL CLOCKWISE (HANDLE POINTS TO FRONT)	HANDLE TURNED FULL COUNTER-CLOCKWISE (HANDLE POINTS RIGHT)

VALVE NUMBER	TYPE	FLOW POSITION	BYPASS POSTION
V4	3-WAY BALL VALVE	HANDLE TURNED FULL COUNTER-CLOCKWISE (HANDLE POINTS UP)	HANDLE TURNED FULL CLOCKWISE (HANDLE POINTS BACK)

TDS5TR VALVE TABLE

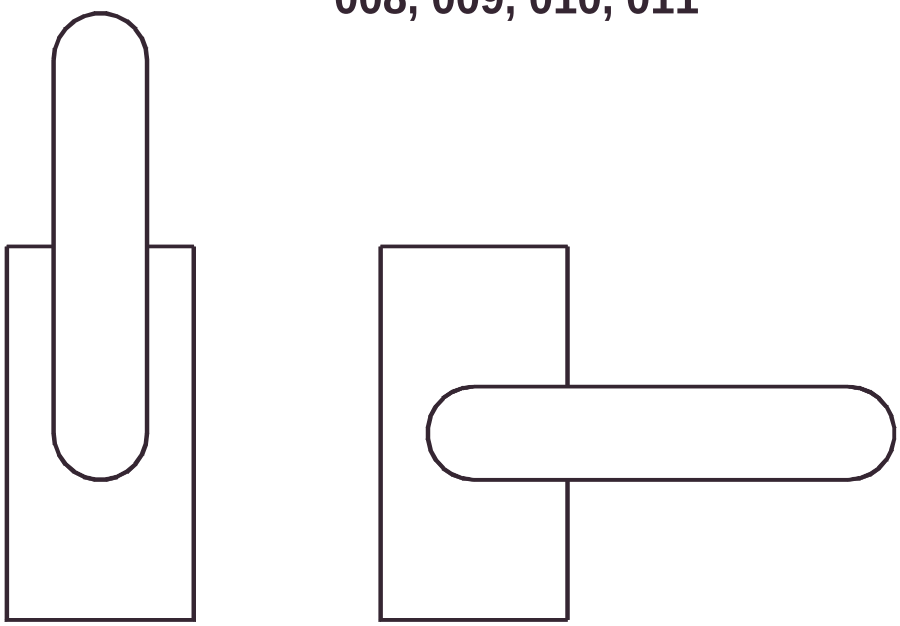
PROCESS DESCRIPTION	SUM-MARIZED STEP #	TRANSFORMER		TDS-5 VALVES									REMARKS
		BOTTOM OUT	TOP IN	V1	V2	V3	V4	V5	V6	V7	V8	V9	
SYSTEM EVACUATION	1-5	CLOSED	CLOSED	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	OPEN	OPEN	CLOSED	CLOSED	EVACUATE SYSTEM WITH VACUUM PUMP. HOLD VACUUM 30 MINUTES MINIMUM.
	6-7	CLOSED	CLOSED	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSE V6 & V7 AFTER EVACUATION. TURN OFF VACUUM PUMP.
PRIMING THE SYSTEM	1-6	OPEN	CLOSED	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	TURN UNIT ON - RUN UNTIL TDR SHUTS UNIT OFF. RESET/RESTART UNTIL HIGH PRESSURE SWITCH SHUTS OFF UNIT.
	7-9	OPEN	CLOSED	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	OPEN BLEED	CLOSED	CLOSED	CLOSED	CLOSED	CRACK OPEN V5 TO BLEED AIR FROM HOUSING, THEN CLOSE V5.
	10 (RUN)	OPEN	OPEN	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	TURN UNIT ON.
SAMPLE	INLET	OPEN	OPEN	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	OPEN	CLOSED	
	OUTLET	OPEN	OPEN	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	OPEN	
CHANGE CARTRIDGES	(RUN)	OPEN	OPEN	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	SAMPLE, THEN SHUT OFF PUMP.
	2-3	OPEN	OPEN	CLOSED	OPEN	CCW-RIGHT (DRAIN)	CW-BACK (BYPASS)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	
	4-6	OPEN	OPEN	CLOSED	OPEN	CCW-RIGHT (DRAIN)	CW-BACK (BYPASS)	OPEN	CLOSED	CLOSED	CLOSED	CLOSED	START PUMP TO DRAIN VESSEL. RUN FOR APPROXIMATELY 1 MINUTE. VESSEL SHOULD BE ½ EMPTY (DO NOT DRAIN COMPLETELY). STOP PUMP.
	6-8	OPEN	OPEN	CLOSED	CLOSED	CCW-RIGHT (DRAIN)	CW-BACK (BYPASS)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	OPEN VESSEL & CHANGE CARTRIDGES. ADD OIL, CLOSE VESSEL.
	8-10	OPEN	OPEN	CLOSED	CLOSED	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	OPEN	OPEN	CLOSED	CLOSED	TURN ON VACUUM PUMP. RUN 15 MINUTES.
	11	OPEN	OPEN	CLOSED	CLOSED	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	SHUT OFF VACUUM PUMP.
	12-14	OPEN	OPEN	OPEN	CLOSED	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	TURN UNIT ON - RUN UNTIL TDR SHUTS UNIT OFF. RESET/RESTART UNTIL HIGH PRESSURE SWITCH SHUTS OFF UNIT. WAIT 2-3 MINUTES.
	15-16	OPEN	OPEN	OPEN	CLOSED	CW-FRONT (FLOW)	CCW-UP (FLOW)	OPEN BLEED	CLOSED	CLOSED	CLOSED	CLOSED	BLEED AIR FROM VESSEL. REPEAT.
	17-19 (RUN)	OPEN	OPEN	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	TURN UNIT ON. AFTER 15 MINUTES, TAKE SAMPLES
REMOVE SYSTEM	1-2 RUN	OPEN	OPEN	OPEN	OPEN	CW-FRONT (FLOW)	CCW-UP (FLOW)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	SAMPLE, THEN SHUT OFF PUMP.
	3-6	CLOSED	OPEN	OPEN	OPEN	CCW-RIGHT (DRAIN)	CW-BACK (BYPASS)	OPEN	CLOSED	CLOSED	CLOSED	CLOSED	START PUMP TO DRAIN VESSEL. RUN FOR APPROXIMATELY 1 MINUTE.
	7-13	CLOSED	CLOSED	OPEN	OPEN	CCW-RIGHT (DRAIN)	CW-BACK (BYPASS)	OPEN	CLOSED	CLOSED	CLOSED	CLOSED	DISCONNECT HOSE FROM TRANSFORMER TOP FILL AND PLACE END IN CONTAINER. START PUMP AND RUN UNTIL SYSTEM IS EMPTY. TURN SYSTEM OFF.
	14-15	CLOSED DISCONN	DISCONN	CLOSED	CLOSED	CCW-RIGHT (DRAIN)	CW-BACK (BYPASS)	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	DISCONNECT HOSE FROM TRANSFORMER BOTTOM DRAIN VALVE.

VALVE NUMBER	TYPE	OPEN POSITION	CLOSED POSITION
V1, V2, V5, V6, V7 V8, V9, V10, V11	BALL VALVE	HANDLE PARALLEL WITH FLOW	HANDLE PERPENDICULAR TO FLOW

VALVE NUMBER	TYPE	FLOW POSITION	DRAIN POSITION
V3	3-WAY BALL VALVE	HANDLE TURNED FULL CLOCKWISE (HANDLE POINTS TO FRONT)	HANDLE TURNED FULL COUNTER-CLOCKWISE (HANDLE POINTS RIGHT)

VALVE NUMBER	TYPE	FLOW POSITION	BYPASS POSTION
V4	3-WAY BALL VALVE	HANDLE TURNED FULL COUNTER-CLOCKWISE (HANDLE POINTS UP)	HANDLE TURNED FULL CLOCKWISE (HANDLE POINTS BACK)

**001, 002, 005, 006, 007,
008, 009, 010, 011**



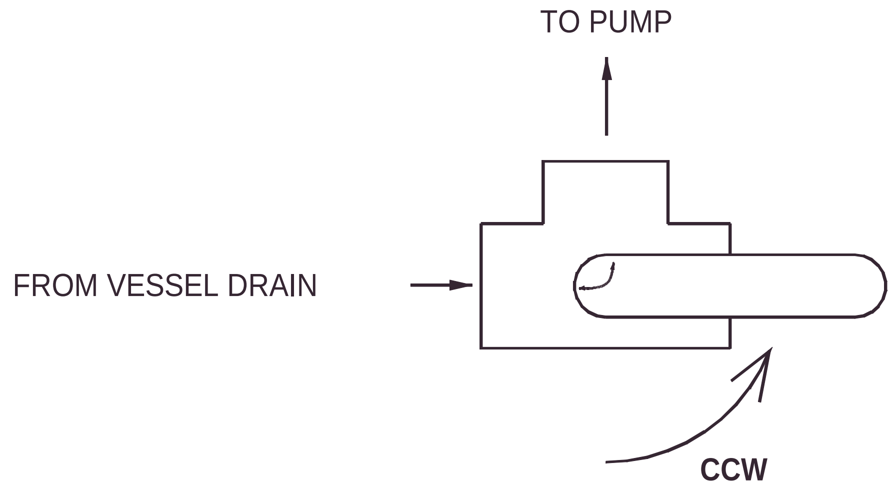
OPEN **CLOSED**

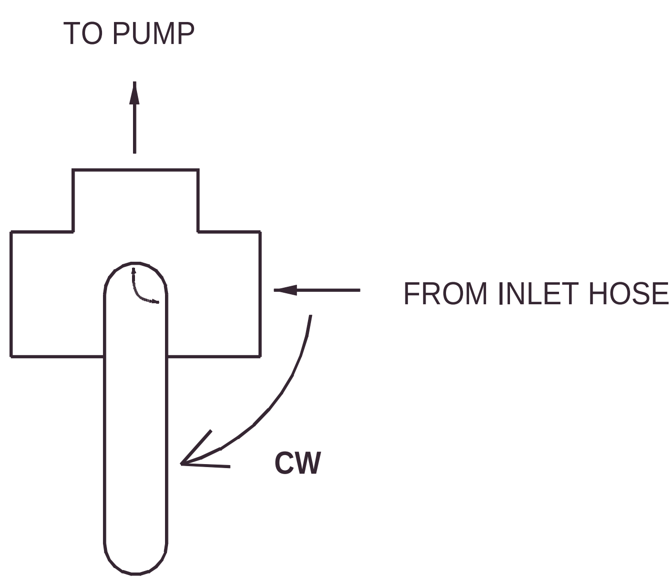
BALL VALVE DIAGRAM

rev2\ballvalv.fcw

VALVE 003

POWER DRAIN SELECTOR VALVE



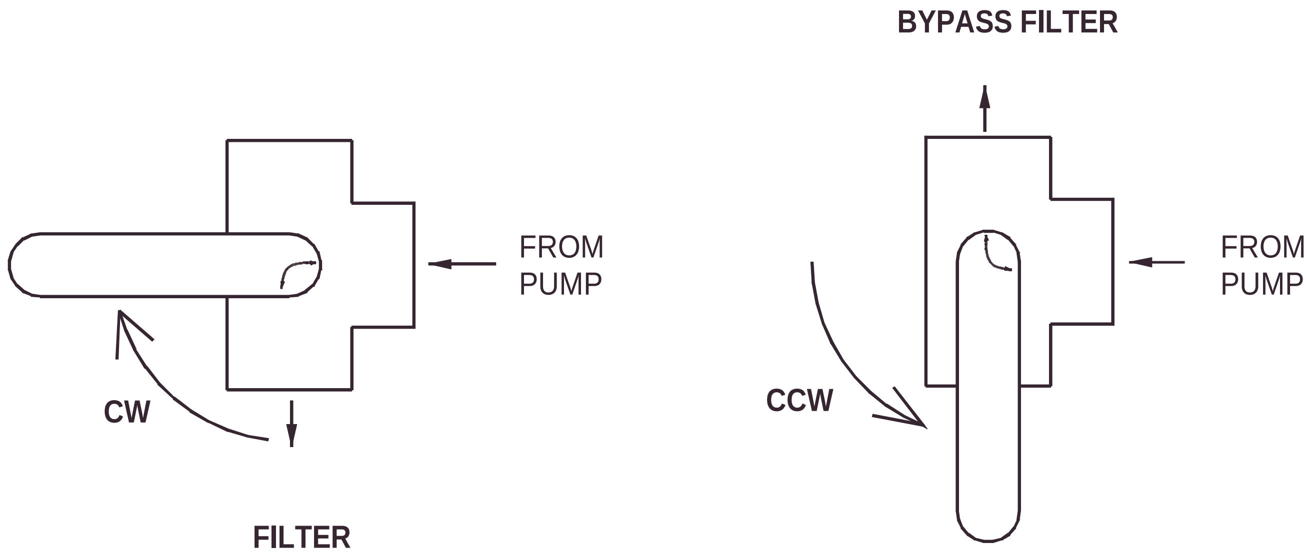


TOP DOWN VIEW

3-WAY VALVE DIAGRAM 003
rev2\3wayvalv.fcw

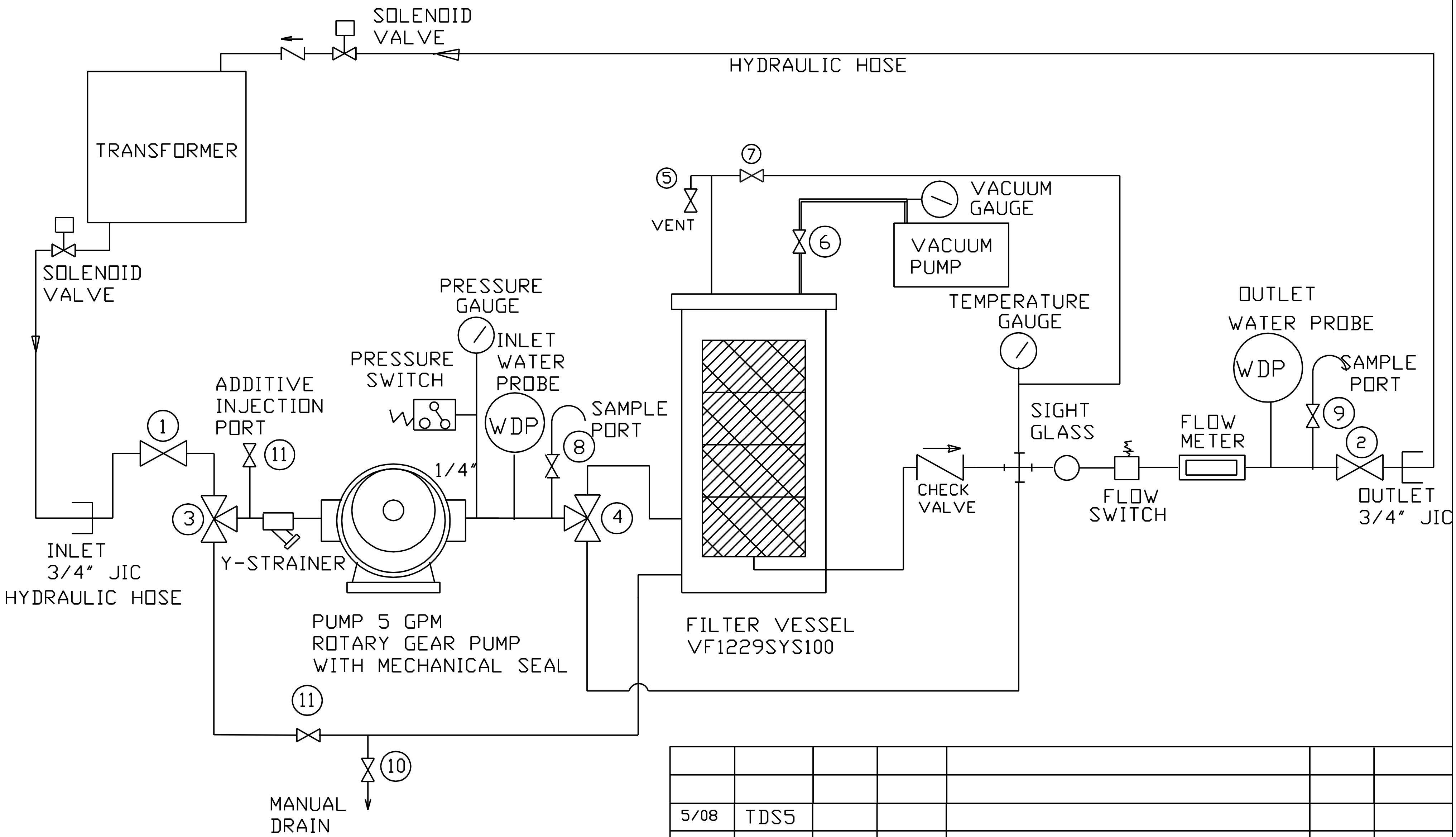
VALVE 004

FILTER BYPASS VALVE



FRONT VIEW

3-WAY VALVE DIAGRAM 004
rev2\3wayval2.fcw



5/08	TDS5			
DWN	DATE	APP'D	DATE	REVISION

SCALE NONE — MODEL TDS5TR-1

ALL DIMENSIONS ARE IN INCHES IF NOT SHOWN, USE FOLLOWING TOLERANCES

FRACTIONS ± 1/8"
DECIMALS ±.005
ANGLES ±

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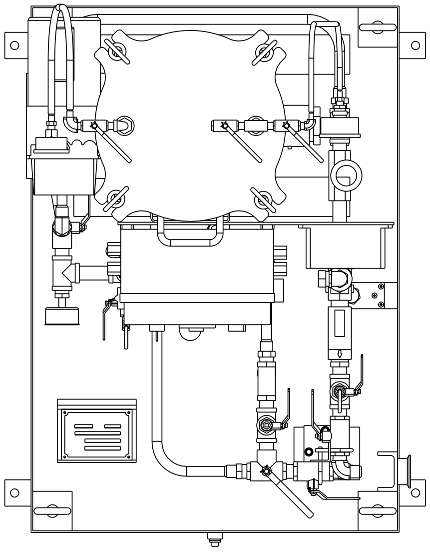
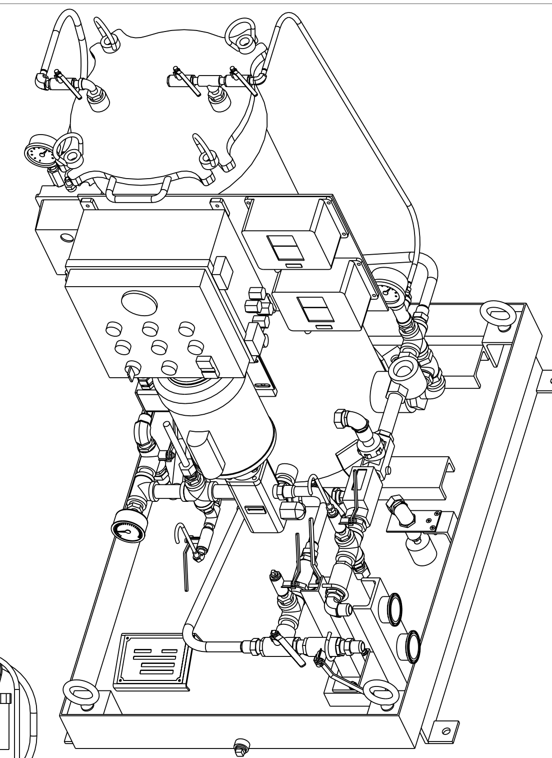
4525 CENTENNIAL BLVD.,COLORADO SPRINGS,CO 80919-3350

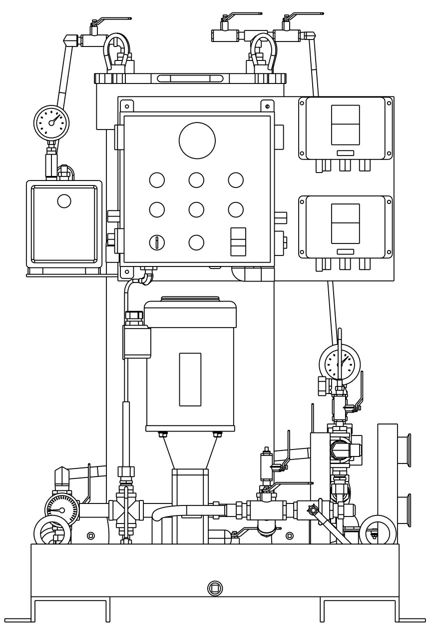
TITLE PIPING SCHEMATIC

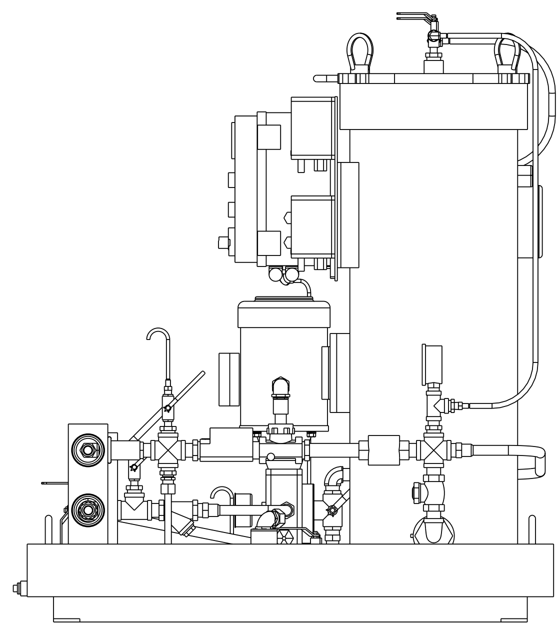
SIZE A — NO. TDS5TR-1 — REV. 0.0





1	1	PUMP ASSY 5 GPM 115/230/1 PH VIKING	101P003-12
2	1	PUMP VAC 3 CFM 115 VAC	103X026
3	1	HOSE ASSY 3/8 FIC SW ENDS	150Z203
4	1	HOSE ASSY 3/8"	150Z205
5	4	ADAPT ELB90 JIC 1/4 X 1/4 STL	240X010
6	1	ADAPT ELB90 JIC 3/8 X 1/4 STL	240X020
7	4	ADAPT ELB90 JIC 3/4 X 3/4 STL	240X051
8	2	ADAPT MJIC 1/4 X 1/4 STL	241X010
9	1	ADAPT MJIC 3/8 X 1/4 STL	241X015
10	1	ADAPT MJIC 3/8 X 3/8 STL	241X020
11	8	ADAPT MJIC 3/4 X 3/4 STL	241X050
12	2	SAMPLING TUBE 1/4 S/S	320X000
13	2	TUBE RUN 1/4 S/S	320X000
14	5	TUBE RUN 3/4 S/S	320X009
15	1	NAMEPLATE	380X001
16	1	BASE ASSY TDS5ABCTR	416Y077
17	1	MOUNTING PLATE TDS5 BOX/PROBE	416Y909
18	1	PIPE SUPPORT TDS5	418Y002
19	1	Y-STRAINER 3/4 BRASS	440X004
20	3	CROSS 3/4 NPT 150#	500X040
21	4	NIPPLE 1/4 X CLOSE BRASS	501X005
22	4	NIPPLE 1/4 X CLOSE CS	501X006
23	1	NIPPLE 1/2 X CLOSE CS	501X083
24	11	NIPPLE 3/4 X CLOSE CS	501X101
25	2	NIPPLE 3/4 X 3 CS	501X130
26	1	NIPPLE 3/4 X 4-1/2 CS	501X140
27	1	NIPPLE 1 X CLOSE CS	501X195
28	1	ELB 90 STR 1/4 150#	502X022
29	1	ELB 90 STR 3/4 150#	502X082
30	2	TEE HYD 1/4	503X075
31	1	TEE NPT 3/8 HYD RUN TEE	503X103
32	1	TEE NPT 1/2 150# CS	503X141
33	3	TEE NPT 3/4 150# CS	503X181
34	1	CPLG NPT 1/2 150#	504X015
35	1	HEX BUSH 3/8 X 1/4 BRASS	507X011
36	1	HEX BUSH 1/2 X 1/4 CS	507X016
37	6	HEX BUSH 3/4 X 1/4 CS	507X020
38	3	HEX BUSH 3/4 X 1/2 CS	507X030
39	2	HEX BUSH 1 X 3/4 CS	507X048
40	2	HEX BUSH 2 X 3/4	507X225
41	3	PLUG 1/4 NPT	509X070
42	1	PLUG 3/4 NPT	509X085
43	2	VALVE 3-WAY BALL 3/4 BRASS	552X030
44	6	VALVE BALL SP 1/4 BRASS	554X001
45	3	VALVE BALL SP 3/4 BRASS	554X030
46	1	CHECK VALVE 3/4 POPPET	556X021
47	1	CONDUIT FITTING LT 1/2	686X001
48	1	CONDUIT ELBOW FITTING	686X003
49	1	PANEL ASSY TDS5ABC W/PLC 120VAC	695Y162
50	1	PRESSURE GAUGE 30/0/30 LF LOGO	700X027
51	1	PRESSURE GAUGE 0-100 PSI LF CBM	700X039
52	1	THERMOMETER 0-250 BTM MT	720X001
53	1	FLOWMETER 0-30 GPM ALUM	722X006
54	1	FLOW SIGHT INDICATOR 3/4 NO WHEEL	722X052
55	1	FLOW SWITCH GEMS 1	723X005
56	1	LEVEL SWITCH ASSY TDS5	724Y011
57	2	DOBLE DOMINO 120/230 VAC	746X012
58	2	DOBLE DOMINO PROBE 120 VAC	IN 746X012
59	1	VESSEL ASSEMBLY TDS	VF1229TDS





NO.	DESCRIPTION	BY	APP.	DATE

DRAWN BY: VLB	DATE: 30-Jul-99	TITLE
CHECKED BY: JM	DATE: 30-Jul-99	DRAWING TYPE
PROJECT ENGINEER: JM	DATE: 30-Jul-99	
APPROVED BY: JM	DATE: 30-Jul-99	
CERTIFIED BY:	DATE:	
SCALE: 0.219	OPTIONS:	

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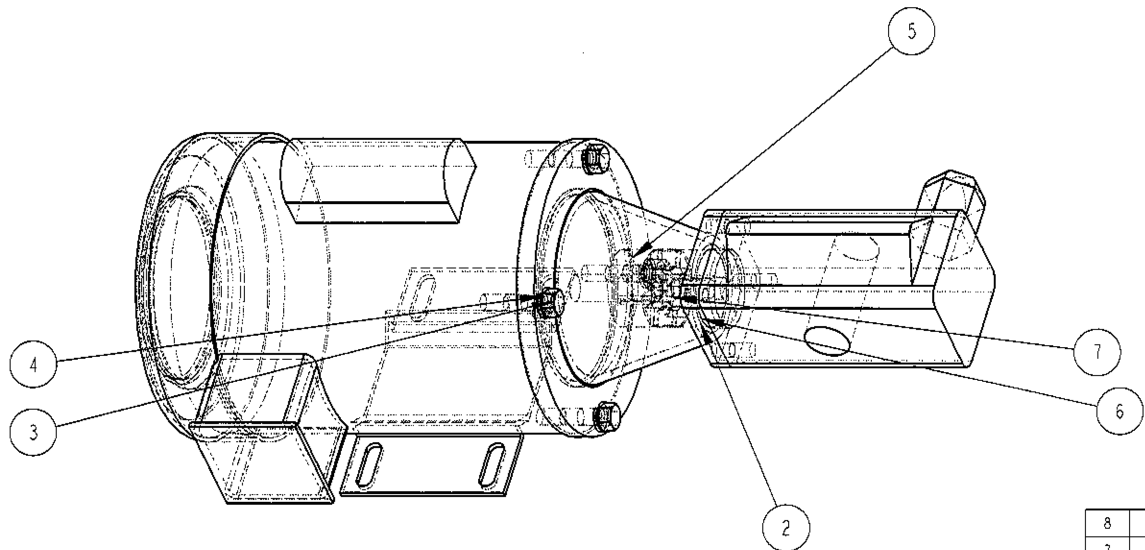
2909 E. GRIMES HARLINGEN, TEXAS 78550

ALL DIMENSIONS ARE IN INCHES IF NOT SHOWN, USE FOLLOWING TOLERANCES
FRACTIONS 1/8" ±
DECIMALS ----±
ANGLES 2° ±

MODEL NO. TRANSFORMER DRY-OUT SYSTEM 5 GPM 115/1/60

SIZE	DRAWING NO.	SERIAL NO.	REV.NO.
D	TDS5TR-1AA		1



ITEM	QTY	DESCRIPTION	CMPNT NO.
8	1	TBD	TBD
7	1	CPLG SPIDER LOVEJOY L075	412X010
6	1	CPLG DRV LOVEJOY L075 7/16	412X009
5	1	CPLG DRV LOVEJOY L075 5/8	412X008
4	4	LOCK WASHER 3/8 PLATED	402X080
3	4	BOLT 3/8-16 X 1 LG	400X100
2	1	PUMP ADAPT 56C FOR VIKING SG SERIES	101X027
1	1	PUMP GR 5 GPM VIKING SG-40514	101X003

NO	DESCRIPTION	BY	DATE

DRAWN BY JDH — DATE 04-Mar-99
CHECKED BY — DATE 04-Mar-99
APPROVED — DATE 04-Mar-99
FILE NAME TP10-1.DWG
SHEET 1 OF :

SCALE 0.375 — MODEL 5 GPM

ALL DIMENSIONS ARE IN INCHES IF NOT SHOWN, USE FOLLOWING TOLERANCES
FRACTIONS ± 1/8"
DECIMALS ± .005
ANGLES ± ---

DO NOT SCALE DRAWING

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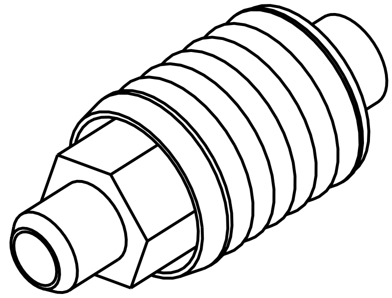
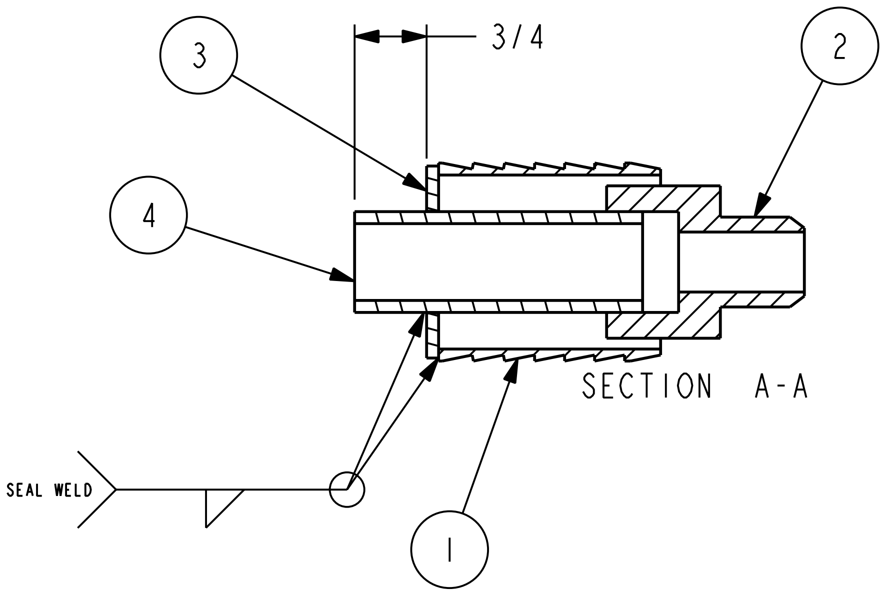
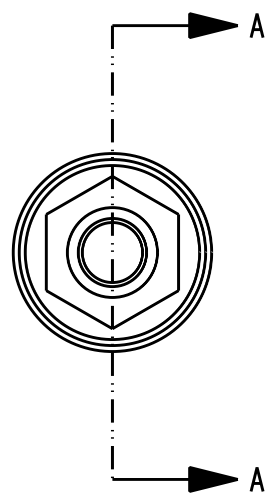
COLORADO SPRINGS, COLORADO 80919

TITLE 5 GPM 115/230/1 PH PUMP ASSY
SIZE B — NO. 101P003-12 — REV. 0







NO	DESCRIPTION	BY	DATE	ITEM	QTY	DESCRIPTION	CMPNT NO.
				4	1	NIPPLE 3/4 X 3 CS	501X130
				3	1	WASHER 1 SAE PLATED	402X150
				2	1	ADAPT MJIC 3/4 X 3/4 FPT STL	241X054
				1	1	HOSE MENDER 2 PLATED	161X022

DRAWN BY JDH	DATE 12-Sep-07	SCALE 1/2	MODEL
CHECKED BY JIM	DATE 12-Sep-07	ALL DIMENSIONS ARE IN INCHES IF NOT SHOWN, USE FOLLOWING TOLERANCES	
APPROVED HEAD	DATE 12-Sep-07	FRACTIONS ± 1/8"	
FILE NAME 156Y003.DRW	SHEET 1 of 1	DECIMALS ± .005 ANGLES ± ---	
-- --	-- --	DO NOT SCALE DRAWING	

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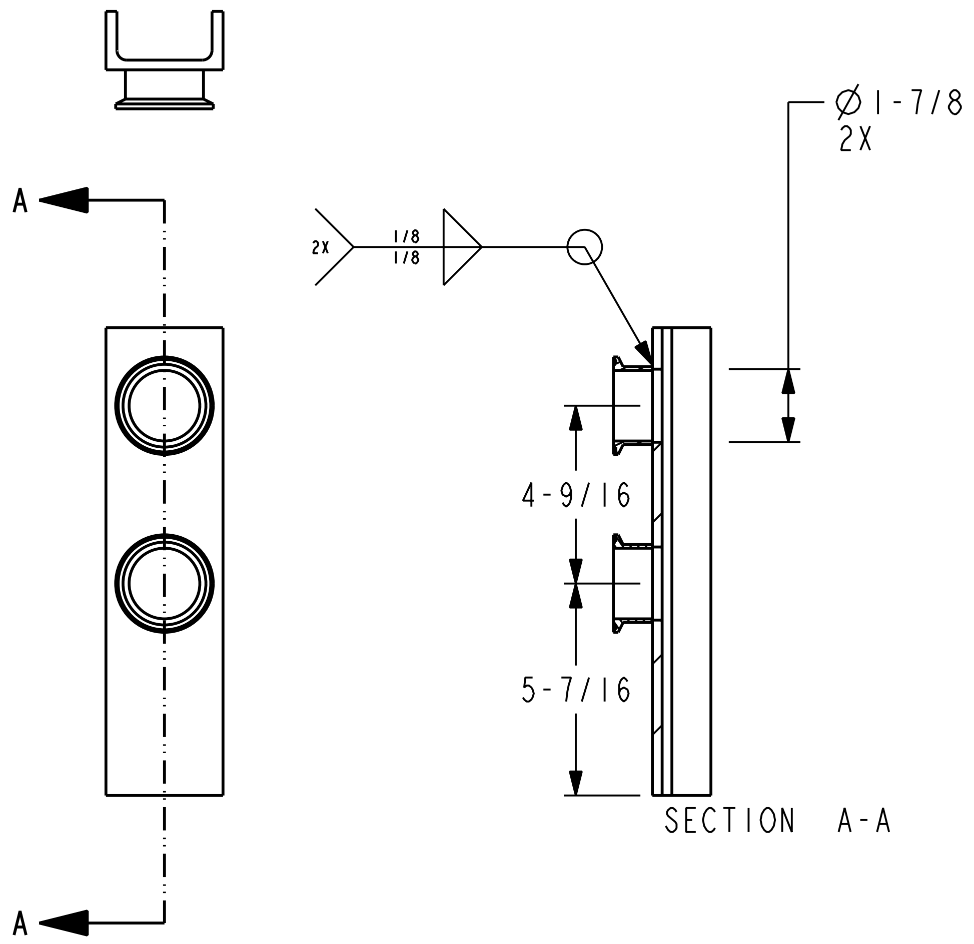
4525 CENTENNIAL BLVD COLORADO SPRINGS, COLORADO 80919

TITLE COAXIAL HOSE END

SIZE	NO.	REV.
A	156Y003	XX



				ITEM	QTY	DESCRIPTION	CMPNT NO.
				2	1	CHANNEL C3 X 13 LG	311X030
				1	2	TRI-CLAMP WELD FERRULE 2"	220X032
NO	DESCRIPTION	BY	DATE				

DRAWN BY: J HEAD	DATE: 28-Sep-06	SCALE: 13/64	MODEL: TDS5ABCTR
CHECKED BY: JIM	DATE: 28-Sep-06		
APPROVED: HEAD	DATE: 28-Sep-06		
FILE NAME: 156Z001.DRW	SHEET: 1 of 1		
JIG NUMBER	LOCATION		

ALL DIMENSIONS ARE IN INCHES
IF NOT SHOWN, USE
FOLLOWING TOLERANCES

FRACTIONS	± 1/8"
DECIMALS	± .005
ANGLES	± ---

DO NOT SCALE DRAWING

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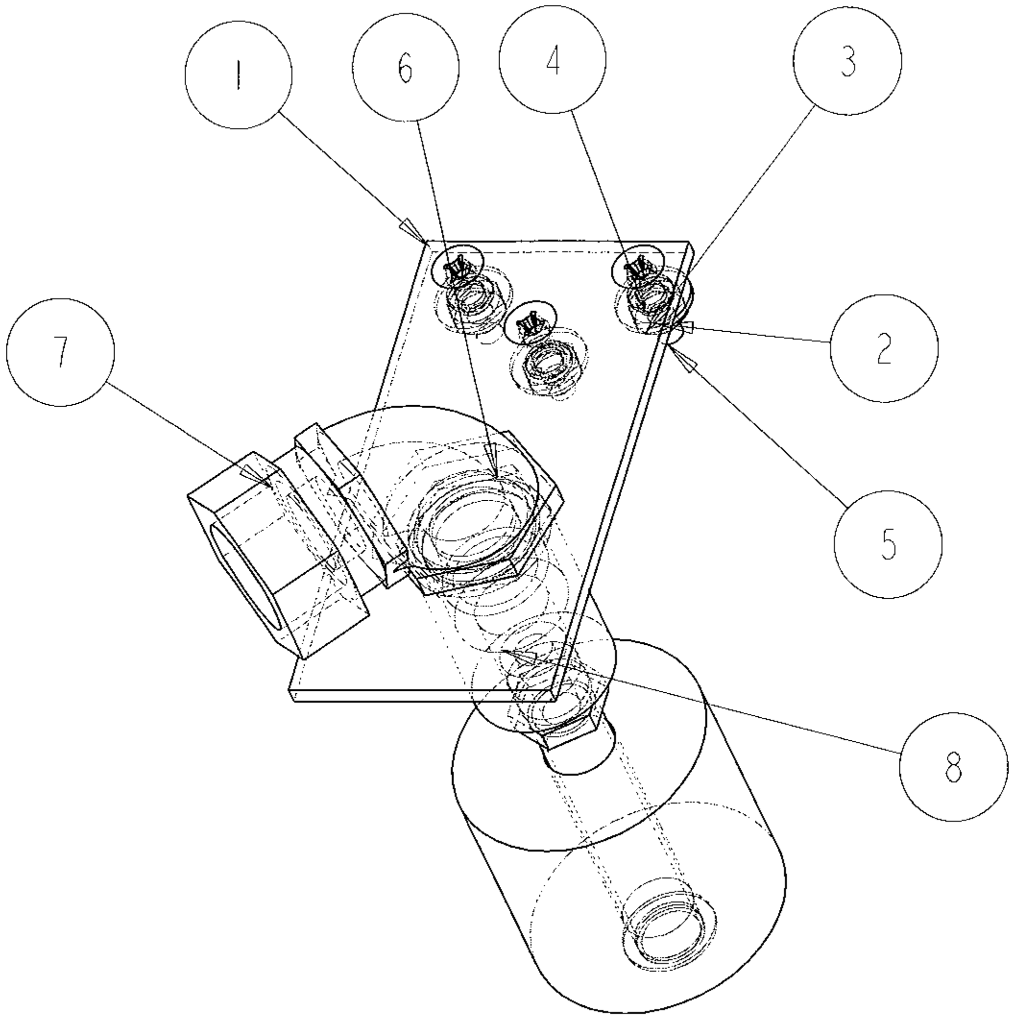
4525 CENTENNIAL BLVD COLORADO SPRINGS, COLORADO 80919

TITLE: HOSE MTG BRACKET TDS5ABCTR

SIZE: A | NO.: 156Z001 | REV.:



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8	1	FLOAT SWITCH GEMS LS-1900	724X011
7	1	CONDUIT ELBOW FITTING	686X003
6	1	RED CPLG 1/2 X 1/4 CS	507X605
5	3	MACH SCREW 10-32 X 3/4	404X030
4	3	LOCK WASHER 10-32 PLATED	402X020
3	3	FLATWASHER 10-32 PLATED	402X015
2	3	HEX NUT 10-32 PLATED	401X015
1	1	FLAT BAR 1/8 X 2 X 4 LG CS	332X004

NO	DESCRIPTION	BY	DATE

DRAWN BY: JDH	DATE: 03-Aug-99
CHECKED BY: JIM H	DATE: 03-Aug-99
APPROVED: J HEAD	DATE: 03-Aug-99
FILE NAME: 724Y011.DRW	SHEET: 1 of 1
JIG NUMBER	LOCATION

SCALE: 0.750
MODEL: TDS5

ALL DIMENSIONS ARE IN INCHES
IF NOT SHOWN, USE
FOLLOWING TOLERANCES

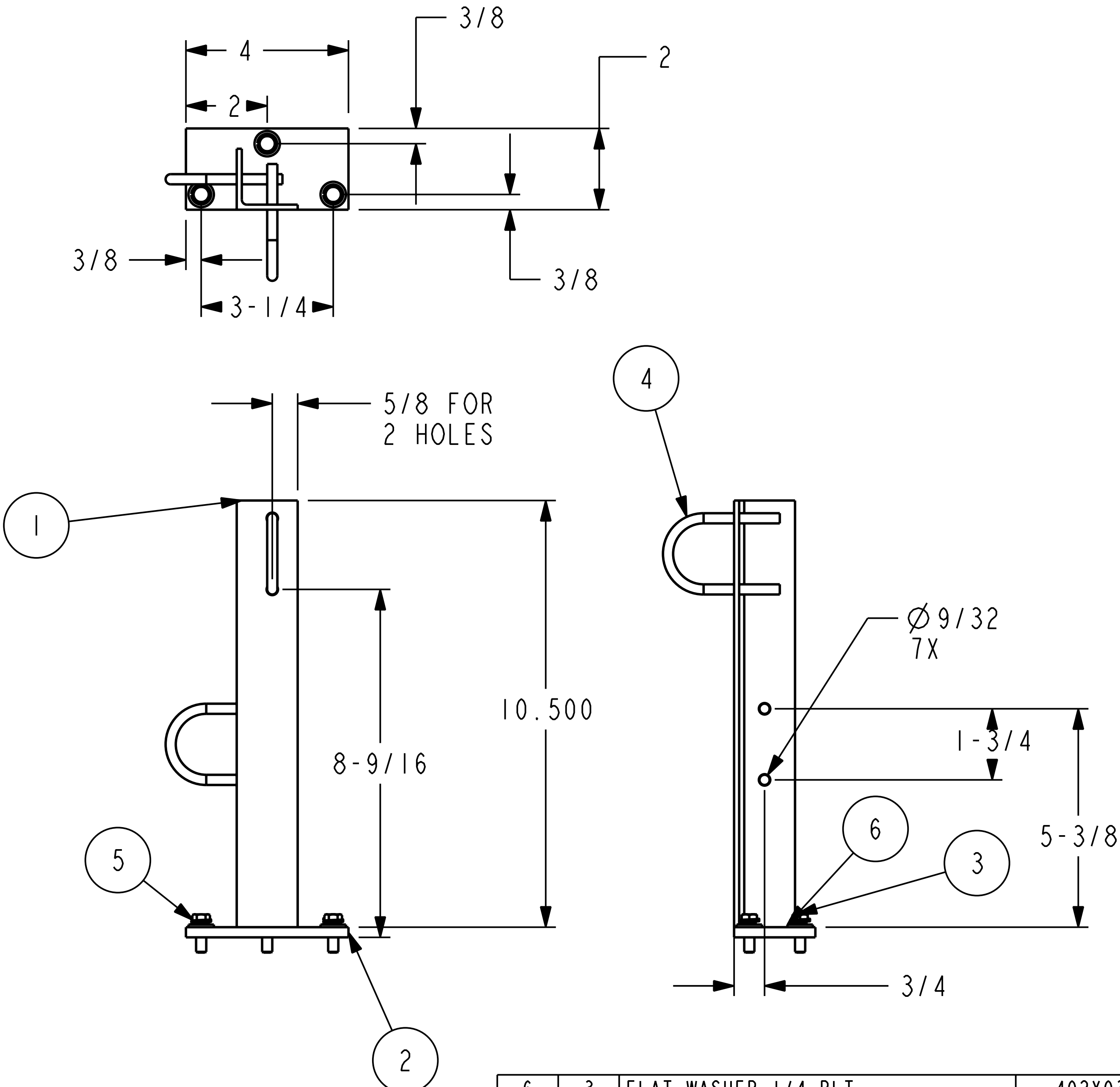
FRACTIONS	± 1/8"
DECIMALS	± .005
ANGLES	± ---

DO NOT SCALE DRAWING

velcon FILTERS
4525 CENTENNIAL BLVD COLORADO SPRINGS, COLORADO 80919

TITLE: LEVEL SWITCH ASSY TDS5

SIZE: A
NO.: 724Y011
REV.:



ITEM	QTY	DESCRIPTION	CMPNT NO.
6	3	FLAT WASHER 1/4 PLT	402X030
5	3	LOCK WASHER 1/4	402X025
4	2	U-BOLT 1/4-20 1-1/ X 2-3/4 I/S	400X715
3	3	BOLT 1/4-20 X 3/4	400X003
2	1	FLAT BAR 1/4 X 2 X 4 LG CS	332X005
1	1	ANGLE 1-1/2 X 1-1/2 X 1/8 X 10-1/2" LG CS	310X010

NO	DESCRIPTION	BY	DATE

DRAWN BY	DATE	SCALE	MODEL
JDH	13-Mar-08	1/4	TDS5TR
CHECKED BY	DATE		
JIM	13-Mar-08		
APPROVED	DATE		
HEAD	13-Mar-08		
FILE NAME	SHEET		
418Y002.DRW	1 of 1		
JIG NUMBER	LOCATION		

ALL DIMENSIONS ARE IN INCHES
IF NOT SHOWN, USE
FOLLOWING TOLERANCES

FRACTIONS	± 1/8"
DECIMALS	± .005
ANGLES	± ---

DO NOT SCALE DRAWING

velcon FILTERS

4525 CENTENNIAL BLVD COLORADO SPRINGS, COLORADO 80919

TITLE
PIPE SUPPORT TDS5

SIZE A | NO. 418Y002 | REV.

PARTS LIST

TDS5TR-1

LEVEL	PART NUMBER	DESCRIPTION	QTY	U/M
0	**TDS5TR-1**	**TRANS DRYOUT SYS 5 GPM**	**1**	**EA**
1	101P003-12	PUMP ASSY 5 GPM 115/230/1	1	EA
2	101X003	PUMP GR W/ADAPT 5 GPM	1	EA
2	121X004	MTR 1/2HP 18 1P 56C TEFC	1	EA
2	400X090	BOLT HCS 3/8-16X1	AR	EA
2	402X080	WASH S/L 3/8	AR	EA
1	103X026	PUMP VAC 3 CFM	1	EA
1	150Z203	HOSE ASSY TDS5 3/8 X 3 FT	1	EA
2	150X002	HOSE 3/8 SINGLE BRAID	3	FT
2	162X004	HOSE FIT JIC 3/8"SW CRIMP	2	EA
1	150Z205	HOSE ASSY TDS5 3/8 X 5 FT	1	EA
2	150X002	HOSE 3/8 SINGLE BRAID	5	FT
2	162X004	HOSE FIT JIC 3/8"SW CRIMP	2	EA
1	240X010	ADAPT ELB90 JIC M 1/4X1/4	4	EA
1	240X020	ADAPT ELB90 JIC M 3/8X1/4	1	EA
1	240X051	ADAPT ELB90 JIC M 3/4X3/4	4	EA
1	241X010	ADAPT JIC M 1/4	2	EA
1	241X015	ADAPT JIC M 3/8 X 1/4	1	EA
1	241X020	ADAPT JIC M 3/8X3/8	1	EA
1	241X050	ADAPT JIC M 3/4X3/4	8	EA
1	246X010	NUT 3 PC JIC 1/4	6	EA
1	246X011	SLEEVE 3 PC JIC 1/4	6	EA
1	246X020	NUT 3 PC JIC 3/8	1	EA
1	246X021	SLEEVE 3 PC JIC 3/8	1	EA
1	246X050	SLEEVE 3 PC JIC 3/4	12	EA
1	246X051	NUT 3 PC JIC 3/4	12	EA
1	320X000	TUBING 304 WLD 1/4*.035	4	FT
1	320X003	TUBING 304 WELDED 3/8"	1.5	FT
1	320X009	TUBING 304 WLD 3/4"*.065	10	FT
1	380X001	PLATE VELCON DATA	1	EA
1	380X049	VALVE TAG SET BRASS 1-25	1	EA
1	416Y077	SYSTEM BASE TDS5ABCTR	1	EA
2	156Z001	HOSE MTG BRKT TDS5ABCTR	1	EA
3	220X032	TRI CLMP FERREL WLD 2"	2	EA
3	223X032	TRI CLMP CAP 2"	2	EA
3	223X132	TRI CLMP CLAMP 2" US	2	EA
3	223X232	TRI CLMP ORING VITON 2"	2	EA
3	311X030	CHANNEL C3X5#	1.38	FT
3	687X026	MIDGET LOCK BODY ML-2R	2	EA
2	311X030	CHANNEL C3X5#	3.9	FT
2	311X040	CHANNEL C4X #	0.3	FT
2	311X060	CHANNEL C6 X 8.2#	6.25	FT
2	313X020	ANGLE IRON 2X2X3/16 A36	0.18	FT
2	313X025	ANGLE 3" X 3" X 1/4" A36	0.3	FT
2	332X005	BAR FLAT 1/4X2	0.9	FT
2	382X001	NAMEPLATE BRACKET	1	EA
2	400X512	BOLT LIFTING EYE 1/2"	4	EA
2	401X050	NUT HEX 1/2	4	EA
2	416X077	DRIP PAN 28 X 40X 4 HI	1	EA
2	505X020	HF CPLG NPT 1/2	1	EA

LEVEL	PART NUMBER	DESCRIPTION	QTY	U/M
2	509X080	PLUG NPT 1/2	1	EA
1	416Y909	MOUNTING PLATE TDS5TR-1AA	1	EA
2	300X125	PLATE 1/8" A36 PER SQ-FT	3	SF
1	418Y002	PIPE SUPPORT TDS5	1	EA
2	313X010	ANGLE 1-1/2X1-1/2X1/8"	1.05	EA
2	332X005	BAR FLAT 1/4X2	0.4	FT
2	400X715	U-BOLT 1/4-20 1-1/2 WIDE	2	EA
1	440X004	STRAINER Y 3/4	1	EA
1	500X040	CROSS NPT 3/4 150# BLK	3	EA
1	501X005	NIP NPT 1/4 CLOSE BRASS	4	EA
1	501X006	NIP NPT 1/4 X CLOSE BLK	4	EA
1	501X083	NIP NPT 1/2 X CLOSE BLK	1	EA
1	501X101	NIP NPT 3/4 CLOSE	11	EA
1	501X130	NIP NPT 3/4X3	2	EA
1	501X140	NIP NPT 3/4X4-1/2	1	EA
1	501X195	NIP NPT 1" CLOSE	1	EA
1	502X022	ELB90 STR NPT 1/4 STEEL	1	EA
1	502X082	ELB90 STR 150# 3/4	1	EA
1	503X075	TEE NPT 1/4 HYDRAULIC	2	EA
1	503X103	TEE NPT 3/8 HYD RUN	1	EA
1	503X141	TEE NPT 1/2 150#	1	EA
1	503X181	TEE NPT 3/4" 150# BLK	3	EA
1	504X015	CPLG NPT 1/2	1	EA
1	507X011	RED BUSH NPT 3/8X1/4 BR	1	EA
1	507X016	RED BUSH NPT 1/2 X 1/4 CS	1	EA
1	507X020	RED BUSH NPT 3/4X1/4	6	EA
1	507X030	RED BUSH NPT 3/4X1/2	3	EA
1	507X048	RED BUSH NPT 1X3/4	2	EA
1	507X225	RED BUSH NPT 2X3/4	2	EA
1	509X070	PLUG PIPE NPT 1/4	3	EA
1	509X085	PLUG NPT HH 3/4	1	EA
1	530X021	VALVE TAG SEAL	10	EA
1	552X030	VALVE BALL 3-WAY 3/4	2	EA
1	554X001	VALVE BALL 1/4	6	EA
1	554X030	VALVE BALL 3/4	3	EA
1	556X021	VALVE CHECK 3/4" POPPET	1	EA
1	681X143	CORD #14/3 SO	25	FT
1	685X004	CONDUIT LT 1/2"	4	FT
1	686X001	CONDUIT FITTING LT 1/2"	1	EA
1	686X003	CONDUIT FITTING LT ELB90	1	EA
1	687X001	PLUG HUBBEL 15AMP	1	EA
1	687X201	BOOT FOR HUBBELL PLUG	1	EA
1	695Y162	PANEL ASSY TDS5 115V/1	1	EA
1	700X024	GAUGE PRESS 30/30 LF BTM	1	EA
1	700X039	GAUGE PRESS 0/100 PSI LF	1	EA
1	720X001	THERMOMETER BOT MT 0-250F	1	EA
1	722X006	FLOWMTR TOTAL 1" 0-30 GPM	1	EA
1	722X052	FLOW SIGHT INDICATOR 3/4	1	EA
1	723X005	FLOW SWITCH POPPET 1" NPT	1	EA
1	724Y011	LEVEL SWITCH ASSY TDS5	1	EA
2	332Y004	LEVEL SWITCH MOUNT TDS	1	EA
3	332X004	BAR FLAT 1/8 X 2 HOT ROLL	0.33	FT
3	140X004	PAINT POWDER ALMOND GE	AR	LB
2	401X015	NUT 10/32	AR	EA
2	402X015	WASH FL 10/32	AR	EA
2	402X020	WASH S/L 10/32	AR	EA
2	404X030	SCREW MACH PH 10/32X3/4	AR	EA

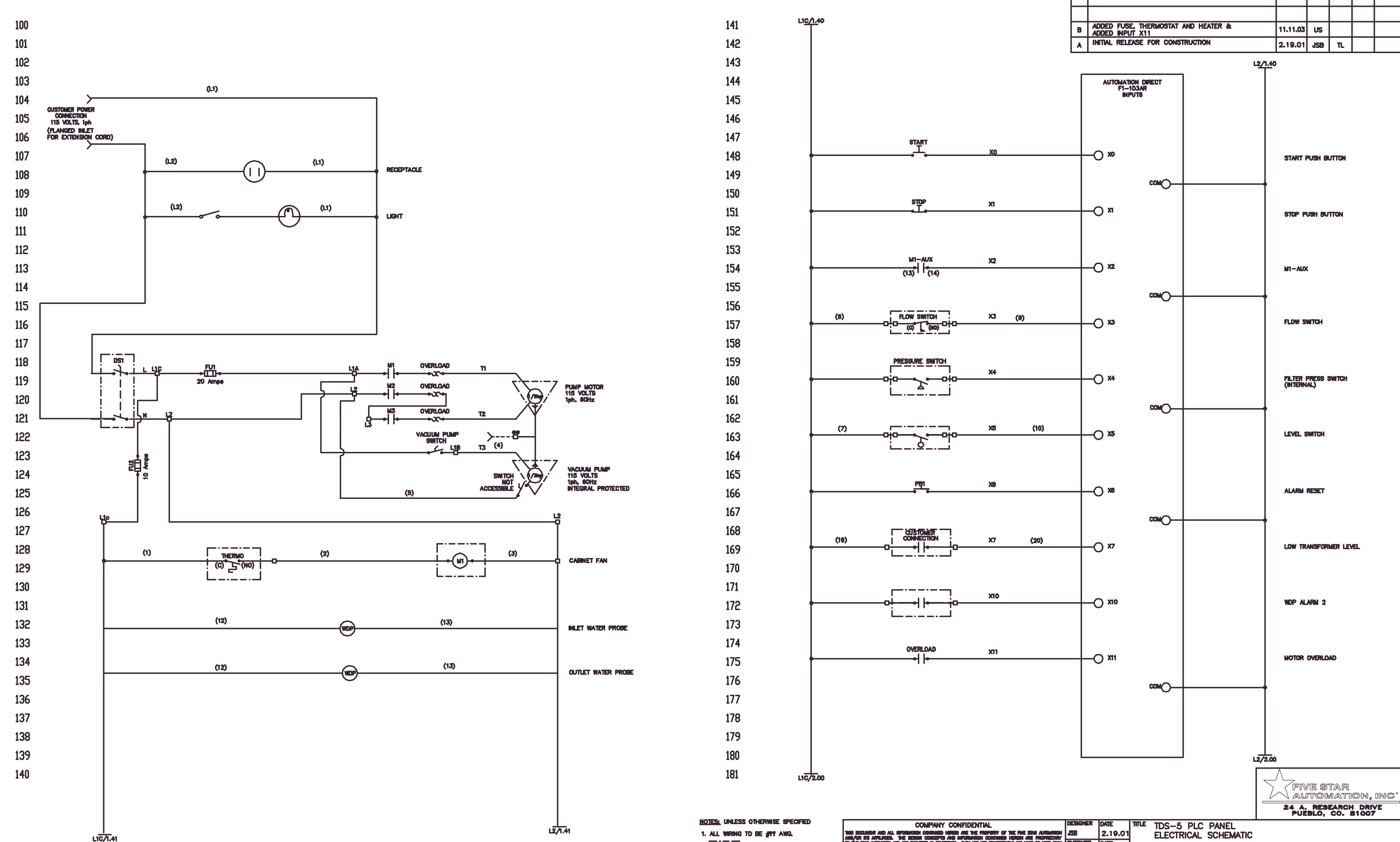
LEVEL	PART NUMBER	DESCRIPTION	QTY	U/M
2	507X605	RED CPLG 1/2 X 1/4 MAL	1	EA
2	686X003	CONDUIT FITTING LT ELB90	1	EA
2	724X011	LEVEL SWITCH GEMS LS-1900	1	EA
1	VF1229TDS	VESSEL VF1229 FOR TDS5	1	EA
2	140X004	PAINT POWDER ALMOND GE	0	LB
2	401X810	NUT EYE 3/4 PLATED	0	EA
2	401X810	NUT EYE 3/4 PLATED	0	EA
3	70E0K4GQ	BLT EYE 3/4 X 5 LONG EYE	4	EA
3	740I2AQ	PIN CLEV 5/8 X 2 1/8 SA	4	EA
3	72HKR	NUT H 3/4 SA-194	4	EA
3	73F0KT	WASH-FL 3/4 SA-3	4	EA
3	900013	PIN, COTTER 3/32 X 1-1/2	4	EA
3	EA15	ELEMENT END CAP VF1429SYS	1	EA
3	G-2031	O-RING BUNA	1	EA
3	K61	BLT HH 1/2 X 2 PL S	2	EA
3	73F0GU	WASH-FL BRASS 1/2	2	EA
3	K125	WASH-FL CAD 1/2	4	EA
0	**440Y004**	**STRAINER Y 5 GPM 3/4" BYPASS OPTION**	**1**	**EA**
1	440X004	STRAINER Y 3/4	1	EA
1	501X101	NIP NPT 3/4 CLOSE	1	EA
0	**156Y006**	**FIRE RESIST HOSES TDS5 OPTION**	**1**	**EA**
1	150A625	HOSE ASSY 1-1/2"X 25'JICS	2	EA
1	156Y007	REMOV FP HOSE MTG BRKT	1	EA
2	241X090	ADAPT JIC M 2 X 2	2	EA
2	300X188	PLATE 3/16" A36 PER SQ-FT	0.75	EA
2	687X025	MIDGET LOCK PLUG ML-2P	2	EA
2	687X026	MIDGET LOCK BODY ML-2R	2	EA
1	156Y008	COAX HOSE END TDS5 W/FP	2	EA
2	241X090	ADAPT JIC M 2 X 2	2	EA
2	241X056	ADAPT JIC M 3/4X3/4 5"LG	2	EA
2	402X150	WASHER FLAT 1 SAE PLAIN	AR	EA
0	**150B350**	**HOSE SET TDS5 COAX X 50FT**	**1**	**EA**
1	150A350	HOSE ASSY TDS5 3/4 X 50FT	2	EA
2	150X051	HOSE 3/4" 1250 PSIG 51FT	2	EA
2	162X010	HOSE FIT JIC 3/4"	4	EA
1	151X024	HOSE 2" PVC CLEAR/GREEN	50	FT
1	151X025	HOSE 2" PVC CLEAR/WHITE	50	FT
1	156Y003	COAX HOSE END TDS5	2	EA
2	161X023	HOSE FIT NPT 2" BARB CS	2	EA
2	241X054	ADAPT JIC F 3/4 X 3/4	2	EA
2	402X150	WASHER FLAT 1 SAE PLAIN	AR	EA
2	501X130	NIP NPT 3/4X3	2	EA
1	160X015	HOSE CLAMP 2-1/2" ID	4	EA
1	223X340	TRI CLMP HOSE ADAPTOR 2"	2	EA
1	241X050	ADAPT JIC M 3/4X3/4	2	EA
1	241X052	ADAPT JICSW 3/4X3/4 MPT	2	EA
1	556X021	VALVE CHECK 3/4" POPPET	1	EA
1	558X040	VALVE SOL 3/4" NC 0-350	1	EA
1	558X041	VALVE SOL 3/4" NC SLO-CLO	1	EA
1	681X183	CORD #18/3 SO	110	FT
1	682X002	CORD GRIP .375-.250	2	EA
1	686X010	CONDUIT NUT 1/2"	2	EA
1	686X011	CONDUIT BOX COVER 1/2" AL	2	EA
1	686X012	CONDUIT BOX GASKET 1/2"	2	EA

LEVEL	PART NUMBER	DESCRIPTION	QTY	U/M
1	686X014	CONDUIT BOX 1/2" TYPE LB	2	EA
1	687X025	MIDGET LOCK PLUG ML-2P	2	EA
0	**150B399**	**HOSE ASSY COAX SET 100 FT**	**1**	**EA**
1	150A399	HOSE ASSY TDS5 3/4X 100FT	2	EA
2	150X101	HOSE 3/4" 1250 PSI 101FT	2	EA
2	162X010	HOSE FIT JIC 3/4"	4	EA
1	151X024	HOSE 2" PVC CLEAR/GREEN	100	FT
1	151X025	HOSE 2" PVC CLEAR/WHITE	100	FT
1	156Y003	COAX HOSE END TDS5	2	EA
2	161X023	HOSE FIT NPT 2" BARB CS	2	EA
2	241X054	ADAPT JIC F 3/4 X 3/4	2	EA
2	402X150	WASHER FLAT 1 SAE PLAIN	AR	EA
2	501X130	NIP NPT 3/4X3	2	EA
1	160X015	HOSE CLAMP 2-1/2" ID	4	EA
1	223X340	TRI CLMP HOSE ADAPTOR 2"	2	EA
1	241X050	ADAPT JIC M 3/4X3/4	2	EA
1	241X052	ADAPT JICSW 3/4X3/4 MPT	2	EA
1	556X021	VALVE CHECK 3/4" POPPET	1	EA
1	558X040	VALVE SOL 3/4" NC 0-350	1	EA
1	558X041	VALVE SOL 3/4" NC SLO-CLO	1	EA
1	681X183	CORD #18/3 SO	220	FT
1	682X002	CORD GRIP .375-.250	2	EA
1	686X010	CONDUIT NUT 1/2"	2	EA
1	686X011	CONDUIT BOX COVER 1/2" AL	2	EA
1	686X012	CONDUIT BOX GASKET 1/2"	2	EA
1	686X014	CONDUIT BOX 1/2" TYPE LB	2	EA
1	687X025	MIDGET LOCK PLUG ML-2P	2	EA
0	**746Y012**	**HI MOISTURE LEVEL ALARM**	**1**	**EA**
1	685X004	CONDUIT LT 1/2"	2	FT
2	746X012	MOISTURE PROBE WITH ALARM	1	EA
0	**472X017**	**TRAILER EXP WGN TW101 SPECIAL**	**1**	**EA**
0	**620X228**	**FUSE MIDGET .5 AMP FNQ-R-1/2**	**1**	**EA**

Caution Disconnect In Panel Located Remotely

(XX) WIRE EXTERNAL TO CONTROL PANEL

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN
B	ADDED FUSE, THERMOSTAT AND HEATER & ADDED INPUT X11	11.11.03	US			
A	INITIAL RELEASE FOR CONSTRUCTION	2.19.01	JSB	TL		



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL WIRING TO BE #?? AWG.
2. [dashed box] DENOTES REMOTE COMPONENTS (WIRED BY OTHERS)
3. ALL PLC I/O WIRING TO BE #18 AWG

BAR = 1" AT PLOT SCALE

DESIGNER JSB	DATE 2.19.01	TITLE TDS-5 PLC PANEL ELECTRICAL SCHEMATIC	
CHECKER	DATE 2.19.01	CLIENT VELCON SYSTEMS	
ENGINEER	DATE 2.19.01		
SCALE: NONE		PROJECT 00001	CODE

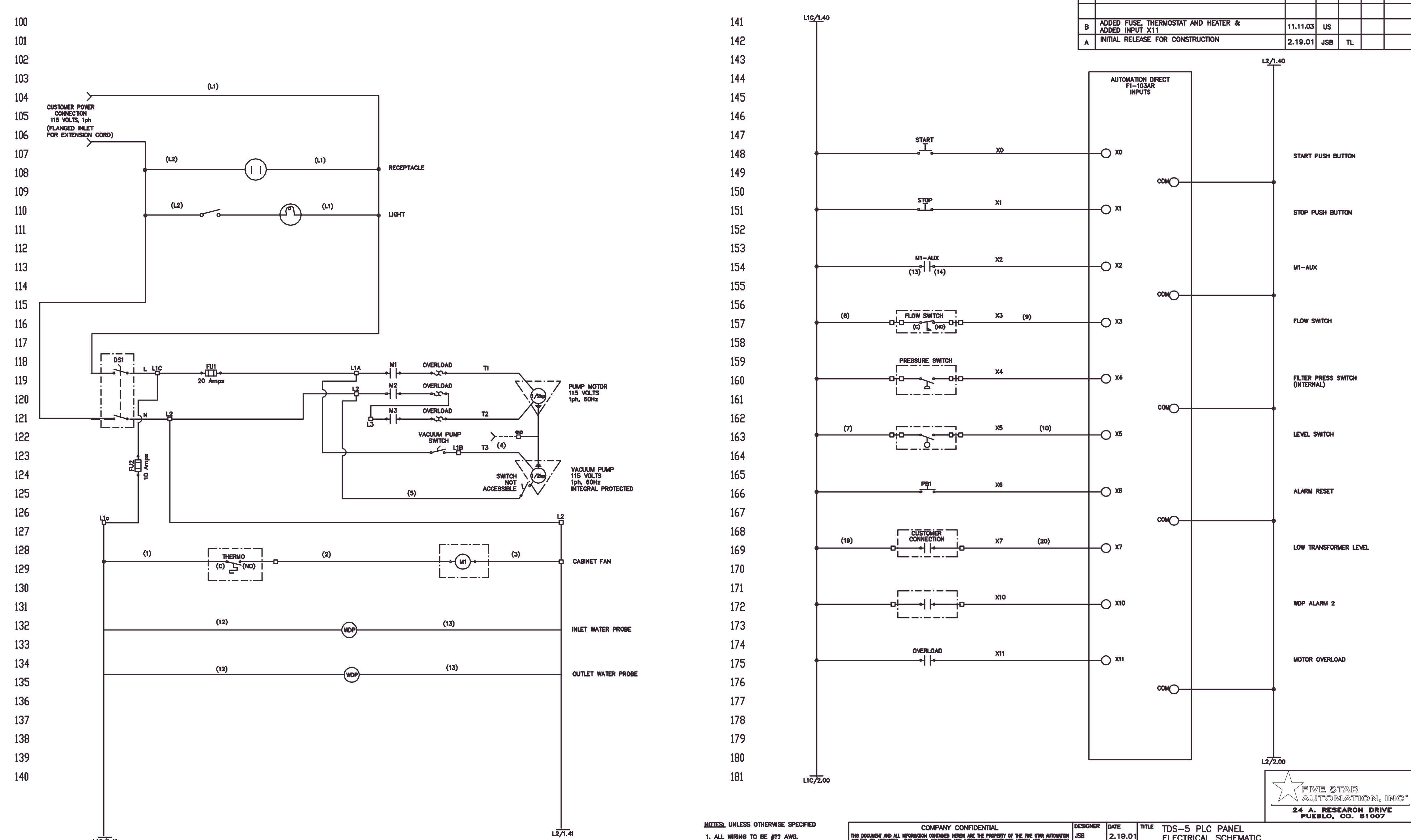
DRAWING 00001-1000 | SHEET 1 OF 2 | REV B

FIVE STAR AUTOMATION, INC.
24 A. RESEARCH DRIVE
PUEBLO, CO. 81007

Caution Disconnect In Panel Located Remotely

(XX) WIRE EXTERNAL TO CONTROL PANEL

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN
B	ADDED FUSE, THERMOSTAT AND HEATER & ADDED INPUT X11	11.11.03	US			
A	INITIAL RELEASE FOR CONSTRUCTION	2.19.01	JSB	TL		



NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL WIRING TO BE #?? AWG.
2. [dashed box] DENOTES REMOTE COMPONENTS (WIRED BY OTHERS)
3. ALL PLC I/O WIRING TO BE #18 AWG

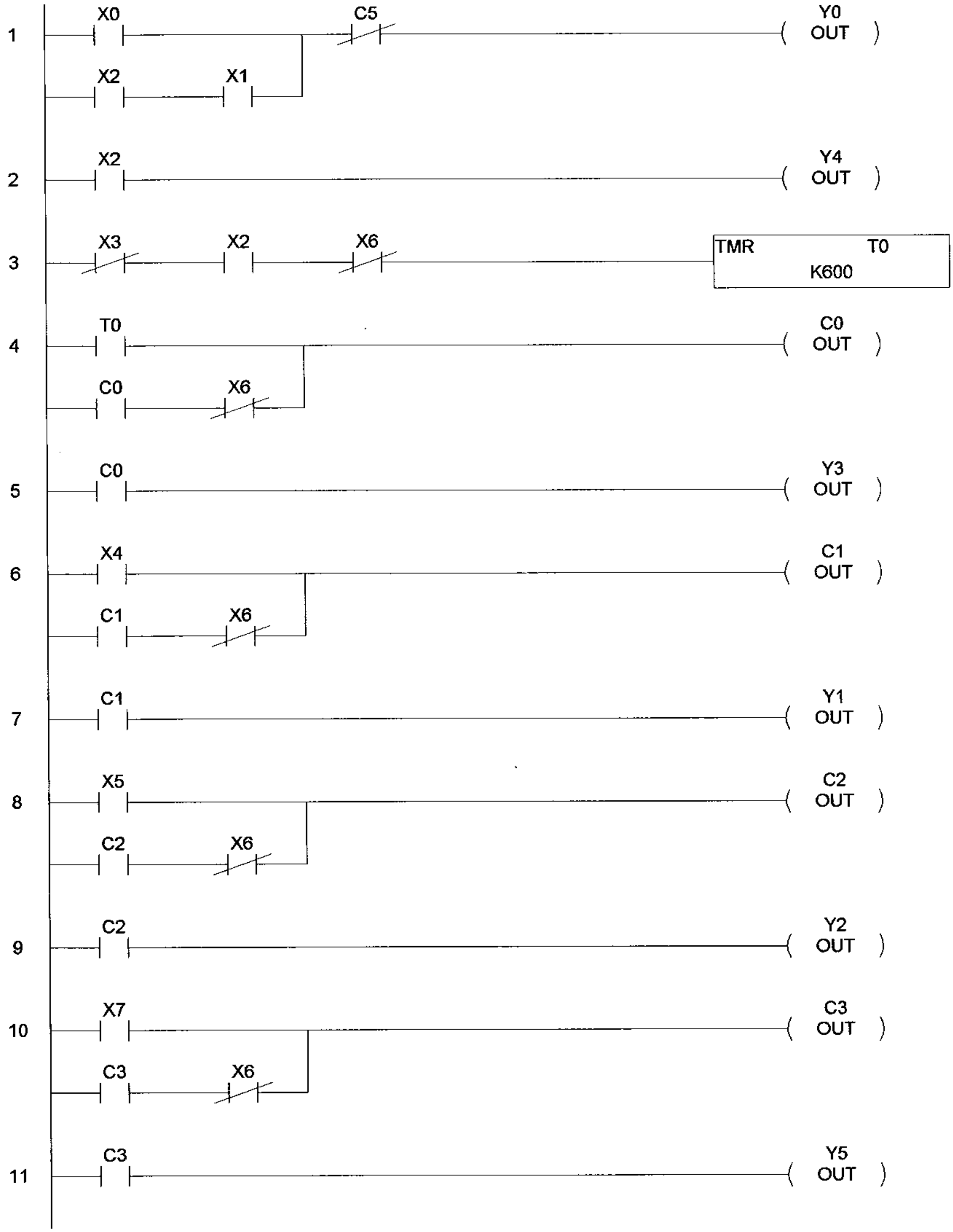
BAR = 1" AT PLOT SCALE

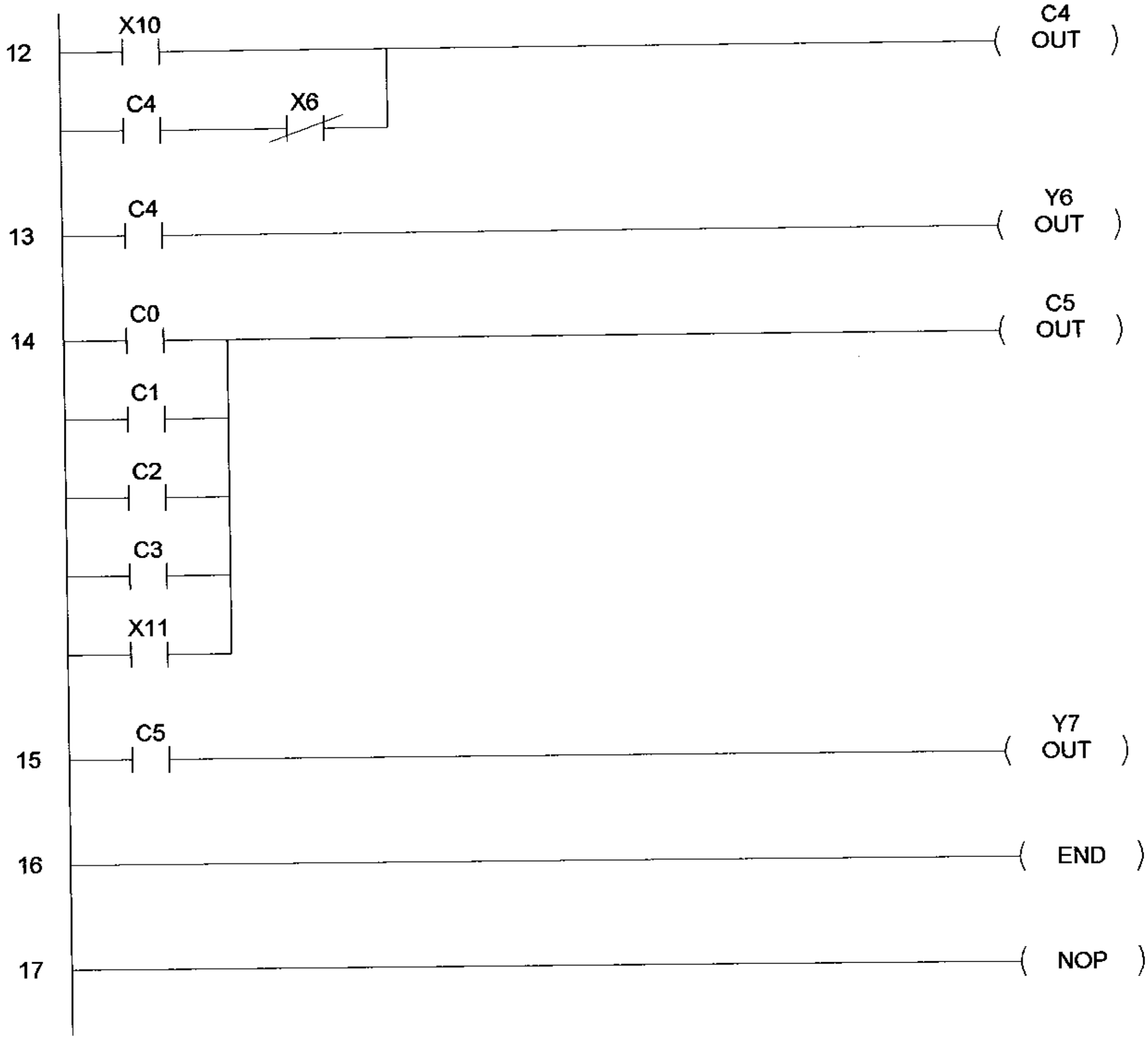
FIVE STAR AUTOMATION, INC.
24 A. RESEARCH DRIVE
PUEBLO, CO. 81007

DESIGNER JSB	DATE 2.19.01	TITLE	TDS-5 PLC PANEL ELECTRICAL SCHEMATIC
CHECKER	DATE 2.19.01	CLIENT	VELCON SYSTEMS
ENGINEER	DATE 2.19.01		
SCALE: NONE			

PROJECT	CODE	DRAWING	SHEET	REV
00001		00001-1000	1 OF 2	B

Path: c:\directsoft32\projects\tds5-60-2.prj
Save Date: 03/07/04 17:21:14
Creation Date: 03/07/04 17:21:10
PLC Type: 130
Class ID: DirectLogic 105 Series
Description: tds5


1
X0
C5
Y0
OUT
X2
X1
2
X2
Y4
OUT
3
X3
X2
X6
TMR T0
K600
4
T0
C0
OUT
C0
X6
5
C0
Y3
OUT
6
X4
C1
OUT
C1
X6
7
C1
Y1
OUT
8
X5
C2
OUT
C2
X6
9
C2
Y2
OUT
10
X7
C3
OUT
C3
X6
11
C3
Y5
OUT


12
X10
C4
OUT
C4
X6
13
C4
Y6
OUT
14
C0
C5
OUT
C1
C2
C3
X11
15
C5
Y7
OUT
16
END
17
NOP

Velcon TDS 5 Program Legend

Input or Output	Description	Point
Input	Start Button	X0
Input	M1- Auxiliary	X2
Input	Flow Switch	X3
Input	Pressure Switch	X4
Input	Level Switch	X5
Input	Alarm Rest Pushbutton	X6
Input	Low Transformer Level	X7
Input	WDP Alarm	X10
Input	Overload Relay Contacts	X11
Output	M1 Coil	Y0
Output	High Pressure Alarm Light	Y1
Output	High Level Alarm Light	Y2
Output	Low Flow Alarm Light	Y3
Output	Solenoid Valve	Y4
Output	Low Xfmr Level	Y5
Output	Change Filter Light	Y6
Output	Customer Remote Alarm Relay Coil	Y7

CHANGE FILTER ALARM SET INSTRUCTIONS

Use keypad on Doble Domino® Moisture-In-Oil-Instrument

STEP	ACTION	DISPLAY
1	Press ►	Main Menu
2	Press ▼ to select ”Interfaces”	
3	Press ►to confirm selection	Interfaces
4	Press ▼ to select “Relay Outputs”	
5	Press ►to confirm selection	Relay Outputs
6	Press ▼to select “Relay 1”	
7	Press ►to confirm selection	Relay 1 Output
8	Press ▼ to select “Quantity”	
9	Press CHANGE	Output Quantity
10	Press ▼ to select “H_2O ppm”	
11	Press SELECT to confirm selection	Output Quantity
12	Press ▼ to select “Activation Above”	
13	Press SET	1st digit of “Activation Above” is highlighted
14	Press MODIFY (if asked)	1st digit of “Activation Above” is highlighted
15	Press ► to select digit to change	
16	Press ▲ or ▼ to select value	
17	Repeat steps 15 and 16 until all digits of “Activation Above” value are set to the desired values	
18	Press OK	
19	Press ▼ to select “Hysteresis”	
20	Press SET	1st digit of “Hysteresis” is highlighted
21	Repeat steps 15, 16 and 17	
22	Press OK	
23	Press ▼ to select “Relay Enable”	
24a	Press ON to activate alarm relay **OR**	“Relay Enabled” is checked
24b	Press OFF to de-activate relay	“Relay Enabled” is un-checked
25	Press EXIT	

Velcon Factory Settings

Relay 1 Enabled
Alarm Relay set to Activate at or above 25 ppm
Hysteresis set to 5 ppm H_2O

“Activate Above” is the measured value above which the alarm activates
“Hysteresis” is the number of units below the activation point the value must reach before the alarm is de-activated

695Y162 File 695Y162.TBL

1/2 HP, 120 Volts, 60 Hz with 1/2 HP, 120 Volt, 60 Hz Vacuum Pump

Revision 0 03/12/08

Wire Table for Control Cabinet Interior Wiring

Wire Number	Wire Color and Size	Connection Points	Notes
		Control Panel Interior Wiring By Others	
L1	BK, 16 AWG	Incoming Power to TB(L1)	SO Cord
L2	WT, 16 AWG	Incoming Power to TB(L2)	SO Cord
T1	BK, 16 AWG	Contactor(T1) - Motor(T1)	
T3	BK, 16 AWG	Contactor(T3) - Motor(T3)	
GND	GN, 16 AWG	Incoming Power Gnd – Cabinet Gnd	SO Cord
GND	GN, 16 AWG	Cabinet Gnd - Motor Gnd	
GND	GN, 16 AWG	Cabinet Gnd - Vacuum Pump Gnd	SO Cord
GND	GN, 16 AWG	Cabinet Gnd - Inlet Solenoid Gnd	SO Cord
GND	GN, 16 AWG	Cabinet Gnd - Outlet Solenoid Gnd	SO Cord
GND	GN, 16 AWG	Cabinet Gnd - Temp Switch Gnd	
1	BK, 16 AWG	TB(L1C) - Temp Switch(COM)	
2	BK, 16 AWG	Temp Switch(NO) - Fan (1)	
3	BK, 16 AWG	TB(L2) - Fan(2)	
4	BK, 16 AWG	TB(L1B) - Vac Pump(1)	SO Cord
5	BK, 16 AWG	TB(L2) - Vac Pump(2)	SO Cord
6	BK, 16 AWG	TB(L1C) - Flow Switch(COM)	
7	BK, 16 AWG	TB(L1C) - Level Switch(COM)	
8	BK, 16 AWG	TB(L1C) - Outlet WDP Alarm(Com)	**Only if 746Y012 Ordered**
9	BK, 16 AWG	TB(X3) - Flow Switch(NO)	
10	BK, 16 AWG	TB(X5) - Level Switch(NO)	
11	BK, 16 AWG	TB(X10) - Outlet WDP Alarm(NO)	**Only if 746Y012 Ordered**
12	BK, 16 AWG	TB(L1C) - Outlet WDP(HOT)	**Only if 746Y012 Ordered**
12	BK, 16 AWG	TB(L1C) - Inlet WDP(HOT)	**Only if 2nd 746Y012 Ordered**

13	BK, 16 AWG	TB(L2) - Outlet WDP(NEU)	**Only if 746Y012 Ordered**
13	BK, 16 AWG	TB(L2) - Inlet WDP(NEU)	**Only if 2nd 746Y012 Ordered**
14	BK, 16 AWG	TB(Y4) - Inlet Solenoid(1)	
15	BK, 16 AWG	TB(Y4) - Outlet Solenoid(1)	
16	BK, 16 AWG	TB(L2) - Inlet Solenoid(2)	
17	BK, 16 AWG	TB(L2) - Outlet Solenoid(2)	
18	BK, 16 AWG	Trailer Light(2) – Light Switch(2)	
19	BK, 16 AWG	TB(L1C) - Transformer LLS(1)	With Plug & Ring Connector
20	WT, 16 AWG	TB(X7) - Transformer Low Level(2)	With Plug & Ring Connector

APPENDIX

INSTALLATION, START UP, TROUBLESHOOTING, PREVENTIVE MAINTENANCE, DO'S & DON'TS

SERIES SG-04, SG-05 & SG-07 SPUR GEAR PUMPS

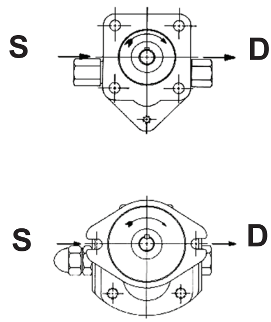


FIGURE 1

INSTALLATION

General

The following items must be considered prior to pump installation:

1. Location - locate the pump as close as possible to the liquid supply. If possible locate the pump below the liquid supply. Viking pumps are self-priming; but the better the suction conditions, the better the pump will perform.

2. Accessibility – the pump must be accessible for inspection, maintenance and repair.

3. Suction/Discharge - SG Series pumps are designed for clockwise rotation as standard (viewed from end of shaft). Refer to Figure 1.

4. Pressure Relief Valve - the SG Series is a positive displacement pump and requires some form of over pressure protection. Without pressure protection, if the discharge line is blocked or becomes closed, pressure will build up until the motor stalls, drive equipment fails, a pump part breaks, or the piping and/or other equipment in the system bursts. To prevent the possibility of any one or more of the above from occurring, the use of a pressure relief valve is recommended.

5. Storage - drain the pump and apply a light coat of non-detergent SAE 30 weight oil to all internal pump parts. Apply grease to the pump shaft extension. Viking suggests rotating the pump shaft by hand one complete revolution every 30 days to circulate the oil.

MOUNTING

1. Surfaces to which the pump mounts must be clean and flat.

2. Use SAE Grade 5 or better capscrews to mount pump.

3. The 4 mounting capscrews for the SG-04 and SG-05 pumps must have a minimum of ½ inch thread engagement, and must be torqued evenly to 12-15 ft-lbs.

4. The 2 mounting capscrews for the SG-07 pumps must have a minimum of ½ inch thread engagement, and be evenly torqued to 50-55 ft-lbs.

5. Standard SG Series pumps are designed to be used with jaw type couplings that do not induce axial thrust on the pump shaft. If an improper type of coupling is used, internal damage may result.

6. Do not strike or press the pump drive coupling to install. Internal pump damage will result. If the coupling does not slide onto the shaft, inspect the coupling, shaft and key for nicks or burrs and remove.

7. If the pump is to be belt or gear driven, the overhung load option must be specified.

8. Once the pump has been mounted and the coupling installed, it is recommended to put lube oil into the suction port and turn the pump by hand to make sure it turns freely.

Alignment

Check alignment after mounting.

1. If the unit has a flexible coupling, remove any coupling guards or covers and check alignment of coupling halves. A straight edge (piece of key stock will work) across the coupling must rest evenly on both rims at the top, bottom and sides. See Figure 3.

2. Make a final check on alignment after the piping is hooked up.

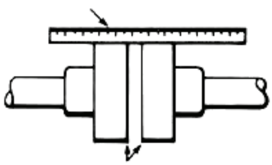


FIGURE 3

Piping/Hose

The cause of many pumping problems can be traced to the suction piping. It should always be as large in diameter and as short in length as possible.

Before starting the layout and installation of your piping system, consider the following points:

1. Never use piping smaller than the pump port connections. Piping larger in diameter than the port connection is sometimes required to reduce friction losses.

2. Be sure the inside of the pipe is clean before installing.

3. When approaching an obstacle to the suction line, go around instead of over it. Going over an obstacle can create an air pocket. Where practical, slope the piping so no air or liquid pockets will be formed. Air pockets in the suction line make it hard for the pump to prime.

4. A strainer on the suction side of the pump should always be considered in any pumping system. The strainer will keep foreign matter from entering the pump. The strainer mesh or perforation size should be large enough so that it does not cause excessive pressure drop, but fine enough to protect the pump. Use of a strainer is particularly important at start up to help clean the system of weld beads, pipe scale and other foreign objects.

5. A pressure relief valve is required in the discharge line. See Pressure Relief Valves, General page 1 item 4.

6. The pump must not be used to support the piping. Hangers, supports, stands, etc. must carry the weight of the pipes.

7. When fastening piping to the pump do not impose any strain on the pump casing. “Springing” or “drawing” the piping up to the pump will cause distortion, possible misalignment and probable rapid wear of the pump. Do not use the pump to correct errors in piping layout or assembly.

8. All joints in the piping system must be tight; liquid thread sealant will help assure leak-free threaded joints. Be careful not to over tighten the fittings to the pump, as this can damage the pump. Leaks in the suction line can permit air to be drawn in, and will cause a noisy pump and reduction in capacity.

9. Drive alignment must be checked after piping is hooked up.

10. Provide a pressure relief device in any part of a pump and piping system that can be valved off and, thus, completely isolated. A rise in temperature will cause a liquid to expand. If there is no provision for pressure relief in the closed off section, there is a chance that the pump or piping will rupture.

Danger !

Before starting pump, be sure all drive equipment guards are in place.

Failure to properly mount guards may result in serious injury or death.

START UP

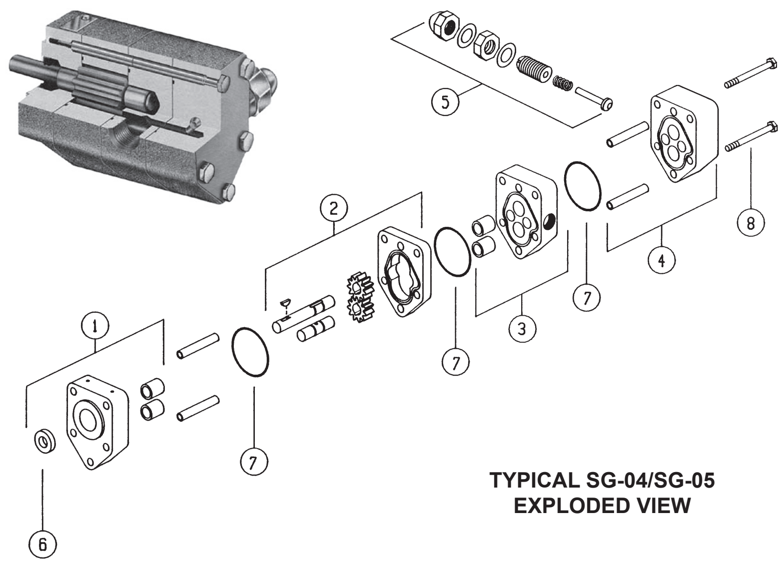
Before pushing “start” button, check the following:

1. Are vacuum and pressure gauges (liquid filled) mounted on or near the pump? Gauges are the quickest and most accurate way of finding out what is happening in the pump.

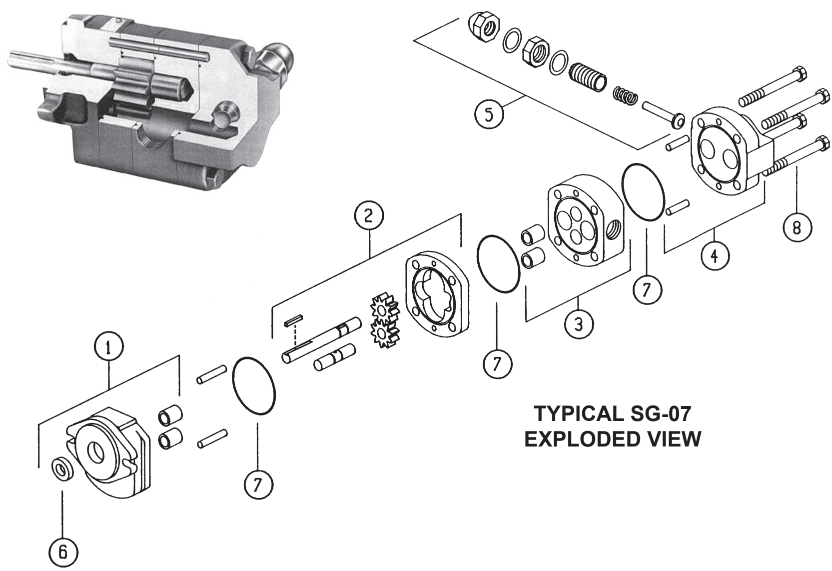
2. Is the pump is correctly aligned with the drive equipment?

3. Make sure there is no pipe strain on the pump ports.

4. Rotate the pump shaft by hand to be sure it turns freely.



TYPICAL SG-04/SG-05
EXPLODED VIEW



TYPICAL SG-07
EXPLODED VIEW

ITEM	DESCRIPTION	ITEM	DESCRIPTION
1.	Bracket, lipseal & bearing section	5.	Relief valve kit
2.	Match ground casing & (2) gears, driver & driven shafts	6.	Lipseal
3.	Separation plate & bearing assy.	7.	O-ring
4.	Head and alignment sleeve assy.	8.	Assembly capscrews

5. Before connecting to the motor, jog it to be sure it is running in the correct direction. Refer to “General” on page 1.

6. Is the pressure relief valve installed properly?

7. Make sure suction piping is properly connected and sealed, and valves are open.

8. Make sure the discharge piping is properly connected and sealed, valves are open, and there is a place for the liquid to go.

9. Make sure all guards are in place.

10. The above checklist is a general guideline to be used prior to starting the pump. Since Viking Pump cannot foresee every application for our product and possible system design, the final responsibility is with the user. The pump must be utilized within the catalog specifications and the pump system must be designed to provide safe working conditions.

The “start” button may now be pushed.

The pump should begin to deliver liquid within 15 seconds! If not, push the stop button. Do not run the pump without liquid flow longer than 30 seconds or the pump may be ruined.

Review Startup steps 1 through 10. Consider what the suction and discharge gauges may indicate. If everything appears in order, re-prime pump. Refer to Mounting page 2, item 8.

Push the “start” button. If nothing is flowing within 30 seconds, stop the pump. The pump is not a compressor, it will not build up much air pressure. It may be necessary to vent discharge line until liquid begins to flow.

If pump still does not deliver, consider one or more of the following:

1. The suction line has air leaks.

2. The end of the suction pipe is not submerged deeply enough in the liquid.

3. The suction lift is too great or the suction piping is too small.

4. Liquid is vaporizing in the suction line before it gets to the pump.

If after consideration of these points, the pump still does not deliver liquid, review all points given under START UP and read through the TROUBLESHOOTING guide and try again. If pump still will not deliver liquid, contact your Viking Pump supplier.

TROUBLESHOOTING

A Viking pump that is properly installed and maintained will give long satisfactory performance.

If trouble does develop, one of the first steps toward finding the difficulty is to install a vacuum gauge in the suction line and a pressure gauge in the discharge line. Readings on these gauges often give a clue on where to start looking for trouble.

DANGER !

Before opening any Viking pump liquid chamber (pumping chamber, reservoir, relief valve adjusting cap fitting etc.) be sure:

1. **That any pressure in chamber has been completely vented through the suction or discharge lines or other appropriate openings or connections.**
2. **That the driving means (motor, turbine, engine, etc.) has been "locked out" or made non-operational so that it cannot be started while work is being done on the pump.**
3. **That you know what liquid the pump has been handling and the precautions necessary to safely handle the liquid. Obtain a material safety data sheet (MSDS) for the liquid to be sure these precautions are understood.**

Failure to follow the above listed precautionary measures may result in serious injury or death.

Vacuum Gauge - Suction Port

High vacuum reading would indicate:

1. The suction line is blocked, valve closed, a strainer is plugged or a pinched suction line.
2. The suction line is too small.
3. The liquid is too viscous to flow through the piping.
4. The lift required is too high.

Low reading would indicate:

1. There may be an air leak in the suction line.
2. The end of the pipe is not in the liquid.
3. The pump is worn.
4. The pump is dry and should be primed.

Fluttery, jumping or erratic reading would indicate:

1. The liquid is vaporizing.
2. Liquid is coming in to the pump in slugs, possibly an air leak or insufficient liquid above the end of the suction pipe.
3. Vibration from cavitation, misalignment, or damaged parts.

Pressure Gauge - Discharge Port

High reading would indicate:

1. High viscosity and small diameter and/or lengthy discharge line.
2. The strainer or filter is plugged.
3. The pressure relief valve is set too high.
4. Valve in the discharge line partially closed.
5. Line partially plugged from build up on inside of pump, solidified product or foreign object.
6. Liquid in the pipe not up to temperature.

Low reading would indicate:

1. Pressure relief valve set too low.
2. Pressure relief valve poppet not seating properly.
3. Pump mounting capscrews into torqued to specifications (GP-04 and GP-05 Series 12-15 ft.-lbs.).
4. Pump assembly bolts not torqued into specifications (GP-07 Series 50-55 ft.-lbs.).
5. The bypass around pump partially open.
6. Pump is damaged or worn.
7. The pump has too much internal clearance.

Fluttery, jumping or erratic reading would indicate:

1. Cavitation.
2. Liquid is coming to the pump in slugs.
3. Air leak in the suction line.
4. Vibrating from misalignment or mechanical problems.

Miscellaneous

Pump does not pump:

1. The pump has lost its prime from air leak or low level in tank.

2. The suction lift is too high.

3. Rotating in the wrong direction.

4. The motor does not come up to speed.

5. The strainer is clogged.

6. The bypass valve is open, pressure relief valve set too low or pressure relief valve poppet stuck open.

7. The pump is worn out.

8. Any changes in liquid, system or operation that would help explain the trouble, e.g. new liquid, additional lines or process changes.

Pump starts, then looses its prime:

1. The supply tank is empty.

2. The liquid is vaporizing in the suction line.

3. There is an air leak or air pockets in the suction line.

4. The pump is worn out.

Pump is noisy:

1. The pump is cavitating (liquid vaporizing in suction line) or being starved (heavy liquid cannot get to pump fast enough). Increase the suction pipe size and/or reduce the length, or decrease the pump speed. If the pump is above the liquid, raise the liquid level closer to the center line of the inlet port. If the liquid is above the pump, increase the head of the liquid.

2. Check alignment.

3. Anchor the base or piping to eliminate vibration.

Pump not delivering up to capacity:

1. The pump is starving or cavitating – see **Pump is noisy**, item 1.
2. The strainer partially clogged.

3. Air leak somewhere in the suction line.

4. Running too slow. Is the motor the correct speed and wired up correctly?

5. Pressure relief valve is set too low, stuck open or has damaged poppet seat.

6. The bypass line around the pump partially opened.

7. The pump is worn out.

Pump takes too much power (stalls motor):

1. The pump sequence valve set too high.
2. Liquid is more viscous than the is unit sized to handle.
3. The system pressure relief valve set too high.
4. The pump is misaligned.

DO'S AND DON'TS

Do's and Don'ts for installation, operation and maintenance of Viking pumps to assure safe, long, trouble free operation.

Installation:

1. DO install the pump as close to supply tank as possible.
2. DO leave working space around the pumping unit.
3. DO use large, short and straight suction port.
4. DO install a strainer in the suction line.
5. DO a double check of alignment after unit is mounted and piping is hooked up.
6. DO provide pressure relief valve for discharge side of pump.
7. DO check for proper rotation.
8. DO use a return line filter.
9. DO use an industrial grade hydraulic oil.
10. DO use piping, hose and fittings rated for maximum system pressure.

Operation

1. DON'T run the pump at speeds faster than 3600 RPM.
2. DON'T allow the pump to develop pressure higher than those shown in catalog at that size.
3. DON'T operate pumps at temperatures above or below limits shown in catalog for model.
4. DON'T operate unit without all guards in place.
5. DON'T operate pump without pressure relief valve in discharge piping; be sure valve is mounted and set correctly.
6. DON'T stick fingers in ports of pump!!! Fingers may be pinched between gears.
7. DON'T work on the pump unless driver has been "locked out" so it cannot be started while work is being done on the pump.

Maintenance:

1. DO record pump model number and serial number and file for further use.
2. DO have spare parts, pump or stand by units available, particularly if pump is essential part of key operation process.
3. DO obtain, read and keep all maintenance instructions furnished with pump.

VIKING PUMP

IDEX CORPORATION

WARRANTY

Viking warrants all products manufactured by it to be free from defects in workmanship or material for a period of one (1) year from date of startup, provided that in no event shall this warranty extend more than eighteen (18) months from the date of shipment from Viking. If, during said warranty period, any products sold by Viking prove to be defective in workmanship or material under normal use and service, and if such products are returned to Viking's factory at Cedar Falls, Iowa, transportation charges prepaid, and if the products are found by Viking to be defective in workmanship or material, they will be replaced or repaired free of charge, FOB. Cedar Falls, Iowa.

Viking assumes no liability for consequential damages of any kind and the purchaser by acceptance of delivery assumes all liability for the consequences of the use or misuse of Viking products by the purchaser, his employees or others. Viking will assume no field expense for service or parts unless authorized by it in advance.

Equipment and accessories purchased by Viking from outside sources which are incorporated into any Viking product are warranted only to the extent of and by the original manufacturer's warranty or guarantee, if any.

THIS IS VIKING'S SOLE WARRANTY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, WHICH ARE HEREBY EXCLUDED, INCLUDING IN PARTICULAR ALL WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. No officer or employee of IDEX Corporation or Viking Pump, Inc.. is authorized to alter this warranty.

AC Motor Installation – Maintenance Instructions

Handling

The weight of the motor and shipping container will vary. Use correct material handling equipment to avoid injury.

Receiving

Inspect the motor for damage before accepting it. The Motor shaft should rotate freely with no rubs. Report any damage immediately to the commercial carrier that delivered your motor.

Safety Notice

Only qualified personnel trained in the safe installation and operation of this equipment should install this motor. When improperly installed or used, rotating equipment can cause serious or fatal injury. Equipment must be installed in accordance with the National Electrical Code (NEC), local codes and NEMA MG2 Safety Standards for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators. Observe the following guidelines:

1. When eyebolts are provided, they must be fully tightened and are intended to lift the motor and its included accessories only.
2. Ground the motor according to NEC and local codes.
3. Provide a permanent guard to prevent accidental contact of body parts or clothing with rotating or moving parts or burns if motor is hot.
4. Shaft key must be secured before starting motor.
5. Do not apply power to the motor until the motor is securely mounted by its mounting holes.
6. This motor must only be connected to the proper line voltage, line frequency and load size.
7. If a motor mounted brake is installed, provide proper safeguards for personnel in case of brake failure.
8. Disconnect all power services and stop the motor before servicing.
9. For single phase motors, discharge the start and/or run capacitors before servicing.
10. Do not by-pass or render inoperative any safety device.
11. When using AC motors with frequency inverters, be certain that the Maximum Speed rating (on nameplate) is not exceeded.
12. Mounting bolts should be high tensile steel. Be sure to use a suitable locking device on each bolt (spring washer or thread lock compound).

Motor Enclosure

ODP, Open drip proof motors are intended for use in clean, dry locations with adequate supply of cooling air. These motors should not be used in the presence of flammable or combustible materials. Open motors can emit flame and/or molten metal in the event of insulation failure.

TEFC, totally enclosed motors are intended for use where moisture, dirt and/or corrosive materials are present in indoor and outdoor locations.

Explosion proof motors, as indicated by the Underwriters Laboratories, Inc. label are intended for use in hazardous areas as specified by the NEC.

Mounting

Foot mounted machines should be mounted to a rigid foundation to prevent excessive vibration. Shims may be used if location is uneven.

Flange mounted machines should be properly seated and aligned. Note: If improper rotation direction is detrimental to the load, check rotation direction prior to coupling the load to the motor shaft.

For V-belt drive, mount the sheave pulley close to the motor housing. Allow clearance for end to end movement of the motor shaft. Do not overtighten belts as this may cause premature bearing failure or shaft breakage.

Mounting Continued

Direct coupled machines should be carefully aligned and the shaft should rotate freely without binding.

Wiring

Connect the motor as shown in the connection diagram. The wiring, fusing and grounding must comply with the National Electrical Code and local codes. When the motor is connected to the load for proper direction of rotation and started, it should start quickly and run smoothly. If not, stop the motor immediately and determine the cause. Possible causes are: low voltage at the motor, motor connections are not correct or the load is too heavy. Check the motor current after a few minutes of operation and compare the measured current with the nameplate rating.

Lubrication

This is a ball bearing motor. The bearings have been lubricated at the factory. Motors that do not have regrease capability are factory lubricated for the normal life of the bearings.

Relubrication Intervals (For motors with regrease capability)

New motors that have been stored for a year or more should be relubricated. Lubrication is also recommended at these intervals:

Relubrication Intervals

NEMA (IEC) Frame Size	Rated Speed (RPM)			
	3600	1800	1200	900
Up to 210 incl. (132)	5500Hrs.	12000Hrs.	18000Hrs.	22000Hrs.
Over 210 to 280 incl. (180)	3600Hrs.	9500Hrs.	15000Hrs.	18000Hrs.
Over 280 to 360 incl. (225)	*2200Hrs.	7400Hrs.	12000Hrs.	15000Hrs.
Over 360 to 5000 incl.(300)	*2200Hrs.	3500Hrs.	7400Hrs.	10500Hrs.

* Lubrication interval for 6313 or 6314 bearings that are used in 360 through 5000 frame, 2 pole motors. If roller bearings are used, bearings must be lubricated more frequently, divide the interval by 2.

Lubricant

Baldor motors are pregreased, normally with Polyrex EM (Exxon Mobil). If other greases are preferred, check with a local Baldor Service Center for recommendations.

Procedure

Clean the grease fitting (or area around grease hole, if equipped with slotted grease screws). If motor has a purge plug, remove it. Motors can be regreased while stopped (at less than 80°C) or running.

Apply grease gun to fitting (or grease hole). Too much grease or injecting grease to quickly can cause premature bearing failure. Slowly apply the recommended amount of grease, taking 1 minute or so to apply. Operate motor for 20 minutes, then reinstall purge plug if previously removed.

Caution: Keep grease clean. Mixing dissimilar grease is not recommended.

Amount of Grease to Add

Frame Size NEMA (IEC)	Weight of grease to add ounce (gram)	Volume of grease to add	
		inches^3	teaspoon
Up to 210 incl. (132)	0.30 (8.4)	0.6	2.0
Over 210 to 280 incl. (180)	0.61 (17.4)	1.2	3.9
Over 280 to 360 incl. (225)	0.81 (23.1)	1.5	5.2
Over 360 to 5000 incl.(300)	2.12 (60.0)	4.1	13.4

BALDOR®
MOTORS AND DRIVES

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LID-EASE® SIMPLEX IN-LINE BASKET-TYPE STRAINERS

CONTENTS

INTRODUCTION

This bulletin deals exclusively with Viking Lid-Ease® Basket-Type Strainers. When ordering parts be sure to give complete part name, serial number and model number (cast on body below serialized nameplate). The basket mesh size is stamped on the basket handle and the o-ring construction can be identified with a Viking color code (listed under O-Ring Information).

Use of basket strainers can avoid costly failures and increase the life of the equipment. Proper use of strainer can minimize down time. A definition for strainers is "a coarse filter". Strainers are typically intended to trap larger foreign objects such as rags, weld beads or bolts. Filters are intended to capture very small particles.

Lid sealing is accomplished with one o-ring, therefore proper application of o-ring is essential. The o-ring must be acceptable for the temperature limits of the system as well as compatible with the fluid being strained. Misapplication may result in o-ring swell, (making lid removal difficult) or premature o-ring failure, causing strainer leakage.

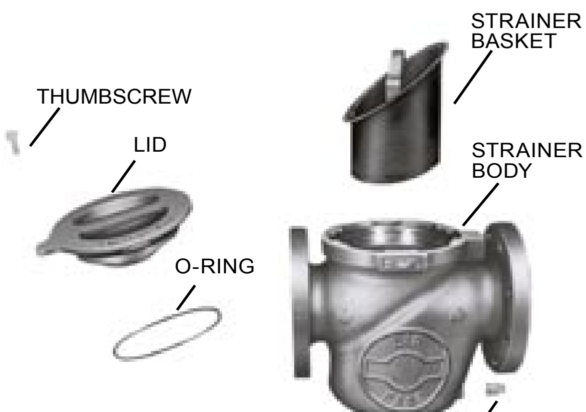

FIGURE 1

Viking does not recommend using Lid-Ease Strainers for the following applications;

1. Fluids having vapor pressure higher than one atmosphere, either at room temperature or operating temperature.
2. Straining of particles finer than 70 microns (50X250 Mesh available through 4").
3. Temperatures below -40 ºF or above +400 ºF.
4. High system pressure applications (See Table A, Page 2).
5. High basket differential pressure (See Table A).
6. Aluminium strainer handling 1,1,1-trichloroethane, methylene chloride or halogenated hydrocarbon solvents.

SPECIAL INFORMATION

DANGER !

Before opening any Viking product (Strainer, pumping chamber, reservoir, relief valve adjusting screw cap etc.) be sure:

1. That any pressure in the strainer or pumping chamber has been completely vented through suction or discharge lines or other appropriate openings or connections.

2. That the driving means (motor, turbine, engine, etc.) has been "Locked Out" or made non-operational so that it cannot be started while maintenance is being preformed.

3. That you know what liquid the strainer has been handling and the necessary precautions to safely handle the liquid. Obtain a Material Safety Data Sheet (MSDS) for the liquid to be sure these precautions are understood.

Failure to follow above listed precautionary measures may result in serious injury or death.

Determine and exercise necessary precautions before removing the lid, involving fluids which are:

-POISONOUS OR TOXIC
-FLAMMABLE
-HARMFUL TO FACE OR HANDS
-HOT (Liquids containing boiling water (+212º F at sea level) can produce steam; extra care to properly vent strainer must be exercised).
-ENTRAINED WITH AIR (Trapped, pressurized air under lid can lift the lid suddenly and violently if the lid is rotated. Be the sure system is completely vented)

DO NOT ATTEMPT TO VENT THE SYSTEM BY TURNING THE LID.

Strainer Size	1"	1 1/2"	2"	3"	4"	6"	8"
Basket Clearance (Required from port centerline)	6.0	6.5	7.5	9.5	11.75	16.5	24.5
Maximum Basket Differential Pressure (PSID)	150	150	150	125	125	75	50
Maximum System Pressure (PSIG)	200	200	200	① 125	① 125	① 125	① 125

① 175 PSI on liquid temperature below 150 °F

TABLE A

INSTALLATION

Strainers should be placed ahead of any equipment needing protection. The mesh size used in the strainer body should be only as small as required to protect the equipment. This will minimize the pressure drop through the strainer. For pump protection locate the strainer on suction side of the pump. Proper sizing of the strainer and basket mesh can prevent the pump from cavitating due to excessive pressure drop across the strainer. There are several factors which influence pressure drop such as viscosity of fluid, percentage and size of particles or contaminants, and frequency of cleaning.

If the liquid contains undesirable ferrous particles, magnetic inserts can be added to the baskets to help remove these particles.

A second strainer (or filter) located on discharge side of pump may be desirable to protect other equipment in the system which requires a smaller mesh basket for finer straining of the liquid. A basket with a smaller mesh opening (the higher the mesh number, the smaller the opening in the mesh) can be permitted on the discharge side because pressure drop is less critical. Maximum differential pressures allowable across strainers are listed in **Table A.**

Locate the strainer in a position where the drain plug can be easily removed (Replace the plug with a drain valve for frequent maintenance). Provide adequate space above the strainer for basket removal as listed in table A. The Lid-Ease strainer has cast arrows on the body to indicate the direction fluid must flow. These strainers are not designed for any type of backwash operation.

NOTE: Mounting the strainer with ports in a vertical position is **NOT** recommended because of increased difficulty during servicing.

For the larger strainers, additional external support of the strainer may be required to reduce pipe strain in the system. This can be accomplished either by supporting the flanges or providing a base for the bottom of the strainer. Lid removal for maintenance will be much easier if the top of the strainer is not over 3 feet off the ground. In the event that the strainer is not at highest point in the system, valves are recommended on both sides of strainer to prevent the strainer from filling up while cleaning the basket.

As the basket becomes clogged with foreign matter, differential pressure will rise. **Table A** shows maximum pressure differential allowable across the basket. If this pressure is exceeded, damage to the basket may occur. A good way to indicate when basket must be cleaned is to: 1) Install a pressure differential gauge or 2) install a pressure gauge on each side of the strainer.

NOTE: Strainers located on the discharge side of the pump must have a safety relief valve between the pump and the strainer set no higher than the strainer's maximum system pressure (see Table A).

DISASSEMBLY

NOTE: Before removing the lid to clean the basket make sure that you have a spare o-ring in the event that the fluid being strained has caused the o-ring to swell.

DANGER !

Before opening any Viking product (Strainer, pumping chamber, reservoir, relief valve adjusting screw cap etc.) be sure:

1. **That any pressure in the strainer or pumping chamber has been completely vented through suction or discharge lines or other appropriate openings or connections.**
2. **That the driving means (motor, turbine, engine, etc.) has been "Locked Out" or made non-operational so that it cannot be started while maintenance is being preformed.**
3. **That you know what liquid the strainer has been handling and the necessary precautions to safely handle the liquid. Obtain a Material Safety Data Sheet (MSDS) for the liquid to be sure these precautions are understood.**

Failure to follow above listed precautionary measures may result in serious injury or death.

1. Remove the thumbscrew from top of lid.
2. Rotate the weatherseal lid counter clockwise until the pin hits and stops. (The lid features an internal pin, which locates the on and off positions.)
3. Raise up the lid.
4. Remove the basket and clean. Do not strike the basket to clean it out; this could deform the basket side or lip and decrease the strainers effectiveness. Avoid using a sharp object such as a screwdriver, which could puncture the mesh. To clean the basket, use a small brush or compressed air.

ASSEMBLY

1. Place basket into strainer body.
2. Reinstall the lid with the tab of the lid just to the left of the boss with the threaded hole on the body (See fig. 2).

   NOTE: Do not attempt to install the lid if the strainer has filled up; drain before installing the lid. Press down on the lid firmly and evenly until it pops into place.

ASSEMBLY (Cont.)

3. Rotate the lid clockwise until the two holes line up.
4. Reinsert the thumbscrew.
5. Reinstall the drain plug (if removed) or close the drain valve (if installed).
6. Before starting up the system, make sure to open all valves that were closed for servicing. After starting up the system, check for any possible leaks. If there is any leakage around the lid, return to Disassembly. Remove the lid and refer to Trouble-Shooting, page 4, for possible causes of leakage.

NOTE: When installing a new o-ring, it is recommended that the o-ring be lubricated with grease before installing onto the lid.

DANGER !

Before starting the system, be sure the lid is turned to the proper position and the thumbscrew is installed to prevent the lid from turning

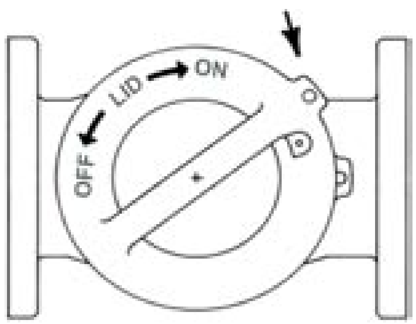

FIGURE 2

O-RING INFORMATION

Proper application and use of the o-ring elastomer will affect the ease of lid removal and the life of the o-ring. Compatibility of the elastomer with the fluid(s) at operating temperature extremes, is essential and **Table B** lists suitability for several o-ring elastomers, along with Viking's means of identification. If an o-ring is incompatible with a fluid, excessive o-ring swell or contraction might result and/or properties of the elastomer may change, reducing the satisfactory performance life of the o-ring. Included in Table B is a general list of fluids that Parker's O-Ring Manual does and does not recommend for specific elastomers. Obviously if an o-ring should swell, sealing will be enhanced between lid and body, but would make the lid difficult to remove. Conversely, o-ring shrinkage will reduce sealing and possibly cause a leak. Several good sources are available covering o-ring compatibility. These include o-ring manufacturers literature, Viking Pump's Liquid List, Viking's Application Department, manufacturers of other components in the system and previous experience.

Generally it is best to have an extra o-ring on hand when removing the lid. Once the lid has been removed, if any swelling has occurred, reinstalling the lid with the existing o-ring will be difficult (if not impossible) and may require another o-ring. Once o-ring dries out, it can sometimes be used again.

Teflon Encapsulated o-rings generally do not swell. Do not attempt to reuse this type of o-ring if it has been removed. Immerse a new o-ring in boiling water for a few minutes. Remove from the water and stretch out the o-ring so it will fit onto the casing hub of the lid without forcing it over a sharp edge. Run hot water over the o-ring until it shrinks down tight into the groove of lid.

TABLE B
O-RING SELECTION

TYPE OF ELASTOMER	VIKING IDENTIFICATION	TEMPERATURE LIMIT ① LIMIT °F	LIQUIDS ②	
			RECOMMENDED	NOT RECOMMENDED
BUNA	NO DOT	-20 TO +225	Petroleum, oils and fluids Silicone greases & oils Ethylene glycol base General purpose sealing	Halogenated hydrocarbon Nitro hydrocarbon Phosphate ester Ketones Ozone Automotive break fluid
VITON	GREEN DOT	-15 TO +400	Petroleum oils Di-Ester base lubricant Silicone fluids & grease Halogenated hydrocarbon Selected phosphate ester acids	Ketones Skydrol Amines Low molecular weight esters & ethers Hot hydrofluoric or chlorosulfonic acids
ETHYLENE PROPYLENE RUBBER	ORANGE DOT	-65 TO +300	Water Dilute Acids Dilute alkalies Ketones Alcohol	Petroleum Oil Di-Ester base lubricant
SANITARY	YELLOW DOT	-20 TO +225	Same as Buna-N	
TEFLON ENCAPSULATED	NO DOT ORANGE CORE	(STANDARD) -40 TO +300	Most solvents & chemicals	Molten alkali metals
	NO DOT PURPLE CORE	(HIGH TEMP) -40 TO +400	Consult factory if unsure about compatibility	Fluorine and strong fluorinating agents

① Temperatures listed are for static seal applications only for the Lid-Ease Simplex strainer line.
② Source: Parker O-Ring Handbook (except for Teflon Encapsulating).

TROUBLESHOOTING		
PROBLEM	**POSSIBLE CAUSE**	**SOLUTIONS**
The Lid is difficult to turn	1) The system is under pressure	1) Relieve the pressure
	2) The o-ring is swollen	2) Check compatibility of the o-ring with the fluid and temperature.
	3) The fluid inside is sticky or solid	3) a) Remove the lid before liquid solidifies b) May require heat tape and insulation around body
The lid is difficult to install	4) The o-ring is swollen	4) Replace with a new o-ring, or a different, more compatible o-ring material
	5) The o-ring is not lubricated	5) Lubricate the o-ring with grease or a suitable lubricant
	6) There is too much fluid in the body	6) Drain out the fluid, leaving more air in the body before installing the lid
Fluid leaks around the top of the strainer	7) The o-ring is cut	7) Replace the o-ring (never try to install a cut o-ring)
	8) There is foreign material under the o-ring	8) Remove & clean the o-ring, groove in lid, & body o-ring seat. Reinstall, making sure to lubricate the o-ring
	9) The o-ring has shrunk	9) Select a compatible o-ring material
There is excessive pressure drop	10) The basket is filled with contaminants	10) Clean the basket more frequently
	11) The basket mesh is too fine	11) Check the pressure drop curves. A larger strainer or a larger mesh basket may be required
	12) The viscosity is too high	12) Increase the strainer unit size or use a larger mesh basket.

VIKING PUMP

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DL105

Micro PLC User Manual

Manual Number D1–USER–M

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Manual Revisions

If you contact us in reference to this manual, remember to include the revision number.

Title: DL105 Micro PLC User Manual
Manual Number: D1–USER–M

Edition/Rev	Date	Description of Changes
Original	9/96	Original Issue
2nd Edition	5/98	Updated
2nd Edition, Rev. A	7/03	Updated with corrections and a new appendix

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Chapter 3: High-Speed Input and Pulse Output Features

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1

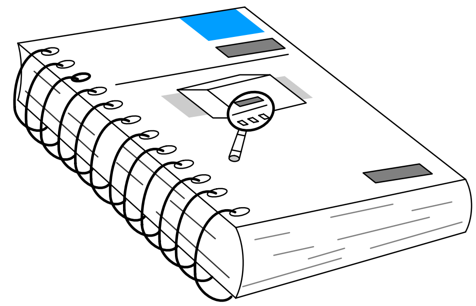
Getting Started

In This Chapter. . . .

Introduction

The Purpose of this Manual

Thank you for purchasing a DL105 Micro PLC. This manual shows you how to install, program, and maintain all the Micro PLCs in the DL105 family. It also helps you understand how to interface them to other devices in a control system.



This manual contains important information for personnel who will install DL105 PLCs, and for the PLC programmer. If you understand PLC systems our manuals will provide all the information you need to get and keep your system up and running.

Where to Begin

If you already understand the DL105 Micro PLC please read Chapter 2, “Installation, Wiring, and Specifications”, and proceed on to other chapters as needed. Be sure to keep this manual handy for reference when you run into questions. If you are a new DL105 customer, we suggest you read this manual completely so you can understand the wide variety of features in the DL105 family of products. We believe you will be pleasantly surprised with how much you can accomplish with ***Direct***LOGIC products.

Supplemental Manuals

If you have purchased operator interfaces or ***Direct***SOFT32, you will need to supplement this manual with the manuals that are written for these products.

Technical Support

We realize that even though we strive to be the best, we may have arranged our information in such a way you cannot find what you are looking for. First, check these resources for help in locating the information:

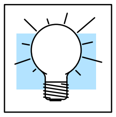
- **Table of Contents** – chapter and section listing of contents, in the front of this manual
- **Appendices** – reference material for key topics, near the end of this manual

You can also check our online resources for the latest product support information:

- **Internet** – the address of our Web site is: **http://www.automationdirect.com**

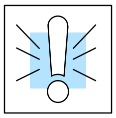
If you still need assistance, please call us at 770–844–4200. Our technical support group is glad to work with you in answering your questions. They are available Monday through Friday from 9:00 A.M. to 6:00 P.M. Eastern Standard Time. If you have a comment or question about any of our products, services, or manuals, please fill out and return the ‘Suggestions’ card that was shipped with this manual.

Conventions Used



When you see the "light bulb" icon in the left-hand margin, the paragraph to its immediate right will give you a **special tip**.
The word **TIP:** in boldface will mark the beginning of the text.

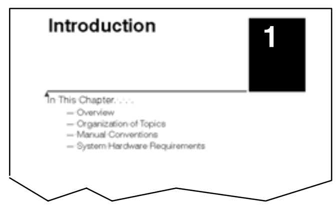
When you see the "notepad" icon in the left-hand margin, the paragraph to its immediate right will be a **special note**.
The word **NOTE:** in boldface will mark the beginning of the text.



When you see the "exclamation mark" icon in the left-hand margin, the paragraph to its immediate right will be a **warning.** This information could prevent injury, loss of property, or even death (in extreme cases).
The word **WARNING:** in boldface will mark the beginning of the text.

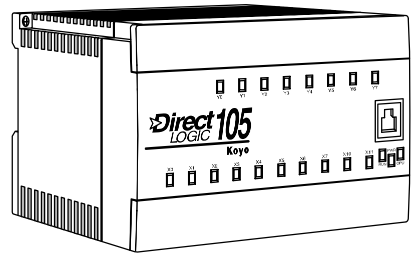
Key Topics for Each Chapter

The beginning of each chapter will list the key topics that can be found in that chapter.



DL105 Micro PLC Components

The DL105 Micro PLC family is a versatile product line that provides a wide variety of features in a very compact footprint. The PLCs are small, yet offer many features usually found in larger, more expensive systems. These include removeable connectors, RS-232C communication port, and +24V auxiliary power supply.



The DL105 Micro PLC Family

The DL105 Micro PLC family includes eight different versions. All have the same appearance and CPU performance. The CPU offers the same instruction set as our popular DL230 CPU, plus several more instructions specifically designed for machine control applications. All DL105 PLCs have an RS–232C communications port, and the AC-powered versions have an auxiliary +24V output. Units with DC inputs have selectable high-speed input features on four input points. Units with DC outputs offer selectable pulse output capability on the first two output points. All DL105 Micro PLCs offer a large amount of program memory, a substantial instruction set and advanced diagnostics. Details of these features and more are covered in Chapter 4, CPU Specifications and Operation. The eight types of DL105 Micro PLCs provide a variety of Input/Output choices, listed in the following table.

DL105 Part Number	Discrete Input Type	Discrete Output Type	External Power	Auxiliary 24V Output	High-Speed Input	Pulse Output
F1–130AR	AC	Relay	94–240 VAC	Yes	No	No
F1–130DR/ F1–130DR–CE*	DC	Relay	94–240 VAC	Yes	Yes	No
F1–130AD	AC	DC	94–240 VAC	Yes	No	Yes
F1–130DD/ F1–130DD–CE*	DC	DC	94–240 VAC	Yes	Yes	Yes
F1–130AA	AC	AC	94–240 VAC	Yes	No	No
F1–130DA	DC	AC	94–240 VAC	Yes	Yes	No
F1–130DR–D	DC	Relay	10–30 VDC	No	Yes	No
F1–130DD–D	DC	DC	10–30 VDC	No	Yes	Yes

* The "–CE" versions look and function the same as the standard versions but are manufactured to comply with CE standards.

Programming Methods

Two programming methods are available: RLL (Relay Ladder Logic) and RLL^{PLUS} Stage programming RLL^{PLUS} combines the added feature of flow chart programming (stage) to the standard RLL language. Both the ***Direct***SOFT32 programming package and the handheld programmer support RLL^{PLUS} as well as standard RLL instructions.

***Direct*SOFT32 Programming for Windows™**

The DL105 Micro PLC can be programmed with one of the most advanced programming packages in the industry —***Direct***SOFT32, a Windows-based software package that supports familiar features such as cut-and-paste between applications, point-and-click editing, viewing and editing multiple application programs at the same time, etc.

DirectSOFT32 universally supports the ***Direct***LOGIC CPU families. This means you can use the full version of ***Direct***SOFT32 to program DL105, DL205, DL305, DL405 or any new CPUs we may add to our product line. (Upgrade software may be required for new CPUs as they become available.) With the introduction of the DL105, we are also offering a low-cost DL105-only version of ***Direct***SOFT32 to make it even more affordable for new customers. A separate manual discusses ***Direct***SOFT32 programming software.

Handheld Programmer

All DL105 Micro PLCs have a built-in programming port for use with the handheld programmer (D2–HPP), the same programmer used with the DL205 family. The handheld programmer can be used to create, modify and debug your application program. A separate manual discusses the Handheld Programmer.

I/O Quick Chart Selection

The eight versions of the DL105 have Input/Output circuits which can interface to a wide variety of field devices. In several instances a particular Input or Output circuit can interface to either DC or AC voltages, or both sinking and sourcing circuit arrangements. Check this chart carefully to find the proper DL105 Micro PLC to interface to the field devices in your application.

DL105 Part Number	INPUTS			OUTPUTS		
	I/O type / commons	Sink / Source	Voltage Ranges	I/O type / commons	Sink / Source	Voltage / Current Ratings
F1–130AR	AC / 3	–	80 – 132 VAC 90 – 150 VDC	Relay / 4	Sink or Source	12 – 30 VDC, 7A * 12 – 250 VAC, 7A *
F1–130DR/ F1–130DR–CE***	DC / 3	Sink or Source	10 – 26.4 VDC 21.6 – 26.4 VAC	Relay / 4	Sink or Source	12 – 30 VDC, 7A * 12 – 250 VAC, 7A *
F1–130AD	AC / 3	–	80 – 132 VAC 90 – 150 VDC	DC / 1 **	Sink	5 – 30 VDC, 0.3A (Y0–Y1) 5 – 30 VDC, 0.6A (Y3–Y7)
F1–130DD/ F1–130DD–CE***	DC / 3	Sink or Source	10 – 26.4 VDC 21.6 – 26.4 VAC	DC / 1 **	Sink	5 – 30 VDC, 0.3A (Y0–Y1) 5 – 30 VDC, 0.6A (Y3–Y7)
F1–130AA	AC / 3	–	80 – 132 VAC 90 – 150 VDC	AC / 4	–	20 – 140 VAC, 47 – 63 Hz 1.7A *
F1–130DA	DC / 3	Sink or Source	10 – 26.4 VDC 21.6 – 26.4 VAC	AC / 4	–	20 – 140 VAC, 47 – 63 Hz 1.7A *
F1–130DR–D	DC / 3	Sink or Source	10 – 26.4 VDC 21.6 – 26.4 VAC	Relay / 4	Sink or Source	12 – 30 VDC, 7A * 12 – 250 VAC, 7A *
F1–130DD–D	DC / 3	Sink or Source	10 – 26.4 VDC 21.6 – 26.4 VAC	DC / 1 **	Sink	5 – 30 VDC, 0.3A (Y0–Y1) 5 – 30 VDC, 0.6A (Y3–Y7)

* Subject to temperature derating chart. See Chapter 2 Specifications for your particular DL105 version.
** DC outputs have one electrical common, but it is accessible at three terminals on the output connector.
*** The “–CE” versions look and function the same as the standard versions but are manufactured to comply with CE standards.

Quick Start for PLC Checkout and Programming

If you have experience with PLCs, or if you just want to setup a quick example, this example is for you! This example is not intended to tell you everything you need to start-up your system, warnings and helpful tips are in the rest of the manual. It is only intended to give you a general picture of what you will need to do to get your system powered-up.

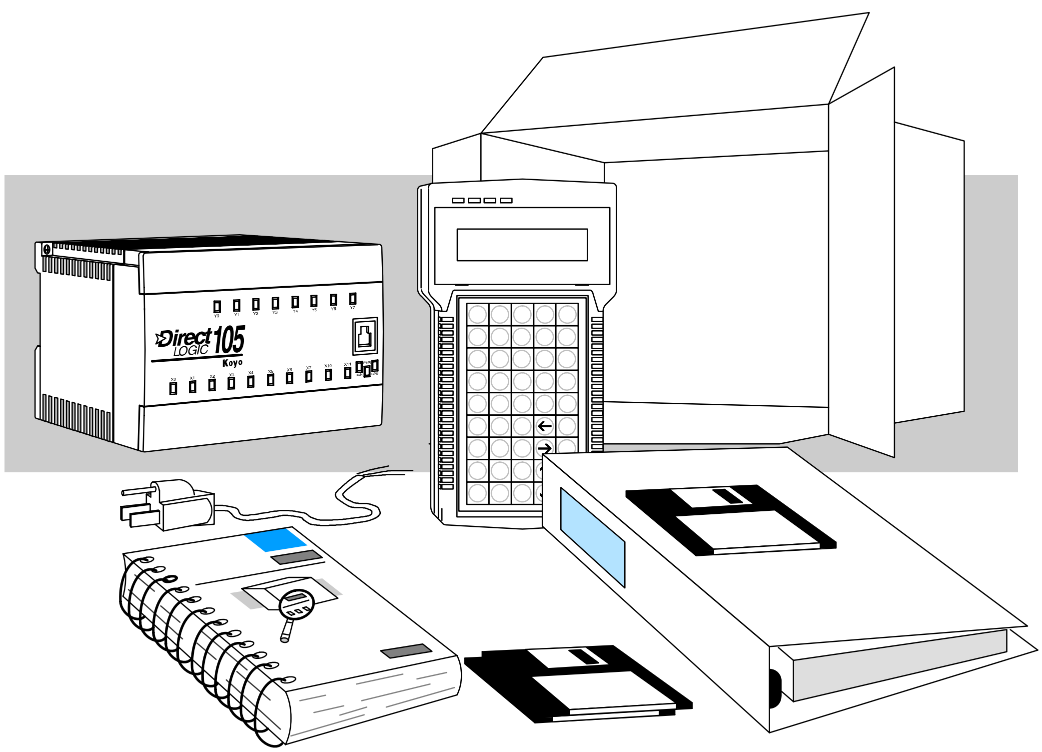
Step 1: Unpack the DL105 Equipment

Unpack the DL105 equipment and verify you have the parts necessary to build this demonstration system. The recommended components are:

- DL105 Micro PLC
- AC power cord for AC-powered units
- F1–04SIM input simulator, or toggle switches (see Step 2 on next page).
- Hook-up wire, 16-20 AWG
- DL105 User Manual (this manual)
- A small screwdriver, regular or #2 Philips type

You will need at least one of the following programming options:

- ***Direct***SOFT32 Programming Software, ***Direct***SOFT32 Manual, and a programming cable (connects the DL105 to a personal computer),or
- D2–HPP Handheld Programmer (comes with programming cable), and the Handheld Programmer Manual

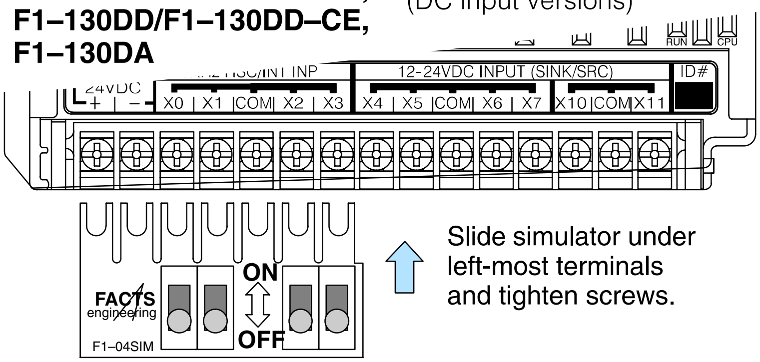


Step 2: Connect Switches to Input Terminals

To finish this quick-start exercise or study other examples in this manual, you'll need to connect some input switches as shown below. For most models, the F1-04SIM Input Simulator is a quick way to install four switches on inputs X0 – X3. DC-powered units will require routing DC power to the simulator as shown. We recommend using one of the models compatible with the input simulator as you learn the DL105.

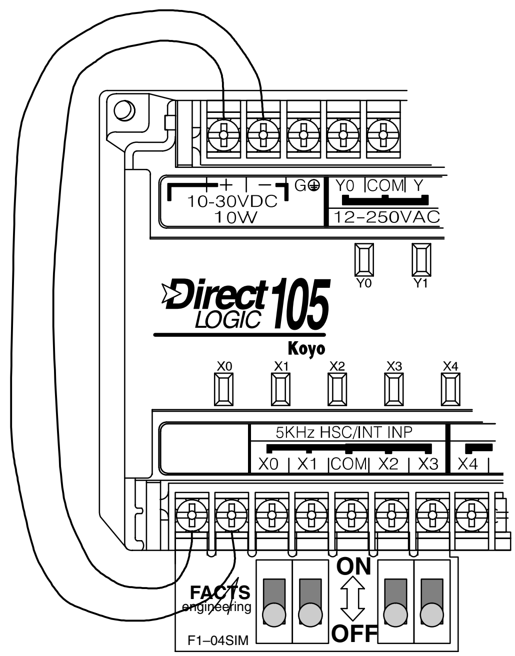
However, you may wire individual toggle switches to AC-powered units as shown, *as long as you follow the instructions in the accompanying WARNING note.*

F1–130DR/F1–130DR–CE, F1–130DD/F1–130DD–CE, F1–130DA (DC input versions)

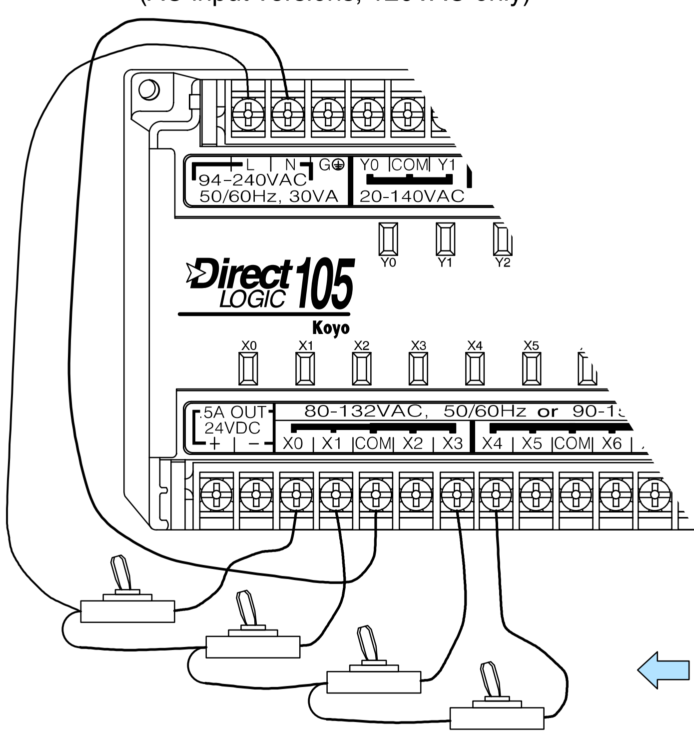


Slide simulator under left-most terminals and tighten screws.

F1–130DR–D, F1–130DD–D
(DC-powered versions)



F1–130AR, F1–130AD, F1–130AA
(AC input versions, 120VAC only)



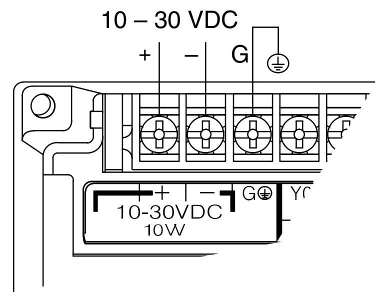
Toggle Switches, UL Listed

WARNING: DO NOT wire the toggle switches as shown to 240VAC-powered units. The discrete inputs will only accept 120VAC nominal. Also, remove power and unplug the DL105 when wiring the switches. Only use UL-approved switches rated for at least 250VAC, 1A. Firmly mount the switches before using.
NEVER use the input simulator on these units with AC-type discrete inputs.

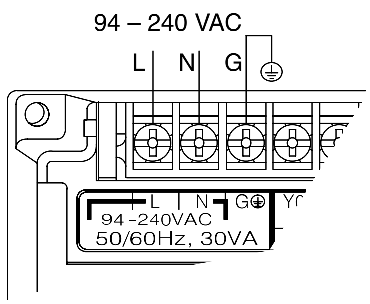
Step 3: Connect the Power Wiring

Connect the power input wiring for the version DL105 you have. Observe all precautions stated earlier in this manual. For more details on wiring, see Chapter 2 on Installation, Wiring, and Specifications. When the wiring is complete, close the connector covers. Do not apply power at this time.

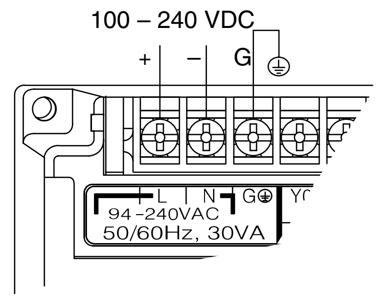
12/24 VDC Power Input



110/220 VAC Power Input

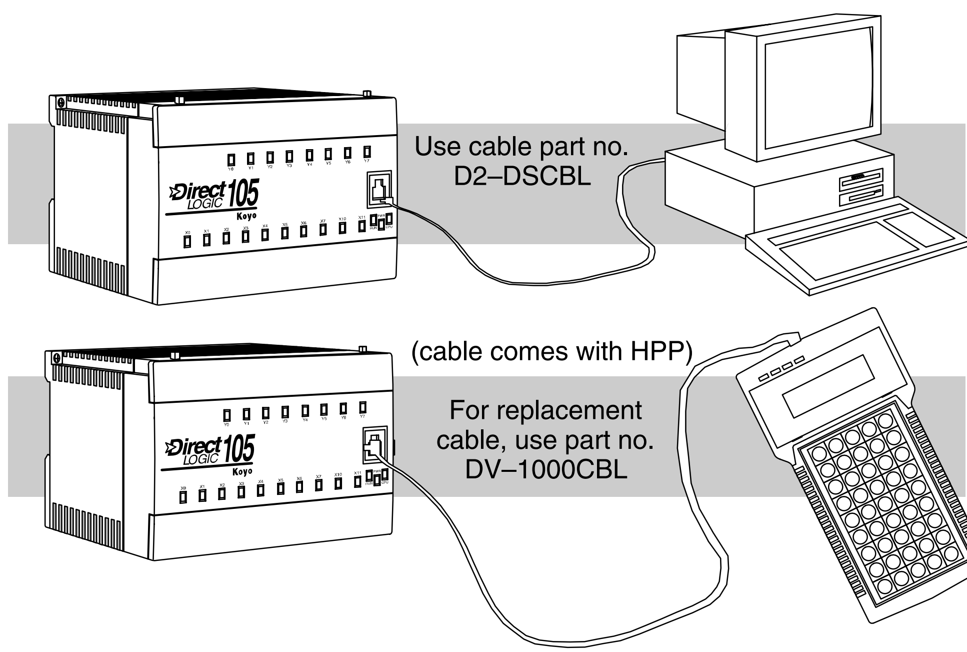


125 VDC Power Input



Step 4: Connect the Programming Device

Most programmers will use ***Direct***SOFT32 programming software, installed on a personal computer. Or, you may need the portability of the Handheld Programmer. Both devices will connect the COM1 port of the DL105 via the appropriate cable.



Step 5: Switch on the System Power

Apply power to the system and ensure the PWR indicator on the DL105 is on. If not, remove power from the system and check all wiring and refer to the troubleshooting section in Chapter 8 for assistance.

Step 6: Initialize Scratchpad Memory

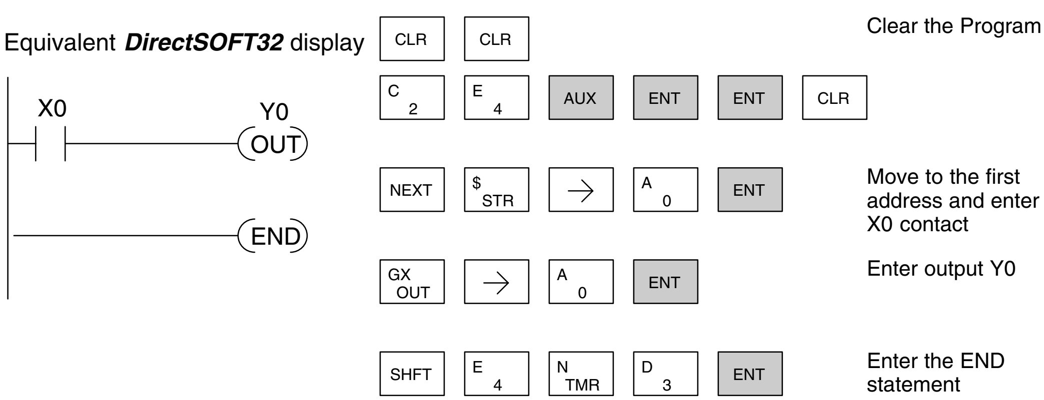
It's a good precaution to always clear the system memory (scratchpad memory) on a new DL105. When a unit has been without power for several days, the system RAM contents may have been corrupted and will require initialization.

- In ***Direct***SOFT32, select the *PLC* menu, then *Setup*, then *Initialize Scratchpad.* For additional information, see the ***Direct***SOFT32 Manual.
- For the Handheld Programmer, use the AUX key and execute AUX 54. For additional information, see the Handheld Programmer Manual.

Step 7: Enter a Ladder Program

At this point, ***Direct***SOFT32 programmers need to refer to the Quick Start Tutorial in the DirectSOFT32 Manual. There you will learn how to establish a communications link with the DL105 PLC, change CPU modes to Run or Program, and enter a program.

If you are learning how to program with the Handheld Programmer, make sure the CPU is in Program Mode (the RUN LED on the front of the DL105 should be off.) If the RUN LED is on, use the MODE key on the Handheld Programmer to put the PLC in Program Mode. Enter the following keystrokes on the Handheld Programmer.



After entering the simple example program put the PLC in Run mode by using the Mode key on the Handheld Programmer.

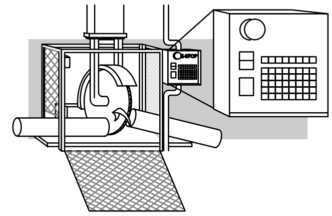
The RUN indicator on the PLC will illuminate indicating the CPU has entered the Run mode. If not, repeat this step, ensuring the program is entered properly or refer to the troubleshooting guide in chapter 8.

After the CPU enters the run mode, the output status indicator for Y should follow the switch status on input channel X0. When the switch is on, the output will be on.

Steps to Designing a Successful System

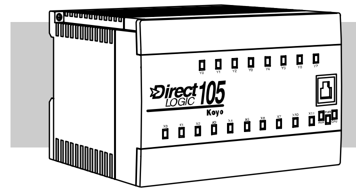
Step 1: Review the Installation Guidelines

Always make safety the first priority in any system design. Chapter 2 provides several guidelines that will help you design a safer, more reliable system. This chapter also includes wiring guidelines for the various versions of the DL105 PLC.



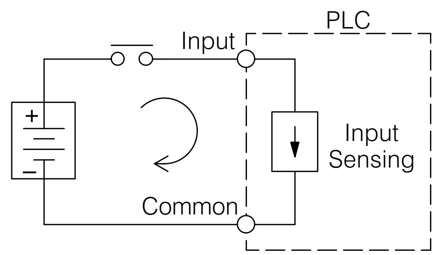
Step 2: Understand the PLC Setup Procedures

The PLC is the heart of your automation system. Make sure you take time to understand the various features and setup requirements.



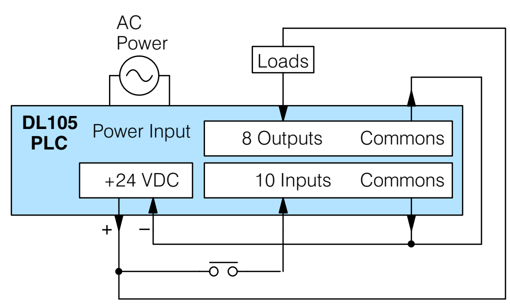
Step 3: Review the I/O Selection Criteria

There are many considerations involved when you select your I/O type and field devices. Take time to understand how the various types of sensors and loads can affect your choice of I/O type.



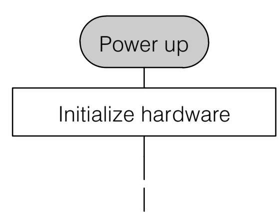
Step 4: Choose a System Wiring Strategy

It is important to understand the various system design options that are available before wiring field devices and field-side power supplies to the Micro PLC.



Step 5: Understand the System Operation

Before you begin to enter a program, it is very helpful to understand how the DL105 system processes information. This involves not only program execution steps, but also involves the various modes of operation and memory layout characteristics.

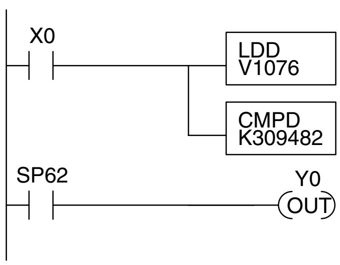


Step 6: Review the Programming Concepts

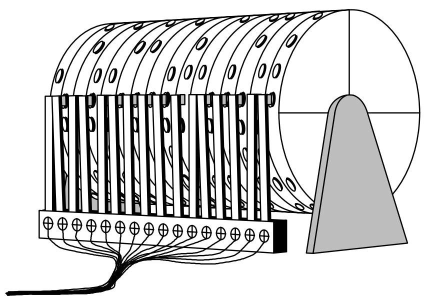
The DL105 PLC instruction set provides for three main approaches to solving the application program, depicted in the figure below.

- RLL diagram-style programming is the best tool for solving boolean logic and general CPU register/accumulator manipulation. It includes dozens of instructions, which will also be needed to augment drums and stages.
- The Timer/Event Drum Sequencer features up to 16 steps and offers both time and/or event-based step transitions. The EDRUM instruction is best for a repetitive process based on a single series of steps.
- Stage programming (also called RLL*Plus*) is based on state-transition diagrams. Stages divide the ladder program into sections which correspond to the states in a flow chart you draw for your process.

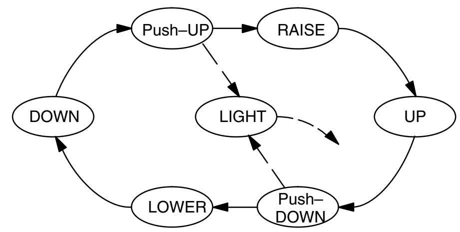
Standard RLL Programming
(see Chapter 5)



Timer/Event Drum Sequencer
(see Chapter 6)



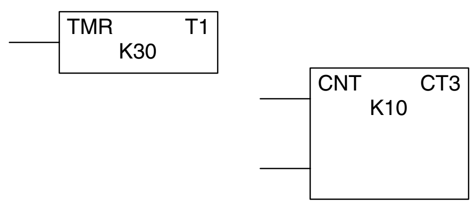
Stage Programming
(see Chapter 7)



After reviewing the programming concepts above, you'll be equipped with a variety of tools to write your application program.

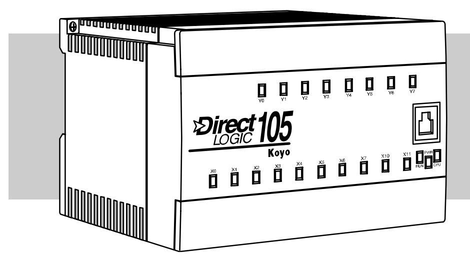
Step 7: Choose the Instructions

Once you have installed the Micro PLC and understand the main programming concepts, you can begin writing your application program. At that time you will begin to use one of the most powerful instruction sets available in a small PLC.



Step 8: Understand the Maintenance and Troubleshooting Procedures

Sometimes equipment failures occur when we least expect it. Switches fail, loads short and need to be replaced, etc. In most cases, the majority of the troubleshooting and maintenance time is spent trying to locate the problem. The DL105 Micro PLC has many built-in features such as error codes that can help you quickly identify problems.



Questions and Answers about DL105 Micro PLCs

Q. What is the instruction set like?

A. The instruction set is very close to our popular DL230 CPU. However, there are significant additions, such as the drum instruction and High-Speed I/O capability.

Q. Do I have to buy the full *Direct*SOFT32 programming package to program the DL105?

A. No. We offer a DL105-specific version of ***Direct***SOFT32 that's very affordable.

Q. Is the DL105 networkable or expandable?

A. No, the DL130 series is stand-alone PLCs. However, our DL205 system is expandable and networkable (with DL240 CPU), yet very compact and affordable.

Q. Does the DL105 have motion control capability?

A. Yes. The High-Speed I/O features offer either encoder inputs with high-speed counting and presets with interrupt, or a pulse/direction output for stepper control. Three types of motion profiles are available, which are explained in Chapter 3.

Q. Are the ladder programs stored in a removable EPROM?

A. The DL105 contains a non-removable EEPROM for program storage, which may be written and erased thousands of times. You may transfer programs to/from ***Direct***SOFT32 on a PC, or the HPP (which does support a removable EEPROM).

Q. Does the DL105 contain fuses for its outputs?

A. There are no output circuit fuses. Therefore, we recommend fusing each channel, or fusing each common. See Chapter 2 for I/O wiring guidelines.

Q. Is the DL105 Micro PLC U.L.® approved?

A. The Micro PLC has been designed to meet the requirements of UL (Underwriters' Laboratories, Inc.), CSA (Canadian Standards Association), and CUL (Canadian Underwriters' Laboratories, Inc.). Approvals are pending the completion of testing.

Q. Does the DL105 Micro PLC comply with European Union (EU) Directives?

A. Currently, the following four versions carry the CE label, indicating compliance with European Union Directives: The F1–130DR–CE and F1–130DD–CE AC powered versions and the F1–130DD–D and F1–130DR–D DC powered versions. See Appendix E for further information on EU Directives.

Q. Which devices can I connect to the Com1 port of the DL105?

A. The port is RS-232C, fixed at 9600 baud, and uses the proprietary K-sequence protocol. The port communicates with the following devices:

- DV-1000 Data Access Unit or Optimation Operator interface panels
- ***Direct***SOFT32 (running on a personal computer)
- D2-HPP handheld programmer
- Other devices which communicate via K-sequence protcol should work with the DL105 Micro PLC. Contact the vendor for details.

Q. Can the DL105 accept 5VDC inputs?

A. No, 5 volts is lower than the DC input ON threshold. However, many TTL logic circuits can drive the inputs if they are wired as open collector (sinking) inputs. See Chapter 2 for I/O wiring guidelines.

2

Installation, Wiring, and Specifications

In This Chapter. . . .

Safety Guidelines

NOTE: Products with CE marks perform their required functions safely and adhere to relevant standards as specified by EC directives provided they are used according to their intended purpose and that the instructions in this manual are adhered to. The protection provided by the equipment may be impaired if this equipment is used in a manner not specified in this manual. A listing of our international affiliates is availble on our Web site: http://www.automationdirect.com.

WARNING: Providing a safe operating environment for personnel and equipment is your responsibility and should be your primary goal during system planning and installation. Automation systems can fail and may result in situations that can cause serious injury to personnel or damage to equipment. Do not rely on the automation system alone to provide a safe operating environment. You should use external electromechanical devices, such as relays or limit switches, that are independent of the PLC application to provide protection for any part of the system that may cause personal injury or damage.
Every automation application is different, so there may be special requirements for your particular application. Make sure you follow all national, state, and local government requirements for the proper installation and use of your equipment.

Plan for Safety

The best way to provide a safe operating environment is to make personnel and equipment safety part of the planning process. You should examine *every* aspect of the system to determine which areas are critical to operator or machine safety. If you are not familiar with PLC system installation practices, or your company does not have established installation guidelines, you should obtain additional information from the following sources.

- NEMA — The National Electrical Manufacturers Association, located in Washington, D.C., publishes many different documents that discuss standards for industrial control systems. You can order these publications directly from NEMA. Some of these include:
  ICS 1, General Standards for Industrial Control and Systems
  ICS 3, Industrial Systems
  ICS 6, Enclosures for Industrial Control Systems
- NEC — The National Electrical Code provides regulations concerning the installation and use of various types of electrical equipment. Copies of the NEC Handbook can often be obtained from your local electrical equipment distributor or your local library.
- Local and State Agencies — many local governments and state governments have additional requirements above and beyond those described in the NEC Handbook. Check with your local Electrical Inspector or Fire Marshall office for information.

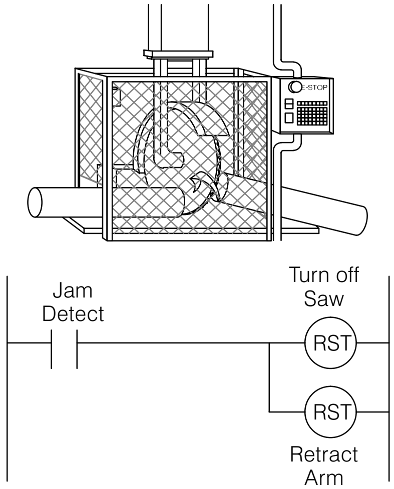
Three Levels of Protection

The publications mentioned provide many ideas and requirements for system safety. At a minimum, you should follow these regulations. Also, you should use the following techniques, which provide three levels of system control.

- Orderly system shutdown sequence in the PLC control program
- Mechanical disconnect for output module power
- Emergency stop switch for disconnecting system power

Orderly System Shutdown

The first level of fault detection is ideally the PLC control program, which can identify machine problems. You must analyze your application and identify any shutdown sequences that must be performed. These types of problems are usually things such as jammed parts, etc. that do not pose a risk of personal injury or equipment damage.



WARNING: The control program *must not* be the only form of protection for any problems that may result in a risk of personal injury or equipment damage.

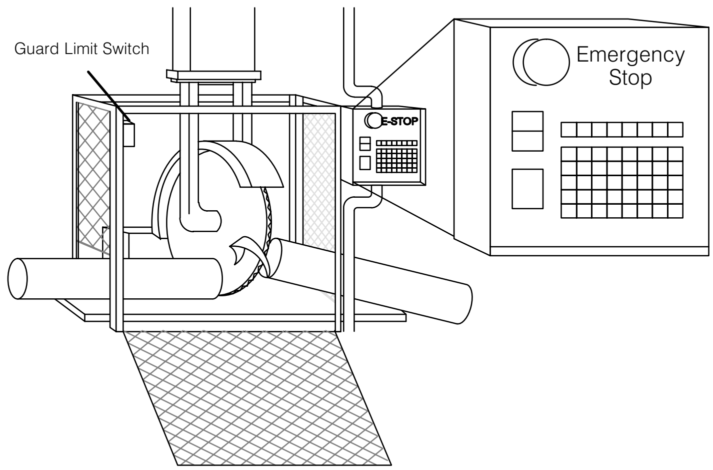
System Power Disconnect

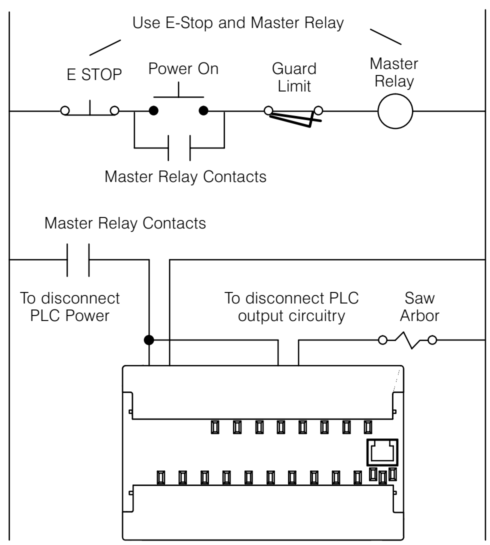
You should also use electromechanical devices, such as master control relays and/or limit switches, to prevent accidental equipment startup at an unexpected time. These devices should be installed in such a manner to prevent *any* machine operations from occurring.

For example, if the machine has a jammed part the PLC control program can turn off the saw blade and retract the arbor. However, since the operator must open the guard to remove the part, you should also include a bypass switch that disconnects *all* system power any time the guard is opened.

Emergency Stop

The machinery must provide a quick *manual* method of disconnecting *all* system power. The disconnect device or switch must be clearly labeled “**Emergency Stop**”.

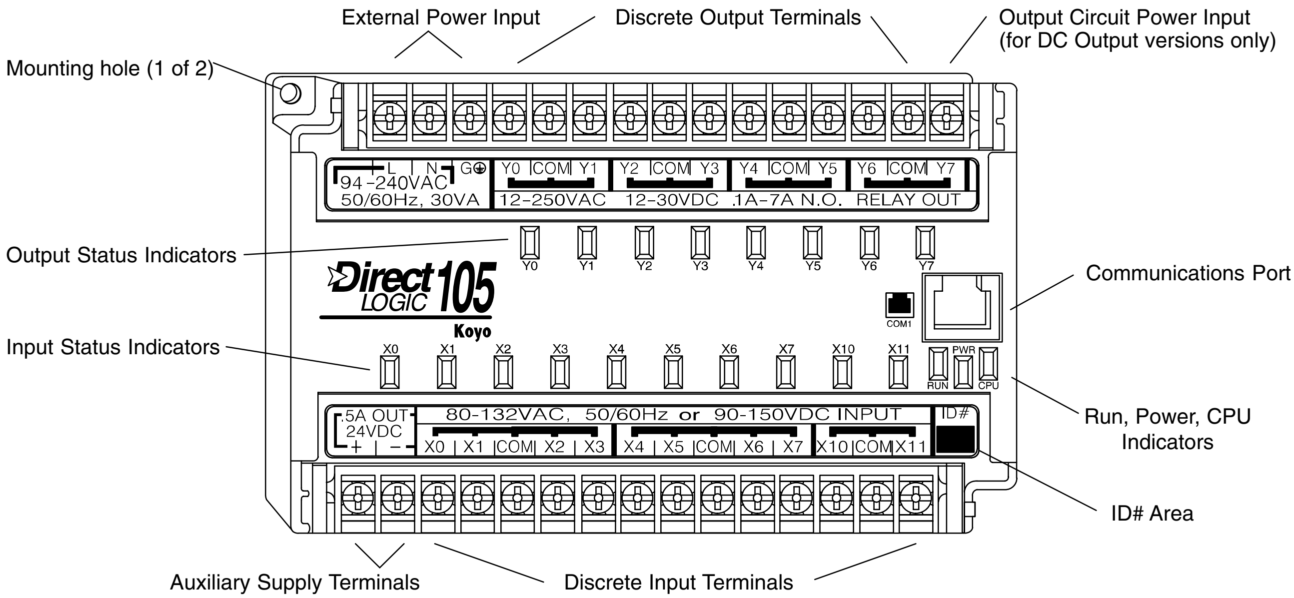




After an Emergency shutdown or any other type of power interruption, there may be requirements that must be met before the PLC control program can be restarted. For example, there may be specific register values that must be established (or maintained from the state prior to the shutdown) before operations can resume. In this case, you may want to use retentive memory locations, or include constants in the control program to ensure a known starting point.

Orientation to DL105 Front Panel

All connections, indicators, and labels on the DL105 Micro PLCs are located on its front panel. Please refer to the drawing below.

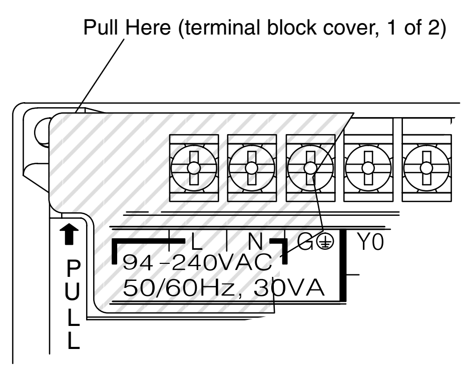


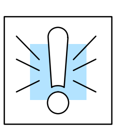
The upper connector accepts external power connections on the left-most terminals. The remainder of the terminals accept wires for the eight output points and their commons. On DC output versions, the end terminal on the right accepts power for the output stage. In many applications the external power to the Micro PLC also powers the loads and output circuit, so this terminal block groups them together.

The lower connector delivers the internal +24VDC auxiliary supply output on the two left-most terminals (AC-powered units only). On DC-powered units, the terminals are not used. The remaining terminals accept wires for the ten discrete inputs and their commons. In many applications the auxiliary +24VDC output also powers the input circuit, so this terminal block groups them together.

Accessing the I/O Terminals

To access the terminals just pull forward on the corner of the terminal cover where it is marked “pull”, as shown to the right. After exposing the connector block, it may be removed from the unit if desired.





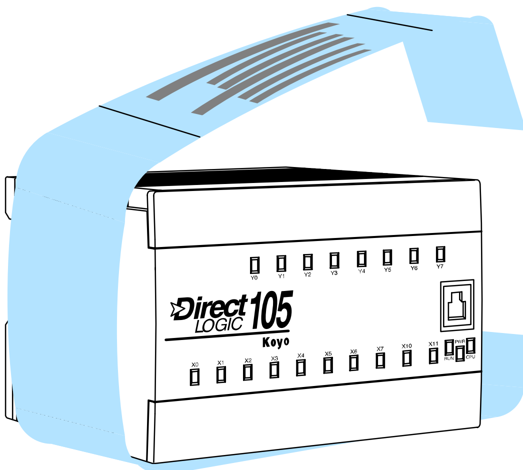
WARNING: For some applications, field device power may still be present on the terminal block even though the Micro PLC is turned off. To minimize the risk of electrical shock, check all field device power *before* you expose or remove either connector. Be sure to leave the covers normally closed.

Protective Sheet for DL105 Vents

Some machine fabrication environments may accidentally cause conductive debris to fall through the DL105 cooling vents and into the unit. All DL105 units come with a protective sheet wrapped around the unit, covering the cooling vents. However, it must be removed before electrical operation. Just unfasten the sheet on the right side of the unit. The instructions are reprinted below for your reference.

CAUTION

1. DO NOT REMOVE THIS PROTECTIVE SHEET until installation and wiring are completed.
2. REMOVE THIS SHEET before operation to enable heat to escape for proper cooling.

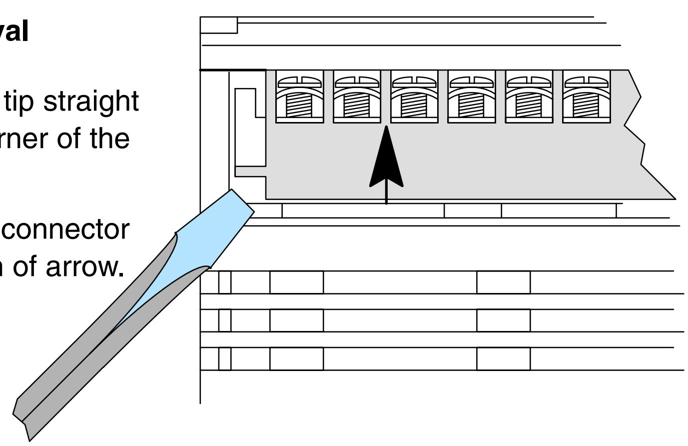


Connector Removal

The input and output terminal block connectors on the DL105 are identical. The connectors are designed for easy removal with just a small screwdriver. The drawing below shows the procedure for removal at one end. You'll need to work at both ends of the connector, so the ends move upwards approximately together.

Connector Removal

1. Insert the screwdriver tip straight into the opening at the corner of the connector as shown.
2. Pry screwdriver tip so connector moves upward in direction of arrow.



The two terminal block connectors on DL105 PLCs have regular screw terminals, which will accept either standard or #2 Philips screwdriver tips. You can insert one 14 AWG wire under a terminal, or two 16 AWG wires (one on each side of the screw). Be careful not to overtighten; maximum torque is 6 inch/ounces.

Spare terminal block connectors and connector covers may be ordered by individual part numbers:

Part Number	Qty Per Package	Description
F1–IOCON	4	DL105 I/O Terminal Block
F1–IOCVR	4	DL105 I/O Terminal Cover

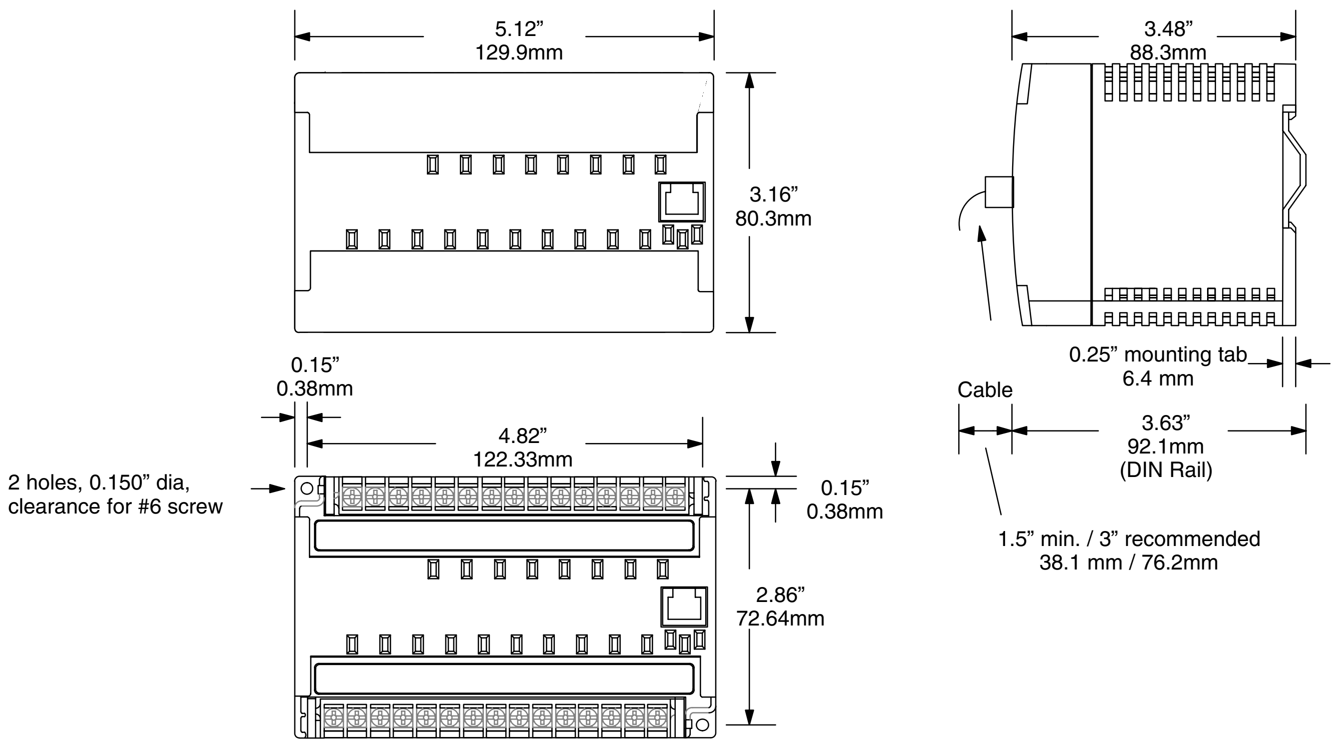
Mounting Guidelines

In addition to the panel layout guidelines, other specifications can affect the definition and installation of a PLC system. Always consider the following:

- Environmental Specifications
- Power Requirements
- Agency Approvals
- Enclosure Selection and Component Dimensions

Unit Dimensions

The following diagram shows the outside dimensions and mounting hole locations for all versions of the DL105. Make sure you follow the installation guidelines to allow proper spacing from other components.



Enclosures

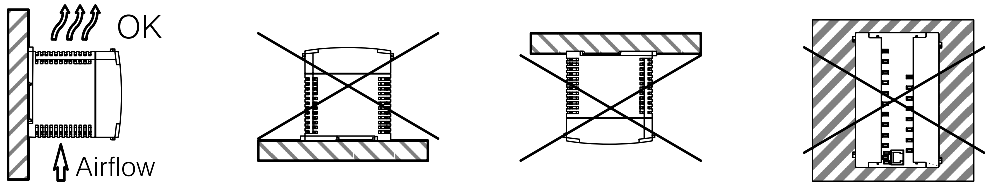
Your selection of a proper enclosure is important to ensure safe and proper operation of your DL105 system. Applications of DL105 systems vary and may require additional features. The minimum considerations for enclosures include:

- Conformance to electrical standards
- Protection from the elements in an industrial environment
- Common ground reference
- Maintenance of specified ambient temperature
- Access to equipment
- Security or restricted access
- Sufficient space for proper installation and maintenance of equipment

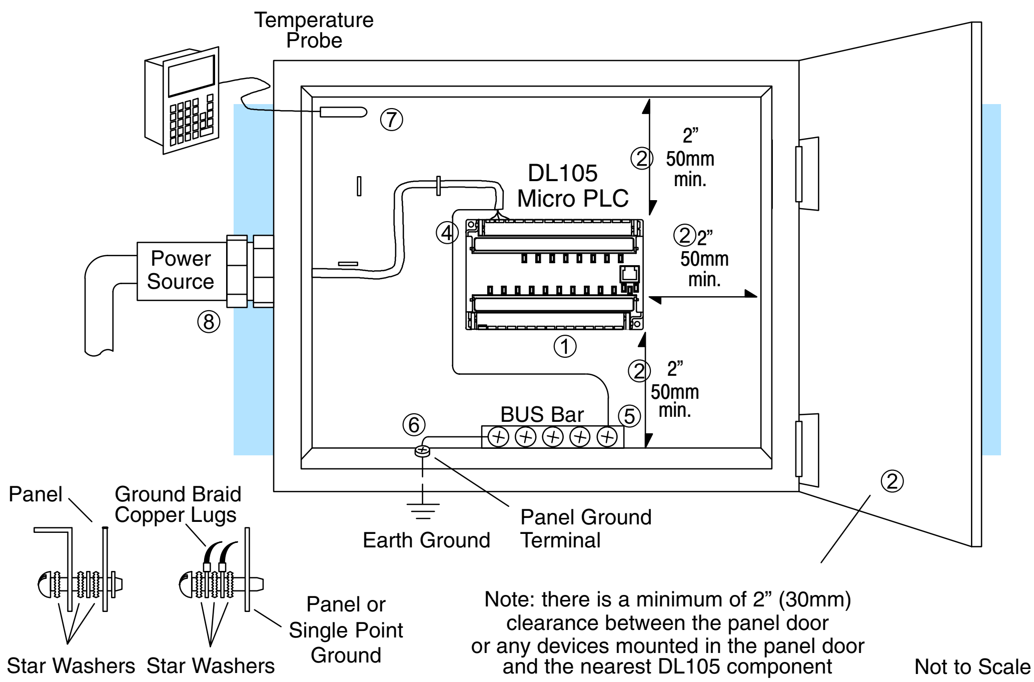
Panel Layout & Clearances

There are many things to consider when designing the panel layout. The following items correspond to the diagram shown. Note: there may be additional requirements, depending on your application and use of other components in the cabinet.

1. Mount the bases horizontally as shown below to provide proper ventilation. You ***cannot*** mount the DL105 units vertically, upside down, or on a flat horizontal surface. If you place more than one unit in a cabinet, there must be a minimum of 7.2” (183mm) between the units.



2. Provide a minimum clearance of 2” (50mm) between the unit and all sides of the cabinet. *Note, remember to allow for any operator panels or other items mounted in the door.*
3. There should also be at least 3” (78mm) of clearance between the unit and any wiring ducts that run parallel to the terminals.



4. The ground terminal on the DL105 base must be connected to a single point ground. Use copper stranded wire to achieve a low impedance. Copper eye lugs should be crimped and soldered to the ends of the stranded wire to ensure good surface contact.
5. There must be a single point ground (i.e. copper bus bar) for all devices in the panel requiring an earth ground return. The single point of ground must be connected to the panel ground termination. The panel ground termination must be connected to earth ground. Minimum wire sizes, color coding, and general safety practices should comply with appropriate electrical codes and standards for your area.

6. A good common ground reference (Earth ground) is essential for proper operation of the DL105. One side of all control and power circuits and the ground lead on flexible shielded cable must be properly connected to Earth ground. There are several methods of providing an adequate common ground reference, including:
   a) Installing a ground rod as close to the panel as possible.
   b) Connection to incoming power system ground.
7. Evaluate any installations where the ambient temperature may approach the lower or upper limits of the specifications. If you suspect the ambient temperature will not be within the operating specification for the DL105 system, measures such as installing a cooling/heating source must be taken to get the ambient temperature within the range of specifications.
8. The DL105 systems are designed to be powered by 110 VAC , 220 VAC, 125 VDC or 24 VDC normally available throughout an industrial environment. Isolation transformers and noise suppression devices are not normally necessary, but may be helpful in eliminating/reducing suspected power problems.

NOTE: If you are using other components in your system, make sure you refer to the appropriate manual to determine how those units can affect mounting dimensions.

Agency Approvals

Some applications require agency approvals for particular components. The DL105 Micro PLC submission status for agency approval is listed below:

- UL (Underwriters' Laboratories, Inc.) pending (Apr., 1998)
- CSA (Canadian Standards Association) pending (Apr., 1998)
- CUL (Canadian Underwriters' Laboratories, Inc.) pending (Apr., 1998)
- CE (European Economic Union) F1–130DD–D, F1–130DR–D, F1–130DR–CE, and F1–130DD–CE carry CE mark

Environmental Specifications

The following table lists the environmental specifications that generally apply to DL105 Micro PLCs. The ranges that vary for the Handheld Programmer are noted at the bottom of this chart. Certain output circuit types may have derating curves, depending on the ambient temperature and the number of outputs ON. Please refer to the appropriate section in this chapter pertaining to your particular DL105.

Specification	Rating
Storage temperature	–4° F to 158° F (–20° C to 70° C)
Ambient operating temperature*	32° F to 140° F (0° C to 60° C)
Ambient humidity**	5% – 95% relative humidity (non–condensing)
Vibration resistance	MIL STD 810C, Method 514.2
Shock resistance	MIL STD 810C, Method 516.2
Noise immunity	NEMA (ICS3–304)
Atmosphere	No corrosive gases

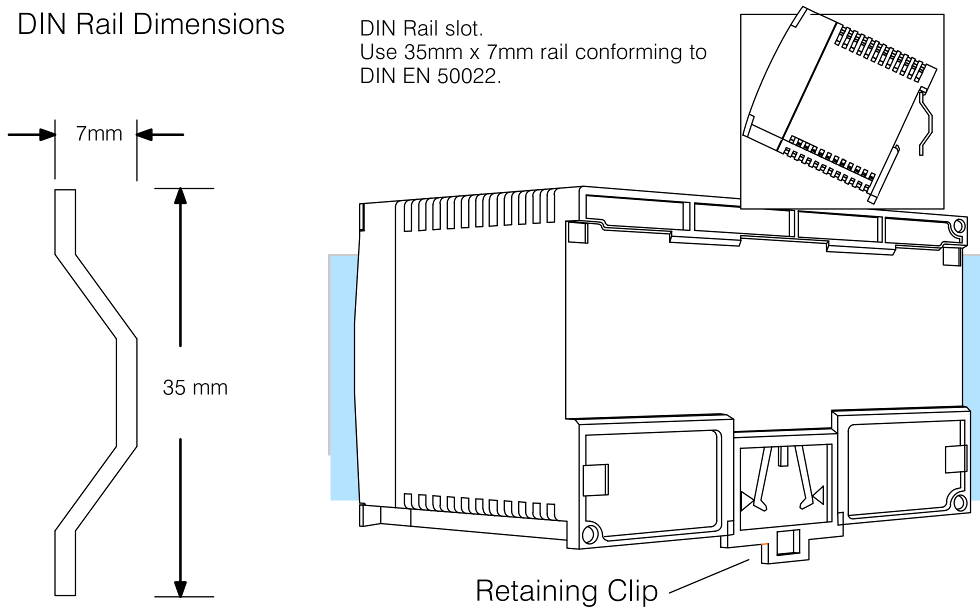
* Operating temperature for the Handheld Programmer and the DV–1000 is 32° to 122° F (0° to 50° C) Storage temperature for the Handheld Programmer and the DV–1000 is –4° to 158° F (–20° to70° C).
**Equipment will operate down to 5% relative humidity. However, static electricity problems occur much more frequently at low humidity levels (below 30%). Make sure you take adequate precautions when you touch the equipment. Consider using ground straps, anti-static floor coverings, etc. if you use the equipment in low-humidity environments.

Using Mounting Rails

DL105 Micro PLCs can also be secured to a cabinet by using mounting rails. We recommend rails that conform to DIN EN standard 50 022. They are approximately 35mm high, with a depth of 7.5mm. If you mount the Micro PLC on a rail, do consider using end brackets on each side of the PLC. The end bracket helps keep the PLC from sliding horizontally along the rail, reducing the possibility of accidentally pulling the wiring loose.

On the bottom of the PLC is a small retaining clip. To secure the PLC to a DIN rail, place it onto the rail and gently push up on the clip to lock it onto the rail.

To remove the PLC, pull down on the retaining clip, lift up on the PLC slightly, then pulling it away from the rail.



NOTE: We provide the following list as a guideline. Local and/or national codes may require the use of a particular type of material. Consult the manufacturer or their authorized representative prior to designing your system.

Vendor	Type	Materials and Lengths
Phoenix Contacts Products P.O. Box 4100 Harrisburg, PA 17111–0100 717–944–1300	NS 35/7,5	Steel, 6.5ft. (2m) (part number 08 01 73 3)
Weidmuller, Inc. 821 Southlake Blvd. Richmond, VA 23236 804–794–2877	TS 35x7.5	Steel, aluminum, copper, PVC Several lengths are available (consult manufacturer for appropriate part number)
Wieland available from Newark Electronics 4108 North Ravenswood Ave. Chicago, Il 60640 312–784–5100	TS 35x27x7.5	Steel, 6.5ft. (2m) (part number 94F2750)

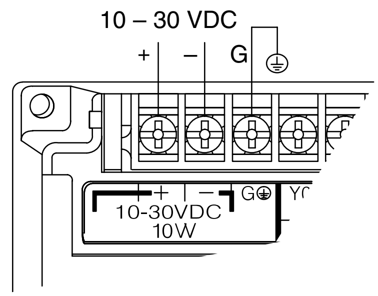
Wiring Guidelines

Power Input Wiring

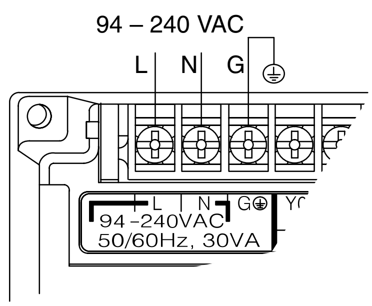
The diagram shows various possible external power connections for DL105 Micro PLCs. The terminals can accept up to 14 AWG wire. You may be able to use larger wiring depending on the wire type, but 14 AWG is the recommended size.

NOTE: You can connect either 115 VAC, 220 VAC, or 125 VDC to AC-powered versions of the DL105. Special wiring or jumpers are not required as with some of the other ***Direct***LOGIC™ products.

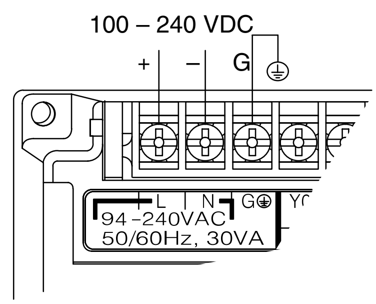
12/24 VDC Power Input



110/220 VAC Power Input



125 VDC Power Input



WARNING: Once the power wiring is connected, secure the terminal block cover in the closed position. When the cover is open there is a risk of electrical shock if you accidentally touch the connection terminals or power wiring.

Fuse Protection for Input Power

There are no internal fuses for the input power circuits, so external circuit protection is needed to ensure the safety of service personnel and the safe operation of the equipment itself. To meet UL/CSA specifications, the input power must be fused.

Depending on the type of input power being used, follow these fuse protection recommendations:

208/240 VAC Operation

When operating the unit from 208/240 VAC, whether the voltage source is a step-down transformer or from two phases, fuse both the line (L) and neutral (N) leads. The recommended fuse size is 0.375A (for example, a Littlefuse 312.375 or equivalent).

110/125 VAC Operation

When operating the unit from 110/125 VAC, it is only necessary to fuse the line (L) lead; it is not necessary to fuse the neutral (N) lead. The recommended fuse size is 0.5A (for example, a Littlefuse 312.500 or equivalent).

125 VDC Operation

Proper fusing techniques are required when operating from 125 VDC. Depending on your ground reference, the hot lead must be fused. A DC failure can maintain an arc for much longer time and distance. Typically, the main bus is fused at a higher level than the branch device, which in this case would be the DL105 unit. This double fusing technique is required when operating from direct current. The recommended fuse size for the branch circuit to the DL105 is 0.5A (for example, a Littlefuse 312.500 or equivalent).

12/24 VDC Operation

When operating at these lower dc voltages, wire gauge size is just as important as proper fusing techniques. Using large conductors minimizes the voltage drop in the conductor. Each DL105 input power terminal can accommodate one 14 AWG or two 16 AWG wires. Each terminal block junction and/or connection creates a voltage drop, so try to keep the number of connections to a minimum. In general, when using 12/24 VDC input power, observe the same double fusing techniques that are used with 125 VDC input power. The recommended fuse size for the branch circuit to the DL105 is 1A (for example, a Littlefuse 312.001 or equivalent).

External Power Source

The power source must be capable of suppling voltage and current complying with individual Micro PLC specifications, according to the following specifications:

Part Numbers	**F1–130AR, F1–130DR / F1–130DR–CE, F1–130AD, F1–130DD / F1–130DD–CE, F1–130AA, F1–130DA**	**F1–130DR–D, F1–130DD–D**
Input Voltage Range	85–132 VAC (110 nominal) 170–264 VAC (220 nominal), 100 – 264 VDC (125 nominal)	10 – 30 VDC (12 to 24VDC) with less than 10% ripple
Maximum Inrush Current	12 A, <1/2 mS	12 A, <1/2 mS
Maximum Power	30 VA (for AC power) 30 W (for DC power)	10W (0.3A @ 30VDC)
Voltage Withstand (dielectric)	1 minute @ 1500 VAC between primary, secondary, field ground	
Insulation Resistance	> 10 MΩ at 500 VDC	
Auxiliary 24 VDC Output	21.6–26.4 VDC Ripple less than 200 mV p-p 500 mA max, isolated.	None

NOTE: The rating between all internal circuits is BASIC INSULATION ONLY.

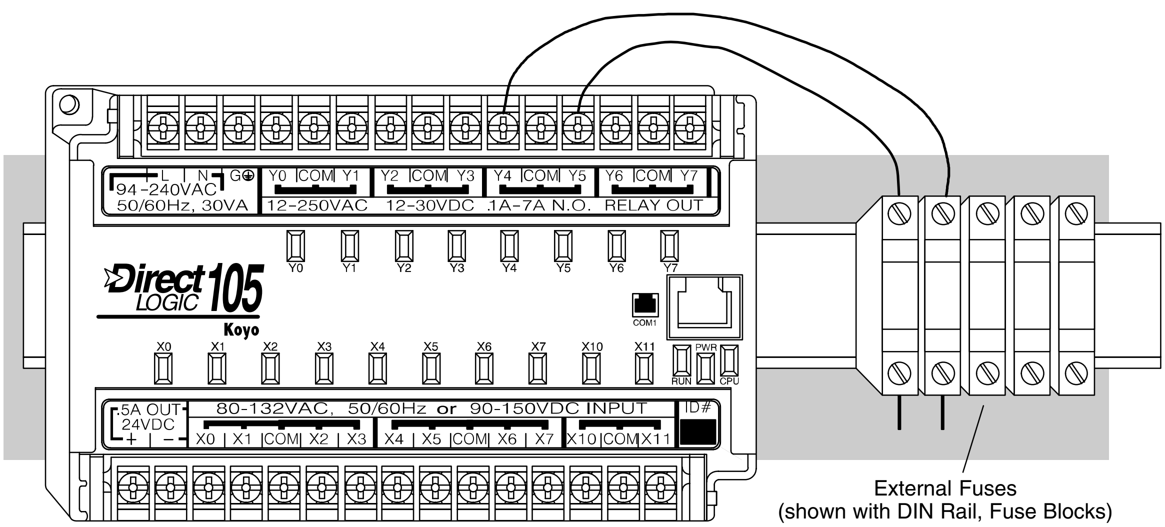
Planning the Wiring Routes

The following guidelines provide general information on how to wire the I/O connections to DL105 Micro PLCs. For specific information on wiring a particular PLC refer to the corresponding specification sheet further in this chapter.

1. Each terminal connection of the DL105 PLC can accept one 14 AWG wire or two 16 AWG size wires. Do not exceed this recommended capacity.
2. Always use a continuous length of wire. Do not splice wires to attain a needed length.
3. Use the shortest possible wire length.
4. Use wire trays for routing where possible.
5. Avoid running wires near high energy wiring.
6. Avoid running input wiring close to output wiring where possible.
7. To minimize voltage drops when wires must run a long distance , consider using multiple wires for the return line.
8. Avoid running DC wiring in close proximity to AC wiring where possible.
9. Avoid creating sharp bends in the wires.

Fuse Protection for Input and Output Circuits

Input and Output circuits on DL105 Micro PLCs do not have internal fuses. However, the +24V Auxiliary Supply is current-limited. In order to protect your Micro PLC, we suggest you add external fuses to your I/O wiring. A fast-blow fuse, with a lower current rating than the I/O bank's common current rating can be wired to each common. Or, a fuse with a rating of slightly less than the maximum current per output point can be added to each output. Refer to the Micro PLC specification sheets further in this chapter to find the maximum current per output point or per output common. Adding the external fuse does not guarantee the prevention of Micro PLC damage, but it will provide added protection.



External Fuses
(shown with DIN Rail, Fuse Blocks)

I/O Point Numbering

All DL105 Micro PLCs have a fixed I/O configuration. It follows the same octal numbering system used on other ***Direct***Logic family PLCs, starting at X0 and Y0. The letter X is always used to indicate inputs and the letter Y is always used for outputs.

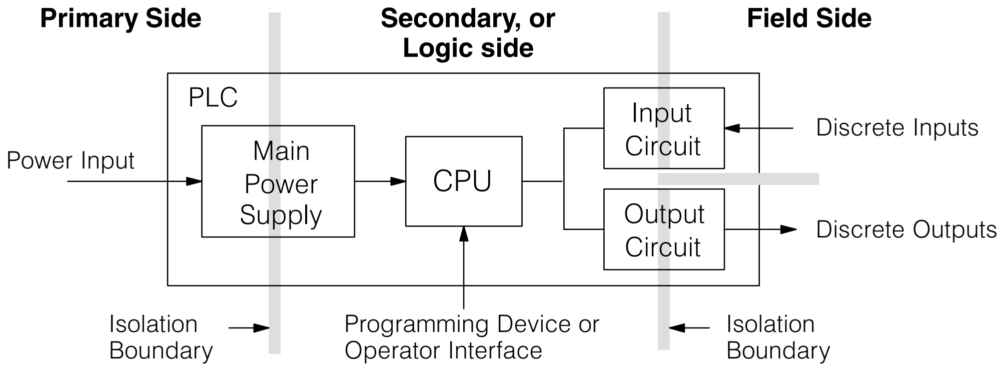
The I/O numbering always starts at zero and does not include the digits 8 or 9. The addresses are typically assigned in groups of 8 or 16, depending on the number of points in an I/O group. For the DL105 the ten inputs use reference numbers X0 – X7 and X10 – X11. The eight output points use references Y0 – Y7.

System Wiring Strategies

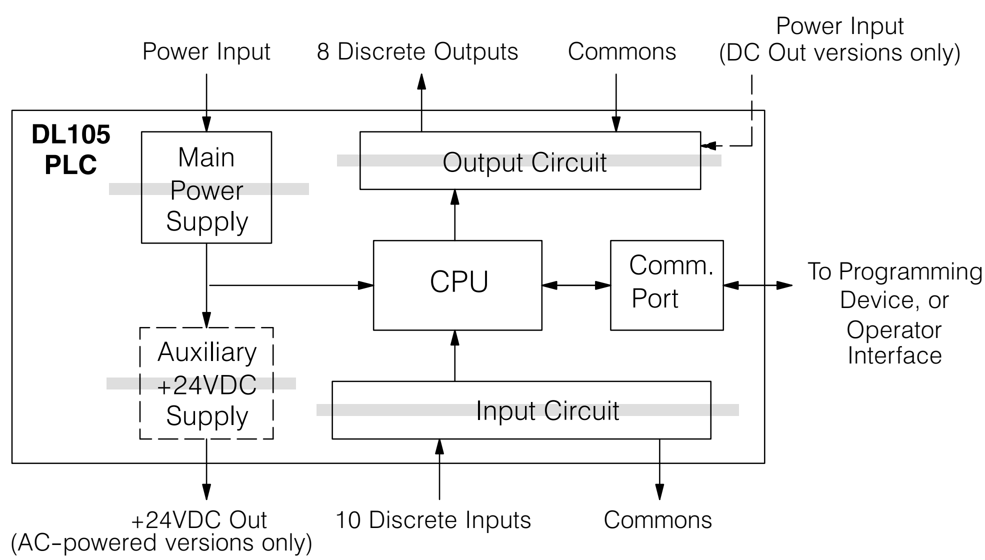
The DL105 Micro PLC is very flexible and will work in many different wiring configurations. By studying this section before actual installation, you can probably find the best wiring strategy for your application . This will help to lower system cost, wiring errors, and avoid safety problems.

PLC Isolation Boundaries

PLC circuitry is divided into three main regions separated by isolation boundaries, shown in the drawing below. Electrical isolation provides safety, so that a fault in one area does not damage another. A transformer in the power supply provides magnetic isolation between the primary and secondary sides. Opto-couplers provide optical isolation in Input and Output circuits. This isolates logic circuitry from the field side, where factory machinery connects. Note that the discrete inputs are isolated from the discrete outputs, because each is isolated from the logic side. Isolation boundaries protect the operator interface (and the operator) from power input faults or field wiring faults. *When wiring a PLC, it is extremely important to avoid making external connections that connect logic side circuits to any other.*



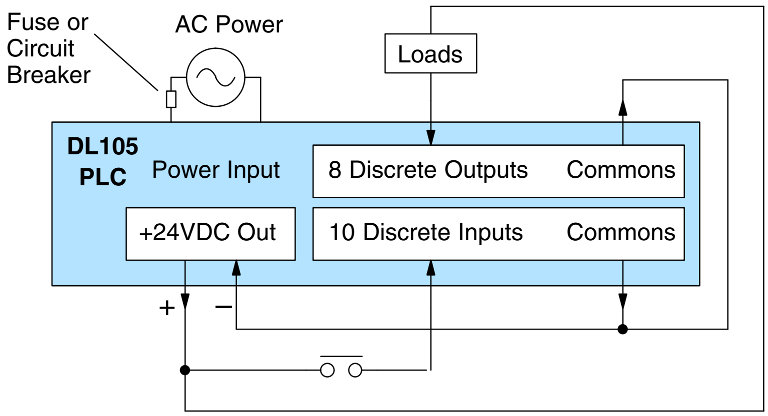
The next figure shows the internal layout of DL105 PLCs, as viewed from the front panel. In addition to the basic circuits covered above, it includes an auxiliary +24VDC power supply with its own isolation boundary. Since the supply output is isolated from the other three circuits, it can power input and/or output circuits!



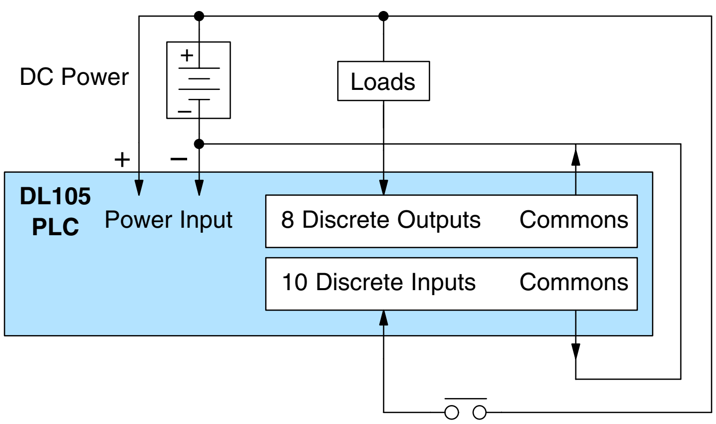
In many cases, using the built-in auxiliary +24VDC supply can result in a cost savings for your control system. It can power combined loads up to 500 mA, which is enough to eliminate the need for an additional power supply in some applications. If you are the system designer for your application, you may be able to select and design in field devices which can use the +24VDC auxiliary supply.

Powering I/O Circuits with the Auxiliary Supply

All AC-powered DL105 Micro PLCs feature the internal auxiliary supply. If input devices AND output loads need +24VDC power, the auxiliary supply can power both circuits as shown in the following diagram.



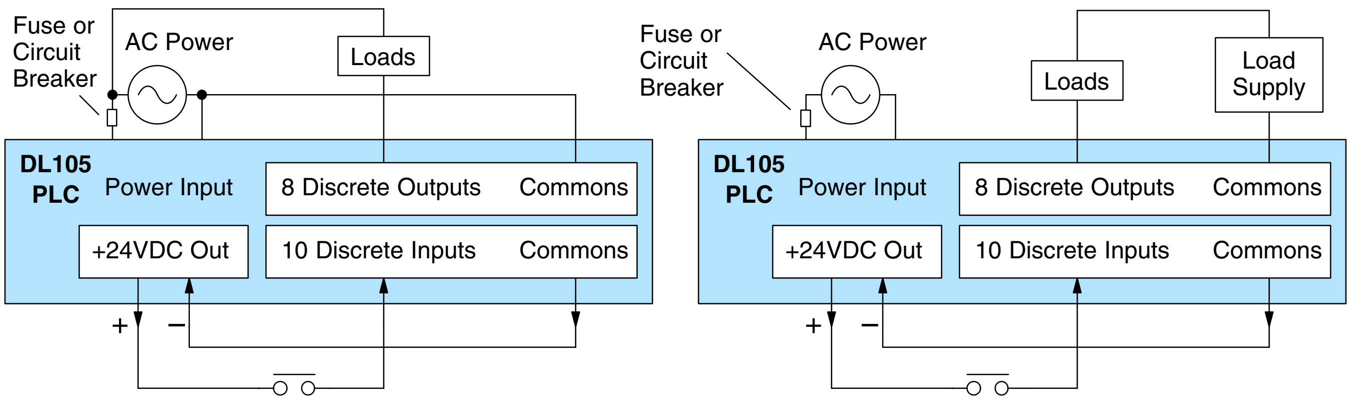
DC-powered DL105 Micro PLCs are designed for application environments in which low-voltage DC power is more readily available than AC. These include a wide range of battery–powered applications, such as remotely-located control, in vehicles, portable machines, etc. For this application type, all input devices and output loads typically use the same DC power source. The F1-130DR-D and F1-130DD-D are compatible with either +12VDC or +24VDC systems. Typical wiring for DC-powered applications is shown in the following diagram.



Powering I/O Circuits Using Separate Supplies

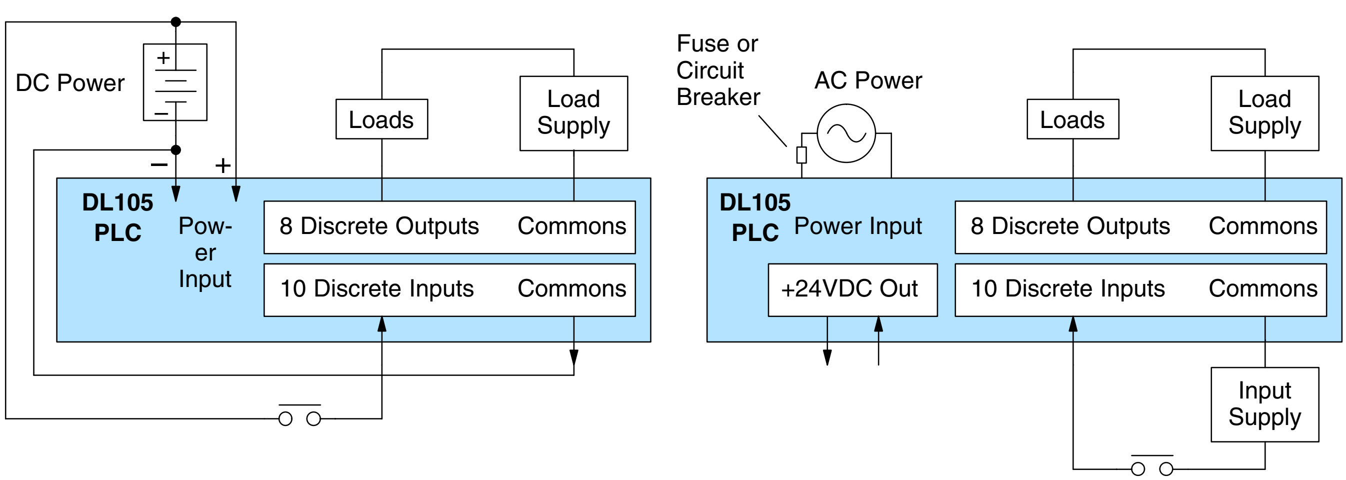
In some applications it will be necessary to power the input devices from one power source, and to power output loads from another source. Loads often require high-energy AC power, while input sensors use low-energy DC. If a machine operator is likely to come in close contact with input wiring, then safety reasons also require isolation from high-energy output circuits. It is most convenient if the loads can use the same power source as the Micro PLC, and the input sensors can use the auxiliary supply, as shown to the left in the figure below.

If the loads cannot be powered from the Micro PLC supply, then a separate supply must be used as shown to the right in the figure below.



Some applications will use the Micro PLC power source to also power the input circuit. This typically occurs on a DC-powered DL105, as shown in the drawing below to the left. The inputs share the PLC power source supply, while the outputs have their own separate supply.

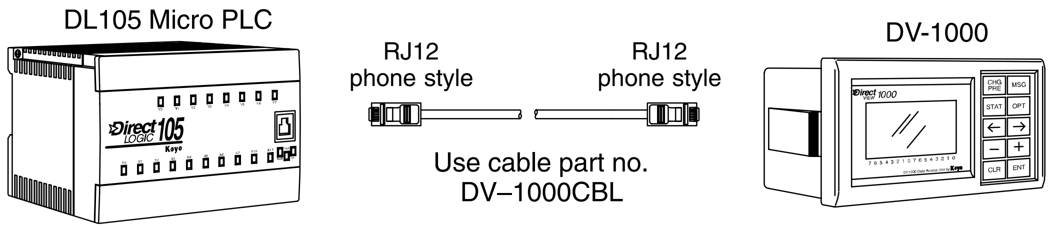
A worst-case scenario, from a cost and complexity view-point, is an application which requires separate power sources for the PLC, input devices, and output loads. The example wiring diagram below on the right shows how this can work, but also that the auxiliary supply out is an unused resource. For these reasons, you'll probably want to avoid this situation if possible.



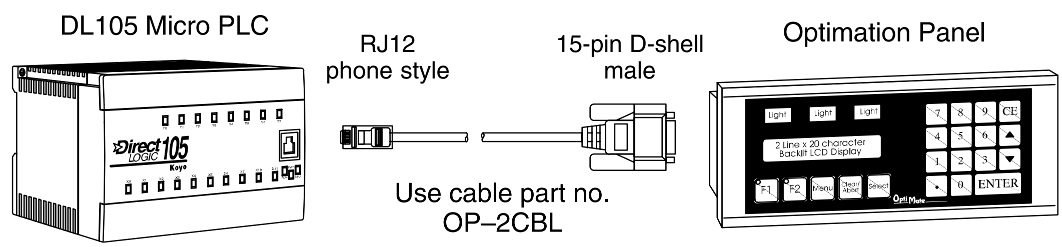
Connecting Operator Interface Devices

Operator interfaces require data and power connections. Operator interfaces with a large CRT usually require separate AC power. However, small operator interface devices like the popular DV-1000 Data Access Unit and the Optimation panels may be powered directly from the DL105 Micro PLC.

Connect the DV-1000 to the DL105 Micro PLC COM1 port using the cable shown below. A single cable contains transmit/receive data wires and +5V power.

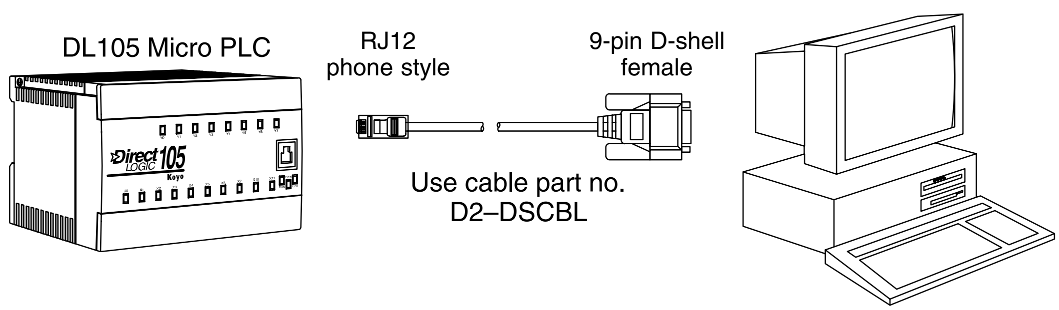


Optimation operator interface panels require separate power and communications connections. Connect the DL105 COM1 port to the 15-pin D-shell connector on the rear of the Optimation panel using the cable shown below. Optimation panels require 8–30VDC power, so use separate wiring to connect the +24VDC supply output on AC-powered DL105 PLCs. Use external +24VDC power for DC-powered DL105s.

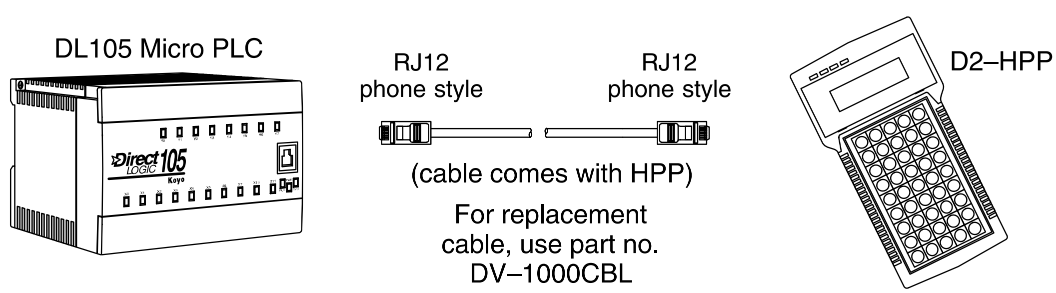


Connecting Programming Devices

DL105 Micro PLCs can be programmed with either a handheld programmer or with ***Direct***SOFT32 on a PC. Connect the DL105 to a PC using the cable shown below.



The D2-HPP Handheld Programmer comes with a communications cable. For a replacement part, use the cable shown below.



Sinking / Sourcing Concepts

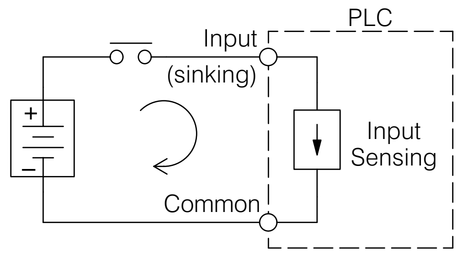
Before going further in our study of wiring strategies, we must have a solid understanding of "*sinking*" and "*sourcing*" concepts. Use of these terms occurs frequently in input or output circuit discussions. It is the goal of this section to make these concepts easy to understand, further ensuring your success in installation. First we give the following short definitions, followed by practical applications.

Sinking = Path to supply **ground (–)**

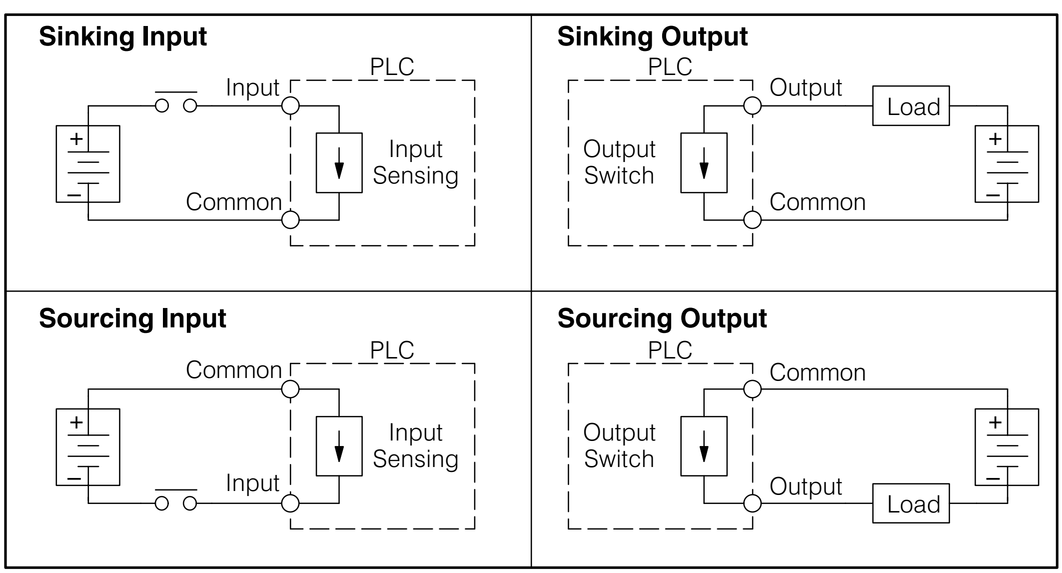
Sourcing = Path to supply **source (+)**

First you will notice that these are only associated with DC circuits and not AC, because of the reference to (+) and (–) polarities. Therefore, *sinking and sourcing terminology only applies to DC input and output circuits.* Input and output points that are either sinking or sourcing can conduct current in only one direction. This means it is possible to connect the external supply and field device to the I/O point with current trying to flow in the wrong direction, and the circuit will not operate. However, we can successfully connect the supply and field device every time by understanding "sourcing" and "sinking".

For example, the figure to the right depicts a "sinking" input. To properly connect the external supply, we just have to connect it so the the input *provides a path to ground (–)*. So, we start at the PLC input terminal, follow through the input sensing circuit, exit at the common terminal, and connect the supply (–) to the common terminal. By adding the switch, between the supply (+) and the input, we have completed the circuit. Current flows in the direction of the arrow when the switch is closed.

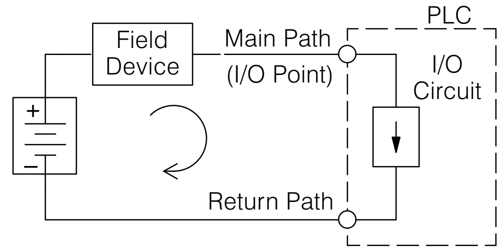


By applying the circuit principle above to the four possible combinations of input/output sinking/sourcing types, we have the four circuits as shown below. DL105 Micro PLCs provide all except the sourcing output I/O circuit types.

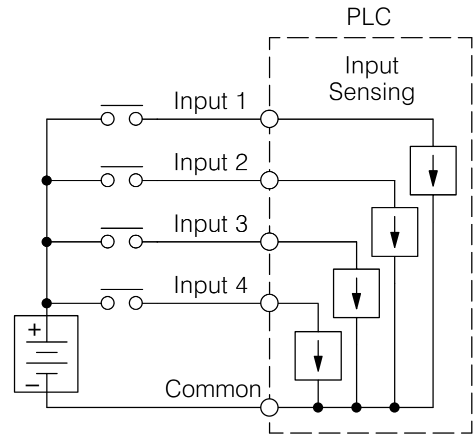


I/O "Common" Terminal Concepts

In order for a PLC I/O circuit to operate, current must enter at one terminal and exit at another. This means at least two terminals are associated with every I/O point. In the figure to the right, the Input or Output terminal is the *main path* for the current. One additional terminal must provide the *return path* to the power supply.

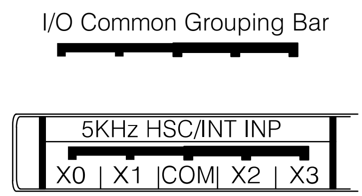


If we had unlimited space and budget for I/O terminals, then every I/O point could have two dedicated terminals just as the figure above shows. However, providing this level of flexibility is not practical or even necessary for most applications. So, most Input or Output point groups on PLCs share the return path among two or more I/O points. The figure to the right shows a group (or *bank*) of 4 input points which share a common return path. In this way, the four inputs require only five terminals instead of eight.

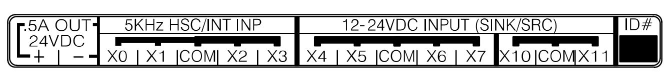


Note: In the circuit above, the current in the common path is 4 times any channel's input current when all inputs are energized. This is especially important in output circuits, where heavier gauge wire is sometimes necessary on commons.

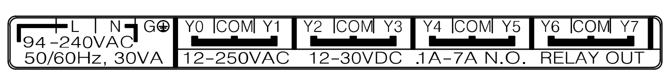
Most DL105 input and output circuits are grouped into banks that share a common return path. The best indication of I/O common grouping is on the wiring label. The I/O common grouping bar, labeled at the right, occurs in the section of wiring label below it. It indicates X0, X1, X2, and X3 share the common terminal located between X1 and X2.



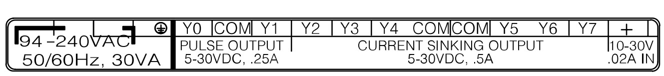
The following complete label shows two banks of four inputs and one bank of two.



The following label for relay outputs shows four banks of two output points each.



The last label below for DC outputs has no common grouping bar. In this unique case, all eight outputs share the same electrical common. The common is available on three terminals, so there is a physical place to connect each point's common wire.

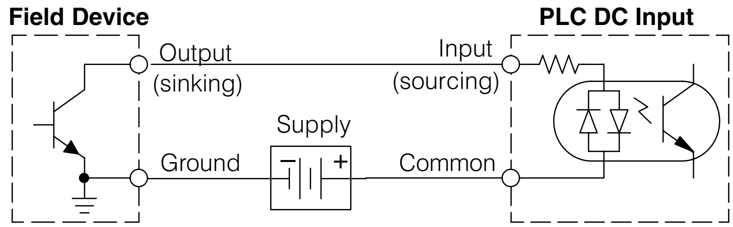


Connecting DC I/O to "Solid State" Field Devices

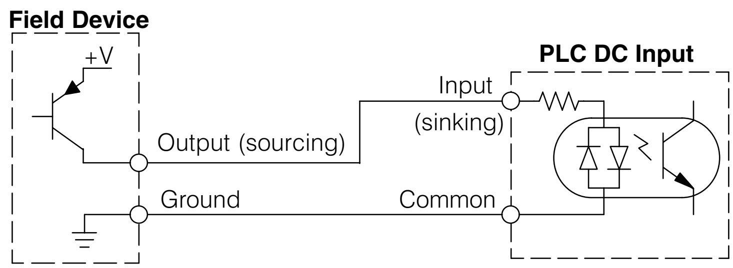
In the previous section on Sourcing and Sinking concepts, we explained that DC I/O circuits sometimes will only allow current to flow one way. This is also true for many of the field devices which have solid-state (transistor) interfaces. In other words, field devices can also be sourcing or sinking. *When connecting two devices in a series DC circuit, one must be wired as sourcing and the other as sinking*.

Solid State Input Sensors

The DL105's DC inputs are flexible in that they detect current flow in either direction, so they can be wired as either sourcing or sinking. In the following circuit, a field device has an open-collector NPN transistor output. It sinks current from the PLC input point, which sources current. The power supply can be the +24 auxiliary supply or another supply (+12 VDC or +24VDC), as long as the input specifications are met.



In the next circuit, a field device has an open-emitter PNP transistor output. It sources current to the PLC input point, which sinks the current back to ground. Since the field device is sourcing current, no additional power supply is required.

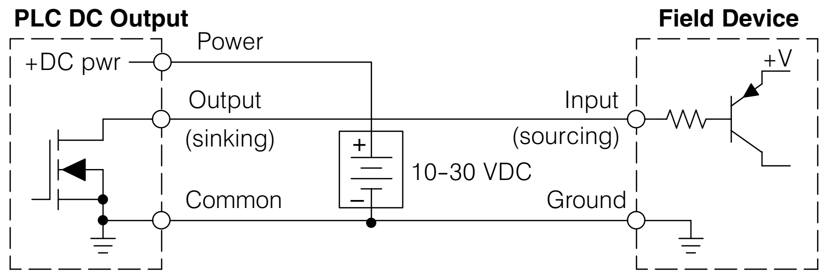


Solid State Output Loads

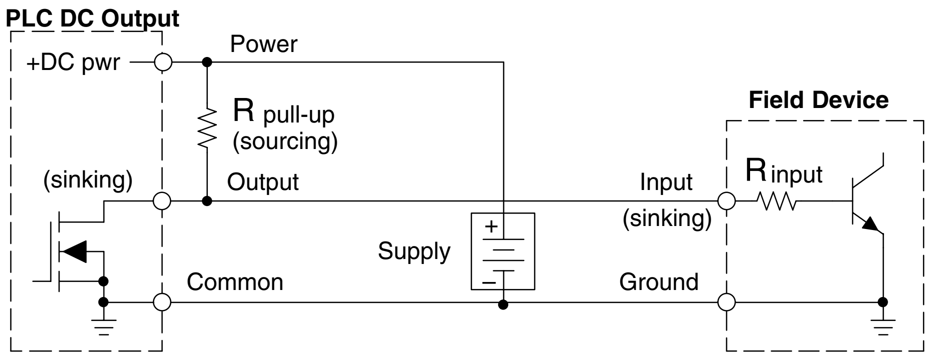
Sometimes an application requires connecting a PLC output point to a solid state input on a device. This type of connection is usually made to carry a low-level signal, not to send DC power to an actuator.

The DL105's DC outputs are sinking-only. This means that each DC output provides a path to ground when it is energized. Also, remember that all eight outputs have the same electrical common, even though there are three common terminal screws. Finally, recall that the DC output circuit requires power (10 – 30 VDC) from an external power source.

In the following circuit, the PLC output point sinks current to the output common when energized. It is connected to a sourcing input of a field device input.



In the next example we connect a PLC DC output point to the sinking input of a field device. This is a bit tricky, because both the PLC output and field device input are sinking type. Since the circuit must have one sourcing and one sinking device, we add sourcing capability to the PLC output by using a pull-up resistor. In the circuit below, we connect $R_{pull\text{-}up}$ from the output to the DC output circuit power input.



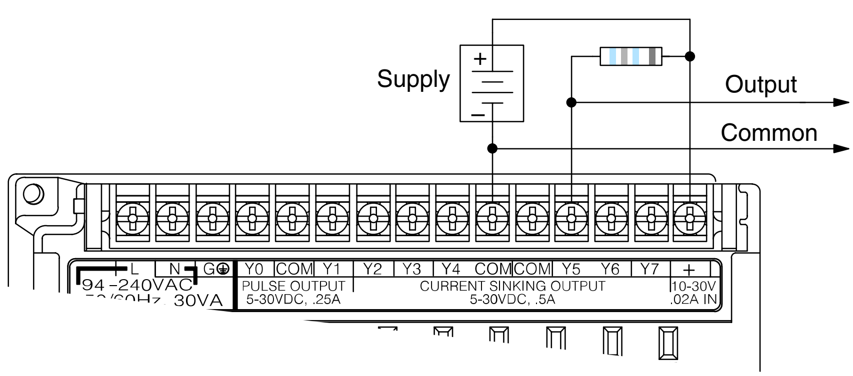
NOTE: DO NOT attempt to drive a heavy load (>25 mA) with this pull-up method.
NOTE 2: Using the pull-up resistor to implement a sourcing output has the effect of inverting the output point logic. In other words, the field device input is energized when the PLC output is OFF, from a ladder logic point-of-view. Your ladder program must comprehend this and generate an inverted output. Or, you may choose to cancel the effect of the inversion elsewhere, such as in the field device.

It is important to choose the correct value of $R_{pull\text{-}up}$. In order to do so, we need to know the nominal input current to the field device (I_{input}) when the input is energized. If this value is not known, it can be calculated as shown (a typical value is 15 mA). Then use I_{input} and the voltage of the external supply to compute $R_{pull\text{-}up}$. Then calculate the power $P_{pull\text{-}up}$ (in watts), in order to size $R_{pull\text{-}up}$ properly.

$$I_{input} = \frac{V_{input\ (turn\text{–}on)}}{R_{input}}$$

$$R_{pull\text{-}up} = \frac{V_{supply} - 0.7}{I_{input}} - R_{input} \qquad P_{pull\text{-}up} = \frac{{V_{supply}}^2}{R_{pullup}}$$

The drawing below shows the actual wiring of the DL105 Micro PLC to the supply and pull-up resistor.



Relay Output Wiring Methods

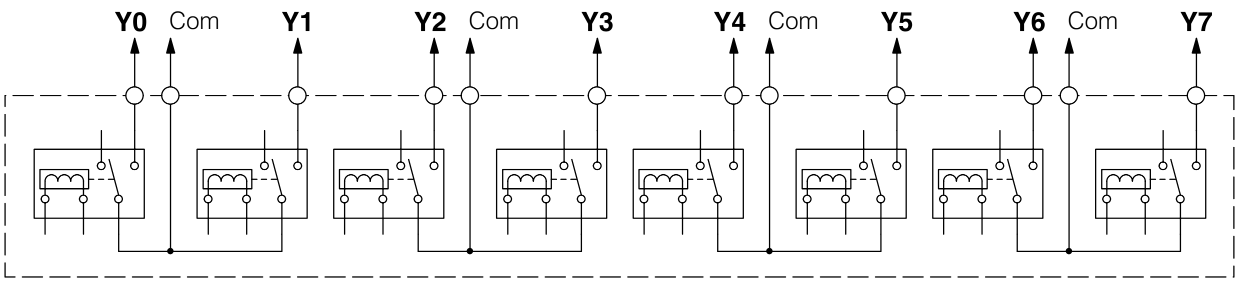
The F1–130AR, F1–130DR/F1–130DR–CE, and F1–130DR–D models feature relay outputs. Relays are best for the following applications:

- Loads that require higher currents than the solid-state DL105 outputs can deliver
- Cost-sensitive applications
- Some output channels need isolation from other outputs (such as when some loads require AC while others require DC)

Some applications in which NOT to use relays:

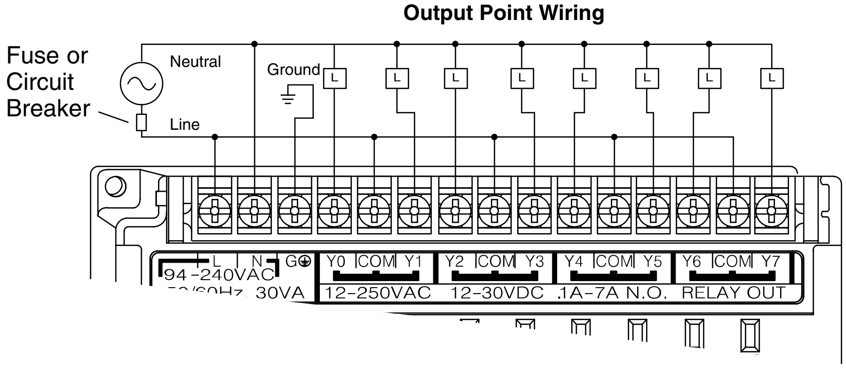
- Loads that require currents under 10 mA
- Loads which must be switched at high speed and duty cycle

Assuming relays are right for your application, we're now ready to explore various ways to wire relay outputs to the loads. Note that there are eight normally-open SPST relays available. They are organized into four pairs with individual commons. The figure below shows the relays and the internal wiring of the PLC. Note that each pair is isolated from the other three relay pairs.

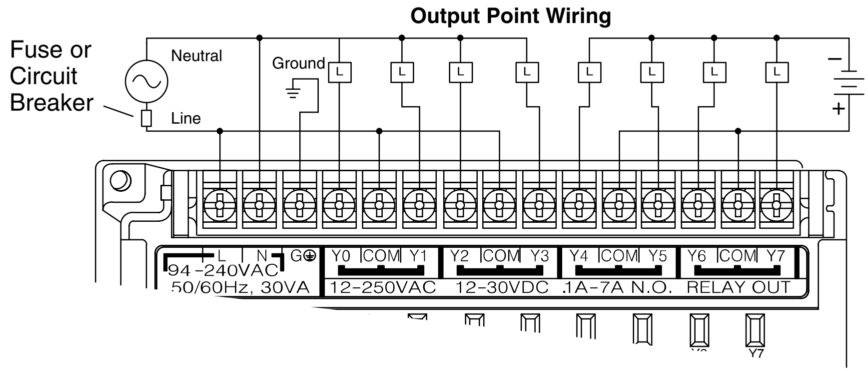


In the circuit below, all loads use the same AC power supply which powers the DL105 PLC. In this example, all commons are connected together.

Output Point Wiring



In the circuit on the following page, loads for Y0 – Y3 use the same AC power supply which powers the DL105 PLC. Loads for Y4 – Y7 use a separate DC supply. In this example, the commons are separated according to which supply powers the associated load.



Surge Suppresion For Inductive Loads

Inductive load devices (devices with a coil) generate transient voltages when de-energized with a relay contact. When a relay contact is closed it “bounces”, which energizes and de-energizes the coil until the “bouncing” stops. The transient voltages generated are much larger in amplitude than the supply voltage, especially with a DC supply voltage.

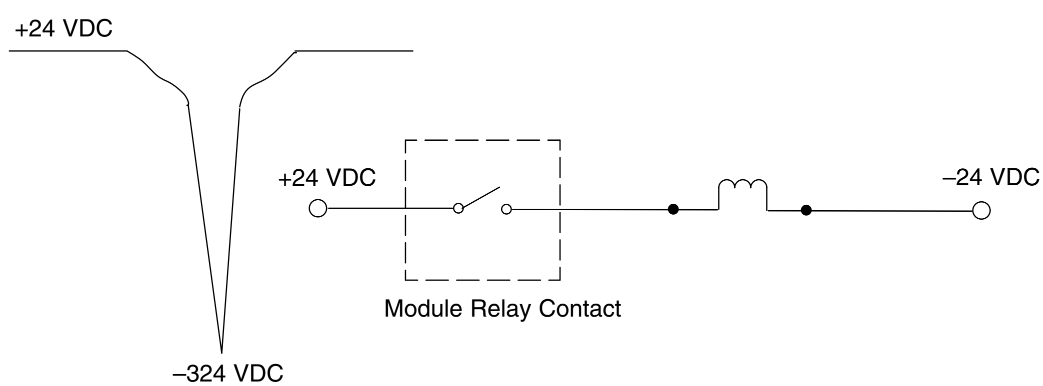
When switching a DC-supplied inductive load the full supply voltage is always present when the relay contact opens (or “bounces”). When switching an AC-supplied inductive load there is one chance in 60 (60 Hz) or 50 (50 Hz) that the relay contact will open (or “bounce”) when the AC sine wave is zero crossing. If the voltage is not zero when the relay contact opens there is energy stored in the inductor that is released when the voltage to the inductor is suddenly removed. This release of energy is the cause of the transient voltages.

When inductive load devices (motors, motor starters, interposing relays, solenoids, valves, etc.) are controlled with relay contacts, it is recommended that a surge suppression device be connected directly across the coil of the field device. If the inductive device has plug-type connectors, the suppression device can be installed on the terminal block of the relay output.

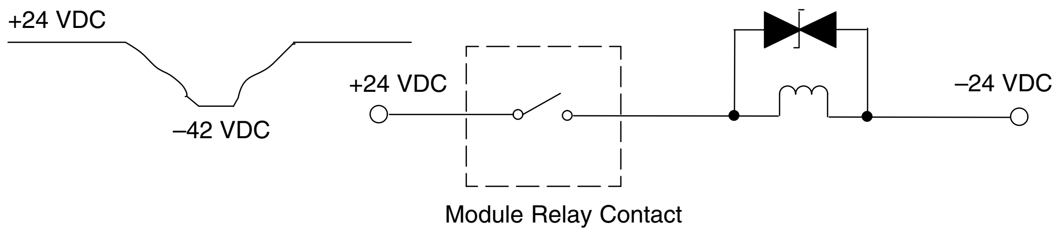
Transient Voltage Suppressors (TVS or transorb) provide the best surge and transient suppression of AC and DC powered coils, providing the fastest response with the smallest overshoot.

Metal Oxide Varistors (MOV) provide the next best surge and transient suppression of AC and DC powered coils.

For example, the waveform in the figure below shows the energy released when opening a contact switching a 24 VDC solenoid. Notice the large voltage spike.



This figure shows the same circuit with a transorb (TVS) across the coil. Notice that the voltage spike is significantly reduced.



Use the following table to help select a TVS or MOV suppressor for your application based on the inductive load voltage.

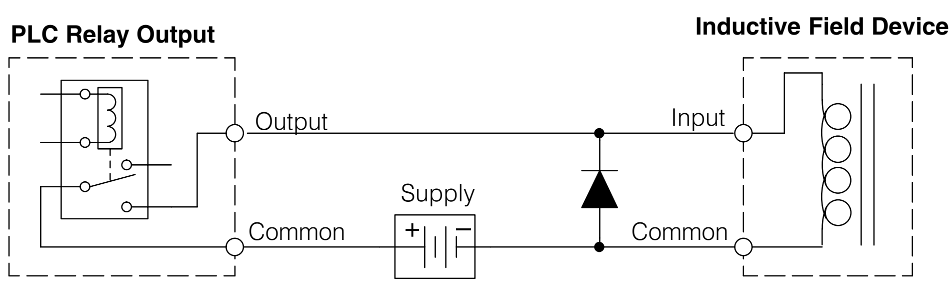
Vendor / Catalog	Type (TVS, MOV, Diode)	Inductive Load Voltage	Part Number
General Instrument Transient Voltage Suppressors, LiteOn Diodes; from DigiKey Catalog; Phone: 1-800-344-4539	TVS TVS TVS Diode	110/120 VAC 220/240 VAC 12/24 VDC or VAC 12/24 VDC or VAC	P6KE180CAGICT–ND P6KE350CA P6K30CAGICT–ND 1N4004CT–ND
Harris Metal Oxide Varistors; from Newark Catalog; Phone: 1-800-463-9275	MOV MOV	110/120 VAC 220/240 VAC	V150LA20C V250LA20C

Prolonging Relay Contact Life

Relay contacts wear according to the amount of relay switching, amount of spark created at the time of open or closure, and presence of airborne contaminants. There are some steps you can take to help prolong the life of relay contacts, such as switching the relay on or off only when it is necessary, and if possible, switching the load on or off at a time when it will draw the least current. Also, take measures to suppress inductive voltage spikes from inductive DC loads such as contactors and solenoids.

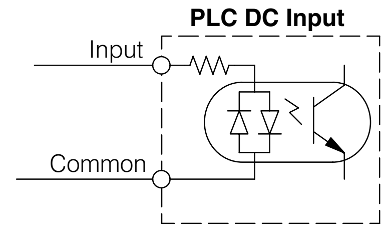
For inductive loads in DC circuits we recommend using a suppression diode as shown in the following diagram (DO NOT use this circuit with an AC power supply). When the load is energized the diode is reverse-biased (high impedance). When the load is turned off, energy stored in its coil is released in the form of a negative-going voltage spike. At this moment the diode is forward-biased (low impedance) and shunts the energy to ground. This protects the relay contacts from the high voltage arc that would occur just as the contacts are opening.

Place the diode as close to the inductive field device as possible. Use a diode with a peak inverse voltage rating (PIV) at least 100 PIV, 3A forward current or larger. Use a fast-recovery type (such as Schottky type). DO NOT use a small-signal diode such as 1N914, 1N941, etc. Be sure the diode is in the circuit correctly before operation. If installed backwards, it short-circuits the supply when the relay energizes.

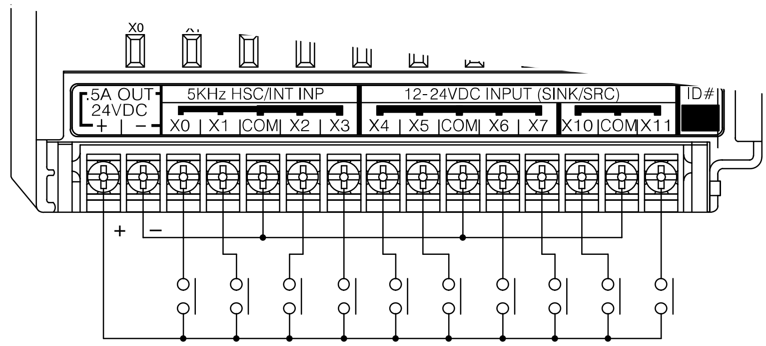


DC Input Wiring Methods

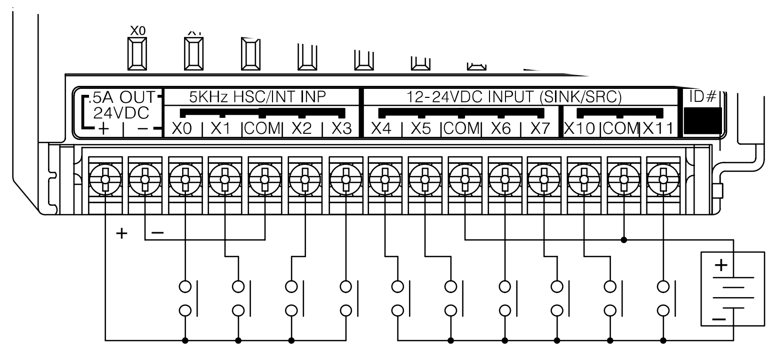
DL105 Micro PLCs with DC inputs are particularly flexible because they can be either sinking or sourcing. The dual diodes (shown to the right) allow current to flow in either direction. The inputs accept either 10 – 26.4 VDC or 21.6 – 26.4 VAC. That's right, either AC or DC voltages will work. The target applications are +12 VDC, +24 VDC, and 24 VAC. You can actually wire part of the inputs as DC sinking, others as DC sourcing, and the rest as AC!



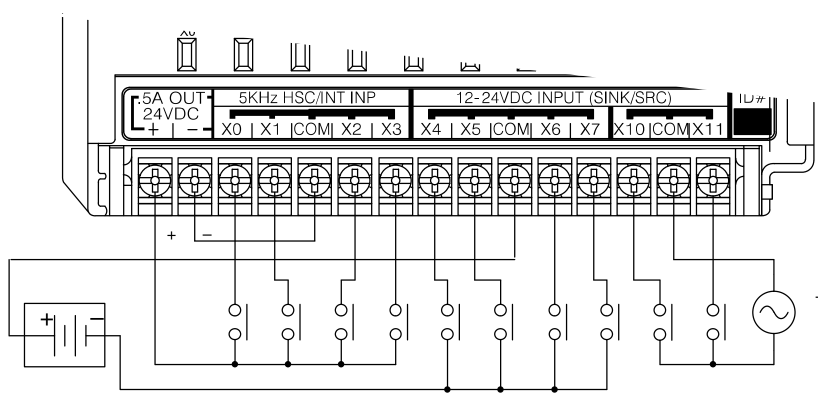
In the first and simplest example below, all commons are connected together and all inputs are sinking.



In the next example, the first four inputs are sinking, and the last six are sourcing.



In the last example, four inputs are sinking DC, four are sourcing DC, and two are AC.



DC Output Wiring Methods

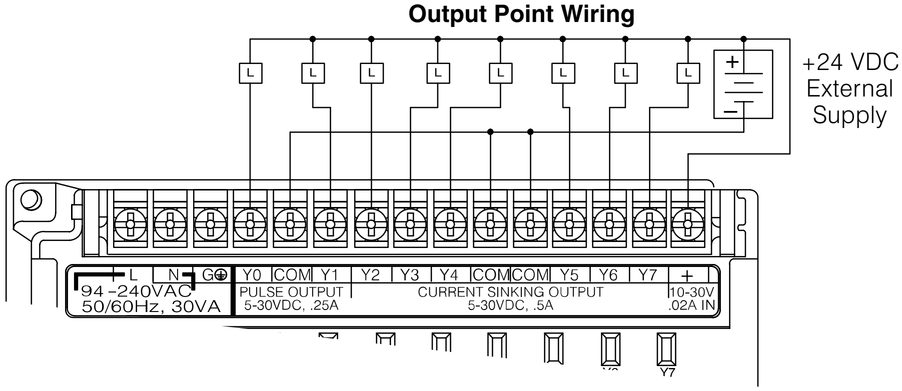
DL105 DC output circuits are high-performance MOSFET switches with low on-resistance and fast switching times. Please note the following characteristics which are unique to the DC output type:

- There is only one electrical common for all eight outputs, even though there are three common terminals. All eight outputs belong to one bank.
- The output switches are current-sinking only. However, you can still use different DC voltages from one load to another.
- The output circuit inside the PLC requires external power. The supply (–) must be connected to a common terminal, and the supply (+) connects the the right-most terminal on the upper connector.

NOTE: Always connect all three common terminals together at the connector with short wires (do not leave some common terminals unconnected).This provides three connections to share the load return current, enhancing reliability.

In the example below, all eight outputs share a common supply. It may be external as shown, or they may use the auxiliary +24VDC supply when available.

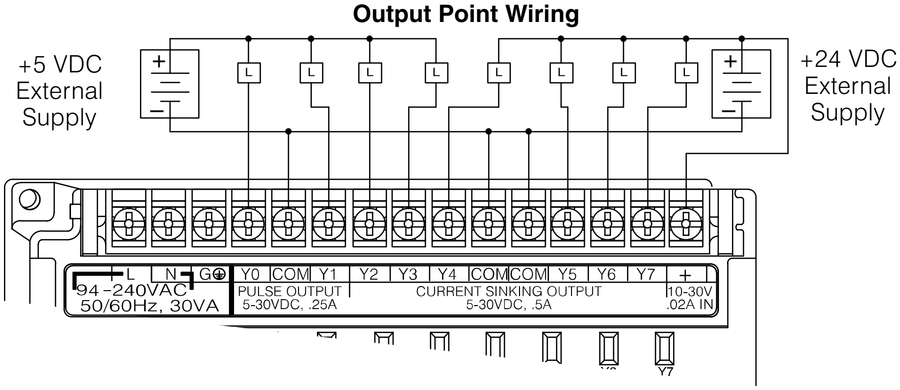
Output Point Wiring



In the next example below, the outputs have “split” supplies. The first four outputs are using a +5 VDC supply, and the last four are using a +24 VDC supply. However, you can split the outputs among any number of supplies, as long as:

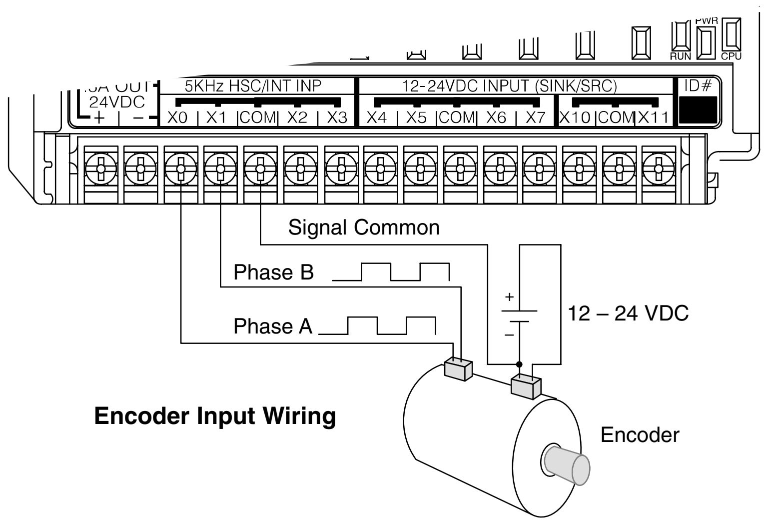
- all supply voltages are within the specified range
- all output points are wired as sinking
- all source (–) terminals are connected together

Output Point Wiring



High-Speed I/O Wiring Methods

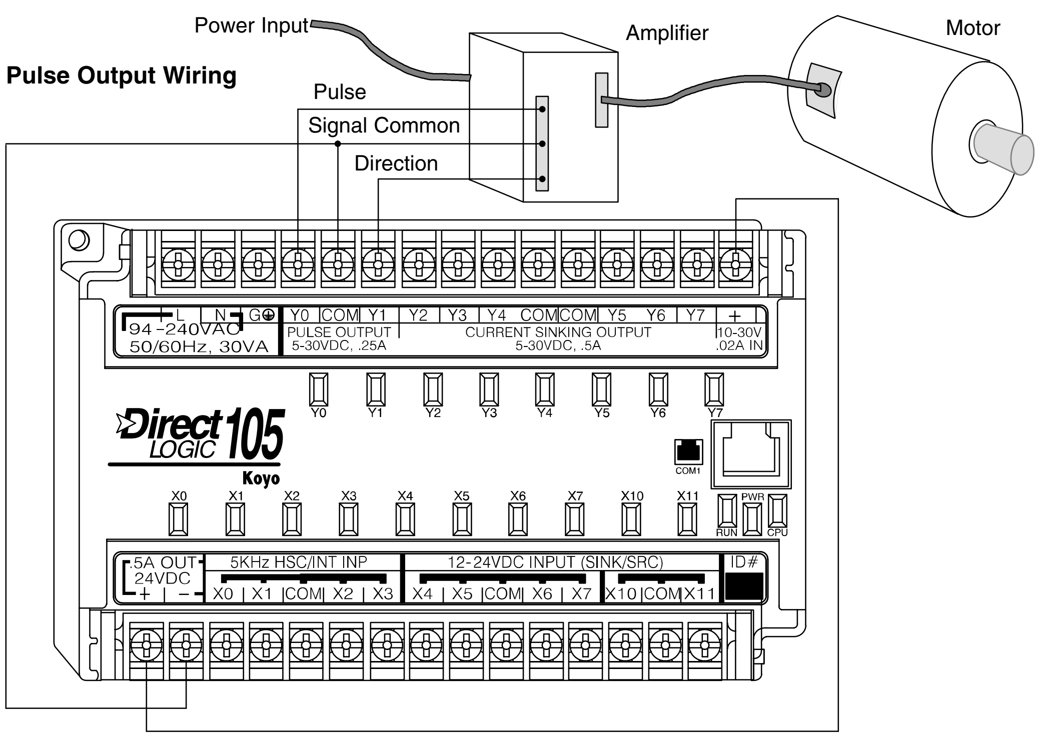
DL105 versions with DC type input or output points contain a dedicated High-Speed I/O circuit (HSIO). The circuit configuration is programmable, and it processes select I/O points independently from the CPU scan. Chapter 4 discusses the programming options for HSIO. While the HSIO circuit has six modes, we show wiring diagrams for two of the most popular modes in this chapter. The high-speed input interfaces to points X0 – X3. Properly configured, the DL105 can count quadrature pulses at up to 5 kHz from an incremental encoder as shown below.



Encoder Input Wiring

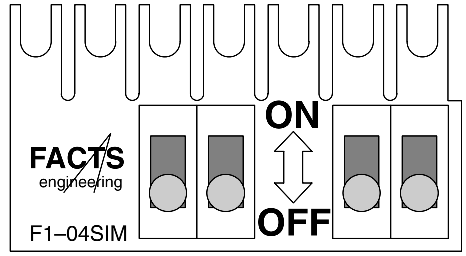
DL105 versions with DC type output points can use the High Speed I/O Pulse Output feature. It can generate high-speed pulses for specialized control such as stepper motor / intelligent drive systems. Outputs Y0 and Y1 can generate pulse and direction signals, or they can generate CCW and CW pulse signals respectively. See Chapter 3 on high-speed input and pulse output options.

Pulse Output Wiring



F1–04SIM Input Simulator Wiring

The F1–04SIM Input Simulator, shown to the right, provides four switches for inputs X0 through X3. The simulator is useful during program development or for debug purposes. It works by using the +24VDC auxiliary supply output, routing the voltage through the switches and into the inputs.



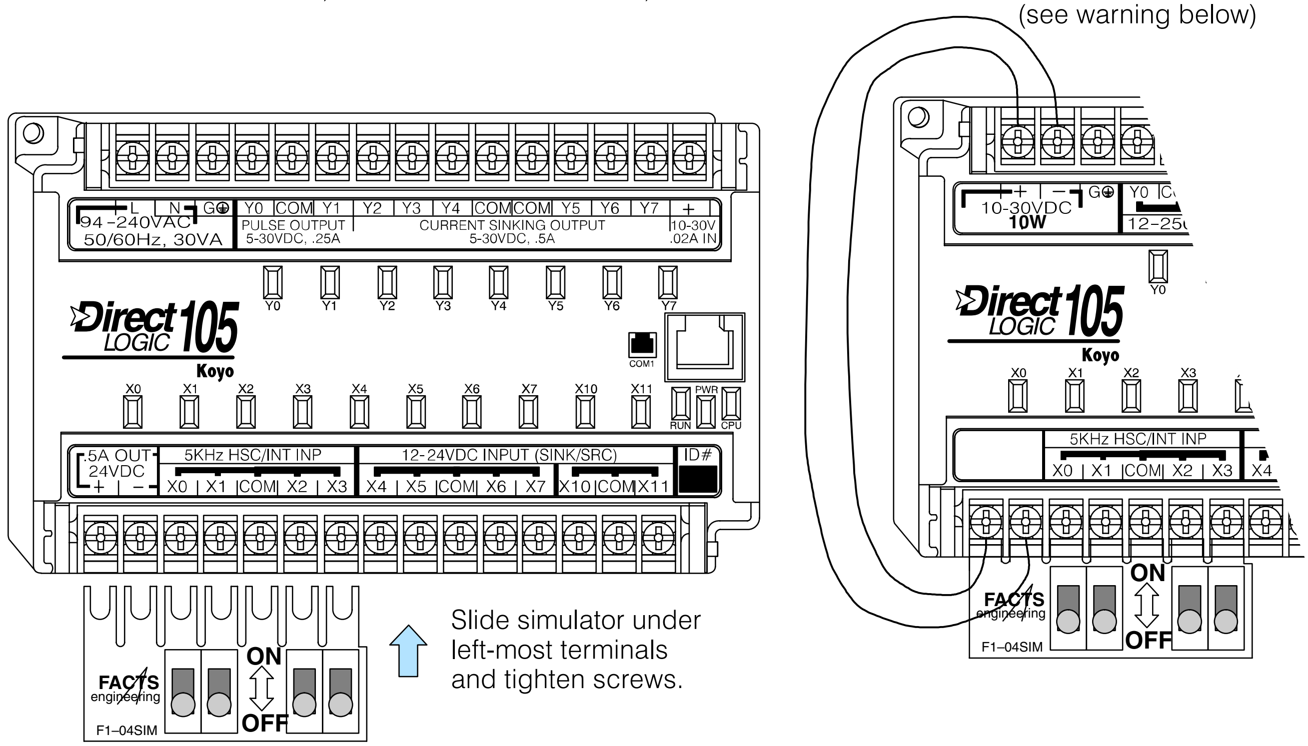
In use, the simulator can quickly provide test inputs to your ladder program. The status of outputs is observable on the front panel LEDs, even without wiring the outputs to any loads.

The Simulator works on all DC input versions of the DL105. DC-powered versions need two wires from the power input to connect to the two left-most terminals on the simulator (wiring shown below), since DC-powered units do not generate +24VDC auxiliary output. Polarity does not matter, since the inputs can be sinking or sourcing.

NOTE: The Input Simulator will not work on DL105 micros with AC type inputs. The +24 VDC auxiliary supply voltage is less than the required input threshold.

F1-130DR/F1-130DR-CE, F1-130DD/F1-130DD-CE, F1-130DA

F1-130DR-D, F1-130DD-D only
(see warning below)



NOTE: Never attempt to install more than one simulator on one DL105 PLC.

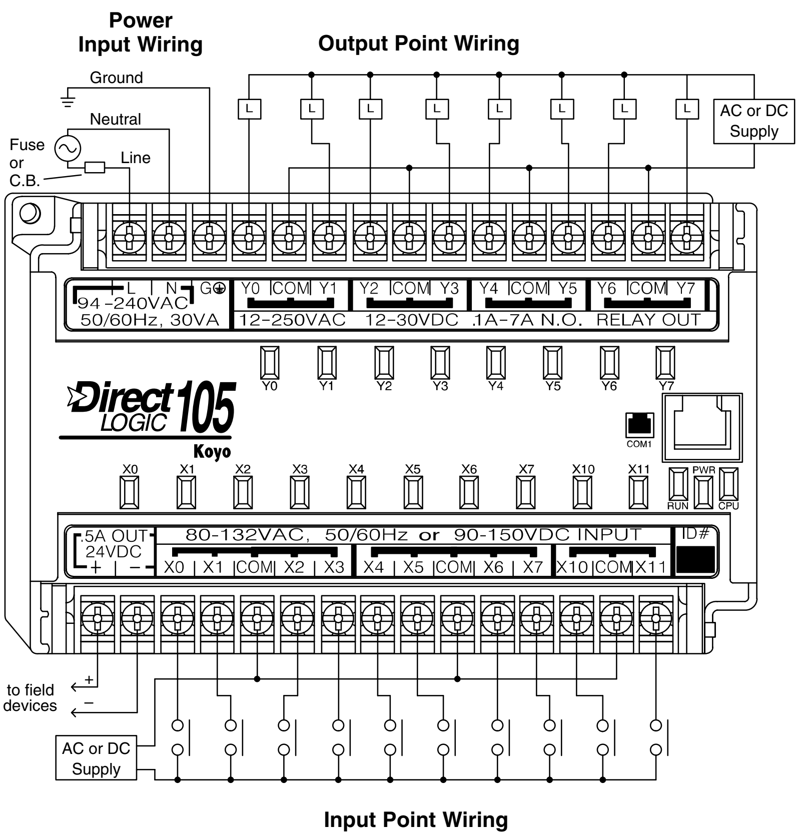
WARNING: DO NOT use the two wires as shown above on AC-powered DL105 PLCs. Doing so will permanently damage the Micro PLC and may result in electrical shock due to the exposed circuit board of the input simulator.

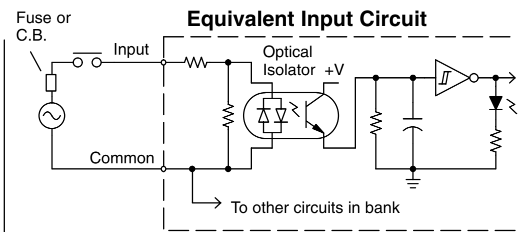
Wiring Diagrams and Specifications

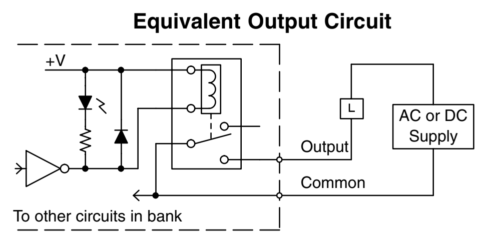
The remainder of this chapter dedicates two to three pages to each of the eight versions of DL105 Micro PLCs. Each section contains a basic wiring diagram, equivalent I/O circuits, and specification tables. Please refer to the section which describes the particular DL105 version used in your application.

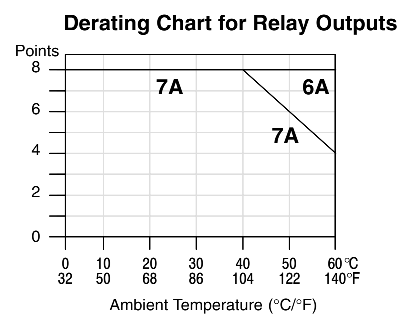
F1–130AR I/O Wiring Diagram

The F1–130AR Micro PLC features ten AC inputs and eight relay contact outputs. The following diagram shows a typical field wiring example. The AC external power connection uses three terminals at the top left as shown.









The ten AC input channels use terminals on the bottom connector. This input type also works for high-voltage DC signals. Inputs are organized into two banks of four, plus one bank of two. Each bank has a common terminal. In the case of DC input signals, the input may be wired in as either the sourcing or sinking type. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent input circuit shows one channel of a typical bank.

The eight relay output channels use terminals on the top connector. Outputs are organized into four banks of two normally-open relay contacts. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank. The relay contacts can switch AC or DC voltages.

Auxiliary +24V Power Supply

The F1–130AR has a +24V supply output to power external devices. The output is rated at 0.5 Amperes, and includes short-circuit protection and full isolation from internal CPU circuitry. These features make it ideal for powering sensors, solenoids, and other field devices. In fact, it can be used as the DC supply for loads in the relay output circuits. Be sure the combined load currents do not exceed 0.5 A. Note that on the F1–130AR, the +24V auxiliary output is not high enough to power its input circuits (input ON threshold is 90VDC).

F1–130AR General Specifications

External Power Requirements	100 – 240 +10% –15%
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Internal Field Supply Ratings	+24VDC , 0.5A maximum, isolated
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

AC Input Specifications X0 – X7, X10 – X11

Input Voltage Range for ON condition	80 – 132 VAC, or 90 – 150 VDC
Input Current	6 mA @ 132 VAC 6.8 mA @ 150 VDC
Maximum Voltage	132 VAC, or 150 VDC
ON Current/Voltage	>4 mA @ 80 VAC, or 90 VDC
OFF Current/Voltage	<2 mA @ 45 VAC, or 60 VDC
OFF to ON Response	< 8 mS
ON to OFF Response	<15 mS
Status Indicators	Logic Side
Commons	4 channels / common x 2 banks, 2 channels / common x 1 bank

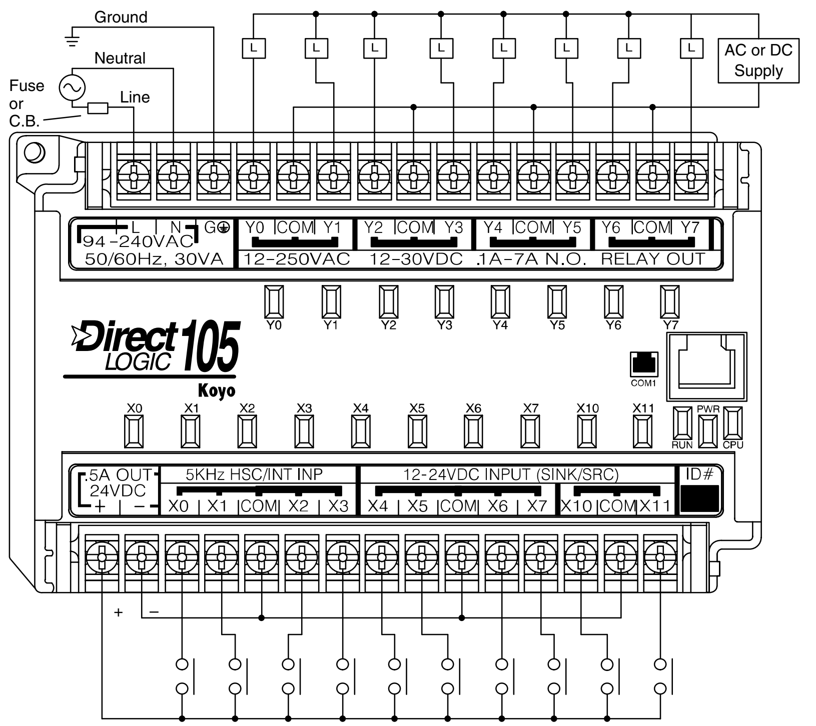
Relay Output Specifications Y0 – Y7

Operating Voltage	12 – 250 VAC, 12 – 30 VDC @ 7A, 30 – 150 VDC @ 0.5A, resistive
Output Current	7A / point (subject to derating) 14A / common
Maximum Motor Load	1/3 HP
Maximum Voltage	265 VAC, 150 VDC
Minimum Off Resistance	100 meg ohms @ 500 VDC
Smallest Recommended Load	10 mA
OFF to ON Response	15 mS
ON to OFF Response	5 mS
Status Indicators	Logic Side
Commons	2 channels / common x 4 banks
Fuses	None (external recommended)

F1–130DR/ F1–130DR–CE I/O Wiring Diagram

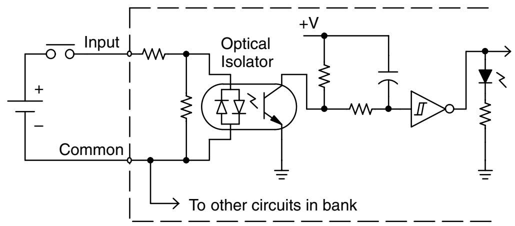
These micro PLCs feature ten DC inputs and eight relay contact outputs. The following diagram shows a typical field wiring example. The AC external power connection uses three terminals at the top left as shown.

Power Input Wiring **Output Point Wiring**

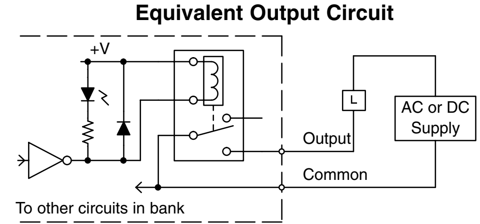


Input Point Wiring

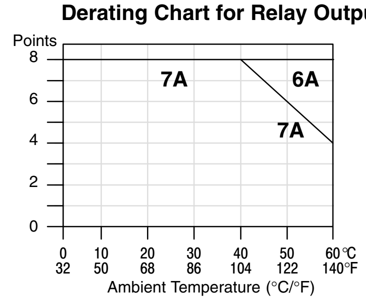
Equivalent Circuit, Standard Inputs (X4 – X11)



Equivalent Output Circuit

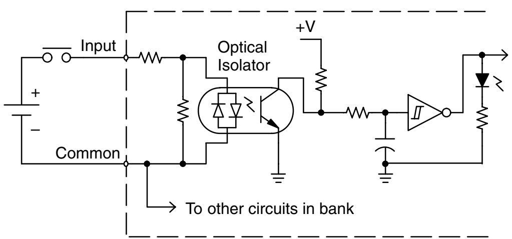


Derating Chart for Relay Outputs



The ten DC input channels use terminals on the bottom connector. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal, and may be wired as either sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs is shown above, and the high-speed input circuit is shown to the right.

Equivalent Circuit, High-Speed Inputs (X0 – X3)



The eight output channels use terminals on the top connector. Outputs are organized into four banks of two normally-open relay contacts. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank. The relay contacts can switch AC or DC voltages.

Auxiliary +24V Power Supply

These versions have a +24V supply output to power external devices. The output is rated at 0.5 Amperes, and includes short-circuit protection and full isolation from internal CPU circuitry. These features make it ideal for powering sensors, solenoids, and other field devices. In fact, it can be used as the DC supply for switches or sensors in the input circuit, or for loads in the relay output circuits. Be sure the combined load currents do not exceed 0.5 A.

F1–130DR/ F1–130DR–CE General Specifications

External Power Requirements	100 – 240 +10% –15%
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Internal Field Supply Ratings	+24VDC , 0.5A maximum, isolated
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

DC Input Specifications

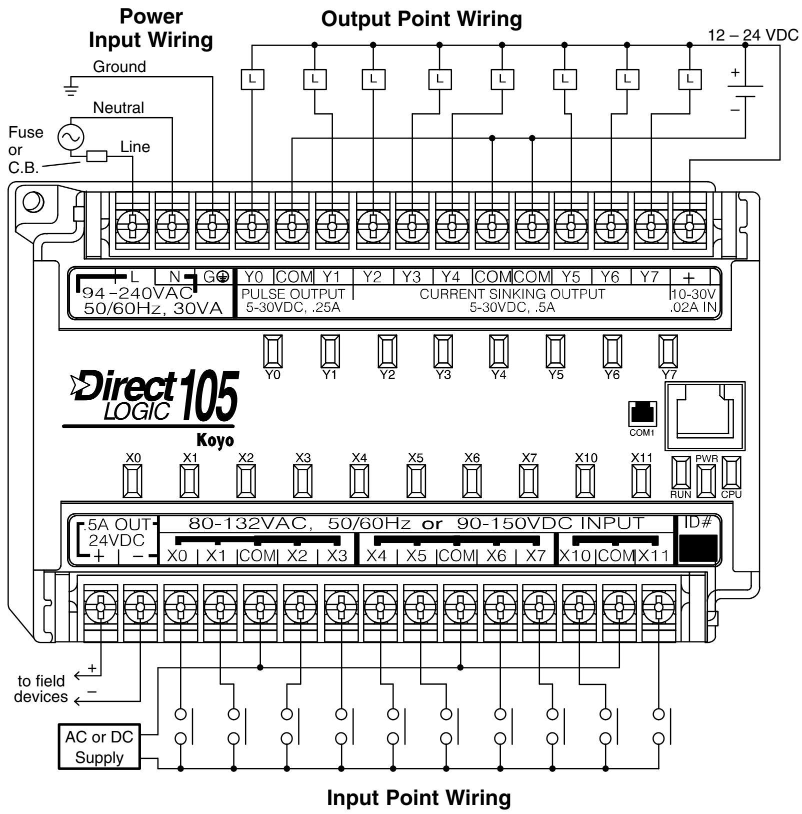
Parameter	High–Speed Inputs, X0 – X3	Standard DC Inputs X4 – X11
Input Voltage Range	10 – 26.4 VDC	10 – 26.4 VDC or 21.6 – 26.4 VAC
Maximum Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 μs	N/A
ON Voltage Level	> 9.0 VDC	> 9.0 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	2.8 kΩ @ 12 – 24 VDC	2.8 kΩ @ 12 – 24 VDC
Minimum ON Current	>3 mA	>3 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<50 μs	2 – 8 mS, 4 mS typical
ON to OFF Response	< 50 μs	2 – 8 mS, 4 mS typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 1 bank	4 channels / common x 1 bank, 2 channels / common x 1 bank

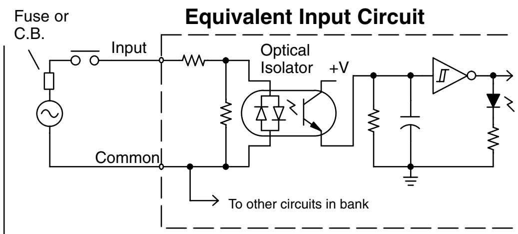
Relay Output Specifications

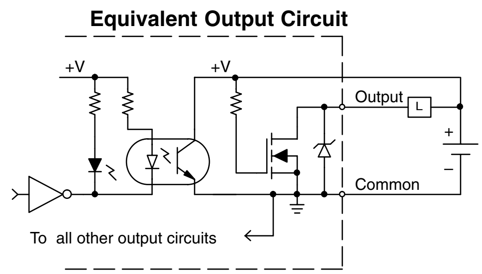
Operating Voltage	12 – 250 VAC, 12 – 30 VDC @ 7A, 30 – 150 VDC @ 0.5A, resistive
Output Current	7A / point (subject to derating) 14A / common
Maximum Motor Load	1/3 HP
Maximum Voltage	265 VAC, 30 VDC
Minimum Off Resistance	100 meg ohms @ 500 VDC
Smallest Recommended Load	10 mA
OFF to ON Response	15 mS
ON to OFF Response	5 mS
Status Indicators	Logic Side
Commons	2 channels / common x 4 banks
Fuses	None (external recommended)

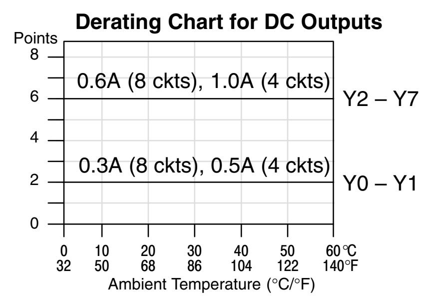
F1–130AD I/O Wiring Diagram

The F1–130AD Micro PLC features ten AC inputs and eight DC outputs. The following diagram shows a typical field wiring example. The AC external power connection uses three terminals at the top left as shown.









The ten AC input channels use terminals on the bottom connector. This input type also works for high-voltage DC signals. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal. In the case of DC input signals, the input may be wired in as either the sourcing or sinking type. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent input circuit shows one channel of a typical bank.

The eight current sinking DC output channels use terminals on the top connector. The three common terminals are internally connected, meaning all outputs actually share the same electrical common. The wiring example above shows all commons connected together, because it is best to share the common current among the three terminal connections. Note the requirement for external power on the end (right-most) terminal. The equivalent output circuit shows one channel of the bank of eight.

Auxiliary +24V Power Supply

The F1–130AD has a +24V supply output to power external devices. The output is rated at 0.5 Amperes, and includes short-circuit protection and full isolation from internal CPU circuitry. These features make it ideal for powering sensors, solenoids, and other field devices. In fact, it can be used as the supply for loads in the DC output circuits. Since the outputs are the sinking type, you'll need to connect +24V to the output commons. Be sure the combined load currents do not exceed 0.5 A. Note that on the F1–130AD, the +24V auxiliary output is not high enough to power its input circuits (input ON threshold is 90VDC).

F1–130AD General Specifications

External Power Requirements	100 – 240 + 10% –15%
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Internal Field Supply Ratings	+24VDC , 0.5A maximum, isolated
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

AC Input Specifications

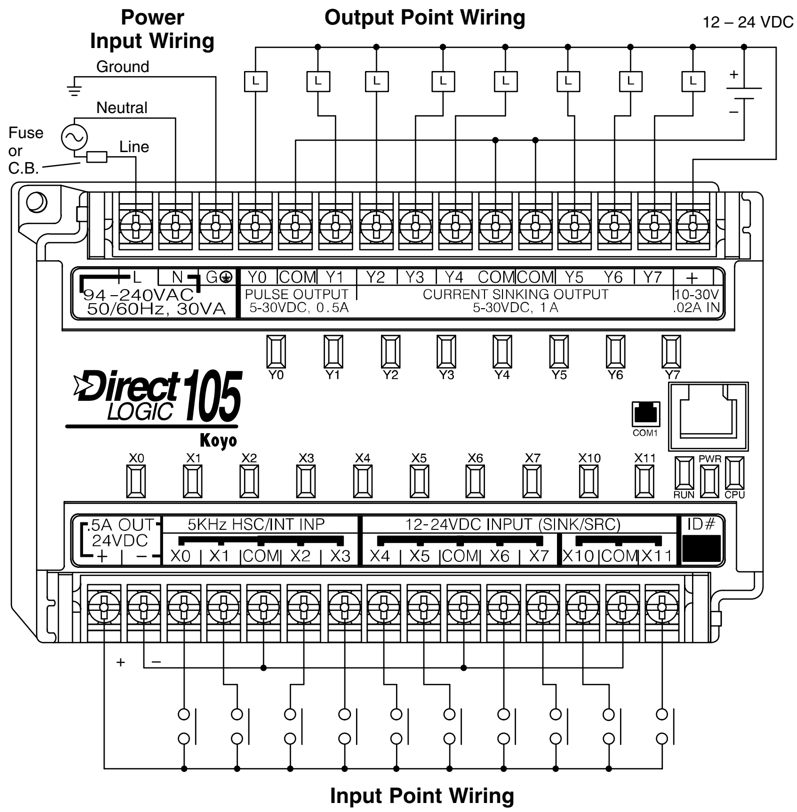
Input Voltage Range for ON condition	80 – 132 VAC, or 90 – 150 VDC
Input Current	6 mA @ 132 VAC 6.8 mA @ 150 VDC
Maximum Voltage	132 VAC, or 150 VDC
ON Current/Voltage	>4 mA @ 80 VAC, or 90 VDC
OFF Current/Voltage	<2 mA @ 45 VAC, or 60 VDC
OFF to ON Response	< 8 mS
ON to OFF Response	<15 mS
Status Indicators	Logic Side
Commons	4 channels / common x 2 banks, 2 channels / common x 1 bank

DC Output Specifications

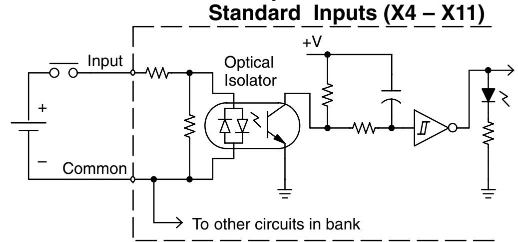
Parameter	Pulse Outputs, Y0 – Y1	Standard Outputs, Y2 – Y7
Operating Voltage	5 – 30 VDC	5 – 30 VDC
Peak Voltage	60 VDC (7 kHz maximum frequency)	60 VDC
On Voltage Drop	0.4 VDC @ 0.25A	0.4 VDC @ 0.5A
Max Current (resistive)	0.5 A / point (subject to derating)	1.0 A / point (subject to derating)
Max leakage current	15 μA @ 30 VDC	15 μA @ 30 VDC
Max inrush current	1.5 A for 10 mS, 0.5 A for 100 mS	3 A for 10 mS, 1 A for 100 mS
Extenal DC power required	10 – 30 VDC @30 mA, plus load current	10 – 30 VDC @30 mA, plus load current
OFF to ON Response	<10 μS	3.5 μS
ON to OFF Response	<70 μS	110 μS
Status Indicators	Logic Side	Logic Side
Commons	Internally connected	Internally connected
Fuses	None	None

F1–130DD/ F1–130DD–CE I/O Wiring Diagram

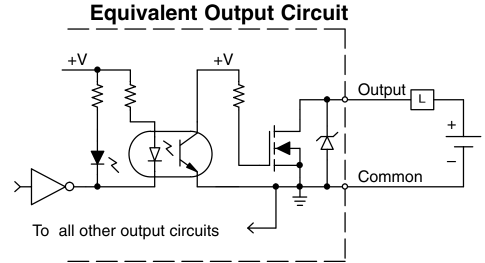
These micro PLCs feature ten DC inputs and eight DC outputs. The following diagram shows a typical field wiring example. The AC external power connection uses three terminals at the top left as shown.



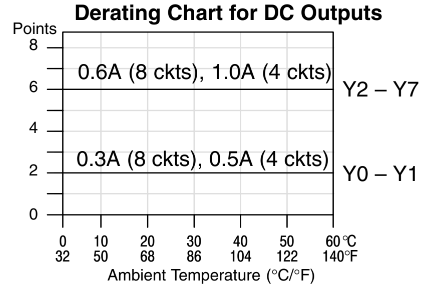
Equivalent Circuit, Standard Inputs (X4 – X11)



Equivalent Output Circuit

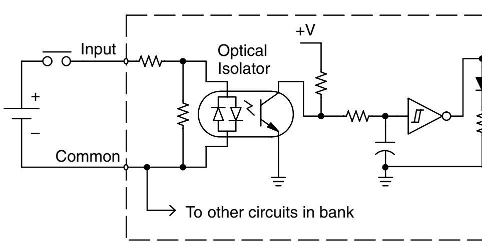


Derating Chart for DC Outputs



The ten DC input channels use terminals on the bottom connector. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal, and may be wired as either sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs is shown above, and the high-speed input circuit is shown to the right.

Equivalent Circuit, High-Speed Inputs (X0 – X3)



The eight current sinking DC output channels use terminals on the top connector. Outputs are organized as one bank of sinking outputs. The three common terminals are internally connected, so all outputs actually share the same electrical common. The wiring example above shows all commons connected together, because it is best to share the common current among the three terminal connections. The equivalent output circuit shows one channel of the bank of eight.

Auxiliary +24V Power Supply

These versions have a +24V supply output to power external devices. The output is rated at 0.5 Amperes, and includes short-circuit protection and full isolation from internal circuitry. These features make it ideal for powering sensors, solenoids, and other field devices. In fact, it can be used as the DC supply for switches or sensors in the input circuit, or for loads in the DC output circuits (up to 0.5 A).

F1–130DD/ F130–DD–CE General Specifications

External Power Requirements	100 – 240 +10% –15%
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Internal Field Supply Ratings	+24VDC , 0.5A maximum, isolated
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

DC Input Specifications

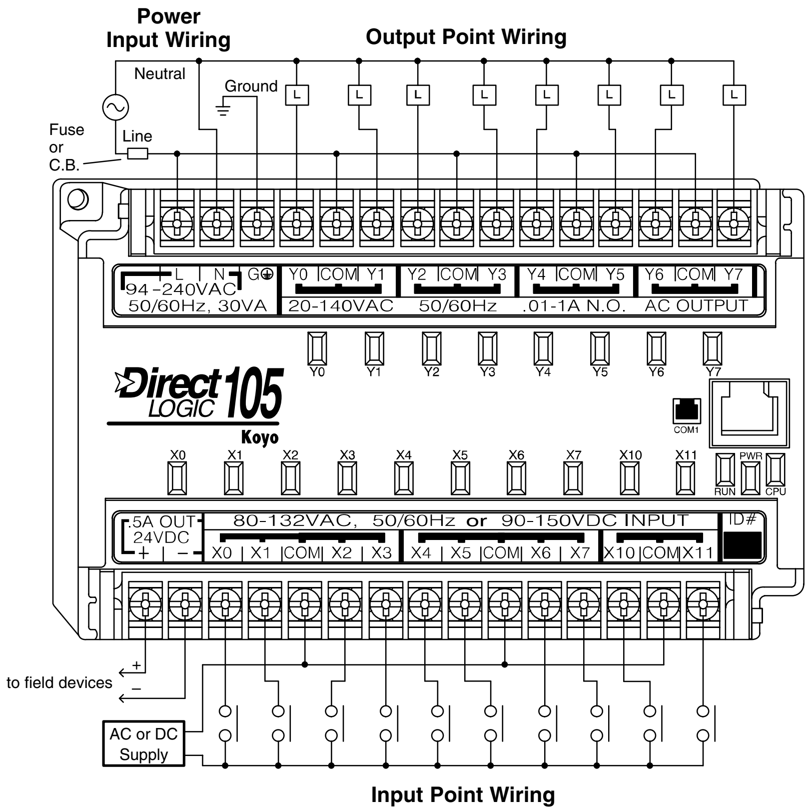
Parameter	High–Speed Inputs, X0 – X3	Standard DC Inputs X4 – X11
Input Voltage Range	10 – 26.4 VDC	10 – 26.4 VDC or 21.6 – 26.4 VAC
Maximum Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 μs	N/A
ON Voltage Level	> 9.0 VDC	> 9.0 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	2.8 kΩ @ 12 – 24 VDC	2.8 kΩ @ 12 – 24 VDC
Minimum ON Current	>3 mA	>3 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<50 μS	2 – 8 mS, 4 mS typical
ON to OFF Response	< 50 μS	2 – 8 mS, 4 mS typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 1 bank	4 channels / common x 1 bank, 2 channels / common x 1 bank

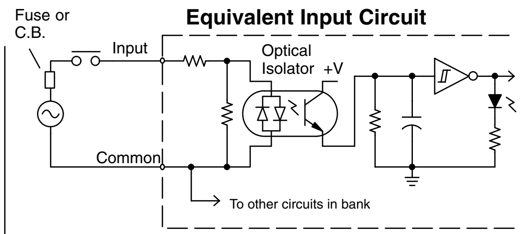
DC Output Specifications

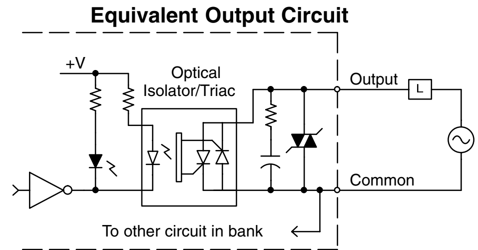
Parameter	Pulse Outputs, Y0 – Y1	Standard Outputs, Y2 – Y7
Operating Voltage	5 – 30 VDC	5 – 30 VDC
Peak Voltage	60 VDC (7 kHz maximum frequency)	60 VDC
On Voltage Drop	0.4 VDC @ 0.25A	0.4 VDC @ 0.5A
Max Current (resistive)	0.5 A / point (subject to derating)	1.0 A / point (subject to derating)
Max leakage current	15 μA @ 30 VDC	15 μA @ 30 VDC
Max inrush current	1.5 A for 10 mS, 0.5 A for 100 mS	3 A for 10 mS, 1 A for 100 mS
External DC power required	10 – 30 VDC @30 mA, plus load current	10 – 30 VDC @30 mA, plus load current
OFF to ON Response	<10 μs	3.5 μs
ON to OFF Response	<70 μs	110 μs
Status Indicators	Logic Side	Logic Side
Commons	Internally connected	Internally connected
Fuses	None	None

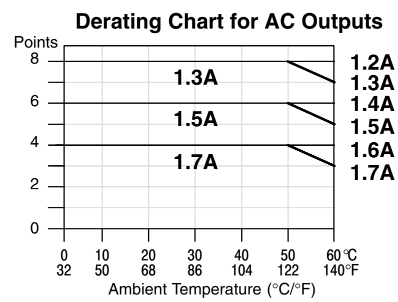
F1–130AA I/O Wiring Diagram

The F1–130AA Micro PLC features ten AC inputs and eight AC outputs. The following diagram shows a typical field wiring example. The AC external power connection uses three terminals at the top left as shown.









The ten AC input channels use terminals on the bottom connector. This input type also works for high-voltage DC signals. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal. In the case of DC input signals, the input may be wired in as either the sourcing or sinking type. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent input circuit shows one channel of a typical bank.

The eight output channels use terminals on the top connector. Outputs are organized into four banks of two triac switches. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank.

Auxiliary +24V Power Supply

The F1–130AA has a +24V supply output to power external devices. The output is rated at 0.5 Amperes, and includes short-circuit protection and full isolation from internal CPU circuitry. These features make it ideal for powering sensors, solenoids, and other field devices. Note that on the F1–130AA, the +24V auxiliary output cannot directly power its input and output circuits(input ON threshold is 90VDC, outputs require AC only).

F1–130AA General Specifications

External Power Requirements	100 – 240 +10% –15%
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Internal Field Supply Ratings	+24VDC , 0.5A maximum, isolated
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

AC Input Specifications

Input Voltage Range for ON condition	80 – 132 VAC, or 90 – 150 VDC
Input Current	6 mA @ 132 VAC 6.8 mA @ 150 VDC
Maximum Voltage	132 VAC, or 150 VDC
ON Current/Voltage	>4 mA @ 80 VAC, or 90 VDC
OFF Current/Voltage	<2 mA @ 45 VAC, or 60 VDC
OFF to ON Response	< 8 mS
ON to OFF Response	<15 mS
Status Indicators	Logic Side
Commons	4 channels / common x 2 banks, 2 channels / common x 1 bank

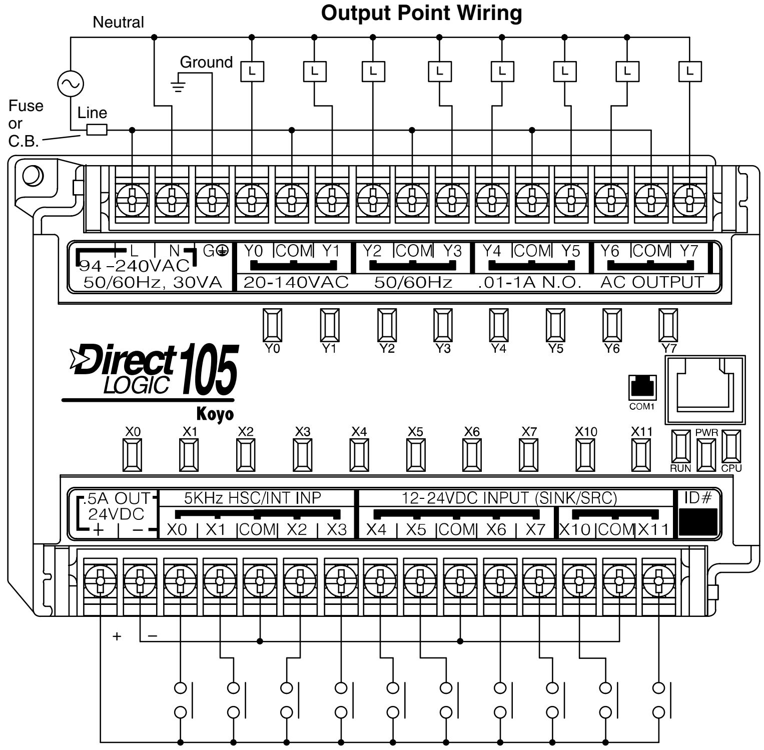
AC Output Specifications

Operating Voltage	20 – 140 VAC, 47 – 63 Hz
Peak Voltage	400 VAC
On Voltage Drop	1.3 VAC @ 2 A
Max Current	1.7 A / point, subject to derating
Max leakage current	1 mA @ 400 VAC
Max inrush current	30 A for 10 mS, 15 A for 100 mS
Minimum Load	10 mA
OFF to ON Response	8.33 mS @ 60 Hz, zero-crossing, 10 mS @ 50 Hz, zero-crossing
ON to OFF Response	8.33 mS @ 60 Hz, zero-crossing, 10 mS @ 50 Hz, zero-crossing
Status Indicators	Logic Side
Commons	2 channels / common x 4 banks
Fuses	None (external recommended)

F1–130DA I/O Wiring Diagram

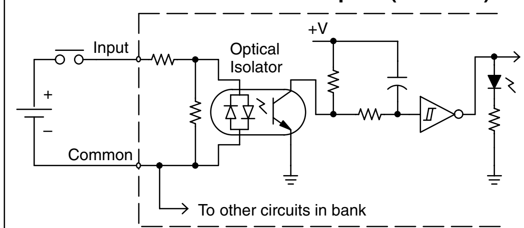
The F1–130DA Micro PLC features ten DC inputs and eight AC outputs. The following diagram shows a typical field wiring example. The AC external power connection uses three terminals at the top left as shown.

Output Point Wiring

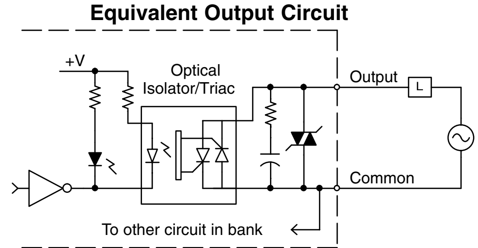


Input Point Wiring

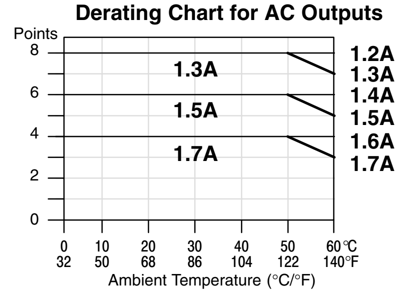
Equivalent Circuit, Standard Inputs (X4 – X11)



Equivalent Output Circuit

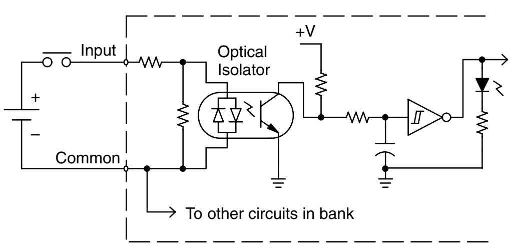


Derating Chart for AC Outputs



The ten DC input channels use terminals on the bottom connector. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal, and may be wired as sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs is shown above, and the high-speed input circuit is shown to the right.

Equivalent Circuit, High-Speed Inputs (X0 – X3)



The eight output channels use terminals on the top connector. Outputs are organized into four banks of two triac switches. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank.

Auxiliary +24V Power Supply

The F1–130DA has a +24V supply output to power external devices. The output is rated at 0.5 Amperes, and includes short-circuit protection and full isolation from internal CPU circuitry. These features make it ideal for powering sensors, solenoids, and other field devices. In fact, it can be used as the DC supply for switches or sensors in the input circuit. Note that on the F1–130DA, the +24V output cannot power its output circuits, because they require AC voltages.

F1–130DA General Specifications

External Power Requirements	100 – 240 +10% –15%
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Internal Field Supply Ratings	+24VDC , 0.5A maximum, isolated
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

DC Input Specifications

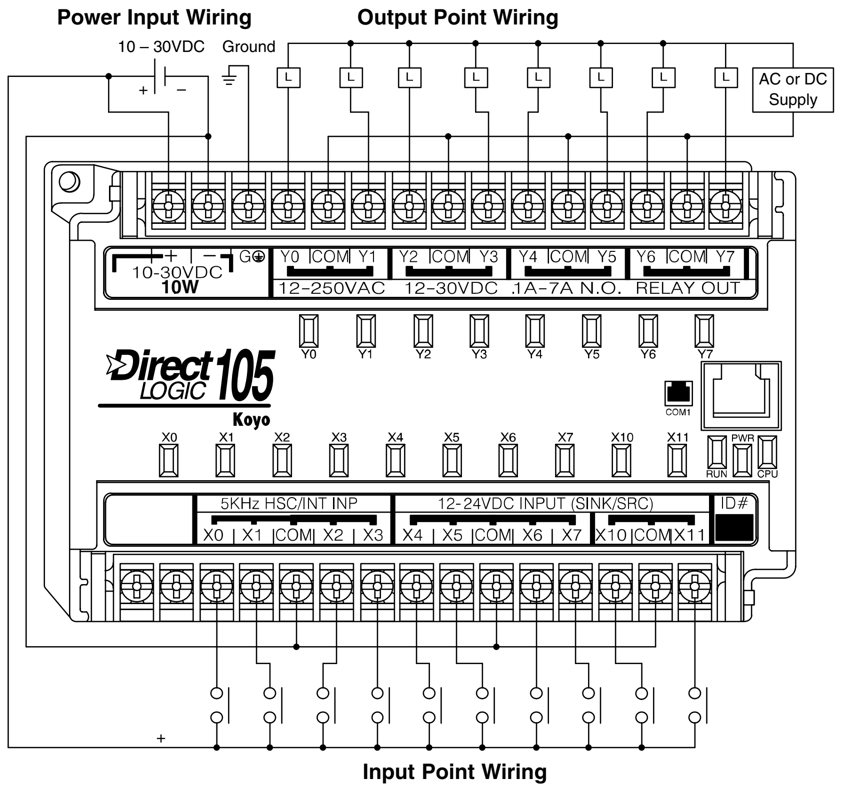
Parameter	High–Speed Inputs, X0 – X3	Standard DC Inputs X4 – X11
Input Voltage Range	10 – 26.4 VDC	10 – 26.4 VDC or 21.6 – 26.4 VAC
Maximum Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 μS	N/A
ON Voltage Level	> 9.0 VDC	> 9.0 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	2.8 kΩ @ 12 – 24 VDC	2.8 kΩ @ 12 – 24 VDC
Minimum ON Current	>3 mA	>3 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<50 μS	2 – 8 mS, 4 mS typical
ON to OFF Response	< 50 μS	2 – 8 mS, 4 mS typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 1 bank	4 channels / common x 1 bank, 2 channels / common x 1 bank

AC Output Specifications

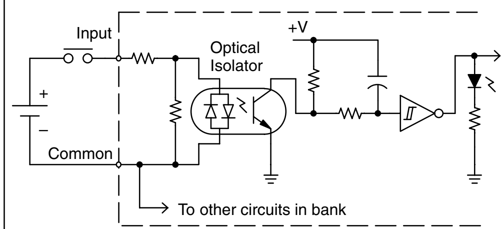
Operating Voltage	20 – 140 VAC, 47 – 63 Hz
Peak Voltage	400 VAC
On Voltage Drop	1.3 VAC @ 2 A
Max Current	1.7 A / point, subject to derating
Max leakage current	1 mA @ 400 VAC
Max inrush current	30 A for 10 mS, 15 A for 100 mS
Minimum Load	10 mA
OFF to ON Response	8.33 mS @ 60 Hz, zero-crossing, 10 mS @ 50 Hz, zero-crossing
ON to OFF Response	8.33 mS @ 60 Hz, zero-crossing, 10 mS @ 50 Hz, zero-crossing
Status Indicators	Logic Side
Commons	2 channels / common x 4 banks
Fuses	None (external recommended)

F1–130DR–D I/O Wiring Diagram

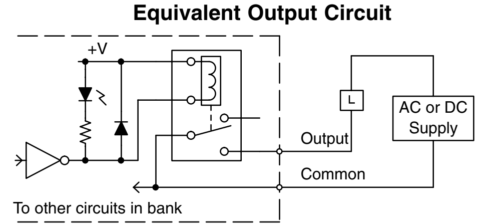
The F1–130DR–D Micro PLC features ten DC inputs and eight relay outputs. The following diagram shows a typical field wiring example. The DC external power connection uses three terminals at the top left as shown.



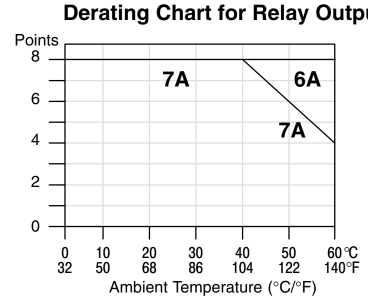
Equivalent Circuit, Standard Inputs (X4 – X11)



Equivalent Output Circuit

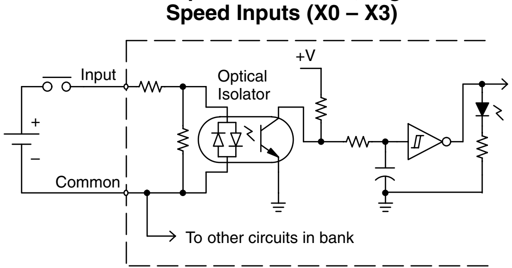


Derating Chart for Relay Outputs



The ten DC input channels use terminals on the bottom connector. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal, and may be wired as sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs is shown above, and the high-speed input circuit is shown to the right.

Equivalent Circuit, High-Speed Inputs (X0 – X3)



The eight output channels use terminals on the top connector. Outputs are organized into four banks of two normally-open relay contacts. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank. The relay contacts can switch AC or DC voltages.

No Auxiliary +24V Power Supply

The F1–130DR–D does not include a +24V output, as do most other DL105 PLCs. Since this unit requires +24V as the main supply input, it it usually most economical to use the same supply to power suitable field devices. In the wiring diagram above, the external power source for the unit also powers the input circuitry. The same external supply can power both input and output circuits, because they are both isolated from the internal logic circuitry.

F1–130DR–D General Specifications

External Power Requirements	10–30VDC, 1.5A
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

DC Input Specifications

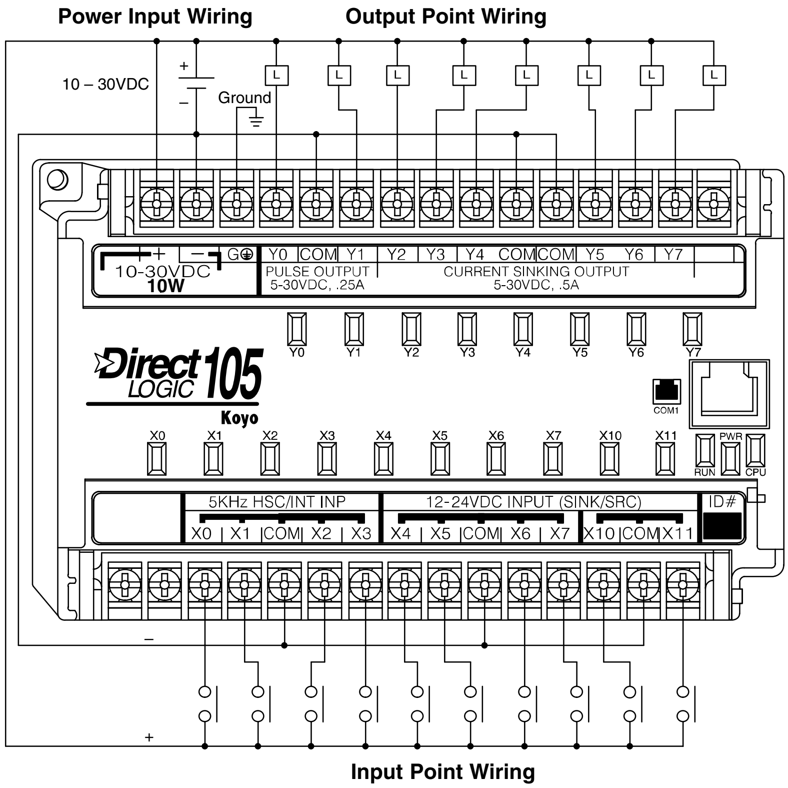
Parameter	High–Speed Inputs, X0 – X3	Standard DC Inputs X4 – X11
Input Voltage Range	10 – 26.4 VDC	10 – 26.4 VDC or 21.6 – 26.4 VAC
Maximum Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 μs	N/A
ON Voltage Level	> 9.0 VDC	> 9.0 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	2.8 kΩ @ 12 – 24 VDC	2.8 kΩ @ 12 – 24 VDC
Minimum ON Current	>3 mA	>3 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<50 μS	2 – 8 mS, 4 mS typical
ON to OFF Response	< 50 μS	2 – 8 mS, 4 mS typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 1 bank	4 channels / common x 1 bank, 2 channels / common x 1 bank

Relay Output Specifications

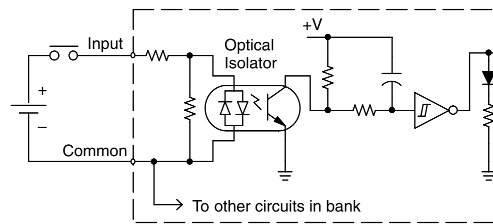
Operating Voltage	12 – 250 VAC, 12 – 30 VDC @ 7A, 30 – 150 VDC @ 0.5A, resistive
Output Current	7A / point (subject to derating) 14A / common
Maximum Motor Load	1/3 HP
Maximum Voltage	265 VAC, 150 VDC
Minimum Off Resistance	100 meg ohms @ 500 VDC
Smallest Recommended Load	10 mA
OFF to ON Response	15 ms
ON to OFF Response	5 ms
Status Indicators	Logic Side
Commons	2 channels / common x 4 banks
Fuses	None (external recommended)

F1–130DD–D I/O Wiring Diagram

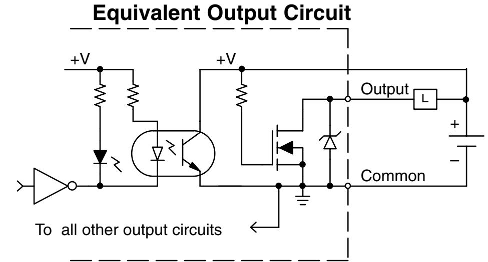
The F1–130DD–D Micro PLC features ten DC inputs and eight DC outputs. The following diagram shows a typical field wiring example. The DC external power connection uses three terminals at the top left as shown.



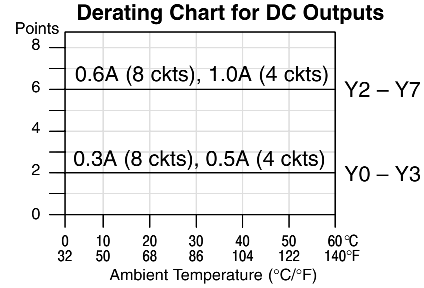
Equivalent Circuit, Standard Inputs (X4 – X11)



Equivalent Output Circuit

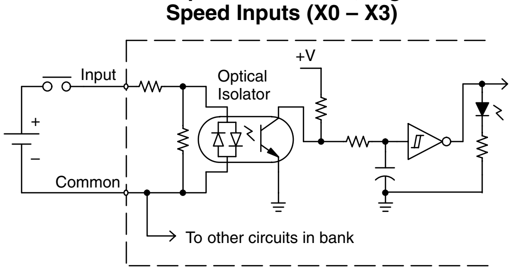


Derating Chart for DC Outputs



The ten DC input channels use terminals on the bottom connector. Inputs are organized into two banks of four, plus one bank of two. Each bank has an isolated common terminal, and can be wired as either sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs is shown above, and the high-speed input circuit is shown to the right.

Equivalent Circuit, High-Speed Inputs (X0 – X3)



The eight current-sinking DC output channels use terminals on the top connector. Outputs are organized as one bank of eight. The three common terminals are internally connected, meaning all outputs actually share the same electrical common. The wiring example above shows all commons connected together, because it is best to share the common current among the three terminal connections. The equivalent output circuit shows one channel of the bank of eight.

No Auxiliary +24V Power Supply

The F1–130DR–D does not include a +24V output, as do most other DL105 PLCs. Since this unit requires +24V as the main supply input, it it usually most economical to use the same supply to power suitable field devices. In the wiring diagram above, the external power source for the unit also powers the input and output circuitry. The same external supply can power both input and output circuits, because they are both isolated from the internal logic circuitry.

F1–130DD–D General Specifications

External Power Requirements	10–30VDC, 1.5A
Communication Port	K–Sequence, 9600 baud, 8 data bits, odd parity
Programming cable type	D2–DSCBL
Operating Temperature	32 to 140° F (0 to 60° C)
Storage Temperature	–4 to 158° F (–20 to 70° C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One AWG14 or two AWG16, AWG24 minimum

DC Input Specifications

Parameter	High–Speed Inputs, X0 – X3	Standard DC Inputs X4 – X11
Input Voltage Range	10 – 26.4 VDC	10 – 26.4 VDC or 21.6 – 26.4 VAC
Maximum Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 μs	N/A
ON Voltage Level	> 9.0 VDC	> 9.0 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	2.8 kΩ @ 12 – 24 VDC	2.8 kΩ @ 12 – 24 VDC
Minimum ON Current	>3 mA	>3 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<50 μS	2 – 8 mS, 4 mS typical
ON to OFF Response	< 50 μS	2 – 8 mS, 4 mS typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 1 bank	4 channels / common x 1 bank, 2 channels / common x 1 bank

DC Output Specifications

Parameter	Pulse Outputs, Y0 – Y1	Standard Outputs, Y2 – Y7
Operating Voltage	5 – 30 VDC	5 – 30 VDC
Peak Voltage	60 VDC (7 kHz maximum frequency)	60 VDC
On Voltage Drop	0.4 VDC @ 0.25A	0.4 VDC @ 0.5A
Max Current (resistive)	0.5 A / point (subject to derating)	1.0 A / point (subject to derating)
Max leakage current	15 μA @ 30 VDC	15 μA @ 30 VDC
Max inrush current	1.5 A for 10 mS, 0.5 A for 100 mS	3 A for 10 mS, 1 A for 100 mS
Extenal DC power required	10 – 30 VDC @30 mA, plus load current	10 – 30 VDC @30 mA, plus load current
OFF to ON Response	<10 μs	3.5 μs
ON to OFF Response	<70 μs	110 μs
Status Indicators	Logic Side	Logic Side
Commons	Internally connected	Internally connected
Fuses	None	None

Glossary of Specification Terms

Discrete Input One of ten input connections to the PLC which converts an electrical signal from a field device to a binary status (off or on), which is read by the internal CPU each PLC scan.

Discrete Output One of eight output connections from the PLC which converts an internal ladder program result (0 or 1) to turn On or Off an output switching device. This enables the program to turn on and off large field loads.

I/O Common A connection in the input or output terminals which is shared by multiple I/O circuits. It usually is in the return path to the power supply of the I/O circuit.

Input Voltage Range The operating voltage range of the input circuit.

Maximum Voltage Maximum voltage allowed for the input circuit.

ON Voltage Level The minimum voltage level at which the input point will turn ON.

OFF Voltage Level The maximum voltage level at which the input point will turn OFF

Input Impedance Input impedance can be used to calculate input current for a particular operating voltage.

Input Current Typical operating current for an active (ON) input.

Minimum ON Current The minimum current for the input circuit to operate reliably in the ON state.

Maximum OFF Current The maximum current for the input circuit to operate reliably in the OFF state.

OFF to ON Response The time the module requires to process an OFF to ON state transition.

ON to OFF Response The time the module requires to process an ON to OFF state transition.

Terminal Type Indicates whether the terminal type is a removable or non-removable connector or a fixed terminal.

Status Indicators The LEDs that indicate the ON/OFF status of an input or output point. All LEDs on DL105 Micro PLCs are electrically located on the logic side of the input or output circuit.

3

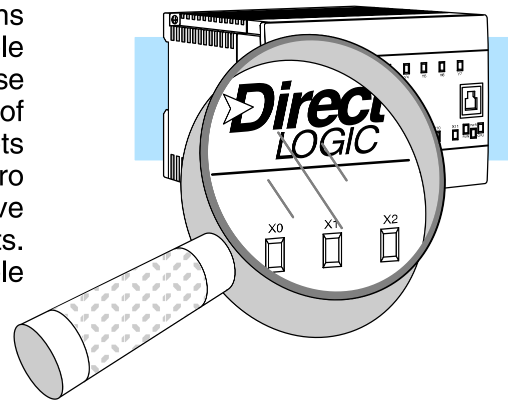
High-Speed Input and Pulse Output Features

In This Chapter. . . .

Introduction

Built-in Motion Control Solution

Many machine control applications require various types of simple high-speed monitoring and control. These applications usually involve some type of motion control, or high-speed interrupts for time-critical events. The DL105 Micro PLC solves this traditionally expensive problem with built-in CPU enhancements. Let's take a closer look at the available high-speed I/O features.



The available **high-speed input features** are:

- High Speed Counter (5 kHz max.) with up to 24 counter presets and built-in interrupt subroutine, counts up only, with reset
- Quadrature encoder inputs to measure counts and clockwise or counter clockwise direction (5 kHz max.), counts up or down, with reset
- High-speed interrupt input for immediate response to critical or time-sensitive tasks
- Pulse catch feature to monitor one input point, having a pulse width as small as 100μS (0.1ms)
- Programmable discrete filtering (both on and off delay up to 99ms) to ensure input signal integrity (this is the default mode for inputs X0–X3)

The available **pulse output features** are:

- Single-axis programmable pulse output (7 kHz max.) with three profile types, including trapezoidal moves, registration, and velocity control

Availability of HSIO Features

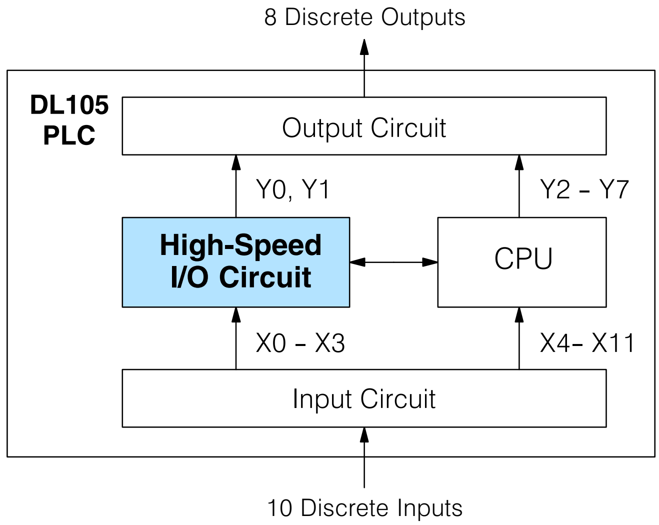
IMPORTANT: Please note the following restrictions on availability of features:

- High-speed input options are available only on DL105s with DC inputs.
- Pulse output options are available only on DL105s with DC outputs.
- Only one HSIO feature may be in use at one time. You cannot use a high–speed input feature and the pulse output at the same time.

DL105 Part Number	Discrete Input Type	Discrete Output Type	High-Speed Input	Pulse Output
F1–130AR	AC	Relay	No	No
F1–130DR	**DC**	Relay	**Yes**	No
F1–130AD	AC	**DC**	No	**Yes**
F1–130DD	**DC**	**DC**	**Yes**	**Yes**
F1–130AA	AC	AC	No	No
F1–130DA	**DC**	AC	**Yes**	No
F1–130DR–D	**DC**	Relay	**Yes**	No
F1–130DD–D	**DC**	**DC**	**Yes**	**Yes**

Dedicated High-Speed I/O Circuit

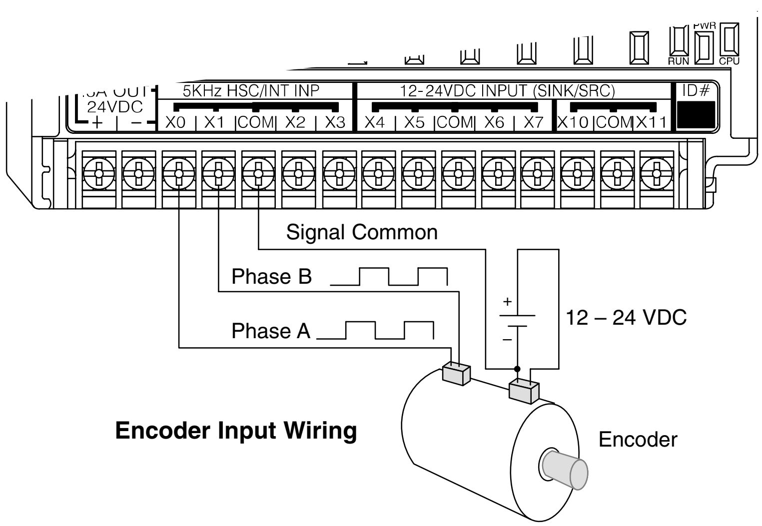
The internal CPU's main task is to execute the ladder program and read/write all I/O points during each scan. In order to service high-speed I/O events, the DL105 includes a special circuit which is dedicated to a portion of the I/O points. Refer to the DL105 block diagram in the figure below.



The high-speed I/O circuit (HSIO) is dedicated to the first four inputs (X0 – X3) and the first two outputs (Y0 – Y1). We might think of this as a "CPU helper". In the default operation (called "Mode 60") the HSIO circuit just passes through the I/O signals to or from the CPU, so that all ten inputs behave equally and all eight outputs behave equally. When the CPU is configured in any other HSIO Mode, the HSIO circuit imposes a specialized function on the portion of inputs and outputs shown. The HSIO circuit *operates independently of the CPU program scan*. This provides accurate measurement and capturing of high-speed I/O activity while the CPU is busy with ladder program execution.

Wiring Diagrams for Each HSIO Mode

After choosing the appropriate HSIO mode for your application, you'll need to refer to the section in this chapter for that specific mode. Each section includes wiring diagram(s) to help you connect the High-Speed I/O points correctly to field devices. An example of the quadrature counter mode diagram is shown below.



Choosing the HSIO Operating Mode

Understanding the Six Modes

The High-Speed I/O circuit operates in one of 6 basic modes as listed in the table below. The number in the left column is the mode number (later, we'll use these numbers to configure the PLC). Choose one of the following modes according to the primary function you want from the dedicated High-Speed I/O circuit. You can simply use all ten inputs and eight outputs as regular I/O points with Mode 60.

Mode Number	Mode Name	Mode Features
10	High-Speed Counter	5 kHz counter with 24 presets and reset input, counts up only, causes interrupt on preset
20	Quadrature Counter	Channel A / Channel B 5 kHz quadrature input, counts up and down
30	Pulse Output	Stepper control – pulse and direction signals, programmable motion profile
40	High-Speed Interrupt	Generates an interrupt based on input transition or time
50	Pulse Catch	Captures narrow pulses on a selected input
60	Discrete/Filtered Input	Rejects narrow pulses on selected inputs

In choosing one of the six high-speed I/O modes, the I/O points listed in the table below operate only as the function listed. If an input point is not specifically used to support a particular mode, it usually operates as a filtered input by default. Similarly, output points operate normally unless Pulse Output mode is selected.

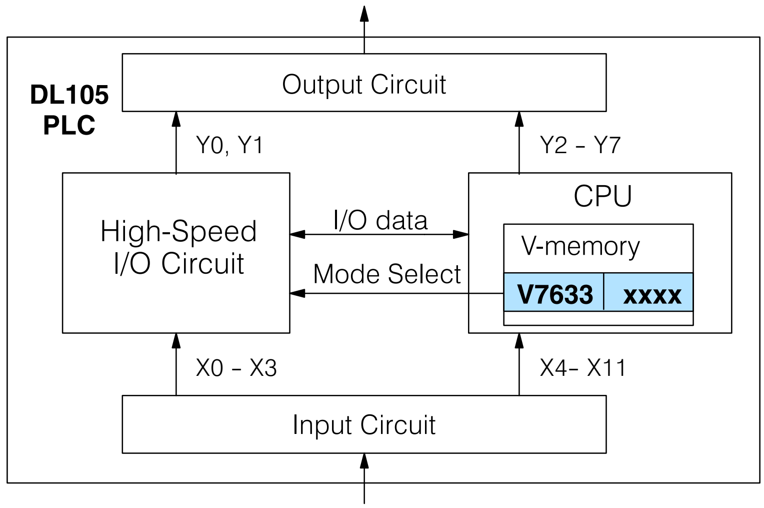
Physical I/O Point Usage						
	DC Input Points				DC Output Points	
Mode	**X0**	**X1**	**X2**	**X3**	**Y0**	**Y1**
High-Speed Counter	Counter clock	Filtered Input	Filtered Input or Reset Cnt	Filtered Input	Regular Output	Regular Output
Quadrature Counter	Phase A Input	Phase B Input	FIltered Input or Reset Cnt	Filtered Input	Regular Output	Regular Output
High-Speed Interrupt	Interrupt Input, or Filtered Input	Filtered Input	Filtered Input	Filtered Input	Regular Output	Regular Output
Pulse Catch	Pulse Input	Filtered Input	Filtered Input	Filtered Input	Regular Output	Regular Output
Pulse Output	Not available	Filtered Input	Filtered Input, or Interrupt to trigger pulse output	Filtered Input	Pulse or CW Pulse	Direction or CCW Pulse
Filtered Input	Filtered Input	Filtered Input	Filtered Input	Filtered Input	Regular Output	Regular Output

Default Mode

Mode 60 (Filtered Inputs) is the default mode. The DL105 is initialized to this mode at the factory, and any time you clear V-memory scratchpad. In the default condition, X0–X3 are filtered inputs (10 mS delay) and Y0–Y1 are standard outputs.

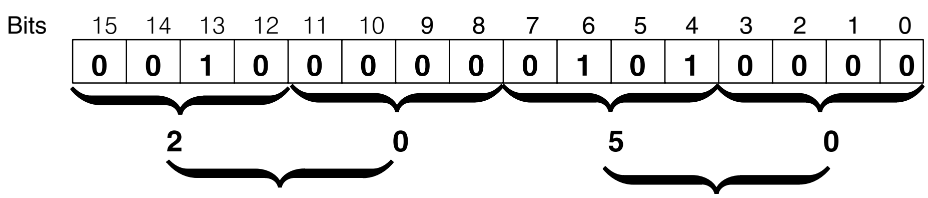
Configuring the HSIO Mode

If you have chosen a mode suited to the high-speed I/O needs of your application, we're ready to proceed to configure the PLC to operate accordingly. In the block diagram below, notice the V-memory detail in the expanded CPU block. V-memory location **V7633** determines the functional mode of the high-speed I/O circuit. *This is the most important V-memory configuration value for HSIO functions!*



The contents of V7633 is a 16-bit word, to be entered in binary–coded decimal. The figure below defines what each 4-bit BCD digit of the word represents.

Memory Location V7633



Miscellaneous Setup (BCD)

00 = Power Up in Previous Mode
20 = Power Up in Run Mode Always

HSIO Mode Setup (BCD)

00 = Not Used
10 = High-Speed Counting Mode
20 = Quadrature Counting Mode
30 = Pulse Output Train
40 = High-Speed Interrupts
50 = Pulse Catching
60 = Discrete Filtered Inputs (default)

Bits 0 – 7 define the mode number 00, 10.. 60 previously referenced in this chapter. The example data "2050" shown selects Mode 50 – Pulse Catch (BCD = 50) and Power Up in Run Mode (BCD=20). Together they form the 4-digit BCD number 2050.

Configuring Inputs X0 – X3

In addition to configuring V7633 for the HSIO mode, you'll need to program the next four locations in certain modes according to the desired function of input points X0 – X3. Other memory locations may require configuring, depending on the HSIO mode (see the corresponding section for particular HSIO modes).

V-memory

Mode	V7633	xxxx
X0	V7634	xxxx
X1	V7635	xxxx
X2	V7636	xxxx
X3	V7637	xxxx

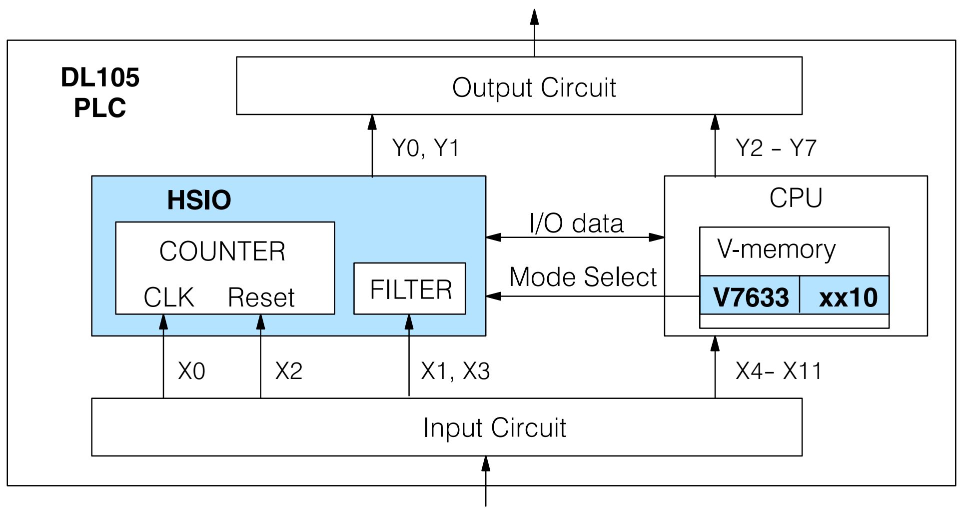
Mode 10: High-Speed Counter

Purpose

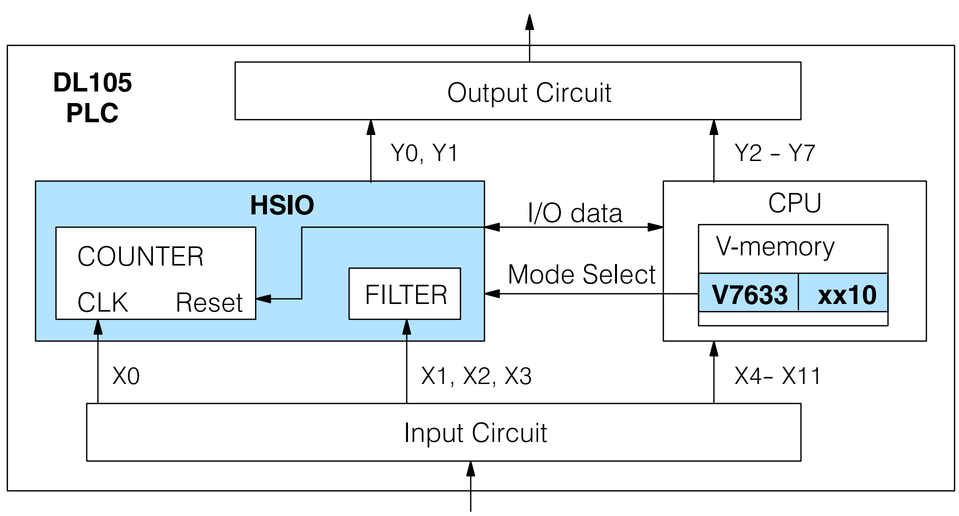
The HSIO circuit contains one high-speed counter. A single pulse train from an external source (X0) clocks the counter on each signal leading edge. The counter counts only upwards, from 0 to 99999999. The counter compares the current count with up to 24 preset values, which you define. The purpose of the presets is to quickly cause an action upon arrival at specific counts, making it ideal for such applications as cut-to-length. It uses counter registers CT76 and CT77 in the CPU.

Functional Block Diagram

Refer to the block diagram below. When the lower byte of HSIO Mode register V7633 contains a BCD “10”, the high-speed up counter in the HSIO circuit is enabled. X0 automatically becomes the “clock” input for the high-speed counter, incrementing it upon each off-to-on transition. The external reset input on X2 is the default configuration for Mode 10. Inputs X1 and X3 are filtered inputs, available to the ladder program.



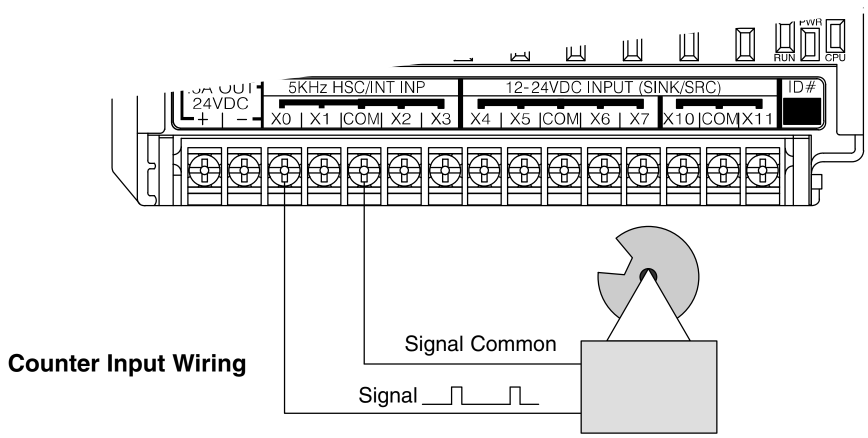
Instead of using X2 as a dedicated reset input, you can configure X2 as a normal filtered input. In this way, the counter reset must be generated in ladder logic.



Next, we will discuss how to program the high-speed counter and its presets.

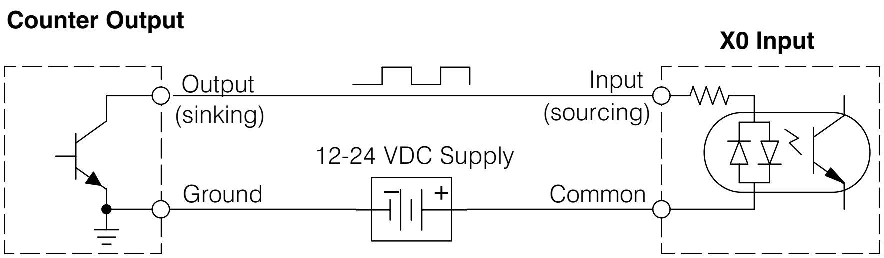
Wiring Diagram

A general wiring diagram for counters/encoders to the DL105 in HSIO Mode 10 is shown below. Many types of pulse-generating devices may be used, such as proximity switches, single-channel encoders, magnetic or optical sensors, etc. Devices with sinking outputs (NPN open collector) are probably the best choice for interfacing. If the counter sources to the inputs, it must output 12 to 24 VDC. Note that devices with 5V sourcing outputs will not work with DL105 inputs.

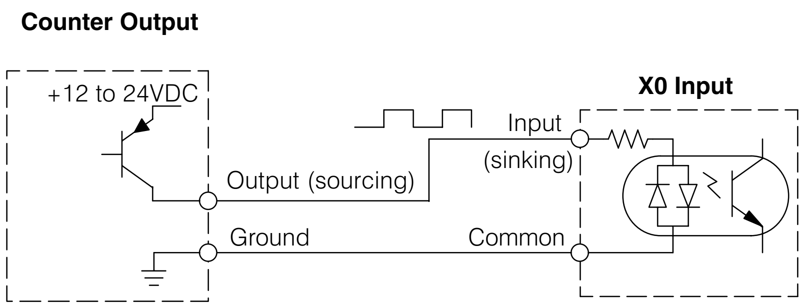


Interfacing to Counter Outputs

The DL105's DC inputs are flexible in that they detect current flow in either direction, so they can be wired to a counter with either sourcing or sinking outputs. In the following circuit, a counter has open-collector NPN transistor outputs. It sinks current from the PLC input point, which sources current. The power supply can be the +24VDC auxiliary supply or another supply (+12VDC or +24VDC), as long as the input specifications are met.



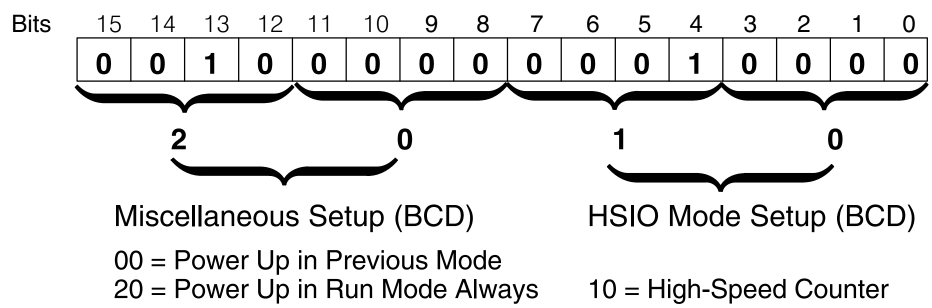
In the next circuit, an encoder has open-emitter PNP transistor outputs. It sources current to the PLC input point, which sinks the current back to ground. Since the encoder sources current, no additional power supply is required. However, note that the encoder output must be 12 to 24 volts (5V encoder outputs will not work).



Setup for Mode 10

Recall that V7633 is the HSIO Mode Select register. Refer to the diagram below. Use BCD 10 in the lower byte to select High-Speed Counter Mode. Use BCD 00 or 20 in the upper byte as required. Combine the two bytes into a data word “xx10”, for writing to V7633.

Memory Location V7633



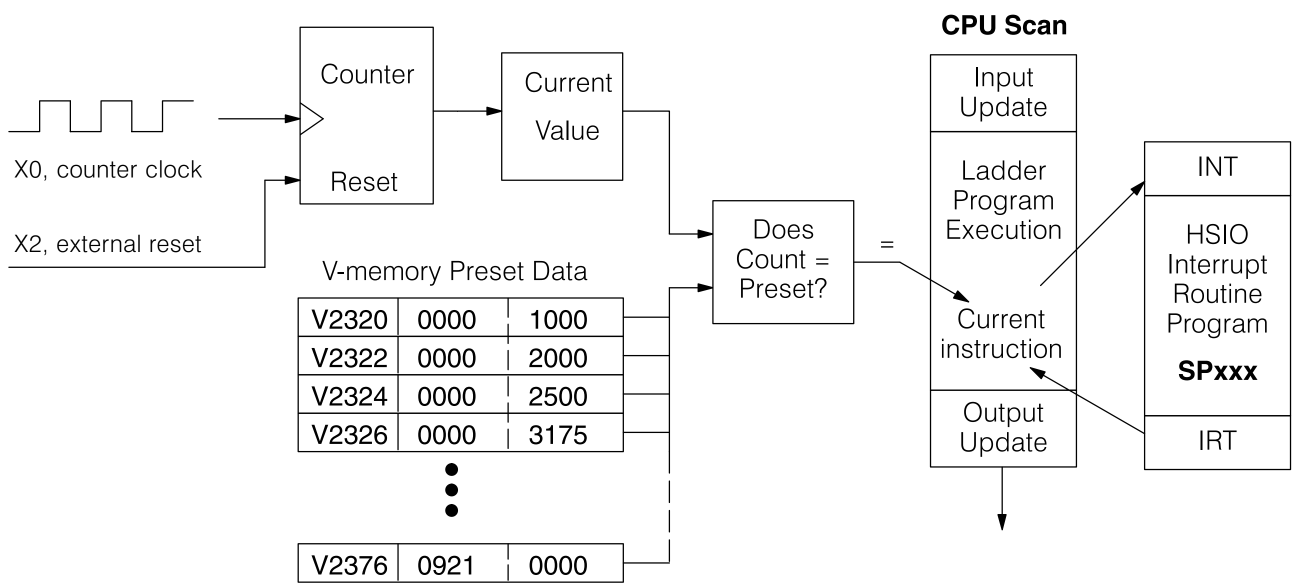
Choose the most convenient method of programming V7633 from the following:

- Include load and out instructions in your ladder program
- ***Direct***SOFT32’s memory editor
- Use the Handheld Programmer D2–HPP

We recommend using the first method above so that the HSIO setup becomes an integral part of your application program. An example program later in this section shows how to to this.

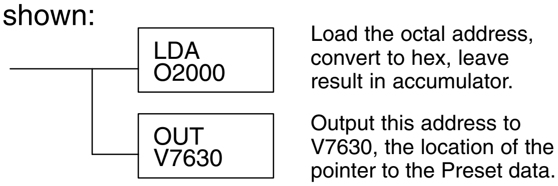
Presets and Special Relays

The goal of counting is to do a special action when the count reaches a preset value. Refer to the figure below. The counter features 24 presets, which you can program. A preset is a number you derive and store so that the counter will constantly compare the current count with the preset. When the two are equal, a special relay contact is energized and program execution jumps to the interrupt routine. We recommend using the special relay(s) in the interrupt service routine to cause any immediate action you desire. After the interrupt service routine is complete, the CPU returns to the ladder program, resuming program execution from the point of interruption. The compare function is ready for the next preset event.



Preset Data Starting Location

V7630 is a pointer location which points to the beginning of the Preset Data Table. The default starting location for the Preset Data Table is V2320 (default after initializing scratchpad V-memory). However, you may change this by programming a different value in V7630. Use the LDA and OUT instructions as shown:



Preset Table Pointer

V7630	**2000**

Preset Data

V2000	0000	1000
V2002	0000	2000
V2004	0000	2500
V2006	0000	3175
•		
•		
•		
V2076	0000	0000

Using Fewer than 24 Presets

When using fewer than 24 preset registers, the HSIO looks for “0000 FFFF” (use LDD Kffff) in the next preset location to indicate the last preset has been reached. The example to the right uses four presets. The 0000 FFFF in V2331-V2330 indicates the previous preset was the last.

Preset Data

V2320	0000	1000
V2322	0000	2000
V2324	0000	2500
V2326	0000	3175
V2330	0000	FFFF

NOTE: Each successive preset must be greater than the previous preset value. If a preset value is less than a lower-numbered preset value, the CPU cannot compare for that value, since the counter can only count upwards.

Equal Relay Numbers

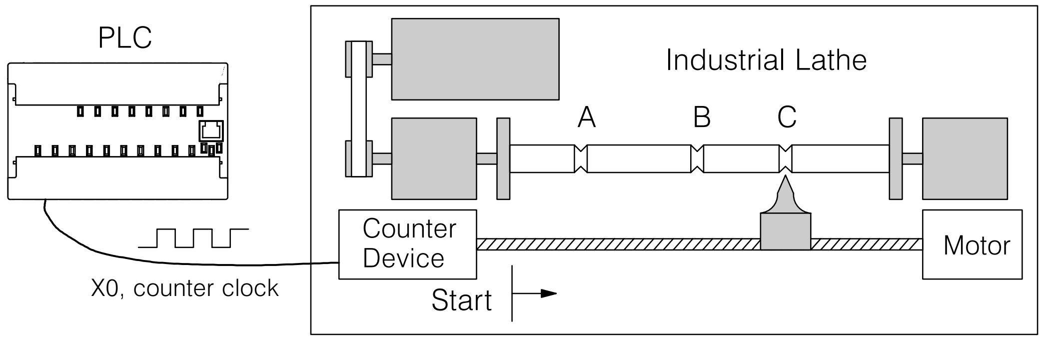
The following table lists all 24 preset register default locations. Each occupies two 16-bit V-memory registers. The corresponding special relay contact number is in the next column. We might also call these “equal” relay contacts, because they are true (closed) when the present high-speed counter value is equal to the preset value. Each contact remains closed until the counter value equals the next preset value.

Preset	Preset V-memory Register	Special Relay Number	Preset	Preset V-memory Register	Special Relay Number
1	V2321 / V2320	SP540	13	V2351 / V2350	SP554
2	V2323 / V2322	SP541	14	V2353 / V2352	SP555
3	V2325 / V2324	SP542	15	V2355 / V2354	SP556
4	V2327 / V2326	SP543	16	V2357 / V2356	SP557
5	V2331 / V2330	SP544	17	V2361 / V2360	SP560
6	V2333 / V2332	SP545	18	V2363 / V2362	SP561
7	V2335 / V2334	SP546	19	V2365 / V2364	SP562
8	V2337 / V2336	SP547	20	V2367 / V2366	SP563
9	V2341 / V2340	SP550	21	V2371 / V2370	SP564
10	V2343 / V2342	SP551	22	V2373 / V2372	SP565
11	V2345 / V2344	SP552	23	V2375 / V2374	SP566
12	V2347 / V2346	SP553	24	V2377 / V2376	SP567

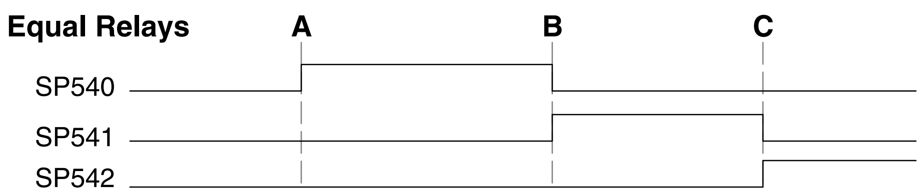
Calculating Your Preset Values

The preset values occupy two data words each. They can range in value from 0000 0000 to 9999 9999, just like the high-speed counter value. All twenty-four values are *absolute* values, meaning that each one is an offset from the counter zero value.

The preset values must be individually derived for each application. In the industrial lathe diagram below, the PLC monitors the position of the lead screw by counting pulses. At points A, B, and C along the linear travel, the cutter head pushes into the work material and cuts a groove.



The timing diagram below shows the duration of each equal relay contact closure. Each contact remains on until the next one closes. All go off when the counter resets.



NOTE: Each successive preset must have a greater value than the previous preset value. In the industrial lathe example, B>A and C>B.

X Input Configuration

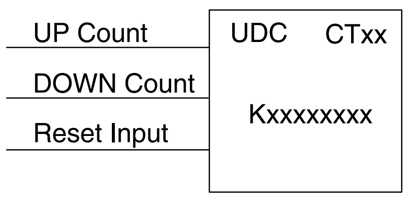
The configurable discrete input options for High-Speed Counter Mode are listed in the table below. Input X0 is dedicated for the counter clock input. Inputs X1 and X3 can only be filtered inputs. The section on Mode 60 operation at the end of this chapter describes programming the filter time constants. Input X2 can be configured as the counter reset, with or without the interrupt option. The interrupt option allows the reset input (X2) to cause an interrupt like presets do, but there is no SP relay contact closure (instead, X2 will be on during the interrupt routine, for 1 scan). Or finally, X2 may be left simply as a filtered input like X1 and X3.

Input	Configuration Register	Function	Hex Code Required
X0	V7634	Counter Clock	0001
X1	V7635	Filtered Input	xx06 (xx = filter time)
X2	V7636	Counter Reset (no interrupt)	0007
		Counter Reset (with interrupt)	0107
		FIltered Input	xx06 (xx = filter time)
X3	V7637	FIltered Input	xx06 (xx = filter time)

Writing Your Control Program

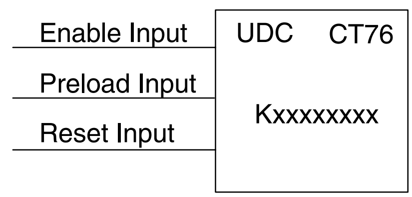
You may recall that the counter instruction is a standard instruction in the DL105 instruction set. Refer to the figure below. The mnemonic for the counter is **UDC** (up-down counter).The DL105 can have up to 64 counters, labeled CT0 through CT77. The high speed counter in the HSIO circuit is accessed in ladder logic by using UDC CT76. It uses counter registers CT76 and CT77 exclusively when the HSIO mode 10 is active (otherwise, CT76 and CT77 are available for standard counter use). The HSIO counter needs two registers because it is a double-word counter. It has three inputs as shown. The first input (Enable) allows counting when active. The middle input (Preload) allows you to change the current count. The bottom signal is the reset. The preload input must be off while the counter is counting.

Standard Counter Function



- Counts UP and DOWN
- Preload counter by write to value
- Reset input is internal only

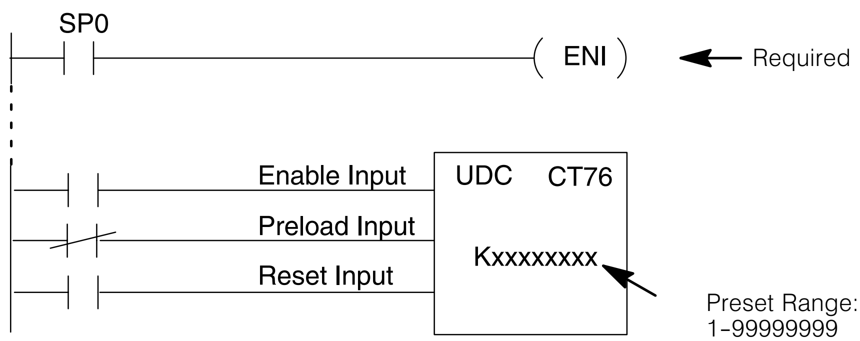
HSIO Counter Function



- Counts UP only
- Can use Preload input to change count
- Reset may be internal or external

The next figure shows how the HSIO counter will appear in a ladder program. Note that the Enable Interrupt (ENI) command must execute before the counter value reaches the first preset value. We do this at powerup by using the first scan relay. When using the counter but not the presets and interrupt, we can omit the ENI.

DirectSOFT32

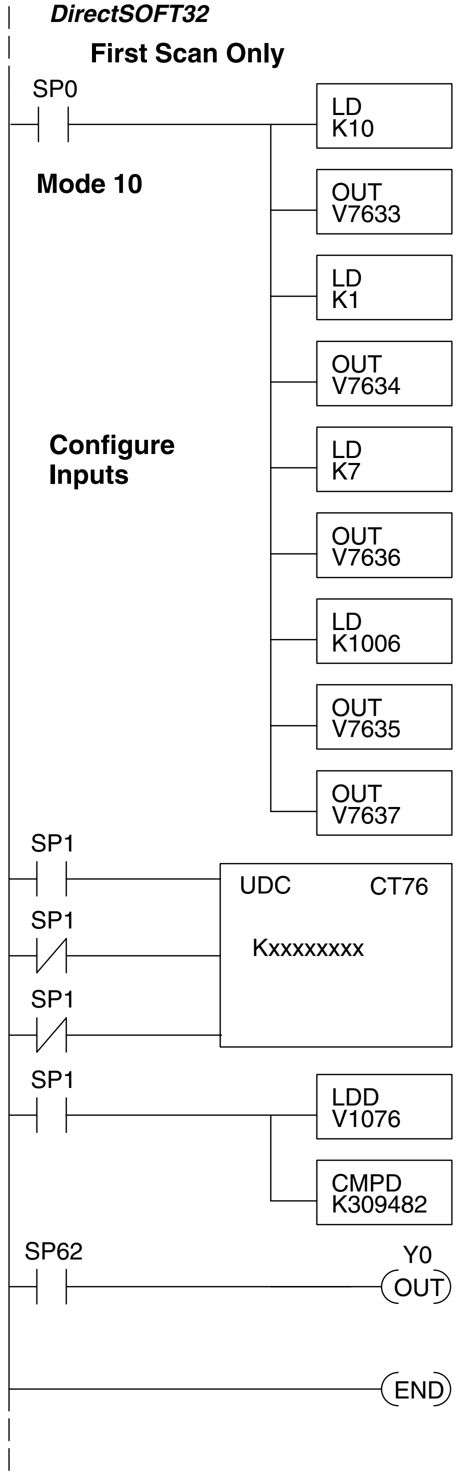


When the enable input is energized, the high-speed counter will respond to pulses on X0 and increment the counter at CT76 – CT77. The reset input contact behaves in a logical OR fashion with the physical reset input X2 (when selected). So,the high speed counter can receive a reset form either the contact(s) on the reset rung in the ladder, OR the external reset X2 if you have configured X2 as an external reset.

Program Example: Counter Without Preset

The following example is the simplest way to use the high-speed counter, which does not use the presets and special relays in the interrupt routine. The program configures the HSIO circuit for Mode 10 operation, so X0 is automatically the counter clock input. It uses the Compare-double (CMPD) instruction to cause action at certain count values. Note that this allows you to have more than 24 “presets”.Then it configures X2 to be the external reset of the counter.

Program Example Cont'd



Load constant K10 into the accumulator. This selects Mode 10 as the HSIO mode.

Output the constant K10 to V7633, the location of HSIO Mode select register.

Load the constant required to configure X0 as the counter clock.

Output the constant K1 to V7634, the location of the setup parameter for X0.

Load the constant required to configure X2 as an external reset without interrupt.

Output the constant K7 to V7636, the location of the setup parameter for X2.

Load the constant required to configure inputs as filtered inputs.

Output the constant K1006 to V7635, the location of setup parameter for X1.

Output the constant K1006 to V7637, the location of setup parameter for X3.

CT76 is the HSIO counter. The first rung's SP1 always enables the counter. The preload contact in the middle is always off. The third rung's Reset input is always off, because we will use the external reset.

Load the current count of the HSIO counter in V1076 and V1077 into the accumulator

Use the Compare-double instruction to compare the double word in the accumulator to the constant K309482

The execution of the above CMPD instruction turns on special relay contact SP62 if the current count is greater than the comparison number (K309482).

END coil marks the end of the main program.

The compare double instruction above uses the current count of the HSIO counter to turn on Y0. This technique can make more than 24 comparisons, but it is scan-time dependent. However, use the 24 built-in presets with the interrupt routine if your application needs a very fast response time, as shown in the next example.

Counter With Presets Program Example

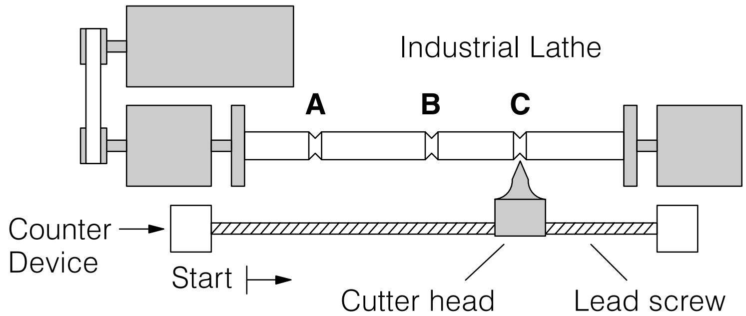
The following example shows how to program the HSIO circuit to trigger on three preset values. You may recall the industrial lathe example from the beginning of this chapter. This example program shows how to control the lathe cutter head to make three grooves in the work-piece at precise positions. When the lead screw turns, the counter device generates pulses which the DL105 can count. The three preset variables A, B, and C represent the positions (number of pulses) corresponding to each of the three grooves.

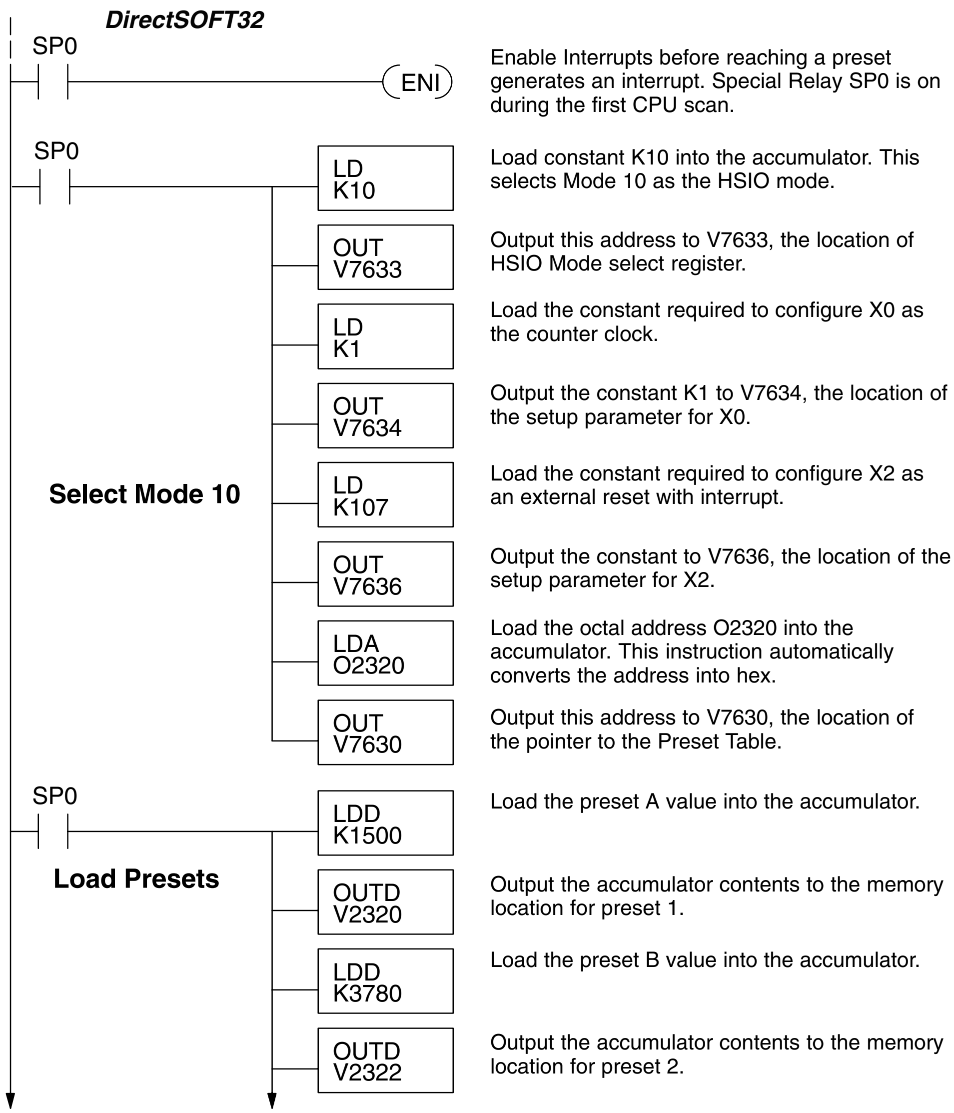
Preset Data

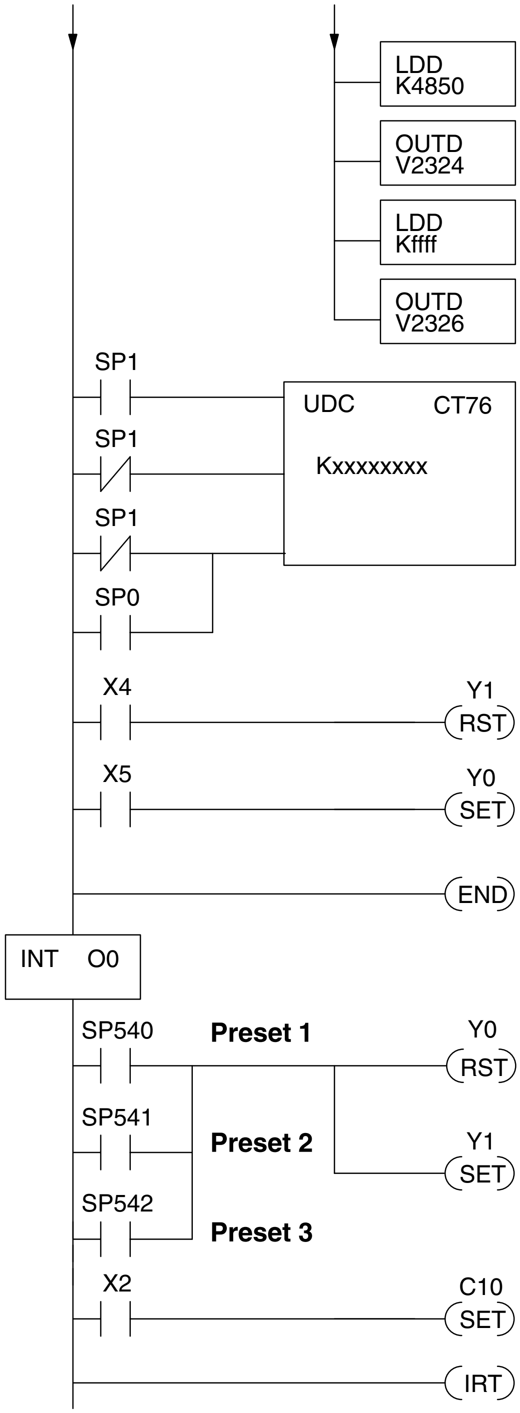
A	V2320	0000	1500
B	V2322	0000	3780
C	V2324	0000	4850
	V2326	0000	FFFF

I/O Assignments

X4 – Cutter head extended
X5 – Cutter head retracted
Y0 – Lead screw motor
Y1 – Cutter head solenoid







Load the preset C value into the accumulator.

Output the accumulator contents to the memory location for preset 3.

Load the constant Kffff into the accumulator. This value represents the end of the preset list.

Output the accumulator contents to the memory location for preset 4 (end of preset marker).

CT76 is the HSIO counter. The first rung's SP1 always enables the counter. The preload contact in the middle is off (unused in this example).

The third rung's Reset input is normally off, because we will use the external reset. You can optionally reset the counter value on each powerup using the SP0 contact.

Input X4 energizes when the groove has finished cutting. So, we retract the cutter head.

Turn lead screw on again, after cutter head has retracted.

END coil marks the end of the main program.

The INT label marks the beginning of the interrupt service routine program.

Inside the interrupt service routine, we turn OFF the lead screw motor immediately.

These special "equal" relays turn on individually as the corresponding preset is reached. In this application, each results in the cutting of a groove (Y1), so they are logically ORed together.

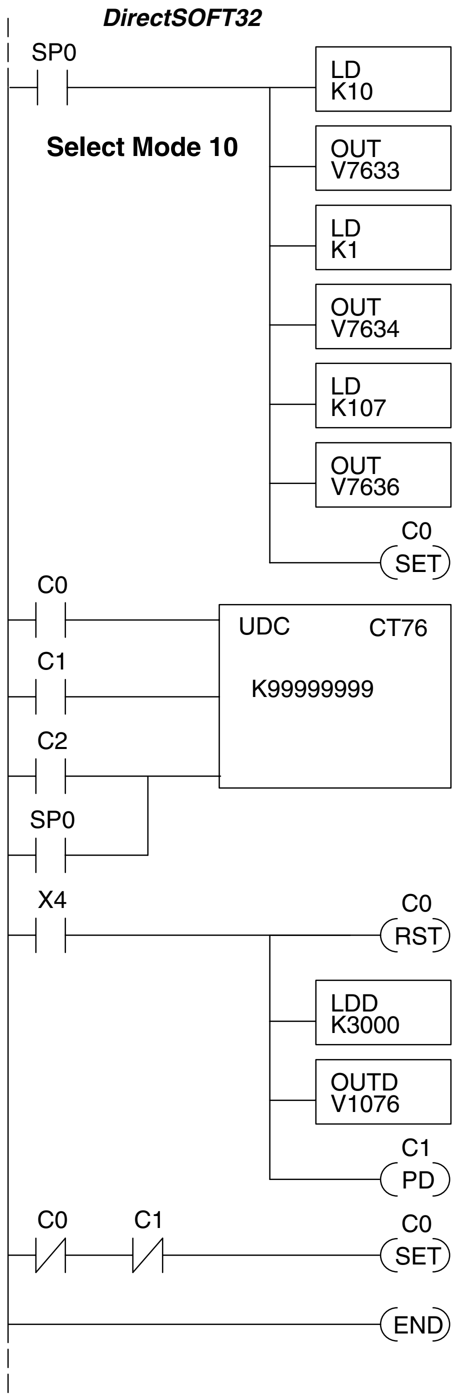
Input X2 will be energized inside the interrupt routine if X2 external interrupt was the source.

Return from the interrupt service routine.

Some applications will require a different type of action at each preset. It is possible for the interrupt routine to distinguish one preset event from another, by turning on a unique output for each equal relay contact SPxxx. We can determine the source of the interrupt by examining the equal relay contacts individually, as well as X2. The X2 contact will be on (inside the interrupt routine only) if the interrupt was caused by the external reset, X2 input.

Counter With Preload Program Example

The following example shows how you can preload the current count with another value. When the preload command input (X4 in this example) is energized, we disable the counter from counting with C0. Then we write the value K3000 to the count register (V1076-V1077). By pulsing C1 on, we preload the current count of the counter with K3000. When the preload command (X4) is turned off, the counter resumes counting any pulses, but now starting from K3000.



Load constant K10 into the accumulator. This selects Mode 10 as the HSIO mode.

Output this address to V7633, the location of HSIO Mode select register.

Load the constant required to configure X0 as the counter clock.

Output the constant K1 to V7634, the location of the setup parameter for X0.

Load the constant required to configure X2 as an external reset with interrupt.

Output the constant to V7636, the location of the setup parameter for X2.

Set C0 on at powerup to enable counting.

CT76 is the HSIO counter. The first rung's C0 contact enables the counter. The preload contact in the middle is off until the logic near the end of this program turns it on.

The third rung's Reset input is normally off, because we will use the external reset. You can optionally reset the counter value on each powerup using the SP0 contact.

When the preload request is made, the user turns on X4. First we disable counting by resetting C0, the counter's enable input.

Load the BCD value K3000 into the accumulator.

Output the constant to V1076/V1077, the location of the accumulated count for CT76.

Generate a preload counter input pulse, which causes the counter to preload from V1076-V1077.

Enable the counter by setting C0, when the preolad pulse on C1 has occurred (C1 is off).

END coil marks the end of the main program.

Troubleshooting Guide for Mode 10

If you're having trouble with Mode 10 operation, please study the following symptoms and possible causes. The most common problems are listed below.

Symptom: The counter does not count.

Possible causes:

1. **Field sensor and wiring** – Verify that the encoder, proximity switch,or counter actually turns on and illuminates the status LED for X0. The problem could be due to sinking-sourcing wiring problem, etc. Remember to check the signal ground connection. Also verify that the pulse on-time is long enough for the PLC to recognize it.
2. **Configuration** – make sure all of the configuration parameters are correct. V7633 must be set to 10, and V7634 must be set to 1 to enable the HSIO counter mode.
3. **Stuck in reset** – check the input status of the reset input, X2. If X2 is on, the counter will not count because it is being held in reset.
4. **Ladder program** – make sure you are using counter CT76 in your program. The top input is the enable signal for the counter. It must be on before the counter will count. The middle input is the preload input and must be off for the counter to count. The bottom input is the counter reset, and must be off during counting.

Symptom: The counter counts but the presets do not function.

Possible causes:

1. **Configuration** – Ensure the preset values are correct. The presets are 32-bit BCD values having a range of 0 to 99999999. Make sure you write all 32 bits to the reserved locations by using the LDD and OUTD instructions. Use only even–numbered addresses, from V2320 to V2376. If using less than 24 presets, be sure to place “0000FFFF” in the location after the last preset used.
2. **Interrupt routine** – Only use Interrupt #0. Make sure the interrupt has been enabled by executing an ENI instruction prior to needing the interrupt. The interrupt routine must be placed after the main program, using the INT label and ending with an interrupt return IRT.
3. **Special relays** – Check the special relay numbers in your program. Use SP540 for Preset 1, SP541 for Preset 2, etc. Remember that only one special equal relay contact is on at a time. When the counter value reaches the next preset, the SP contact which is on now goes off and the next one turns on.

Symptom: The counter counts up but will not reset.

Possible causes:

1. Check the LED status indicator for X2 to make sure it is active when you want a reset. Or, if you are using an internal reset, use the status mode of ***Direct***SOFT32 to monitor the reset input to the counter.

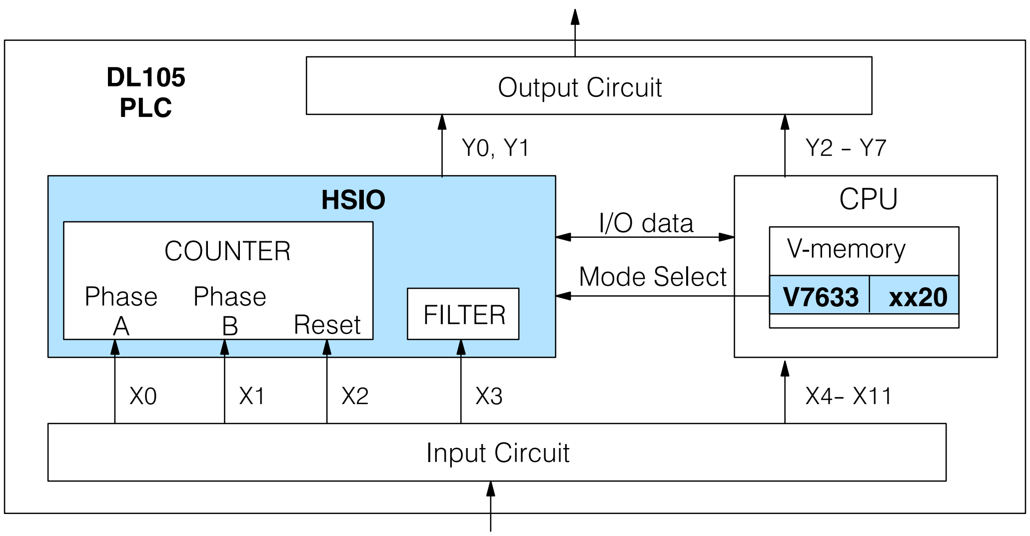
Mode 20: Quadrature Counter

Purpose

The counter in the HSIO circuit can count two quadrature signal pulses instead of a single pulse train (mode 10 operation). Quadrature signals are commonly generated from incremental encoders, which may be rotary or linear. The quadrature counter has a range from 0 to 99999999, and can count at up to a 5 kHz rate, using CT76 and CT77. Unlike Mode 10 operation, the quadrature counter can count UP or DOWN, but *does not feature automated preset values or "interrupt on external reset" capability.* However, you have the standard ladder instruction preset of CT76.

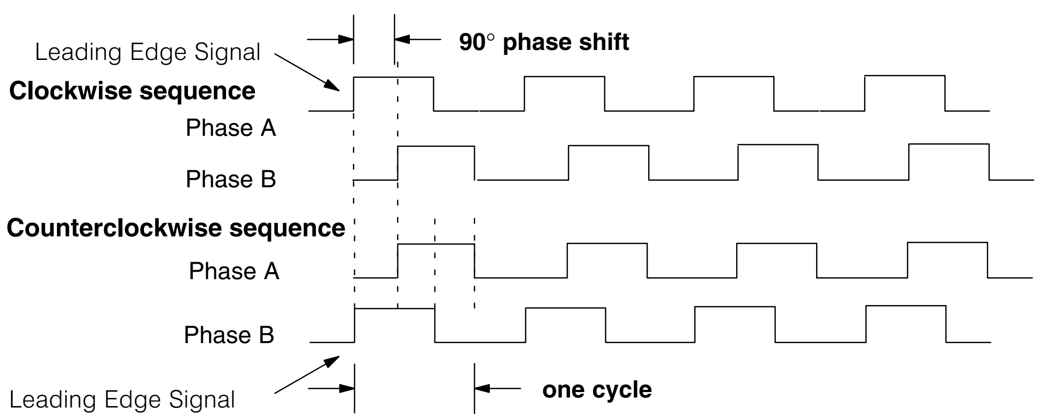
Functional Block Diagram

The diagram below shows HSIO functionality in Mode 20. When the lower byte of HSIO Mode register V7633 contains a BCD "20", the quadrature counter in the HSIO circuit is enabled. Input X0 is dedicated to the Phase A quadrature signal, and input X1 receives Phase B signal. X2 is dedicated to reset the counter to zero value when energized. X3 can only be a regular filtered input in Mode 20.



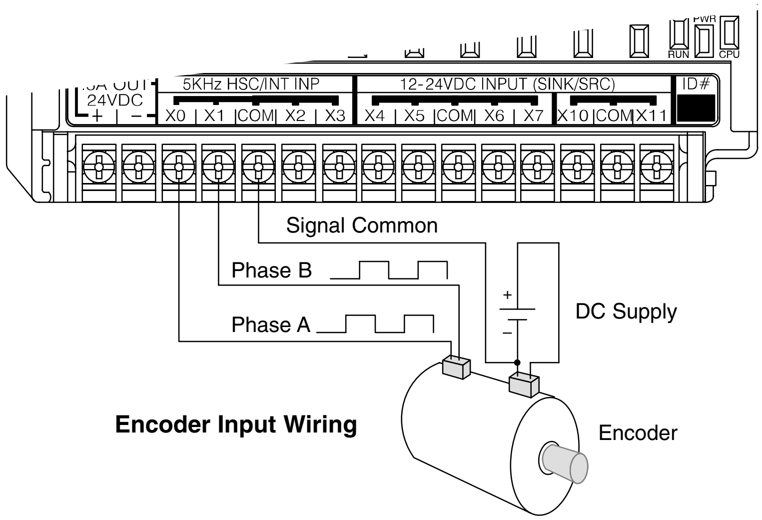
Quadrature Encoder Signals

Quadrature encoder signals contain position and direction information, while their frequency represents speed of motion. Phase A and B signals shown below are phase-shifted 90 degrees, thus the quadrature name. When the rising edge of Phase A precedes Phase B's leading edge (indicates clockwise motion by convention), the HSIO counter counts UP. If Phase B's rising edge precedes Phase A's rising edge (indicates counter-clockwise motion), the counter counts DOWN.



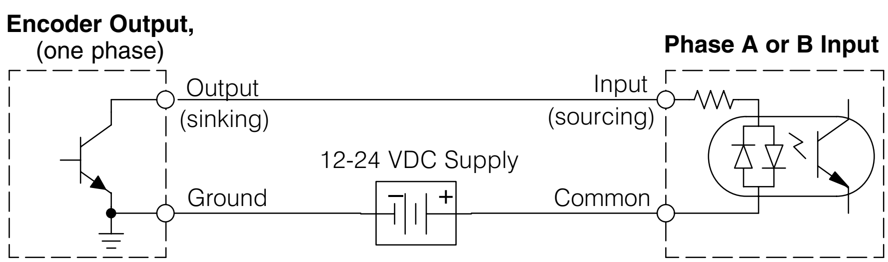
Wiring Diagram

A general wiring diagram for encoders to the DL105 in HSIO Mode 20 is shown below. Encoders with sinking outputs (NPN open collector) are probably the best choice for interfacing. If the encoder sources to the inputs, it must output 12 to 24 VDC. Note that encoders with 5V sourcing outputs will not work with DL105 inputs.

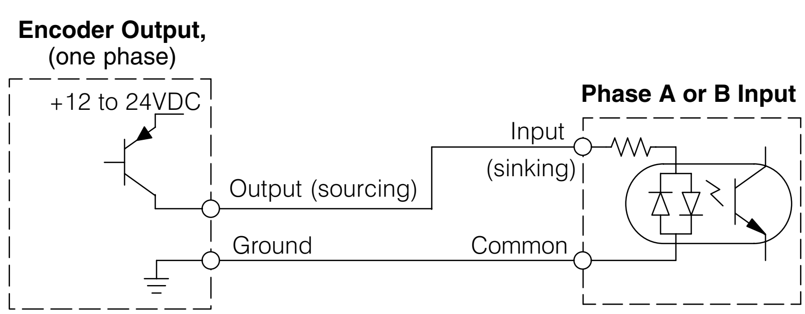


Interfacing to Encoder Outputs

The DL105's DC inputs are flexible in that they detect current flow in either direction, so they can be wired to an encoder with either sourcing or sinking outputs. In the following circuit, an encoder has open-collector NPN transistor outputs. It sinks current from the PLC input point, which sources current. The power supply can be the +24VDC auxiliary supply or another supply (+12VDC or +24VDC), as long as the input specifications are met.



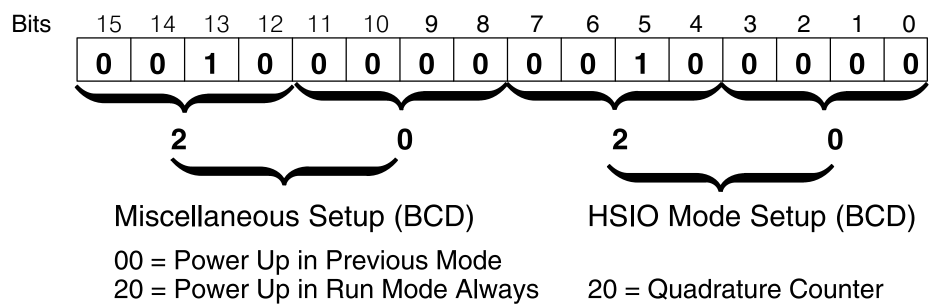
In the next circuit, an encoder has open-emitter PNP transistor outputs. It sources current to the PLC input point, which sinks the current back to ground. Since the encoder sources current, no additional power supply is required. However, note that the encoder output must be 12 to 24 volts (5V encoder outputs will not work).



Setup for Mode 20

Recall that V7633 is the HSIO Mode Select register. Refer to the diagram below. Use BCD 20 in the lower byte to select High-Speed Counter Mode. Use BCD 00 or 20 in the upper byte as required. Combine the two bytes into a data word “xx20”, for writing to V7633.

Memory Location V7633



Choose the most convenient method of programming V7633 from the following:

- Include load and out instructions in your ladder program
- ***Direct***SOFT32’s memory editor
- Use the Handheld Programmer D2–HPP

We recommend using the first method above so that the HSIO setup becomes an integral part of your application program. An example program later in this section shows how to to this.

X Input Configuration

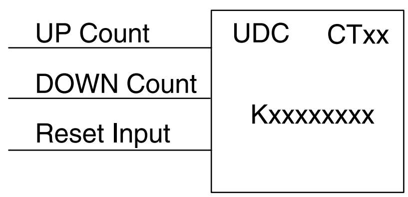
The configurable discrete input options for High-Speed Counter Mode are listed in the table below. Input X0 is dedicated for Phase A, and input X1 is for Phase B. Input X2 is the reset input to the quadrature counter, but it does not cause an interrupt. Input X3 can only be a filtered input. The section on Mode 60 operation at the end of this chapter describes programming the filter time constants.

Input	Configuration Register	Function	Hex Code Required
X0	V7634	Phase A	0012
X1	V7635	Phase B	0000
X2	V7636	Counter Reset (no interrupt)	0007
X3	V7637	Filtered Input	xx06 (xx = filter time)

Writing Your Control Program

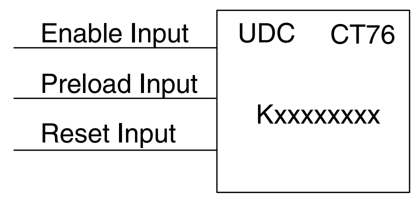
You may recall that the Up-Down counter instruction is standard in the DL105 instruction set. Refer to the figure below. The mnemonic for the counter is **UDC** (up-down counter).The DL105 can have up to 64 counters, labeled CT0 through CT77. The quadrature counter in the HSIO circuit is accessed in ladder logic by using UDC CT76. It uses counter registers CT76 and CT77 exclusively when the HSIO mode 20 is active (otherwise, CT76 and CT77 are available for standard counter use). The HSIO counter needs two registers because it is a double-word counter. It also has three inputs as shown, but they are redefined. The first input is the enable signal, the middle is a preload (write), and the bottom is the reset. The enable input must be on before the counter will count. The preload input allows you to write a new value to the current count. The enable input must be off during a preload.

Standard Counter Function



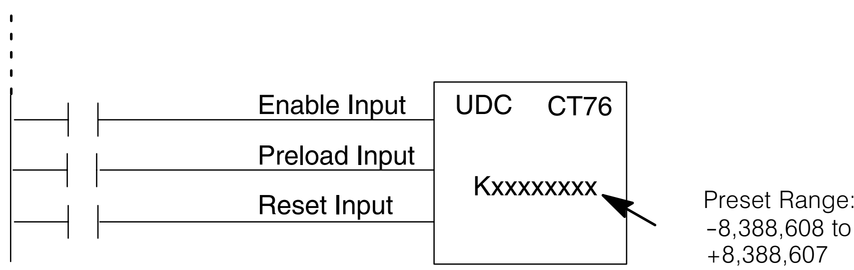
- Counts UP and DOWN
- Preload counter by write to value
- Reset input is internal only

HSIO Counter Function



- Counts UP and DOWN (from X0, X1)
- Can use Preload input to change count
- Reset may be internal or external

The next figure shows the how the HSIO quadrature counter will appear in a ladder program.

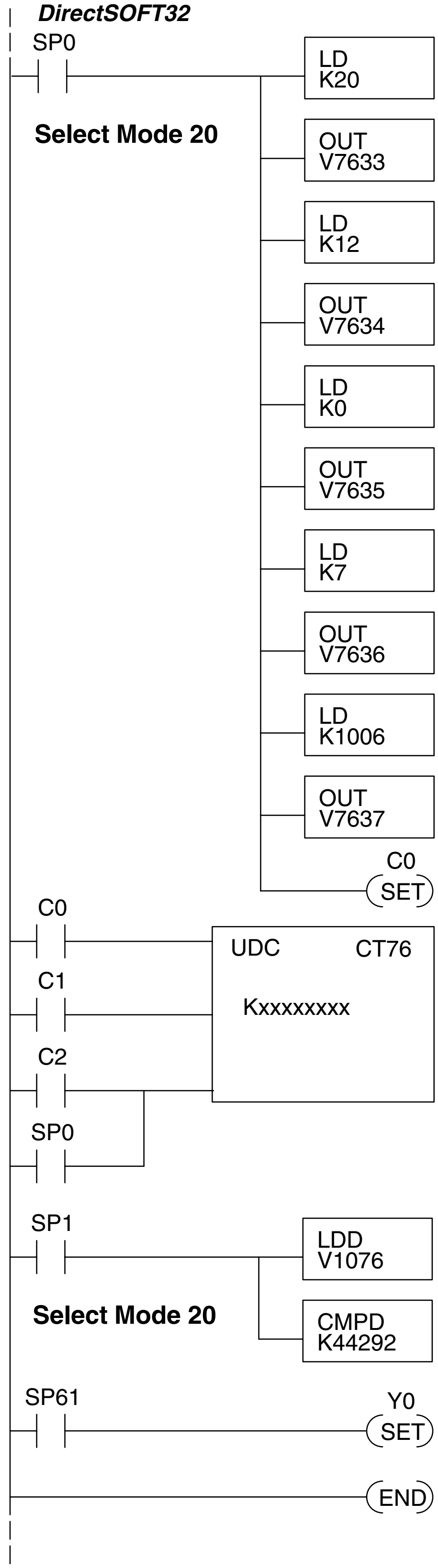


When the enable input is energized, the counter will respond to quadrature pulses on X0 and X1, incrementing or decrementing the counter at CT76 – CT77. The reset input contact behaves in a logical OR fashion with the physical reset input X2. This means the quadrature counter can receive a reset from either the contact(s) on the reset rung in the ladder, OR the external reset X2.

Quadrature Counter w/Preload Program Example

Since presets are not available in quadrature counting, this mode is best suited for simple counting and measuring. The example program on the following page shows how to configure the quadrature counter. The program configures the HSIO circuit for Mode 20 operation, so X0 is Phase A and X1 is Phase B clock inputs.

Program Example Cont'd



Load constant K20 into the accumulator. This selects Mode 20 as the HSIO mode.

Output this address to V7633, the location of the HSIO Mode select register.

Load the constant required to configure X0 as Phase A input.

Output the constant to V7634, the location of the setup register for X0.

Load the constant required to configure X1 as Phase B input.

Output the constant to V7635, the location of the setup register for X1.

Load the constant required to configure X2 as an external reset.

Output the constant to V7636, the location of the setup register for X2.

Load the constant required to configure X3 as a filtered discrete input with a 10 mS time constant.

Output the constant to V7637, the location of the setup register for X3.

Set C0 on at powerup to enable counting.

CT76 is the HSIO quadrature counter. The first rung's SP1 always enables the counter. The preload contact in the middle is controlled by the logic below this counter instruction.

The third rung's Reset input is normally off, because we will use the external reset. You can optionally reset the counter value on each powerup using the SP0 contact.

Load the current value of the counter into the accumulator on each scan.

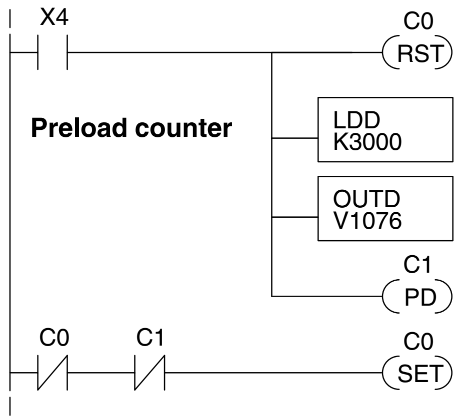
Compare the value in the accumulator with the constant K44292. If they are equal, the SP61 contact will be turned on.

Set Y1 to ON when the counter reaches our comparison value.

END coil marks the end of the main program..

To preload the counter, just add the following example rungs to the program above.

Counter Preload Program Example



When the preload request is made, the user turns on X4. First we disable counting by resetting C0, the counter's enable input.

Load the BCD value K3000 into the accumulator.

Output the constant to V1076/V1077, the location of the accumulated pulse count.

Generate a preload counter input pulse, which causes the counter to preload from V1076-V1077.

Enable the counter by setting C0, when the preolad pulse on C1 has occurred (C1 is off).

Troubleshooting Guide for Mode 20

If you're having trouble with Mode 20 operation, please study the following symptoms and possible causes. The most common problems are listed below.

Symptom: The counter does not count.

Possible causes:

1. **Field sensor and wiring** – Verify that the encoder or other field device inputs actually turn on and illuminates the status LEDs for X0 and X1. A standard incremental encoder will visibly, alternately turn on the LEDs for X0 and X1 when rotating slowly (1 RPM). Or, the problem could be due to a sinking-sourcing wiring problem, etc. Remember to check the signal ground connection. Also verify that the pulse on-time, duty cycle, voltage level, and frequency are within the input specifications.
2. **Configuration** – make sure all of the configuration parameters are correct. V7633 must be set to 20, and V7634 must be set to "0012" to enable the Phase A input, and V7635 must be set to "0000" to enable the Phase B input.
3. **Stuck in reset** – check the input status of the reset input, X2. If X2 is on, the counter will not count because it is being held in reset.
4. **Ladder program** – make sure you are using counter CT76 in your program. The top input is the enable signal for the counter. It must be on before the counter will count. The middle input is the preload input and must be off for the counter to count. The bottom input is the counter reset, and must be off during counting.

Symptom: The counter counts in the wrong direction (up instead of down, and visa-versa).

Possible causes:

1. **Channel A and B assignment** – It's possible that Channel A and B assignments of the encoder wires is backwards from the desired rotation/counting orientation. Just swap the X0 and X1 inputs, and the counting direction will be reversed.

Symptom: The counter counts up and down but will not reset.

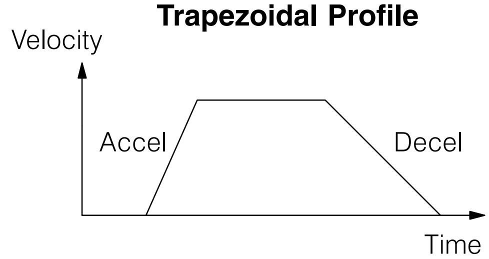
Possible causes:

1. Check the LED status indicator for X2 to make sure it is active when you want a reset. Also verify the configuration register V7636 for X2 is set to 7. Or, if you are using an internal reset, use the status mode of ***Direct***SOFT32 to monitor the reset input to the counter.

Mode 30: Pulse Output

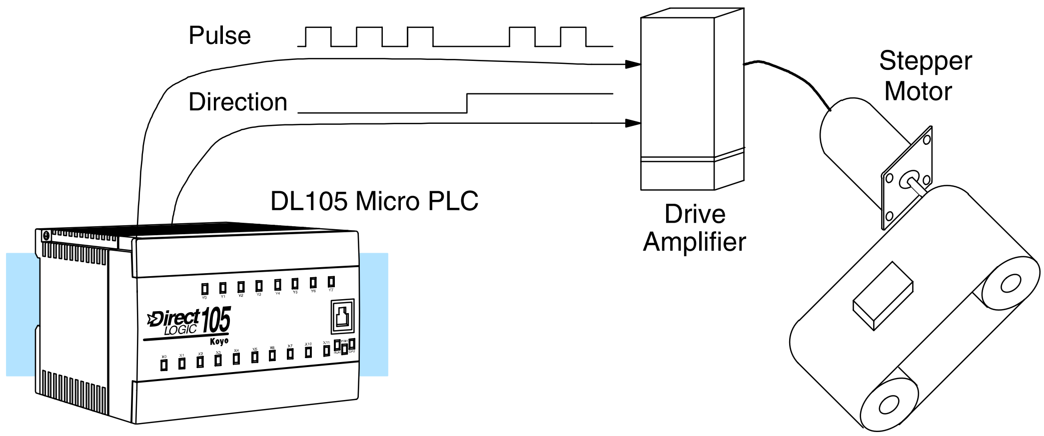
Purpose

The HSIO circuit in Mode 30 generates output pulse trains suitable for open-loop control of a single-axis motion positioning system. It generates pulse (stepper increment) and direction signals which you can connect to motor drive systems and perform various types of motion control. Using Mode 30 Pulse Output, you can select from three profile types:

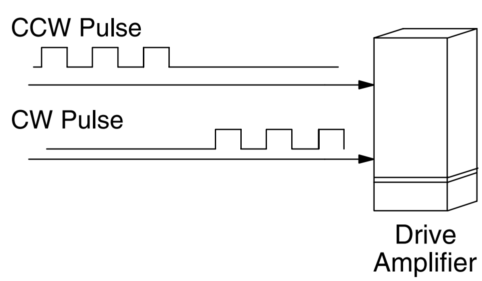


- **Trapezoidal** – Accel Slope to Target Velocity to Decel Slope
- **Registration** – Velocity to Position Control on Interrupt (also used for home search moves)
- **Velocity Control** – Speed and Direction only

The HSIO circuit becomes a high-speed pulse generator (up to 7 kHz) in Mode 30. By programming acceleration and deceleration values, position and velocity target values, the HSIO function automatically calculates the entire motion profile. The figure below shows the DL105 generating pulse and direction signals to the drive amplifier of a stepper positioning system. The pulses accomplish the profile independently and without interruption to ladder program execution in the CPU.



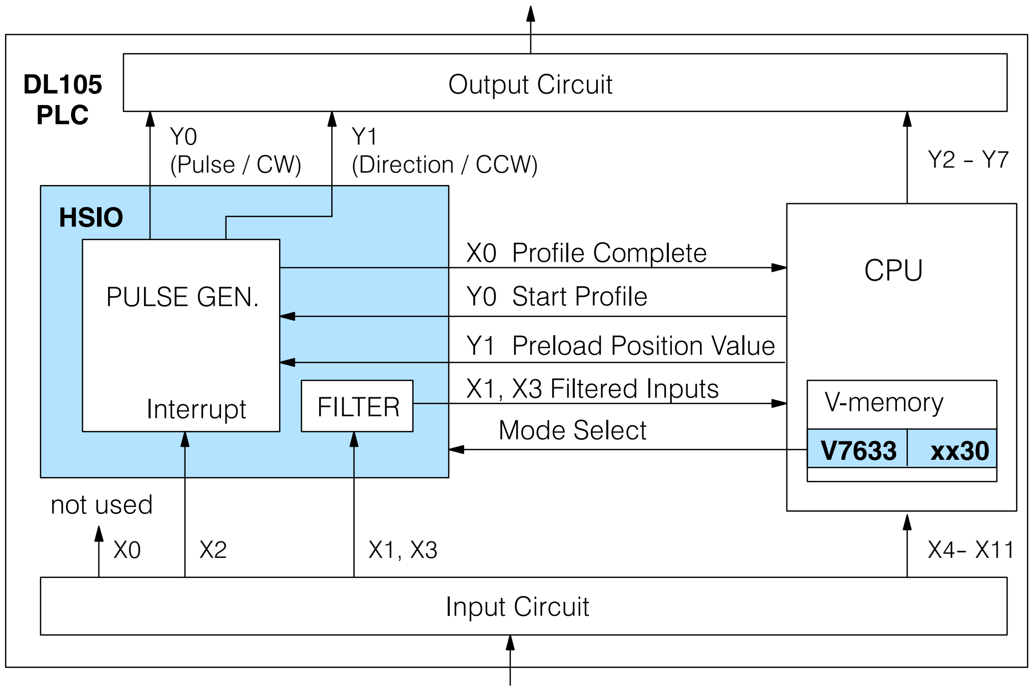
In the figure above, the DL105 generates pulse and direction signals. Each pulse represents the smallest increment of motion to the positioning system (such as one step or micro-step to a stepper system). Alternatively, the HSIO Pulse Output Mode may be configured to deliver counter clock-wise (CCW) and clock-wise (CW) pulse signals as shown to the right.



NOTE: The pulse output is designed for open loop stepper motor systems. This, plus its minimum velocity of 40 pps make it unsuitable for servo motor control.

Functional Block Diagram

The diagram below shows HSIO functionality in Mode 30. When the lower byte of HSIO Mode register V7633 contains a BCD “30”, the pulse output capability in the HSIO circuit is enabled. The pulse outputs use Y0 and Y1 terminals on the output connector. Remember that the outputs can only be DC type to operate.



IMPORTANT NOTE: In Pulse Output Mode, X0, Y0, and Y1 references are redefined or are used differently in two ways. *Physical* references refer to terminal screws, while *logical* references refer to I/O references in the ladder program. Please read the items below to understand this very crucial point.

Notice the I/O point assignment and usage in the above diagram:

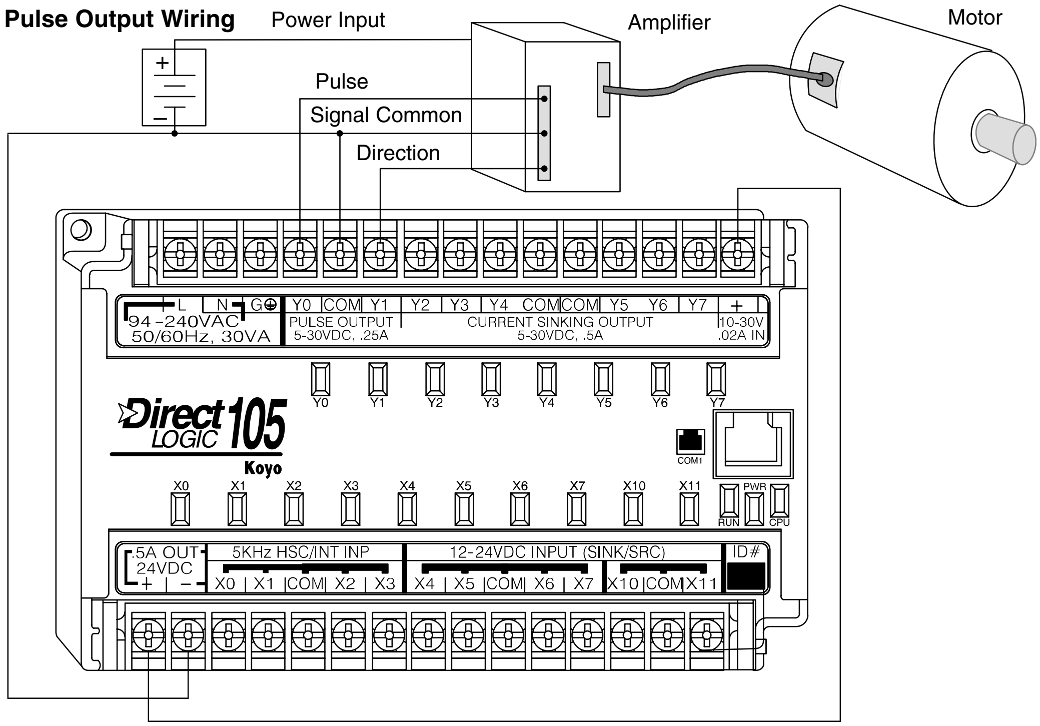
- Physical input X0 is not used, so the terminal screw will not be wired. However, the HSIO function uses logical reference X0 for “Profile Complete” contact, which is available for ladder program use.
- X1 and X3 can only be filtered inputs in Pulse Output Mode, and they are available as input contacts to the ladder program.
- X2 behaves as an external interrupt to the pulse generator for registration profiles. In other profile modes, it can be used as a filtered input just like X1 and X3 (registration mode configuration shown above).
- References “Y0” and “Y1” are used in two different ways. At the output connector, Y0 and Y1 terminals deliver the pulses to the motion system. The ladder program uses logical references Y0 and Y1 to initiate “Start Profile” and “Load Position Value” HSIO functions in Mode 30.

Hopefully, the above discussion will explain why some I/O reference names have dual meanings in Pulse Output Mode. **Please read the remainder of this section with care**, to avoid confusion about which actual I/O function is being discussed.

Wiring Diagram

The generalized wiring diagram below shows pulse outputs Y0 and Y1 connected to the drive amplifier inputs of a motion control system.

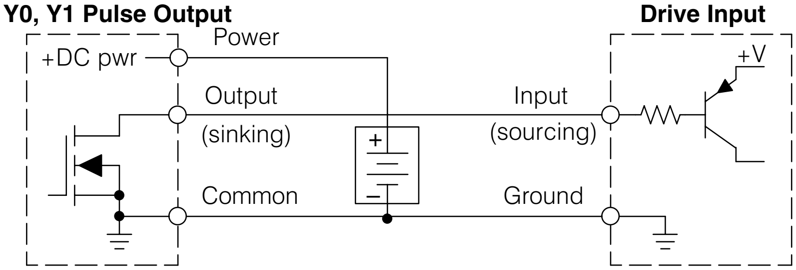
Pulse Output Wiring



Interfacing to Drive Inputs

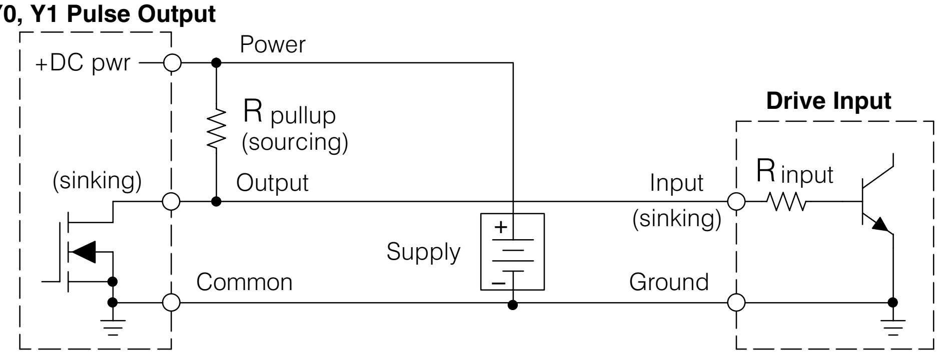
The pulse signals from Y0 and Y1 outputs will typically go to drive input circuits as shown above. Remember that the DL105's DC outputs are sinking-only. It will be helpful to locate equivalent circuit schematics of the drive amplifier. The following diagram shows how to interface to a sourcing drive input circuit.

Y0, Y1 Pulse Output **Drive Input**



The following circuit shows how to interface to a sinking drive input using a pullup resistor. Please refer to Chapter 2 to learn how to calculate and install R_{pullup}.

Y0, Y1 Pulse Output



Motion Profile Specifications

The motion control profiles generated in Pulse Output Mode have the following specifications:

Parameter	Specification
Profiles	Trapezoidal – Accel Slope / Target Velocity / Decel Slope
	Registration – Velocity to Position Control on Interrupt
	Velocity Control – Speed and Direction only
Position Range	–88388608 to 88388607
Positioning	Absolute / relative command
Velocity Range	40 Hz to 7 kHz
V-memory registers	V2320 to V2325 (Profile Parameter Table)
Current Position	CT76 and CT77 (V1076 and V1077)

Physical I/O Configuration

The configurable discrete I/O options for Pulse Output Mode are listed in the table below. Physical input X0 is not available, because the CPU uses logical X0 contact to sense “profile complete”. Therefore, V7634 is put to another use: selecting pulse/direction or CCW/CW modes for the pulse outputs. Inputs X1 and X3 can only be filtered inputs. Input X2 is dedicated as the external interrupt for use in registration mode.

Physical Input	Configuration Register	Function	Hex Code Required
–	V7634	Y0 = Pulse Y1 = Direction	0103
		Y0 = CW Pulse Y1 = CCW Pulse	0003
X1	V7635	Filtered Input	xx06 (xx = filter time)
X2	V7636	External Interrupt	1006
X3	V7637	Filtered Input	xx06 (xx = filter time)

Logical I/O Functions

The following logical I/O references define functions that allow the HSIO to communicate with the ladder program.

Logical I/O	Function
X0	Profile Complete – the HSIO turns on X0 to the CPU when the profile completes. Goes back off when Start Profile (Y0) turns on.
Y0	Start Profile – the ladder program turns on Y0 to start motion. If turned off before the move completes, motion stops. Turning it on again will start another profile, unless the current position equals the target position.
Y1	Preload Position Value – if motion is stopped and Start Profile is off, you can load a new value in CT76/CT77, and turn on Y1. At that transition, the value in CT76/CT77 becomes the current position.

Setup for Mode 30

Recall that V7633 is the HSIO Mode Select register. Refer to the diagram below. Use BCD 30 in the lower byte to select Pulse Output Mode. Use BCD 00 or 20 in the upper byte as required. Combine the two bytes into a data word “xx30”, for writing to V7633.

Memory Location V7633

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0
	2				0				3				0			

Miscellaneous Setup (BCD)
00 = Power Up in Previous Mode
20 = Power Up in Run Mode Always

HSIO Mode Setup (BCD)
30 = Pulse Output

Choose the most convenient method of programming V7633 from the following:

- Include load and out instructions in your ladder program
- ***DirectSOFT32***’s memory editor
- Use the Handheld Programmer D2–HPP

We recommend using the first method above so that the HSIO setup becomes an integral part of your application program. An example program later in this section shows how to to this.

Profile / Velocity Select Register

The first location in the Profile Parameter Table stores two key pieces of information. The upper four bits (12–15) select the type of profile required. The lower 12 bits (0–11) select the Target Velocity.

Memory Location V2320 (default)

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
	0				7				0				0			

Profile Select (BCD)
0 = Trapezoidal Profile, Absolute Position
8 = Trapezoidal Profile, Relative Position
9 = Registration Profile, Relative Position
2 = Velocity Profile

Target Velocity Value
Range = 4 to 700, representing
40 Hz to 7 kHz pulse rate

The ladder program must program this location before initiating any of the three profiles. The LD and OUT instruction will write all 16 bits, so be sure to fully specify the full four-digit BCD value for the Position / Velocity Select Register each time.

The absolute and relative selection determines how the HSIO circuit will interpret your specified target position. Absolute position targets are referenced to zero. Relative position targets are referenced to the current position (previous target position). You may choose whichever reference method that is most convenient for your application.

Profile Parameter Table

V7630 is a pointer location which points to the beginning of the Profile Parameter Table. The default starting location for the profile parameter table is V2320. However, you may change this by programming a different value in V7630. Remember to use the LDA (load address) instruction, converting octal into hex.

The HSIO uses the next V-memory register past the bottom of the profile parameter table to indicate profile errors. See the error table at the end of this section for error code definitions.

Profile Table Pointer

V7630	**2320**

Profile Parameter Table

V2320	xxxx	
V2321	xxxx	xxxx
V2323	xxxx	
V2324	xxxx	
V2325	xxxx	

Pulse Output Error Code

V2326	00xx

Trapezoidal Profile

V-Memory	Function	Range	Units
V2320, bits 12–15	Trapezoidal Profile	0=absolute, 8=relative	–
V2320, bits 0–11	Target Velocity Value	4 to 700	x 10 pps
V2321/ 2322	Target Position Value	–88388608 to 88388607	Pulses
V2323	Starting Velocity	4 to 100	x 10 pps
V2324	Acceleration Time	1 to 100	x 100 mS
V2325	Deceleration Time	1 to 100	x 100 mS
V2326	Error Code	(see end of section)	–

Registration Profile

V-Memory	Function	Range	Units
V2320, bits 12–15	Registration Profile	9=relative	–
V2320, bits 0–11	Target Velocity Value	4 to 700	x 10 pps
V2321/ 2322	Target Position Value	–88388608 to 88388607	Pulses
V2323	Starting Velocity	4 to 100	x 10 pps
V2324	Acceleration Time	1 to 100	x 100 mS
V2325	Deceleration Time	1 to 100	x 100 mS
V2326	Error Code	(see end of section)	–

Velocity Profile

V-Memory	Function	Range	Units
V2320	Velocity Profile	2000 only	–
V2321/ 2322	Direction Select	80000000=CCW, 0=CW	Pulses
V2323	Velocity	4 to 700	x 10 pps
V2326	Error Code	(see end of section)	–

Choosing the Profile Type

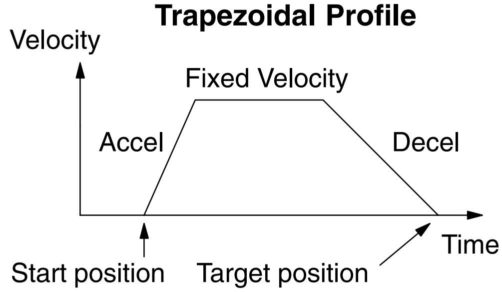
Pulse Output Mode generates three types of motion profiles. Most applications use one type for most moves. However, each move can be different if required.

- Trapezoidal – Accel Slope to Target Velocity to Decel Slope
- Registration – Velocity to Position Control on Interrupt
- Velocity Control – Speed and Direction only

Trapezoidal Profile Defined

The trapezoidal profile is the most common positioning profile. It moves the load to a pre-defined target position by creating a move profile. The acceleration slope is applied at the starting position. The deceleration slope is applied backwards from the target position. The remainder of the move in the middle is spent traveling at a defined velocity.

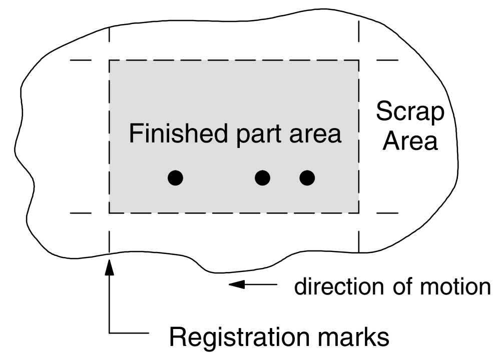
Trapezoidal Profile



Trapezoidal profiles are best for simple point-to-point moves, when the distance between the starting and ending positions of the move is known in advance.

Registration and Home Search Profiles Defined

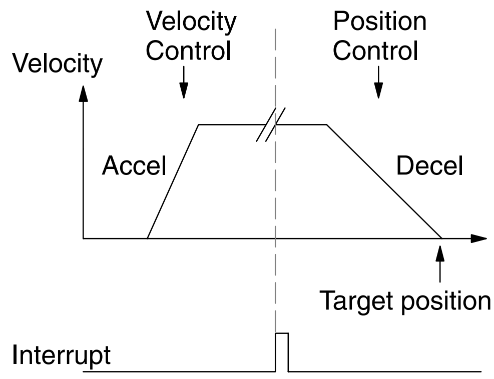
Registration profiles solve a class of motion control problems. In some applications, product material in work moves past a work tool such as a drill station. Shown to the right, registration marks on the scrap area of the work-piece allow a machine tool to register its position relative to the rectangle, to drill properly.



Home search moves allow open-loop motion systems to re-calibrate (preload) the current position value at powerup.

Registration profiles are a combination of velocity and position control modes. The move begins by accelerating to a programmed velocity. The velocity is sustained and the move is of indefinite duration. When an external interrupt signal occurs (due to registration sensing), the profile switches from velocity to position control. The move ends by continuing motion a pre-defined distance past the interrupt point (such as a drill hole location). The deceleration ramp is applied in advance of the target position.

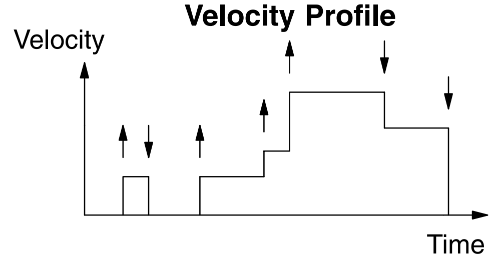
Registration Profile



Velocity Profile Defined

The velocity profile controls only the direction and speed of motion. There is no target position specified, so the move can be of indefinite length. Only the first velocity value needs to be defined. The remaining velocity values can be created while motion in in progress. Arrows in the profile shown indicate velocity changes.

Velocity Profile

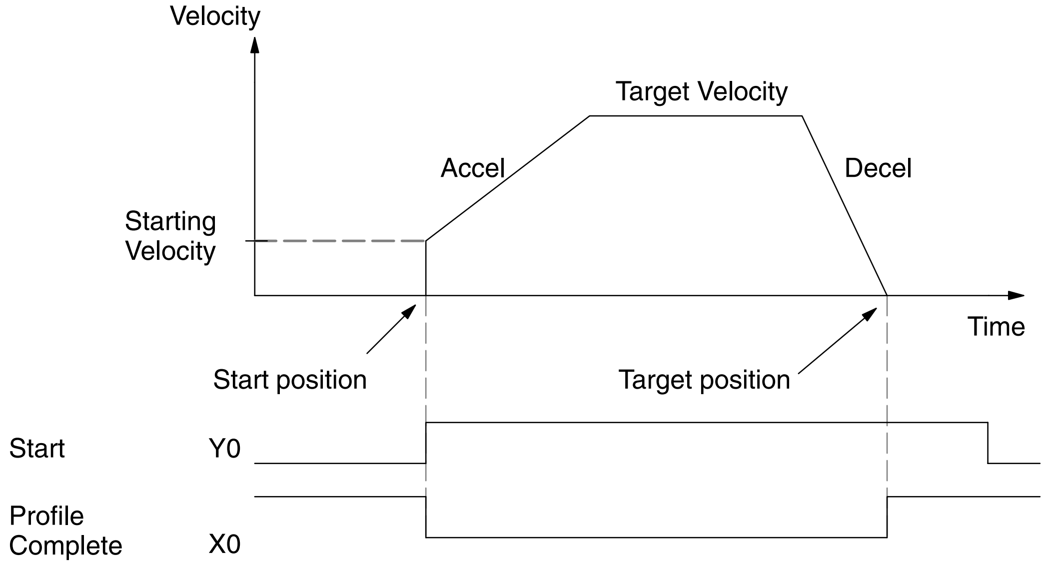


Trapezoidal Profile Operation

Trapezoidal Profile Applications

The trapezoidal profile is best suited for simple point-to-point moves, when the target position is known in advance. Starting velocities must be within the rage of 40 pps to 1 kpps. The remainder of the profile parameters are in the profile parameter table.

Trapezoidal Profile



The time line of signal traces below the profile indicates the order of events.

The HSIO uses logical output Y0 as the Start input to the HSIO, which starts the profile. Immediately the HSIO turns off the Profile Complete signal (logical X0), so the ladder program can monitor the progress of the move. Typically a ladder program will monitor this bit so it knows when to initiate the next profile move.

If you are familiar with motion control, you'll notice that we do not have to specify the direction of the move. The HSIO function examines the target position relative to the current position, and automatically outputs the correct direction information to the motor drive.

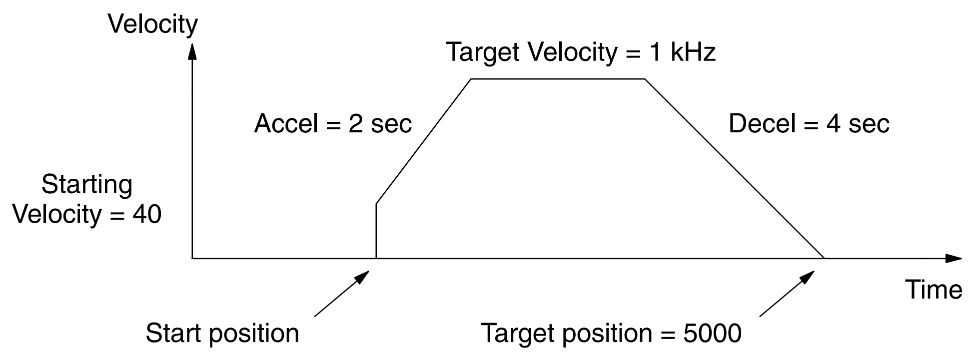
Notice that the motion accelerates immediately to the starting velocity. This segment is useful in stepper systems so we can jump past low speed areas when low-torque problems or a resonant point in the motor might cause a stall. (When a stepper motor stalls, we have lost the position of the load in open-loop positioning systems). However, is is preferable not to make the starting velocity too large, because the stepper motor will also "slip" some pulses due to the inertia of the system.

When you need to change the current position value, use logical Y1 output coil to load a new value into the HSIO counter. If the ladder program loads a new value in CT76/CT77 (V1076/V1077), then energizing Y1 will copy that value into the HSIO circuit counter. This must occur before the profile begins, because the HSIO ignores Y1 during motion.

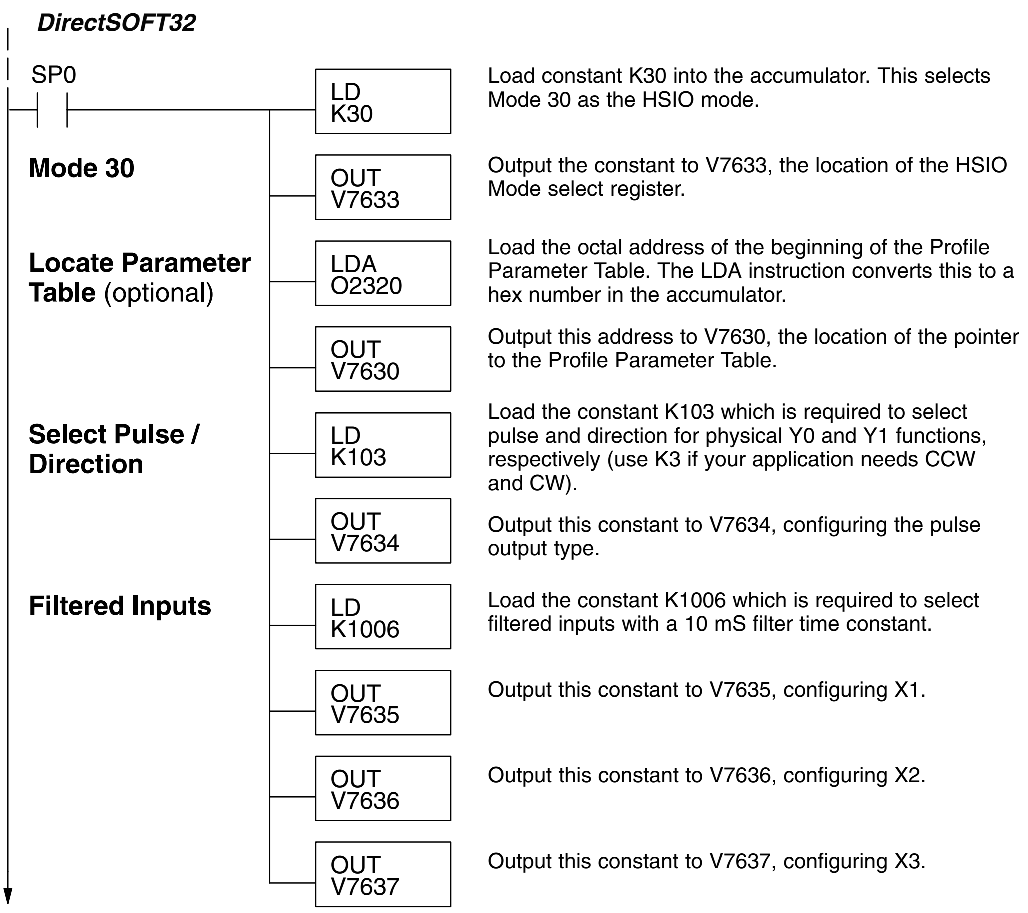
Trapezoidal Profile Program Example

The trapezoidal profile we want to perform is drawn and labeled in the following figure. It consists of a non-zero starting velocity, and moderate target velocity.

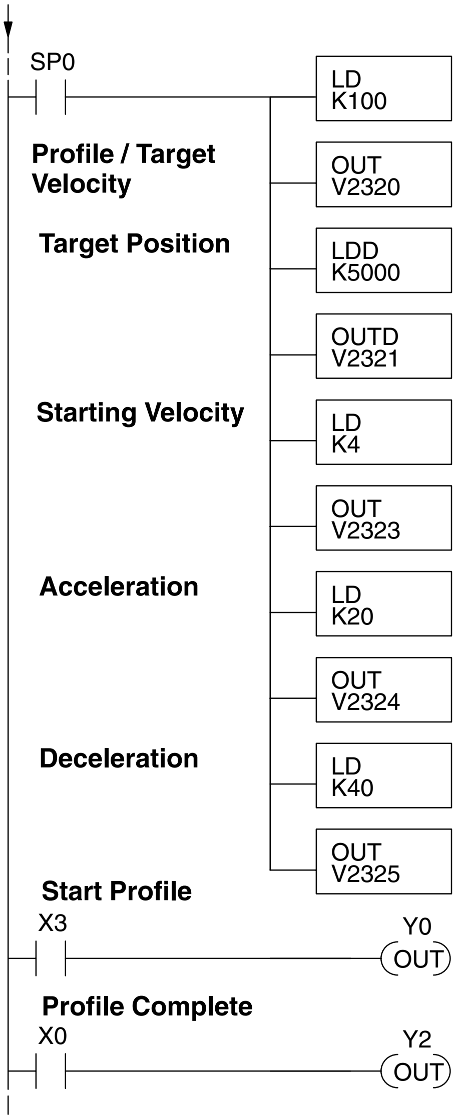
Trapezoidal Profile



The following program will realize the profile drawn above, when executed. The beginning of the program contains all the necessary setup parameters for Pulse Output Mode 30. We only have to do this once in the program, so we use first-scan contact SP0 to trigger the setup.



Program Example Cont'd



Load the constant K100 which is required to select Trapzoidal Profile, absolute positioning, and a target velocity of 1 kHz.

Output this constant to V2320, the location of the Profile Select / Starting Velocity setup register.

Load the constant K5000 which selects a target position of 5000 pulses. Don't forget to use double word size (8-digit BCD position value).

Output this constant to V2321 and V2322, the location of the Target Position double-word register.

Load the constant K4 which is required to select a starting velocity of 40 Hz (4 x 10 pps).

Output this constant to V2323, the location of the starting velocity parameter register.

Load the constant K20 which is required to select an acceleration time of 2 seconds (20 x 100 mS).

Output this constant to V2324, the location of the acceleration parameter register.

Load the constant K40 which is required to select a deceleration time of 4 seconds (40 x 100 mS).

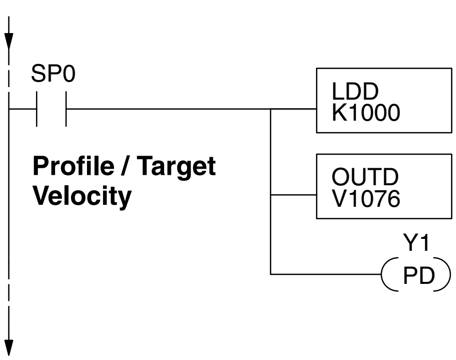
Output this constant to V2325, the location of the deceleration parameter register.

We use a spare filtered input to allow the operator to start the profile. When the operator turns X3 ON, then OFF, logical output Y0 starts the profile.

X0 is the logical output of the HSIO to indicate the move is complete. We use Y2 to energize an annunciator that the profile has finished.

Preload Position Value

At any time you can write (preload) a new position into the current position value. This often done after a home search (see the registration example programs).



Load the constant K1000 as the new current position value.

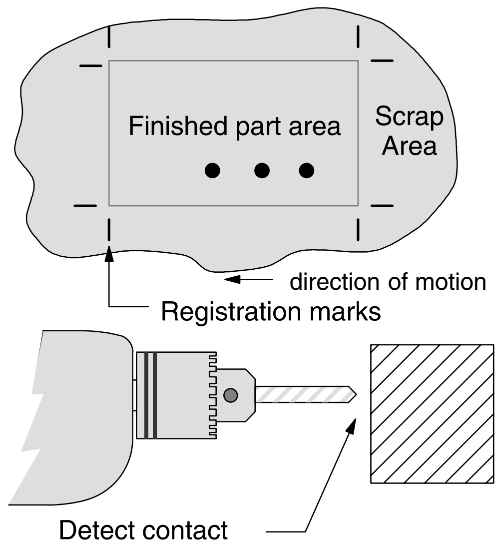
Output this constant to V1076/V1077 (CTA76/CTA77). the location of the current position value.

Turn on Y1 for 1 scan. The off-to-on transition causes the HSIO to preload the current position with the value in

Registration Profile Operation

Registration Applications

1. In a typical application shown to the right, product material in work moves past a work tool such as a drill. Registration marks on the scrap area of the work-piece allow a machine tool to register its position relative to the rectangle, to drill properly.

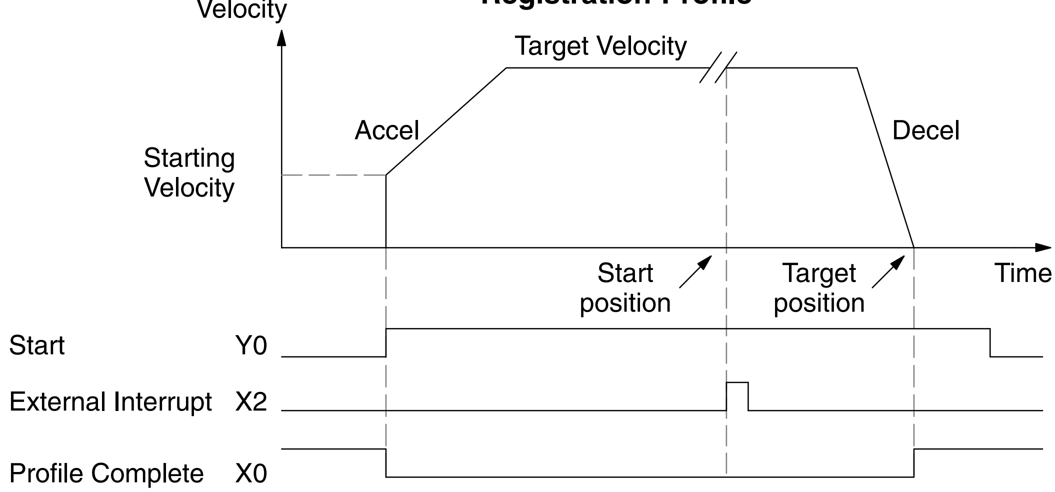


2. In other examples of registration, the work piece is stationary and the tool moves. A drill bit may approach the surface of a part in work, preparing to drill a hole of precise depth. However, the drill bit length gradually decreases due to tool wear. A method to overcome this is to detect the moment of contact with the part surface on each drill, moving the bit into the part a constant distance after contact.

3. The home search move allows a motion system to calibrate its position on startup. In this case, the positioning system makes an indefinite move and waits for the load to pass by a home limit switch. This creates an interrupt at the moment when the load is in a known position. We then stop motion and preload the position value with a number which equates to the physical "home position".

The registration profile begins with only velocity control. When an interrupt pulse occurs on physical input X2, the starting position is declared to be the present count (current load position). The velocity control switches to position control, moving the load to the target position. Note that the minimum starting velocity is 40 pps. This instantaneous velocity accommodates stepper motors that can stall at low speeds.

Registration Profile

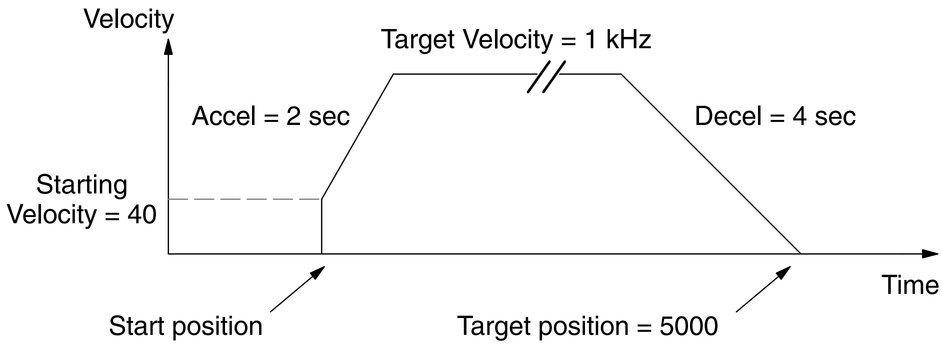


The time line of signal traces below the profile indicates the order of events. The CPU uses logical output Y0 to start the profile. Immediately the HSIO turns off the Profile Complete signal (logical X0), so the ladder program can monitor the move's completion by sensing the signal's on state.

Registration Profile Program Example

The registration profile we want to perform is drawn and labeled in the following figure. It consists of a non-zero starting velocity, and moderate target velocity.

Registration Profile



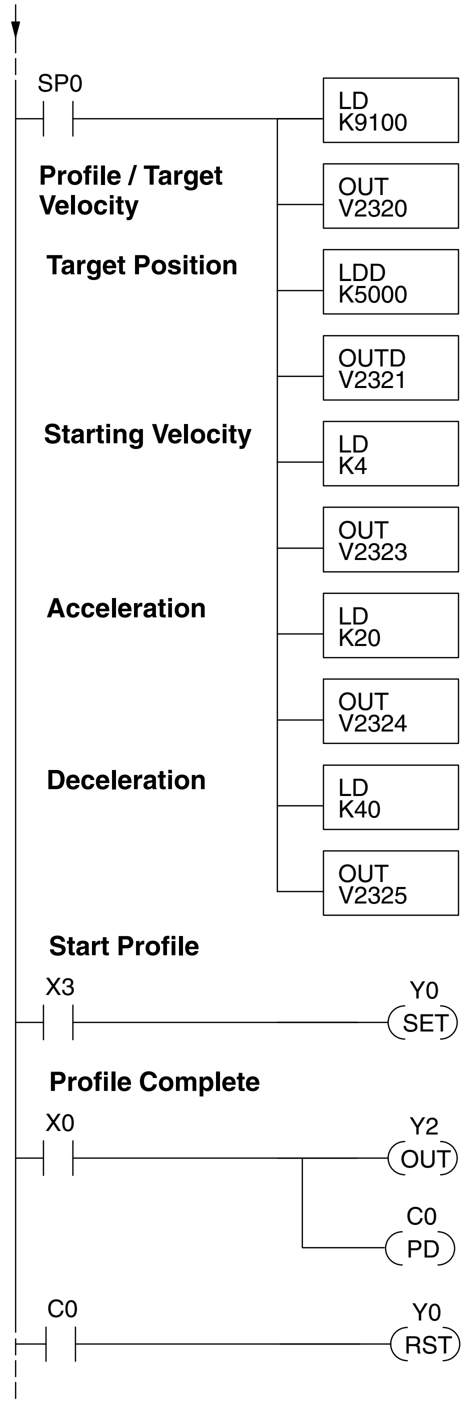
The following program will realize the profile drawn above, when executed. The first program rung contains all the necessary setup parameters. We only have to do this once in the program, so we use first-scan contact SP0 to trigger the setup.

DirectSOFT32

SP0

Mode 30	LD K30	Load constant K30 into the accumulator. This selects Mode 30 as the HSIO mode.
	OUT V7633	Output this constant to V7633, the location of the HSIO Mode select register.
Locate Parameter Table (optional)	LDA O2320	Load the octal address of the beginning of the Profile Parameter Table. The LDA instruction converts this to a hex number in the accumulator.
	OUT V7630	Output this address to V7630, the location of the pointer to the Profile Parameter Table.
Select Pulse / Direction	LD K103	Load the constant K103 which is required to select pulse and direction for physical Y0 and Y1 functions, respectively (your application may use CCW and CW).
	OUT V7634	Output this constant to V7634, configuring the pulse output type.
Filtered Inputs	LD K2006	Load the constant K2006 which is required to select filtered inputs with a 20 mS filter time constant.
	OUT V7635	Output this constant to V7635, configuring X1.
	OUT V7637	Output this constant to V7637, configuring X3.
	LD K1006	Load the constant K1006 which is required to select the external interrupt.
	OUT V7636	Output this constant to V7636, configuring X2, the registration interrupt input.

Program Example Cont'd



Load the constant K9100 which is required to select Registration Profile, relative positioning, and a target velocity of 1 kHz (9xxx times 10 pps).

Output this constant to V2320, the location of the Profile Select / Starting Velocity setup register.

Load the constant K5000 which selects a target position of 5000 pulses. Don't forget to use double word size (8-digit BCD position value).

Output this constant to V2321 and V2322, the location of the Target Position double-word register.

Load the constant K4 which is required to select a starting velocity of 40 Hz (4 x 10 pps).

Output this constant to V2323, the location of the starting velocity parameter register.

Load the constant K20 which is required to select an acceleration time of 2 seconds (20 x 100 mS).

Output this constant to V2324, the location of the acceleration parameter register.

Load the constant K40 which is required to select a deceleration time of 4 seconds (40 x 100 mS).

Output this constant to V2325, the location of the deceleration parameter register.

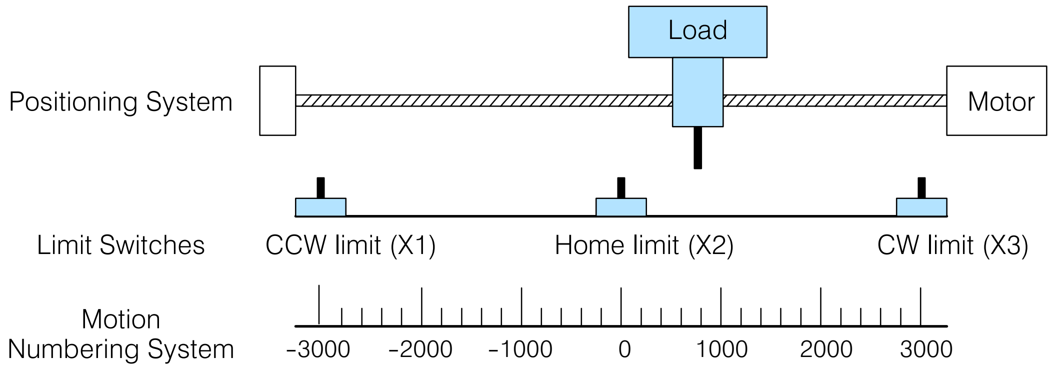
We use a spare filtered input to allow the operator to start the profile. X3 is a momentary Start switch. When the operator turns X3 ON, logical output Y0 starts the profile.

X0 is the logical output of the HSIO to indicate the move is complete. We use Y2 to energize an annunciator that the profile has finished. This won't occur until after the interrupt from X2 has occurred and the profile is complete.

The profile will begin when the start input (X3) is given. Then the motion begins an indefinite move, which lasts until an external interrupt on X2 occurs. Then the motion continues on for 5000 more pulses before stopping.

Home Search Program Example

One of the more challenging aspects of motion control is the establishment of actual position at powerup. This is especially true for open-loop systems which do not have a position feedback device. However, a simple limit switch located at an exact location on the positioning mechanism can provide “position feedback” at one point. For most stepper control systems, this method is a good and economical solution.

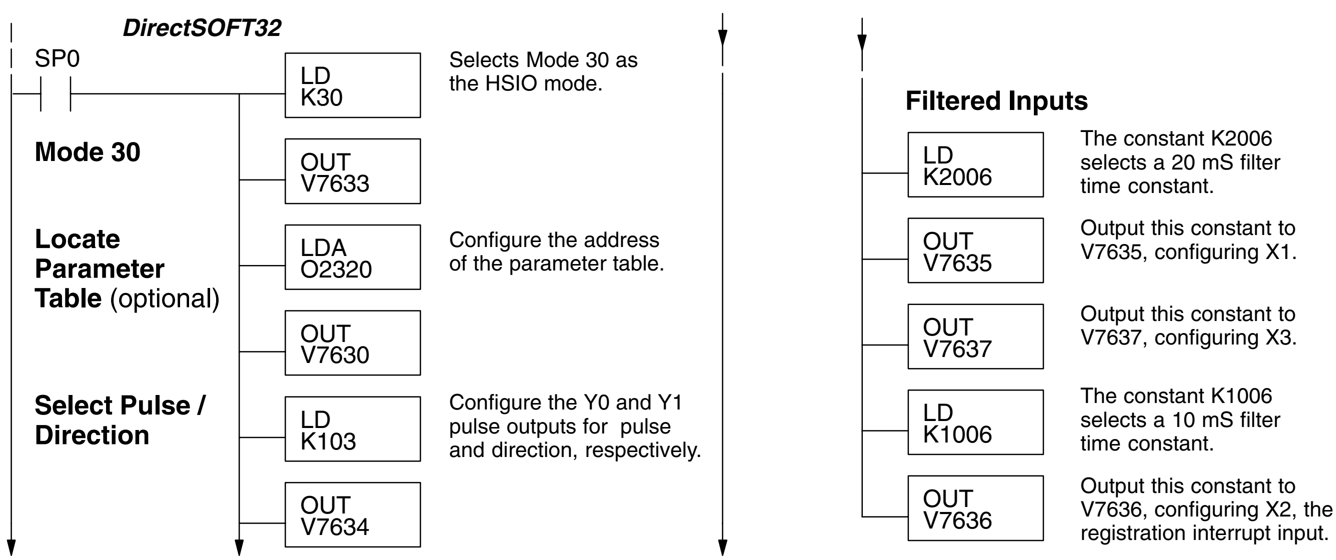


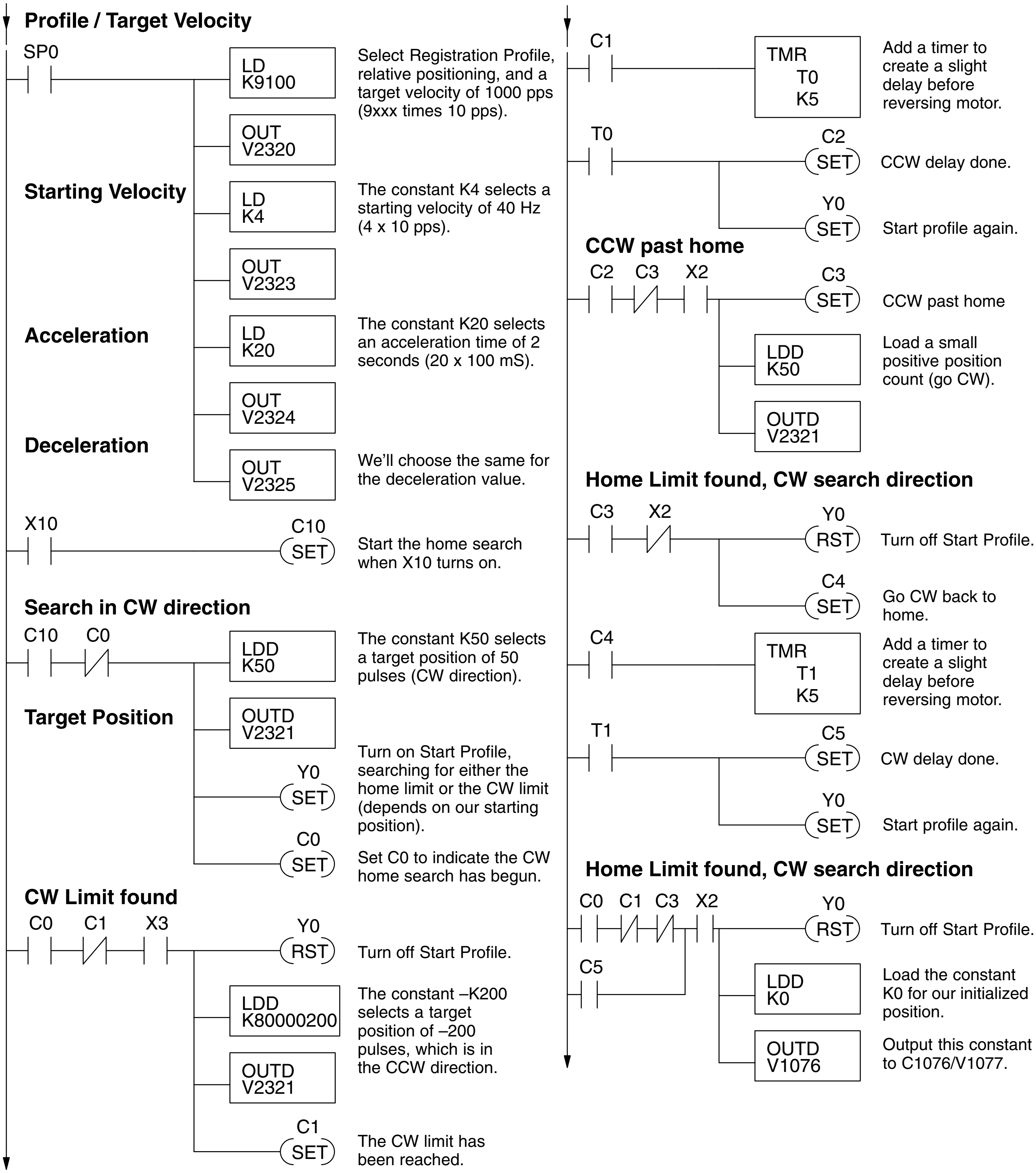
In the drawing above, the load moves left or right depending on the CCW/CW direction of motor rotation. The PLC ladder program senses the CCW and CW limit switches to stop the motor, before the load moves out-of-bounds and damages the machine. The home limit switch is used at powerup to establish the actual position. The numbering system is arbitrary, depending on a machine’s engineering units.

At powerup, we do not know whether the load is located to the left or to the right of the home limit switch. Therefore, we will initiate a *home search profile*, using the registration mode. The home limit switch is wired to X2, causing the interrupt. We choose an arbitrary initial search direction, moving in the CW (left-to-right) direction.

- If the home limit switch closes first, then we stop and initialize the position (this value is typically “0”, but it may be different if preferred).
- However, if the CW limit switch closes first, we must reverse the motor and move until the home limit switch closes, stopping just past it.

In the latter case, we repeat the first move, because we always need to make the final approach to the home limit switch *from the same direction*, so that the final *physical* position is the same in either case!





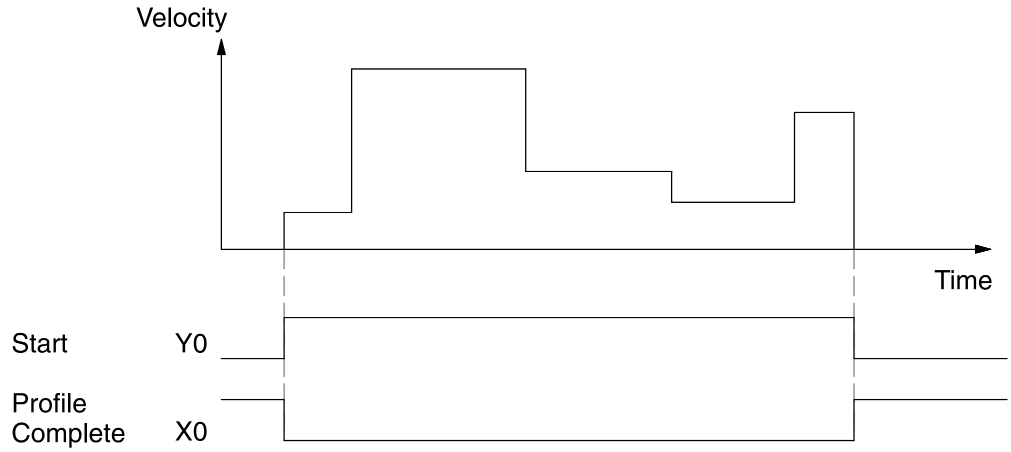
The home search profile will execute specific parts of the program, based on the order of detection of the limit switches. Ladder logic sets C0 to initiate a home search in the CW direction. If the CW limit is encountered, the program searches for home in the CCW direction, passes it slightly, and does the final CW search for home. After reaching home, the last ladder rung preloads the current position to "0".

Velocity Profile Operation

Velocity Profile Applications

The velocity profile is best suited for applications which involve motion but do not require moves to specific points. Conveyor speed control is a typical example.

Velocity Profile



The time line of signal traces below the profile indicates the order of events. Assuming the velocity is set greater than zero, motion begins when the Start input (Y0) energizes. Since there is no end position target, the profile is considered in progress as long as the Start input remains active. The profile complete logical input to ladder logic (X0) correlates directly to the Start input status when velocity profiles are in use.

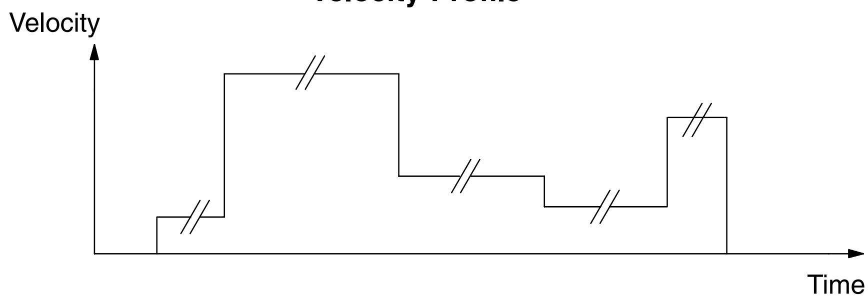
While the Start input is active, the ladder program can command a velocity change by writing a new value to the velocity register (V2323 by default). The full speed range of 40 Hz to 7 kHz is available. Notice from the drawing that there are no acceleration or deceleration ramps between velocity updates. This is how velocity profiling works with the HSIO. However, the ladder program can command more gradual velocity changes by incrementing or decrementing the velocity value more slowly. A counter or timer can be useful in creating your own acceleration/deceleration ramps. Unless the load must do a very complex move, it is easier to let the HSIO function generate the accel/decel ramps by selecting the trapezoidal or registration profiles instead.

Unlike the trapezoidal and registration profiles, you must specify the desired direction of travel with velocity profiles. Load the direction select register (V2321/V2322 by default) with 8000 0000 hex for CCW direction, or 0 for CW direction.

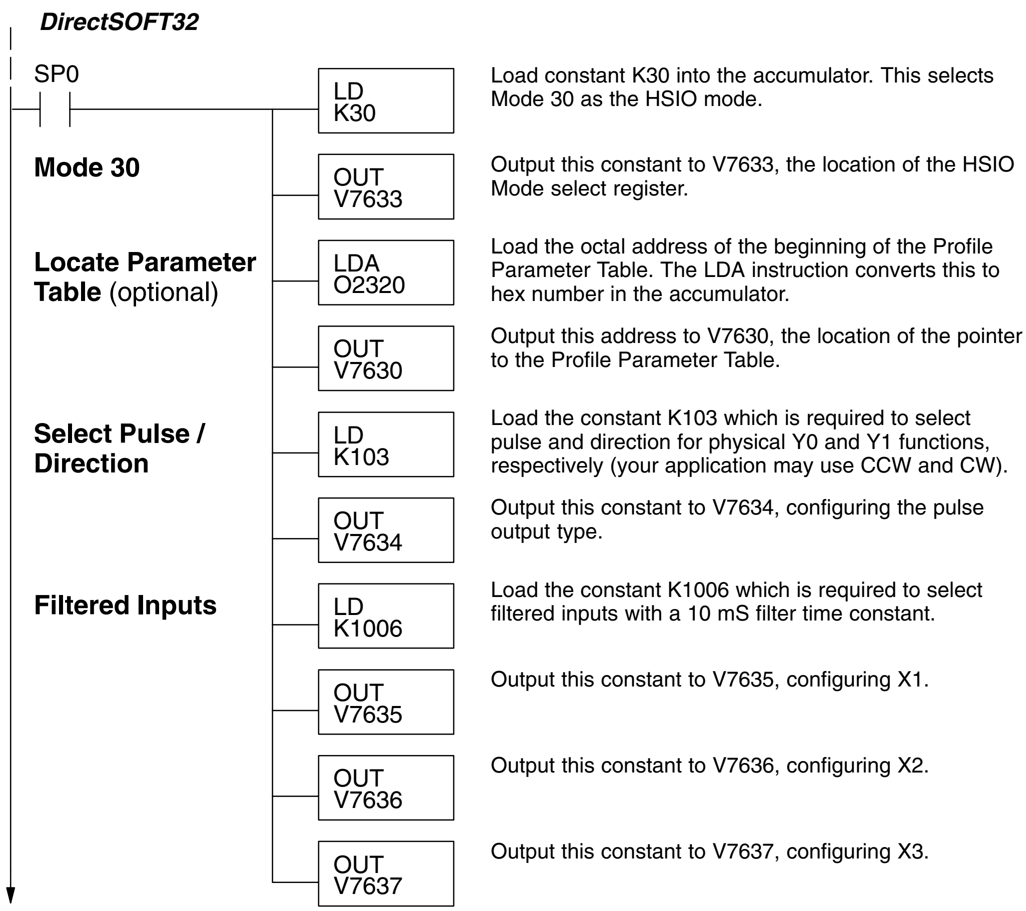
Velocity Profile Program Example

The velocity profile we want to perform is drawn and labeled in the following figure. Each velocity segment is of indefinite length. The velocity only changes when ladder logic (or other device writing to V-memory) updates the velocity parameter.

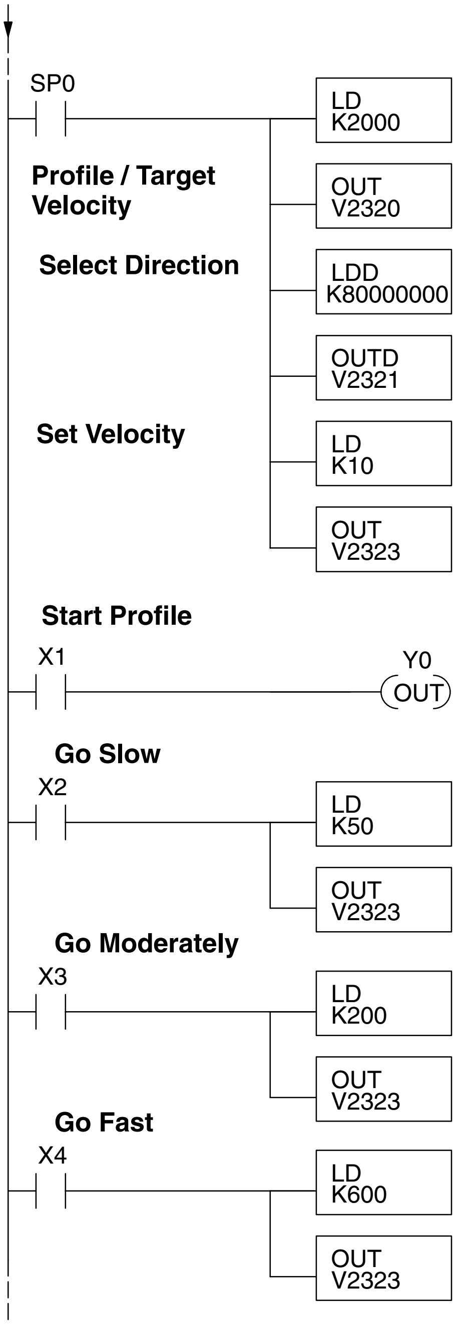
Velocity Profile



The following program uses dedicated discrete inputs to load in new velocity values. This is a fun program to try, because you can create an infinite variety of profiles with just two or three input switches. The intent is to turn on only one of X1, X2, or X3 at a time. The beginning of the program contains all the necessary setup parameters for Pulse Output Mode 30. We only have to do this once in the program, so we use first-scan contact SP0 to trigger the setup.



Program Example Cont'd



Load the constant K2000 which is required to select Velocity Profile. This data word contains no velocity information in the case of velocity mode.

Output this constant to V2320, the location of the Profile Select setup register.

Load the constant K80000000 which selects CCW direction for Velocity Profiles. Don't forget to use double word size (8-digit BCD position value).

Output this constant to V2321 and V2322, the location of the Target Position double-word register.

Load the constant K10 which is required to select an initial velocity of 100 pps (uses x10 multiplier).

Output this constant to V2323, the location of the velocity parameter register. After the program is running, we can write here again, using discrete input switches.

We use a spare filtered input to allow the operator to start the profile. When the operator turns X1 ON and leaves it on, logical output Y0 starts the profile.

Load the constant K50 which is required to select a velocity of 500 pps when the operator closes X2.

Output this constant to V2323, the location of the velocity parameter register. The speed will change immediately.

Load the constant K200 which is required to select a velocity of 2000 pps when the operator closes X3.

Output this constant to V2323, the location of the velocity parameter register. The speed will change immediately.

Load the constant K600 which is required to select a velocity of 6000 pps when the operator closes X4.

Output this constant to V2323, the location of the velocity parameter register. The speed will change immediately.

Pulse Output Error Codes

The Profile Parameter Table starting at V2320 (default location) defines the profile. Certain numbers will result in a error when the HSIO attempts to use the parameters to execute a move profile. When an error occurs, the HSIO writes an error code in V2326.

Error Code	Error Description
0000	No error
0010	Requested profile type code is invalid (must use 0, 1, 2, 8, or 9)
0020	Target Velocity is not in BCD
0021	Target Velocity is specified to be less than 40 pps
0022	Target Velocity is specified to be greater than 7,000 pps
0030	Target Position value is not in BCD
0040	Starting Velocity is not in BCD
0041	Starting Velocity is specified to be less than 40 pps
0042	Starting Velocity is specified to be greater than 1,000 pps
0050	Acceleration Time is not in BCD
0051	Acceleration Time is zero
0052	Acceleration Time is greater than 10 seconds
0010	Deceleration Time is not in BCD
0010	Deceleration Time is zero
0010	Deceleration Time is greater than 10 seconds

Most errors can be corrected by rechecking the Profile Parameter Table values. The error is automatically cleared at powerup and at Program-to-Run Mode transitions.

Troubleshooting Guide for Mode 30

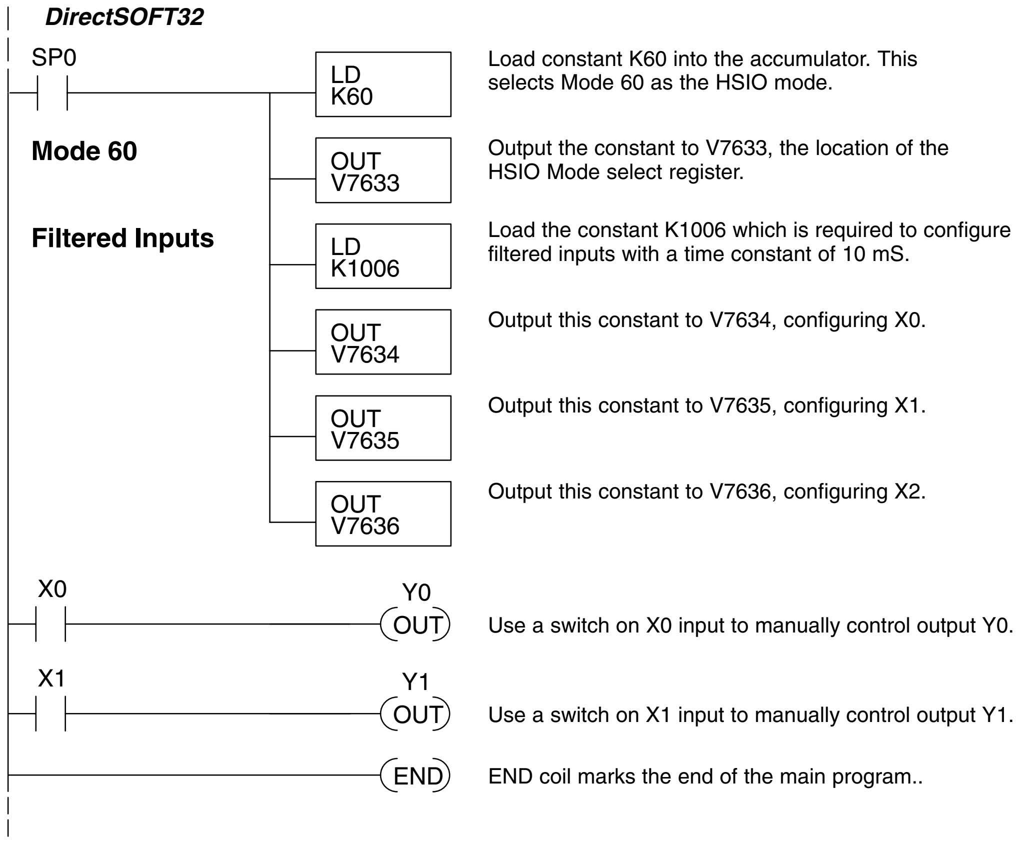
If you're having trouble with Mode 30 operation, please study the following symptoms and possible causes. The most common problems are listed below:

Symptom: The stepper motor does not rotate.

Possible causes:

1. **Configuration** – Verify that the HSIO actually generates pulses on outputs Y0 and Y1. Watch the status LEDs for Y0 and Y1 when you start a motion profile. If the LEDs flicker on and off or are steadily on, the configuration is probably correct.
2. **Programming error** – If there are no pulses on Y0 or Y1 you may have a programming error. Check the contents of V2326 for an error code that may be generated when the PLC attempts to do the move profile. Error code descriptions are given above.

3. **Wiring** – Verify the wiring to the stepper motor is correct. Remember the signal ground connection from the PLC to the motion system is required.
4. **Motion system** – Verify that the drive is powered and enabled. To verify the motion system is working, you can use Mode 60 operation (normal PLC inputs/outputs) as shown in the test program below. With it, you can manually control Y0 and Y1 with X0 and X1, respectively. Using an input simulator is ideal for this type of manual debugging. With the switches you can single-step the motor in either direction. If the motor will not move with this simple control, Mode 30 operation will not be possible until the problem with the motor drive system or wiring is corrected.



5. **Memory Error** – HSIO configuration parameters are stored in the CPU system memory. Corrupted data in this memory area can sometimes interfere with proper HSIO operation. If all other corrective actions fail, initializing the scratchpad memory may solve the problem. With ***Direct***SOFT32, select the *PLC* menu, then *Setup*, then *Initialize Scratchpad*.

Symptom: The motor turns in the wrong direction.

Possible causes:

1. **Wiring** – If you have selected CW and CCW type operation, just swap the wires on Y0 and Y1 outputs.
2. **Direction control** – If you have selected Pulse and Direction type operation, just change the direction bit to the opposite state.

Mode 40: High-Speed Interrupts

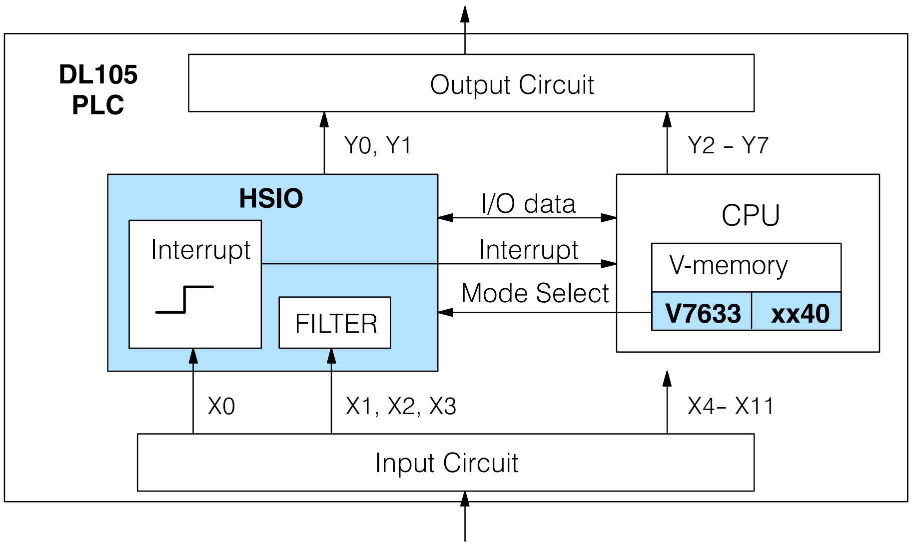
Purpose

The HSIO Mode 40 provides a high-speed interrupt to the ladder program. This capability is provided for your choice of the following application scenarios:

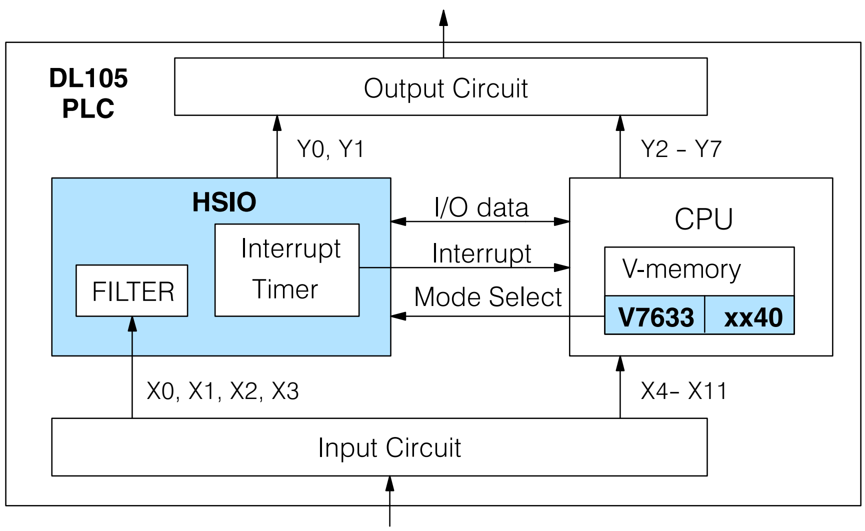
- An external event needs to trigger an interrupt subroutine in the CPU. Using immediate I/O instructions in the subroutine is typical.
- An interrupt routine needs to occur on a timed basis which is different from the CPU scan time (either faster or slower). The timed interrupt is programmable, from 5 to 999 mS.

Functional Block Diagram

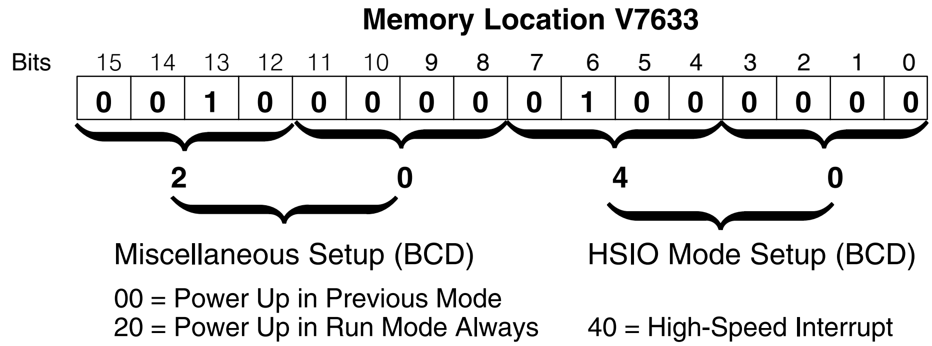
The HSIO circuit creates the high-speed interrupt to the CPU. The following diagram shows the external interrupt option, which uses X0. In this configuration, X1, X2, and X3 are all normal filtered inputs.



Alternately, you may configure the HSIO circuit to generate interrupts based on a timer, as shown below. In this configuration, inputs X0 through X3 are filtered inputs.



Setup for Mode 40 Recall that V7633 is the HSIO Mode Select register. Refer to the diagram below. Use BCD 40 in the lower byte to select High-Speed Interrupt Mode. Use BCD 00 or 20 in the upper byte as required. Combine the two bytes into a data word “xx40”, for writing to V7633.



Choose the most convenient method of programming V7633 from the following:

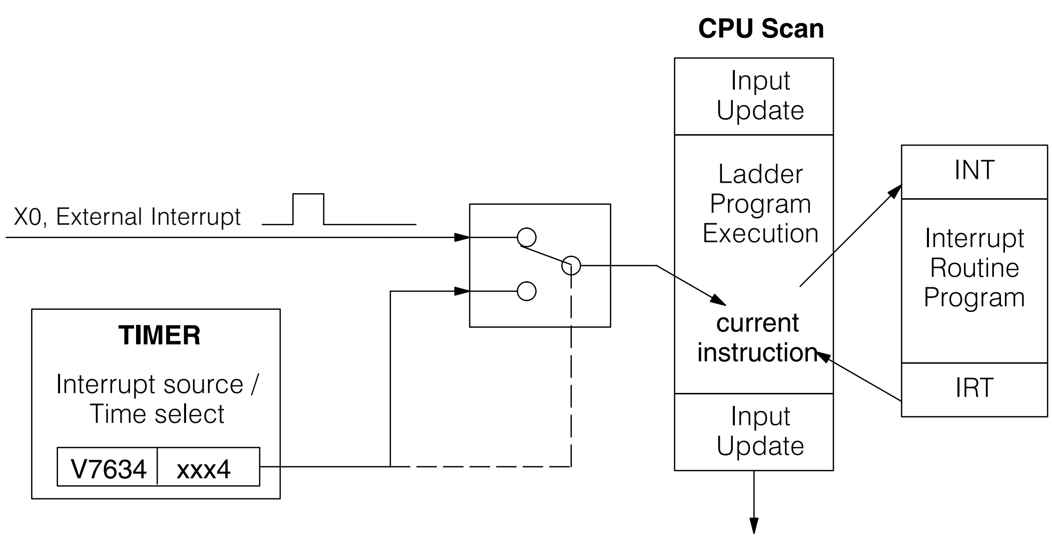
- Include load and out instructions in your ladder program
- ***Direct***SOFT32’s memory editor
- Use the Handheld Programmer D2–HPP

We recommend using the first method above so that the HSIO setup becomes an integral part of your application program. An example program later in this section shows how to to this.

Interrupts and the Ladder Program Refer to the drawing below. The source of the interrupt may be external (X0), or the HSIO timer function. The setup parameter in V7634 serves a dual purpose:,

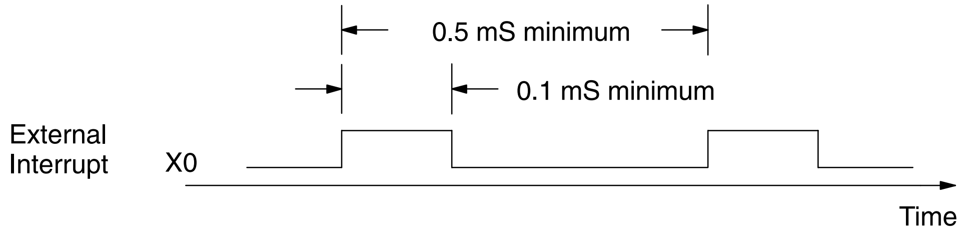
- It selects between the two interrupt sources, external (X0) or an internal timer.
- In the case of the timer interrupt, it programs the interrupt timebase between 5 and 999 mS.

The resulting interrupt uses label INT 0 in the ladder program. Be sure to include the Enable Interrupt (ENI) instruction at the beginning of your program. Otherwise, the interrupt routine will not be executed.



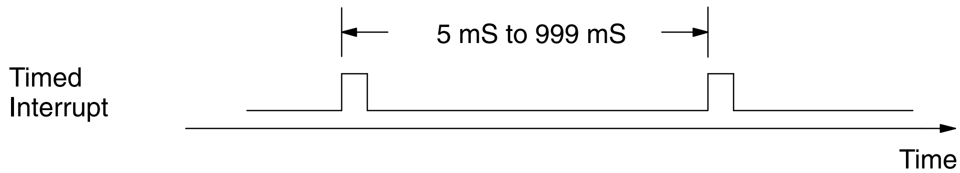
External Interrupt Timing Parameters

Signal pulses at X0 must meet certain timing criteria to guarantee an interrupt will result. Refer to the timing diagram below. The input characteristics of X0 are fixed (it is not a programmable filtered input). The minimum pulse width is 0.1 mS. There must be some delay before the next interrupt pulse arrives, such that the interrupt period cannot be smaller than 0.5 mS.



Timed Interrupt Parameters

When the timed interrupt is selected, the HSIO generates the interrupt to ladder logic. There is no interrupt “pulse width” in this case, but the interrupt period can be adjusted from 5 to 999 mS.



X Input / Timed INT Configuration

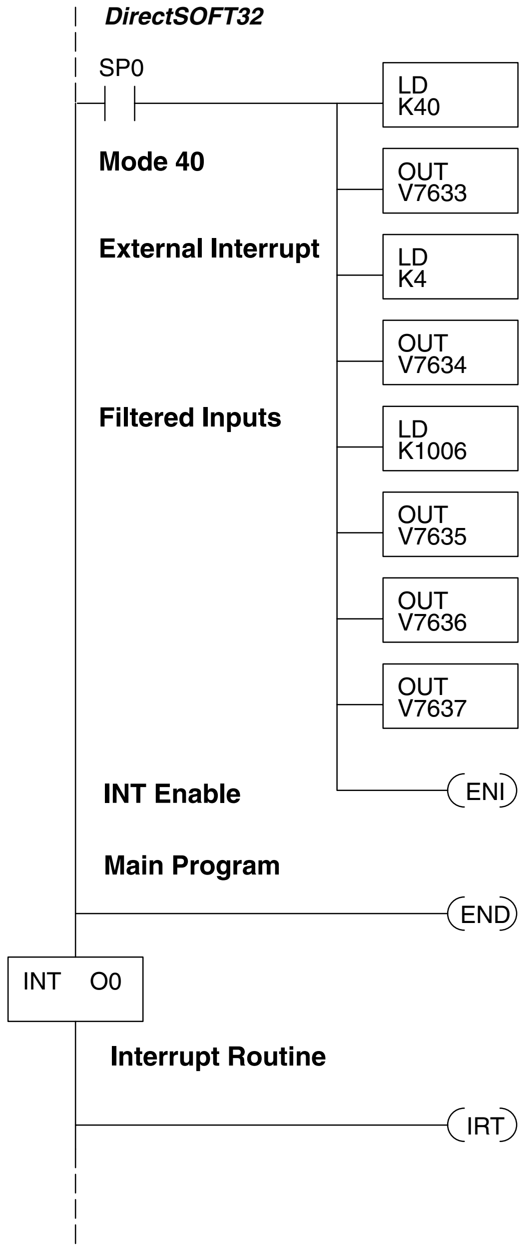
The configurable discrete input options for High-Speed Interrupt Mode are listed in the table below. Input X0 is the external interrupt when “0004” is in V7634. If you need a timed interrupt instead, then V7634 contains the interrupt time period, and input X0 becomes a filtered input (uses X1’s filter time constant by default). Inputs X1, X2, and X3 can only be filtered inputs, having individual configuration registers and filter time constants. However, X0 will have the same filter time constant as X1 when the timed interrupt is selected.

Input	Configuration Register	Function	Hex Code Required
X0	V7634	External Interrupt	0004
	Uses X1’s code in V7635	Filtered Input (when timed interrupt is in use)	0054 to 9994, which is the timed INT timebase
X1	V7635	Filtered Input	xx06 (xx = filter time)
X2	V7636	Filtered Input	xx06 (xx = filter time)
X3	V7637	Filtered Input	xx06 (xx = filter time)

High-Speed Input and Pulse Output Features

External Interrupt Program Example

The following program selects Mode 40, then selects the external interrupt option. Inputs X1, X2, and X3 are all configured as filtered inputs with a 10 mS time constant. The program is otherwise generic, and may be adapted to your application.



Load constant K40 into the accumulator. This selects Mode 40 as the HSIO mode.

Output this constant to V7633, the location of the HSIO Mode select register.

Load the constant K4 which is required to select the external interrupt option. X0 is the interrupt input.

Output this constant to V7634, configuring the external interrupt option for X0.

Load the constant K1006 which is required to select filtered inputs with a 10 mS filter time constant.

Output this constant to V7635, configuring X1.

Output this constant to V7636, configuring X2.

Output this constant to V7637, configuring X3.

Enable Interrupts at the beginning of the program.

Insert Main Program rungs here for your application.

END coil marks the end of the main program..

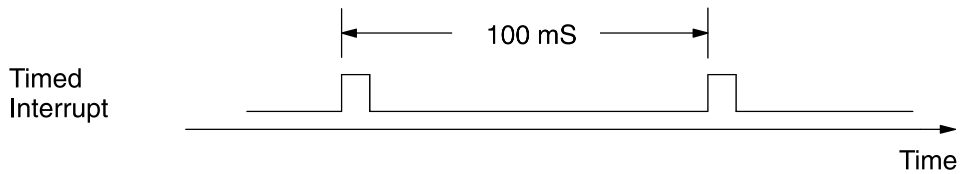
The INT label marks the beginning of the interrupt service routine program.

Insert interrupt service routine rungs here for your application.

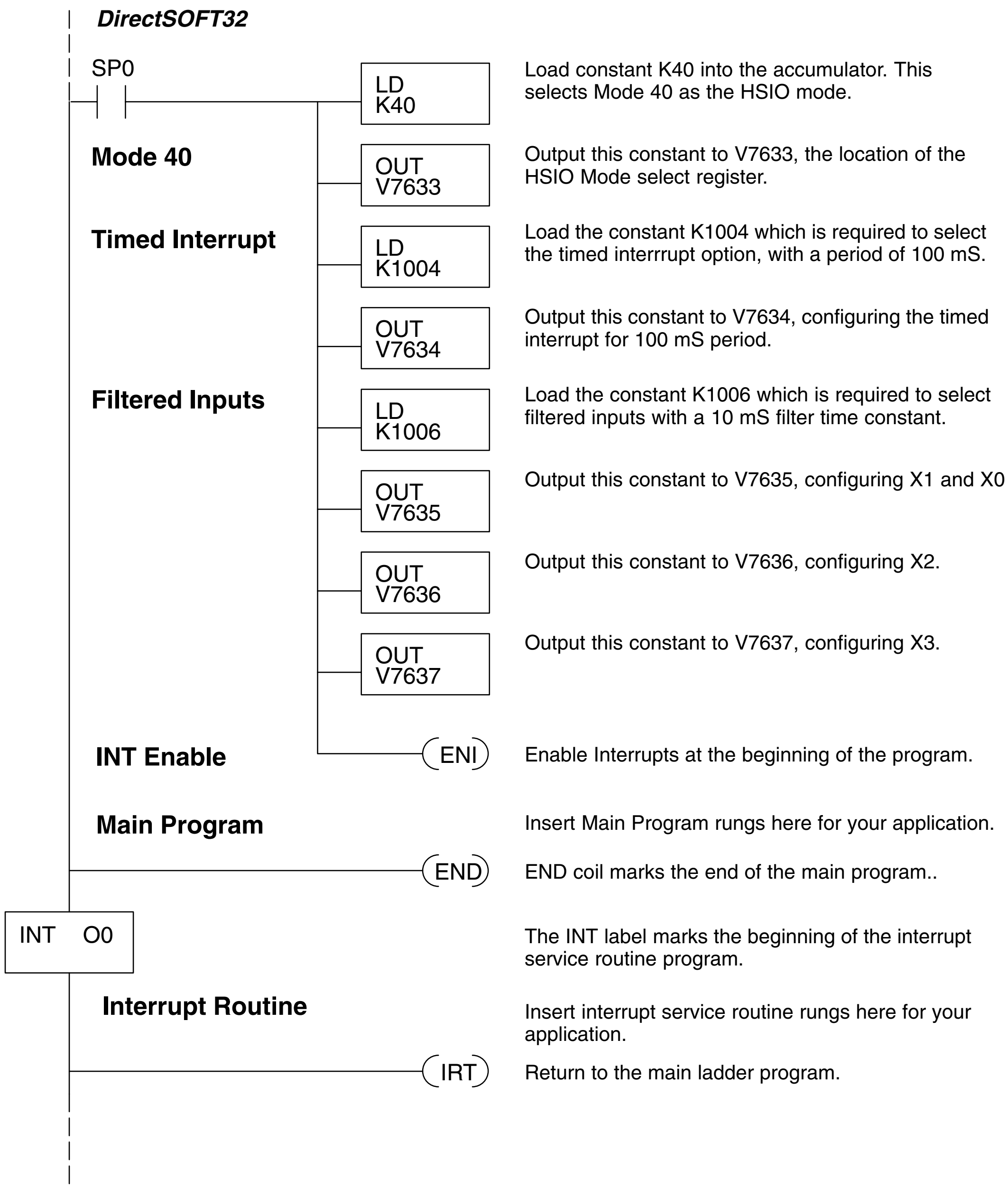
Return to the main ladder program.

Timed Interrupt Program Example

The following program selects Mode 40, then selects the timed interrupt option, with an interrupt period of 100 mS.



Inputs X0, X1, X2, and X3 are all configured as filtered inputs with a 10 mS time constant. Note that X0 uses the time constant from X1. The program is otherwise generic, and may be adapted to your application.



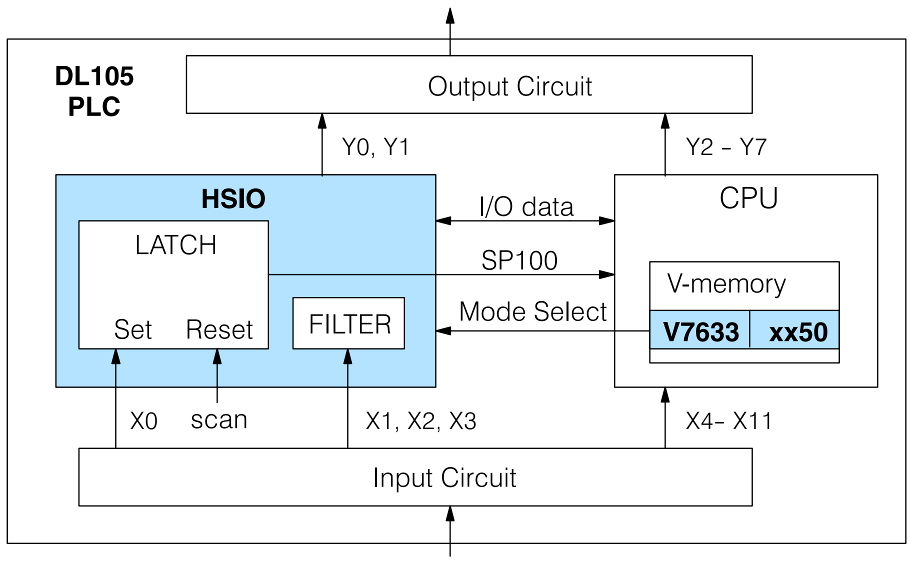
Mode 50: Pulse Catch Input

Purpose

The HSIO circuit has a pulse-catch mode of operation. It monitors the signal on input X0, preserving the occurrence of a narrow pulse. The purpose of the pulse catch mode is to enable the ladder program to "see" an input pulse which is shorter in duration than the current scan time. The HSIO circuit latches the input event on input X0 for one scan, and presents it to ladder logic through special relay SP100 contact. This contact automatically goes off after one scan. *Note that the ladder program cannot read the status of X0 directly.*

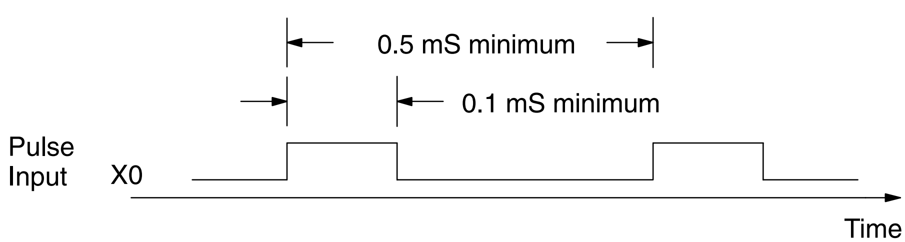
Functional Block Diagram

Refer to the block diagram below. When the lower byte of HSIO Mode register V7633 contains a BCD "50", the pulse catch mode in the HSIO circuit is enabled. X0 automatically becomes the pulse catch input, which sets the latch on each rising edge. The HSIO resets the latch at the end of the next CPU scan. The latch output is available to the ladder program through the special relay contact SP100. Inputs X1, X2, and X3 are available as filtered discrete inputs.



Pulse Catch Timing Parameters

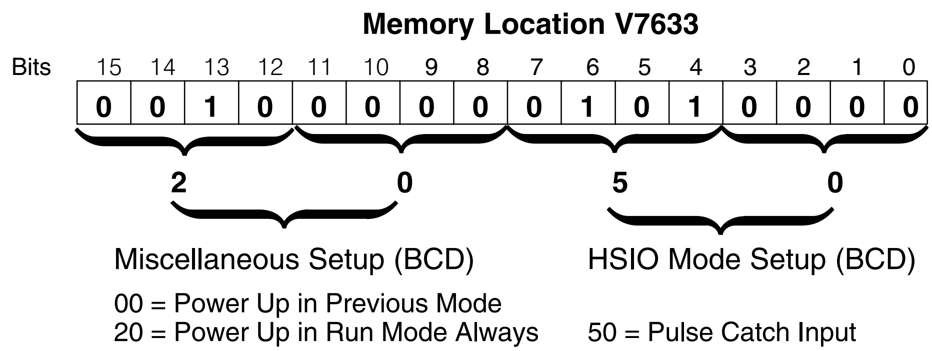
Signal pulses at X0 must meet certain timing criteria to guarantee a pulse capture will result. Refer to the timing diagram below. The input characteristics of X0 are fixed (it is not a programmable filtered input). The minimum pulse width is 0.1 mS. There must be some delay before the next pulse arrives, such that the pulse period cannot be smaller than 0.5 mS. If the pulse period is smaller than 0.5 mS, the next pulse will be considered part of the current pulse.



Note that the pulse catch and filtered input functions are opposite in nature. The pulse catch feature on X0 seeks to *capture* narrow pulses, while the filter input feature on X1, X2, and X3 seeks to *reject* narrow pulses.

Setup for Mode 50

Recall that V7633 is the HSIO Mode Select register. Refer to the diagram below. Use BCD 50 in the lower byte to select High-Speed Counter Mode. Use BCD 00 or 20 in the upper byte as required. Combine the two bytes into a data word “xx50”, for writing to V7633.



Choose the most convenient method of programming V7633 from the following:

- Include load and out instructions in your ladder program
- ***Direct***SOFT32’s memory editor
- Use the Handheld Programmer D2–HPP

We recommend using the first method above so that the HSIO setup becomes an integral part of your application program. An example program later in this section shows how to to this.

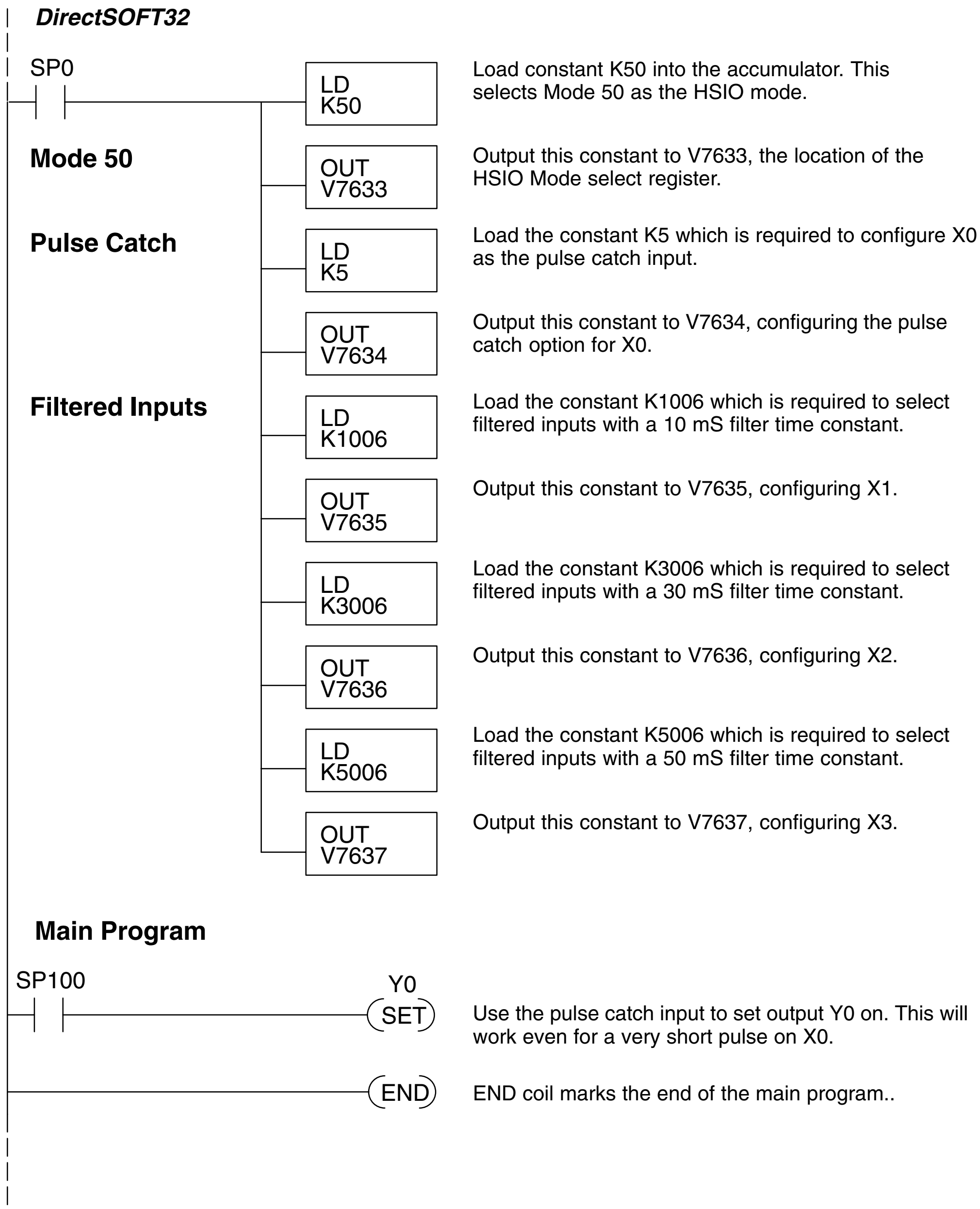
X Input Configuration

The configurable discrete input options for Pulse Catch Mode are listed in the table below. Input X0 is the pulse input, and must have “0005” loaded into it configuration register V7634. Inputs X1, X2, and X3 can only be filtered inputs. Each input has its own configuration register and filter time constant.

Input	Configuration Register	Function	Hex Code Required
X0	V7634	Pulse Catch Input	0005
X1	V7635	Filtered Input	xx06 (xx = filter time)
X2	V7636	Filtered Input	xx06 (xx = filter time)
X3	V7637	Filtered Input	xx06 (xx = filter time)

Pulse Catch Program Example

The following program selects Mode 50, then programs the pulse catch code for X0. Inputs X1, X2, and X3 are all configured as filtered inputs with 10, 30, and 50 mS time constants respectively. The program is otherwise generic, and may be adapted to your application.



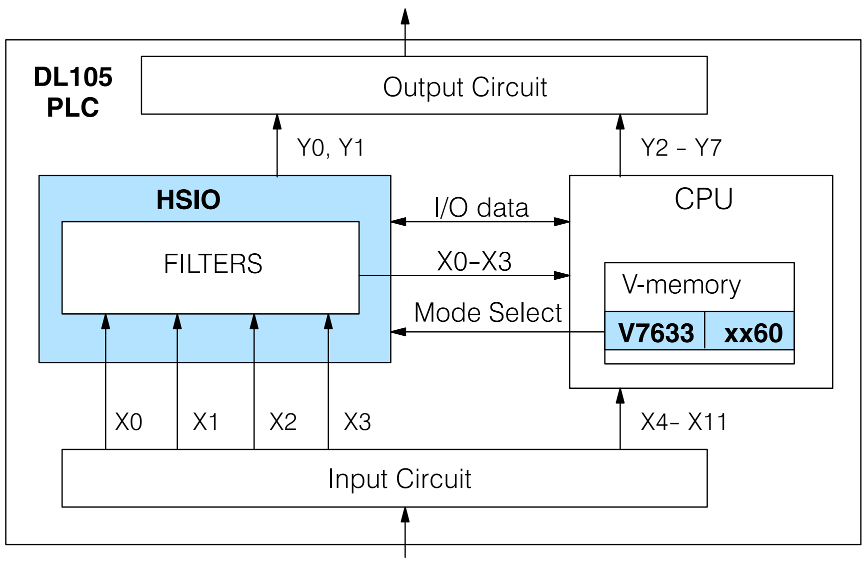
Mode 60: Discrete Inputs with Filter

Purpose

The last mode we will discuss for the HSIO circuit is Mode 60, Discrete Inputs with Filter. The purpose of this mode is to allow the input circuit to reject narrow pulses and accept wide ones, as viewed from the ladder program. This is useful in especially noisy environments or other applications where pulse width is important. In all other modes in this chapter, X0 to X3 usually support the mode functions as special inputs. Only spare inputs operate as filtered inputs by default. Now in Mode 60, all four inputs X0 through X3 function only as discrete filtered inputs.

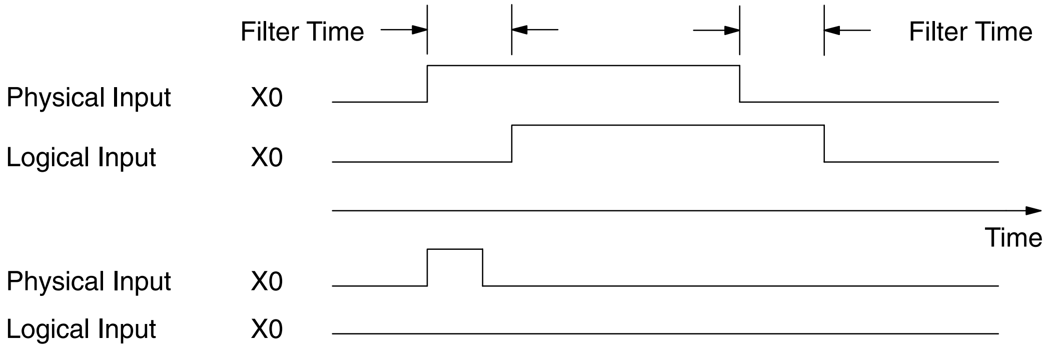
Functional Block Diagram

Refer to the block diagram below. When the lower byte of HSIO Mode register V7633 contains a BCD “60”, the input filter in the HSIO circuit is enabled. Each input X0 through X3 has its own filter time constant. The filter circuit assigns the outputs of the filters as logical references X0 through X3.



Input Filter Timing Parameters

Signal pulses at inputs X0 – X3 are filtered by using a delay time. In the figure below, the input pulse on the top line is longer than the filter time. The resultant logical input to ladder is phase-shifted (delayed) by the filter time on both rising and falling edges. In the bottom waveforms, the physical input pulse width is smaller than the filter time. In this case, the logical input to the ladder program remains in the OFF state (input pulse was filtered out).

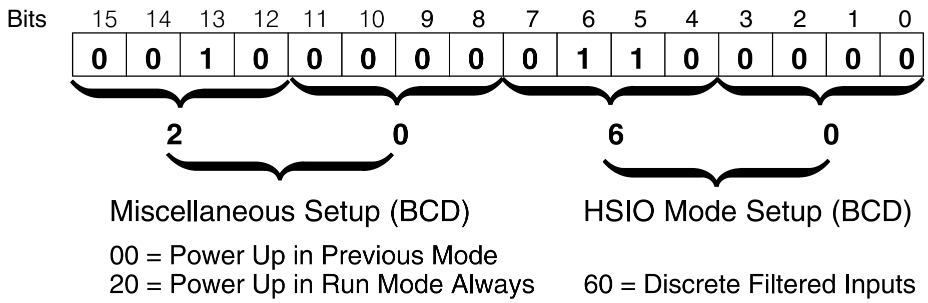


High-Speed Input and Pulse Output Features

Setup for Mode 60

Recall that V7633 is the HSIO Mode Select register. Refer to the diagram below. Use BCD 60 in the lower byte to select High-Speed Counter Mode. Use BCD 00 or 20 in the upper byte as required. Combine the two bytes into a data word “xx60”, for writing to V7633.

Memory Location V7633



Choose the most convenient method of programming V7633 from the following:

- Include load and out instructions in your ladder program
- ***DirectSOFT32***’s memory editor
- Use the Handheld Programmer D2–HPP

We recommend using the first method above so that the HSIO setup becomes an integral part of your application program. An example program later in this section shows how to to this.

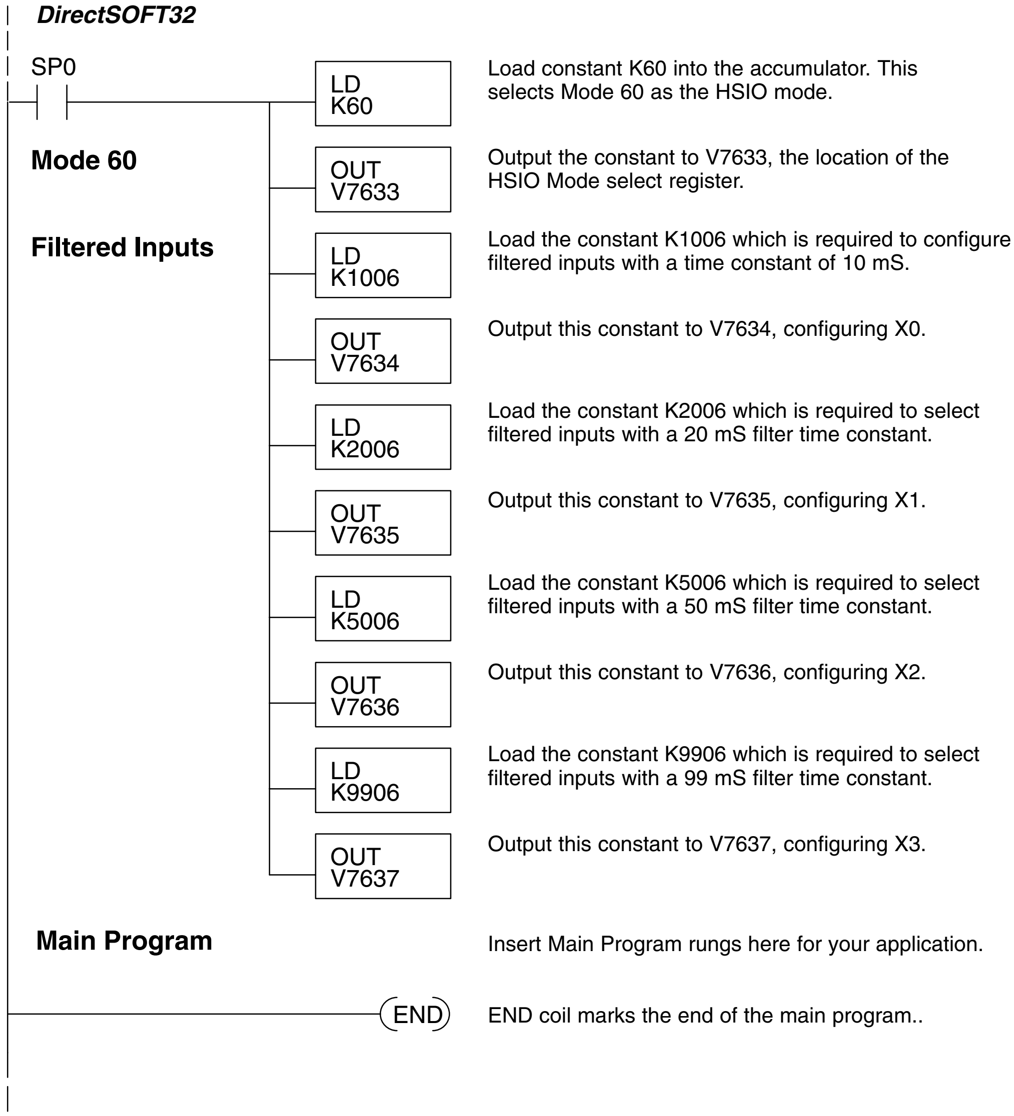
X Input Configuration

The configurable discrete input options for Discrete Filtered Inputs Mode are listed in the table below. The filter time constant (delay) is programmable from 10 to 99 mS. The code for this selection occupies the upper byte of the configuration register in BCD. We combine this number with the required “06” in the lower byte to get “xx06”, where xx = 10 to 99. Input X0, X1, X2, and X3 can only be filtered inputs. Each input has its own configuration register and filter time constant.

Input	Configuration Register	Function	Hex Code Required
X0	V7634	Filtered Input	xx06 (xx = filter delay time)
X1	V7635	Filtered Input	xx06 (xx = filter delay time)
X2	V7636	Filtered Input	xx06 (xx = filter delay time)
X3	V7637	Filtered Input	xx06 (xx = filter delay time)

Filtered Inputs Program Example

The following program selects Mode 60, then programs the filter delay time constants for inputs X0, X1, X2, and X3. Each filter time constant is different, for illustration purposes. The program is otherwise generic, and may be adapted to your application.



CPU Specifications and Operation

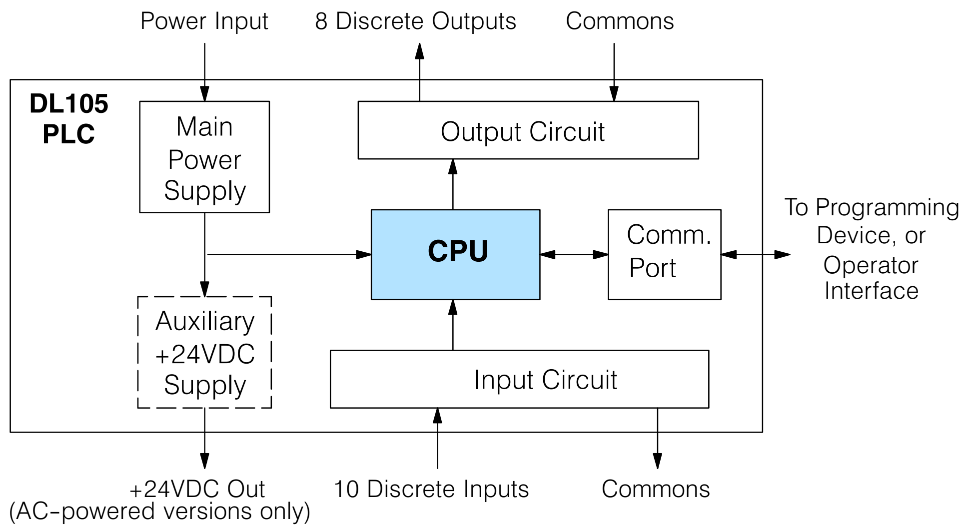
4

In This Chapter. . . .

Introduction

The Central Processing Unit (CPU) is the heart of the Micro PLC. Almost all PLC operations are controlled by the CPU, so it is important that it is set up correctly. This chapter provides the information needed to understand:

- Steps required to set up the CPU
- Operation of ladder program, organization of Variable Memory



NOTE: The High-Speed I/O function (HSIO) consists of dedicated but configurable hardware in the DL105. It is not considered part of the CPU, because it does not execute the ladder program. For more on HSIO operation, see Chapter 3.

DL105 CPU Features

The DL105 Micro PLC which has 2.4K words of memory comprised of 2.0K of ladder memory and 384 words of V-memory (data registers). Program storage is in the FLASH memory which is a part of the CPU board in the PLC. In addition, there is RAM with the CPU which will store system parameters, V-memory, and other data which is not in the application program. The RAM is backed up by a “super-capacitor”, storing the data for several days in the event of a power outage. The capacitor automatically charges during powered operation of the PLC.

The DL105 supports fixed I/O which includes ten discrete input points and eight output points. No provision for expansion beyond these eighteen I/O points are available in the F1–130 model PLCs.

Over 90 different instructions are available for program development as well as extensive internal diagnostics that can be monitored from the application program or from an operator interface. Chapter 5 provides a detailed description of the instructions.

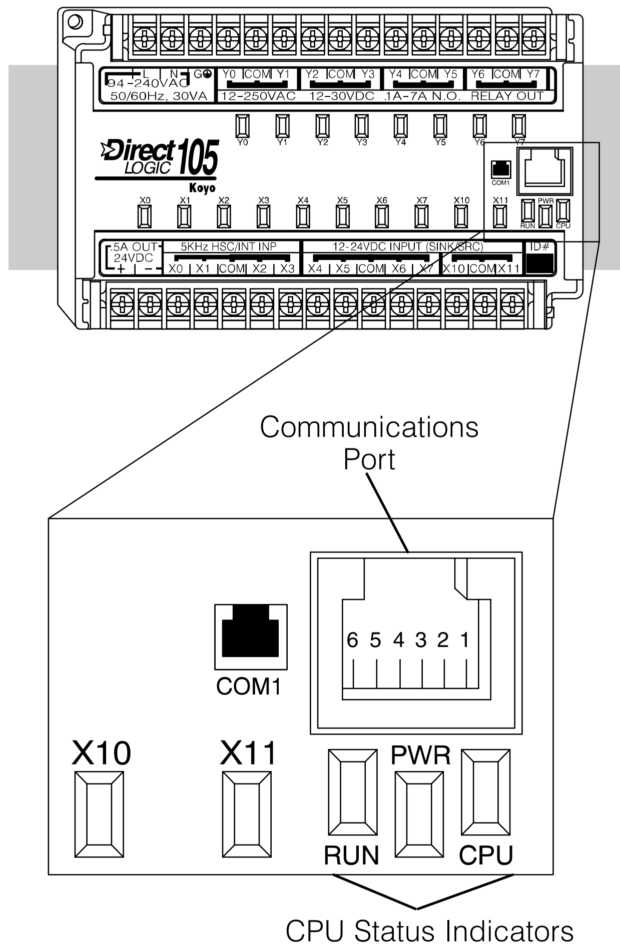
The DL105 provides one built-in RS232C communication port, so you can easily connect a handheld programmer or a personal computer without needing any additional hardware.

CPU Specifications

Feature	DL105
Total Program memory (words)	2.4K
Ladder memory (words)	2048
Total V-memory (words) (See Appendix E)	384
User V-memory (words)	256
Non-volatile V Memory (words)	128
Contact execution (boolean)	3.3 μS
Typical scan (boolean)	4 – 6 mS
RLL Ladder style Programming	Yes
RLL and RLL*PLUS* Programming	Yes
Run Time Edits	Yes
Variable / fixed scan	Variable
Handheld programmer	Yes
DirectSOFT32 programming for Windows™	Yes
Built-in communication ports (RS232C)	Yes
EEPROM or FLASH	Standard on CPU
Local Discrete I/O points available	18
Local Analog input / output channels maximum	None
High-Speed I/O (quad., pulse out, interrupt, pulse catch, etc.)	Yes
I/O Point Density	10 inputs, 8 outputs
Number of instructions available (see Chapter 5 for details)	91
Control relays	256
Special relays (system defined)	112
Stages in RLL*PLUS*	256
Timers	64
Counters	64
Immediate I/O	Yes
Interrupt input (external / timed)	Yes
Subroutines	No
For/Next Loops	No
Math	Integer
Drum Sequencer Instruction	Yes
Time of Day Clock/Calendar	No
Internal diagnostics	Yes
Password security	Yes
System error log	No
User error log	No
Battery backup	No (uses super-cap.)

CPU Hardware Setup

CPU Status Indicators		
RUN	ON OFF	CPU is in RUN mode CPU is in Program mode
CPU	ON OFF	CPU internal diagnostics has detected an error. CPU is OK.
PWR	ON OFF	CPU power good CPU power failure



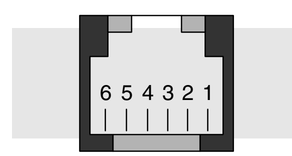
Communication Port	
Com 1	Connects to HPP, ***Direct***SOFT32, operator interfaces, etc. 6-pin, RS232C 9600 Baud Odd parity Station address fixed (1) 8 data bits 1 start, 1 stop bit Asynchronous, Half-duplex, DTE K sequence protocol

Communication Port Pinout Diagrams

Cables are available that allow you to quickly and easily connect a Handheld Programmer or a personal computer to the DL105 PLCs. However, if you need to build your own cables, use the pinout diagrams shown. The DL105 PLCs require an RJ-12 phone plug to fit the built-in jacks.

The Micro PLC has one built-in RS232C communication port. The port is generally used for programming either with the Handheld Programmer or ***Direct***SOFT32, and has a fixed station address of 1. The baud rate is fixed at 9600 baud. This port supports the K–sequence protocol, which is a proprietary protocol.

NOTE: The 5V pins are rated at 200mA maximum, primarilly for use with some operator interface units.



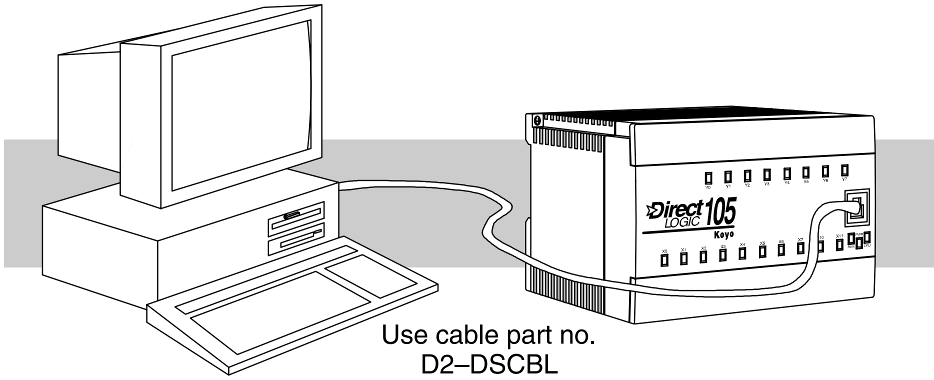
Phone Jack Connector

Port Pinouts

Pin	Signal Definition
1	0 V
2	5 V
3	RS232C Data in
4	RS232C Data out
5	5 V
6	0 V

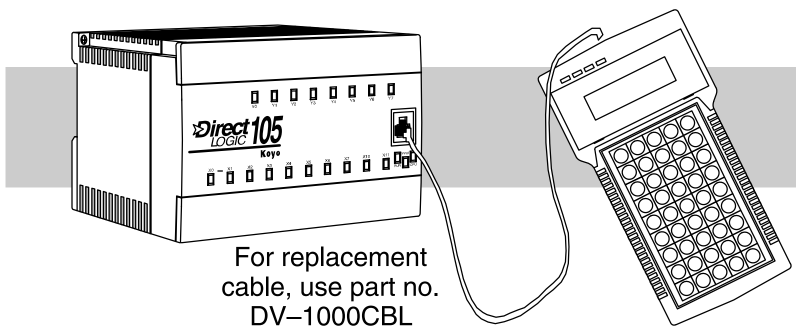
Connecting the Programming Devices

If you're using a Personal Computer with the ***Direct***SOFT32 programming package, you can connect the computer to the DL105's programming port. For an engineering office environment (typical during program development), this is the preferred method of programming.



Use cable part no. D2–DSCBL

The Handheld programmer is connected to the CPU with a handheld programmer cable. This device is ideal for maintaining existing installations or making small program changes. The handheld programmer is shipped with a cable, which is approximately 6.5 feet (200 cm) long.



For replacement cable, use part no. DV–1000CBL

CPU Setup Information

Even if you have years of experience using PLCs, there are a few things you need to do before you can start entering programs. This section includes some basic things, such as changing the CPU mode, but it also includes some things that you may never have to use. Here's a brief list of the items that are discussed.

- Using Auxiliary Functions
- Selecting and Changing the CPU Modes
- Clearing the program (and other memory areas)
- How to initialize system memory
- Setting retentive memory ranges

The following paragraphs provide the setup information necessary to get the CPU ready for programming. They include setup instructions for either type of programming device you are using. The D2–HPP Handheld Programmer Manual provides the Handheld keystrokes required to perform all of these operations. The ***Direct***SOFT32 Manual provides a description of the menus and keystrokes required to perform the setup procedures via ***Direct***SOFT32.

CPU Modes

There are two possible operating modes available with DL105 Micro PLCs.

- RUN — executes program and updates I/O points.
- PROGRAM — allows program changes. The CPU halts execution of the ladder program and all output points are turned off.

Mode of Operation at Power-up

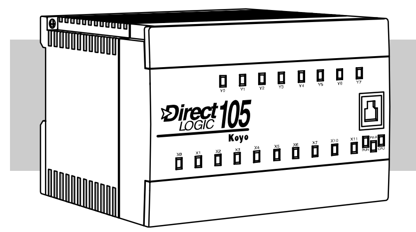
The DL105 operates as follows when the power is connected.

1. The DL105 CPU will normally power-up in the mode that it was in just prior to the power interruption. For example, if the CPU was in Program Mode when the power was disconnected, the CPU will power-up in Program Mode (see warning note below).
2. You can configure the DL105 to always power-up in the Run Mode. You can set bit 13 in V7633 (nonvolatile memory) to enable this feature; we'll show you how to set the bit later in this chapter.

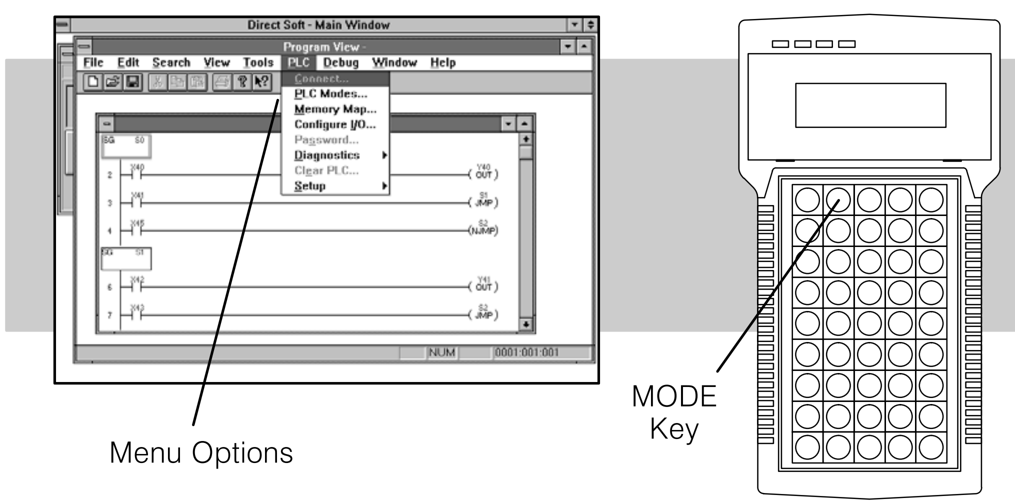
WARNING: If bit 13 in memory location V7633 is *not set*, once the super capacitor has discharged the system memory may not retain the previous mode of operation. When this occurs, the PLC can power-up in either Run or Program Mode. There is no way to determine which mode will be entered. Failure to adhere to this warning greatly increases the risk of unexpected equipment startup.

Changing Modes in the DL105 PLC

The DL105 Micro PLC does not have an external switch to switch CPU operating modes. You have to use a programming device, such as the handheld programmer or ***Direct***SOFT32, to change the operating mode.



You can use either ***Direct***SOFT32 or the Handheld Programmer to change the CPU mode of operation. With ***Direct***SOFT32 you use a menu option in the PLC menu. With the Handheld Programmer, you use the MODE key.

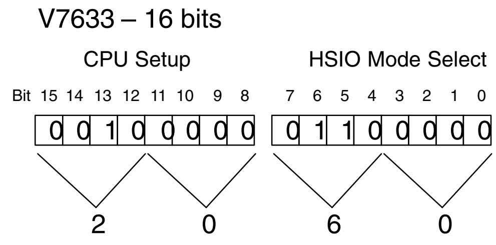


Setting Bits in V7633

You can use the Handheld Programmer or ***Direct***SOFT32 to set the proper bits in V7633.

Since you cannot access the bits individually, you have to enter a constant that will result in the appropriate bit being set. The first two digits of the constant are used to select the CPU options. The second two digits are used with the High-Speed I/O function to select various options. If you're using High Speed I/O functions, make sure you also enter the appropriate code for the feature selected If you want the HSIO inputs and outputs to default to regular I/O point operation, just enter 60 as the last two digits of the code. This configures all I/O points to operate only as standard discrete I/O.

The diagram shows how the upper and lower bytes of V7633 are used. For example, if you entered 2060 into V7633, the powerup-in-run option is selected, and the discrete filtered inputs are selected.

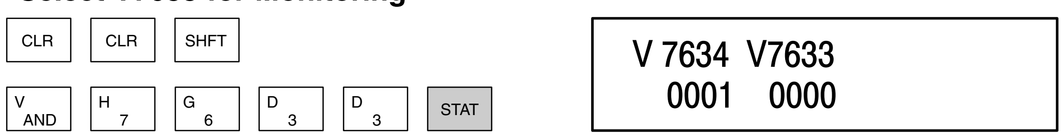


Codes:
00: Default
20: Power-up in Run

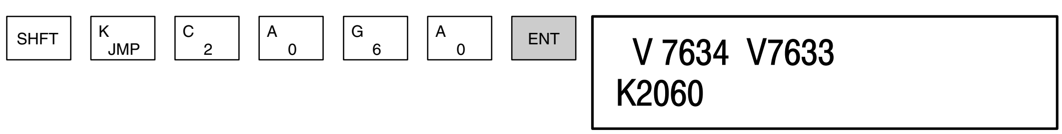
Codes:
10: Up Counter
20: Quadrature
30: Pulse output (High Speed)
40: Interrupt (High Speed)
50: Pulse catch (High Speed)
60: Discrete Filtered Input (default)

The following keystrokes show how you can enter the codes into V7633 with the D2–HPP Handheld Programmer.

Select V7633 for Monitoring



Enter the Code



Since the changes take affect immediately, you may receive an error message. For example, if you select Power-up in Run Mode and the CPU does not yet contain a program, an error will occur.

Auxiliary Functions Many CPU setup tasks involve the use of Auxiliary (AUX) Functions. The AUX Functions perform many different operations, ranging from clearing ladder memory, displaying the scan time, copying programs to EEPROM in the handheld programmer, etc. They are divided into categories that affect different system parameters. Appendix A provides a description of the AUX functions.

You can access the AUX Functions from ***Direct***SOFT32 or from the D2–HPP Handheld Programmer. The manuals for those products provide step-by-step procedures for accessing the AUX Functions. Some of these AUX Functions are designed specifically for the Handheld Programmer setup, so they will not be needed (or available) with the ***Direct***SOFT32 package. The following table shows a list of the Auxiliary functions for the Handheld Programmer.

AUX 2* — RLL Operations			**AUX 6* — Handheld Programmer Configuration**	
21	Check Program		61	Show Revision Numbers
22	Change Reference		62	Beeper On / Off
23	Clear Ladder Range		65	Run Self Diagnostics
24	Clear All Ladders		**AUX 7* — EEPROM Operations**	
AUX 3* — V-Memory Operations			71	Copy CPU memory to HPP EEPROM
31	Clear V Memory		72	Write HPP EEPROM to CPU
AUX 4* — I/O Configuration			73	Compare CPU to HPP EEPROM
41	Show I/O Configuration		74	Blank Check (HPP EEPROM)
AUX 5* — CPU Configuration			75	Erase HPP EEPROM
51	Modify Program Name		76	Show EEPROM Type (CPU and HPP)
53	Display Scan Time		**AUX 8* — Password Operations**	
54	Initialize Scratchpad		81	Modify Password
55	Set Watchdog Timer		82	Unlock CPU
57	Set Retentive Ranges		83	Lock CPU
58	Test Operations			
5B	HSIO Configuration			

Clearing an Existing Program

Before you enter a new program, be sure to always clear ladder memory. You can use AUX Function 24 to clear the complete program.

You can also use other AUX functions to clear other memory areas.

- AUX 23 — Clear Ladder Range
- AUX 24 — Clear all Ladders
- AUX 31 — Clear V Memory

Initializing System Memory

The DL105 Micro PLC maintain system parameters in a memory area often referred to as the “scratchpad”. In some cases, you may make changes to the system setup that will be stored in system memory. For example, if you specify a range of Control Relays (CRs) as retentive, these changes are stored in system memory.

AUX 54 resets the system memory to the default values.

WARNING: You may never have to use this feature unless you want to clear any setup information that is stored in system memory. Usually, you’ll only need to initialize the system memory if you are changing programs and the old program required a special system setup. You can usually load in new programs without ever initializing system memory.

Remember, this AUX function will reset all system memory. If you have set special parameters such as retentive ranges, etc. they will be erased when AUX 54 is used. Make sure you that you have considered all ramifications of this operation before you select it.

Setting Retentive Memory Ranges

The DL105 PLCs provide certain ranges of retentive memory by default. The default ranges are suitable for many applications, but you can change them if your application requires additional retentive ranges or no retentive ranges at all. (see Appendix E) The default settings are:

Memory Area	DL105	
	Default Range	Available Range
Control Relays	C300 – C377	C0 – C377
V Memory	V2000 – V2377	V0 – V2377
Timers	None by default	T0 – T77
Counters	CT0 – CT77	CT0 – CT77
Stages	None by default	S0 – S377

You can use AUX 57 (see Appendix A) to set the retentive ranges. You can also use ***Direct***SOFT32 menus to select the retentive ranges.

WARNING: The DL105 PLCs do not have battery back-up. The super capacitor will retain the values in the event of a power loss, but only for a short period of time, depending on conditions. If the retentive ranges are important for your application, make sure you program critical parameters into EEPROM locations.

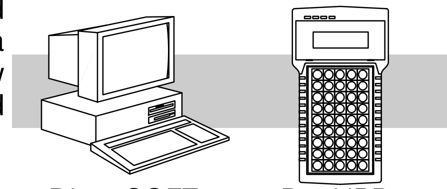
Using a Password

The DL105 PLCs allow you to use a password to help minimize the risk of unauthorized program and/or data changes. Once you enter a password you can “lock” the PLC against access. Once the CPU is locked you must enter the password before you can use a programming device to change any system parameters.

You can select an 8-digit numeric password. The Micro PLCs are shipped from the factory with a password of 00000000. All zeros removes the password protection. If a password has been entered into the CPU you cannot just enter all zeros to remove it. Once you enter the correct password, you can change the password to all zeros to remove the password protection.

WARNING: Make sure you remember your password. If you forget your password you will not be able to access the CPU. The Micro PLC must be returned to the factory to have the password removed.

You can use the D2–HPP Handheld Programmer or ***Direct***SOFT32 to enter a password. The following diagram shows how you can enter a password with the Handheld Programmer.



*Direct*SOFT32   D2–HPP

Select AUX 81

CLR   CLR   I 8   B 1   AUX   ENT

PASSWORD
00000000

Enter the new 8-digit password

X   X   • • •   X   ENT

PASSWORD
XXXXXXXX

Press CLR to clear the display

There are three ways to lock the CPU once the password has been entered.

1. If the CPU power is disconnected, the CPU will be automatically locked against access.
2. If you enter the password with ***Direct***SOFT32, the CPU will be automatically locked against access when you exit ***Direct***SOFT32.
3. Use AUX 83 to lock the CPU.

When you use ***Direct***SOFT32, you will be prompted for a password if the CPU has been locked. If you use the Handheld Programmer, you have to use AUX 82 to unlock the CPU. Once you enter AUX 82, you will be prompted to enter the password.

CPU Operation

Achieving the proper control for your equipment or process requires a good understanding of how DL105 CPUs control all aspects of system operation. There are four main areas to understand before you create your application program:

- CPU Operating System — the CPU manages all aspects of system control. A quick overview of all the steps is provided in the next section.
- CPU Operating Modes — The two primary modes of operation are Program Mode and Run Mode.
- CPU Timing — The two important areas we discuss are the I/O response time and the CPU scan time.
- CPU Memory Map — DL105 CPUs offer a wide variety of resources, such as timers, counters, inputs, etc. The memory map section shows the organization and availability of these data types.

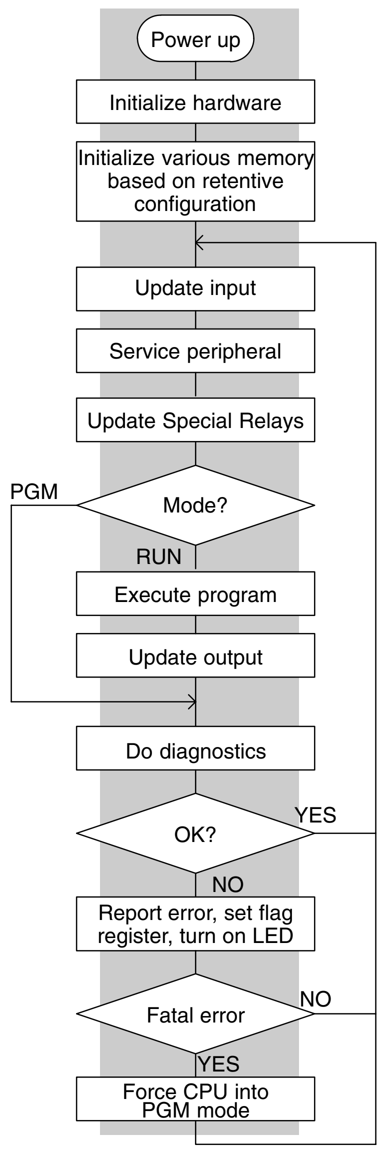
CPU Operating System

At powerup, the CPU initializes the internal electronic hardware. Memory initialization starts with examining the retentive memory settings. In general, the contents of retentive memory is preserved, and non-retentive memory is initialized to zero (unless otherwise specified).

After the one-time powerup tasks, the CPU begins the cyclical scan activity. The flowchart to the right shows how the tasks differ, based on the CPU mode and the existence of any errors. The *"scan time"* is defined as the average time around the task loop. Note that the CPU is always reading the inputs, even during program mode. This allows programming tools to monitor input status at any time.

The outputs are only updated in Run mode. In program mode, they are in the off state.

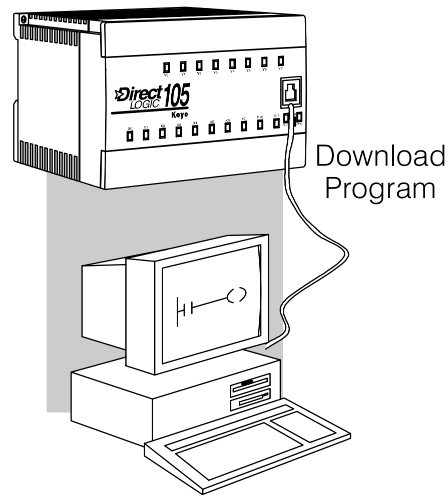
Error detection has two levels. Non-fatal errors are reported, but the CPU remains in its current mode. If a fatal error occurs, the CPU is forced into program mode and the outputs go off.



Program Mode

In Program Mode, the CPU does not execute the application program or update the output points. The primary use for Program Mode is to enter or change an application program. You also use program mode to set up the CPU parameters, such as HSIO features, retentive memory areas, etc.

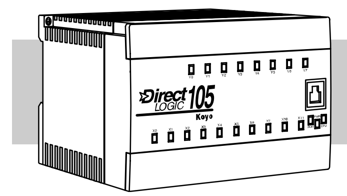
You can use a programming device, such as ***Direct***SOFT32 or the D2–HPP Handheld Programmer to place the CPU in Program Mode.



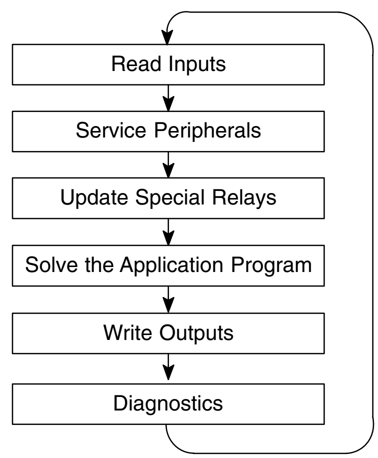
Run Mode

In Run Mode, the CPU executes the application program and updates the I/O system. You can perform many operations during Run Mode. Some of these include:

- Monitor and change I/O point status
- Update timer/counter preset values
- Update Variable memory locations



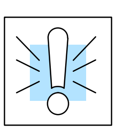
Normal Run mode scan



Run Mode operation can be divided into several key areas. For the vast majority of applications, some of these execution segments are more important than others. For example, you need to understand how the CPU updates the I/O points, handles forcing operations, and solves the application program. The remaining segments are not that important for most applications.

You can use ***Direct***SOFT32 or the D2–HPP Handheld Programmer to place the CPU in Run Mode.

You can also edit the program during Run Mode. The Run Mode Edits are not “bumpless” to the outputs. Instead, the CPU maintains the outputs in their last state while it accepts the new program information. If an error is found in the new program, then the CPU will turn all the outputs off and enter the Program Mode. This feature is discussed in more detail in Chapter 8.



WARNING: Only authorized personnel fully familiar with all aspects of the application should make changes to the program. Changes during Run Mode become effective immediately. Make sure you thoroughly consider the impact of any changes to minimize the risk of personal injury or damage to equipment.

Read Inputs

The CPU reads the status of all inputs, then stores it in the image register. Input image register locations are designated with an X followed by a memory location. Image register data is used by the CPU when it solves the application program.

Of course, an input may change *after* the CPU has just read the inputs. Generally, the CPU scan time is measured in milliseconds. If you have an application that cannot wait until the next I/O update, you can use Immediate Instructions. These do not use the status of the input image register to solve the application program. The Immediate instructions immediately read the input status directly from the I/O modules. However, this lengthens the program scan since the CPU has to read the I/O point status again. A complete list of the Immediate instructions is included in Chapter 5.

Service Peripherals and Force I/O

After the CPU reads the inputs from the input modules, it reads any attached peripheral devices. This is primarily a communications service for any attached devices. For example, it would read a programming device to see if any input, output, or other memory type status needs to be modified.

Forced I/O— temporarily changes the status of a discrete bit. For example, you may want to force an input on, even though it is really off. This allows you to change the point status that was stored in the image register. This value will be valid until the image register location is written to during the next scan. This is primarily useful during testing situations when you just need to force a bit on to trigger another event.

Forced Inputs — The CPU reads the status of X inputs during the Read Inputs portion of the scan. When the CPU services the programming device, it logs any request to force an X input on. If the input is used in the application program, the ladder X contact is considered closed (on). Since an X input is a real-world input point, the CPU will change the status when it reads the inputs on the next scan.

Forced Outputs— Outputs which are not used in the program can be forced on and off for troubleshooting and maintenance purposes. You can temporarily allow the forcing of any output by inserting an END coil instruction at the beginning of the ladder program. Then you can use ***Direct***SOFT32 or a HPP to force outputs on and off.

The DL105 PLCs only retain the forced value for one scan. There is an exception to this rule. For example, if the point address is greater than X11 or Y7 or it is not used in the ladder program, then the point will maintain the forced status.

WARNING: Only authorized personnel fully familiar with all aspects of the application should make changes to the program. Make sure you thoroughly consider the impact of any changes to minimize the risk of personal injury or damage to equipment.

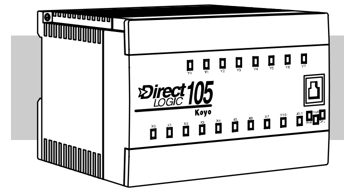
Update Special Relays and Special Registers

There are certain V-memory locations that contain Special Relays and other dedicated register information. This portion of the execution cycle makes sure these locations get updated on every scan. Also, there are several different Special Relays, such as diagnostic relays, etc., that are also updated during this segment.

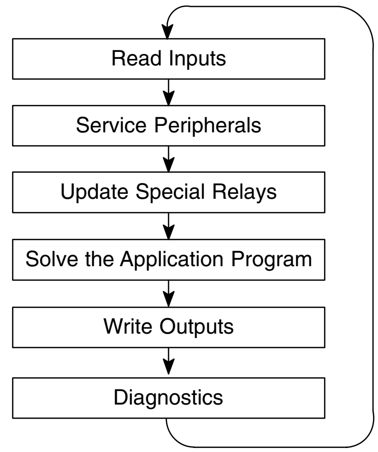
Solve Application Program

The CPU evaluates each instruction in the application program during this segment of the scan cycle. The instructions define the relationship between the input conditions and the desired output response. The CPU uses the output image register area to store the status of the desired action for the outputs. Output image register locations are designated with a Y followed by a memory location. The actual outputs are updated during the write outputs segment of the scan cycle. There are immediate output instructions available that will update the output points immediately instead of waiting until the write output segment. A complete list of the Immediate instructions is provided in Chapter 5.

The internal control relays (C), the stages (S), and the variable memory (V) are also updated in this segment.



Normal Run mode scan



You may recall that you can force various types of points in the system. (This was discussed earlier in this chapter.) If any I/O points or memory data have been forced, the output image register also contains this information.

Write Outputs

Once the application program has solved the instruction logic and constructed the output image register, the CPU writes the contents of the output image register to the corresponding output points. Remember, the CPU also made sure that any forcing operation changes were stored in the output image register, so the forced points get updated with the status specified earlier.

Diagnostics

During this part of the scan, the CPU performs all system diagnostics and other tasks such as calculating the scan time and resetting the watchdog timer. There are many different error conditions that are automatically detected and reported by the DL105 PLCs. Appendix B contains a listing of the various error codes.

Probably one of the more important things that occurs during this segment is the scan time calculation and watchdog timer control. The DL105 CPU has a “watchdog” timer that stores the maximum time allowed for the CPU to complete the solve application segment of the scan cycle. If this time is exceeded the CPU will enter the Program Mode and turn off all outputs. The default value set from the factory is 200 ms. An error is automatically reported. For example, the Handheld Programmer would display the following message “E003 S/W TIMEOUT” when the scan overrun occurs.

You can use AUX 53 to view the minimum, maximum, and current scan time. Use AUX 55 to increase or decrease the watchdog timer value.

I/O Response Time

Is Timing Important for Your Application?

I/O response time is the amount of time required for the control system to sense a change in an input point and update a corresponding output point. In the majority of applications, the CPU performs this task in such a short period of time that you may never have to concern yourself with the aspects of system timing. However, some applications do require extremely fast update times. In these cases, you may need to know how to to determine the amount of time spent during the various segments of operation.

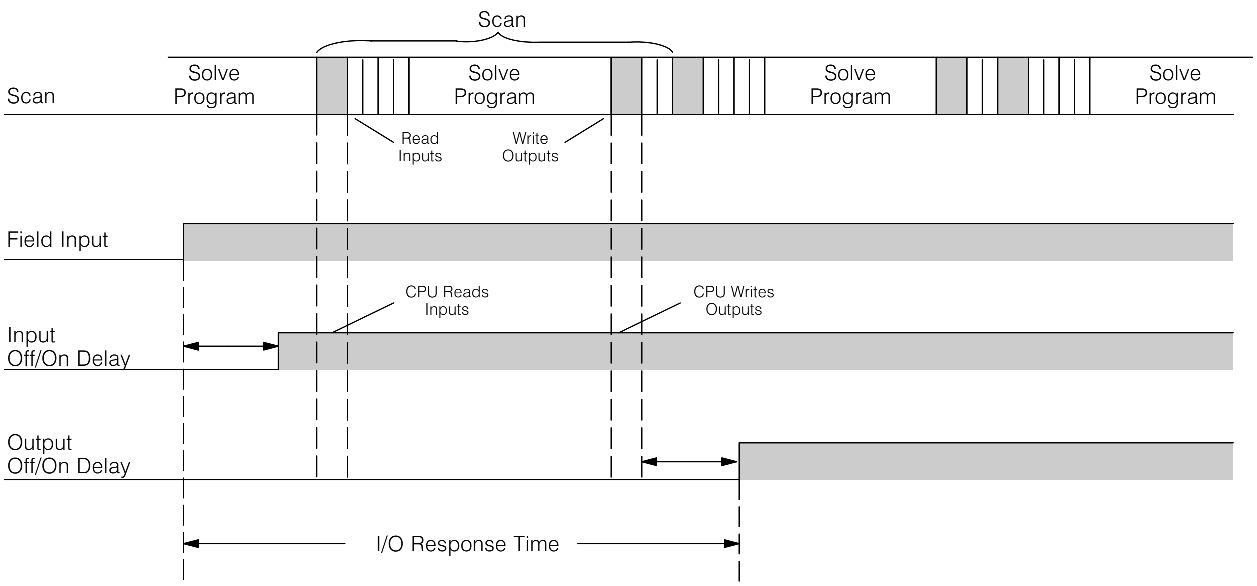
There are four things that can affect the I/O response time.

- The point in the scan cycle when the field input changes states
- Input Off to On delay time
- CPU scan time
- Output Off to On delay time

The next paragraphs show how these items interact to affect the response time.

Normal Minimum I/O Response

The I/O response time is shortest when the input changes just before the Read Inputs portion of the execution cycle. In this case the input status is read, the application program is solved, and the output point gets updated. The following diagram shows an example of the timing for this situation.

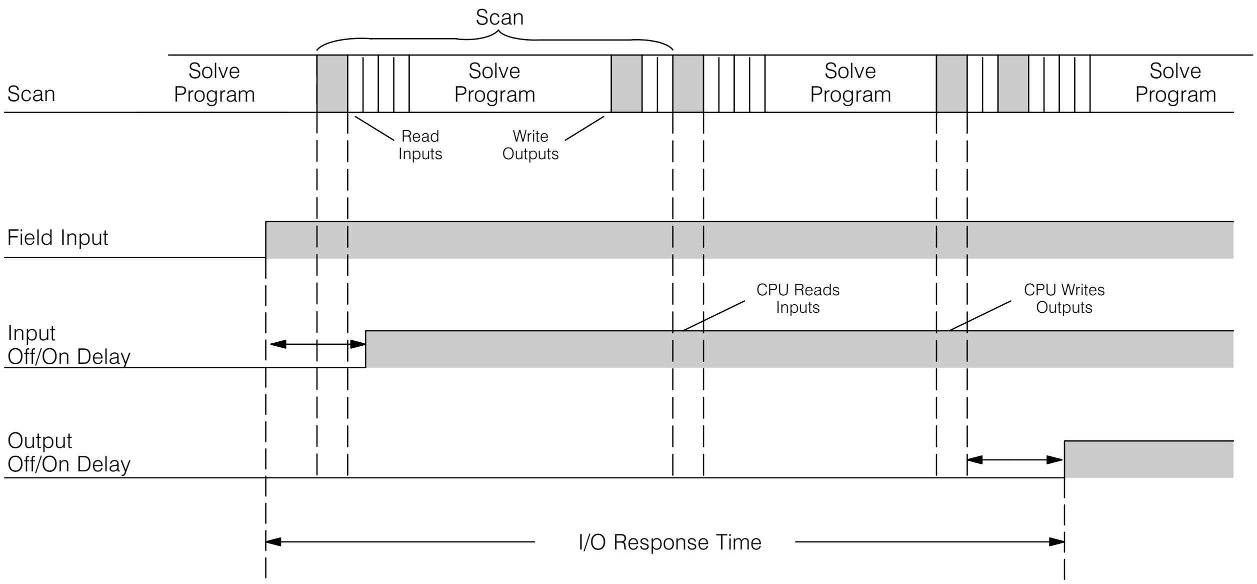


In this case, you can calculate the response time by simply adding the following items:

Input Delay + Scan Time + Output Delay = Response Time

Normal Maximum I/O Response

The I/O response time is longest when the input changes just after the Read Inputs portion of the execution cycle. In this case the new input status does not get read until the following scan. The following diagram shows an example of the timing for this situation.



In this case, you can calculate the response time by simply adding the following items:

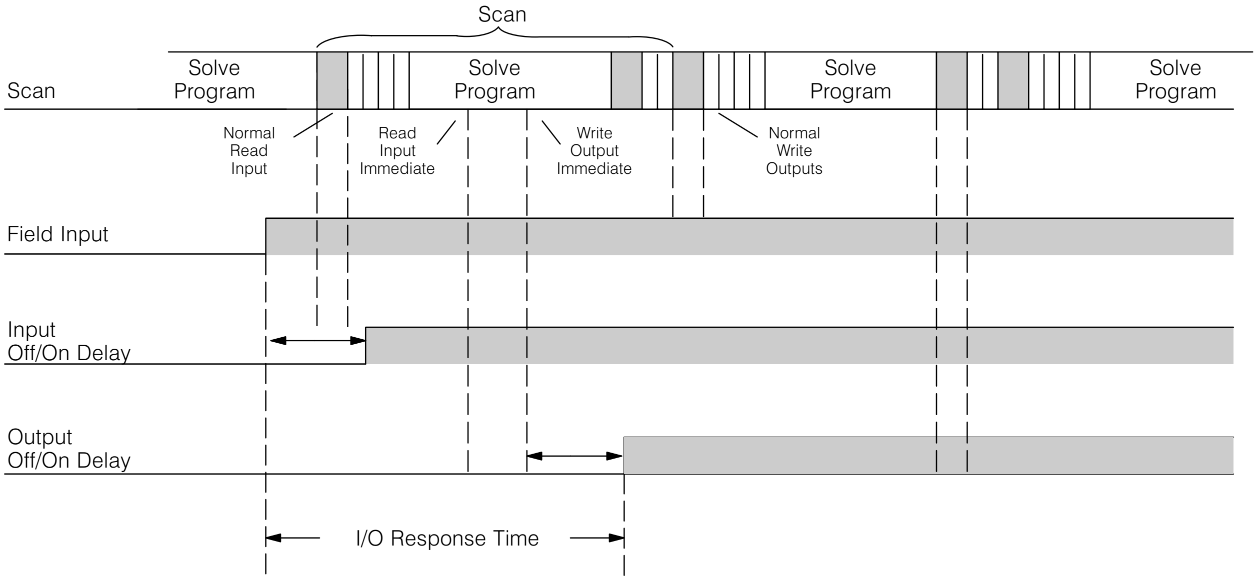
Input Delay +(2 x Scan Time) + Output Delay = Response Time

Improving Response Time

There are a few things you can do the help improve throughput.

- You can choose instructions with faster execution times
- You can use immediate I/O instructions (which update the I/O points during the program execution)
- You can use the HSIO Mode 50 Pulse Catch features designed to operate in high-speed environments. See the Chapter 3 for details on using this feature.

Of these three things the Immediate I/O instructions are probably the most important and most useful. The following example shows how an immediate input instruction and immediate output instruction would affect the response time.



In this case, you can calculate the response time by simply adding the following items.

Input Delay + Instruction Execution Time + Output Delay = Response Time

The instruction execution time would be calculated by adding the time for the immediate input instruction, the immediate output instruction, and any other instructions in between the two.

NOTE: Even though the immediate instruction reads the most current status from I/O, it only uses the results to solve that one instruction. It does not use the new status to update the image register. Therefore, any regular instructions that follow will still use the image register values. Any immediate instructions that follow will access the I/O again to update the status.

CPU Scan Time Considerations

The scan time covers all the cyclical tasks that are performed by the operating system. You can use ***Direct***SOFT32 or the Handheld Programmer to display the minimum, maximum, and current scan times that have occurred since the previous Program Mode to Run Mode transition. This information can be very important when evaluating the performance of a system.

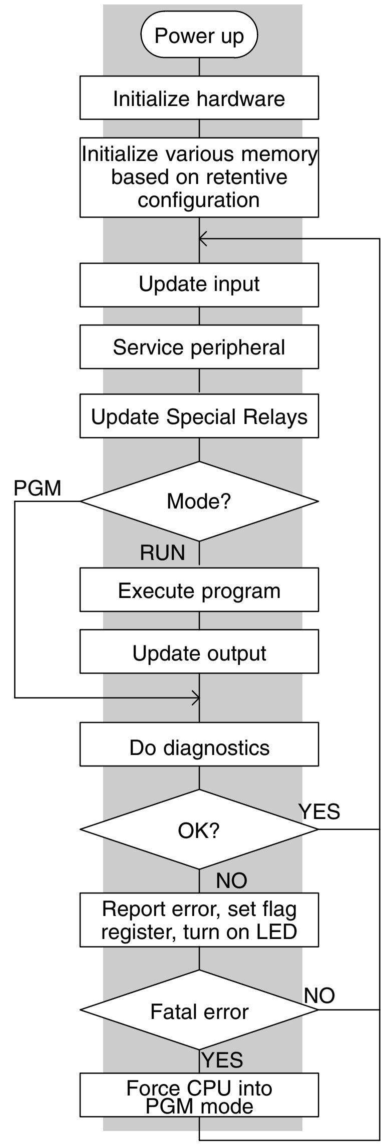
As we've shown previously there are several segments that make up the scan cycle. Each of these segments requires a certain amount of time to complete. Of all the segments, the following are the most important.

- Input Update
- Peripheral Service
- Program Execution
- Output Update
- Timed Interrupt Execution

The only one you really have the most control over is the amount of time it takes to execute the application program. This is because different instructions take different amounts of time to execute. So, if you think you need a faster scan, then you can try to choose faster instructions.

Your choice of I/O type and peripheral devices can also affect the scan time. However, these things are usually dictated by the application.

The following paragraphs provide some general information on how much time some of the segments can require.



Reading Inputs The time required during each scan to read the input status is 40 µS. Don't confuse this with the I/O response time that was discussed earlier.

Writing Outputs The time required to write the output status is 629 µS. Don't confuse this with the I/O response time that was discussed earlier.

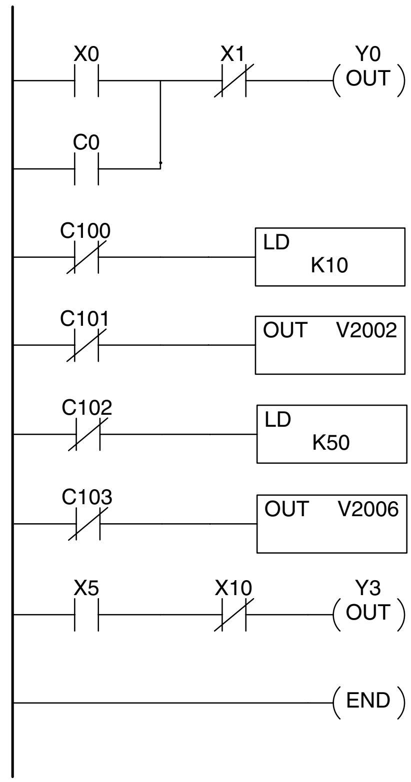
Application Program Execution

The CPU processes the program from address 0 to the END instruction. The CPU executes the program left to right and top to bottom. As each rung is evaluated the appropriate image register or memory location is updated. The time required to solve the application program depends on the type and number of instructions used, and the amount of execution overhead.

Just add the execution times for all the instructions in your program to determine to total execution time. Appendix C provides a complete list of the instruction execution times for the DL105 Micro PLC. For example, the execution time for running the program shown below is calculated as follows:

Instruction	Time
STR X0	3.3 µs
OR C0	2.7 µs
ANDN X1	2.7 µs
OUT Y0	3.4 µs
STRN C100	3.9 µs
LD K10	62 µs
STRN C101	3.9 µs
OUT V2002	60 µs
STRN C102	3.9 µs
LD K50	62 µs
STRN C103	3.9 µs
OUT V2006	60 µs
STR X5	3.3 µs
ANDN X10	2.7 µs
OUT Y3	3.4 µs
END	27 µs
TOTAL	308.1 µs

Overhead	DL105
Minimum	0.86 mS
Maximum	3.85 ms



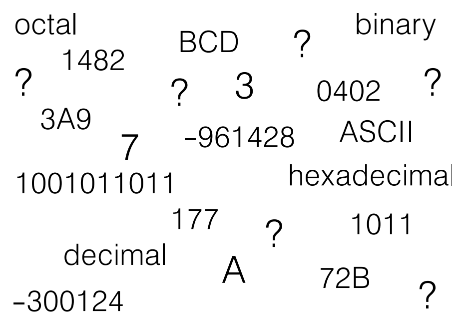
The program above takes only 308.1 µs to execute during each scan. The total scan time is the sum of the program execution plus the overhead as shown above. “Overhead” includes all other housekeeping and diagnostic tasks. The scan time will vary slightly from one scan to the next, because of fluctuation in overhead tasks.

NOTE: You can move words to EEPROM from within the application program. This can add up to 10ms per 32 word boundary.

Program Control Instructions — the DL105 PLCs have an interrupt routine feature that changes the way a program executes. Since this instruction interrupts normal program flow, it will have an effect on the program execution time. For example, a timed interrupt routine with a 10 mS period interrupts the main program execution (before the END statement) every 10 mS, so the CPU can execute the interrupt routine. Chapter 5 provides detailed information on interrupts.

PLC Numbering Systems

If you are a new PLC user or are using ***Direct***LOGIC PLCs for the first time, please take a moment to study how our PLCs use numbers. You'll find that each PLC manufacturer has their own conventions on the use of numbers in their PLCs. We want to take just a moment to familiarize you with how numbers are used in ***Direct***LOGIC PLCs. The information you learn here applies to all our PLCs!

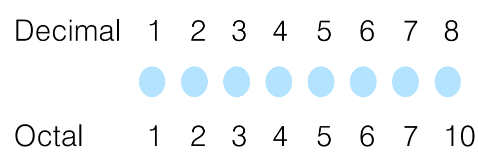


As any good computer does, PLCs store and manipulate numbers in binary form: just ones and zeros. So why do we have to deal with numbers in so many different forms? Numbers have meaning, and some *representations* are more convenient than others for particular purposes. Sometimes we use numbers to represent a size or amount of something. Other numbers refer to locations or addresses, or to time. In science we attach engineering units to numbers to give a particular meaning.

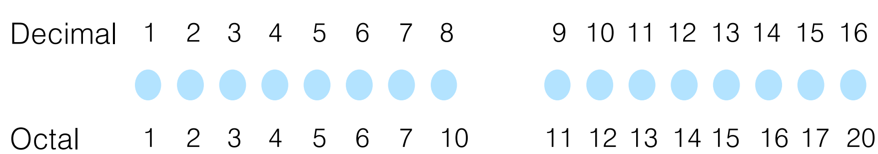
PLC Resources

PLCs offer a fixed amount of resources, depending on the model and configuration. We use the word "resources" to include variable memory (V-memory), I/O points, timers, counters, etc. Most modular PLCs allow you to add I/O points in groups of eight. In fact, all the resources of our PLCs are counted in octal. It's easier for computers to count in groups of eight than ten, because eight is an even power of 2.

Octal means simply counting in groups of eight things at a time. In the figure to the right, there are eight circles. The quantity in decimal is "8", but in octal it is "10" (8 and 9 are not valid in octal). In octal, "10" means 1 group of 8 plus 0 (no individuals).

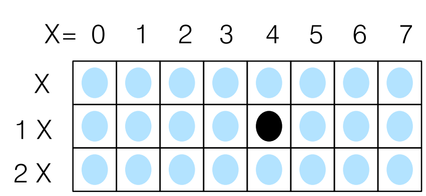


In the figure below, we have two groups of eight circles. Counting in octal we have "20" items, meaning 2 groups of eight, plus 0 individuals Don't say "twenty", say "two–zero octal". This makes a clear distinction between number systems.



After *counting* PLC resources, it's time to *access* PLC resources (there's a difference). The CPU instruction set accesses resources of the PLC using octal addresses. Octal addresses are the same as octal quantities, except they start counting at zero. The number zero is significant to a computer, so we don't skip it.

Our circles are in an array of square containers to the right. To access a resource, our PLC instruction will address its location using the octal references shown. If these were counters, "CT14" would access the black circle location.



V–Memory

Variable memory (called “V-memory”) stores data for the ladder program and for configuration settings (see Appendix E). V-memory locations and V-memory addresses are the same thing, and are numbered in octal. For example, V2073 is a valid location, while V1983 is not valid (“9” and “8” are not valid octal digits).

Each V-memory location is one data word wide, meaning 16 bits. For configuration registers, our manuals will show each bit of a V-memory word. The least significant bit (LSB) will be on the right, and the most significant bit (MSB) on the left. We use the word “significant”, referring to the relative binary weighting of the bits.

V-memory address (octal)	V-memory data (binary) MSB … LSB
V2017	0 1 0 0 1 1 1 0 0 0 1 0 1 0 0 1

V-memory data is 16-bit binary, but we rarely program the data registers one bit at a time. We use instructions or viewing tools that let us work with decimal, octal, and hexadecimal numbers. All these are converted and stored as binary for us.

A frequently-asked question is “How do I tell if a number is octal, BCD, or hex”? The answer is that we usually cannot tell just by looking at the data... but it does not really matter. What matters is: the source or mechanism which writes data into a V-memory location and the thing which later reads it must both use the same data type (i.e., octal, hex, binary, or whatever). The V-memory location is just a storage box... that’s all. It does not convert or move the data on its own.

Binary-Coded Decimal Numbers

Since humans naturally count in decimal (10 fingers, 10 toes), we prefer to enter and view PLC data in decimal as well. However, computers are more efficient in using pure binary numbers. A compromise solution between the two is Binary-Coded Decimal (BCD) representation. A BCD digit ranges from 0 to 9, and is stored as four binary bits (a nibble). This permits each V-memory location to store four BCD digits, with a range of decimal numbers from 0000 to 9999.

BCD number	4	9	3	6
V-memory storage	0 1 0 0	1 0 0 1	0 0 1 1	0 1 1 0

In a pure binary sense, a 16-bit word can represent numbers from 0 to 65535. In storing BCD numbers, the range is reduced to only 0 to 9999. Many math instructions use Binary-Coded Decimal (BCD) data, and ***Direct***SOFT32 and the handheld programmer allow us to enter and view data in BCD.

Hexadecimal Numbers

Hexadecimal numbers are similar to BCD numbers, except they utilize all possible binary values in each 4-bit digit. They are base-16 numbers so we need 16 different digits. To extend our decimal digits 0 through 9, we use A through F as shown.

Decimal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

A 4-digit hexadecimal number can represent all 65536 values in a V-memory word. The range is from 0000 to FFFF (hex). PLCs often need this full range for sensor data, etc. Hexadecimal is just a convenient way for humans to view full binary data.

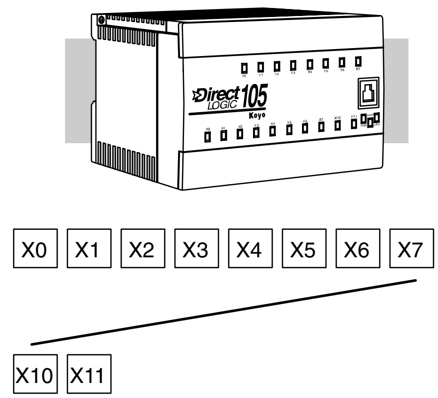
Hexadecimal number	A	7	F	4
V-memory storage	1 0 1 0	0 1 1 1	1 1 1 1	0 1 0 0

Memory Map

With any PLC system, you generally have many different types of information to process. This includes input device status, output device status, various timing elements, parts counts, etc. It is important to understand how the system represents and stores the various types of data. For example, you need to know how the system identifies input points, output points, data words, etc. The following paragraphs discuss the various memory types used in DL105 Micro PLCs. A memory map overview for the CPU follows the memory descriptions.

Octal Numbering System

All memory locations and resources are numbered in Octal (base 8). For example, the diagram shows how the octal numbering system works for the discrete input points. Notice the octal system does not contain any numbers with the digits 8 or 9.

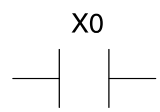


Discrete and Word Locations

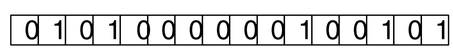
As you examine the different memory types, you'll notice two types of memory in the DL105, discrete and word memory. Discrete memory is one bit that can be either a 1 or a 0. Word memory is referred to as V memory (variable) and is a 16-bit location normally used to manipulate data/numbers, store data/numbers, etc.

Some information is automatically stored in V memory. For example, the timer current values are stored in V memory.

Discrete – On or Off, 1 bit



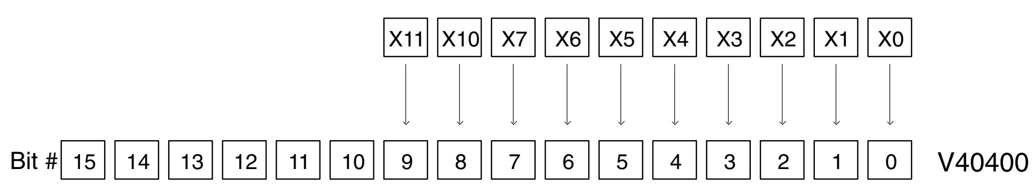
Word Locations – 16 bits



V Memory Locations for Discrete Memory Areas

The discrete memory area is for inputs, outputs, control relays, special relays, stages, timer status bits and counter status bits. However, you can also access the bit data types as a V-memory word. Each V-memory location contains 16 consecutive discrete locations. For example, the following diagram shows how the X input points are mapped into V-memory locations.

10 Discrete (X) Input Points



These discrete memory areas and their corresponding V memory ranges are listed in the memory area table for DL105 Micro PLCs on the following pages.

Input Points (X Data Type)

The discrete input points are noted by an X data type. There are 10 discrete input points available with DL105 CPUs. In this example, the output point Y0 will be turned on when input X0 energizes.

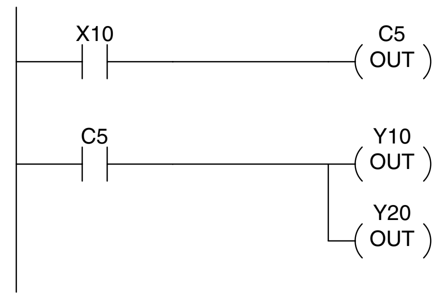
Output Points (Y Data Type)

The discrete output points are noted by a Y data type. There are 128 discrete output points available with DL105 CPUs. In this example, output point Y1 will be turned on when input X1 energizes.

Control Relays (C Data Type)

Control relays are discrete bits normally used to control the user program. The control relays do not represent a real world device, that is, they cannot be physically tied to switches, output coils, etc. They are internal to the CPU. Because of this, control relays can be programmed as discrete inputs or discrete outputs. These locations are used in programming the discrete memory locations (C) or the corresponding word location which contains 16 consecutive discrete locations.

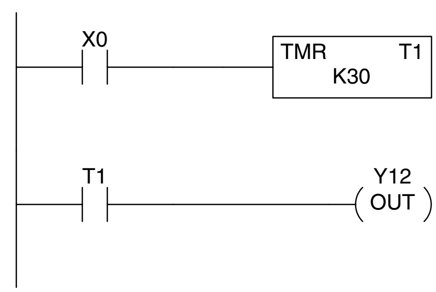
In this example, memory location C5 will energize when input X10 turns on. The second rung shows a simple example of how to use a control relay as an input.



Timers and Timer Status Bits (T Data type)

Timer status bits reflect the relationship between the current value and the preset value of a specified timer. The timer status bit will be on when the current value is equal or greater than the preset value of a corresponding timer.

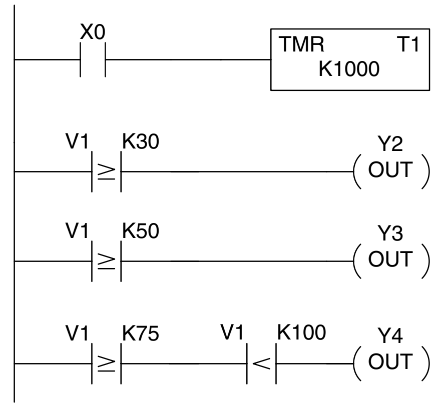
When input X0 turns on, timer T1 will start. When the timer reaches the preset of 3 seconds (K of 30) timer status contact T1 turns on. When T1 turns on, output Y12 turns on. Turning off X0 resets the timer.



Timer Current Values (V Data Type)

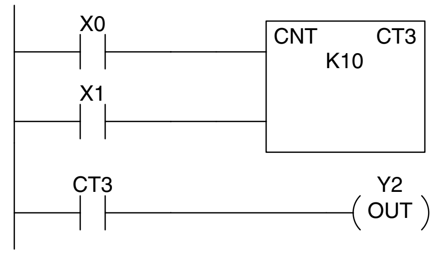
As mentioned earlier, some information is automatically stored in V memory. This is true for the current values associated with timers. For example, V0 holds the current value for Timer 0, V1 holds the current value for Timer 1, etc.

The primary reason for this is programming flexibility. The example shows how you can use relational contacts to monitor several time intervals from a single timer.



Counters and Counter Status Bits (CT Data type)

Counter status bits that reflect the relationship between the current value and the preset value of a specified counter. The counter status bit will be on when the current value is equal to or greater than the preset value of a corresponding counter.

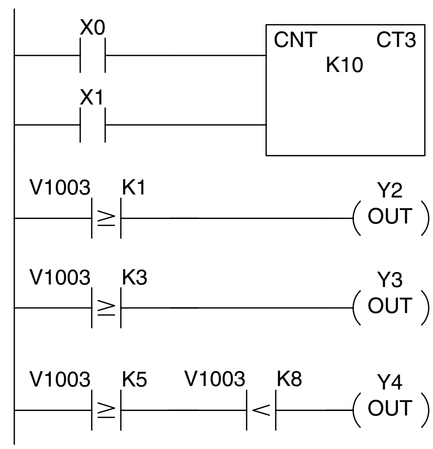


Each time contact X0 transitions from off to on, the counter increments by one. (If X1 comes on, the counter is reset to zero.) When the counter reaches the preset of 10 counts (K of 10) counter status contact CT3 turns on. When CT3 turns on, output Y12 turns on.

Counter Current Values (V Data Type)

Just like the timers, the counter current values are also automatically stored in V memory. For example, V1000 holds the current value for Counter CT0, V1001 holds the current value for Counter CT1, etc.

The primary reason for this is programming flexibility. The example shows how you can use relational contacts to monitor the counter values.

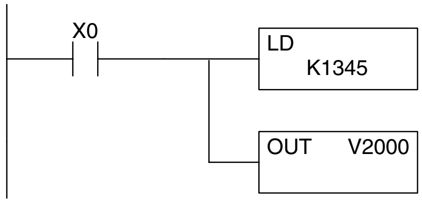


Word Memory (V Data Type)

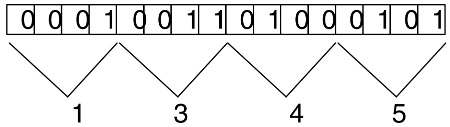
Word memory is referred to as V memory (variable) and is a 16-bit location normally used to manipulate data/numbers, store data/numbers, etc. (see Appendix E).

Some information is automatically stored in V memory. For example, the timer current values are stored in V memory.

The example shows how a four-digit BCD constant is loaded into the accumulator and then stored in a V-memory location.



Word Locations – 16 bits

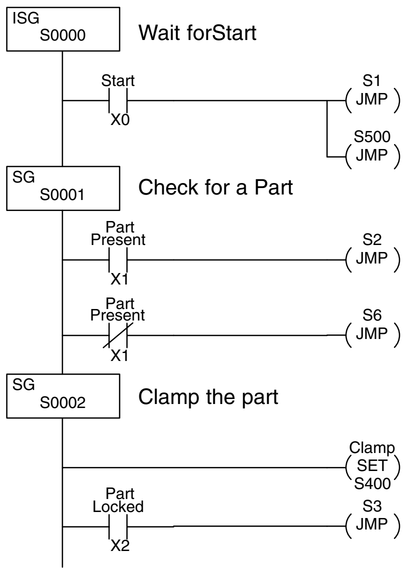


Stages (S Data type)

Stages are used in RLL*PLUS* Stage programs to create a structured program, similar to a flowchart. Each program stage denotes a program segment. When the program segment, or stage, is active, the logic within that segment is executed. If the stage is off, or inactive, the logic is not executed and the CPU skips to the next active stage. (See Chapter 7 for a more detailed description of RLL*PLUS* Stage programming.)

Each stage also has a discrete status bit that can be used as an input to indicate whether the stage is active or inactive. If the stage is active, then the status bit is on. If the stage is inactive, then the status bit is off. This status bit can also be turned on or off by other instructions, such as the SET or RESET instructions. This allows you to easily control stages throughout the program.

Ladder Representation



Special Relays (SP Data Type)

Special relays are discrete memory locations with pre-defined functionality. There are many different types of special relays. For example, some aid in program development, others provide system operating status information, etc. Appendix D provides a complete listing of the special relays.

In this example, control relay C10 will energize for 50 ms and de-energize for 50 ms because SP5 is a pre–defined relay that will be on for 50 ms and off for 50 ms.

SP4: 1 second clock
SP5: 100 ms clock
SP6: 50 ms clock

DL105 System V-memory

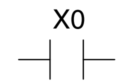
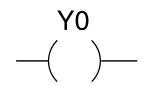
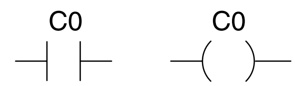
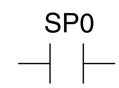
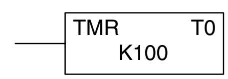
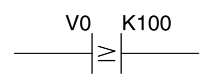
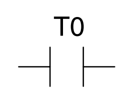
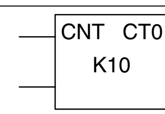
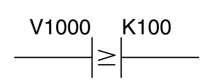
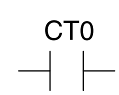
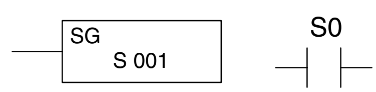
System Parameters and Default Data Locations (V Data Type)

The DL105 PLCs reserve several V-memory locations for storing system parameters or certain types of system data. These memory locations store things like the error codes, High-Speed I/O data, and other types of system setup information.

System V-memory	Description of Contents	Default Values / Ranges
V2320–V2377	The default location for multiple preset values for the High-Speed Counter	N/A
V7620–V7627	Locations for DV–1000 operator interface parameters	
V7620	Sets the V-memory location that contains the value.	V0 – V2377
V7621	Sets the V-memory location that contains the message.	V0 – V2377
V7622	Sets the total number (1 – 16) of V-memory locations to be displayed.	1 – 16
V7623	Sets the V-memory location that contains the numbers to be displayed.	V0 – V2377
V7624	Sets the V-memory location that contains the character code to be displayed.	V0 – V2377
V7625	Contains the function number that can be assigned to each key.	V-memory location for X, Y, or C points used.
V7626	Powerup operational mode.	0, 1, 2, 12, 3
V7627	Change preset value.	0000 to 9999
V7630	Starting location for the multi–step presets for channel 1. The default value is 2320, which indicates the first value should be obtained from V2320. Since there are 24 presets available, the default range is V2320 – V2377. You can change the starting point if necessary.	Default: V2320 Range: V0 – V2320
V7631–V7632	Not used	N/A
V7633	Sets the desired function code for the high speed counter, interrupt, pulse catch, pulse train, and input filter. Location is also used for setting the power-up in Run Mode option.	Default: 0060 Lower Byte Range: Range: 10 – Counter 20 – Quadrature 30 – Pulse Out 40 – Interrupt 50 – Pulse Catch 60 – Filtered discrete In. Upper Byte Range: Bits 8 – 12, 14,15: Unused Bit 13: Power-up in Run
V7634	X0 Setup Register for High-Speed I/O functions	Default: 1006
V7635	X1 Setup Register for High-Speed I/O functions	Default: 1006
V7636	X2 Setup Register for High-Speed I/O functions	Default: 1006
V7637	X3 Setup Register for High-Speed I/O functions	Default: 1006

System V-memory	Description of Contents	Default Values / Ranges
V7640–V7647	Not used	N/A
V7751	Fault Message Error Code — stores the 4-digit code used with the FAULT instruction when the instruction is executed.	N/A
V7752–V7754	Not used	N/A
V7755	Error code — stores the fatal error code.	
V7756	Error code — stores the major error code.	
V7757	Error code — stores the minor error code.	
V7760–V7762	Not used	
V7763	Program address where syntax error exists	N/A
V7764	Syntax error code	N/A
V7765	Scan — stores the total number of scan cycles that have occurred since the last Program Mode to Run Mode transition.	N/A
V7666–V7774	Not used	N/A
V7775	Scan — stores the current scan time (milliseconds).	N/A
V7776	Scan — stores the minimum scan time that has occurred since the last Program Mode to Run Mode transition (milliseconds).	N/A
V7777	Scan — stores the maximum scan time that has occurred since the last Program Mode to Run Mode transition (milliseconds).	N/A

DL105 Memory Map

Memory Type	Discrete Memory Reference (octal)	Word Memory Reference (octal)	Qty. Decimal	Symbol
Input Points (See note 1)	X0 – X177	V40400 – V40407	128	 X0
Output Points (See note 1)	Y0 – Y177	V40500 – V40507	128	 Y0
Control Relays	C0 – C377	V40600 – V40617	256	 C0 C0
Special Relays	SP0 – SP117 SP540 – SP577	V41200 – V41204 V41226 – V41227	112	 SP0
Timers	T0 – T77		64	 TMR T0 K100
Timer Current Values	None	V0 – V77	64	 V0 K100 ≥
Timer Status Bits	T0 – T77	V41100 – V41103	64	 T0
Counters	CT0 – CT77		64	 CNT CT0 K10
Counter Current Values	None	V1000 – V1077	64	 V1000 K100 ≥
Counter Status Bits	CT0 – CT77	V41140 – V41143	64	 CT0
Data Words (See Appendix E)	None	V2000 – V2377	256	None specific, used with many instructions
Data Words Non–volatile (See Appendix E)	None	V4000 – V4177	128	None specific, used with many instructions
Stages	S0 – S377	V41000 – V41017	256	 SG S 001 S0
System parameters	None	V7620 – V7647 V7750–V7777	48	None specific, used for various purposes

1 – The DL105 systems are limited to 10 discrete inputs and 8 discrete outputs with the present available hardware, but 128 point addresses exist.

X Input Bit Map

This table provides a listing of individual Input points associated with each V-memory address bit for the DL105's ten physical inputs. Actual available references are X0 to X177 (V40400 – V40407).

MSB						DL105 Input (X) Points									LSB	Address
17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
–	–	–	–	–	–	011	010	007	006	005	004	003	002	001	000	V40400

Y Output Bit Map

This table provides a listing of individual output points associated with each V-memory address bit for the DL105's eight physical outputs. Actual available references are Y0 to Y177 (V40500 – V40507).

MSB						DL105 Output (Y) Points									LSB	Address
17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
–	–	–	–	–	–	–	–	007	006	005	004	003	002	001	000	V40500

Control Relay Bit Map

This table provides a listing of the individual control relays associated with each V-memory address bit.

MSB						DL105 Control Relays (C)									LSB	Address
17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
017	016	015	014	013	012	011	010	007	006	005	004	003	002	001	000	V40600
037	036	035	034	033	032	031	030	027	026	025	024	023	022	021	020	V40601
057	056	055	054	053	052	051	050	047	046	045	044	043	042	041	040	V40602
077	076	075	074	073	072	071	070	067	066	065	064	063	062	061	060	V40603
117	116	115	114	113	112	111	110	107	106	105	104	103	102	101	100	V40604
137	136	135	134	133	132	131	130	127	126	125	124	123	122	121	120	V40605
157	156	155	154	153	152	151	150	147	146	145	144	143	142	141	140	V40606
177	176	175	174	173	172	171	170	167	166	165	164	163	162	161	160	V40607
217	216	215	214	213	212	211	210	207	206	205	204	203	202	201	200	V40610
237	236	235	234	233	232	231	230	227	226	225	224	223	222	221	220	V40611
257	256	255	254	253	252	251	250	247	246	245	244	243	242	241	240	V40612
277	276	275	274	273	272	271	270	267	266	265	264	263	262	261	260	V40613
317	316	315	314	313	312	311	310	307	306	305	304	303	302	301	300	V40614
337	336	335	334	333	332	331	330	327	326	325	324	323	322	321	320	V40615
357	356	355	354	353	352	351	350	347	346	345	344	343	342	341	340	V40616
377	376	375	374	373	372	371	370	367	366	365	364	363	362	361	360	V40617

Stage Control / Status Bit Map

This table provides a listing of individual Stage™ control bits associated with each V-memory address bit.

MSB						DL105 Stage (S) Control Bits									LSB	Address
17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
017	016	015	014	013	012	011	010	007	006	005	004	003	002	001	000	V41000
037	036	035	034	033	032	031	030	027	026	025	024	023	022	021	020	V41001
057	056	055	054	053	052	051	050	047	046	045	044	043	042	041	040	V41002
077	076	075	074	073	072	071	070	067	066	065	064	063	062	061	060	V41003
117	116	115	114	113	112	111	110	107	106	105	104	103	102	101	100	V41004
137	136	135	134	133	132	131	130	127	126	125	124	123	122	121	120	V41005
157	156	155	154	153	152	151	150	147	146	145	144	143	142	141	140	V41006
177	176	175	174	173	172	171	170	167	166	165	164	163	162	161	160	V41007
217	216	215	214	213	212	211	210	207	206	205	204	203	202	201	200	V41010
237	236	235	234	233	232	231	230	227	226	225	224	223	222	221	220	V41011
257	256	255	254	253	252	251	250	247	246	245	244	243	242	241	240	V41012
277	276	275	274	273	272	271	270	267	266	265	264	263	262	261	260	V41013
317	316	315	314	313	312	311	310	307	306	305	304	303	302	301	300	V41014
337	336	335	334	333	332	331	330	327	326	325	324	323	322	321	320	V41015
357	356	355	354	353	352	351	350	347	346	345	344	343	342	341	340	V41016
377	376	375	374	373	372	371	370	367	366	365	364	363	362	361	360	V41017

Timer Status Bit Map

This table provides a listing of individual timer contacts associated with each V-memory address bit.

MSB						DL105 Timer (T) Contacts									LSB	Address
17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
017	016	015	014	013	012	011	010	007	006	005	004	003	002	001	000	V41100
037	036	035	034	033	032	031	030	027	026	025	024	023	022	021	020	V41101
057	056	055	054	053	052	051	050	047	046	045	044	043	042	041	040	V41102
077	076	075	074	073	072	071	070	067	066	065	064	063	062	061	060	V41103

Counter Status Bit Map

This table provides a listing of individual counter contacts associated with each V-memory address bit.

MSB						DL105 Counter (CT) Contacts									LSB	Address
17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
017	016	015	014	013	012	011	010	007	006	005	004	003	002	001	000	V41140
037	036	035	034	033	032	031	030	027	026	025	024	023	022	021	020	V41141
057	056	055	054	053	052	051	050	047	046	045	044	043	042	041	040	V41142
077	076	075	074	073	072	071	070	067	066	065	064	063	062	061	060	V41143

5

Standard RLL Instructions

In This Chapter. . . .

Introduction

DL105 Micro PLCs offer a wide variety of instructions to perform many different types of operations. This chapter shows you how to use each standard Relay Ladder Logic (RLL) instruction. In addition to these instructions, you may also need to refer to the Drum instruction in Chapter 6, or the Stage programming instructions in Chapter 7.

There are two ways to quickly find the instruction you need.

- If you know the instruction category (Boolean, Comparative Boolean, etc.) just use the title at the top of the page to find the pages that discuss the instructions in that category.
- If you know the individual instruction name, use the following table to find the page(s) that discusses the instruction.

Instruction	Page
ACON	5–83
ADD	5–59
ADDD	5–11
AND	5–10, 5–21, 5–51
AND STR	5–11
ANDD	5–52
ANDE	5–18
ANDI	5–23
ANDN	5–10, 5–21
ANDNE	5–18
ANDNI	5–23
BCD	5–71
BIN	5–70
CMP	5–57
CMPD	5–58
CNT	5–32
DECB	5–65
DECO	5–69
DISI	5–79
DIV	5–64
DLBL	5–83
EDRUM	6–2, 6–12
ENCO	5–68
END	5–76
ENI	5–79
FAULT	5–82
INCB	5–65
INT	5–79

Instruction	Page
INV	5–72
IRT	5–79
ISG	7–20
JMP	7–20
LD	5–44
LDA	5–47
LDD	5–45
LDF	5–46
LDLBL	5–74
MLR	5–77
MLS	5–77
MOV	5–73
MOVMC	5–74
MUL	5–63
NCON	5–83
NOP	5–76
OR	5–9, 5–20, 5–53
OR OUT	5–13
OR OUTI	5–24
OR STR	5–11
ORD	5–54
ORE	5–17
ORI	5–22
ORN	5–9, 5–20
ORNE	5–17
ORNI	5–22
OUT	5–13, 5–48
OUTD	5–48
OUTF	5–49

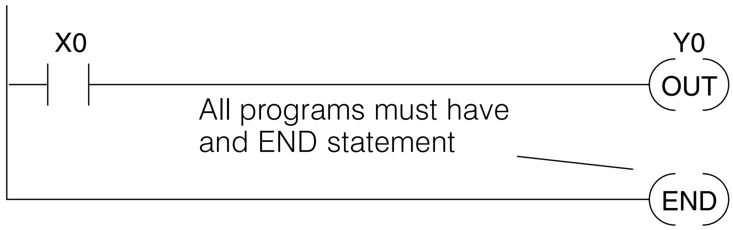
Instruction	Page
PAUSE	5–15
PD	5–14
POP	5–49
RST	5–14
RSTI	5–25
SET	5–14
SETI	5–25
SG	7–19
SGCNT	5–34
SHFL	5–66
SHFR	5–67
SR	5–38
STOP	5–76
STR	5–8, 5–19
STRE	5–16
STRI	5–22
STRN	5–8, 5–19
STRNE	5–16
STRNI	5–22
SUB	5–61
SUBD	5–62
TMR	5–27
TMRF	5–27
TMRA	5–29
TMRAF	5–29
UDC	5–36
XOR	5–55
XORD	5–56

Using Boolean Instructions

Do you ever wonder why so many PLC manufacturers always quote the scan time for a 1K boolean program? Simple. Most all programs utilize many boolean instructions. These are typically very simple instructions designed to join input and output contacts in various series and parallel combinations. Since the ***Direct***SOFT32 software allows you to use graphic symbols to build the program, you don't absolutely *have* to know the mnemonics of the instructions. However, it may helpful at some point, especially if you ever have to troubleshoot the program with a Handheld Programmer.The following paragraphs show how these instructions are used to build simple ladder programs.

END Statement

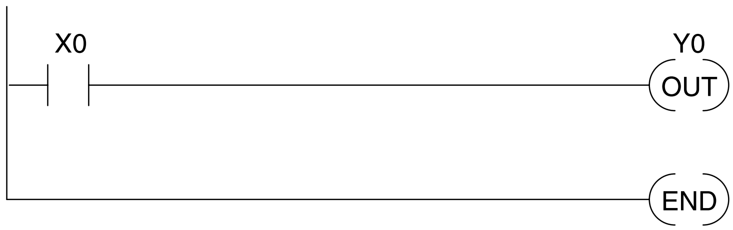
All DL105 programs require an END statement as the last instruction. This tells the CPU that this is the end of the program. Normally, any instructions placed after the END statement will not be executed. There are exceptions to this such as interrupt routines, etc. Chapter 5 discusses the instruction set in detail.



Simple Rungs

You use a contact to start rungs that contain both contacts and coils. The boolean instruction that does this is called a Store or, STR instruction. The output point is represented by the Output or, OUT instruction. The following example shows how to enter a single contact and a single output coil.

DirectSOFT32 Example



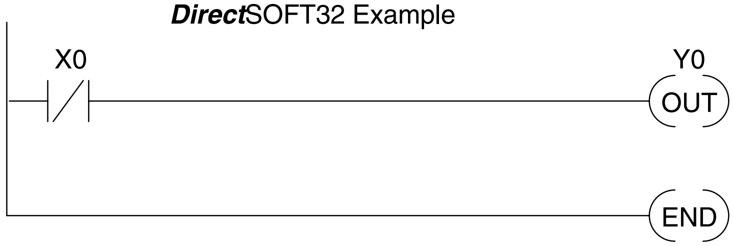
Handheld Mnemonics

STR X0
OUT Y0
END

Normally Closed Contact

Normally closed contacts are also very common. This is accomplished with the Store Not or, STRN instruction. The following example shows a simple rung with a normally closed contact.

DirectSOFT32 Example



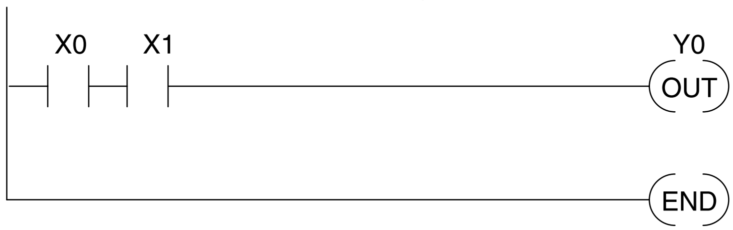
Handheld Mnemonics

STRN X0
OUT Y0
END

Contacts in Series

Use the AND instruction to join two or more contacts in series. The following example shows two contacts in series and a single output coil. The instructions used would be STR X0, AND X1, followed by OUT Y0.

DirectSOFT32 Example



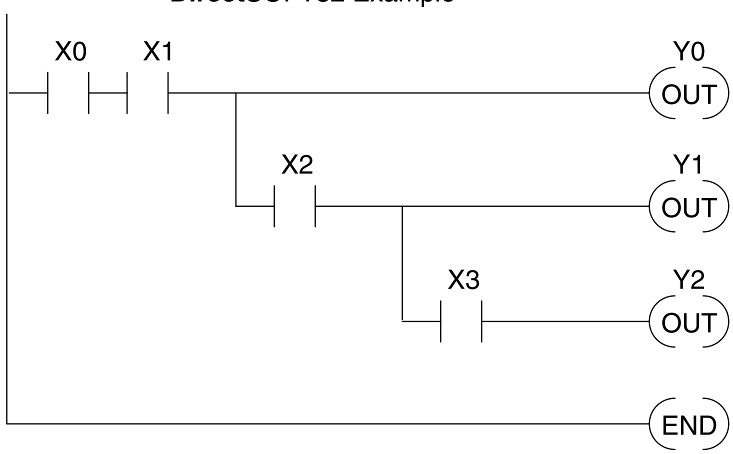
Handheld Mnemonics

STR X0
AND X1
OUT Y0
END

Midline Outputs

Sometimes it is necessary to use midline outputs to get additional outputs that are conditional on other contacts. The following example shows how you can use the AND instruction to continue a rung with more conditional outputs.

DirectSOFT32 Example



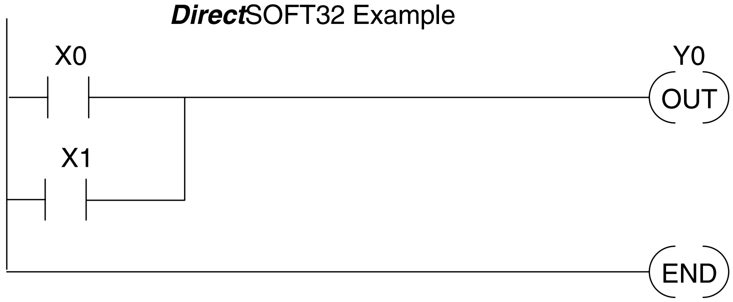
Handheld Mnemonics

STR X0
AND X1
OUT Y0
AND X2
OUT Y1
AND X3
OUT Y2
END

Parallel Elements

You also have to join contacts in parallel. The OR instruction allows you to do this. The following example shows two contacts in parallel and a single output coil. The instructions would be STR X0, OR X1, followed by OUT Y0.

DirectSOFT32 Example



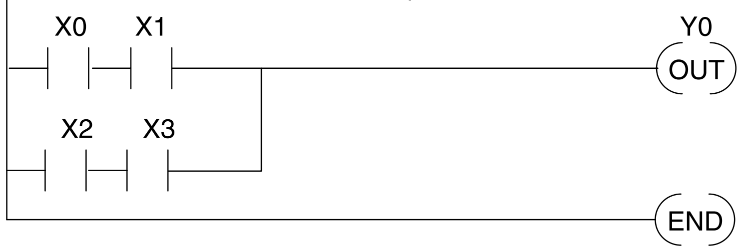
Handheld Mnemonics

STR X0
OR X1
OUT Y0
END

Joining Series Branches in Parallel

Quite often it is necessary to join several groups of series elements in parallel. The Or Store (ORSTR) instruction allows this operation. The following example shows a simple network consisting of series elements joined in parallel.

DirectSOFT32 Example



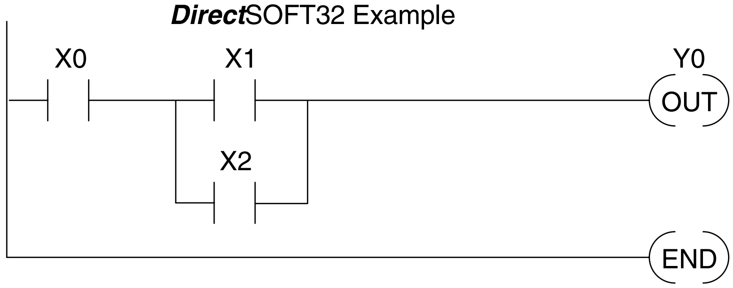
Handheld Mnemonics

```
STR X0
AND X1
STR X2
AND X3
ORSTR
OUT Y0
END
```

Joining Parallel Branches in Series

You can also join one or more parallel branches in series. The And Store (ANDSTR) instruction allows this operation. The following example shows a simple network with contact branches in series with parallel contacts.

DirectSOFT32 Example

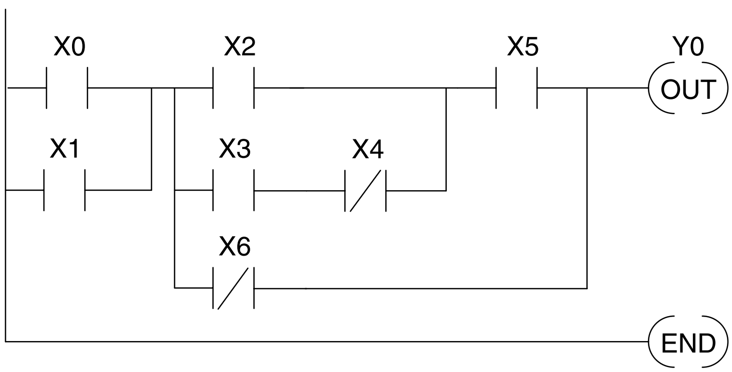


Handheld Mnemonics

```
STR X0
STR X1
OR X2
ANDSTR
OUT Y0
END
```

Combination Networks

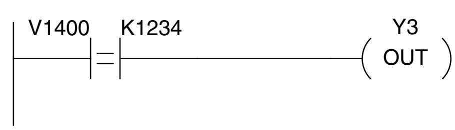
You can combine the various types of series and parallel branches to solve most any application problem. The following example shows a simple combination network.



Comparative Boolean

Some PLC manufacturers make it really difficult to do a simple comparison of two numbers. Some of them require you to move the data all over the place before you can actually perform the comparison. The DL105 Micro PLCs provide Comparative Boolean instructions that allow you to quickly and easily solve this problem. The Comparative Boolean provides evaluation of two 4-digit values using boolean contacts. The valid evaluations are: equal to, not equal to, equal to or greater than, and less than.

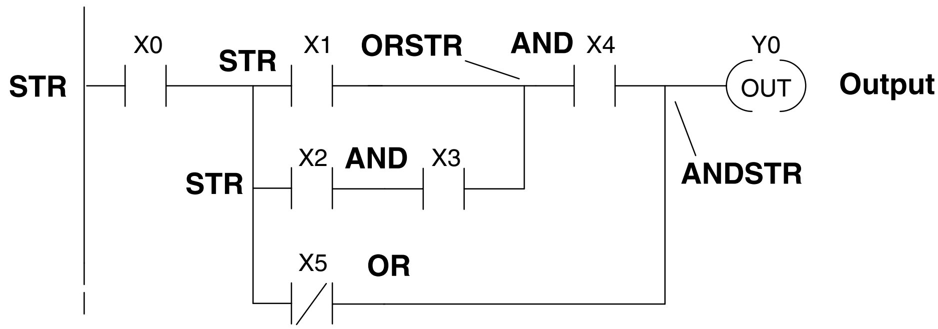
In the following example when the value in V-memory location V1400 is equal to the constant value 1234, Y3 will energize.



Boolean Stack

There are limits to how many elements you can include in a rung. This is because the DL105 PLCs use an 8-level boolean stack to evaluate the various logic elements. The boolean stack is a temporary storage area that solves the logic for the rung. Each time the program encounters a STR instruction, the instruction is placed on the top of the stack. Any other STR instructions already on the boolean stack are pushed down a level. The ANDSTR, and ORSTR instructions combine levels of the boolean stack when they are encountered. An error will occur during program compilation if the CPU encounters a rung that uses more than the eight levels of the boolean stack.

The following example shows how the boolean stack is used to solve boolean logic.



STR X0

1	STR X0
2	
3	
4	
5	
6	
7	
8	

STR X1

1	STR X1
2	STR X0
3	
4	
5	
6	
7	
8	

STR X2

1	STR X2
2	STR X1
3	STR X0
4	
5	
6	
7	
8	

AND X3

1	X2 AND X3
2	STR X1
3	STR X0
4	
5	
6	
7	
8	

ORSTR

1	X1 OR (X2 AND X3)
2	STR X0
3	
:	
8	

AND X4

1	X4 AND [X1 OR (X2 AND X3)]
2	STR X0
3	
:	
8	

ORNOT X5

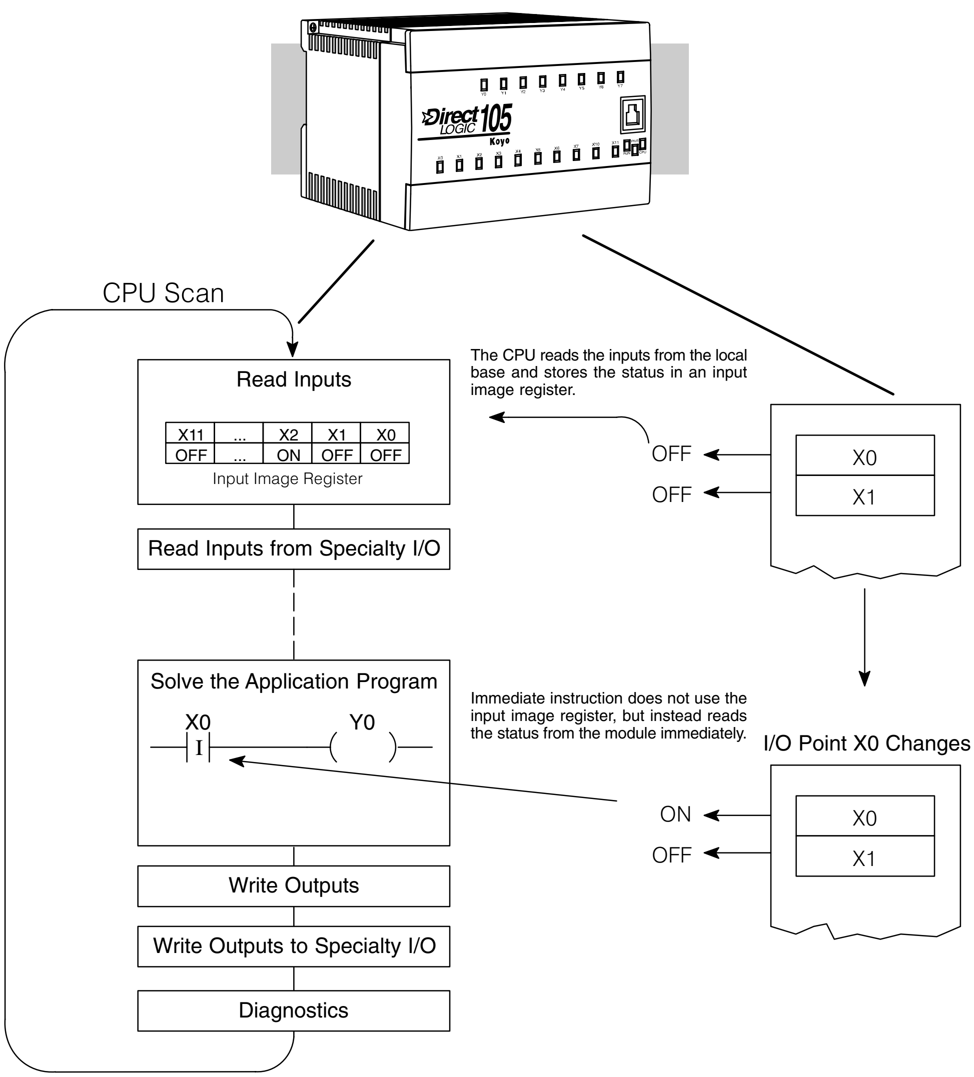
1	NOT X5 OR X4 AND [X1 OR (X2 AND X3)]
2	STR X0
3	
:	
8	

ANDSTR

1	X0 AND (NOT X5 OR X4) AND [X1 OR (X2 AND X3)]
2	
3	
:	
8	

Immediate Boolean The DL105 Micro PLCs usually can complete an operation cycle in a matter of milliseconds. However, in some applications you may not be able to wait a few milliseconds until the next I/O update occurs. The DL105 PLCs offer Immediate input and outputs which are special boolean instructions that allow reading directly from inputs and writing directly to outputs during the program execution portion of the CPU cycle. You may recall that this is normally done during the input or output update portion of the CPU cycle. The immediate instructions take longer to execute because the program execution is interrupted while the CPU reads or writes the I/O point. This function is not normally done until the read inputs or the write outputs portion of the CPU cycle.

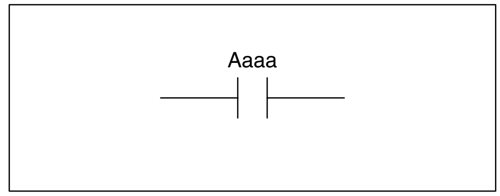
NOTE: Even though the immediate input instruction reads the most current status from the input point, it only uses the results to solve that one instruction. It does not use the new status to update the image register. Therefore, any regular instructions that follow will still use the image register values. Any immediate instructions that follow will access the I/O again to update the status. The immediate output instruction will write the status to the I/O and update the image register.



Boolean Instructions

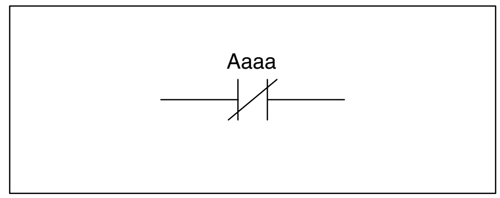
Store (STR)

The Store instruction begins a new rung or an additional branch in a rung with a normally open contact. Status of the contact will be the same state as the associated image register point or memory location.



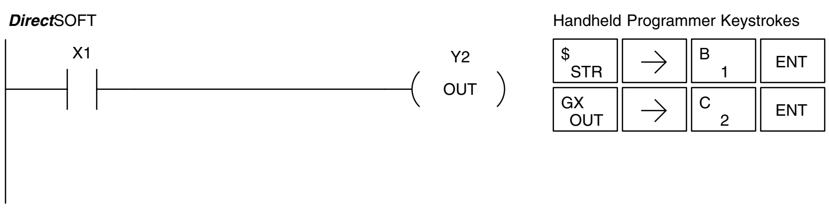
Store Not (STRN)

The Store Not instruction begins a new rung or an additional branch in a rung with a normally closed contact. Status of the contact will be opposite the state of the associated image register point or memory location.

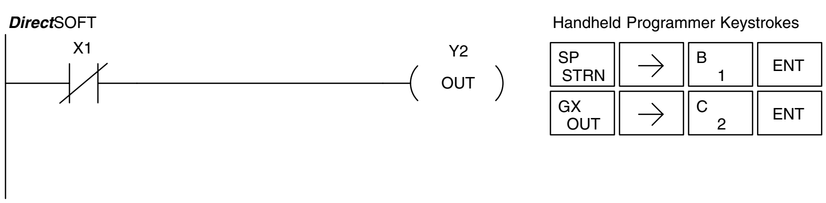


Operand Data Type		DL130 Range
	A	aaa
Inputs	X	0–11
Outputs	Y	0–7
Control Relays	C	0–377
Stage	S	0–377
Timer	T	0–77
Counter	CT	0–77
Special Relay	SP	0–117, 540–577

In the following Store example, when input X1 is on, output Y2 will energize.

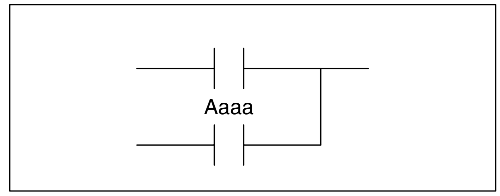


In the following Store Not example, when input X1 is off output Y2 will energize.



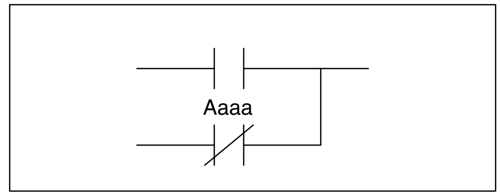
Or (OR)

The Or instruction logically ors a normally open contact in parallel with another contact in a rung. The status of the contact will be the same state as the associated image register point or memory location.



Or Not (ORN)

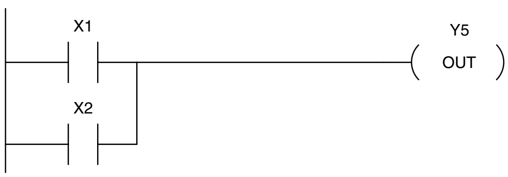
The Or Not instruction logically ors a normally closed contact in parallel with another contact in a rung. The status of the contact will be opposite the state of the associated image register point or memory location.



Operand Data Type		DL130 Range
	A	aaa
Inputs	X	0–11
Outputs	Y	0–7
Control Relays	C	0–377
Stage	S	0–377
Timer	T	0–77
Counter	CT	0–77
Special Relay	SP	0–117, 540–577

In the following Or example, when input X1 or X2 is on, output Y5 will energize.

***Direct*SOFT**

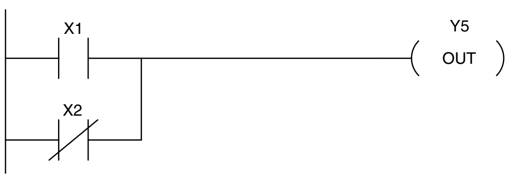


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT
Q OR	→	C 2	ENT
GX OUT	→	F 5	ENT

In the following Or Not example, when input X1 is on or X2 is off, output Y5 will energize.

***Direct*SOFT**

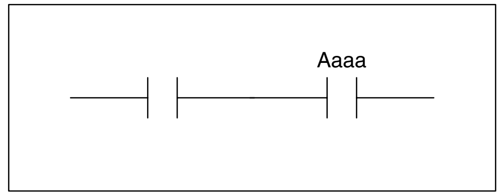


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT
R ORN	→	C 2	ENT
GX OUT	→	F 5	ENT

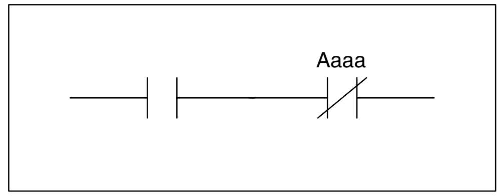
And (AND)

The And instruction logically ands a normally open contact in series with another contact in a rung. The status of the contact will be the same state as the associated image register point or memory location.



And Not (ANDN)

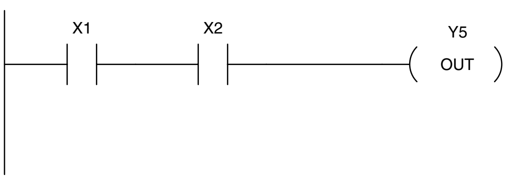
The And Not instruction logically ands a normally closed contact in series with another contact in a rung. The status of the contact will be opposite the state of the associated image register point or memory location.



Operand Data Type		DL130 Range
	A	aaa
Inputs	X	0–11
Outputs	Y	0–7
Control Relays	C	0–377
Stage	S	0–377
Timer	T	0–77
Counter	CT	0–77
Special Relay	SP	0–117, 540–577

In the following And example, when input X1 and X2 are on output Y5 will energize.

***Direct*SOFT**

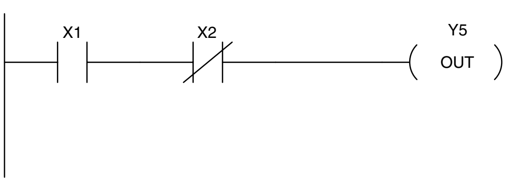


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT
V AND	→	C 2	ENT
GX OUT	→	F 5	ENT

In the following And Not example, when input X1 is on and X2 is off output Y5 will energize.

***Direct*SOFT**

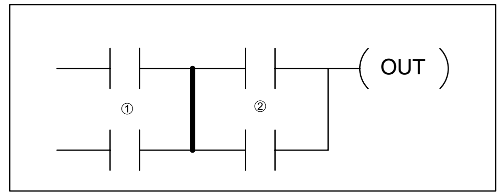


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT
W ANDN	→	C 2	ENT
GX OUT	→	F 5	ENT

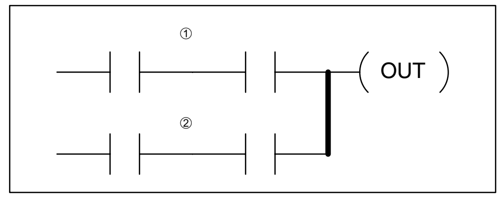
And Store (AND STR)

The And Store instruction logically ands two branches of a rung in series. Both branches must begin with the Store instruction.



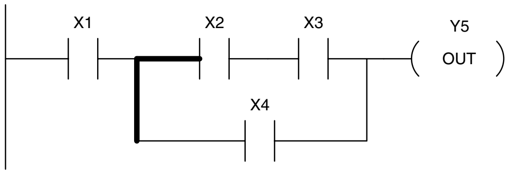
Or Store (OR STR)

The Or Store instruction logically ors two branches of a rung in parallel. Both branches must begin with the Store instruction.



In the following And Store example, the branch consisting of contacts X2, X3, and X4 have been anded with the branch consisting of contact X1.

***Direct*SOFT**

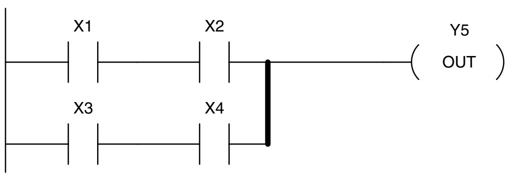


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT
$ STR	→	C 2	ENT
V AND	→	D 3	ENT
Q OR	→	E 4	ENT
L ANDST	ENT		
GX OUT	→	F 5	ENT

In the following Or Store example, the branch consisting of X1 and X2 have been ored with the branch consisting of X3 and X4.

***Direct*SOFT**

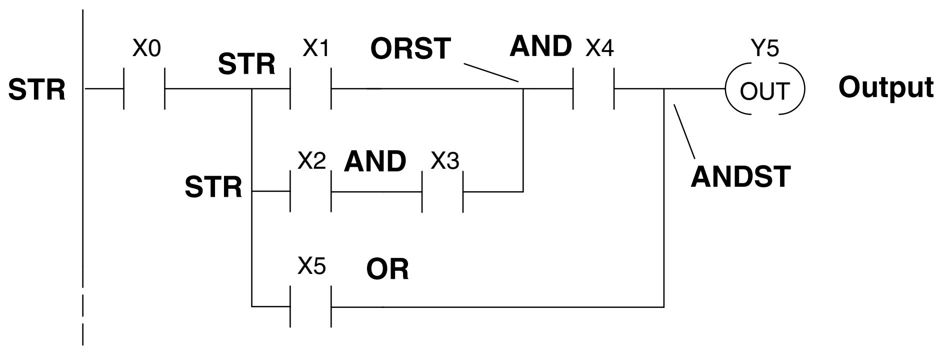


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT
V AND	→	C 2	ENT
$ STR	→	D 3	ENT
V AND	→	E 4	ENT
M ORST	ENT		
GX OUT	→	F 5	ENT

There are limits to what you can enter with boolean instructions. This is because the DL105 internal CPU uses an 8-level stack to evaluate the various logic elements. The stack is a temporary storage area that helps solve the logic for the rung. Each time you enter a STR instruction, the instruction is placed on the top of the stack. Any other instructions on the stack are pushed down a level. The And Store and Or Store instructions combine levels of the stack when they are encountered. Since the stack is only eight levels, an error will occur if the CPU encounters a rung that uses more than the eight levels of the stack.

The following example shows how the stack is used to solve boolean logic.



STR X0

1	STR X0
2	
3	
4	
5	
6	
7	
8	

STR X1

1	STR X1
2	STR X0
3	
4	
5	
6	
7	
8	

STR X2

1	STR X2
2	STR X1
3	STR X0
4	
5	
6	
7	
8	

AND X3

1	X2 AND X3
2	STR X1
3	STR X0
4	
5	
6	
7	
8	

ORST

1	X1 OR (X2 AND X3)
2	STR X0
3	
⋮	
8	

AND X4

1	X4 AND [X1 OR (X2 AND X3)]
2	STR X0
3	
⋮	
8	

OR X5

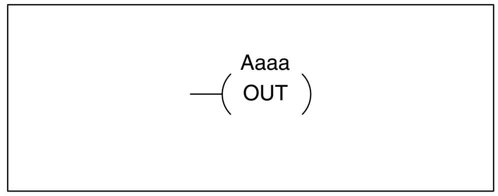
1	X5 OR [X4 AND [X1 OR (X2 AND X3)]]
2	STR X0
3	
⋮	
8	

ANDST

1	X0 AND [(X5 OR [X4) AND [X1 OR (X2 AND X3)]]]
2	
3	
⋮	
8	

Out (OUT)

The Out instruction reflects the status of the rung (on/off) and outputs the discrete (on/off) state to the specified image register point or memory location.

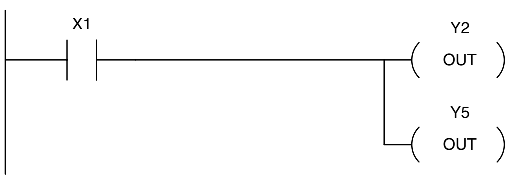


Multiple Out instructions referencing the same discrete location should not be used since only the last Out instruction in the program will control the physical output point. Instead, use the next instruction, the Or Out.

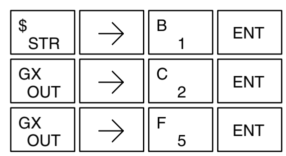
Operand Data Type		DL130 Range
	A	aaa
Inputs	X	0–11
Outputs	Y	0–7
Control Relays	C	0–377

In the following Out example, when input X1 is on, output Y2 and Y5 will energize.

*Direct*SOFT

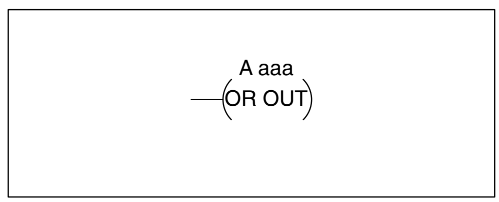


Handheld Programmer Keystrokes



Or Out (OR OUT)

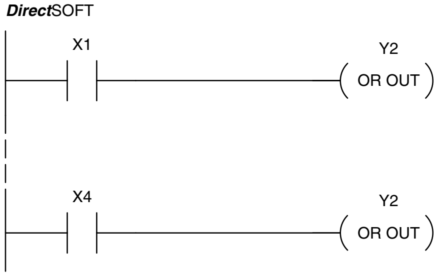
The Or Out instruction allows more than one rung of discrete logic to control a single output. Multiple Or Out instructions referencing the same output coil may be used, since *all* contacts controlling the output are logically ORed together. If the status of *any* rung is on, the output will also be on.



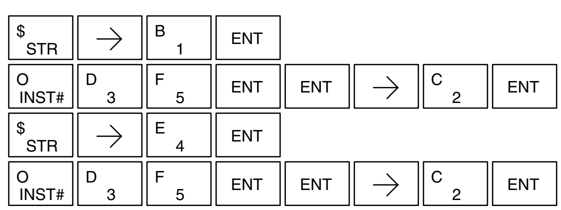
Operand Data Type		DL130 Range
	A	aaa
Inputs	X	0–177
Outputs	Y	0–177
Control Relays	C	0–377

In the following example, when X1 or X4 is on, Y2 will energize.

*Direct*SOFT

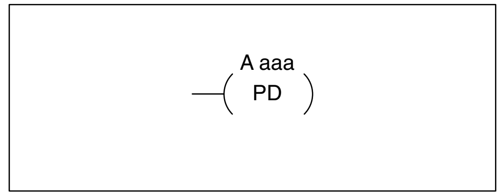


Handheld Programmer Keystrokes



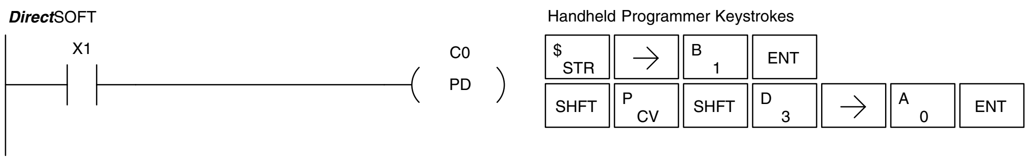
Positive Differential (PD)

The Positive Differential instruction is typically known as a one shot. When the input logic produces an off to on transition, the output will energize for one CPU scan.



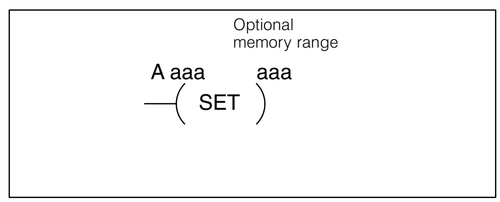
Operand Data Type		DL130 Range
	A	aaa
Inputs	X	0–11
Outputs	Y	0–7
Control Relays	C	0–377

In the following example, every time X1 makes an off to on transition, C0 will energize for one scan.



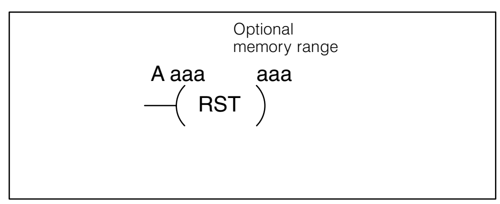
Set (SET)

The Set instruction sets or turns on an image register point/memory location or a consecutive range of image register points/memory locations. Once the point/location is set it will remain on until it is reset using the Reset instruction. It is not necessary for the input controlling the Set instruction to remain on.



Reset (RST)

The Reset instruction resets or turns off an image register point/memory location or a range of image registers points/memory locations. Once the point/location is reset it is not necessary for the input to remain on.



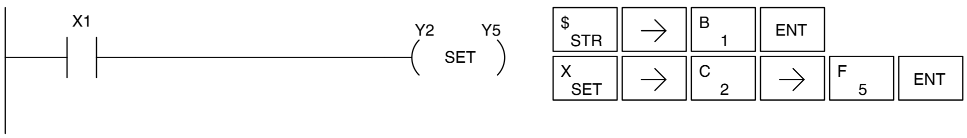
Operand Data Type		DL105 Range
	A	aaa
Inputs	X	0–11
Outputs	Y	0–7
Control Relays	C	0–377
Stage	S	0–377
Timer	T	0–77
Counter	CT	0–77

Set, Reset Instr. Continued

In the following example when X1 is on, Y2 through Y5 will energize.

*Direct*SOFT

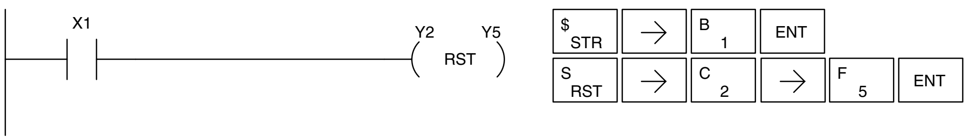
Handheld Programmer Keystrokes



In the following example when X1 is on, Y2 through Y5 will be reset or de–energized.

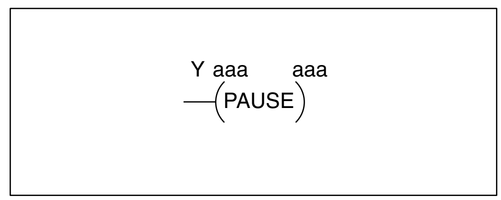
*Direct*SOFT

Handheld Programmer Keystrokes



Pause (PAUSE)

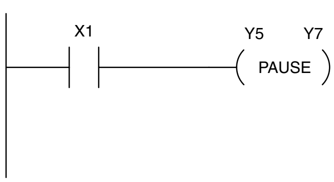
The Pause instruction disables the output update on a range of outputs. The ladder program will continue to run and update the image register. However, the outputs in the range specified in the Pause instruction will be turned off at the output points.



Operand Data Type		DL130 Range
		aaa
Outputs	Y	0–7

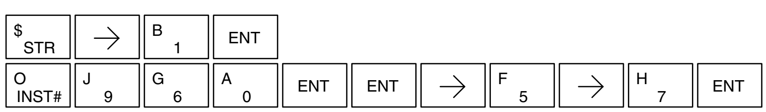
In the following example, when X1 is ON, Y5–Y7 will be turned OFF. The execution of the ladder program will not be affected.

*Direct*SOFT



Since the D2–HPP Handheld Programmer does not have a specific Pause key, you can use the corresponding instruction number for entry (#960), or type each letter of the command.

Handheld Programmer Keystrokes

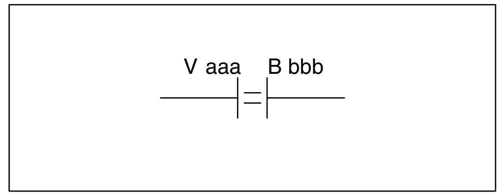


In some cases, you may want certain output points in the specified pause range to operate normally. In that case, use Aux 58 to over-ride the Pause instruction.

Comparative Boolean

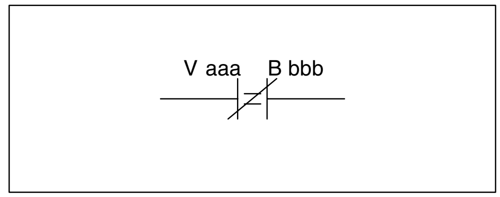
Store If Equal (STRE)

The Store If Equal instruction begins a new rung or additional branch in a rung with a normally open comparative contact. The contact will be on when Vaaa =Bbbb .



Store If Not Equal (STRNE)

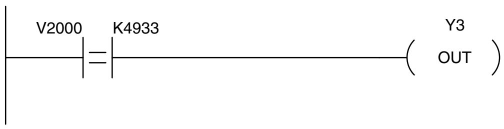
The Store If Not Equal instruction begins a new rung or additional branch in a rung with a normally closed comparative contact. The contact will be on when Vaaa $\neq$ Bbbb.



Operand Data Type		DL130 Range	
	B	aaa	bbb
V memory	V	All (See page 4–28)	All (See page 4–28)
Constant	K	—	0–FFFF

In the following example, when the value in V memory location V2000 = 4933 , Y3 will energize.

***Direct*SOFT32**



Handheld Programmer Keystrokes

$ STR	SHFT	E 4	→	C 2	A 0	A 0	A 0
→	E 4	J 9	D 3	D 3	ENT		
GX OUT	→	D 3	ENT				

In the following example, when the value in V memory location V2000 $\neq$ 5060, Y3 will energize.

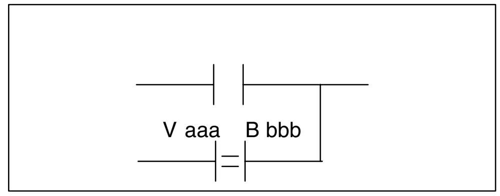
***Direct*SOFT32**

Handheld Programmer Keystrokes

SP STRN	SHFT	E 4	→	C 2	A 0	A 0	A 0
→	F 5	A 0	G 6	A 0	ENT		
GX OUT	→	D 3	ENT				

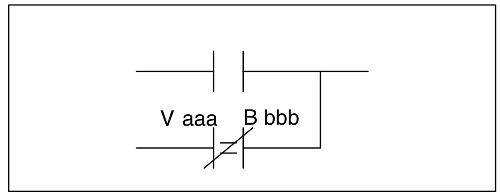
Or If Equal (ORE)

The Or If Equal instruction connects a normally open comparative contact in parallel with another contact. The contact will be on when Vaaa = Bbbb.



Or If Not Equal (ORNE)

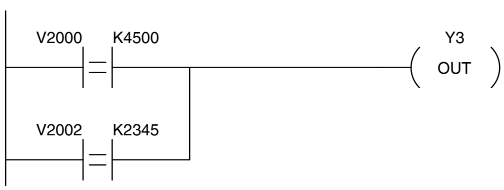
The Or If Not Equal instruction connects a normally closed comparative contact in parallel with another contact. The contact will be on when Vaaa $\neq$ Bbbb.



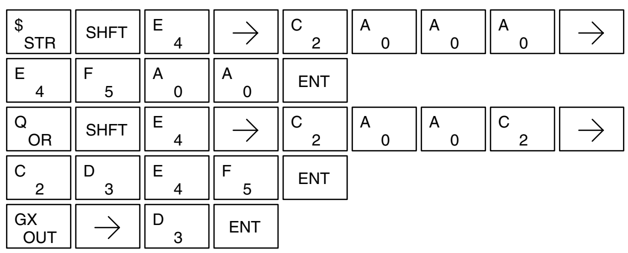
Operand Data Type		DL130 Range	
	B	aaa	bbb
V memory	V	All (See page 4–28)	All (See page 4–28)
Constant	K	—	0–FFFF

In the following example, when the value in V memory location V2000 = 4500 or V2002 = 2345 , Y3 will energize.

*Direct*SOFT32

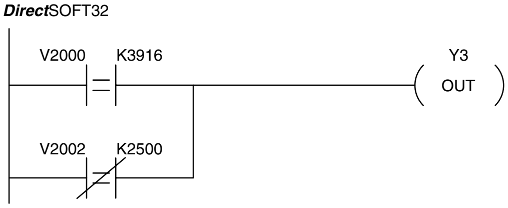


Handheld Programmer Keystrokes

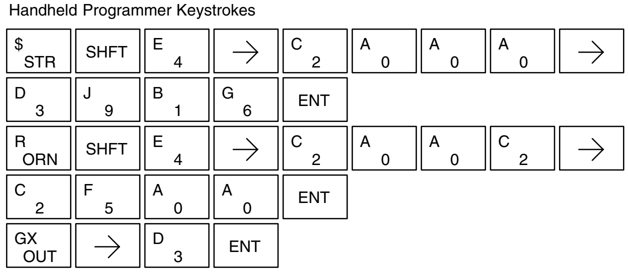


In the following example, when the value in V memory location V2000 = 3916 or V2002 $\neq$ 2500, Y3 will energize.

*Direct*SOFT32

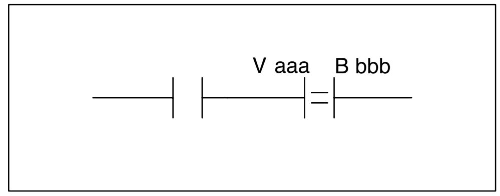


Handheld Programmer Keystrokes



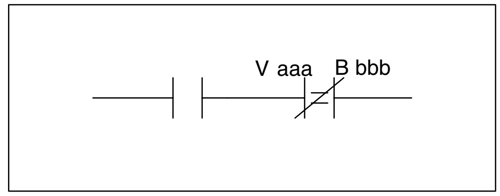
And If Equal (ANDE)

The And If Equal instruction connects a normally open comparative contact in series with another contact. The contact will be on when Vaaa = Bbbb.



And If Not Equal (ANDNE)

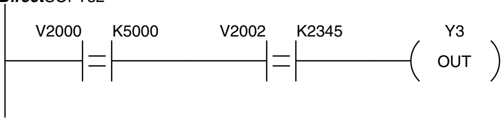
The And If Not Equal instruction connects a normally closed comparative contact in series with another contact. The contact will be on when Vaaa ≠ Bbbb



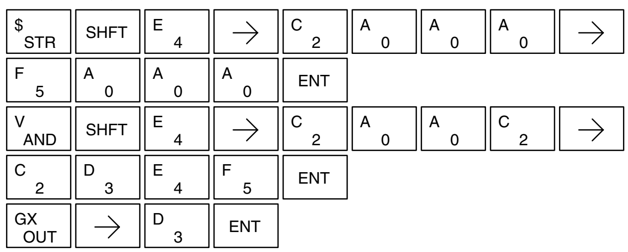
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
V memory	V	All (See page 4–28)	All (See page 4–28)
Constant	K	—	0–FFFF

In the following example, when the value in V memory location V2000 = 5000 and V2002 = 2345, Y3 will energize.

***Direct*SOFT32**

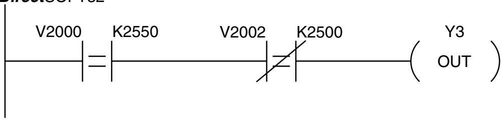


Handheld Programmer Keystrokes

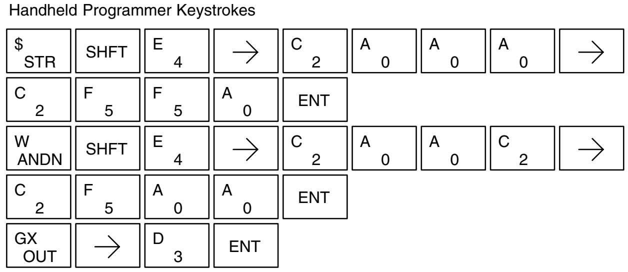


In the following example, when the value in V memory location V2000 = 2550 and V2002 ≠ 2500, Y3 will energize.

***Direct*SOFT32**

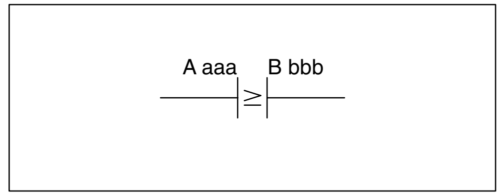


Handheld Programmer Keystrokes



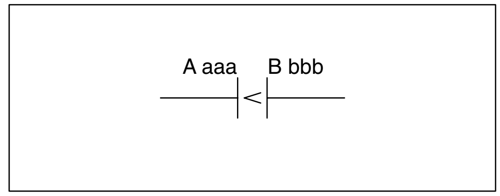
Store (STR)

The Comparative Store instruction begins a new rung or additional branch in a rung with a normally open comparative contact. The contact will be on when Aaaa $\geq$ Bbbb.



Store Not (STRN)

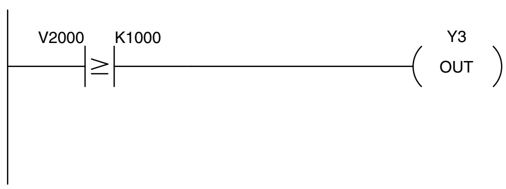
The Comparative Store Not instruction begins a new rung or additional branch in a rung with a normally closed comparative contact. The contact will be on when Aaaa < Bbbb.



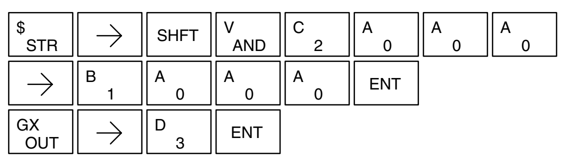
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
V memory	V	All (See page 4–28)	All (See page 4–28)
Constant	K	—	0–FFFF
Timer	T	0–77	
Counter	CT	0–77	

In the following example, when the value in V memory location V2000 $\geq$ 1000, Y3 will energize.

***Direct*SOFT32**

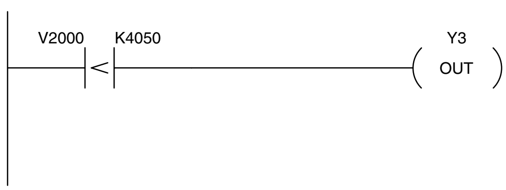


Handheld Programmer Keystrokes

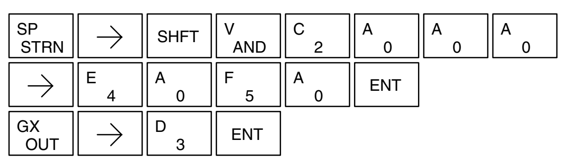


In the following example, when the value in V memory location V2000 < 4050, Y3 will energize.

***Direct*SOFT32**

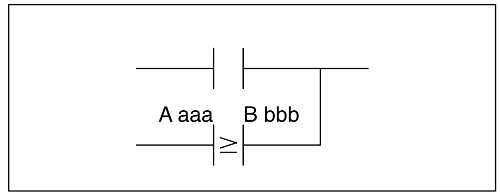


Handheld Programmer Keystrokes



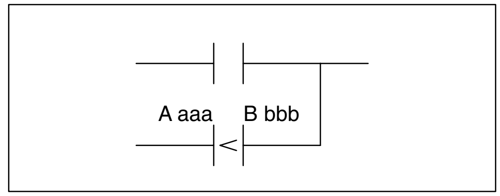
Or (OR)

The Comparative Or instruction connects a normally open comparative contact in parallel with another contact. The contact will be on when Aaaa $\geq$ Bbbb.



Or Not (ORN)

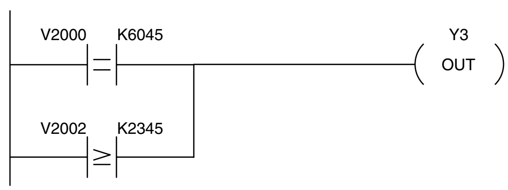
The Comparative Or Not instruction connects a normally open comparative contact in parallel with another contact. The contact will be on when Aaaa < Bbbb.



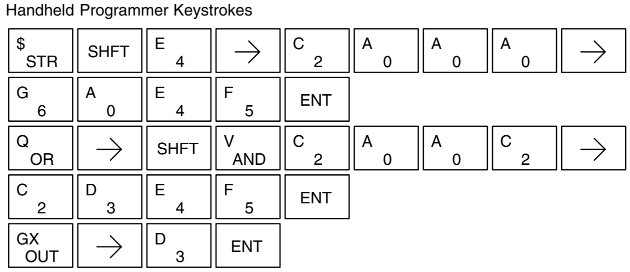
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
V memory	V	All (See page 4–28)	All (See page 4–28)
Constant	K	—	0–FFFF
Timer	T	0–77	
Counter	CT	0–77	

In the following example, when the value in V memory location V2000 = 6045 or V2002 $\geq$ 2345, Y3 will energize.

*Direct*SOFT32

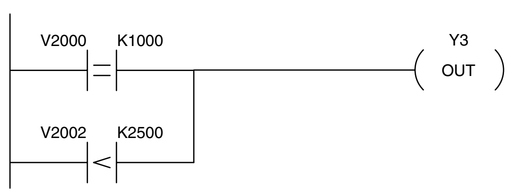


Handheld Programmer Keystrokes

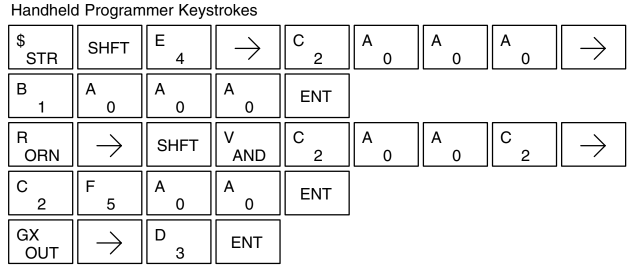


In the following example when the value in V memory location V2000 = 1000 or V2002 < 2500, Y3 will energize.

*Direct*SOFT32

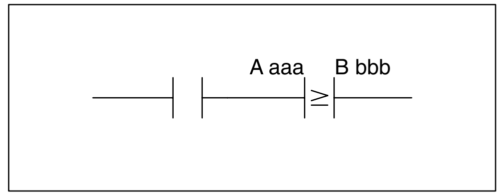


Handheld Programmer Keystrokes



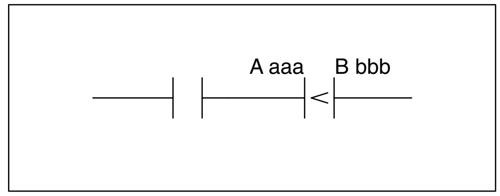
And (AND)

The Comparative And instruction connects a normally open comparative contact in series with another contact. The contact will be on when Aaaa $\geq$ Bbbb.



And Not (ANDN)

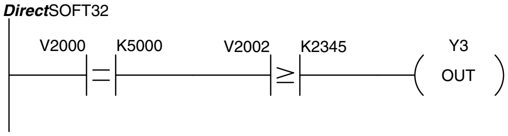
The Comparative And Not instruction connects a normally open comparative contact in parallel with another contact. The contact will be on when Aaaa < Bbbb.



Operand Data Type		DL130 Range	
	A/B	aaa	bbb
V memory	V	All (See page 4–28)	All (See page 4–28)
Constant	K	—	0–FFFF
Timer	T	0–77	
Counter	CT	0–77	

In the following example, when the value in V memory location V2000 = 5000, and V2002 $\geq$ 2345, Y3 will energize.

***Direct*SOFT32**

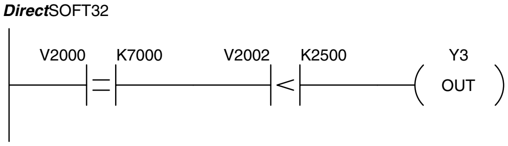


Handheld Programmer Keystrokes

$ STR	SHFT	E 4	→	C 2	A 0	A 0	A 0	→
F 5	A 0	A 0	A 0	ENT				
V AND	→	SHFT	V AND	C 2	A 0	A 0	C 2	→
C 2	D 3	E 4	F 5	ENT				
GX OUT	→	D 3	ENT					

In the following example, when the value in V memory location V2000 = 7000 and V2002 < 2500, Y3 will energize.

***Direct*SOFT32**



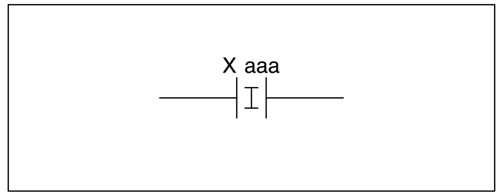
Handheld Programmer Keystrokes

$ STR	SHFT	E 4	→	C 2	A 0	A 0	A 0	→
H 7	A 0	A 0	A 0	ENT				
W ANDN	→	SHFT	V AND	C 2	A 0	A 0	C 2	→
C 2	F 5	A 0	A 0	ENT				
GX OUT	→	SHFT	Y AND	D 3	ENT			

Immediate Instructions

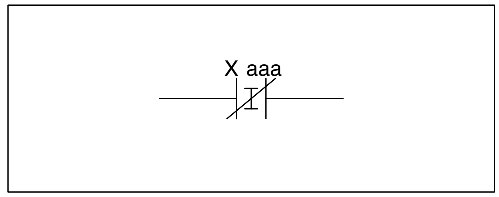
Store Immediate (STRI)

The Store Immediate instruction begins a new rung or additional branch in a rung. The status of the contact will be the same as the status of the associated input point *at the time the instruction is executed*. The image register is not updated.



Store Not Immediate (STRNI)

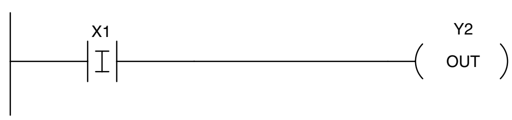
The Store Not Immediate instruction begins a new rung or additional branch in a rung. The status of the contact will be opposite the status of the associated input point *at the time the instruction is executed*. The image register is not updated.



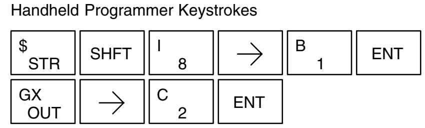
Operand Data Type		DL130 Range
		aaa
Inputs	X	0–11

In the following example, when X1 is on, Y2 will energize.

DirectSOFT32



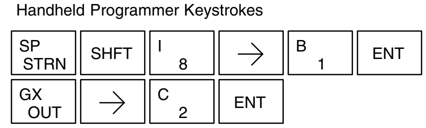
Handheld Programmer Keystrokes



In the following example when X1 is off, Y2 will energize.

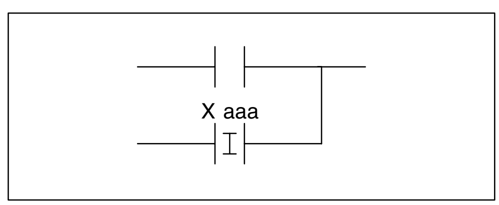
DirectSOFT32

Handheld Programmer Keystrokes



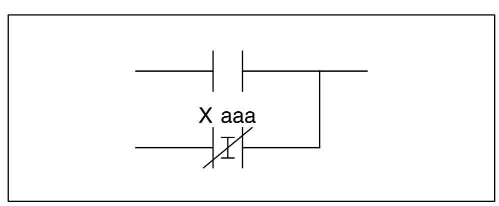
Or Immediate (ORI)

The Or Immediate connects two contacts in parallel. The status of the contact will be the same as the status of the associated input point *at the time the instruction is executed*. The image register is not updated.



Or Not Immediate (ORNI)

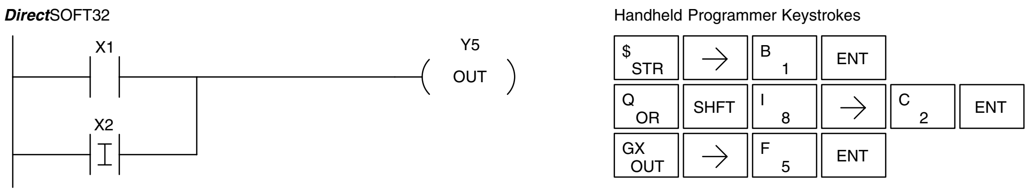
The Or Not Immediate connects two contacts in parallel. The status of the contact will be opposite the status of the associated input point *at the time the instruction is executed*. The image register is not updated.



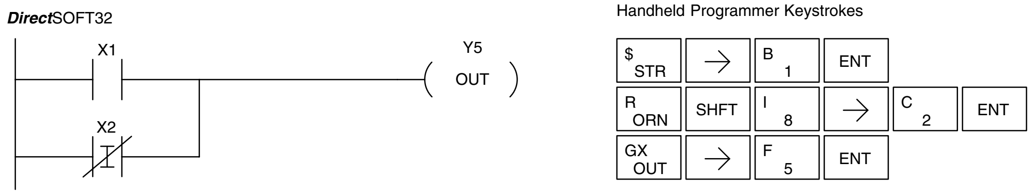
OR Immediate Instructions Cont'd

Operand Data Type		DL130 Range
		aaa
Inputs	X	0–177

In the following example, when X1 or X2 is on, Y5 will energize.

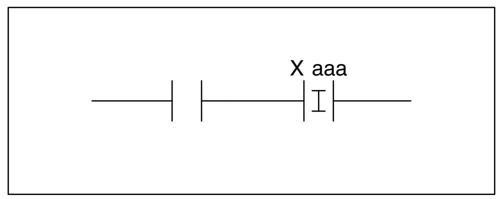


In the following example, when X1 is on or X2 is off, Y5 will energize.



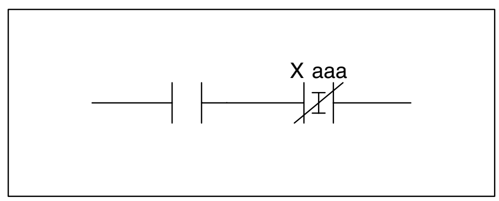
And Immediate (ANDI)

The And Immediate connects two contacts in series. The status of the contact will be the same as the status of the associated input point *at the time the instruction is executed*. The image register is not updated.



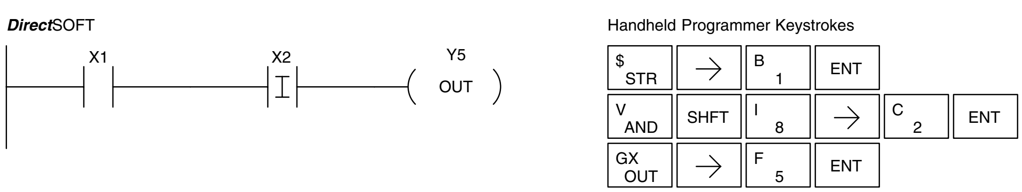
And Not Immediate (ANDNI)

The And Not Immediate connects two contacts in series. The status of the contact will be opposite the status of the associated input point *at the time the instruction is executed*. The image register is not updated.

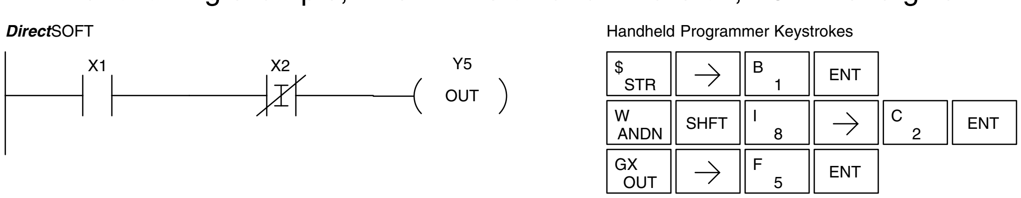


Operand Data Type		DL130 Range
		aaa
Inputs	X	0–11

In the following example, when X1 and X2 are on, Y5 will energize.

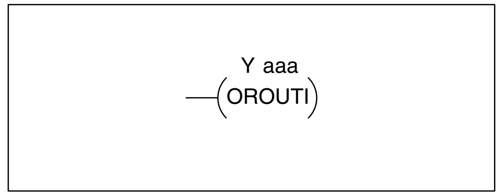


In the following example, when X1 is on and X2 are off, Y5 will energize.



Or Out Immediate (OROUTI)

The Or Out Immediate instruction has been designed to use more than 1 rung of discrete logic to control a single output. Multiple Or Out Immediate instructions referencing the same output coil may be used, since all contacts controlling the output are ored together. If the status of *any* rung is on *at the time the instruction is executed*, the output will also be on.



Operand Data Type		DL130 Range
		aaa
Outputs	Y	0–177

In the following example, when X1 is on, output point Y2 on the output module will turn on. For instruction entry on the Handheld Programmer, you can use the instruction number (#350) as shown, or type each letter of the command.

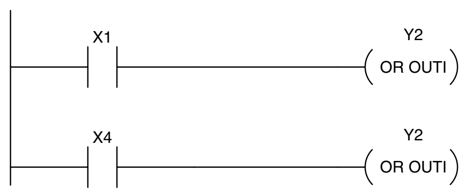
***Direct*SOFT32**

Handheld Programmer Keystrokes

$ STR → B 1 ENT
O INST# D 3 F 5 A 0 ENT ENT
→ C 2 ENT

In the following example, when X1 or X4 is on, Y2 will energize.

***Direct*SOFT32**

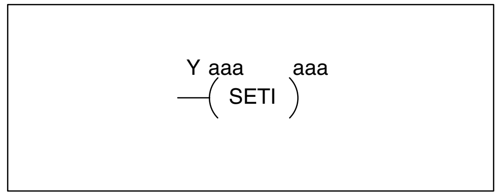


Handheld Programmer Keystrokes

$ STR → B 1 ENT
O INST# D 3 F 5 A 0 ENT ENT
→ C 2 ENT
$ STR → E 4 ENT
O INST# D 3 F 5 A 0 ENT ENT
→ C 2 ENT

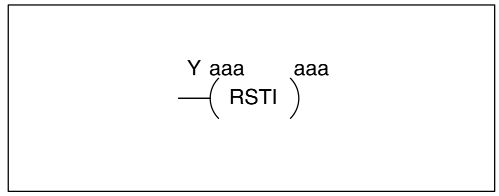
Set Immediate (SETI)

The Set Immediate instruction immediately sets, or turns on an output or a range of outputs in the image register and the corresponding output point(s) *at the time the instruction is executed*. Once the outputs are set it is not necessary for the input to remain on. The Reset Immediate instruction can be used to reset the outputs.



Reset Immediate (RSTI)

The Reset Immediate instruction immediately resets, or turns off an output or a range of outputs in the image register and the output point(s) *at the time the instruction is executed*. Once the outputs are reset it is not necessary for the input to remain on.

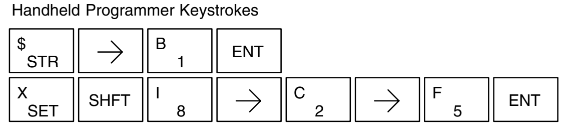


Operand Data Type		DL130 Range
		aaa
Outputs	Y	0–177

In the following example, when X1 is on, Y2 through Y5 will be set on in the image register and on the corresponding output points.

DirectSOFT32

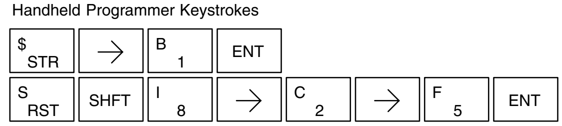
Handheld Programmer Keystrokes



In the following example, when X1 is on, Y5 through Y22 will be reset (off) in the image register and on the corresponding output module(s).

DirectSOFT32

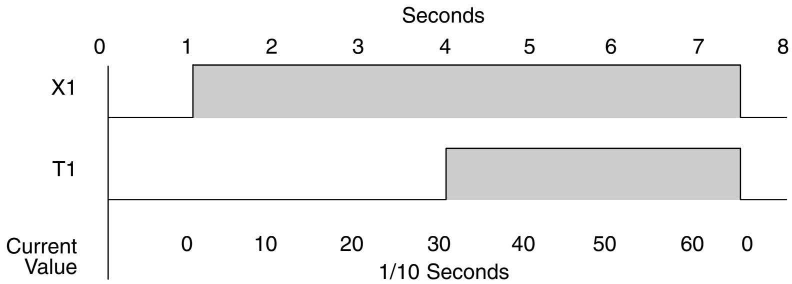
Handheld Programmer Keystrokes

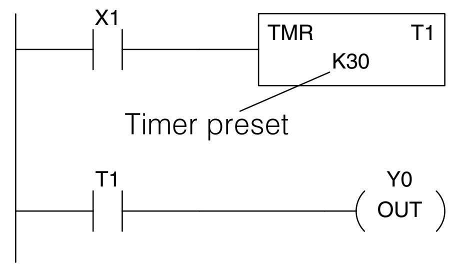


Timer, Counter and Shift Register Instructions

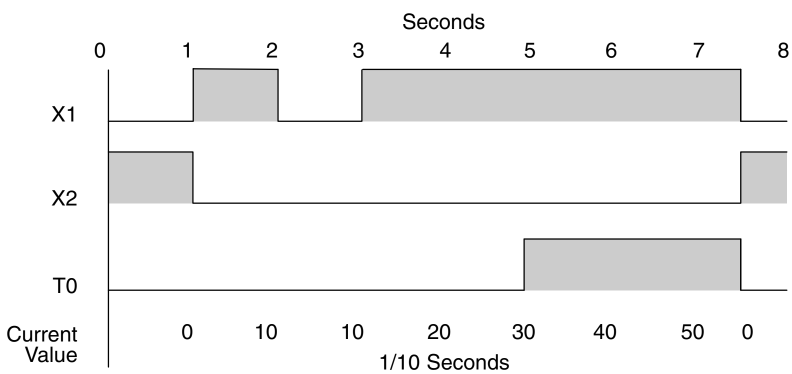
Using Timers

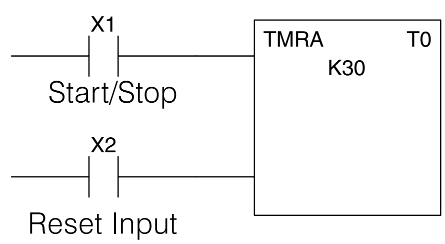
Timers are used to time an event for a desired length of time. The single input timer will time as long as the input is on. When the input changes from on to off the timer current value is reset to 0. There is a tenth of a second and a hundredth of a second timer available with a maximum time of 999.9 and 99.99 seconds respectively. There is a discrete bit associated with each timer to indicate that the current value is equal to or greater than the preset value. The timing diagram below shows the relationship between the timer input, associated discrete bit, current value, and timer preset.





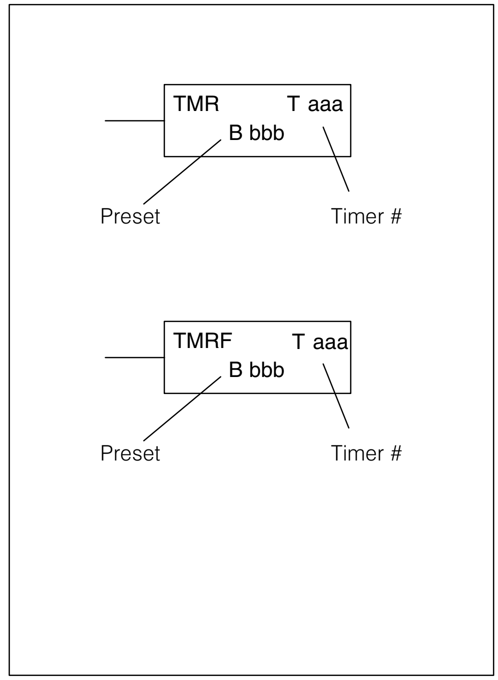
There are those applications that need an accumulating timer, meaning it has the ability to time, stop, and then resume from where it previously stopped. The accumulating timer works similarly to the regular timer, but two inputs are required. The start/stop input starts and stops the timer. When the timer stops, the elapsed time is maintained. When the timer starts again, the timing continues from the elapsed time. When the reset input is turned on, the elapsed time is cleared and the timer will start at 0 when it is restarted. There is a tenth of a second and a hundredth of a second timer available with a maximum time of 9999999.9 and 999999.99 seconds respectively. The timing diagram below shows the relationship between the timer input, timer reset, associated discrete bit, current value, and timer preset.





Timer (TMR) and Timer Fast (TMRF)

The Timer instruction is a 0.1 second single input timer that times to a maximum of 999.9 seconds. The Timer Fast instruction is a 0.01 second single input timer that times up to a maximum of 99.99 seconds. These timers will be enabled if the input logic is true (on) and will be reset to 0 if the input logic is false (off).



The timer discrete status bit and the current value are not specified in the timer instruction.

Instruction Specifications

Timer Reference (Taaa): Specifies the timer number.

Preset Value (Bbbb): Constant value (K) or a V memory location.

Current Value: Timer current values are accessed by referencing the associated V or T memory location*. For example, the timer current value for T3 physically resides in V-memory location V3.

Discrete Status Bit: The discrete status bit is referenced by the associated T memory location. Operating as a “timer done bit”, it will be on if the current value is equal to or greater than the preset value. For example, the discrete status bit for Timer 2 is TA2.

NOTE: Timer preset constants (K) may be changed by using a handheld programmer, even when the CPU is in Run Mode. Therefore, a V-memory preset is required only if the ladder program must change the preset.

Operand Data Type		DL130 Range	
	A/B	aaa	bbb
Timers	T	0–77	—
V memory for preset values	V	—	2000–2377 4000–4177
Constants (preset only)	K	—	0–9999
Timer discrete status bits	T/V	0–77 or V41100–41103	
Timer current values	V /T*	0–77	

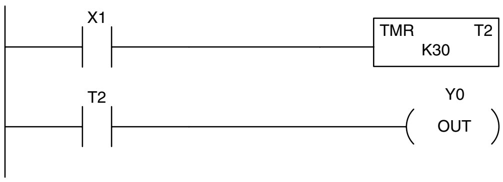
NOTE: * With the HPP, both the Timer discrete status bits and current value are accessed with the same data reference. ***Direct***SOFT32 uses separate references, such as “T2” for discrete status bit for Timer T2, and “TA2” for the current value of Timer T2.

You can perform functions when the timer reaches the specified preset using the discrete status bit. Or, use comparative contacts to perform functions at different time intervals, based on one timer. The examples on the following page show these two methods of programming timers.

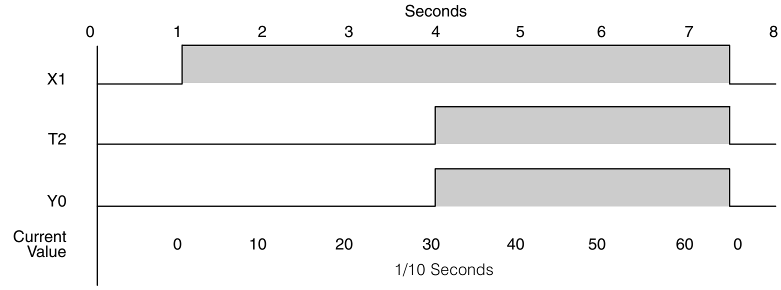
Timer Example Using Discrete Status Bits

In the following example, a single input timer is used with a preset of 3 seconds. The timer discrete status bit (T2) will turn on when the timer has timed for 3 seconds. The timer is reset when X1 turns off, turning the discrete status bit off and resetting the timer current value to 0.

***Direct*SOFT**



Timing Diagram



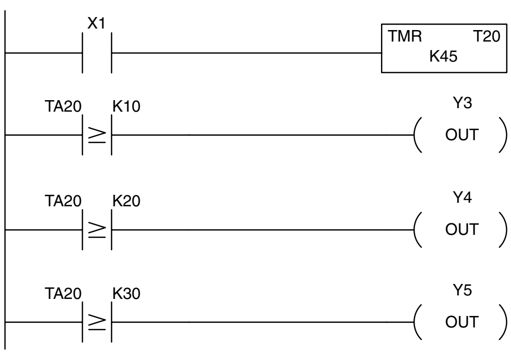
Handheld Programmer Keystrokes

$ STR	→	B 1	ENT			
N TMR	→	C 2	→	D 3	A 0	ENT
$ STR	→	SHFT	T MLR	C 2	ENT	
GX OUT	→	A 0	ENT			

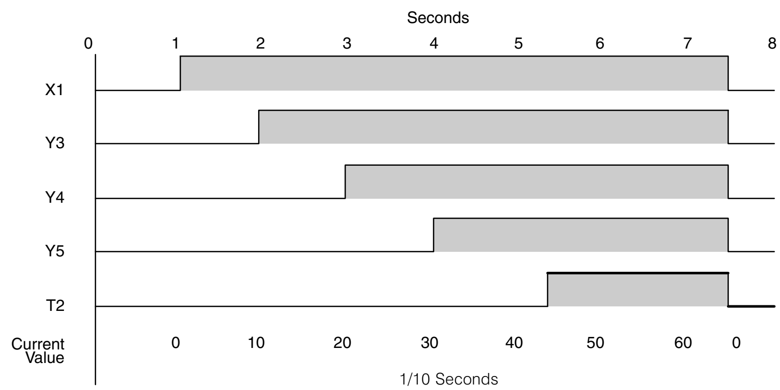
Timer Example Using Comparative Contacts

In the following example, a single input timer is used with a preset of 4.5 seconds. Comparative contacts are used to energize Y3, Y4, and Y5 at one second intervals respectively. When X1 is turned off the timer will be reset to 0 and the comparative contacts will turn off Y3, Y4, and Y5.

***Direct*SOFT**



Timing Diagram



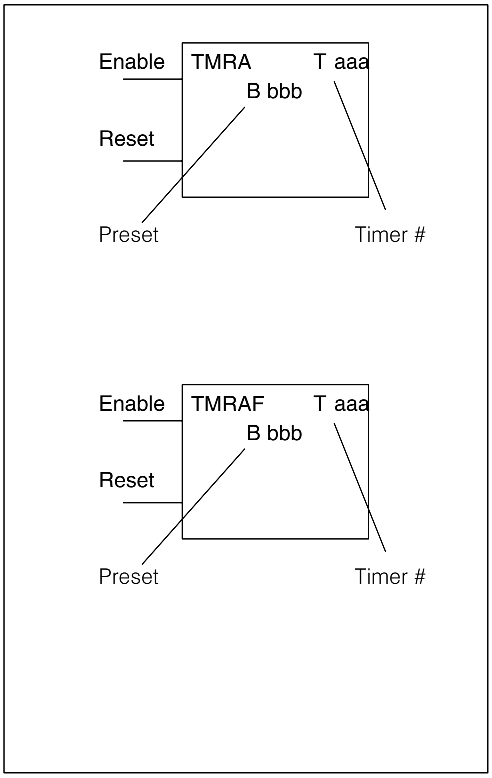
Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
N TMR	→	C 2	A 0	→	E 4	F 5	ENT		
$ STR	→	SHFT	T MLR	C 2	A 0	→	B 1	A 0	ENT
GX OUT	→	D 3	ENT						
$ STR	→	SHFT	T MLR	C 2	A 0	→	C 2	A 0	ENT
GX OUT	→	E 4	ENT						
$ STR	→	SHFT	T MLR	C 2	A 0	→	D 3	A 0	ENT
GX OUT	→	F 5	ENT						

Accumulating Timer (TMRA)

Accumulating Fast Timer (TMRAF)

The Accumulating Timer is a 0.1 second two input timer that will time to a maximum of 9999999.9. The Accumulating Fast Timer is a 0.01 second two-input timer that will time to a maximum of 999999.99. *Each one uses two timer registers in V-memory.* These timers have two inputs, an enable and a reset. The timer starts timing when the enable is on and stops when the enable is off (without resetting the count). The reset will reset the timer when on and allow the timer to time when off.



The timer discrete status bit and the current value are not specified in the timer instruction.

Instruction Specifications

Timer Reference (Taaa): Specifies the timer number.

Preset Value (Bbbb): Constant value (K) or a V memory location.

Current Value: Timer current values are accessed by referencing the associated V or T memory location*. For example, the timer current value for T3 resides in V-memory location V3.

Discrete Status Bit: The discrete status bit is accessed by referencing the associated T memory location. Operating as a “timer done bit”, it will be on if the current value is equal to or greater than the preset value. For example the discrete status bit for timer 2 would be T2.

NOTE: The accumulating type timer uses **two consecutive V-memory locations** for the 8-digit value, and therefore two consecutive timer locations. For example, if TMR 1 is used, the next available timer number is TMR 3.

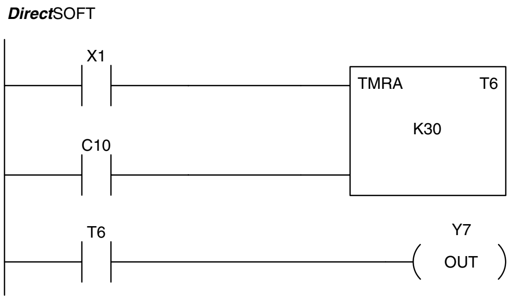
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
Timers	T	0–77	—
V memory for preset values	V	—	2000–2376 4000–4176
Constants (preset only)	K	—	0–99999999
Timer discrete status bits	T/V	0–77 or V41100–41103	
Timer current values	V /T*	0–77	

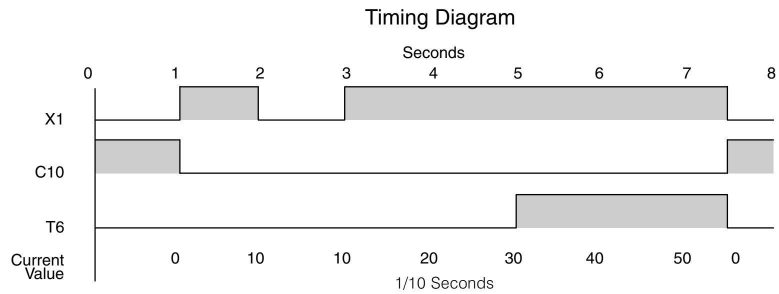
NOTE: * With the HPP, both the Timer discrete status bits and current value are accessed with the same data reference. ***Direct***SOFT32 uses separate references, such as T2 for discrete status bit for Timer T2, and TA2 for the current value of Timer T2.

The following examples show two methods of programming timers. One performs functions when the timer reaches the preset value using the discrete status bit, or use comparative contacts to perform functions at different time intervals.

Accumulating Timer Example using Discrete Status Bits

In the following example, a two input timer (accumulating timer) is used with a preset of 3 seconds. The timer discrete status bit (T6) will turn on when the timer has timed for 3 seconds. Notice in this example that the timer times for 1 second , stops for one second, then resumes timing. The timer will reset when C10 turns on, turning the discrete status bit off and resetting the timer current value to 0.





Handheld Programmer Keystrokes

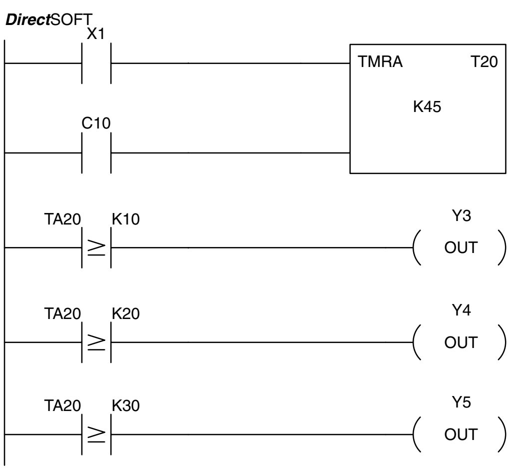
$ STR	→	B 1	ENT			
$ STR	→	SHFT	C 2	B 1	A 0	ENT
N TMR	SHFT	A 0	→	G 6	→	

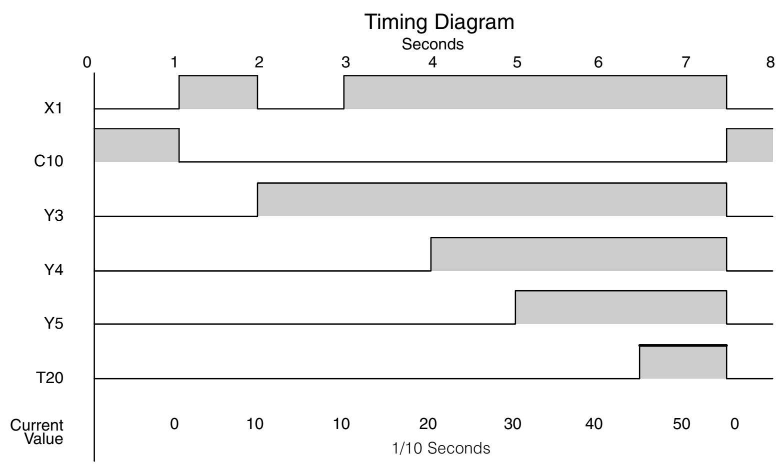
Handheld Programmer Keystrokes (cont)

D 3	A 0	ENT			
$ STR	→	SHFT	T MLR	G 6	ENT
GX OUT	→	B 1	A 0	ENT	

Accumulator Timer Example Using Comparative Contacts

In the following example, a single input timer is used with a preset of 4.5 seconds. Comparative contacts are used to energized Y3, Y4, and Y5 at one second intervals respectively. The comparative contacts will turn off when the timer is reset.





Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
$ STR	→	SHFT	C 2	B 1	A 0	ENT			
N TMR	SHFT	A 0	→	C 2	A 0	→	E 4	F 5	ENT
$ STR	→	SHFT	T MLR	C 2	A 0	→	B 1	A 0	ENT
GX OUT	→	D 3	ENT						
$ STR	→	SHFT	T MLR	C 2	A 0	→	C 2	A 0	ENT

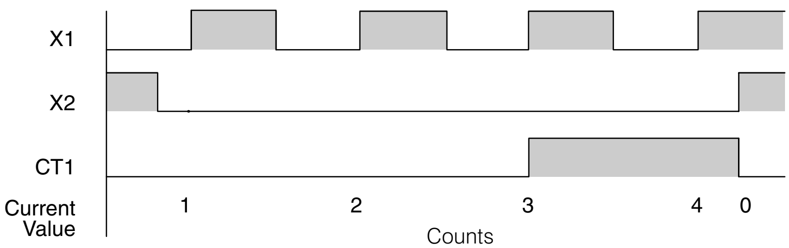
Handheld Programmer Keystrokes (cont)

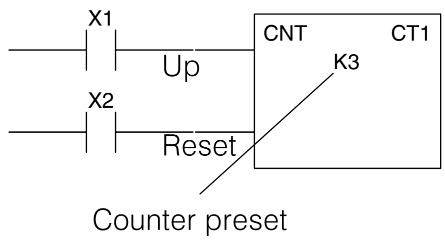
GX OUT	→	E 4	ENT			
$ STR	→	SHFT	T MLR	C 2	A 0	→
D 3	A 0	ENT				
GX OUT	→	F 5	ENT			

Using Counters

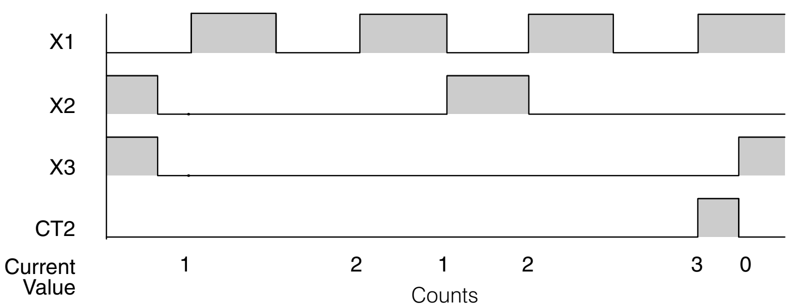
Counters are used to count events . The counters available are up counters, up/down counters, and stage counters (used with RLL*PLUS* programming).

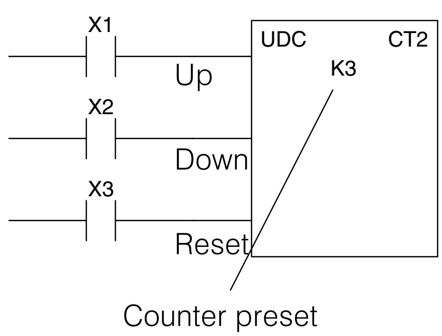
The up counter has two inputs, a count input and a reset input. The maximum count value is 9999. The timing diagram below shows the relationship between the counter input, counter reset, associated discrete bit, current value, and counter preset.



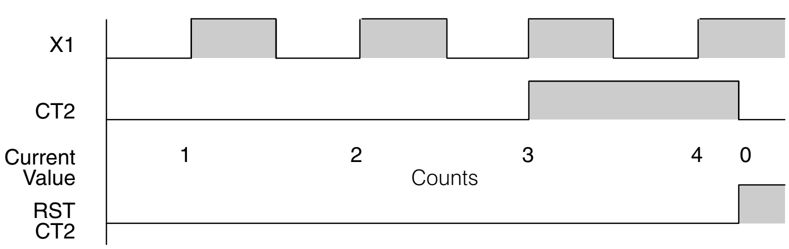


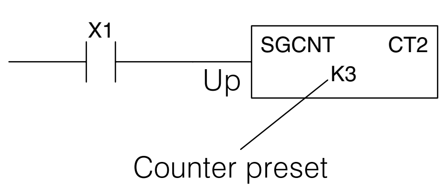
The up down counter has three inputs, a count up input, count down input and reset input. The maximum count value is 99999999. The timing diagram below shows the relationship between the counter input, counter reset, associated discrete bit, current value, and counter preset.





The stage counter has a count input and is reset by the RST instruction. This instruction is useful when programming using the RLL*PLUS* structured programming. The maximum count value is 9999. The timing diagram below shows the relationship between the counter input, associated discrete bit, current value, counter preset and reset instruction.





Counter (CNT)

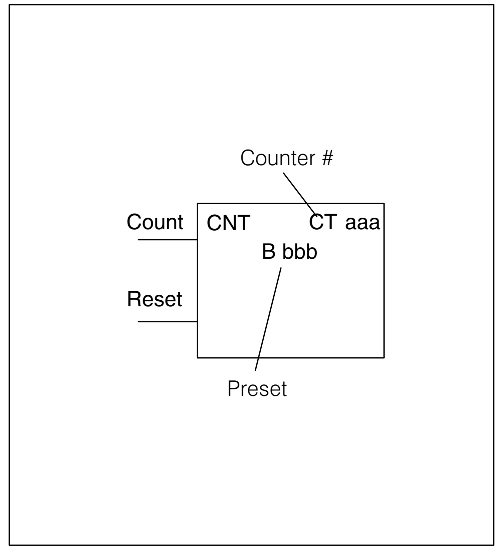
The Counter is a two input counter that increments when the count input logic transitions from off to on. When the counter reset input is on the counter resets to 0. When the current value equals the preset value, the counter status bit comes on and the counter continues to count up to a maximum count of 9999. The maximum value will be held until the counter is reset.

Instruction Specifications

Counter Reference (CTaaa): Specifies the counter number.

Preset Value (Bbbb): Constant value (K) or a V memory location.

Current Values: Counter current values are accessed by referencing the associated V or CT memory locations*. The V-memory location is the counter location + 1000. For example, the counter current value for CT3 resides in V memory location V1003.



The counter discrete status bit and the current value are not specified in the counter instruction.

Discrete Status Bit: The discrete status bit is accessed by referencing the associated CT memory location. It will be on if the value is equal to or greater than the preset value. For example the discrete status bit for counter 2 would be CT2.

NOTE: Counter preset constants (K) may be changed by using a programming device, even when the CPU is in Run Mode. Therefore, a V-memory preset is required only if the ladder program must change the preset.

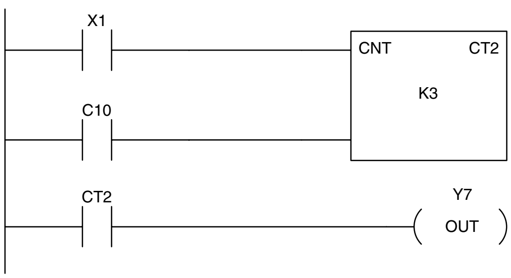
Operand Data Type		DL130 Range	
	A/B	**aaa**	**bbb**
Counters	CT	0–77	—
V memory (preset only)	V	—	2000–2377 4000–4177
Constants (preset only)	K	—	0–9999
Counter discrete status bits	CT/V	0–77 or V41140–41143	
Counter current values	V/CT*	1000–1077	

NOTE: * With the HPP, both the Counter discrete status bits and current value are accessed with the same data reference. ***Direct***SOFT32 uses separate references, such as “CT2” for discrete status bit for Counter CT2, and “CTA2” for the current value of Counter CT2.

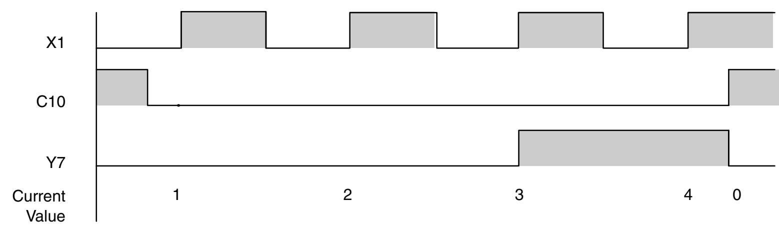
Counter Example Using Discrete Status Bits

In the following example, when X1 makes an off to on transition, counter CT2 will increment by one. When the current value reaches the preset value of 3, the counter status bit CT2 will turn on and energize Y7. When the reset C10 turns on, the counter status bit will turn off and the current value will be 0. The current value for counter CT2 will be held in V memory location V1002.

***Direct*SOFT**



Counting diagram



Handheld Programmer Keystrokes

$ STR	→	B 1	ENT			
$ STR	→	SHFT	C 2	B 1	A 0	ENT
GY CNT	→	C 2	→	D 3	ENT	

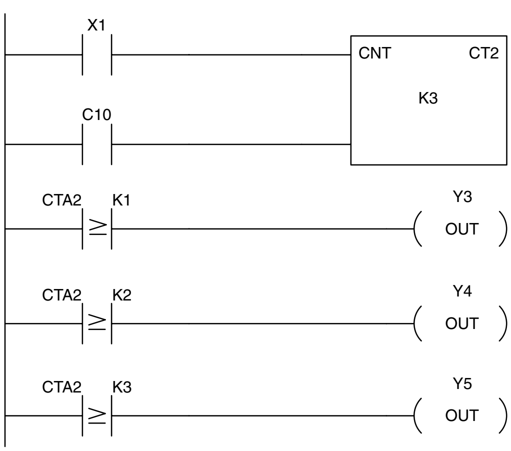
Handheld Programmer Keystrokes (cont)

$ STR	→	SHFT	C 2	SHFT	T MLR	C 2	ENT
GX OUT	→	B 1	A 0	ENT			

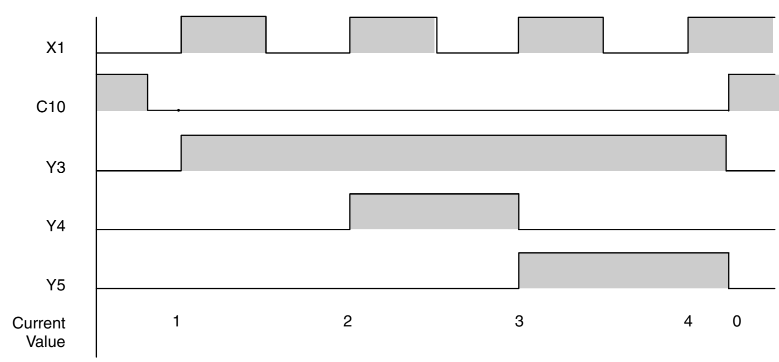
Counter Example Using Comparative Contacts

In the following example, when X1 makes an off to on transition, counter CT2 will increment by one. Comparative contacts are used to energize Y3, Y4, and Y5 at different counts. When the reset C10 turns on, the counter status bit will turn off and the counter current value will be 0, and the comparative contacts will turn off.

***Direct*SOFT**



Counting diagram



Handheld Programmer Keystrokes

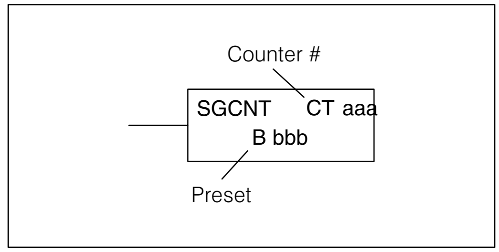
$ STR	→	B 1	ENT			
$ STR	→	SHFT	C 2	B 1	A 0	ENT
GY CNT	→	C 2	→	D 3	ENT	
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	B 1	ENT				
GX OUT	→	D 3	ENT			

Handheld Programmer Keystrokes (cont)

$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	C 2	ENT				
GX OUT	→	E 4	ENT			
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	D 3	ENT				
GX OUT	→	F 5	ENT			

Stage Counter (SGCNT)

The Stage Counter is a single input counter that increments when the input logic transitions from off to on. This counter differs from other counters since it will hold its current value until reset using the RST instruction. The Stage Counter is designed for use in RLL^{PLUS} programs but can be used in relay ladder logic programs. When the current value equals the preset value, the counter status bit turns on and the counter continues to count up to a maximum count of 9999. The maximum value will be held until the counter is reset.



The counter discrete status bit and the current value are not specified in the counter instruction.

Instruction Specifications

Counter Reference (CTaaa): Specifies the counter number.

Preset Value (Bbbb): Constant value (K) or a V memory location.

Current Values: Counter current values are accessed by referencing the associated V or CT memory locations*. The V-memory location is the counter location + 1000. For example, the counter current value for CT3 resides in V memory location V1003.

Discrete Status Bit: The discrete status bit is accessed by referencing the associated CT memory location. It will be on if the value is equal to or greater than the preset value. For example the discrete status bit for counter 2 would be CT2.

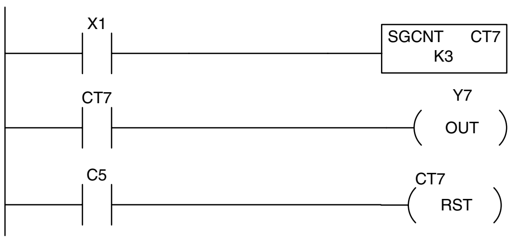
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
Counters	CT	0–77	—
V memory (preset only)	V	—	2000–2377
Constants (preset only)	K	—	0–9999
Counter discrete status bits	CT/V	0–77 or V41140–41143	
Counter current values	V/CT*	1000–1077	

NOTE: * With the HPP, both the Counter discrete status bits and current value are accessed with the same data reference. ***Direct***SOFT32 uses separate references, such as “CT2” for discrete status bit for Counter CT2, and “CTA2” for the current value of Counter CT2.

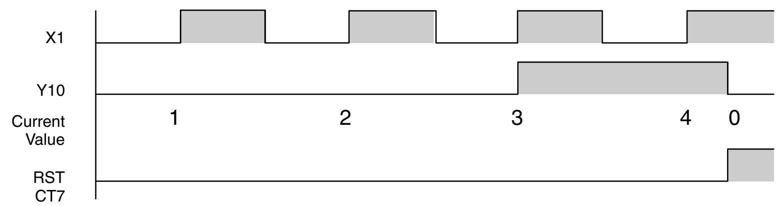
Stage Counter Example Using Discrete Status Bits

In the following example, when X1 makes an off to on transition, stage counter CT7 will increment by one. When the current value reaches 3, the counter status bit CT7 will turn on and energize Y7. The counter status bit CT7 will remain on until the counter is reset using the RST instruction. When the counter is reset, the counter status bit will turn off and the counter current value will be 0. The current value for counter CT7 will be held in V memory location V1007.

*Direct*SOFT



Counting diagram



Handheld Programmer Keystrokes

$ STR	→	B 1	ENT				
SHFT	S RST	SHFT	G 6	SHFT	GY CNT	→	
H 7	→	D 3	ENT				
$ STR	→	SHFT	C 2	SHFT	T MLR	H 7	ENT

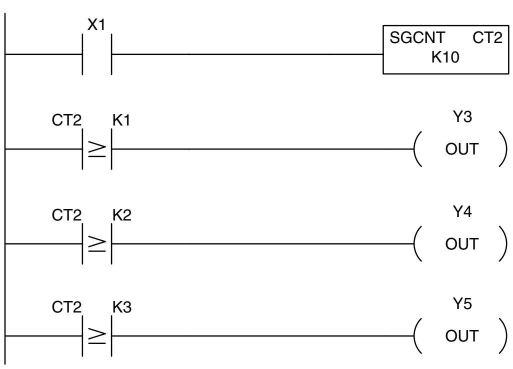
Handheld Programmer Keystrokes (cont)

GX OUT	→	B 1	A 0	ENT			
$ STR	→	SHFT	C 2	F 5	ENT		
S RST	→	SHFT	C 2	SHFT	T MLR	H 7	ENT

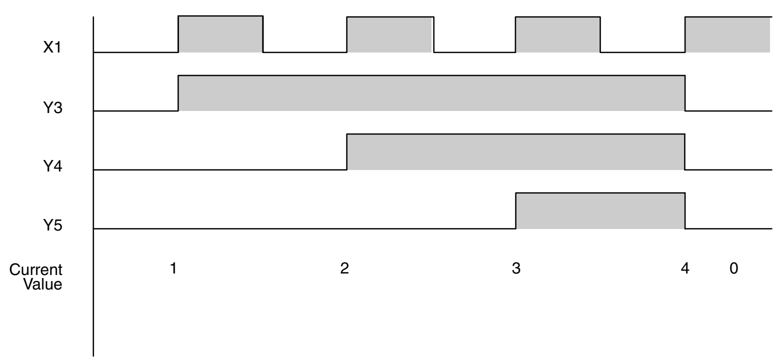
Stage Counter Example Using Comparative Contacts

In the following example, when X1 makes an off to on transition, counter CT2 will increment by one. Comparative contacts are used to energize Y3, Y4, and Y5 at different counts. Although this is not shown in the example, when the counter is reset using the Reset instruction, the counter status bit will turn off and the current value will be 0. The current value for counter CT2 will be held in V memory location V1002.

*Direct*SOFT



Counting diagram



Handheld Programmer Keystrokes

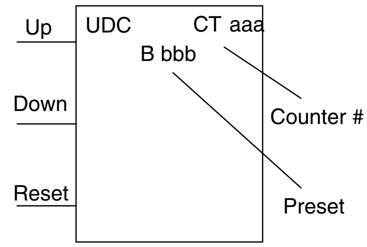
$ STR	→	B 1	ENT			
SHFT	S RST	G 6	SHFT	GY CNT	→	
C 2	→	B 1	A 0	ENT		
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	B 1	ENT				
GX OUT	→	D 3	ENT			

Handheld Programmer Keystrokes (cont)

$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	C 2	ENT				
GX OUT	→	E 4	ENT			
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	D 3	ENT				
GX OUT	→	F 5	ENT			

Up Down Counter (UDC)

This Up/Down Counter counts up on each off to on transition of the Up input and counts down on each off to on transition of the Down input. The counter is reset to 0 when the Reset input is on. The count range is 0–99999999. The count input not being used must be off in order for the active count input to function.



Caution: The UDC uses two V memory locations for the 8 digit current value. This means that the UDC uses two consecutive counter locations. If UDC CT1 is used in the program, the next available counter is CT3.

The counter discrete status bit and the current value are not specified in the counter instruction.

Instruction Specification

Counter Reference (CTaaa): Specifies the counter number.

Preset Value (Bbbb): Constant value (K) or two consecutive V memory locations.

Current Values: Current count is a double word value accessed by referencing the associated V or CT memory locations*. The V-memory location is the counter location + 1000. For example, the counter current value for CT5 resides in V memory location V1005 and V1006.

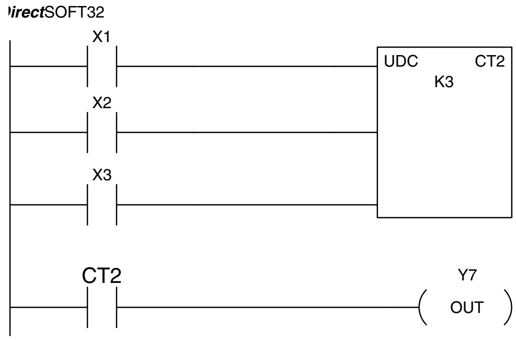
Discrete Status Bit: The discrete status bit is accessed by referencing the associated CT memory location. Operating as a “counter done bit” it will be on if the value is equal to or greater than the preset value. For example the discrete status bit for counter 2 would be CT2.

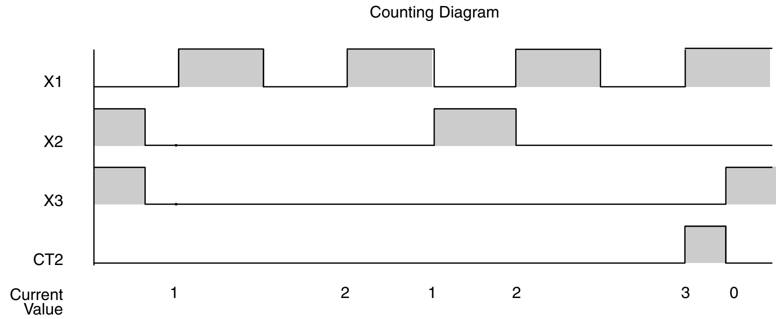
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
Counters	CT	0–77	—
V memory (preset only)	V	—	2000–2377 4000–4177
Constants (preset only)	K	—	0–99999999
Counter discrete status bits	CT/V	0–77 or V41140–41143	
Counter current values	V/CT*	1000–1077	

NOTE: * With the HPP, both the Counter discrete status bits and current value are accessed with the same data reference. ***Direct***SOFT32 uses separate references, such as “CT2” for discrete status bit for Counter CT2, and “CTA2” for the current value of Counter CT2.

Up / Down Counter Example Using Discrete Status Bits

In the following example if X2 and X3 are off ,when X1 toggles from off to on the counter will increment by one. If X1 and X3 are off the counter will decrement by one when X2 toggles from off to on. When the count value reaches the preset value of 3, the counter status bit will turn on. When the reset X3 turns on, the counter status bit will turn off and the current value will be 0.





Handheld Programmer Keystrokes

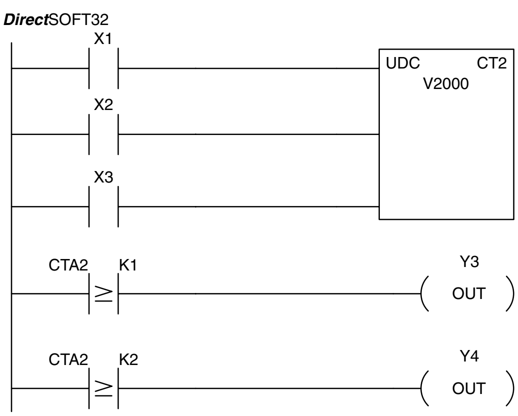
$ STR	→	B 1	ENT		
$ STR	→	C 2	ENT		
$ STR	→	D 3	ENT		
SHFT	U ISG	D 3	C 2	→	C 2

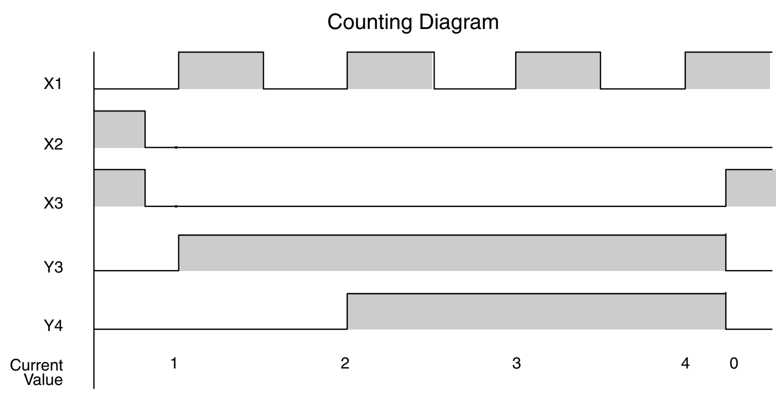
Handheld Programmer Keystrokes (cont)

→	D 3	ENT					
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2	ENT
GX OUT	→	B 1	A 0	ENT			

Up / Down Counter Example Using Comparative Contacts

In the following example, when X1 makes an off to on transition, counter CT2 will increment by one. Comparative contacts are used to energize Y3 and Y4 at different counts. When the reset (X3) turns on, the counter status bit will turn off, the current value will be 0, and the comparative contacts will turn off.





Handheld Programmer Keystrokes

$ STR	→	B 1	ENT			
$ STR	→	C 2	ENT			
$ STR	→	D 3	ENT			
SHFT	U ISG	D 3	C 2	→	C 2	→
SHFT	V AND	C 2	A 0	A 0	A 0	ENT
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2

Handheld Programmer Keystrokes (cont)

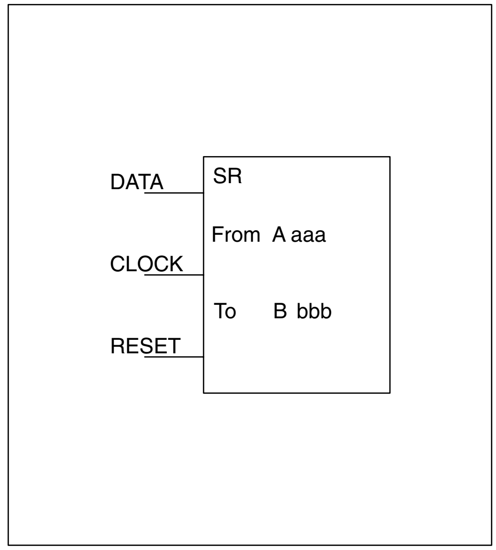
→	B 1	ENT				
GX OUT	→	D 3	ENT			
$ STR	→	SHFT	C 2	SHFT	T MLR	C 2
→	C 2	ENT				
GX OUT	→	E 4	ENT			

Shift Register (SR)

The Shift Register instruction shifts data through a predefined number of control relays. The control ranges in the shift register block must start at the beginning of an 8 bit boundary use 8-bit blocks.

The Shift Register has three contacts.

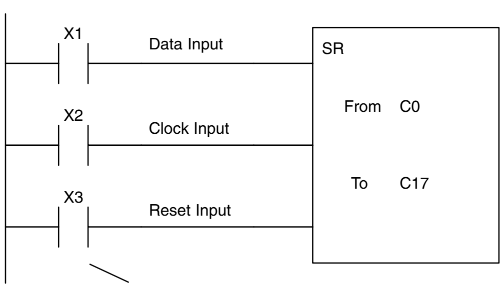
- Data — determines the value (1 or 0) that will enter the register
- Clock — shifts the bits one position on each low to high transition
- Reset —resets the Shift Register to all zeros.



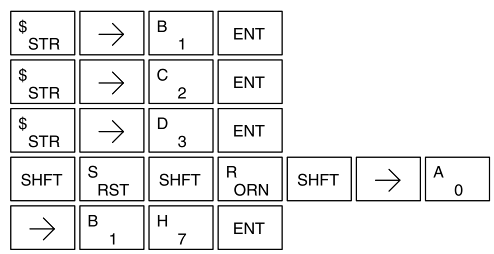
With each off to on transition of the clock input, the bits which make up the shift register block are shifted by one bit position and the status of the data input is placed into the starting bit position in the shift register. The direction of the shift depends on the entry in the From and To fields. From C0 to C17 would define a block of sixteen bits to be shifted from left to right. From C17 to C0 would define a block of sixteen bits, to be shifted from right to left. The maximum size of the shift register block depends on the number of available control relays. The minimum block size is 8 control relays.

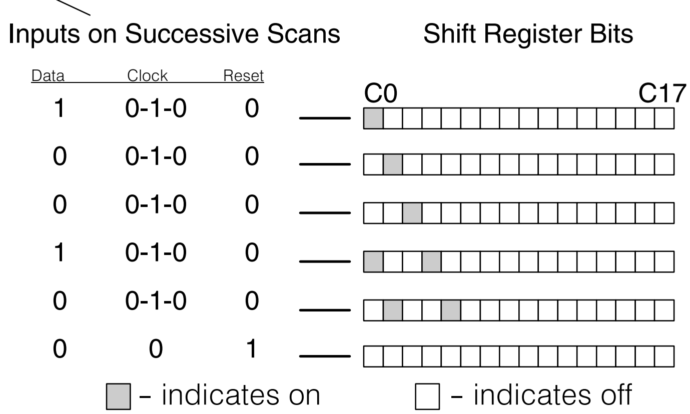
Operand Data Type		DL130 Range	
	A/B	aaa	bbb
Control Relay	C	0–377	0–377

*Direct*SOFT32



Handheld Programmer Keystrokes





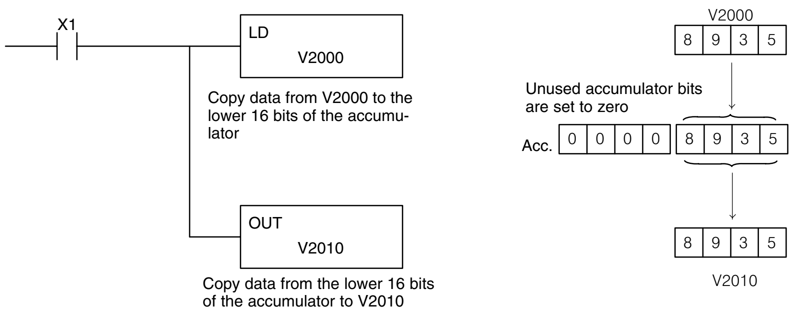
Accumulator / Stack Load and Output Data Instructions

Using the Accumulator

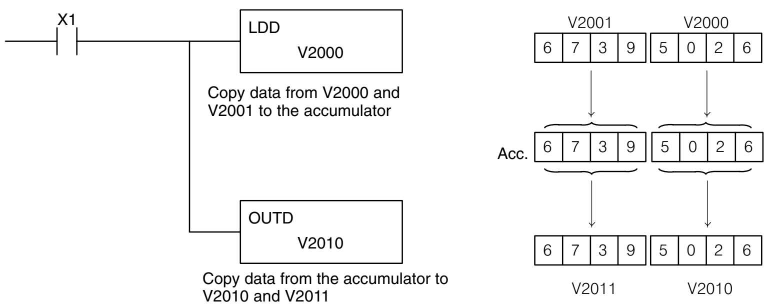
The accumulator in the DL105 internal CPUs is a 32 bit register which is used as a temporary storage location for data that is being copied or manipulated in some manor. For example, you have to use the accumulator to perform math operations such as add, subtract, multiply, etc. Since there are 32 bits, you can use up to an 8-digit BCD number. The accumulator is reset to 0 at the end of every CPU scan.

Copying Data to the Accumulator

The Load and Out instructions and their variations are used to copy data from a V-memory location to the accumulator, or, to copy data from the accumulator to V memory. The following example copies data from V-memory location V2000 to V-memory location V2010.



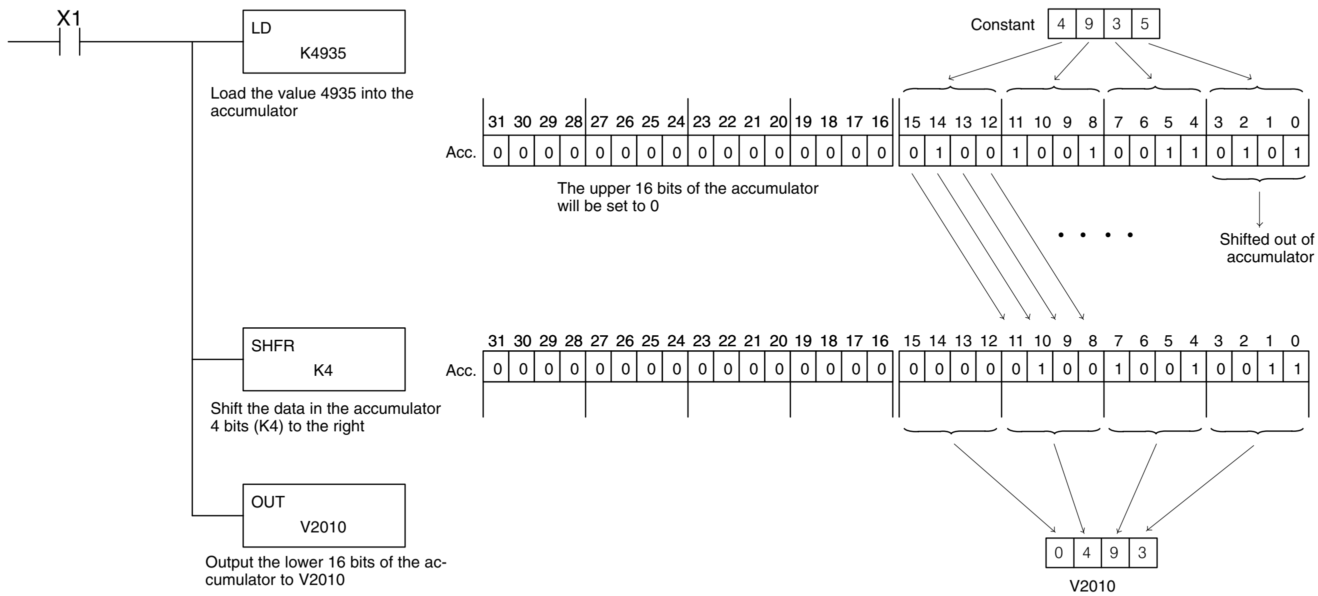
Since the accumulator is 32 bits and V memory locations are 16 bits the Load Double and Out Double (or variations thereof) use two consecutive V-memory locations or 8 digit BCD constants to copy data either to the accumulator from a V-memory address or from a V-memory address to the accumulator. For example if you wanted to copy data from V2000 and V2001 to V2010 and V2011 the most efficient way to perform this function would be as follows:



Standard RLL Instructions

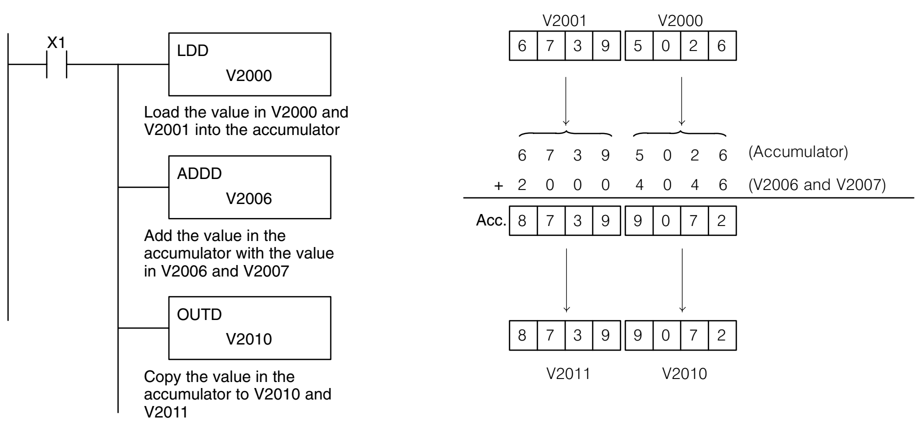
Changing the Accumulator Data

Instructions that manipulate data also use the accumulator. The result of the manipulated data resides in the accumulator. The data that was being manipulated is cleared from the accumulator. The following example loads the constant value 4935 into the accumulator, shifts the data right 4 bits, and outputs the result to V2010.



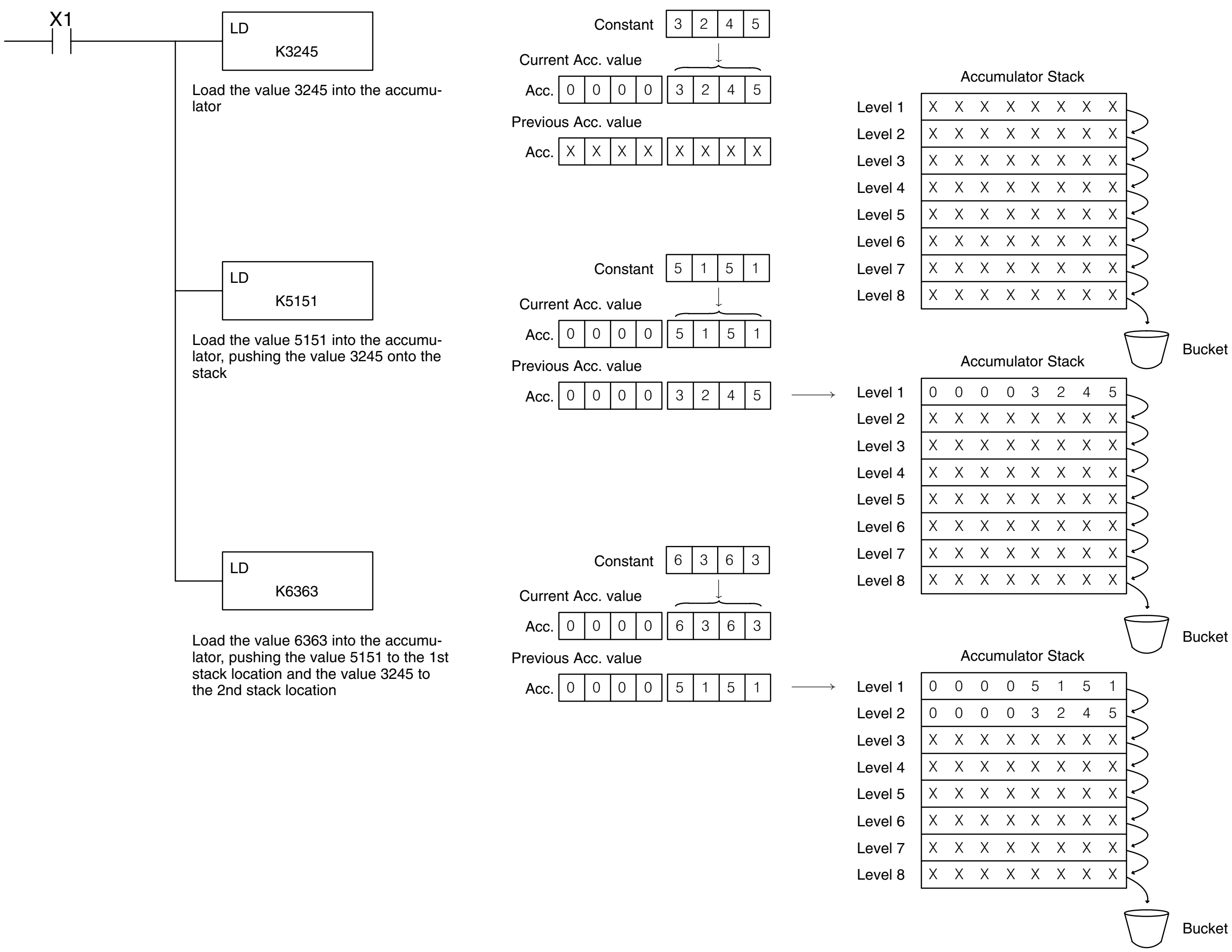
Some of the data manipulation instructions use 32 bits. They use two consecutive V memory locations or an 8 digit BCD constant to manipulate data in the accumulator.

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is added with the value in V2006 and V2007 using the Add Double instruction. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.

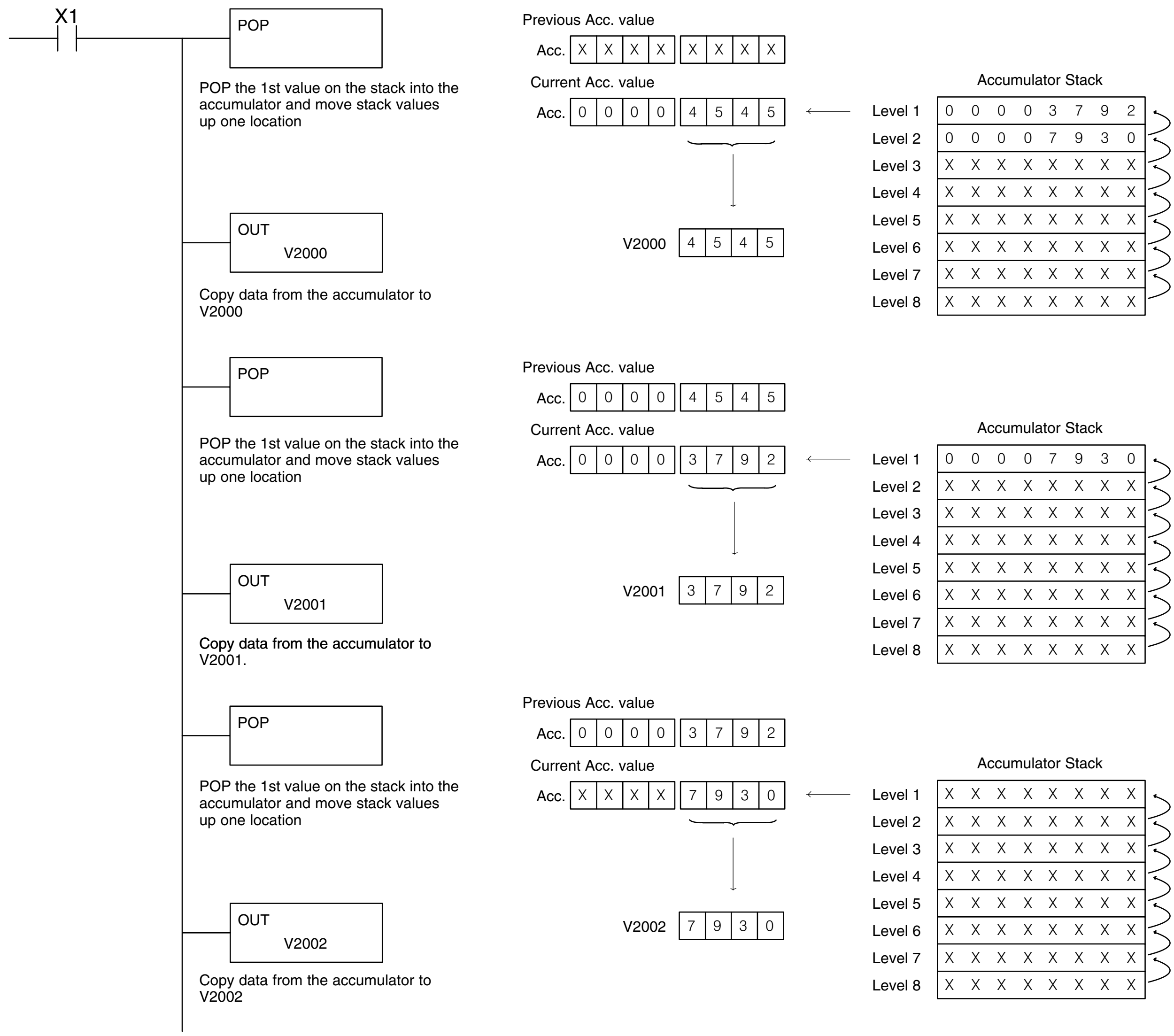


Using the Accumulator Stack

The accumulator stack is used for instructions that require more than one parameter to execute a function or for user defined functionality. The accumulator stack is used when more than one Load instruction is executed without the use of an Out instruction. The first load instruction in the scan places a value into the accumulator. Every Load instruction thereafter without the use of an Out instruction places a value into the accumulator and the value that was in the accumulator is placed onto the accumulator stack. The Out instruction nullifies the previous load instruction and does not place the value that was in the accumulator onto the accumulator stack when the next load instruction is executed. Every time a value is placed onto the accumulator stack the other values in the stack are pushed down one location. The accumulator is eight levels deep (eight 32 bit registers). If there is a value in the eighth location when a new value is placed onto the stack, the value in the eighth location is pushed off the stack and cannot be recovered.



The POP instruction rotates values upward through the stack into the accumulator. When a POP is executed the value which was in the accumulator is cleared and the value that was on top of the stack is in the accumulator. The values in the stack are shifted up one position in the stack.

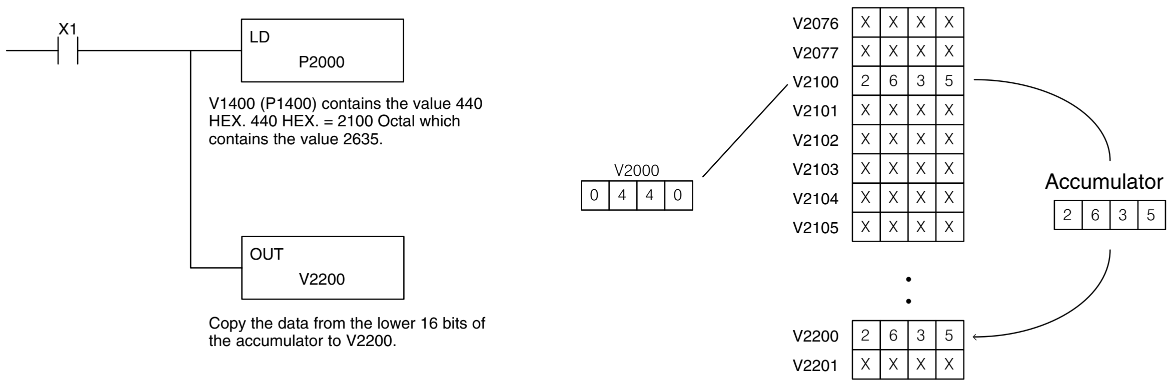


Using Pointers

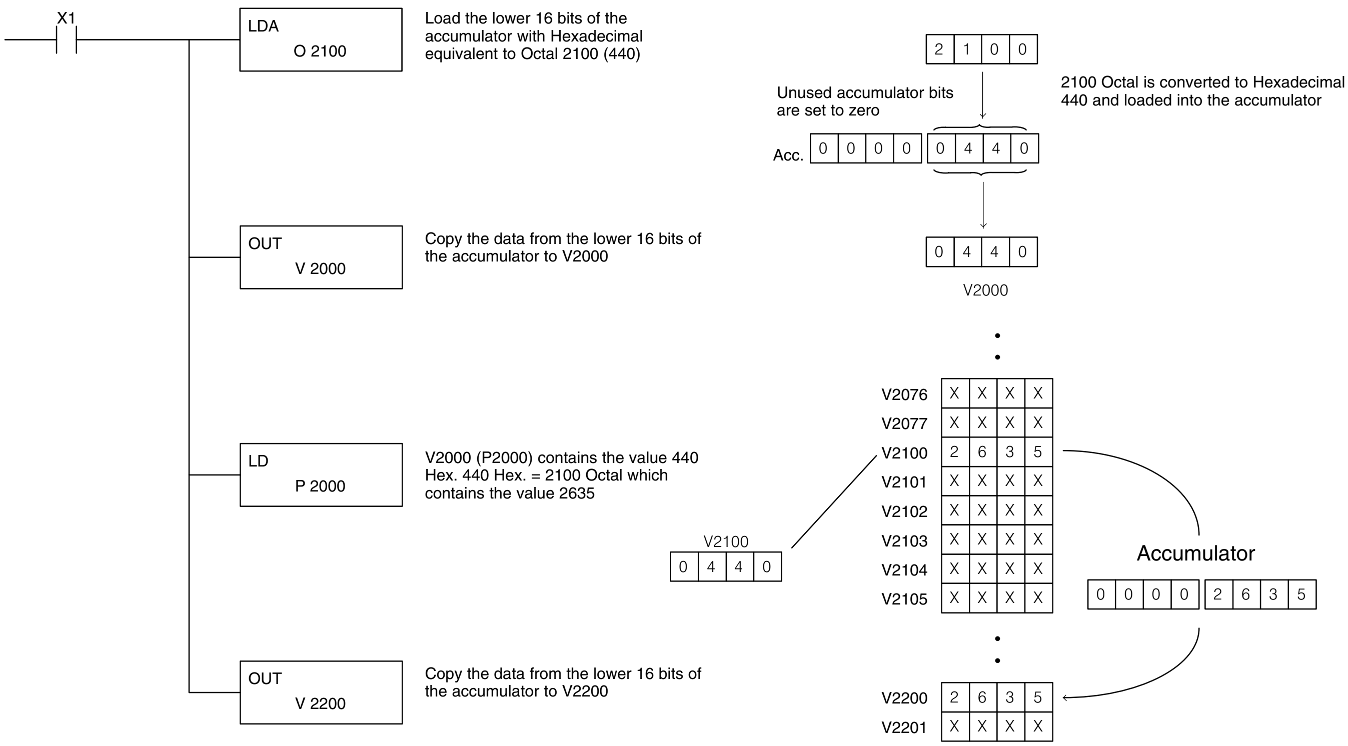
Many of the DL105 series instructions will allow V-memory pointers as a operand (commonly known as indirect addressing). Pointers allow instructions to obtain data from V-memory locations referenced by the pointer value.

NOTE: DL105 V-memory addressing is in octal. However, the pointers reference a V-memory location with values viewed as HEX. Use the Load Address (LDA) instruction to move an address into the pointer location. This instruction performs the Octal to Hexadecimal conversion automatically.

In the following simple example we are using a pointer operand in a Load instruction. V-memory location 2000 is being used as the pointer location. V2000 contains the value 440 which the CPU views as the Hex equivalent of the Octal address V-memory location V2100. The CPU will copy the data from V2100 which in this example contains the value 2635 into the lower word of the accumulator.

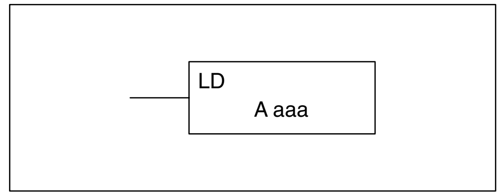


The following example is identical to the one above with one exception. The LDA (Load Address) instruction automatically converts the Octal address to Hex.



Load (LD)

The Load instruction is a 16 bit instruction that loads the value (Aaaa), which is either a V memory location or a 4 digit constant, into the lower 16 bits of the accumulator. The upper 16 bits of the accumulator are set to 0.

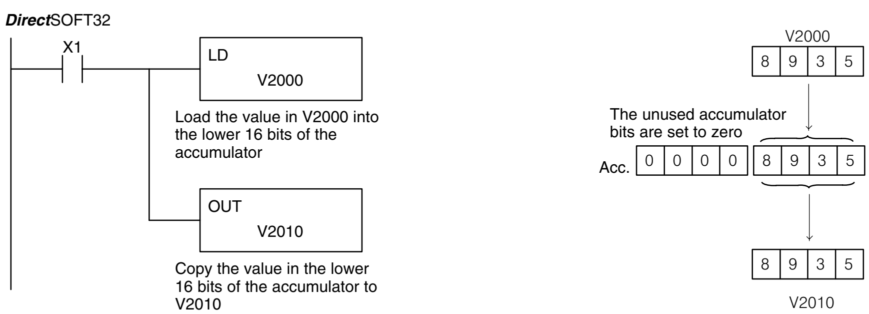


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Pointer	P	All V mem. (See page 4–28)
Constant	K	0–FFFF

Discrete Bit Flags	Description
SP76	on when the value loaded into the accumulator by any instruction is zero.

NOTE: Two consecutive Load instructions will place the value of the first load instruction onto the accumulator stack.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator and output to V2010.

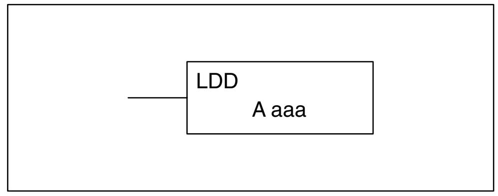


Handheld Programmer Keystrokes

$ STR	→	B 1	X SET					
SHFT	L ANDST	D 3	→					
C 2	A 0	A 0	A 0	ENT				
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT

Load Double (LDD)

The Load Double instruction is a 32 bit instruction that loads the value (Aaaa), which is either two consecutive V memory locations or an 8 digit constant value, into the accumulator.



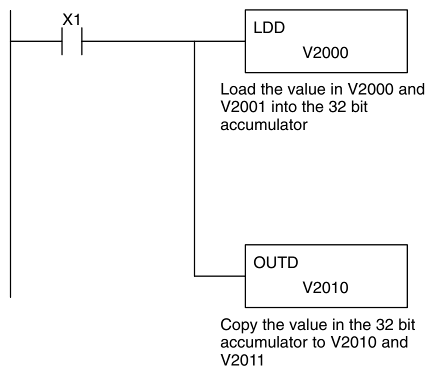
Operand Data Type		DL230 Range
	A	aaa
V memory	V	All (See page 4–28)
Pointer	P	All V mem. (See page 4–28)
Constant	K	0–FFFFFFFF

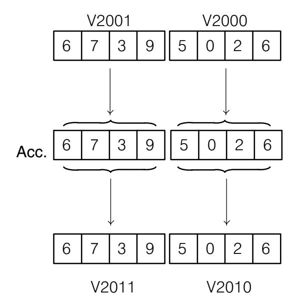
Discrete Bit Flags	Description
SP76	on when the value loaded into the accumulator by any instruction is zero.

NOTE: Two consecutive Load instructions will place the value of the first load instruction onto the accumulator stack.

In the following example, when X1 is on, the 32 bit value in V2000 and V2001 will be loaded into the accumulator and output to V2010 and V2011.

DirectSOFT32



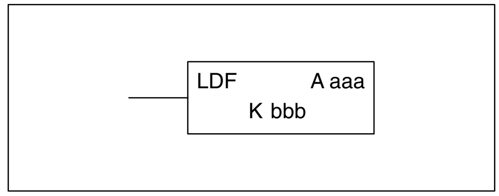


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT	
SHFT	L ANDST	D 3	D 3	→
C 2	A 0	A 0	A 0	ENT
GX OUT	SHFT	D 3	→	
C 2	A 0	B 1	A 0	ENT

Load Formatted (LDF)

The Load Formatted instruction loads 1–32 consecutive bits from discrete memory locations into the accumulator. The instruction requires a starting location (Aaaa) and the number of bits (Kbbb) to be loaded. Unused accumulator bit locations are set to zero.

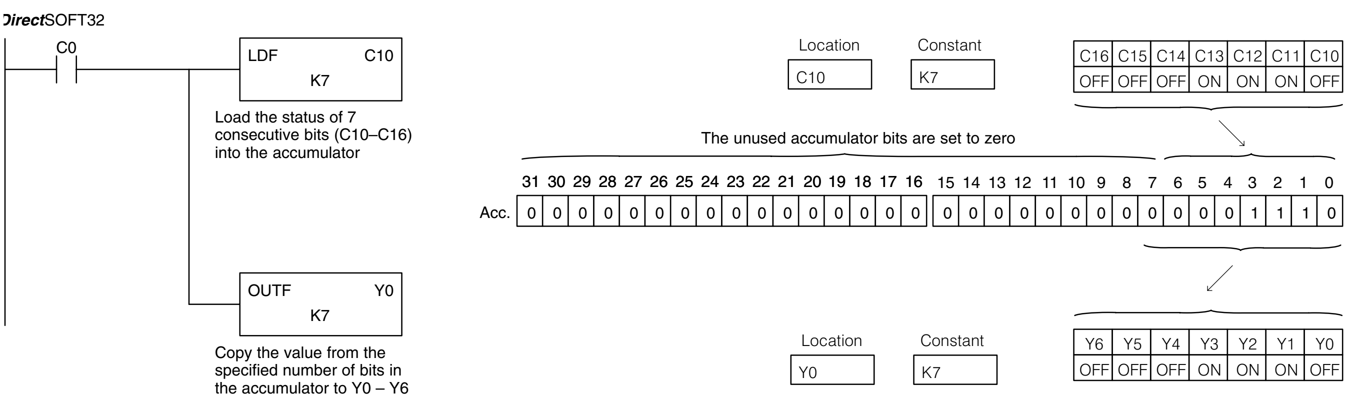


Operand Data Type		DL130 Range	
	A	aaa	bbb
Inputs	X	0–11	—
Outputs	Y	0–7	—
Control Relays	C	0–377	—
Stage Bits	S	0–377	—
Timer Bits	T	0–77	—
Counter Bits	CT	0–77	—
Special Relays	SP	0–117 540–577	—
Constant	K	—	1–32

Discrete Bit Flags	Description
SP76	on when the value loaded into the accumulator by any instruction is zero.

NOTE: Two consecutive Load instructions will place the value of the first load instruction onto the accumulator stack.

In the following example, when C0 is on, the binary pattern of C10–C16 (7 bits) will be loaded into the accumulator using the Load Formatted instruction. The lower 7 bits of the accumulator are output to Y0–Y6 using the Out Formatted instruction.

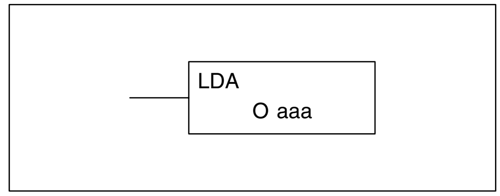


Handheld Programmer Keystrokes

$ STR	→	SHFT	C 2	A 0	ENT	
SHFT	L ANDST	D 3	F 5	→		
SHFT	C 2	B 1	A 0	→	H 7	ENT
GX OUT	SHFT	F 5	→			
A 0	→	H 7	ENT			

Load Address (LDA)

The Load Address instruction is a 16 bit instruction. It converts any octal value or address to the HEX equivalent value and loads the HEX value into the accumulator. This instruction is useful when an address parameter is required since all addresses for the DL105 system are in octal.



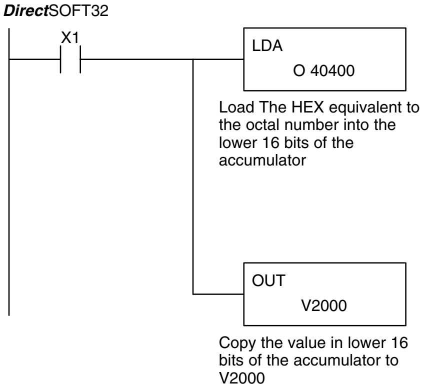
Operand Data Type		DL130 Range
		aaa
Octal Address	O	All V mem. (See page 4–28)

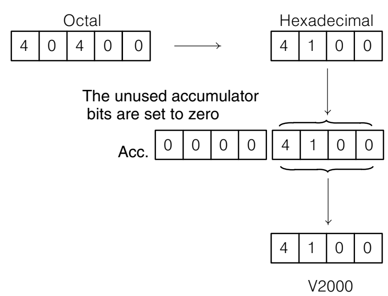
Discrete Bit Flags	Description
SP76	on when the value loaded into the accumulator by any instruction is zero.

NOTE: Two consecutive Load instructions will place the value of the first load instruction onto the accumulator stack.

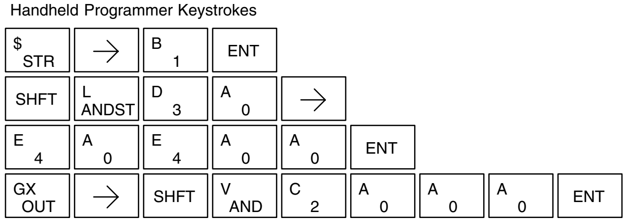
In the following example when X1 is on, the octal number 40400 will be converted to a HEX 4100 and loaded into the accumulator using the Load Address instruction. The value in the lower 16 bits of the accumulator is copied to V2000 using the Out instruction.

***Direct*SOFT32**





Handheld Programmer Keystrokes

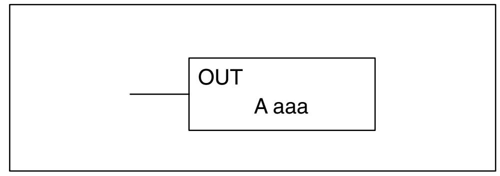


Standard RLL Instructions

Out (OUT)

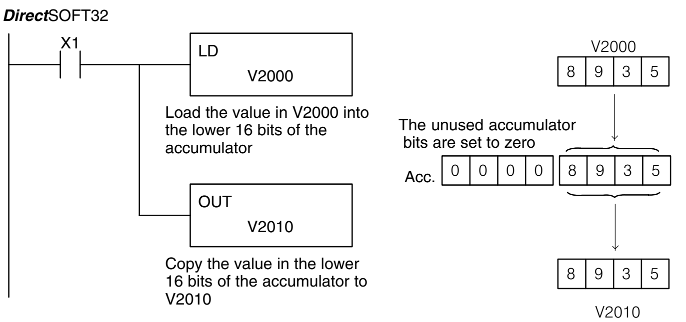
The Out instruction is a 16 bit instruction that copies the value in the lower 16 bits of the accumulator to a specified V memory location (Aaaa).

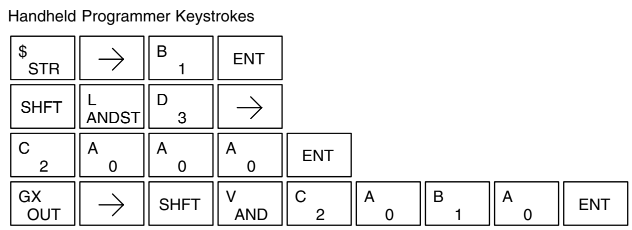
Note: See Appendix E



Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Pointer	P	All V mem. (See page 4–28)

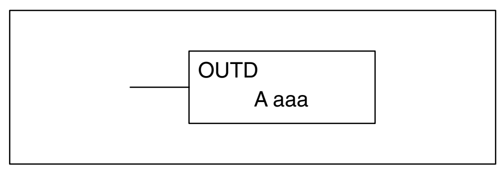
In the following example, when X1 is on, the value in V2000 will be loaded into the lower 16 bits of the accumulator using the Load instruction. The value in the lower 16 bits of the accumulator are copied to V2010 using the Out instruction.





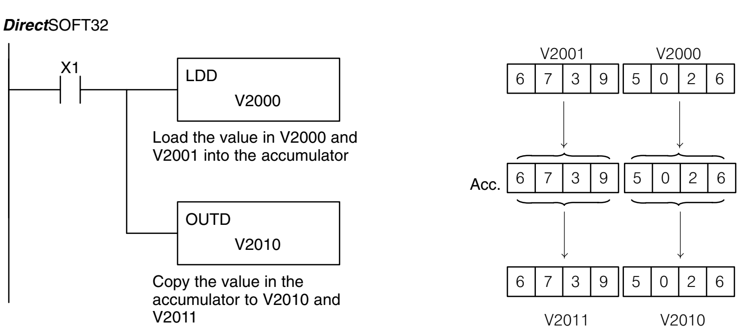
Out Double (OUTD)

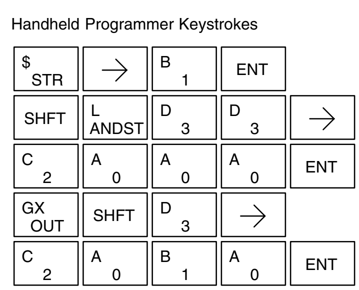
The Out Double instruction is a 32 bit instruction that copies the value in the accumulator to two consecutive V memory locations at a specified starting location (Aaaa). Note: See Appendix E



Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Pointer	P	All V mem. (See page 4–28)

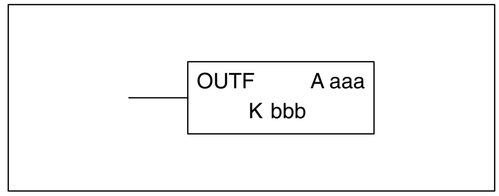
In the following example, when X1 is on, the 32 bit value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is output to V2010 and V2011 using the Out Double instruction.





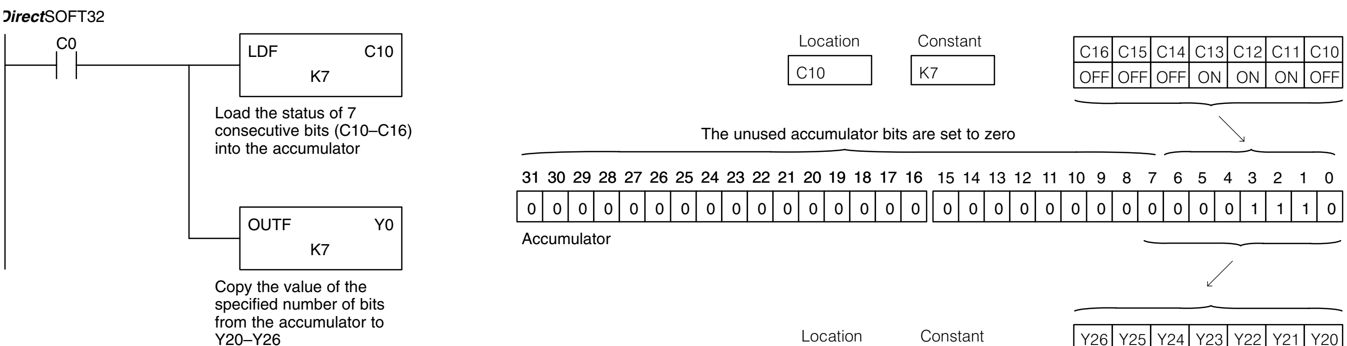
Out Formatted (OUTF)

The Out Formatted instruction outputs 1–32 bits from the accumulator to the specified discrete memory locations. The instruction requires a starting location (Aaaa) for the destination and the number of bits (Kbbb) to be output.



Operand Data Type		DL130 Range	
	A	aaa	bbb
Inputs	X	0–77	—
Outputs	Y	0–77	—
Control Relays	C	0–377	—
Constant	K	—	1–32

In the following example, when C0 is on, the binary pattern of C10–C16 (7 bits) will be loaded into the accumulator using the Load Formatted instruction. The lower 7 bits of the accumulator are output to Y0–Y6 using the Out Formatted instruction.

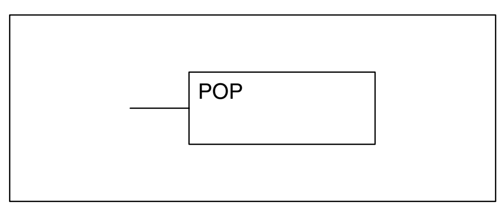


Handheld Programmer Keystrokes

$ STR	→	SHFT	C 2	A 0	ENT	
SHFT	L ANDST	D 3	F 5	→		
SHFT	C 2	B 1	A 0	→	H 7	ENT
GX OUT	SHFT	F 5	→			
A 0	→	H 7	ENT			

Pop (POP)

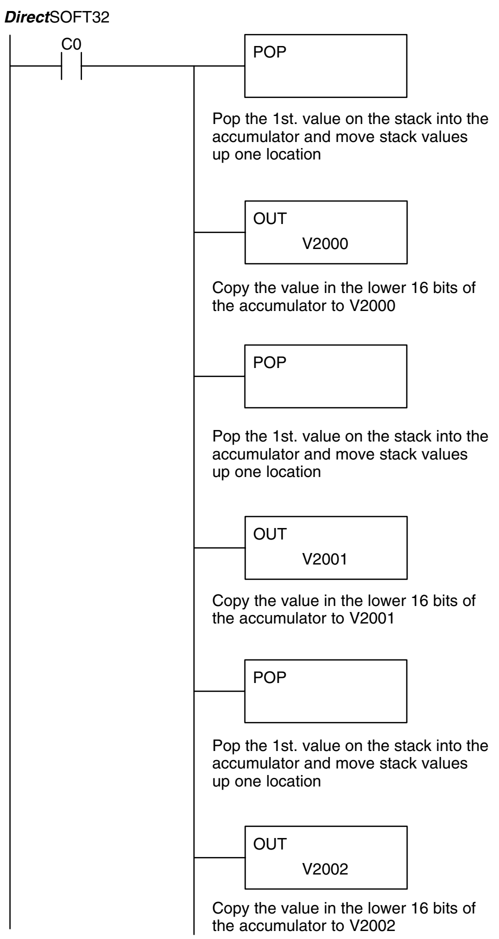
The Pop instruction moves the value from the first level of the accumulator stack (32 bits) to the accumulator and shifts each value in the stack up one level.

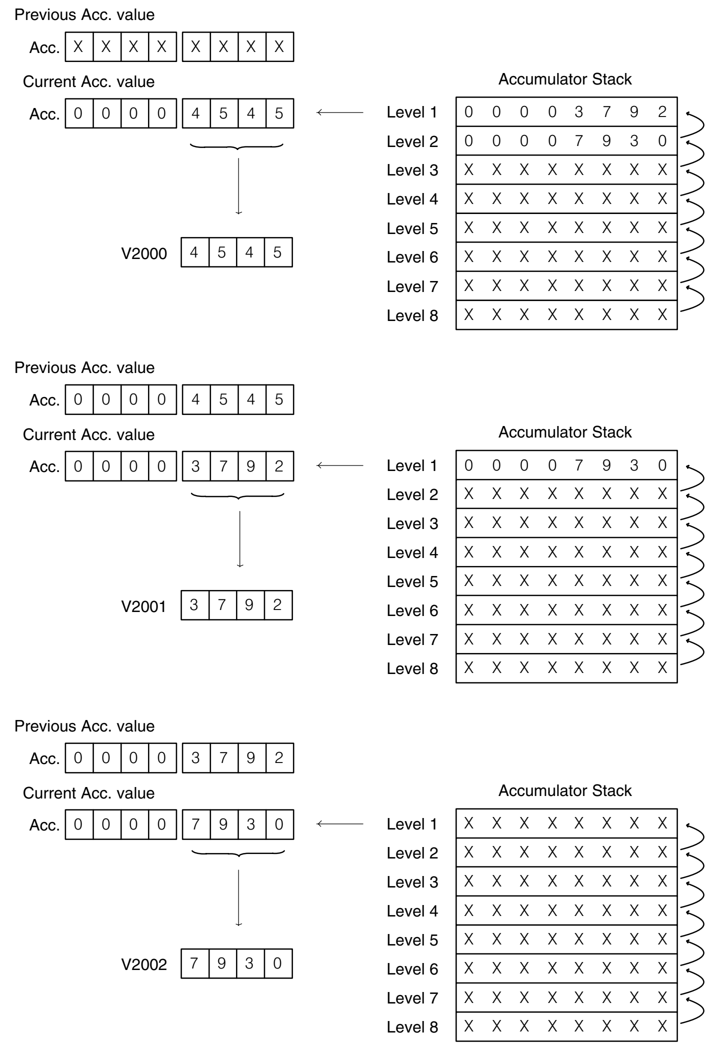


Discrete Bit Flags	Description
SP63	on when the result of the instruction causes the value in the accumulator to be zero.

Pop Instruction Continued

In the example below, when C0 is on, the value 4545 that was on top of the stack is moved into the accumulator using the Pop instruction The value is output to V2000 using the Out instruction. The next Pop moves the value 3792 into the accumulator and outputs the value to V2001. The last Pop moves the value 7930 into the accumulator and outputs the value to V2002. Please note if the value in the stack were greater than 16 bits (4 digits) the Out Double instruction would be used and 2 V memory locations for each Out Double must be allocated.





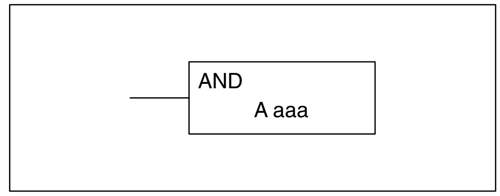
Handheld Programmer Keystrokes

$ STR	→	SHFT	C 2	A 0	ENT			
SHFT	P CV	SHFT	O INST#	P CV	ENT			
GX OUT	→	SHFT	V AND	C 2	A 0	A 0	A 0	ENT
SHFT	P CV	SHFT	O INST#	P CV	ENT			
GX OUT	→	SHFT	V AND	C 2	A 0	A 0	B 1	ENT
SHFT	P CV	SHFT	O INST#	P CV	ENT			
GX OUT	→	SHFT	V AND	C 2	A 0	A 0	C 2	ENT

Logical Instructions (Accumulator)

And (AND)

The And instruction is a 16 bit instruction that logically ands the value in the lower 16 bits of the accumulator with a specified V memory location (Aaaa). The result resides in the accumulator. The discrete status flag indicates if the result of the And is zero.

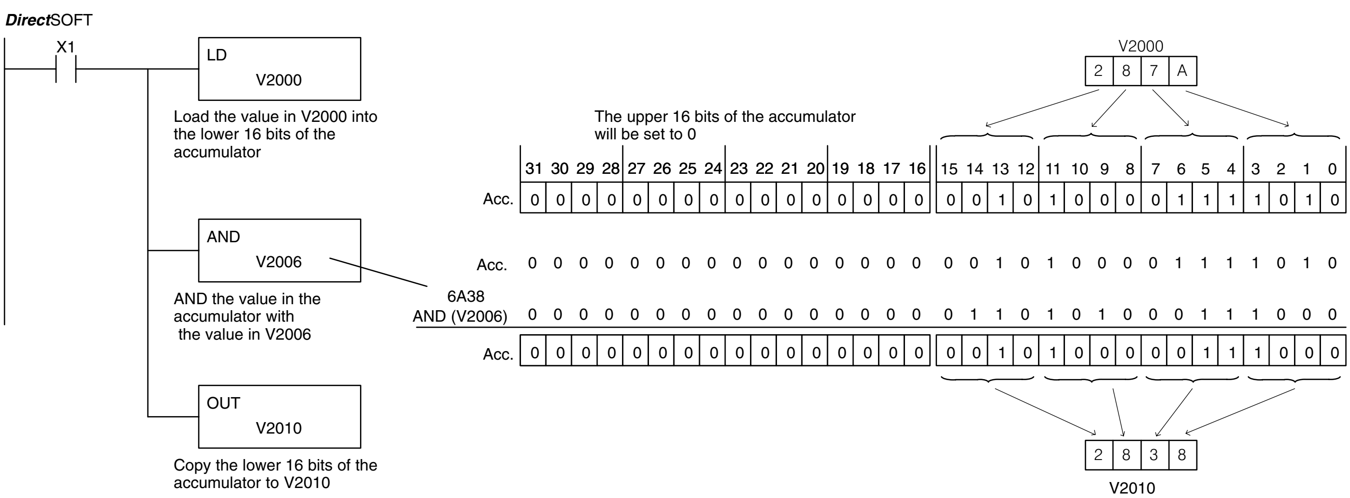


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	Will be on if the result in the accumulator is zero

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in the accumulator is anded with the value in V2006 using the And instruction. The value in the lower 16 bits of the accumulator is output to V2010 using the Out instruction.

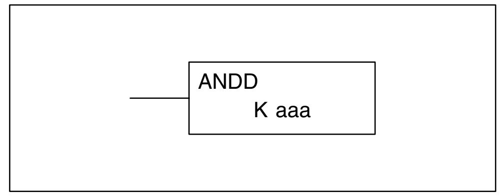


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT				
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT
V AND	→	SHFT	V AND	C 2	A 0	A 0	G 6	ENT
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT

And Double (ANDD)

The And Double is a 32 bit instruction that logically ands the value in the accumulator with two consecutive V memory locations or an 8 digit (max.) constant value (Aaaa). The result resides in the accumulator. Discrete status flags indicate if the result of the And Double is zero or a negative number (the most significant bit is on).

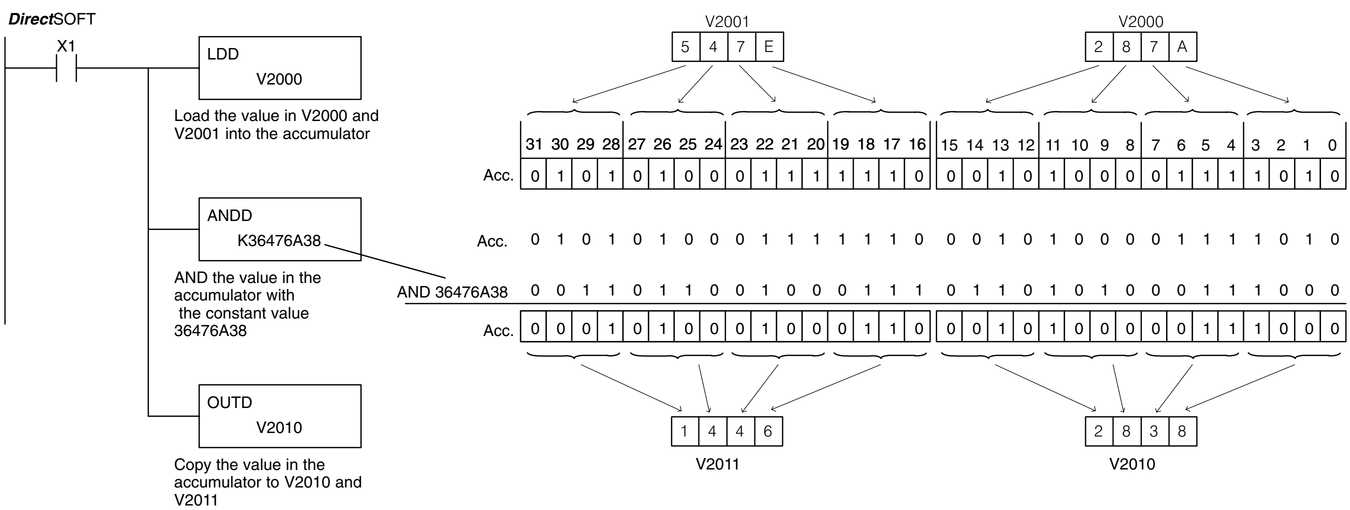


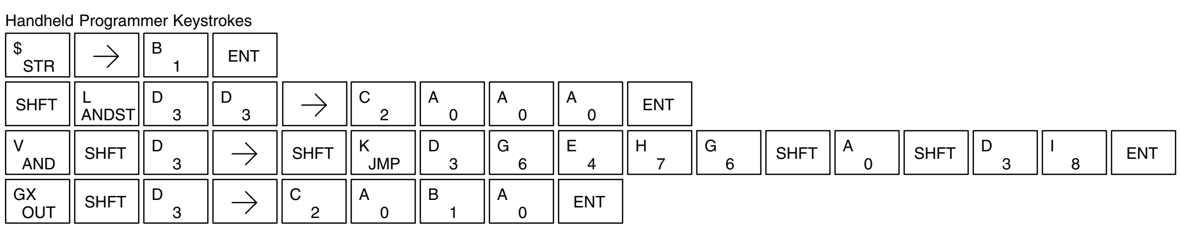
Operand Data Type		DL130 Range
		aaa
V memory	V	All (See page 4–28)
Constant	K	0–FFFFFFFF

Discrete Bit Flags	Description
SP63	Will be on if the result in the accumulator is zero
SP70	Will be on is the result in the accumulator is negative

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

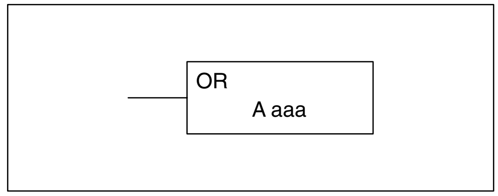
In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is anded with 36476A38 using the And double instruction. The value in the accumulator is output to V2010 and V2011 using the Out Double instruction.





Or (OR)

The Or instruction is a 16 bit instruction that logically ors the value in the lower 16 bits of the accumulator with a specified V memory location (Aaaa). The result resides in the accumulator. The discrete status flag indicates if the result of the Or is zero.

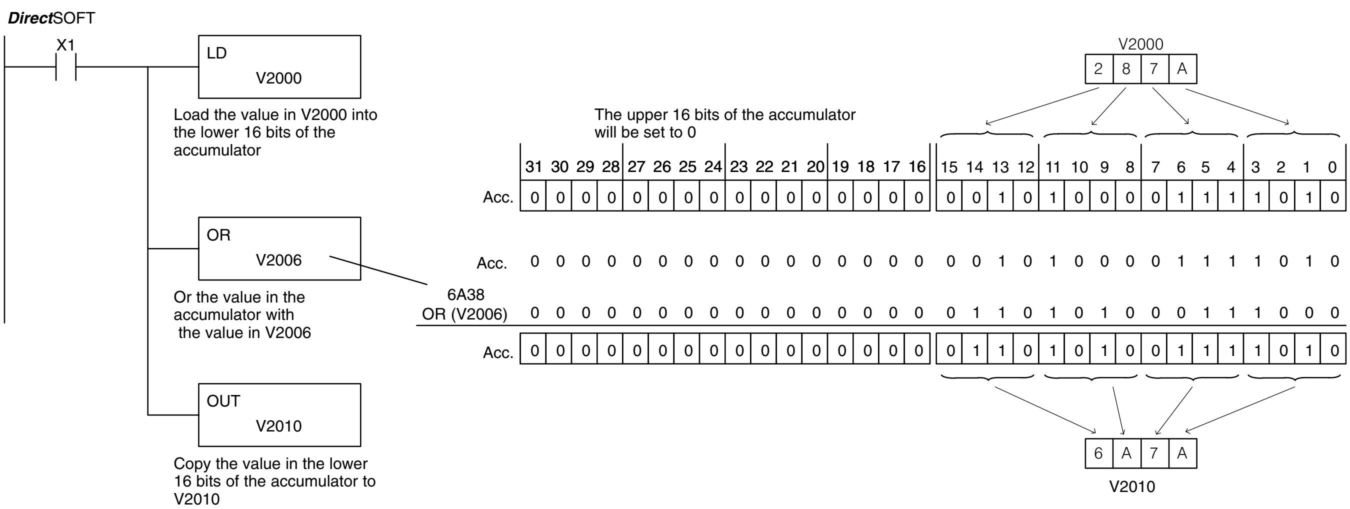


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	Will be on if the result in the accumulator is zero

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in the accumulator is ored with V2006 using the Or instruction. The value in the lower 16 bits of the accumulator are output to V2010 using the Out instruction.



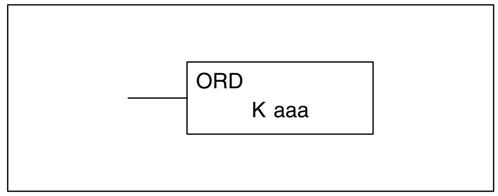
Handheld Programmer Keystrokes

$ STR	→	B 1	ENT					
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT
Q OR	→	SHFT	V AND	C 2	A 0	A 0	G 6	ENT
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT

Standard RLL Instructions

Or Double (ORD)

The Or Double is a 32 bit instruction that ors the value in the accumulator with the value (Aaaa), which is either two consecutive V memory locations or an 8 digit (max.) constant value. The result resides in the accumulator. Discrete status flags indicate if the result of the Or Double is zero or a negative number (the most significant bit is on).

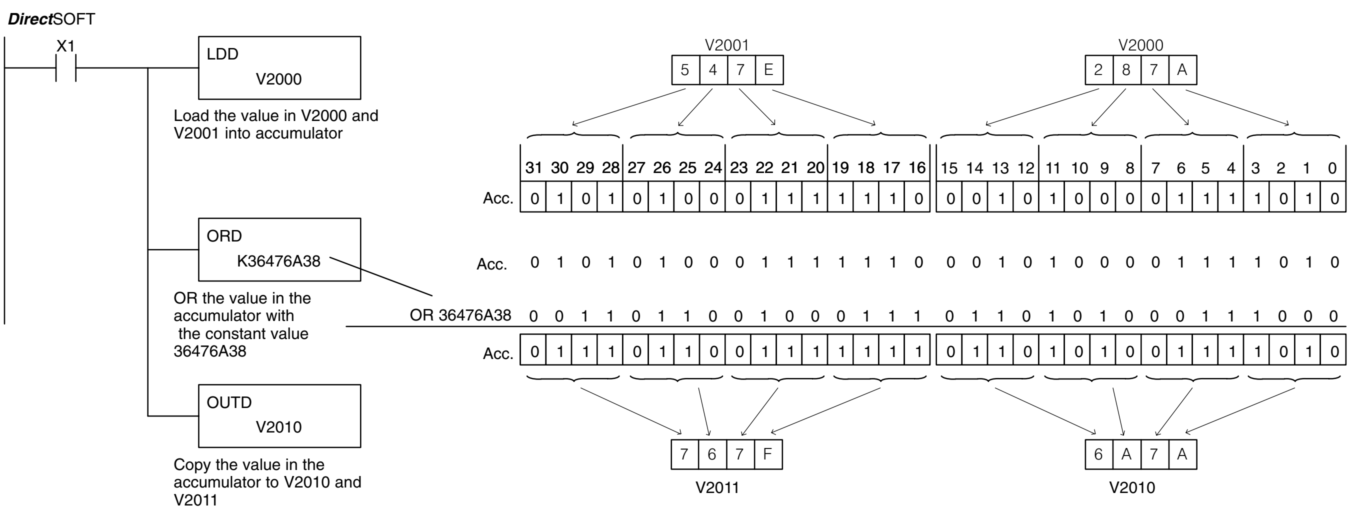


Operand Data Type		DL130 Range
		aaa
V memory	V	All (See page 4–28)
Constant	K	0–FFFFFFFF

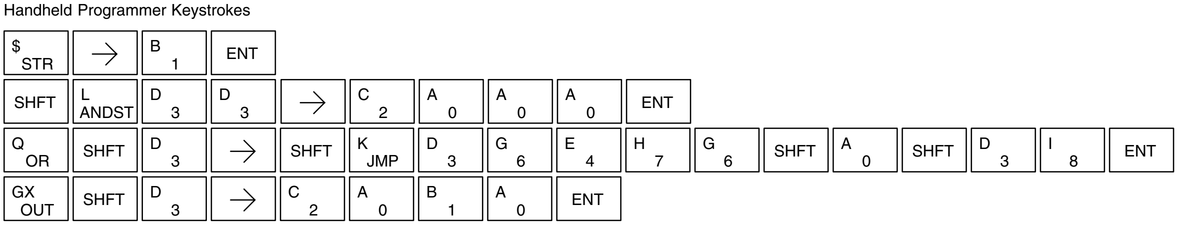
Discrete Bit Flags	Description
SP63	Will be on if the result in the accumulator is zero
SP70	Will be on is the result in the accumulator is negative

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is ored with 36476A38 using the Or Double instruction. The value in the accumulator is output to V2010 and V2011 using the Out Double instruction.

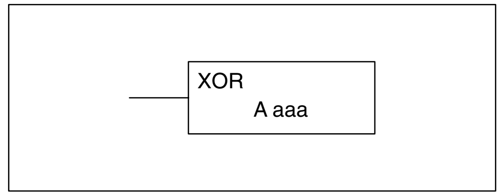


Handheld Programmer Keystrokes



Exclusive Or (XOR)

The Exclusive Or instruction is a 16 bit instruction that performs an exclusive or of the value in the lower 16 bits of the accumulator and a specified V memory location (Aaaa). The result resides in the in the accumulator. The discrete status flag indicates if the result of the XOR is zero.

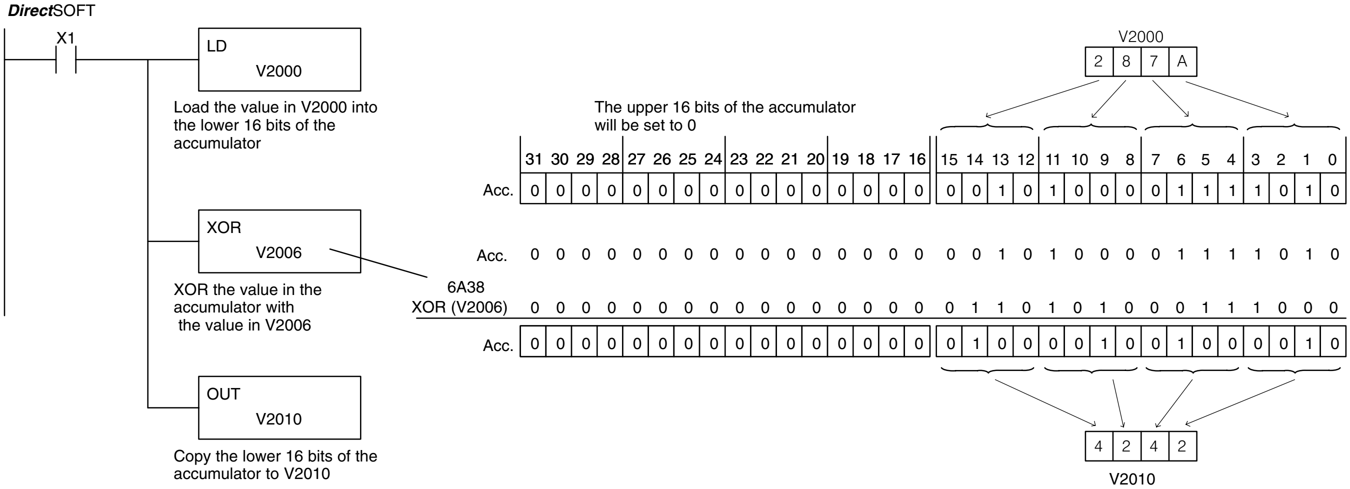


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	Will be on if the result in the accumulator is zero

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in the accumulator is exclusive ored with V2006 using the Exclusive Or instruction. The value in the lower 16 bits of the accumulator are output to V2010 using the Out instruction.

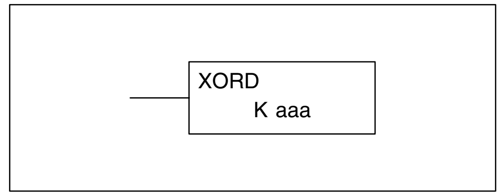


Handheld Programmer Keystrokes

$ STR	→	SHFT	X SET	B 1	ENT						
SHFT	L ANDST	D 3	→	SHFT	V AND	C 2	A 0	A 0	A 0	ENT	
SHFT	X SET	SHFT	Q OR	→	SHFT	V AND	C 2	A 0	A 0	G 6	ENT
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT			

Exclusive Or Double (XORD)

The Exclusive OR Double is a 32 bit instruction that performs an exclusive or of the value in the accumulator and the value (Aaaa), which is either two consecutive V memory locations or an 8 digit (max.) constant. The result resides in the accumulator. Discrete status flags indicate if the result of the Exclusive Or Double is zero or a negative number (the most significant bit is on).

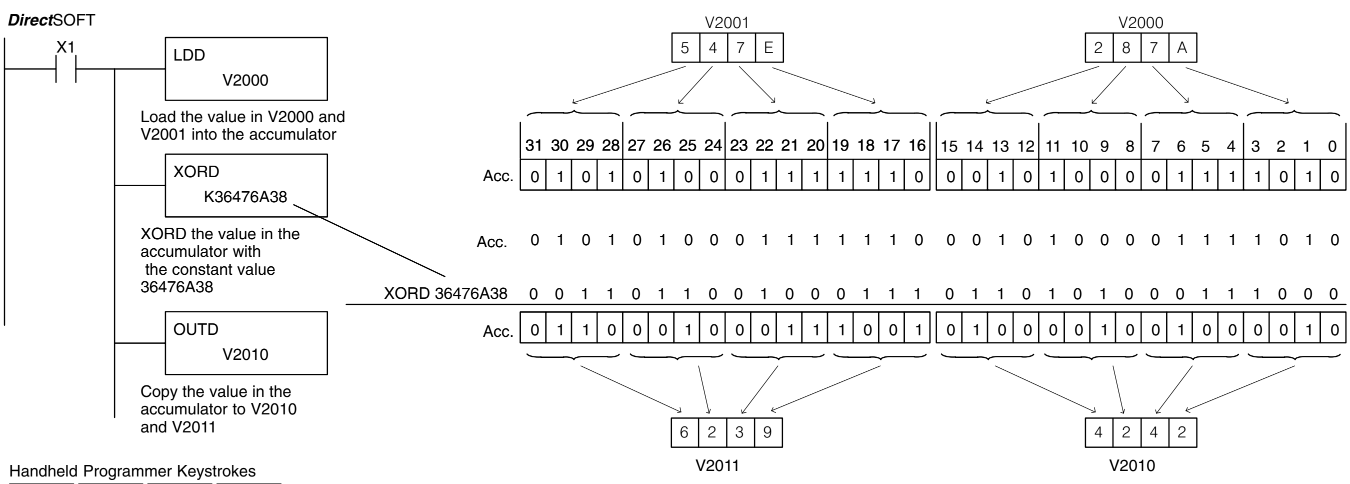


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	0–FFFFFFFF

Discrete Bit Flags	Description
SP63	Will be on if the result in the accumulator is zero
SP70	Will be on is the result in the accumulator is negative

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is exclusively ored with 36476A38 using the Exclusive Or Double instruction. The value in the accumulator is output to V2010 and V2011 using the Out Double instruction.

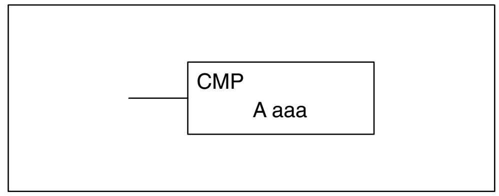


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	X SET	Q OR	SHFT	D 3	→	SHFT	K JMP		
D 3	G 6	E 4	H 7	G 6	SHFT	A 0	SHFT	D 3	I 8	ENT
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT	

Compare (CMP)

The compare instruction is a 16 bit instruction that compares the value in the lower 16 bits of the accumulator with the value in a specified V memory location (Aaaa). The corresponding status flag will be turned on indicating the result of the comparison.

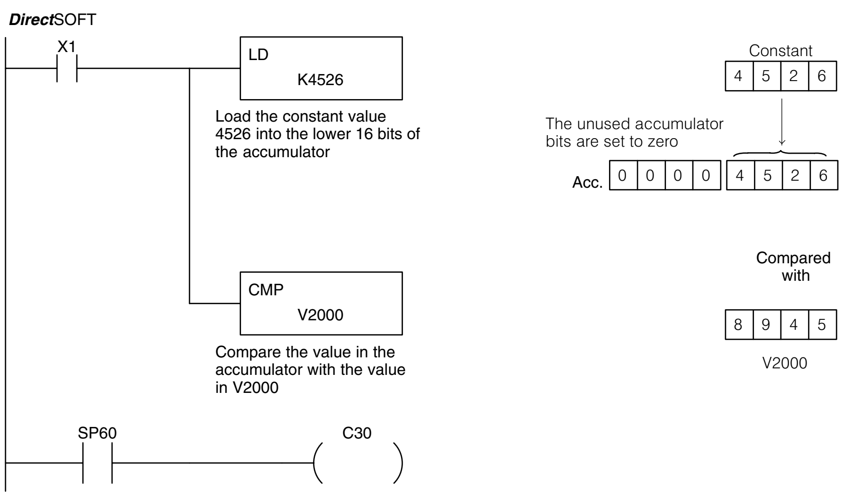


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP60	On when the value in the accumulator is less than the instruction value.
SP61	On when the value in the accumulator is equal to the instruction value.
SP62	On when the value in the accumulator is greater than the instruction value.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example when X1 is on, the constant 4526 will be loaded into the lower 16 bits of the accumulator using the Load instruction. The value in the accumulator is compared with the value in V2000 using the Compare instruction. The corresponding discrete status flag will be turned on indicating the result of the comparison. In this example, if the value in the accumulator is less than the value specified in the Compare instruction, SP60 will turn on energizing C30.

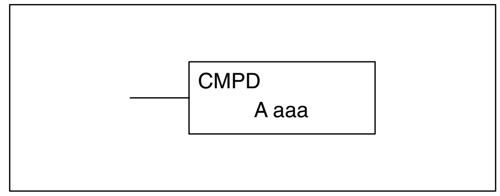


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT							
SHFT	L ANDST	D 3	→	SHFT	K JMP	E 4	F 5	C 2	G 6	ENT
SHFT	C 2	SHFT	M ORST	P CV	→	C 2	A 0	A 0	A 0	ENT
$ STR	→	SHFT	SP STRN	G 6	A 0	ENT				
GX OUT	→	SHFT	C 2	D 3	A 0	ENT				

Compare Double (CMPD)

The Compare Double instruction is a 32–bit instruction that compares the value in the accumulator with the value (Aaaa), which is either two consecutive V memory locations or an 8–digit (max.) constant. The corresponding status flag will be turned on indicating the result of the comparison.



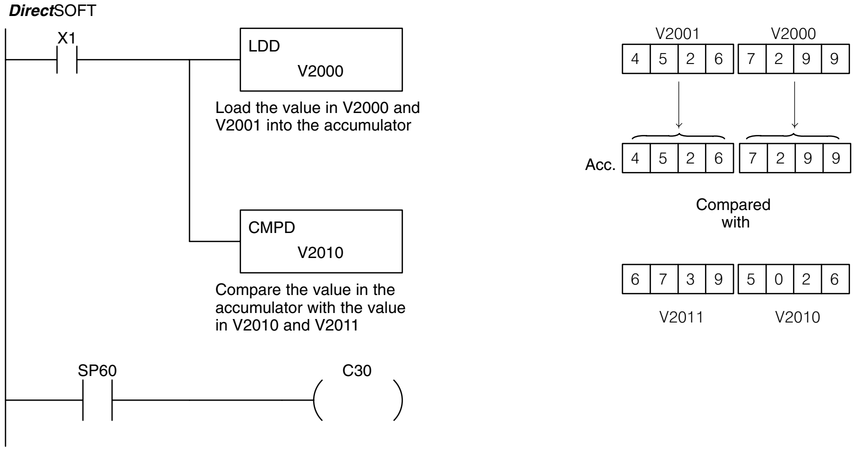
Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	1–FFFFFFFF

Discrete Bit Flags	Description
SP60	On when the value in the accumulator is less than the instruction value.
SP61	On when the value in the accumulator is equal to the instruction value.
SP62	On when the value in the accumulator is greater than the instruction value.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is compared with the value in V2010 and V2011 using the CMPD instruction. The corresponding discrete status flag will be turned on indicating the result of the comparison. In this example, if the value in the accumulator is less than the value specified in the Compare instruction, SP60 will turn on energizing C30.

***Direct*SOFT**



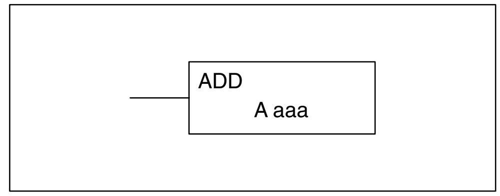
Handheld Programmer Keystrokes

$ STR	→	B 1	ENT							
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT	
SHFT	C 2	SHFT	M ORST	P CV	D 3	→	C 2	A 0	B 1	A 0	ENT
$ STR	→	SHFT	SP STRN	G 6	A 0	ENT				
GX OUT	→	SHFT	C 2	D 3	A 0	ENT				

Math Instructions

Add (ADD)

Add is a 16 bit instruction that adds a BCD value in the accumulator with a BCD value in a V memory location (Aaaa). The result resides in the accumulator.

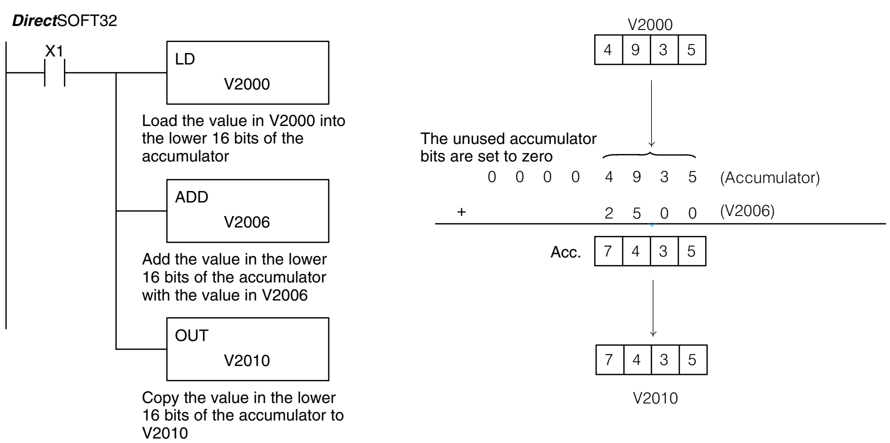


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	On when the result of the instruction causes the value in the accumulator to be zero.
SP66	On when the 16 bit addition instruction results in a carry.
SP67	On when the 32 bit addition instruction results in a carry.
SP70	On anytime the value in the accumulator is negative.
SP75	On when a BCD instruction is executed and a NON–BCD number was encountered.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in the lower 16 bits of the accumulator are added to the value in V2006 using the Add instruction. The value in the accumulator is copied to V2010 using the Out instruction.

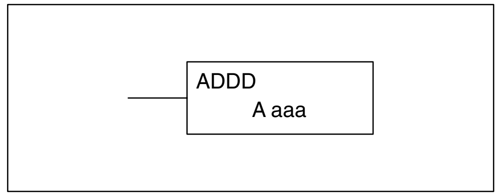


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT	
SHFT	A 0	D 3	D 3	→	C 2	A 0	A 0	G 6	ENT
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT	

Add Double (ADDD)

Add Double is a 32 bit instruction that adds the BCD value in the accumulator with a BCD value (Aaaa), which is either two consecutive V memory locations or an 8–digit (max.) BCD constant. The result resides in the accumulator.

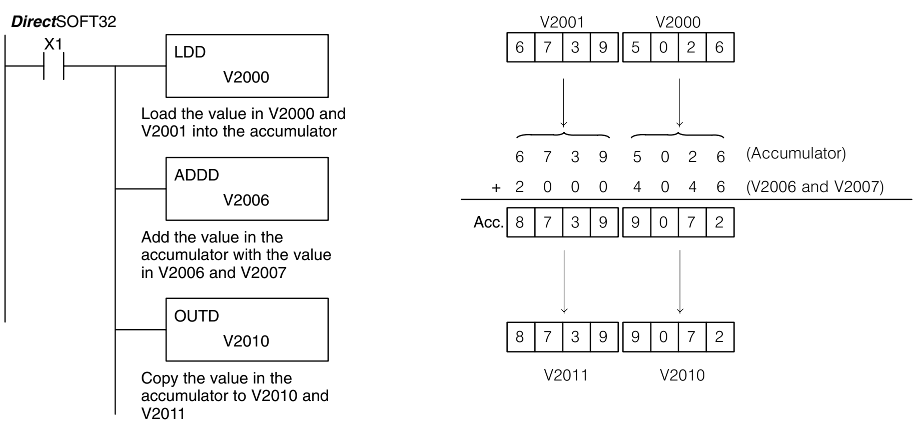


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	0–99999999

Discrete Bit Flags	Description
SP63	On when the result of the instruction causes the value in the accumulator to be zero.
SP66	On when the 16 bit addition instruction results in a carry.
SP67	On when the 32 bit addition instruction results in a carry.
SP70	On anytime the value in the accumulator is negative.
SP75	On when a BCD instruction is executed and a NON–BCD number was encountered.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is added with the value in V2006 and V2007 using the Add Double instruction. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.



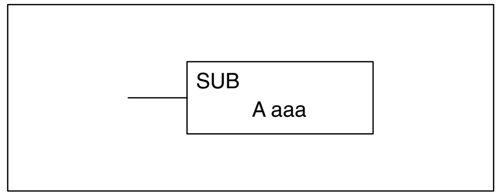
Handheld Programmer Keystrokes

$ STR	→	B 1	ENT							
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT	
SHFT	A 0	D 3	D 3	D 3	→	C 2	A 0	A 0	G 6	ENT
GX OUT	SHFT	D 3	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT

Standard RLL Instructions

Subtract (SUB)

Subtract is a 16 bit instruction that subtracts the BCD value (Aaaa) in a V memory location from the BCD value in the lower 16 bits of the accumulator. The result resides in the accumulator.

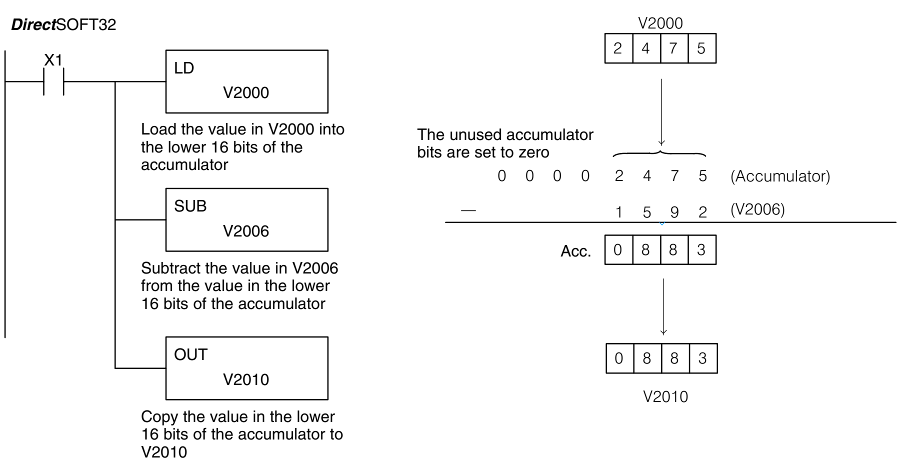


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

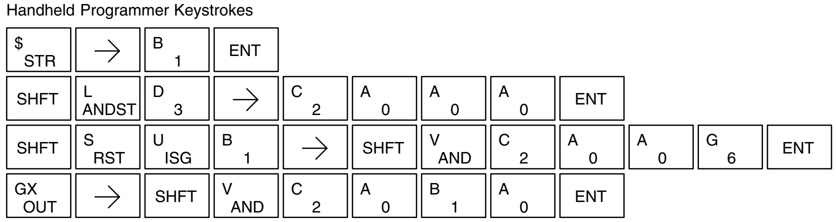
Discrete Bit Flags	Description
SP63	On when the result of the instruction causes the value in the accumulator to be zero.
SP64	On when the 16 bit subtraction instruction results in a borrow.
SP65	On when the 32 bit subtraction instruction results in a borrow.
SP70	On anytime the value in the accumulator is negative.
SP75	On when a BCD instruction is executed and a NON–BCD number was encountered.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in V2006 is subtracted from the value in the accumulator using the Subtract instruction. The value in the accumulator is copied to V2010 using the Out instruction.

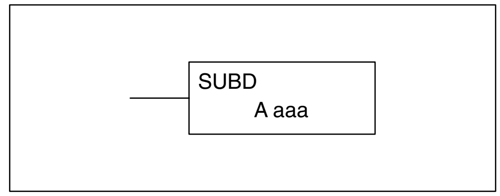


Handheld Programmer Keystrokes



Subtract Double (SUBD)

Subtract Double is a 32 bit instruction that subtracts the BCD value (Aaaa), which is either two consecutive V memory locations or an 8-digit (max.) constant, from the BCD value in the accumulator. The result resides in the accumulator.

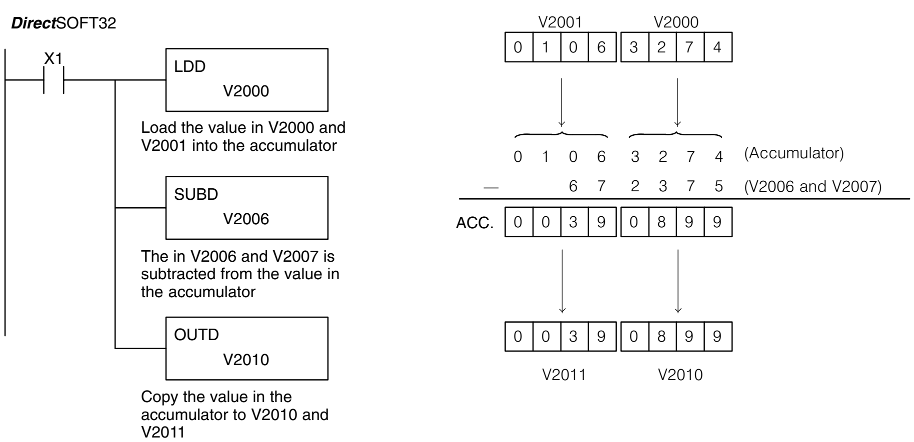


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	0–99999999

Discrete Bit Flags	Description
SP63	On when the result of the instruction causes the value in the accumulator to be zero.
SP64	On when the 16 bit subtraction instruction results in a borrow.
SP65	On when the 32 bit subtraction instruction results in a borrow.
SP70	On anytime the value in the accumulator is negative.
SP75	On when a BCD instruction is executed and a NON–BCD number was encountered.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in V2006 and V2007 is subtracted from the value in the accumulator. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.

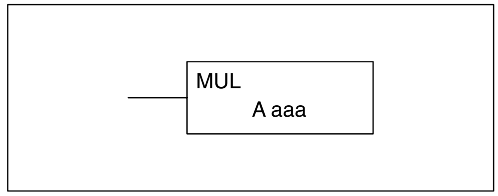


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT								
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT		
SHFT	S RST	SHFT	U ISG	B 1	D 3	→	C 2	A 0	A 0	G 6	ENT
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT			

Multiply (MUL)

Multiply is a 16 bit instruction that multiplies the BCD value (Aaaa), which is either a V memory location or a 4–digit (max.) constant, by the BCD value in the lower 16 bits of the accumulator The result can be up to 8 digits and resides in the accumulator.

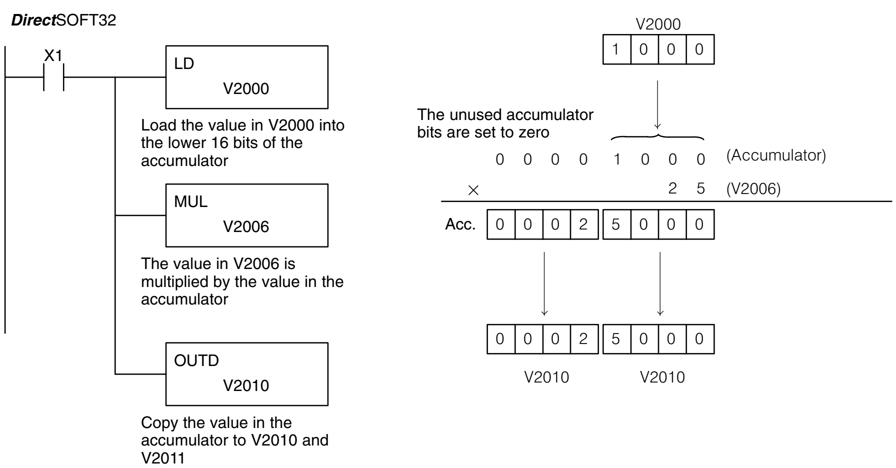


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	0–9999

Discrete Bit Flags	Description
SP63	On when the result of the instruction causes the value in the accumulator to be zero.
SP70	On anytime the value in the accumulator is negative.
SP75	On when a BCD instruction is executed and a NON–BCD number was encountered.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in V2006 is multiplied by the value in the accumulator. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.

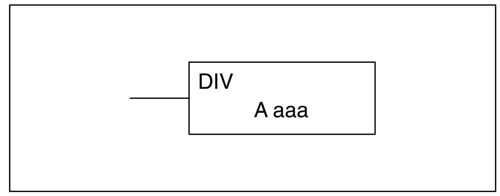


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT	
SHFT	M ORST	U ISG	L ANDST	→	C 2	A 0	A 0	G 6	ENT
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT	

Divide (DIV)

Divide is a 16 bit instruction that divides the BCD value in the accumulator by a BCD value (Aaaa), which is either a V memory location or a 4-digit (max.) constant. The first part of the quotient resides in the accumulator and the remainder resides in the first stack location.

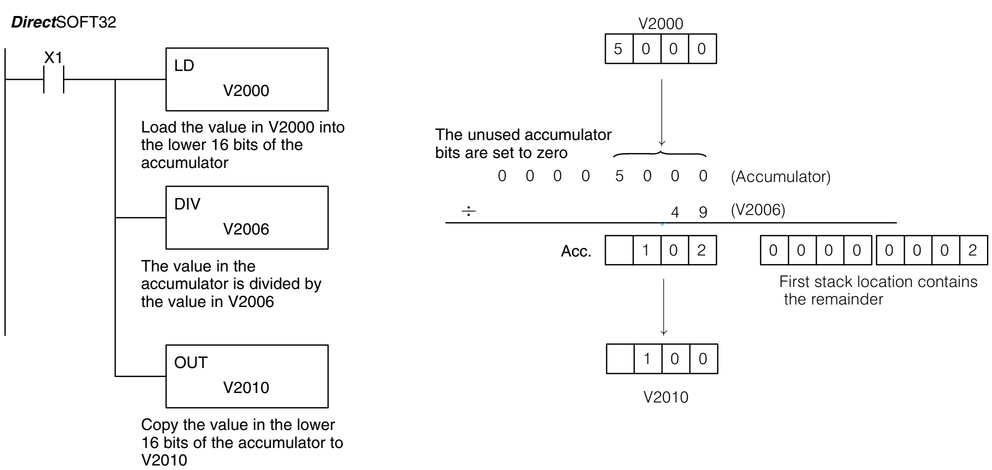


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	0–9999

Discrete Bit Flags	Description
SP53	On when the value of the operand is larger than the accumulator can work with.
SP63	On when the result of the instruction causes the value in the accumulator to be zero.
SP70	On anytime the value in the accumulator is negative.
SP75	On when a BCD instruction is executed and a NON–BCD number was encountered.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, the value in V2000 will be loaded into the accumulator using the Load instruction. The value in the accumulator will be divided by the value in V2006 using the Divide instruction. The value in the accumulator is copied to V2010 using the Out instruction.

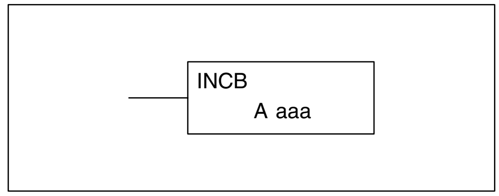


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT	
SHFT	D 3	I 8	V AND	→	C 2	A 0	A 0	G 6	ENT
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT	

Increment Binary (INCB)

The Increment Binary instruction increments a binary value in a specified V memory location by "1" each time the instruction is executed.

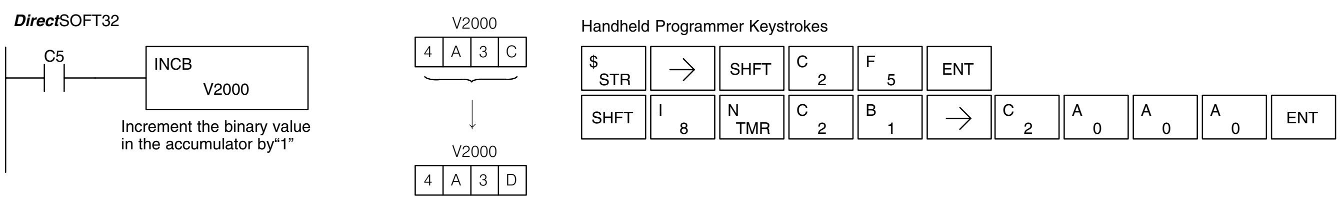


Operand Data Type		DL105 Range
	A	aaa
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	on when the result of the instruction causes the value in the accumulator to be zero.

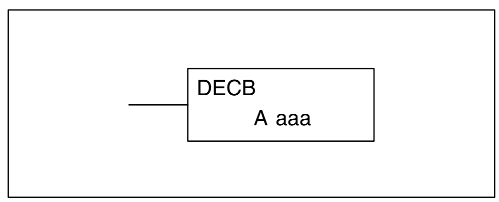
NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example when C5 is on, the binary value in V2000 is increased by 1.



Decrement Binary (DECB)

The Decrement Binary instruction decrements a binary value in a specified V memory location by "1" each time the instruction is executed.

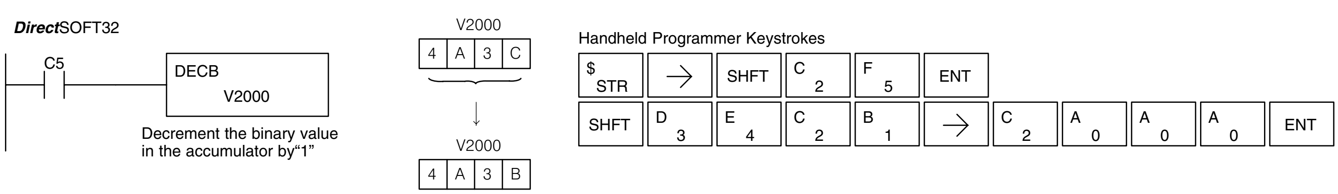


Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

Discrete Bit Flags	Description
SP63	on when the result of the instruction causes the value in the accumulator to be zero.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

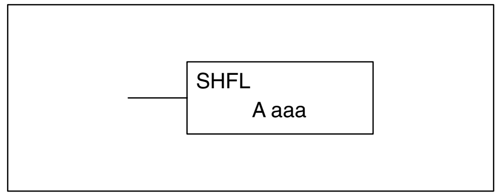
In the following example when C5 is on, the value in V2000 is decreased by 1.



Bit Operation Instructions

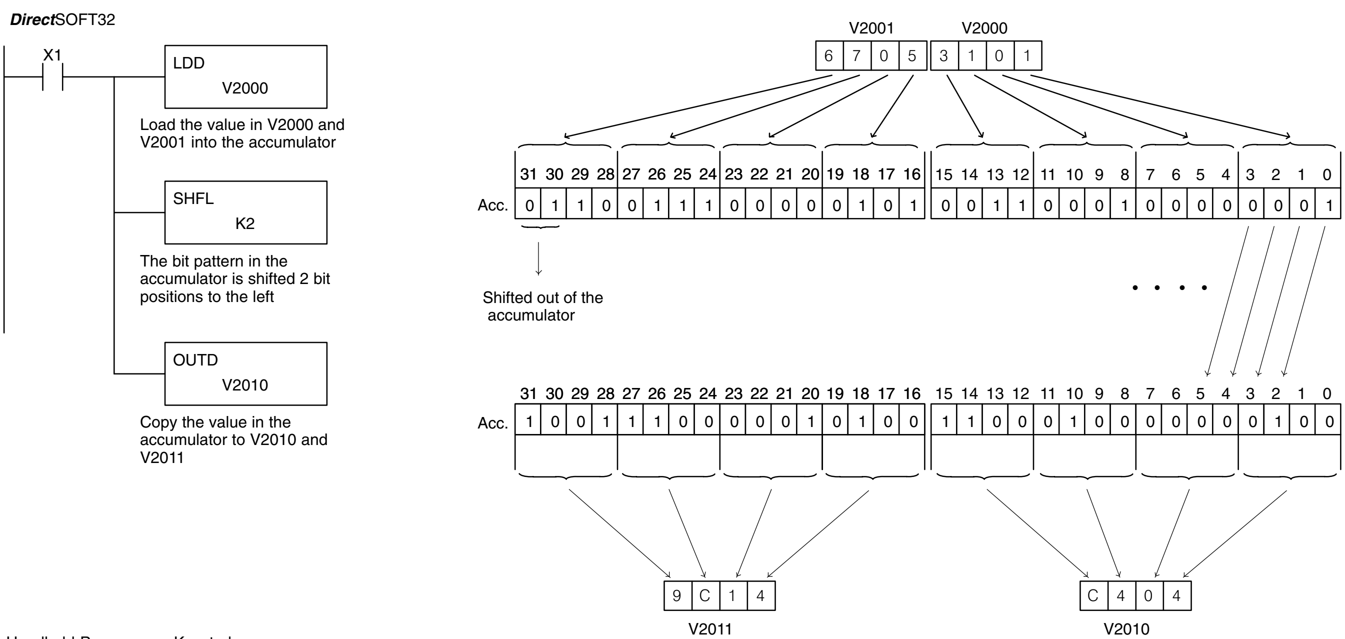
Shift Left (SHFL)

Shift Left is a 32 bit instruction that shifts the bits in the accumulator a specified number (Aaaa) of places to the left. The vacant positions are filled with zeros and the bits shifted out of the accumulator are discarded.



Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	1–32

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The bit pattern in the accumulator is shifted 2 bits to the left using the Shift Left instruction. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.

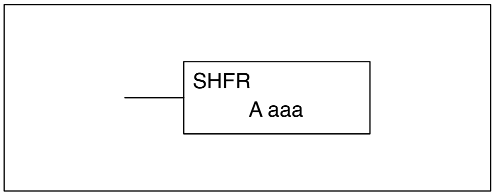


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	S RST	SHFT	H 7	F 5	L ANDST	→	C 2	ENT	
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT	

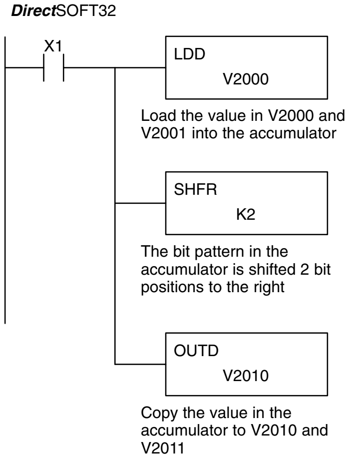
Shift Right (SHFR)

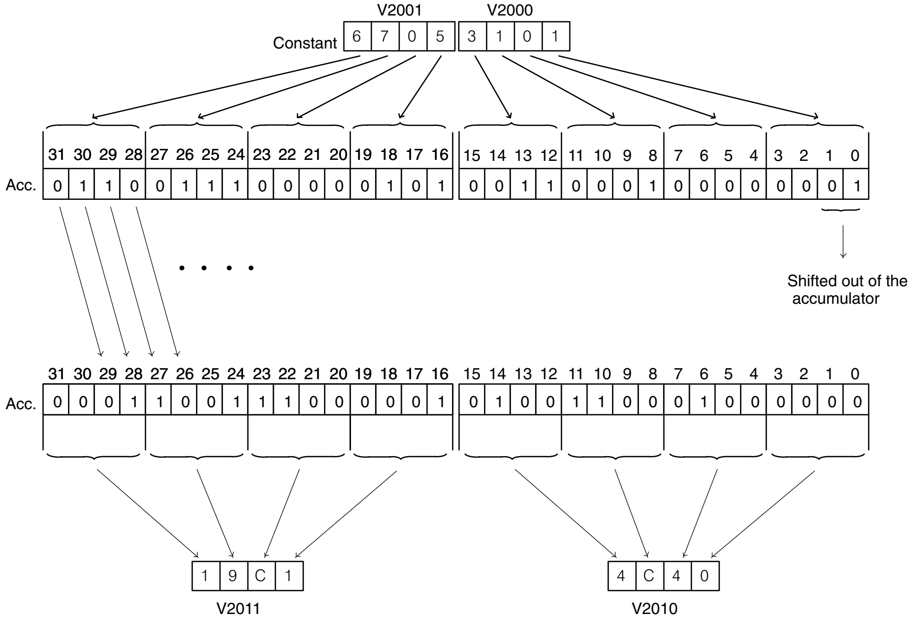
Shift Right is a 32 bit instruction that shifts the bits in the accumulator a specified number (Aaaa) of places to the right. The vacant positions are filled with zeros and the bits shifted out of the accumulator are lost.



Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	1–32

In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The bit pattern in the accumulator is shifted 2 bits to the right using the Shift Right instruction. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.



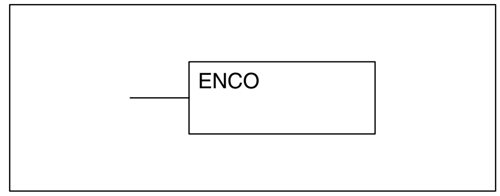


Handheld Programmer Keystrokes

$ STR	→	B 1	ENT					
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	S RST	SHFT	H 7	F 5	R ORN	→	C 2	ENT	
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT	

Encode (ENCO)

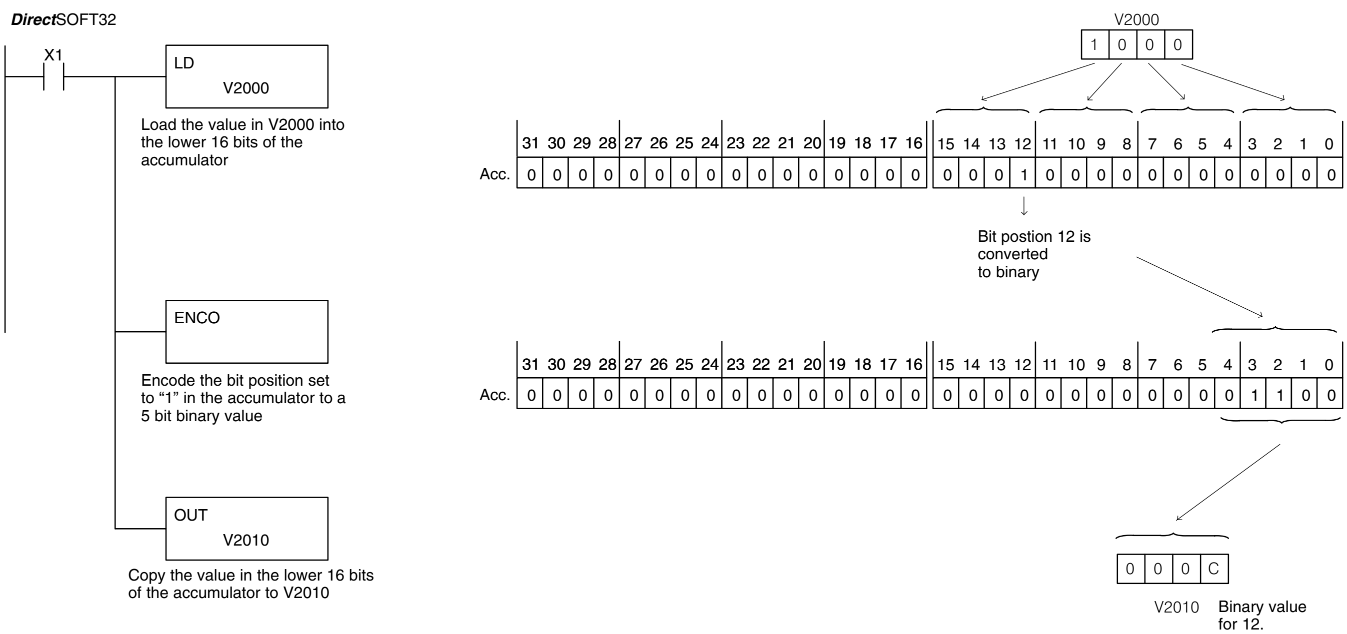
The Encode instruction encodes the bit position in the accumulator having a value of 1, and returns the appropriate binary representation. If the most significant bit is set to 1 (Bit 31), the Encode instruction would place the value HEX 1F (decimal 31) in the accumulator. If the value to be encoded is 0000 or 0001, the instruction will place a zero in the accumulator. If the value to be encoded has more than one bit position set to a “1”, the least significant “1” will be encoded and SP53 will be set on.



Discrete Bit Flags	Description
SP53	On when the value of the operand is larger than the accumulator can work with.

NOTE: The status flags are only valid until another instruction that uses the same flags is executed.

In the following example, when X1 is on, The value in V2000 is loaded into the accumulator using the Load instruction. The bit position set to a “1” in the accumulator is encoded to the corresponding 5 bit binary value using the Encode instruction. The value in the lower 16 bits of the accumulator is copied to V2010 using the Out instruction.

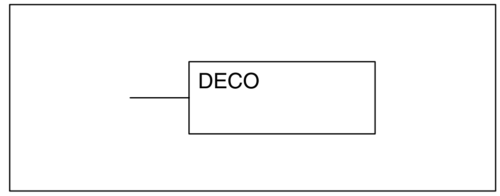


Handheld Programmer Keystrokes

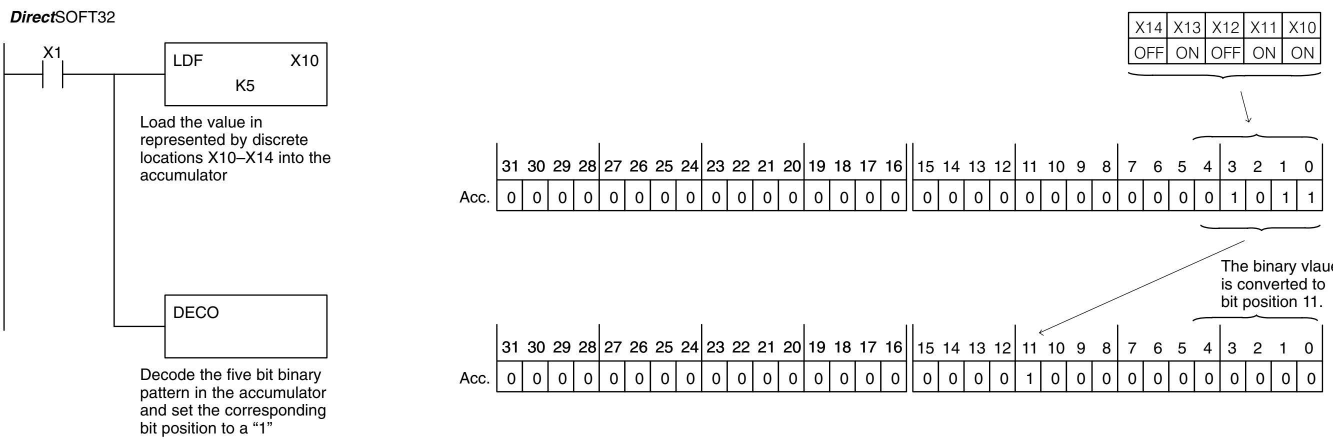
$ STR	→	B 1	ENT					
SHFT	L ANDST	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	E 4	N TMR	C 2	O INST#	ENT			
GX OUT	→	SHFT	V AND	C 2	A 0	B 1	A 0	ENT

Decode (DECO)

The Decode instruction decodes a 5 bit binary value of 0–31 (0–1F HEX) in the accumulator by setting the appropriate bit position to a 1. If the accumulator contains the value F (HEX), bit 15 will be set in the accumulator. If the value to be decoded is greater than 31, the number is divided by 32 until the value is less than 32 and then the value is decoded.



In the following example when X1 is on, the value formed by discrete locations X10–X14 is loaded into the accumulator using the Load Formatted instruction. The five bit binary pattern in the accumulator is decoded by setting the corresponding bit position to a "1" using the Decode instruction.



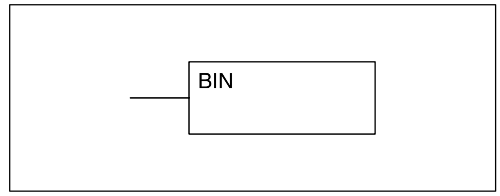
Handheld Programmer Keystrokes

$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	F 5	→	B 1	A 0	→	F 5	ENT
SHFT	D 3	E 4	C 2	O INST#	ENT				

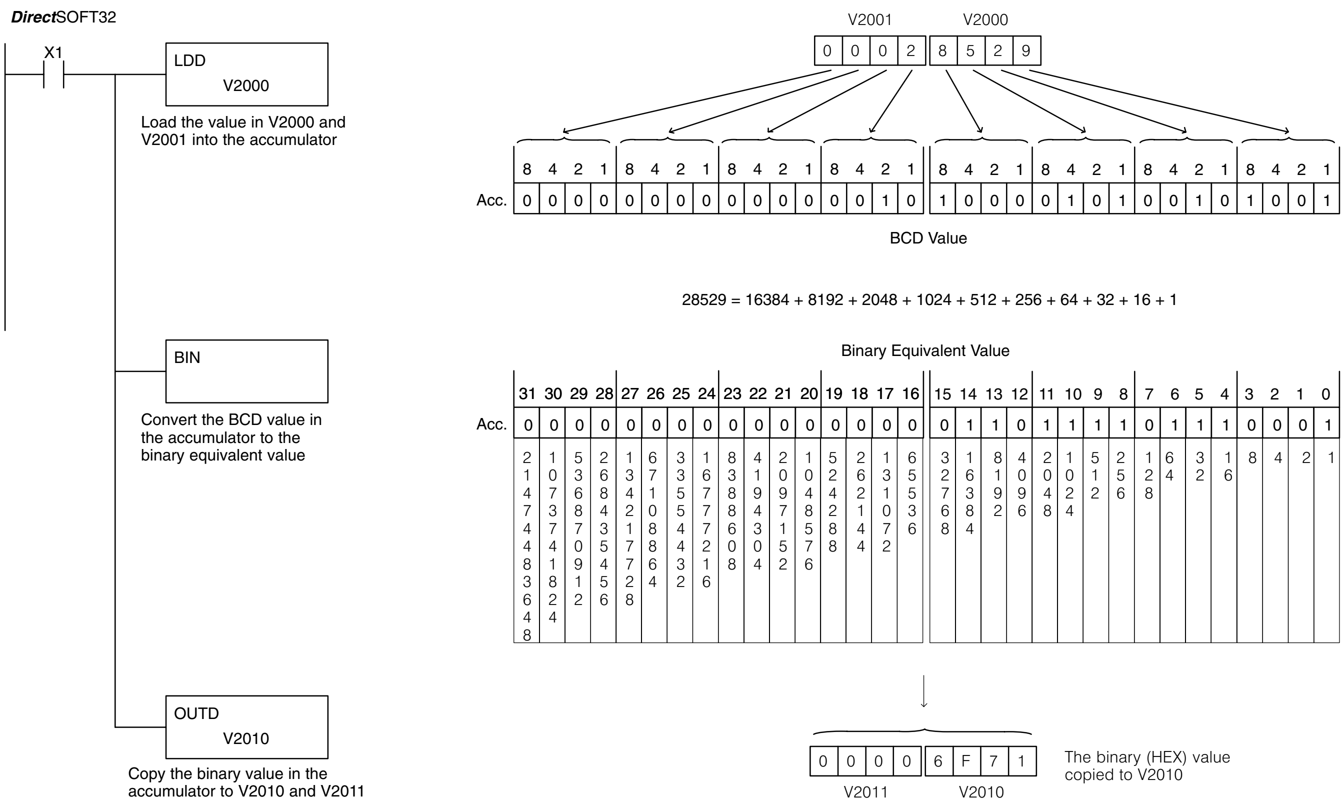
Number Conversion Instructions (Accumulator)

Binary (BIN)

The Binary instruction converts a BCD value in the accumulator to the equivalent binary value. The result resides in the accumulator.



In the following example, when X1 is on, the value in V2000 and V2001 is loaded into the accumulator using the Load Double instruction. The BCD value in the accumulator is converted to the binary (HEX) equivalent using the BIN instruction. The binary value in the accumulator is copied to V2010 and V2011 using the Out Double instruction. (The handheld programmer will display the binary value in V2010 and V2011 as a HEX value.)

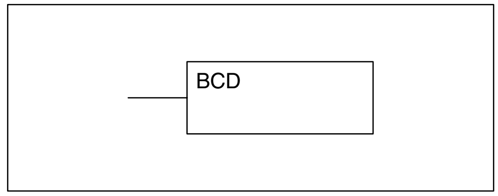


Handheld Programmer Keystrokes

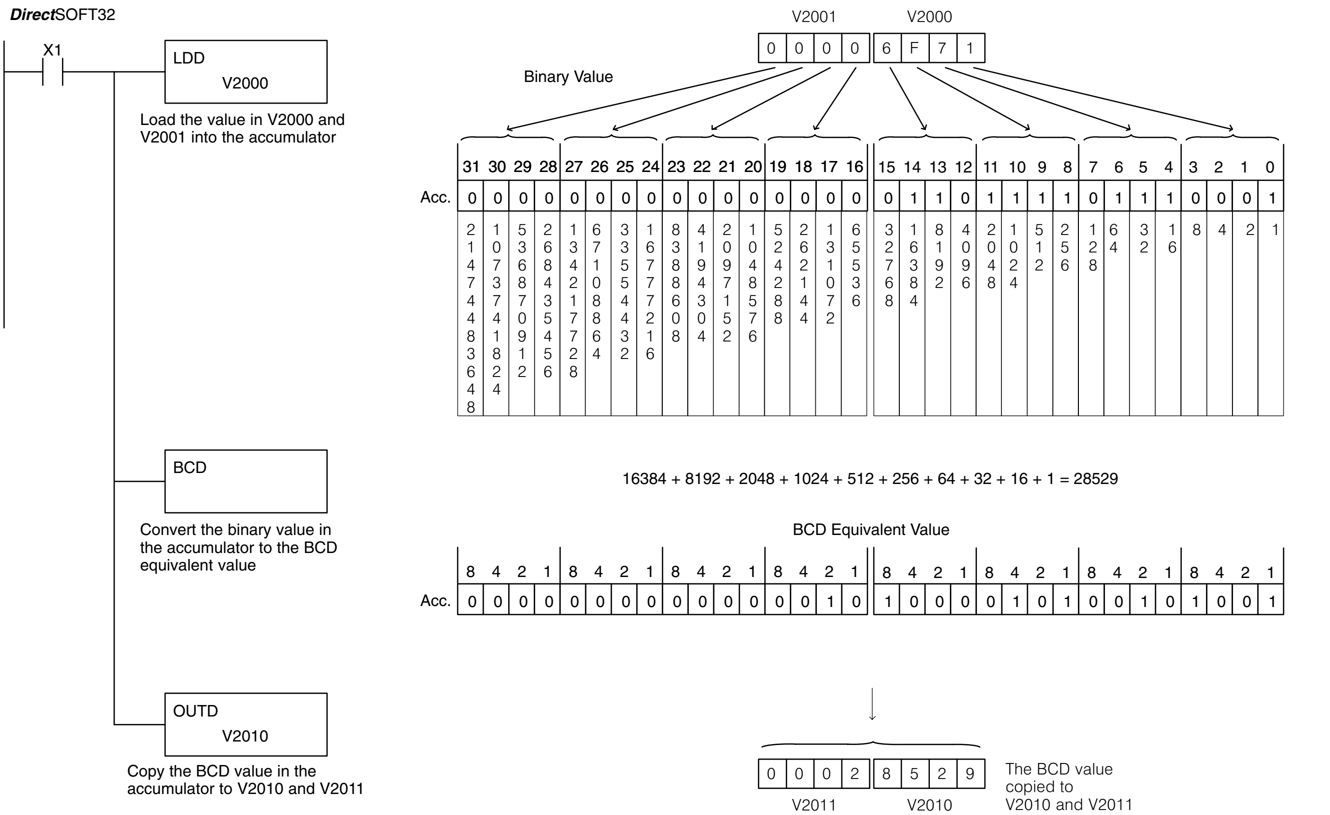
$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	B 1	I 8	N TMR	ENT					
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT	

Binary Coded Decimal (BCD)

The Binary Coded Decimal instruction converts a binary value in the accumulator to the equivalent BCD value. The result resides in the accumulator.



In the following example, when X1 is on, the binary (HEX) value in V2000 and V2001 is loaded into the accumulator using the Load Double instruction. The binary value in the accumulator is converted to the BCD equivalent value using the BCD instruction. The BCD value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.

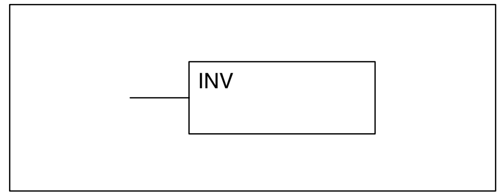


Handheld Programmer Keystrokes

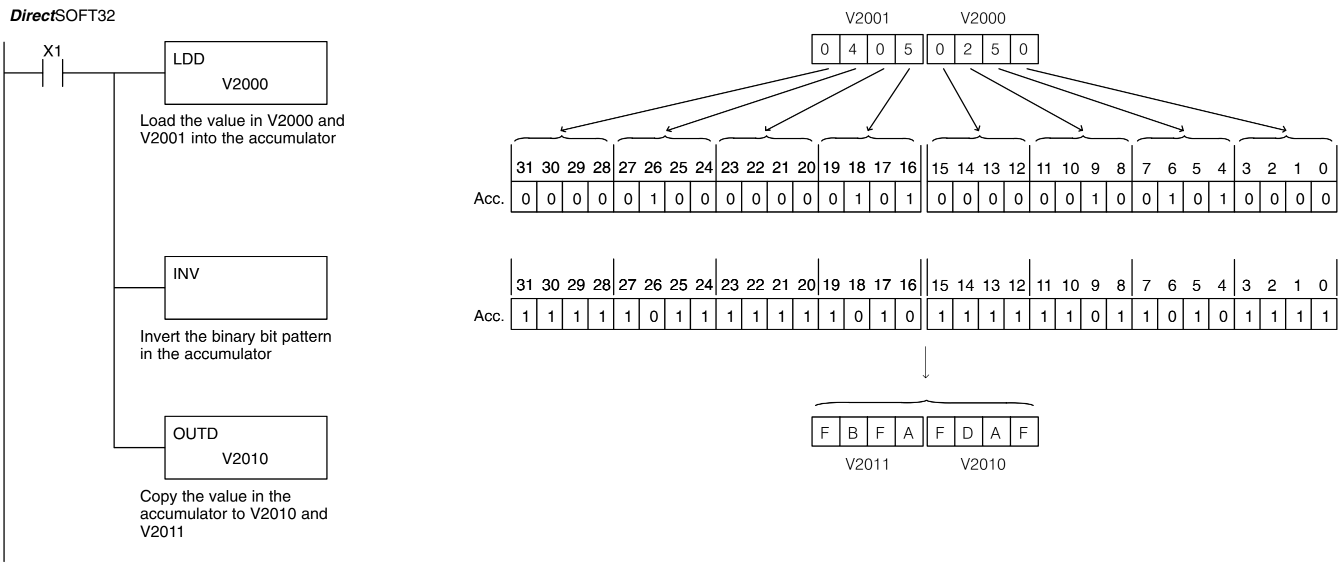
$ STR	→	B 1	ENT						
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	B 1	C 2	D 3	ENT					
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT	

Invert (INV)

The Invert instruction inverts or takes the one's complement of the 32 bit value in the accumulator. The result resides in the accumulator.



In the following example, when X1 is on, the value in V2000 and V2001 will be loaded into the accumulator using the Load Double instruction. The value in the accumulator is inverted using the Invert instruction. The value in the accumulator is copied to V2010 and V2011 using the Out Double instruction.



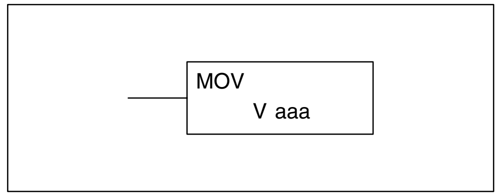
Handheld Programmer Keystrokes

$ STR	→	B 1	ENT					
SHFT	L ANDST	D 3	D 3	→	C 2	A 0	A 0	A 0	ENT
SHFT	I 8	N TMR	V AND	ENT				
GX OUT	SHFT	D 3	→	C 2	A 0	B 1	A 0	ENT

Table Instructions

Move (MOV)

The Move instruction moves the values from a V memory table to another V memory table the same length. The function parameters are loaded into the first level of the accumulator stack and the accumulator by two additional instructions. Listed below are the steps necessary to program the Move function.

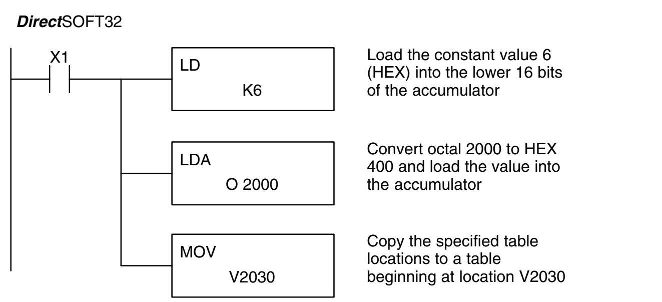


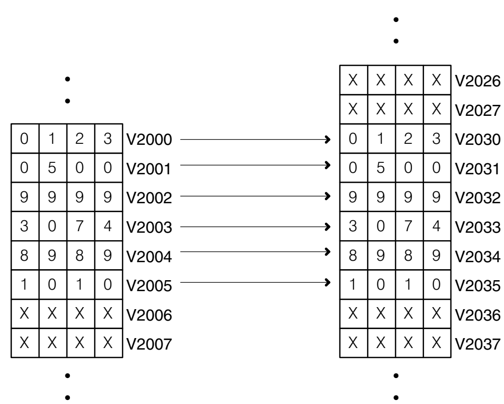
- Step 1:— Load the number of V memory locations to be moved into the first level of the accumulator stack. This parameter is a HEX value (K40 max, 100 octal).
- Step 2:— Load the starting V memory location for the locations to be moved into the accumulator. This parameter is a HEX value.
- Step 3:— Insert the MOVE instruction which specifies starting V memory location (Vaaa) for the destination table.

Helpful Hint: — For parameters that require HEX values when referencing memory locations, the LDA instruction can be used to convert an octal address to the HEX equivalent and load the value into the accumulator.

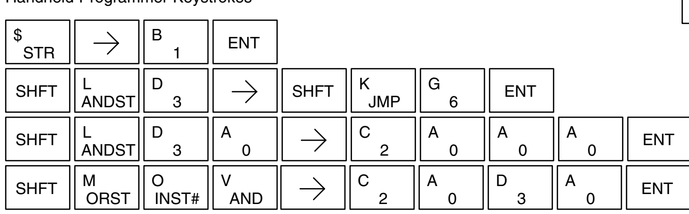
Operand Data Type		DL130 Range
		aaa
V memory	V	All (See page 4–28)

In the following example, when X1 is on, the constant value (K6) is loaded into the accumulator using the Load instruction. This value specifies the length of the table and is placed in the first stack location after the Load Address instruction is executed. The octal address 2000 (V2000), the starting location for the source table is loaded into the accumulator. The destination table location (V2030) is specified in the Move instruction.





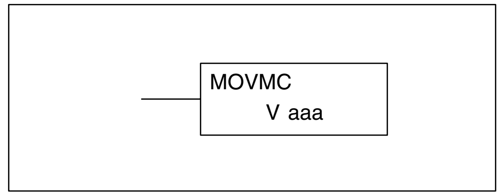
Handheld Programmer Keystrokes



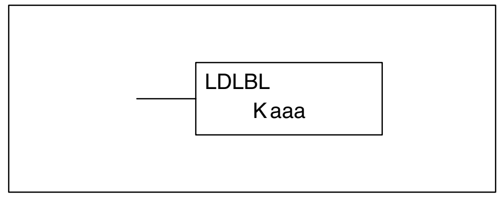
Move Memory Cartridge / Load Label

(MOVMC), (LDLBL)

The Move Memory Cartridge instruction is used to copy data between V memory and program ladder memory. The Load Label instruction is *only* used with the MOVMC instruction when copying data *from* program ladder memory *to* V memory.



To copy data between V memory and program ladder memory, the function parameters are loaded into the first two levels of the accumulator stack and the accumulator by two additional instructions. Listed below are the steps necessary to program the Move Memory Cartridge and Load Label functions.



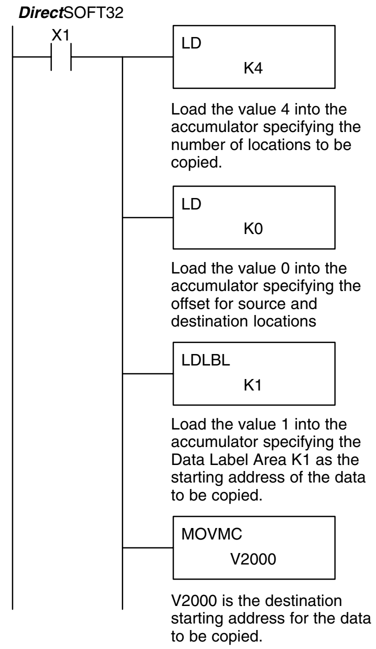
- Step 1:— Load the number of words to be copied into the second level of the accumulator stack.
- Step 2:— Load the offset for the data label area in ladder memory and the beginning of the V memory block into the first level of the stack.
- Step 3:— Load the *source data label* (LDLBL Kaaa) into the accumulator when copying data from ladder memory to V memory. Load the *source address* (LDA Oaaa) into the accumulator when copying data from V-memory to ladder memory. This is the source location of the value. Source addresses in V-memory must be entered in HEX.
- Step 4:— Insert the MOVMC instruction which specifies destination V-memory (Vaaa), or data label (Kaaa). This is the copy destination.

Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)

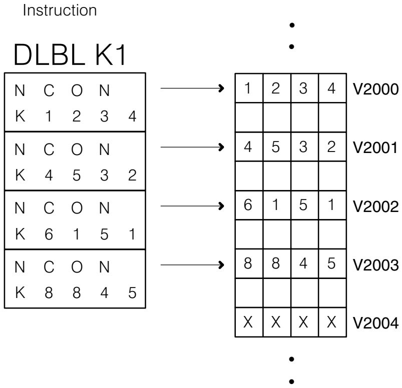
NOTE: See Appendix E for an explanation of the DL105 memory system.

Copy Data From a Data Label Area to V Memory

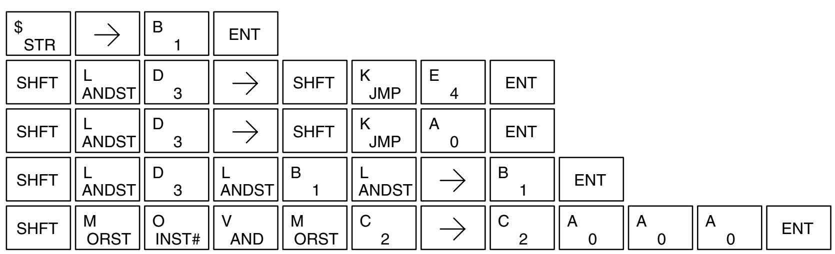
In the example to the right, data is copied from a Data Label Area to V memory. When X1 is on, the constant value (K4) is loaded into the accumulator using the Load instruction. This value specifies the length of the table and is placed in the second stack location after the next Load and Load Label (LDLBL) instructions are executed. The constant value (K0) is loaded into the accumulator, specifying the offset for the source and destination data. It is placed in the first stack location after the LDLBL instruction is executed. The source address where data is being copied from is loaded into the accumulator using the LDLBL instruction. The MOVMC instruction specifies the destination starting location and executes the copying of data from the Data Label Area to V memory.



Data Label Area Programmed After the END Instruction



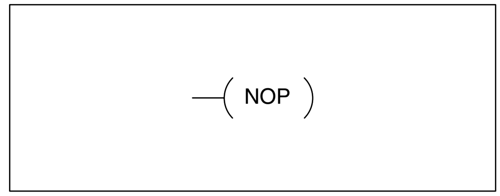
Handheld Programmer Keystrokes



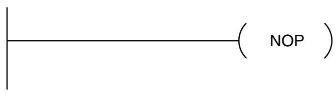
CPU Control Instructions

No Operation (NOP)

The No Operation is an empty (not programmed) memory location.



DirectSOFT32

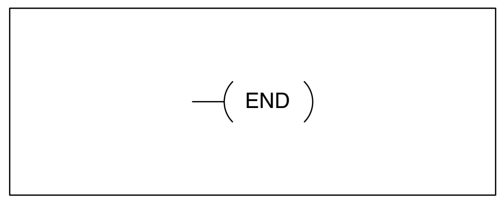


Handheld Programmer Keystrokes

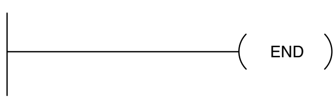
SHFT | N TMR | O INST# | P CV | ENT

End (END)

The End instruction marks the termination point of the normal program scan. An End instruction is required at the end of the main program body. If the End instruction is omitted an error will occur and the CPU will not enter the Run Mode. Data labels, subroutines and interrupt routines are placed after the End instruction. The End instruction is not conditional; therefore, no input contact is allowed.



DirectSOFT32

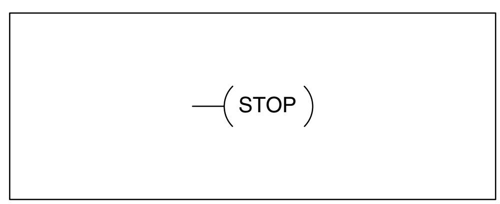


Handheld Programmer Keystrokes

SHFT | E 4 | N TMR | D 3 | ENT

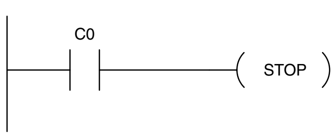
Stop (STOP)

The Stop instruction changes the operational mode of the CPU from Run to Program (Stop) mode. This instruction is typically used to stop PLC operation in an error condition.



In the following example, when C0 turns on, the CPU will stop operation and switch to the program mode.

DirectSOFT32



Handheld Programmer Keystrokes

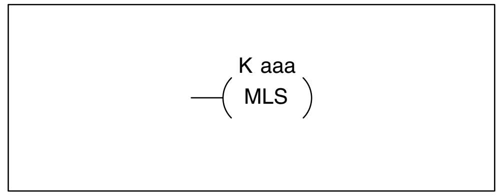
$ STR | → | SHFT | C 2 | A 0 | ENT

SHFT | S RST | SHFT | T MLR | O INST# | P CV | ENT

Program Control Instructions

Master Line Set (MLS)

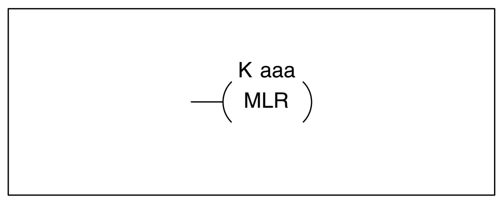
The Master Line Set instruction allows the program to control sections of ladder logic by forming a new power rail controlled by the main left power rail. The main left rail is always master line 0. When a MLS K1 instruction is used, a new power rail is created at level 1. Master Line Sets and Master Line Resets can be used to nest power rails up to seven levels deep.



Operand Data Type		DL130 Range
		aaa
Constant	K	1–7

Master Line Reset (MLR)

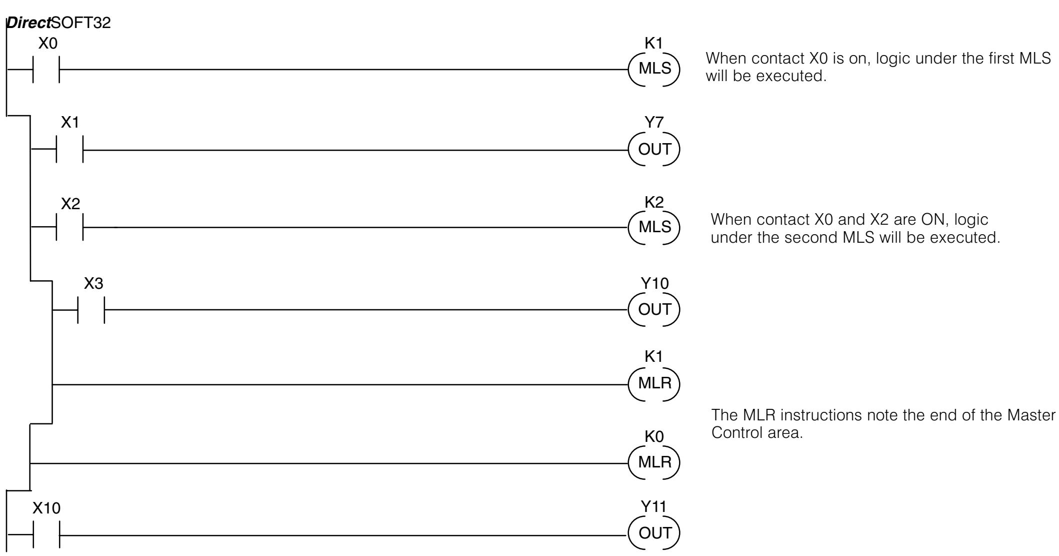
The Master Line Reset instruction marks the end of control for the corresponding MLS instruction. The MLR reference is one less than the corresponding MLS.



Operand Data Type		DL130 Range
		aaa
Constant	K	0–6

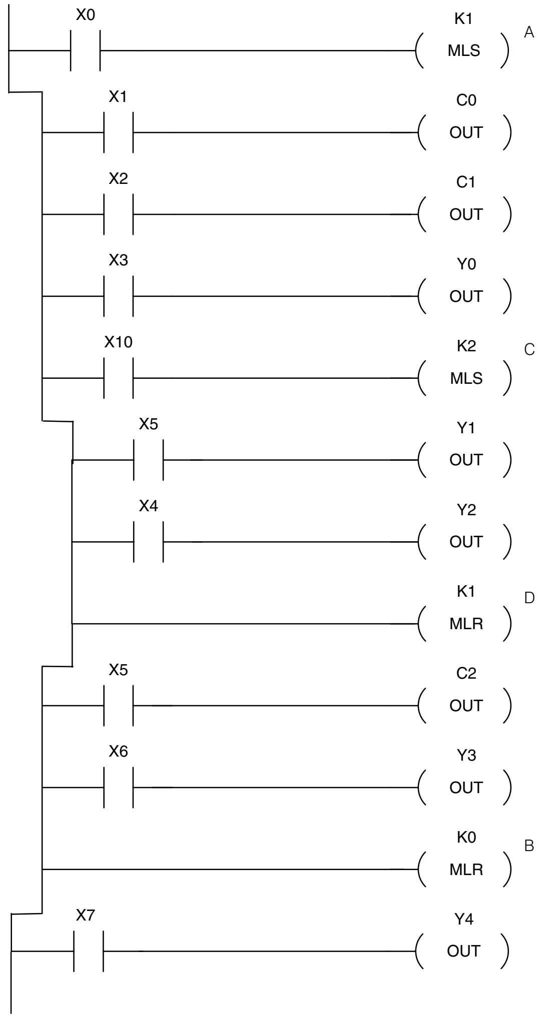
Understanding Master Control Relays

The Master Line Set (MLS) and Master Line Reset (MLR) instructions allow you to quickly enable (or disable) sections of the RLL program. This provides program control flexibility. The following example shows how the MLS and MLR instructions operate by creating a sub power rail for control logic.



MLS/MLR Example In the following MLS/MLR example logic between the first MLS K1 (A) and MLR K0 (B) will function only if input X0 is on. The logic between the MLS K2 (C) and MLR K1 (D) will function only if input X10 and X0 is on. The last rung is not controlled by either of the MLS coils.

*Direct*SOFT32



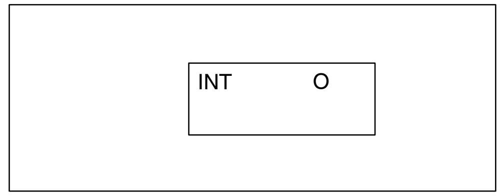
Handheld Programmer Keystrokes

$ STR	→	A 0	ENT		
Y MLS	→	B 1	ENT		
$ STR	→	B 1	ENT		
GX OUT	→	SHFT	C 2	A 0	ENT
$ STR	→	C 2	ENT		
GX OUT	→	SHFT	C 2	B 1	ENT
$ STR	→	D 3	ENT		
GX OUT	→	A 0	ENT		
$ STR	→	B 1	A 0	ENT	
Y MLS	→	C 2	ENT		
$ STR	→	F 5	ENT		
GX OUT	→	B 1	ENT		
$ STR	→	E 4	ENT		
GX OUT	→	C 2	ENT		
T MLR	→	B 1	ENT		
$ STR	→	F 5	ENT		
GX OUT	→	SHFT	C 2	C 2	ENT
$ STR	→	G 6	ENT		
GX OUT	→	D 3	ENT		
T MLR	→	A 0	ENT		
$ STR	→	H 7	ENT		
GX OUT	→	E 4	C 2	ENT	

Interrupt Instructions

Interrupt (INT)

The Interrupt instruction allows a section of ladder logic to be placed below the main body of the program and executed only when needed. High-Speed I/O Modes 10, 20, and 40 can generate an interrupt. With Mode 40, you may select an external interrupt (input X0), or a time-based interrupt (5–999 mS).



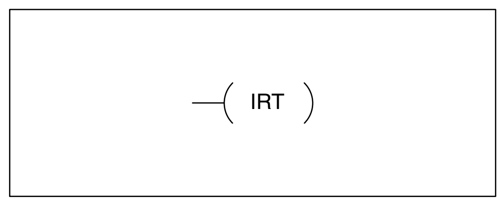
Typically, interrupts are used in an application when a fast response to an input is needed or a program section must execute faster than the normal CPU scan. The interrupt label and all associated logic must be placed after the End statement in the program. When an interrupt occurs, the CPU will complete execution of the current instruction it is processing in ladder logic, then execute the interrupt routine. After interrupt routine execution, the ladder program resumes from the point at which it was interrupted.

See Chapter 3, the section on Mode 40 (Interrupt) Operation for more details on interrupt configuration. In the DL105, only one interrupt is available.

Operand Data Type		DL130 Range
Constant	O	0

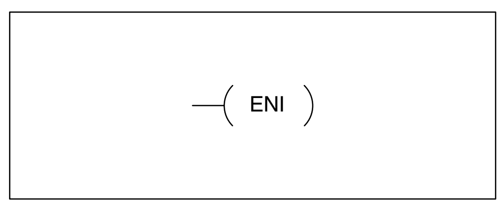
Interrupt Return (IRT)

An Interrupt Return is normally executed as the last instruction in the interrupt routine. It returns the CPU to the point in the main program from which it was called. The Interrupt Return is a stand-alone instruction (no input contact on the rung).



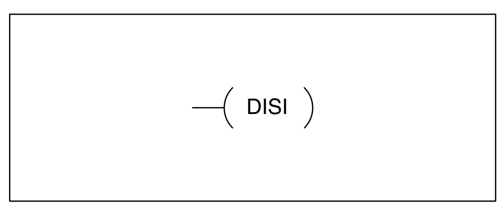
Enable Interrupts (ENI)

The Enable Interrupt instruction is placed in the main ladder program (before the End instruction), enabling the interrupt. The interrupt remains enabled until the program executes a Disable Interrupt instruction.



Disable Interrupts (DISI)

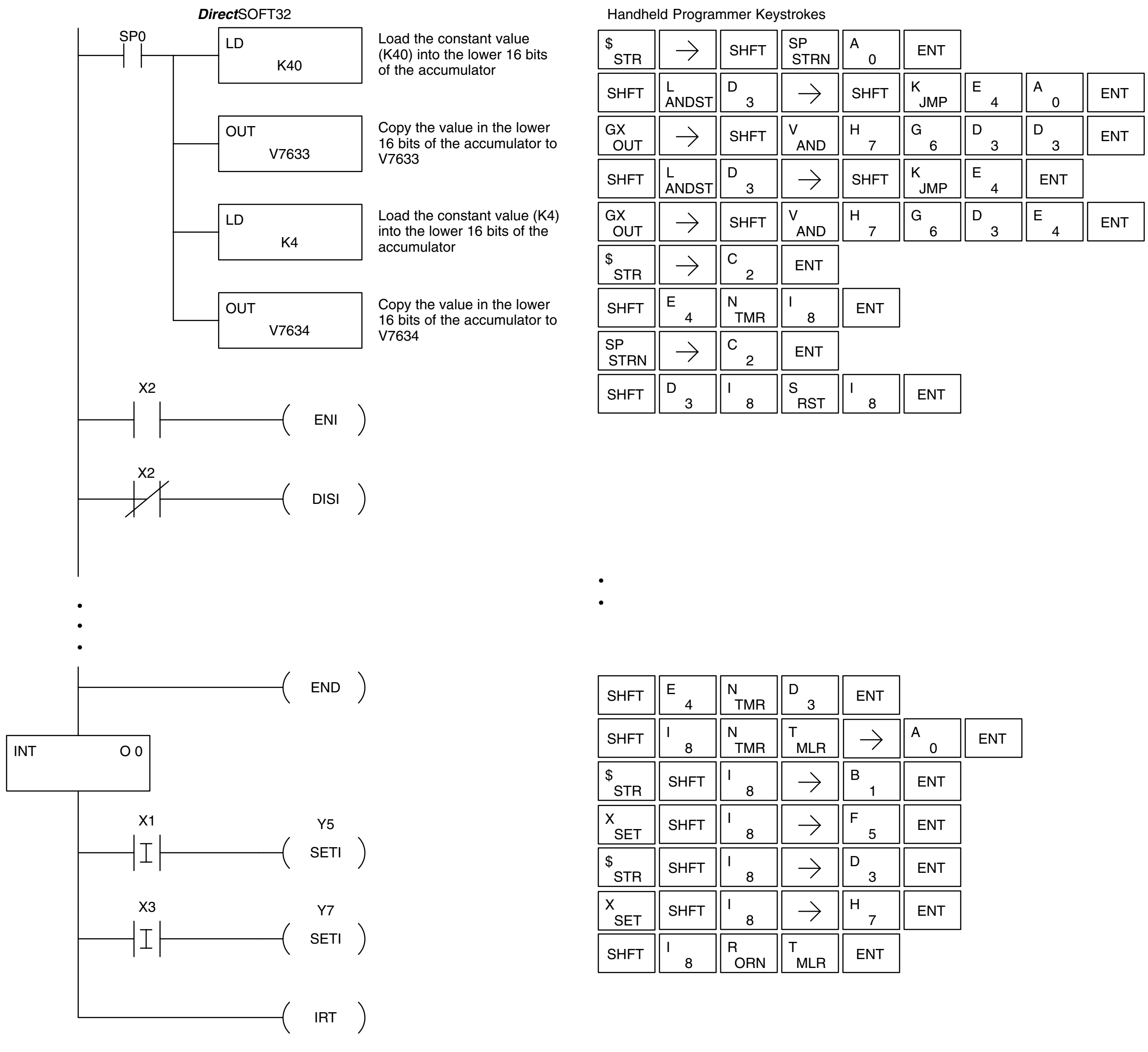
A Disable Interrupt instruction in the main body of the application program (before the End instruction) will disable the interupt (either extenal or timed). The interrupt remains disabled until the program executes an Enable Interrupt instruction.



External Interrupt Program Example

In the following example, we do some initialization on the first scan, using the first-scan contact SP0. The interrupt feature is the HSIO Mode 40. Then we configure X0 as the external interrupt by writing to its configuration register, V7634. See Chapter 3, Mode 40 Operation for more details.

During program execution, when X2 is on the interrupt is enabled. When X2 is off the interrupt will be disabled. When an interrupt signal (X0) occurs the CPU will jump to the interrupt label INT O 0. The application ladder logic in the interrupt routine will be performed. The CPU will return to the main body of the program after the IRT instruction is executed.

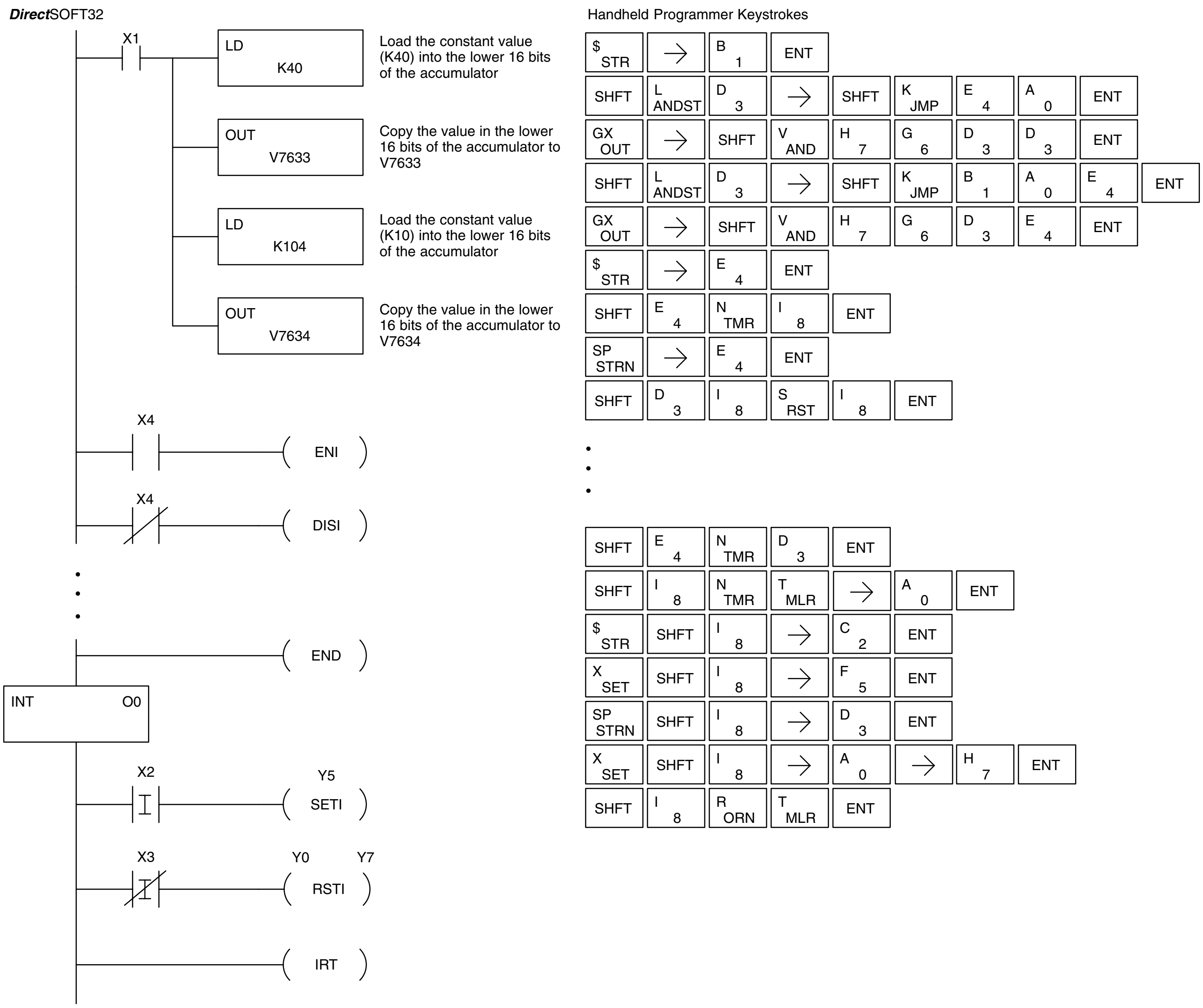


NOTE: Only one interrupt is available in the DL105 and it must be Int 0.

Timed Interrupt Program Example

In the following example, we do some initialization on the first scan, using the first-scan contact SP0. The interrupt feature is the HSIO Mode 40. Then we configure the HSIO timer as a 10 mS interrupt by writing K104 to the configuration register for X0 (V7634). See Chapter 3, Mode 40 Operation for more details.

When X4 turns on, the interrupt will be enabled. When X4 turns off, the interrupt will be disabled. Every 10 mS the CPU will jump to the interrupt label INT O 0. The application ladder logic in the interrupt routine will be performed. If X3 is not on Y0–Y7 will be reset to off and then the CPU will return to the main body of the program.

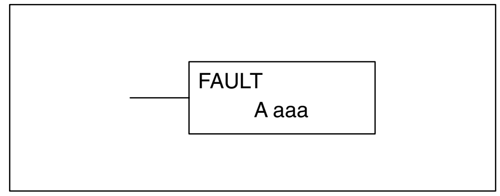


NOTE: Only one interrupt is available in the DL105 and it must be Int 0.

Message Instructions

Fault (FAULT)

The Fault instruction is used to display a message on the handheld programmer or in the ***Direct***SOFT32 status bar. The message has a maximum of 23 characters and can be either V memory data, numerical constant data or ASCII text.



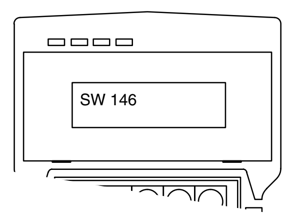
To display the value in a V memory location, specify the V memory location in the instruction. To display the data in ACON (ASCII constant) or NCON (Numerical constant) instructions, specify the constant (K) value for the corresponding data label area.

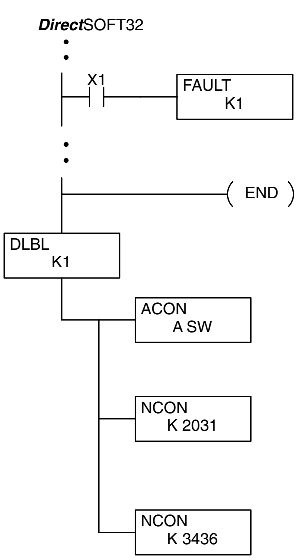
Operand Data Type		DL130 Range
	A	aaa
V memory	V	All (See page 4–28)
Constant	K	1–FFFF

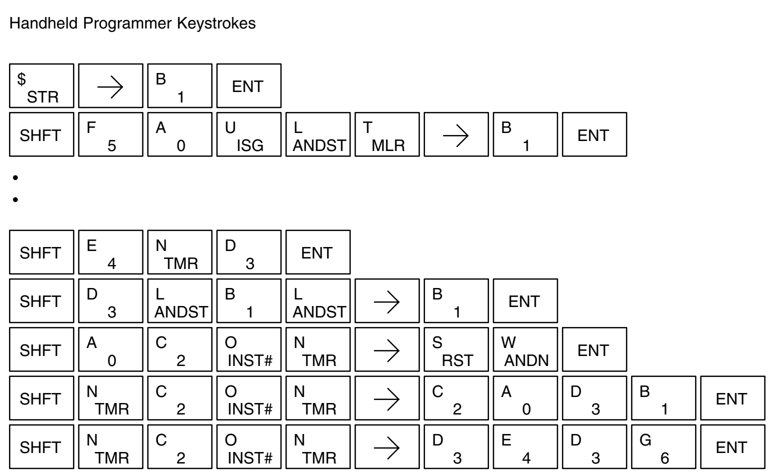
NOTE: The FAULT instruction takes a considerable amount of time to execute. This is because the FAULT parameters are stored in EEPROM. Be sure to consider the instructions execution times (shown in Appendix C) if you are attempting to use the FAULT instructions in applications that require faster than normal execution cycles.

Fault Example

In the following example when X1 is on, the message SW 146 will display on the handheld programmer. The NCONs use the HEX ASCII equivalent of the text to be displayed. (The HEX ASCII for a blank is 20, a 1 is 31, 4 is 34 ...)

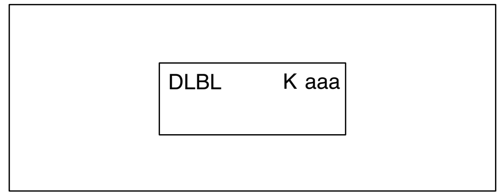






Data Label (DLBL)

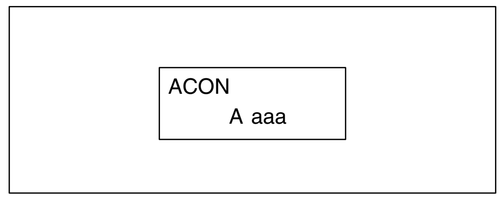
The Data Label instruction marks the beginning of an ASCII / numeric data area. DLBLs are programmed after the End statement. A maximum of 32 DLBL instructions can be used in a program. Multiple NCONs and ACONs can be used in a DLBL area.



Operand Data Type		DL130 Range
		aaa
Constant	K	1–FFFF

ASCII Constant (ACON)

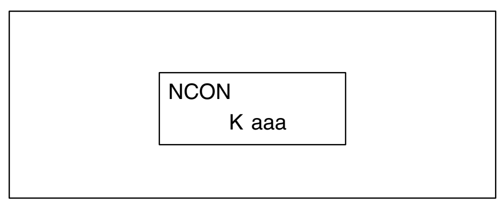
The ASCII Constant instruction is used with the DLBL instruction to store ASCII text for use with other instructions. Two ASCII characters can be stored in an ACON instruction. If only one character is stored in a ACON a leading space will be inserted.



Operand Data Type		DL130 Range
		aaa
ASCII	A	0–9 A–Z

Numerical Constant (NCON)

The Numerical Constant instruction is used with the DLBL instruction to store the HEX ASCII equivalent of numerical data for use with other instructions. Two digits can be stored in an NCON instruction.

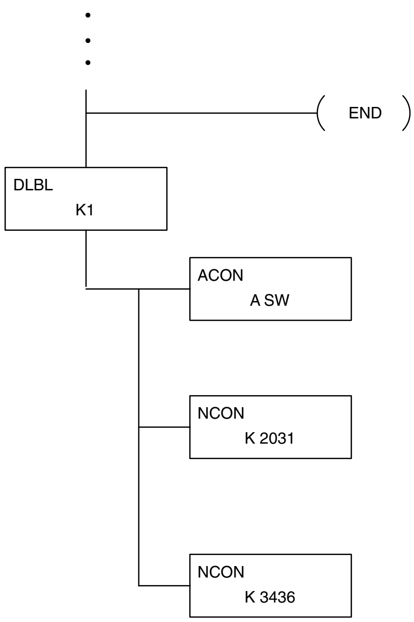


Operand Data Type		DL130 Range
		aaa
Constant	K	0–FFFF

Data Label Example

In the following example, an ACON and two NCON instructions are used within a DLBL instruction to build a text message. See the FAULT instruction for information on displaying messages. The DV-1000 Manual also has information on displaying messages.

***Direct*SOFT32**



Handheld Programmer Keystrokes

•
•

SHFT	E 4	N TMR	D 3	ENT						
SHFT	D 3	L ANDST	B 1	L ANDST	→	B 1	ENT			
SHFT	A 0	C 2	O INST#	N TMR	→	S RST	W ANDN	ENT		
SHFT	N TMR	C 2	O INST#	N TMR	→	C 2	A 0	D 3	B 1	ENT
SHFT	N TMR	C 2	O INST#	N TMR	→	D 3	E 4	D 3	G 6	ENT

6

Drum Instruction Programming

In This Chapter. . . .

Introduction

Purpose

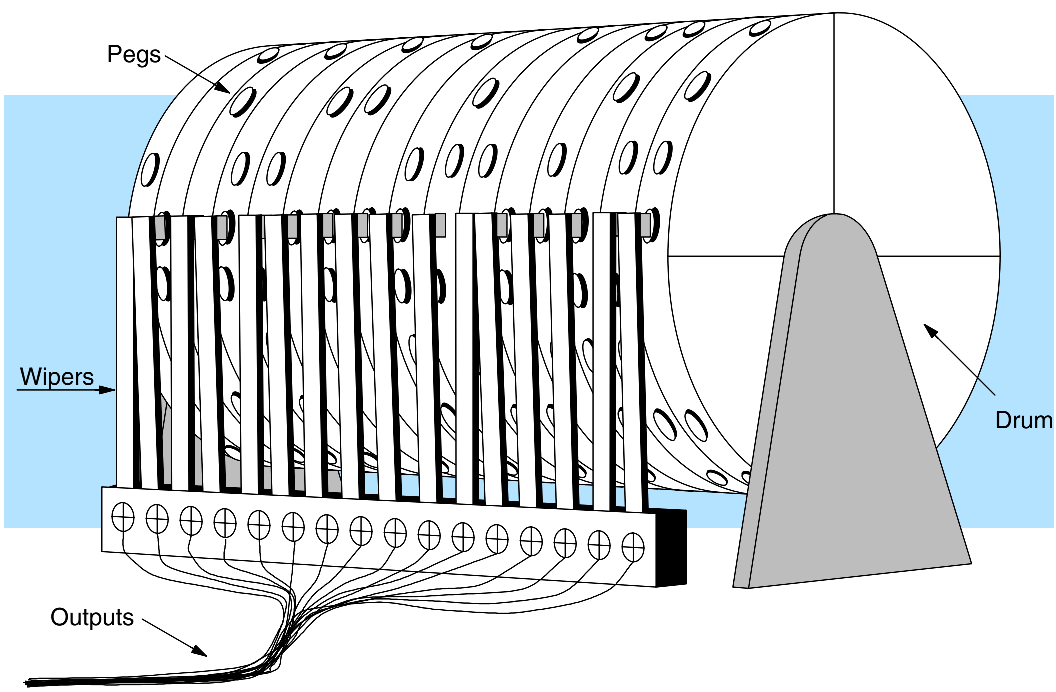
The Event Drum (EDRUM) instruction in the F1–130 CPU electronically simulates an electro-mechanical drum sequencer. The instruction offers enhancements to the basic principle, which we describe first.

Drum Terminology

Drum instructions are best suited for repetitive processes that consist of a finite number of steps. They can do the work of many rungs of ladder logic with elegant simplicity. Therefore, drums can save a lot of programming and debugging time.

We introduce some terminology associated with the drum instruction by describing the original mechanical drum shown below. The mechanical **drum** generally has pegs on its curved surface. The pegs are populated in a particular **pattern**, representing a set of desired actions for machine control. A motor or solenoid rotates the drum a precise amount at specific times. During rotation, stationary wipers sense the presence of pegs (present = on, absent = off). This interaction makes or breaks electrical contact with the wipers, creating electrical **outputs** from the drum. The outputs are wired to devices on a machine for On/Off control.

Drums usually have a finite number of positions within one rotation, called **steps**. Each step represents some process step. At powerup, the drum **resets** to a particular step. The drum rotates from one step to the next based on a **timer**, or on some external **event**. During special conditions, a machine operator can manually increment the drum step using a **jog** control on the drum's drive mechanism. The contact closure of each wiper generates a unique on/off pattern called a **sequence**, designed for controlling a specific machine. Because the drum is circular, it automatically repeats the sequence once per rotation. Applications vary greatly, and a particular drum may rotate once per second, or as slowly as once per week.



Electronic drums provide the benefits of mechanical drums and more. For example, they have a **preset** feature that is impossible for mechanical drums: The preset function lets you move from the present step *directly* to any other step on command!

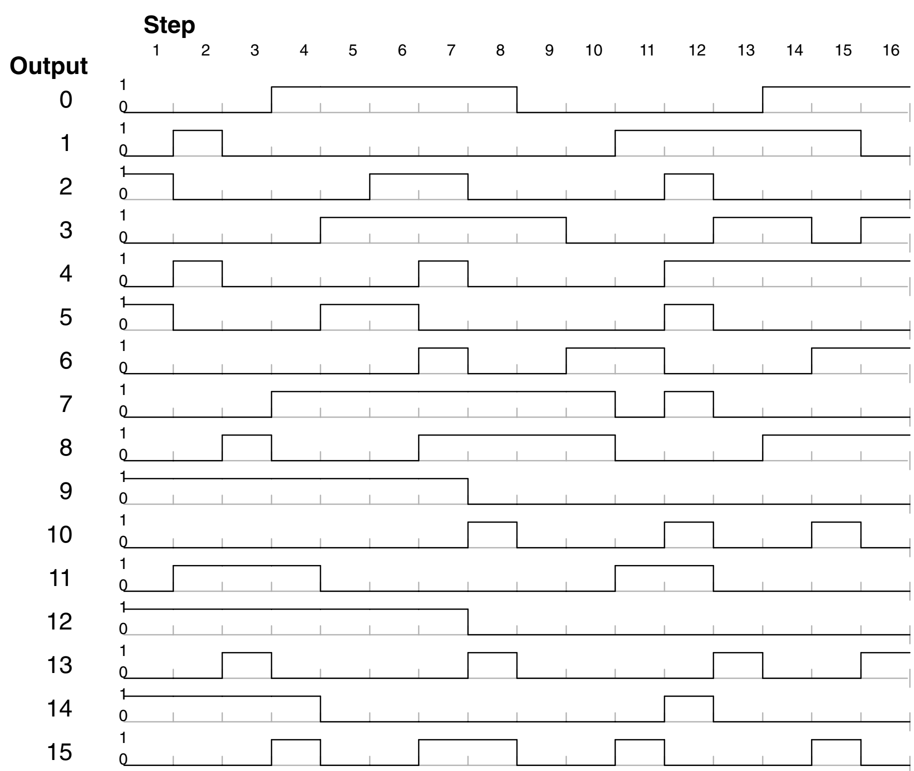
Drum Chart Representation

For editing purposes, the electronic drum is presented in chart form in ***Direct***SOFT32 and in this manual. Imagine slicing the surface of a hollow drum cylinder between two rows of pegs, then pressing it flat. Now you can view the drum as a chart as shown below. Each row represents a step, numbered 1 through 16. Each column represents an output, numbered 0 through 15 (to match word bit numbering). The solid circles in the chart represent pegs (On state) in the mechanical drum, and the open circles are empty peg sites (Off state).

	OUTPUTS															
STEP	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	○	●	○	●	○	○	●	○	○	○	●	○	○	●	○	○
2	○	●	○	●	●	○	●	○	○	○	○	●	○	○	●	○
3	○	●	●	●	●	○	●	●	○	○	○	○	○	○	○	○
4	●	●	○	●	●	○	●	○	●	○	○	○	○	○	○	●
5	○	○	○	●	○	○	●	○	●	○	●	○	●	○	○	●
6	○	○	○	●	○	○	●	○	●	○	●	○	●	●	○	●
7	●	○	○	●	○	○	●	●	●	●	○	●	●	●	○	●
8	●	○	●	○	○	●	○	●	●	○	○	○	●	○	○	●
9	○	○	○	○	○	○	○	●	●	○	○	○	●	○	○	○
10	○	○	○	○	○	○	○	●	●	●	○	○	○	○	○	○
11	●	○	○	○	●	○	○	○	○	●	○	○	○	○	●	○
12	○	●	○	○	●	●	○	○	●	○	●	●	○	●	●	○
13	○	○	●	○	○	○	○	○	○	○	○	●	●	○	●	○
14	○	○	○	○	○	○	○	●	○	○	○	●	●	○	●	●
15	●	○	○	○	○	●	○	●	○	●	○	●	○	○	●	●
16	○	○	●	○	○	○	○	●	○	●	○	●	●	○	○	●

Output Sequences

The mechanical drum sequencer derives its name from sequences of control changes on its electrical outputs. The following figure shows the sequence of On/Off controls generated by the drum pattern above. Compare the two, and you will find that they are equivalent! If you can see their equivalence, you are well on your way to understanding drum instruction operation.



Step Transitions

Drum Instruction Parameters

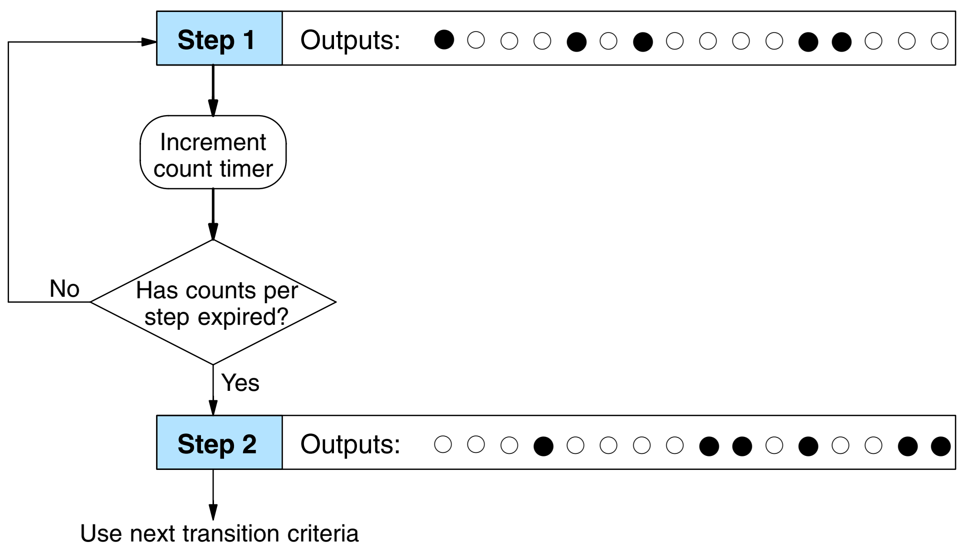
EDRUM operation in the F1–130 includes the following features:

- Up to 16 steps
- Time-based step transitions
- Event-based step transitions
- Up to 16 discrete outputs per drum (X, Y, or C type)

The EDRUM has 16 steps, and each step has 16 outputs. Refer to the figure below. Each output can be either an X, Y, or C coil, offering a lot of programming flexibility. We assign Step 1 an arbitrary unique output pattern (○= Off, ●= On) as shown. When programming the EDRUM instruction, you also determine both the output assignment and the On/Off state (pattern) at that time. All steps use the same output assignment, but each step may have its own unique output pattern.

Timer-Only Transitions

Drums move from one step to another based on time and/or an external event (input). Each step has its own transition condition which you assign during the drum instruction entry. The figure below shows how timer-only transitions work.



The drum stays in Step 1 for a specific duration (user-programmable). The timebase of the timer is programmable, from 0.01 seconds to 99.99 seconds. This establishes the resolution, or the duration of each “tick of the clock”. Each step uses the same timebase, but has its own unique counts per step, which you program. When the counts for Step 1 have expired, then the drum moves to Step 2. The outputs change immediately to match the new pattern for Step 2.

The drum spends a specific amount of time in each step, given by the formula:

Time in step = 0.01 seconds X Timebase x Counts per step

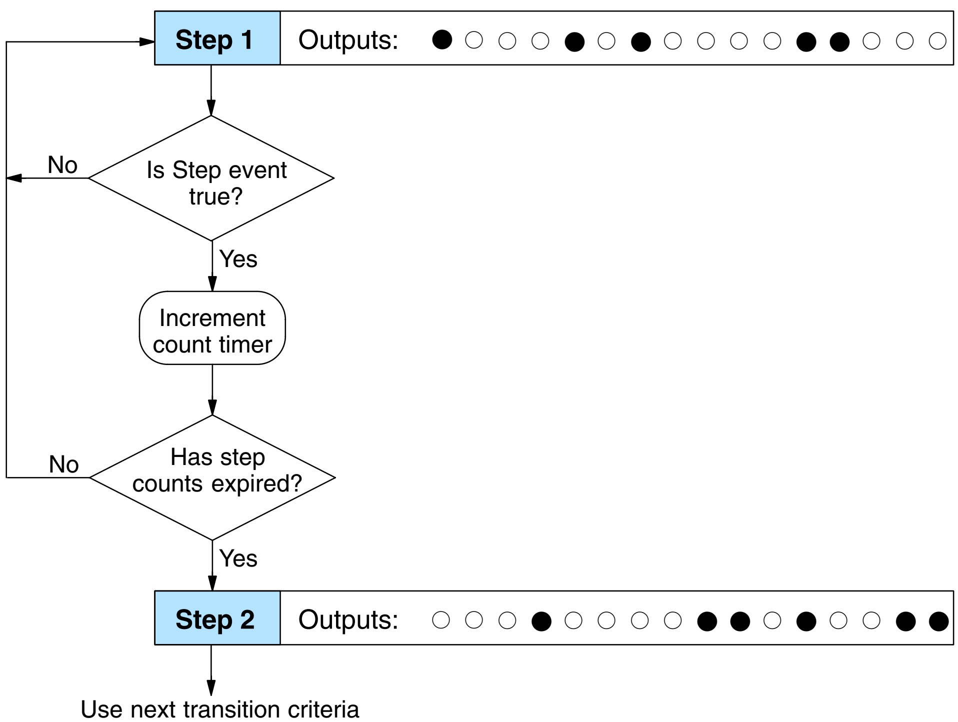
For example, if you program a 5 second time base and 12 counts for Step 1, then the drum will spend 60 seconds in Step 1. The maximum time for any step is given by the formula:

Max Time per step = 0.01 seconds X 9999 X 9999
= 999,800 seconds = 277.7 hours = 11.6 days

NOTE: When first choosing the timebase resolution, a good rule of thumb is to make it about 1/10 the duration of the shortest step in your drum. Then you will be able to optimize the duration of that step in 10% increments. Other steps with longer durations allow optimizing by even smaller increments (percentage-wise). Also, note that the drum instruction executes once per CPU scan. Therefore, it is pointless to specify a drum timebase that is much faster than the CPU scan time.

Timer and Event Transitions

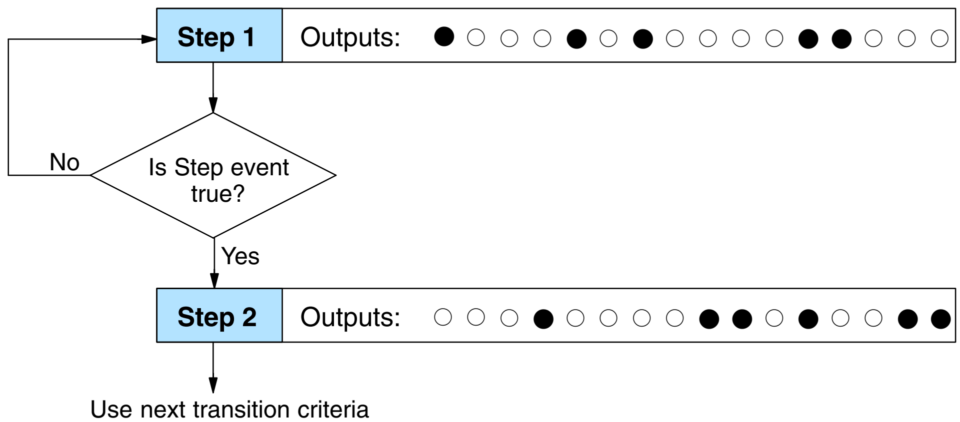
Step transitions may also occur based on time and/or external events. The figure below shows how step transitions work in these cases.



When the drum enters Step 1, it sets the output pattern as shown. Then it begins polling the external input programmed for that step. You can define event inputs as X, Y, or C discrete point types. Suppose we select X0 for the Step 1 event input. If X0 is off, then the drum remains in Step 1. When X0 is On, the event criteria is met and the timer increments. The timer increments as long as the event (X0) remains true. When the counts for Step 1 have expired, then the drum moves to Step 2. The outputs change immediately to match the new pattern for Step 2.

Event-Only Transitions

Step transitions do not require both the event and the timer criteria programmed for each step. You have the option of programming just one of the two, and even mixing transition types among all the steps of the drum. For example, you might want Step 1 to transition on an event, Step 2 to transition on time only, and Step 3 to transition on both time and an event. Furthermore, you may elect to use only part of the 16 steps, and only part of the 16 outputs.



Counter Assignments

Each drum instruction uses the resources of four counters in the CPU. When programming the drum instruction, you select the first counter number. The drum also uses the next three counters automatically. The counter bit associated with the first counter turns on when the drum has completed its cycle, going off when the drum is reset. These counter values and the counter bit precisely indicate the progress of the drum instruction, and can be monitored by your ladder program.

Suppose we program a timer drum to have 8 steps, and we select CT10 for the counter number (remember, counter numbering is in octal). Counter usage is shown to the right. The right column holds typical values, interpreted below.

Counter Assignments

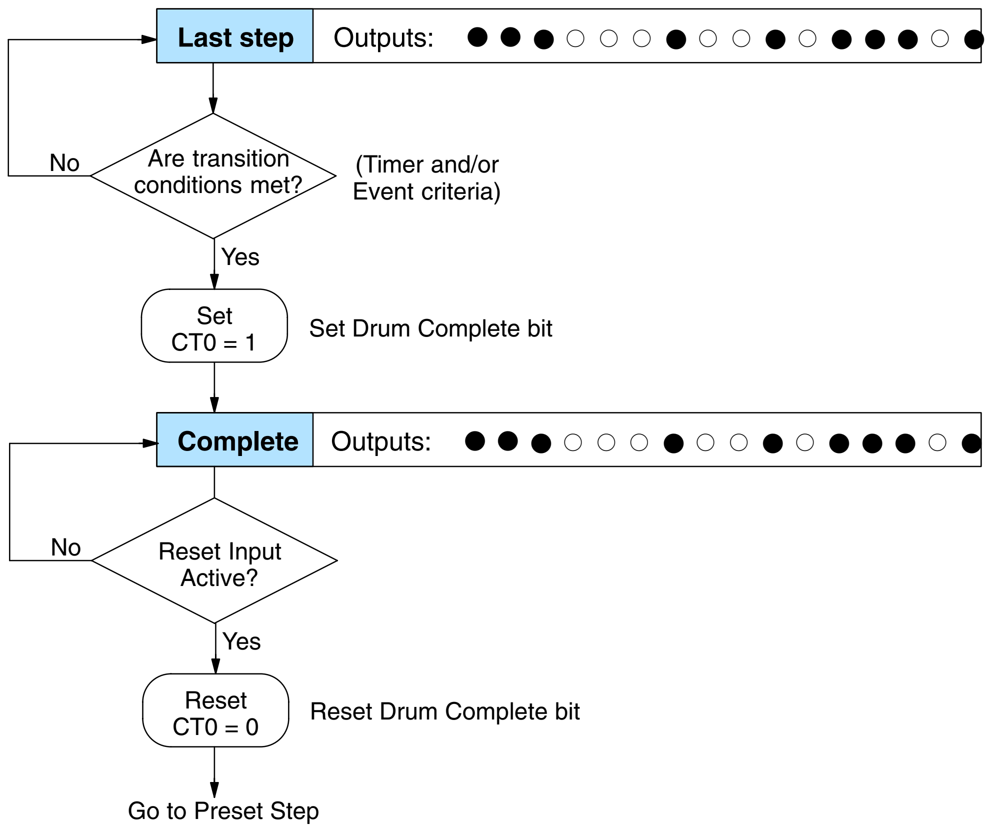
CT10	Counts in step	V1010	1528
CT11	Timer Value	V1011	0200
CT12	Preset Step	V1012	0001
CT13	Current Step	V1013	0004

CT10 shows that we are at the 1528th count in the current step, which is step 4 (shown in CT13). If we have programmed step 4 to have 3000 counts, then the step is just over half completed. CT11 is the count timer, shown in units of 0.01 seconds. So, each least-significant-digit change represents 0.01 seconds. The value of 200 means that we have been in the current count (1528) for 2 seconds (0.01 x 100). Finally, CT12 holds the preset step value which was programmed into the drum instruction. When the drum's Reset input is active, it presets to step 1 in this case. The value of CT12 changes only if the ladder program writes to it, or the drum instruction is edited and the program is restarted. Counter bit CT10 turns on when the drum cycle is complete, and turns off when the drum is reset.

Last Step Completion

The last step in a drum sequence may be any step number, since partial drums are valid. Refer to the following figure. When the transition conditions of the last step are met, the drum sets the counter bit corresponding to the counter named in the drum instruction box (such as CT0). Then it moves to a final “drum complete” state. The drum outputs remain in the pattern defined for the last step. Having finished a drum cycle, the Start and Jog inputs have no effect at this point.

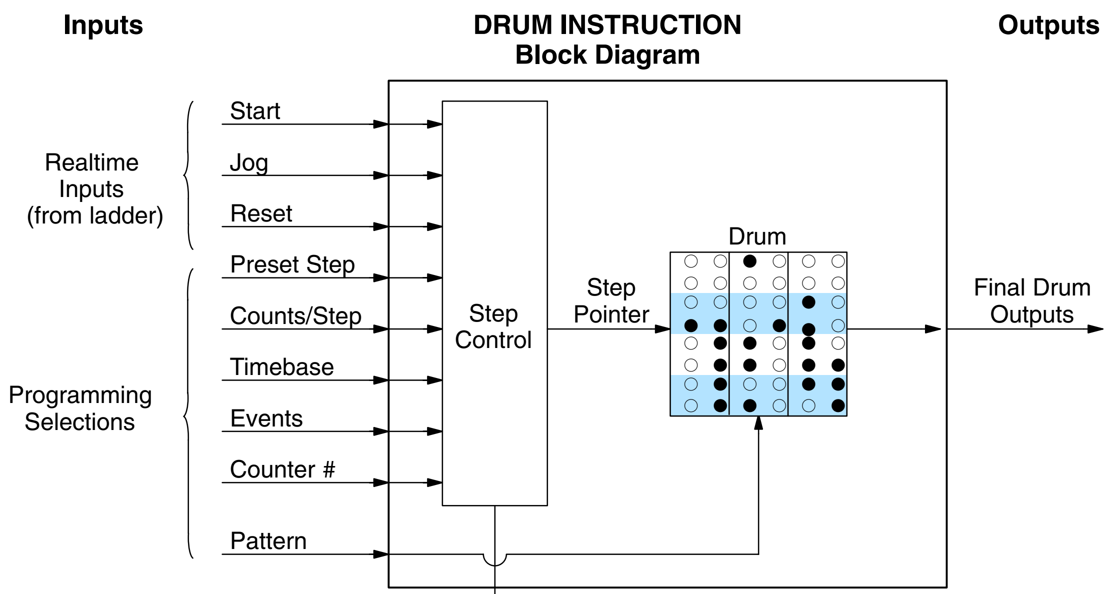
The drum leaves the “drum complete” state when the Reset input becomes active (or on a program-to–run mode transition). It resets the drum complete bit (such as CT0), and then goes directly to the appropriate step number defined as the preset step.



Overview of Drum Operation

Drum Instruction Block Diagram

The drum instruction utilizes various inputs and outputs in addition to the drum pattern itself. Refer to the figure below.



Counter Assignments

CT0	Counts in step	V1000	xxxx
CT1	Timer Value	V1001	xxxx
CT2	Preset Step	V1002	xxxx
CT3	Current Step	V1003	xxxx

The drum instruction accepts several inputs for step control, the main control of the drum. The inputs and their functions are:

- **Start** – The Start input is effective only when Reset is off. When Start is on, the drum timer runs if it is in a timed transition, and the drum looks for the input event during event transitions. When Start is off, the drum freezes in its current state (Reset must remain off), and the drum outputs maintain their current on/off pattern.
- **Jog** – The jog input is only effective when Reset is off (Start may be either on or off). The jog input increments the drum to the next step on each off-to-on transition.
- **Reset** – The Reset input has priority over the Start input. When Reset is on, the drum moves to its preset step. When Reset is off, then the Start input operates normally.
- **Preset Step** – A step number from 1 to 16 that you define (typically is step 1). The drum moves to this step whenever Reset is on, and whenever the CPU first enters run mode.

- **Counts/Step** – The number of timer counts the drum spends in each step. Each step has its own counts parameter. However, programming the counts/step is optional.
- **Timer Value** – the current value of the counts/step timer.
- **Counter #** – The counter number specifies the first of four consecutive counters which the drum uses for step control. You can monitor these to determine the drum's progress through its control cycle. The DL105 has 64 counters (CT0 – CT77 in octal).
- **Events** – Either an X, Y, C, S, T, or CT type discrete point serves as step transition inputs. Each step has its own event. However, programming the event is optional.

WARNING: The outputs of a drum are enabled any time the CPU is in Run Mode. The Start Input **does not** have to be on, and the Reset input does not disable the outputs. Upon entering Run Mode, drum outputs automatically turn on or off according to the pattern of the current step of the drum. This initial step number depends on the counter memory configuration: non-retentive versus retentive.

Powerup State of Drum Registers

The choice of the starting step on powerup and program-to-run mode transitions are important to consider for your application. Please refer to the following chart. If the counter memory is configured as non-retentive, the drum is initialized the same way on every powerup or program-to-run mode transition. However, if the counter memory is configured to be retentive, the drum will stay in its previous state.

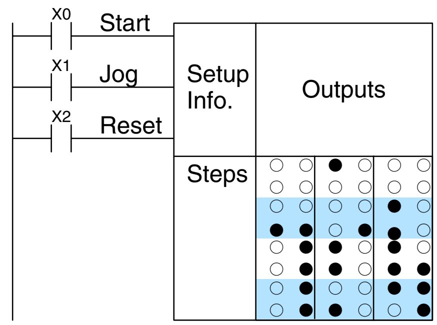
Counter Number	Function	Initialization on Powerup	
		Non-Retentive Case	Retentive Case
CT(n)	Current Step Count	Initialize = 0	Use Previous (no change)
CT(n + 1)	Counter Timer Value	Initialize = 0	Use Previous (no change)
CT(n + 2)	Preset Step	Initialize = Preset Step #	Use Previous (no change)
CT(n + 3)	Current Step #	Initialize = Preset Step #	Use Previous (no change)

Applications with relatively fast drum cycle times typically will need to be reset on powerup, using the non-retentive option. Applications with relatively long drum cycle times may need to resume at the previous point where operations stopped, using the retentive case. The default option is the retentive case. This means that if you initialize scratchpad V-memory, the memory will be retentive.

Drum Control Techniques

Drum Control Inputs

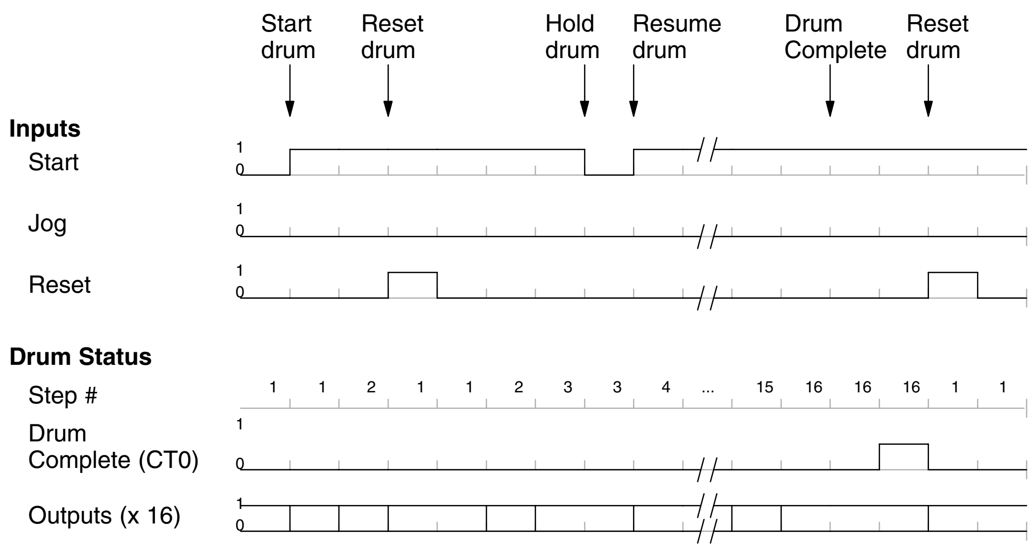
Now we are ready to put together the concepts on the previous pages and demonstrate general control of the drum instruction box. The drawing to the right shows a simplified generic drum instruction. Inputs from ladder logic control the Start, Jog, and Reset Inputs. The first counter bit of the drum (CT0, for example) indicates the drum cycle is done.



The timing diagram below shows an arbitrary timer drum input sequence and how the drum responds. As the CPU enters Run mode it initializes the step number to the preset step number (typically it is Step 1). When the Start input turns on the drum begins running, waiting for an event and/or running the timer (depends on the setup).

After the drum enters Step 2, Reset turns On while Start is still On. Since Reset has priority over Start, the drum goes to the preset step (Step 1). Note that the drum is *held* in the preset step during Reset, and that step *does not run* (respond to events or run the timer) until Reset turns off.

After the drum has entered step 3, the Start input goes off momentarily, halting the drum's timer until Start turns on again.

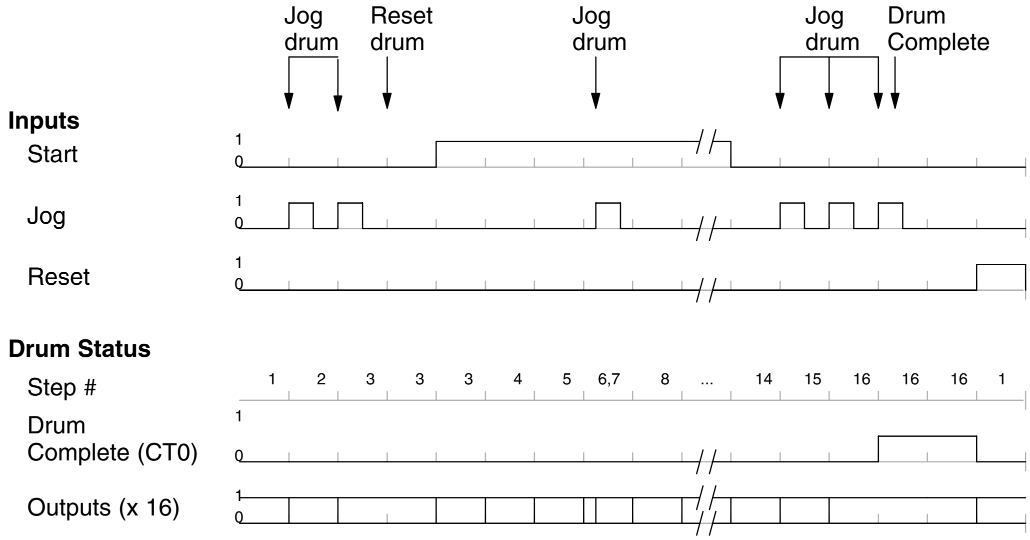


When the drum completes the last step (Step 16 in this example), the Drum Complete bit (CT0) turns on, and the step number remains at 16. When the Reset input turns on, it turns off the Drum Complete bit (CT0), and forces the drum to enter the preset step.

NOTE: The timing diagram shows all steps using equal time durations. Step times can vary greatly, depending on the counts/step programmed.

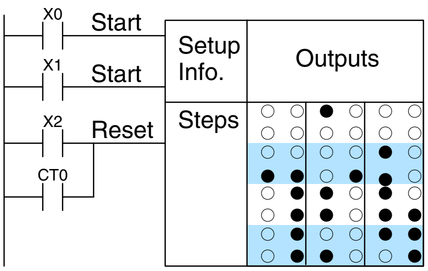
In the figure below, we focus on how the Jog input works on event drums. To the left of the diagram, note that the off-to-on transitions of the Jog input increments the step. Start may be either on or off (however, Reset must be off). Two jogs takes the drum to step three. Next, the Start input turns on, and the drum begins running normally. During step 6 another Jog input signal occurs. This increments the drum to step 7, setting the timer to 0. The drum begins running immediately in step 7, because Start is already on. The drum advances to step 8 normally.

As the drum enters step 14, the Start input turns off. Two more Jog signals moves the drum to step 16. However, note that a third Jog signal is required to move the drum through step 16 to “drum complete”. Finally, a Reset input signal arrives which forces the drum into the preset step and turns off the drum complete bit.



Self-Resetting Drum

Applications often require drums that automatically start over once they complete a cycle. This is easily accomplished, using the drum complete bit. In the figure to the right, the drum instruction setup is for CT0, so we logically OR the drum complete bit (CT0) with the Reset input. When the last step is done, the drum turns on CT0 which resets itself to the preset step, also resetting CT0. Contact X2 still works as a manual reset.



Initializing Drum Outputs

The outputs of a drum are enabled any time the CPU is in run mode. On program-to-run mode transitions, the drum goes to the preset step, and the outputs energize according to the pattern of that step. If your application requires all outputs to be off at powerup, make the preset step in the drum a “reset step”, with all outputs off.

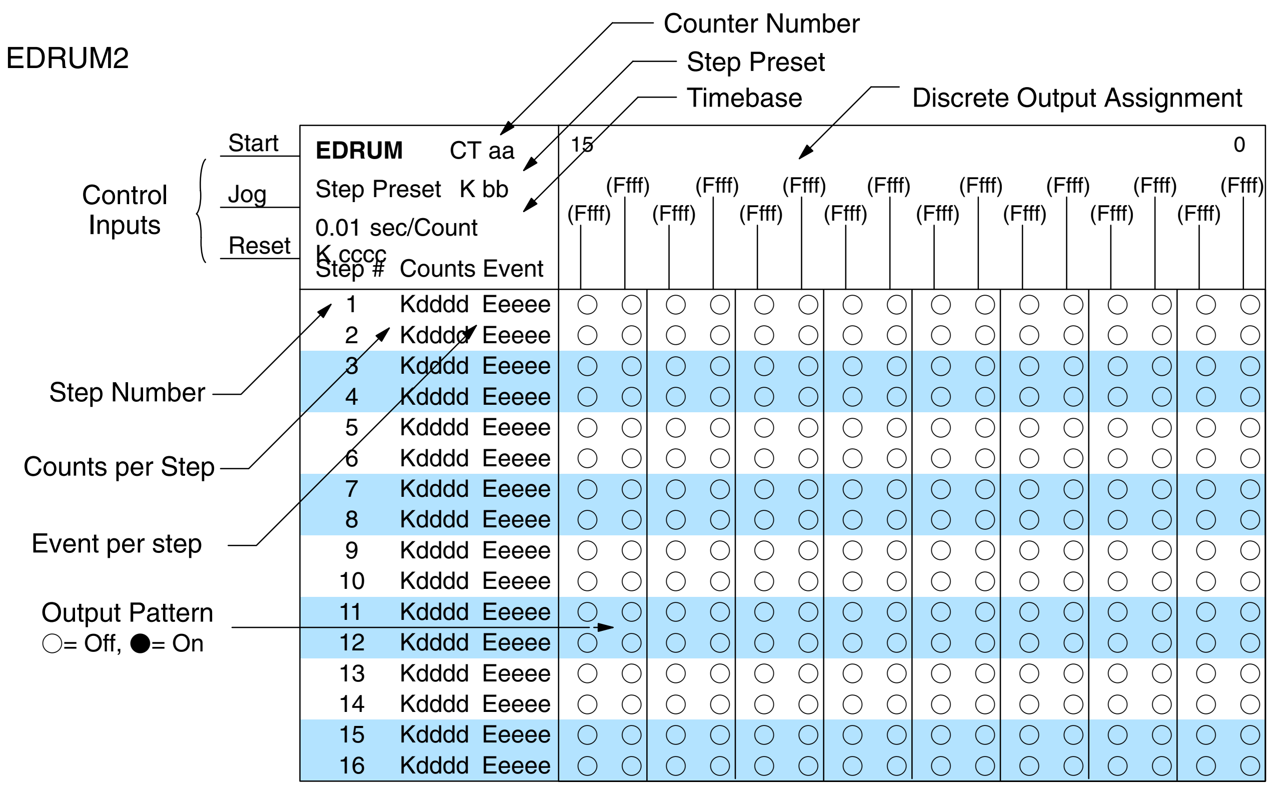
Using Complex Event Step Transitions

Each event-based transition accepts only one contact reference for the event. However, this does not limit events to just one contact. Just use a control relay contact such as C0 for the step transition event. Elsewhere in ladder logic, you may use C0 as an output coil, making it dependent on many other “events” (contacts).

Drum Instruction

Event Drum (EDRUM)

The Event Drum (EDRUM) features time-based and event-based step transitions. It operates according to the general principles of drum operation covered in the beginning of this chapter. Below is the instruction as displayed by ***Direct***SOFT32.



The Event Drum features 16 steps and 16 discrete outputs. Step transitions occur on timed and/or event basis. The jog input also advances the step on each off-to-on transition. Time is specified in counts per step, and events are specified as discrete contacts. Unused steps must be programmed with "counts per step" = 0, and event = "K0000". The discrete output points may be individually assigned.

Whenever the Start input is energized, the drum's timer is enabled. As long as the event is true for the current step, the timer runs during that step. When the step count equals the counts per step, the drum transitions to the next step. This process stops when the last step is complete, or when the Reset input is energized. The drum enters the preset step chosen upon a CPU program-to-run mode transition, and whenever the Reset input is energized.

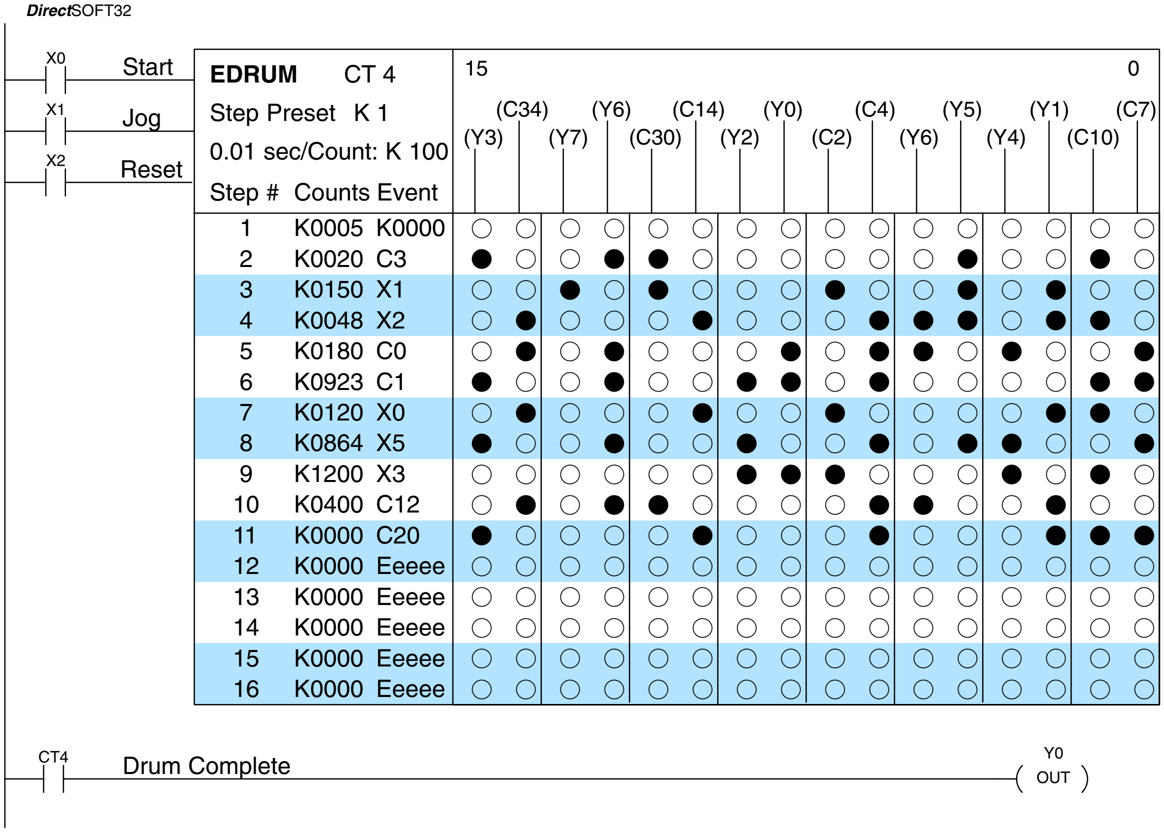
Drum Parameters	Field	Data Types	Ranges
Counter Number	aa	–	0 – 74
Preset Step	bb	K	1 – 16
Timer base	cccc	K	0.01 – 99.99 seconds
Counts per step	dddd	K	0 – 9999
Event	eeee	X, Y, C, S, T, CT	see page 4–28
Discrete Outputs	ffff	X, Y, C	see page 4–28

Drum instructions use four counters in the CPU. The ladder program can read the counter values for the drum's status. The ladder program may write a new preset step number to CT(n+2) at any time. However, the other counters are for monitoring purposes only.

Counter Number	Ranges of (n)	Function	Counter Bit Function
CT(n)	0 – 74	Counts in step	CTn = Drum Complete
C(n+1)	1 – 75	Timer value	CT(n+1) = (not used)
CT(n+2)	2 –76	Preset Step	CT(n+2) = (not used)
CT(n+3)	3 –77	Current Step	CT(n+1) = (not used)

The following ladder program shows the EDRUM instruction in a typical ladder program, as shown by ***Direct***SOFT32. Steps 1 through 11 are used, and all sixteen output points are used. The preset step is step 1. The timebase runs at (K100 x 0.01) = 0.1 second per count. Therefore, the duration of step 1 is (5 x 0.1) = 0.5 seconds. Note that step 1 is time-based only (event = "K0000"). And, the output pattern for step 1 programs all outputs off, which is a typically desirable powerup condition. In the last rung, the Drum Complete bit (CT4) turns on output Y0 upon completion of the last step (step 10). A drum reset also resets CT4.

DirectSOFT32

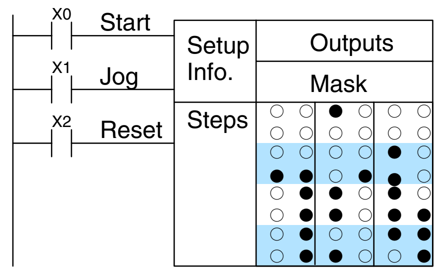


Handheld Programer Drum Mnemonics

The EDRUM instruction may be programmed using either ***Direct***SOFT32 or a handheld programmer. This section covers entry via the handheld programmer (Refer to the ***Direct***SOFT32 manual for drum instruction entry using that tool).

First, enter Store instructions for the ladder rungs controlling the drum's ladder inputs. In the example to the right, the timer drum's Start, Jog, and Reset inputs are controlled by X0, X1 and X2 respectively. The required keystrokes are listed beside the mnemonic.

These keystrokes *precede* the EDRUM instruction mnemonic. Note that the ladder rungs for Start, Jog, and Reset inputs are *not* limited to being single–contact rungs.



Handheld Programmer Keystrokes

Store X0 | $ STR | → | A 0 | ENT

(Repeat for Store X1 and Store X2)

After the Store instructions, enter the EDRUM (using Counter CT0) as shown:

Handheld Programmer Keystrokes

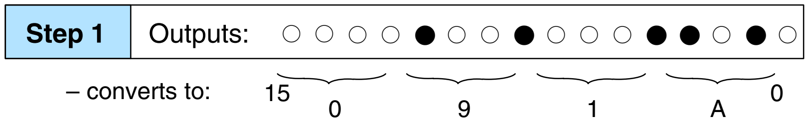
EDRUM CNT0 | SHFT | E 4 | D 3 | R ORN | U ISG | M ORST | → | A 0 | ENT

After entering the EDRUM mnemonic as above, the handheld programmer creates an input form for all the drum parameters. The input form consists of approximately fifty or more default mnemonic entries containing DEF (define) statements. The default mnemonics are already "input" for you, so they appear automatically. Use the NXT and PREV keys to move forward and backward through the form. Only the editing of default values is required, thus eliminating many keystrokes. The entries required for the basic timer drum are in the chart below.

Drum Parameters	Multiple Entries	Mnemonic / Entry	Default Mnemonic	Valid Data Types	Ranges
Start Input	–	STR (plus input rung)	–	–	–
Jog Input	–	STR (plus input rung)	–	–	–
Reset Input	–	STR (plus input rung)		–	–
Drum Mnemonic	–	DRUM CNT aa	–	K	0 – 74
Preset Step	1	bb	DEF K0000	K	1 – 16
Timer base	1	cccc	DEF K0000	K	2 – 9999
Output points	16	ffff	DEF 0000	X, Y, C *	see page 4–28
Counts per step	16	dddd	DEF K0000	K	0 – 9999
Events	16	dddd	DEF K0000	X, Y, C, S, T, CT	see page 4–28
Output pattern	16	gggg	DEF K0000	K	0 – FFFF

NOTE: Default entries for output points and events are "DEF 0000", which means they are unassigned. If you need to go back and change an assigned output as unused again, enter "K0000". The entry will again show as "DEF 0000".

Using the DRUM entry chart (two pages before), we show the method of entry for the basic time/event drum instruction. First, we convert the output pattern for each step to the equivalent hex number, as shown in the following example.



The following diagram shows the method for entering the previous EDRUM example on the HHP. The default entries of the form are in parenthesis. After the drum instruction entry (on the fourth row), the remaining keystrokes over-write the numeric portion of each default DEF statement. **NOTE**: Drum editing requires Handheld Programmer firmware version 1.7 or later.

NOTE: You may use the NXT and PREV keys to skip past entries for unused outputs or steps.

Handheld Programmer Keystrokes

		Keystrokes
Start		$ STR, →, A 0, ENT
Jog		$ STR, →, B 1, ENT
Reset		$ STR, →, C 2, ENT
Drum Inst.		SHFT, E 4, D 3, R ORN, U ISG, M ORST, →, A 0, ENT
Preset Step	(DEF K0001)	NEXT
Time Base	(DEF K0000)	G 6, E 4, NEXT
Outputs 1	(DEF 0000)	SHFT, C 2, H 7, NEXT
	(DEF 0000)	SHFT, C 2, B 1, A 0, NEXT
	(DEF 0000)	SHFT, Y MLS, B 1, NEXT
	(DEF 0000)	SHFT, Y MLS, E 4, NEXT
	(DEF 0000)	SHFT, Y MLS, F 5, NEXT
	(DEF 0000)	SHFT, Y MLS, G 6, NEXT
	(DEF 0000)	SHFT, C 2, E 4, NEXT
	(DEF 0000)	SHFT, C 2, C 2, NEXT
	(DEF 0000)	SHFT, Y MLS, A 0, NEXT
	(DEF 0000)	SHFT, Y MLS, C 2, NEXT
	(DEF 0000)	SHFT, C 2, B 1, E 4, NEXT
	(DEF 0000)	SHFT, C 2, D 3, A 0, NEXT
	(DEF 0000)	SHFT, Y MLS, G 6, NEXT
	(DEF 0000)	SHFT, Y MLS, H 7, NEXT
	(DEF 0000)	SHFT, C 2, D 3, E 4, NEXT
16	(DEF 0000)	SHFT, Y MLS, B 1, NEXT

Handheld Programmer Keystrokes cont'd

		Keystrokes
Counts/Step 1	(DEF K0000)	F 5, NEXT
	(DEF K0000)	C 2, A 0, NEXT
	(DEF K0000)	B 1, F 5, A 0, NEXT
	(DEF K0000)	E 4, F 5, NEXT
	(DEF K0000)	B 1, I 8, A 0, NEXT
	(DEF K0000)	J 9, C 2, D 3, NEXT
	(DEF K0000)	B 1, C 2, A 0, NEXT
	(DEF K0000)	I 8, G 6, E 4, NEXT
	(DEF K0000)	B 1, C 2, A 0, A 0, NEXT
	(DEF K0000)	E 4, A 0, A 0, NEXT
	(DEF K0000)	NEXT
	(DEF K0000)	NEXT
	(DEF K0000)	NEXT ← skip over unused steps
	(DEF K0000)	NEXT
	(DEF K0000)	NEXT
16	(DEF K0000)	NEXT

(Continued on next page)

Handheld Programmer Keystrokes cont'd

Events

		Keystrokes
1	(DEF 0000)	NEXT ← skip over unused event
	(DEF 0000)	SHFT, Y MLS, E 4, NEXT
	(DEF 0000)	SHFT, X SET, B 1, NEXT
	(DEF 0000)	SHFT, X SET, C 2, NEXT
	(DEF 0000)	SHFT, C 2, A 0, NEXT
	(DEF 0000)	SHFT, C 2, B 1, NEXT
	(DEF 0000)	SHFT, X SET, A 0, NEXT
	(DEF 0000)	SHFT, X SET, F 5, NEXT
	(DEF 0000)	SHFT, X SET, D 3, NEXT
	(DEF 0000)	SHFT, Y MLS, H 7, NEXT
	(DEF 0000)	SHFT, C 2, C 2, A 0, NEXT
	(DEF 0000)	NEXT
	(DEF 0000)	NEXT
	(DEF 0000)	NEXT
	(DEF 0000)	NEXT
16	(DEF 0000)	NEXT

Handheld Programmer Keystrokes cont'd

Output Pattern

		Keystrokes
1	(DEF K0000)	NEXT ← step 1 pattern = 0000
	(DEF K0000)	J 9, I 8, B 1, C 2, NEXT
	(DEF K0000)	C 2, I 8, J 9, E 4, NEXT
	(DEF K0000)	E 4, E 4, H 7, G 6, NEXT
	(DEF K0000)	F 5, B 1, G 6, J 9, NEXT
	(DEF K0000)	J 9, D 3, E 4, D 3, NEXT
	(DEF K0000)	E 4, E 4, I 8, G 6, NEXT
	(DEF K0000)	J 9, E 4, F 5, J 9, NEXT
	(DEF K0000)	D 3, I 8, SHFT, A 0, NEXT
	(DEF K0000)	F 5, I 8, G 6, E 4, NEXT
	(DEF K0000)	I 8, E 4, E 4, H 7, NEXT
	(DEF K0000)	NEXT
	(DEF K0000)	NEXT
	(DEF K0000)	NEXT ← unused steps
	(DEF K0000)	NEXT
16	(DEF K0000)	NEXT

Last rung

$ STR, GY CNT, A 0, NEXT

SHFT, Y MLS, A 0, NEXT

NOTE: You may use the NXT and PREV keys to skip past entries for unused outputs or steps.

7

RLL*PLUS*
Stage Programming

In This Chapter. . . .

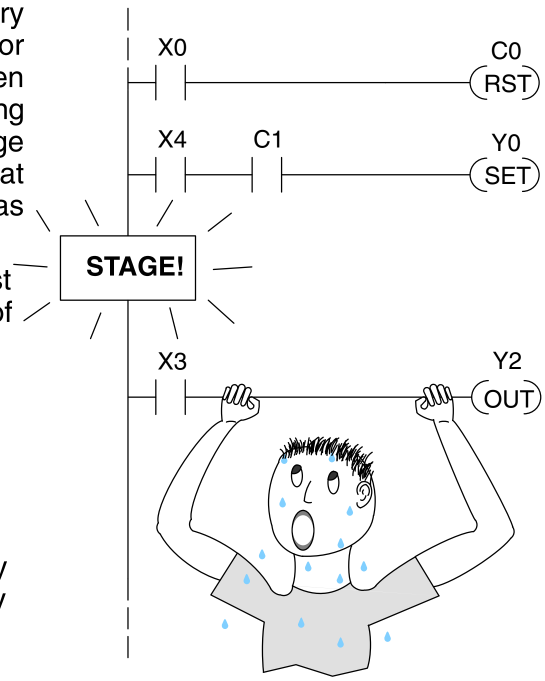
Introduction to Stage Programming

Stage Programming provides a way to organize and program complex applications with relative ease, when compared to purely relay ladder logic (RLL) solutions. Stage programming does not replace or negate the use of traditional boolean ladder programming. This is why Stage Programming is also called RLL^{PLUS}. You won't have to discard any training or experience you already have. Stage programming simply allows you to divide and organize a RLL program into groups of ladder instructions called stages. This allows quicker and more intuitive ladder program development than traditional RLL alone provides.

Overcoming "Stage Fright"

Many PLC programmers in the industry have become comfortable using RLL for every PLC program they write... but often remain skeptical or even fearful of learning new techniques such as stage programming. While RLL is great at solving boolean logic relationships, it has disadvantages as well:

- Large programs can become almost unmanageable, because of a lack of structure.
- In RLL, latches must be tediously created from self-latching relays.
- When a process gets stuck, it is difficult to find the rung where the error occurred.
- Programs become difficult to modify later, because they do not intuitively resemble the application problem they are solving.



It's easy to see that these inefficiencies consume a lot of additional time, and time is money. *Stage programming overcomes these obstacles!* We believe a few moments of studying the stage concept is one of the greatest investments in programming speed and efficiency a PLC programmer can make!

So, we encourage you to study stage programming and add it to your "toolbox" of programming techniques. This chapter is designed as a self-paced tutorial on stage programming. For best results:

- Start at the beginning and do not skip over any sections.
- Study each stage programming concept by working through each example. The examples build progressively on each other.
- Read the stage Questions and Answers at the end of the chapter for a quick review.

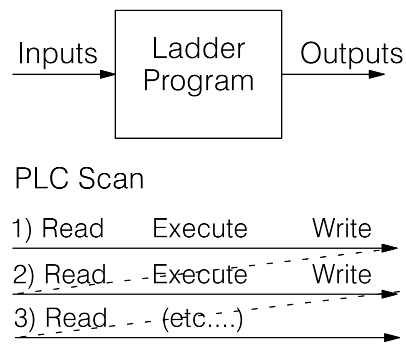
Learning to Draw State Transition Diagrams

Introduction to Process States

Those familiar with ladder program execution know that the CPU must scan the ladder program repeatedly, over and over. Its three basic steps are:

1. Read the inputs
2. Execute the ladder program
3. Write the outputs

The benefit is that a change at the inputs can affect the outputs in just a few milliseconds.



Most manufacturing processes consist of a series of activities or conditions , each lasting for several seconds. minutes, or even hours. We might call these “process states”, which are either active or inactive at any particular time. A challenge for RLL programs is that a particular input event may last for just a brief instant. We typically create latching relays in RLL to preserve the input event in order to maintain a process state for the required duration.

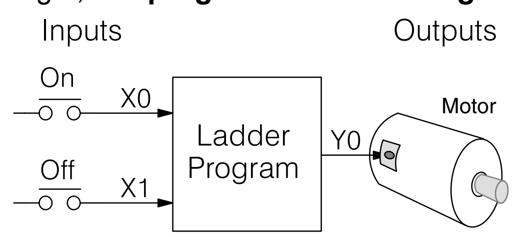
We can organize and divide ladder logic into sections called “stages”, representing process states. But before we describe stages in detail, we will reveal **the secret to understanding stage programming:** state transition diagrams.

The Need for State Diagrams

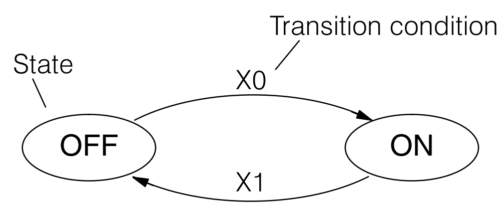
Sometimes we need to forget about the scan nature of PLCs, and focus our thinking toward the states of the process we need to identify. Clear thinking and concise analysis of an application gives us the best chance at writing efficient, bug-free programs. *State diagrams are just a tool to help us draw a picture of our process!* You’ll discover that if we can get the picture right, **our program will also be right!**

A 2–State Process

Consider the simple process shown to the right, which controls an industrial motor. We will use a green momentary SPST pushbutton to turn the motor on, and a red one to turn it off. The machine operator will press the appropriate pushbutton for just a second or so. The two states of our process are ON and OFF.



The next step is to draw a *state transition diagram*, as shown to the right. It shows the two states OFF and ON, with two transition lines in-between. When the event X0 is true, we transition from OFF to ON. When X1 is true, we transition from ON to OFF.

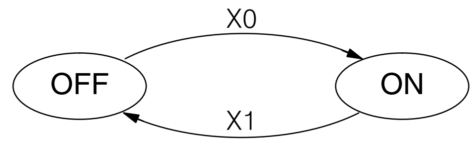


Output equation: Y0 = ON

If you’re following along, you are very close to grasping the concept and the problem-solving power of state transition diagrams. The output of our controller is Y0, which is true any time we are in the ON state. In a boolean sense, Y0=ON state.

Next, we will implement the state diagram first as RLL, then as a stage program. This will help you see the relationship between the two methods in problem solving.

The state transition diagram to the right is a picture of the solution we need to create. The beauty of it is this: it expresses the problem independently of the programming language we may use to realize it. In other words, *by drawing the diagram we have already solved the control problem!*



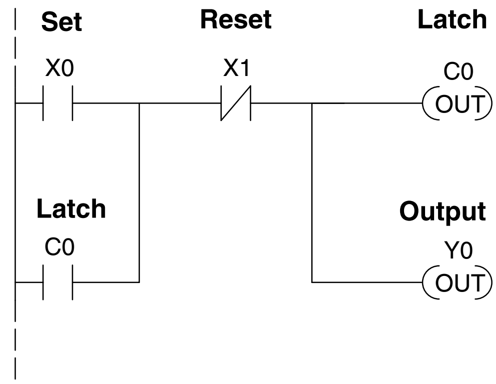
Output equation: Y0 = ON

First, we'll translate the state diagram to traditional RLL. Then we'll show how easy it is to translate the diagram into a stage programming solution.

RLL Equivalent

The RLL solution is shown to the right. It consists of a self-latching control relay, C0. When the On pushbutton (X0) is pressed, output coil C0 turns on and the C0 contact on the second row latches itself on. So, X0 **sets the latch** C0 on, and it remains on after the X0 contact opens. The motor output Y0 also has power flow, so the motor is now on.

When the Off pushbutton (X1) is pressed, it opens the normally-closed X1 contact, which **resets the latch**. Motor output Y0 turns off when the latch coil C0 goes off.

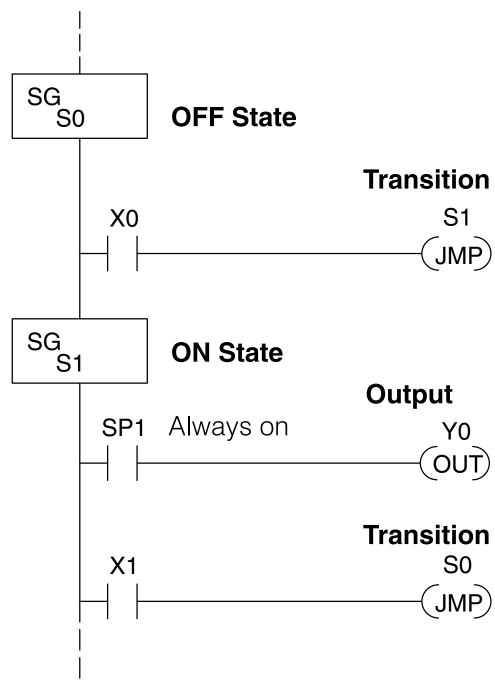


Stage Equivalent

The stage program solution is shown to the right. The two inline stage boxes S0 and S1 correspond to the two states OFF and ON. The ladder rung(s) below each stage box belong to each respective stage. This means that the PLC only has to scan those rungs when the corresponding stage is active!

For now, let's assume we begin in the OFF State, so stage S0 is active. When the On pushbutton (X0) is pressed, a stage transition occurs. The JMP S1 instruction executes, which simply turns off the stage bit S0 and turns on stage bit S1. So on the next PLC scan, the CPU will not execute stage S0, but will execute stage S1!

In the On State (stage S1), we want the motor to always be on. The special relay contact SP1 is defined as always on, so Y0 turns the motor on.

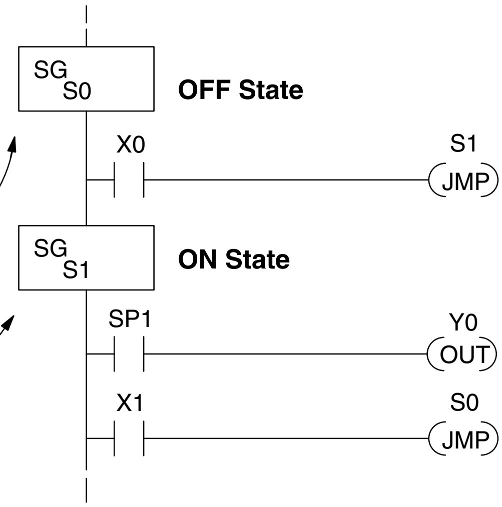


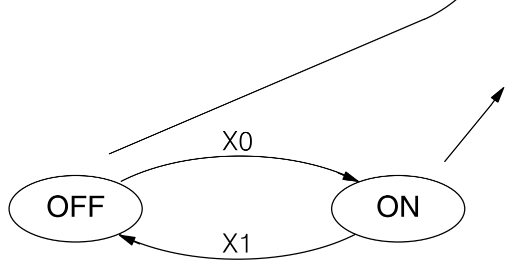
When the Off pushbutton (X1) is pressed, a transition back to the Off State occurs. The JMP S0 instruction executes, which simply turns off the stage bit S1 and turns on stage bit S0. On the next PLC scan, the CPU will not execute stage S1, so the motor output Y0 will turn off. The Off state (stage 0) will be ready for the next cycle.

Let's Compare

Right now, you may be thinking "I don't see the big advantage to Stage Programming... in fact, the stage program is longer than the plain RLL program". Well, now is the time to exercise a bit of faith. As control problems grow in complexity, stage programming quickly out-performs RLL in simplicity, program size, etc.

For example, consider the diagram below. Notice how easy it is to correlate the OFF and ON states of the state transition diagram below to the stage program at the right. Now, we challenge anyone to easily identify the same states in the RLL program on the previous page!



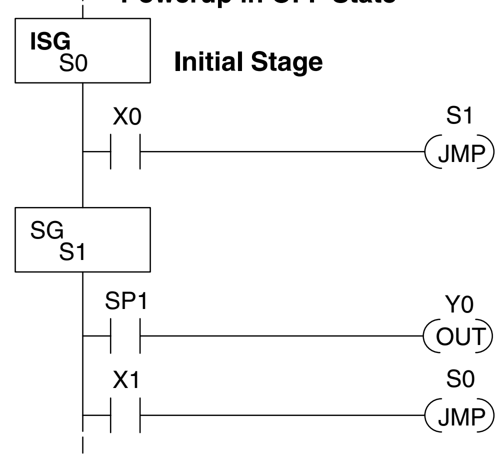


Initial Stages

At powerup and Program-to-Run Mode transitions, the PLC always begins with all normal stages (SG) off. So, the stage programs shown so far have actually had no way to get started (because rungs are not scanned unless their stage is active).

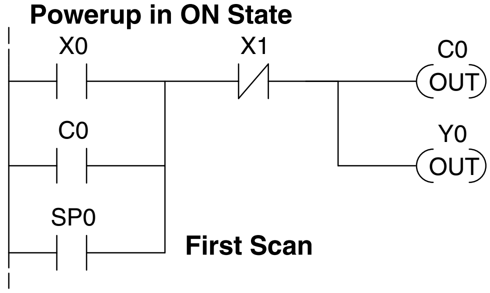
Assume that we want to always begin in the Off state (motor off), which is how the RLL program works. The Initial Stage (ISG) is defined to be active at powerup. In the modified program to the right, we have changed stage S0 to the ISG type. This ensures the PLC will scan contact X0 after powerup, because Stage S0 is active. **After powerup, an Initial Stage (ISG) works just like any other stage!**

Powerup in OFF State

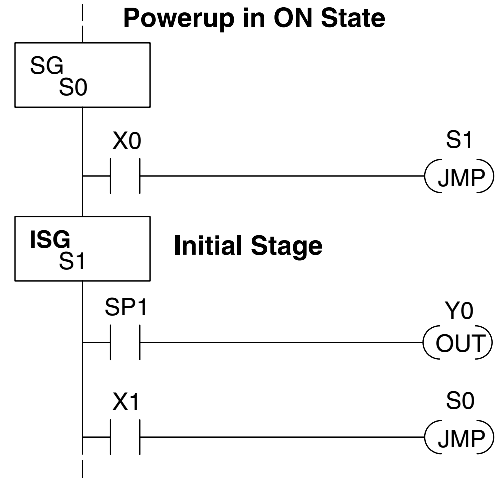


We can change both programs so that the motor is ON at powerup. In the RLL below, we must add a first scan relay SP0, latching C0 on. In the stage example to the right, we simply make Stage S1 an initial stage (ISG) instead of S0.

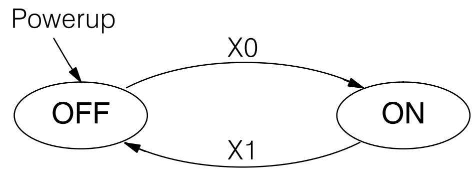
Powerup in ON State



Powerup in ON State



We can mark our desired powerup state as shown to the right, which helps us remember to use the appropriate Initial Stages when creating a stage program. It is permissible to have as many initial stages as the process requires.

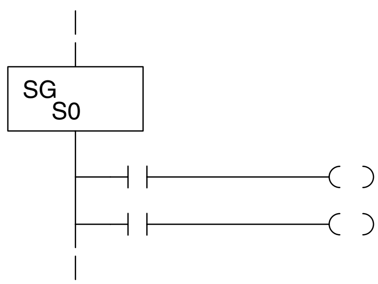


What Stage Bits Do You may recall that a stage is just a section of ladder program which is either active or inactive at a given moment. All stage bits (S0 to S77) reside in the PLC's image register as individual status bits. Each stage bit is either a boolean 0 or 1 at any time.

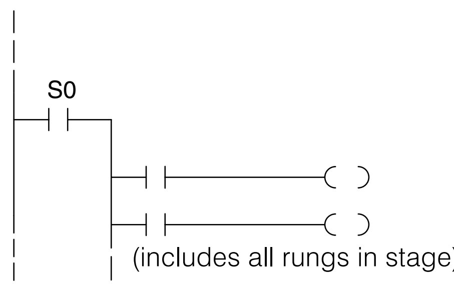
Program execution always reads ladder rungs from top to bottom, and from left to right. The drawing below shows the effect of stage bit status. The ladder rungs below the stage instruction continuing until the next stage instruction or the end of program belong to stage 0. Its equivalent operation is shown on the right. When S0 is true, the two rungs have power flow.

- If Stage bit S0 = 0, its ladder rungs *are not* scanned (executed).
- If stage bit S0 = 1, its ladder rungs *are* scanned (executed).

Actual Program Appearance

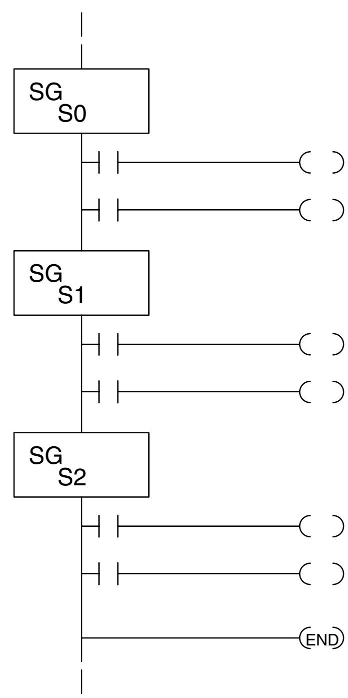


Functionally Equivalent Ladder



Stage Instruction Characteristics The inline stage boxes on the left power rail divide the ladder program rungs into stages. Some stage rules are:

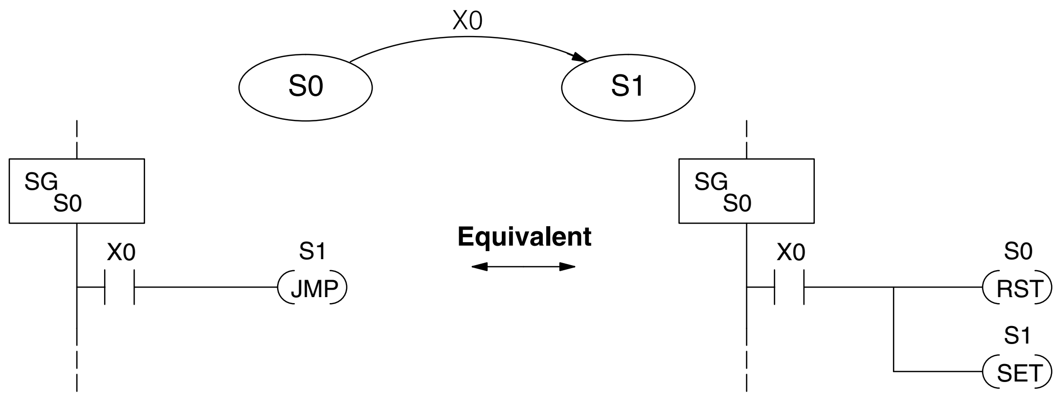
- **Execution** – Only logic in active stages are executed on any scan.
- **Transitions** – Stage transition instructions take effect on the next occurrence of the stages involved.
- **Octal numbering** – Stages are numbered in octal, like I/O points, etc. So "S8" is not valid.
- **Total Stages** – The DL105 offers up to 256 stages (S0 to S377 in octal).
- **No duplicates** – Each stage number is unique and can be used just once.
- **Any order** – You can skip numbers and sequence the stage numbers in any order.
- **Last Stage** – the last stage in the ladder program includes all rungs from its stage box until the end coil.



Using the Stage Jump Instruction for State Transitions

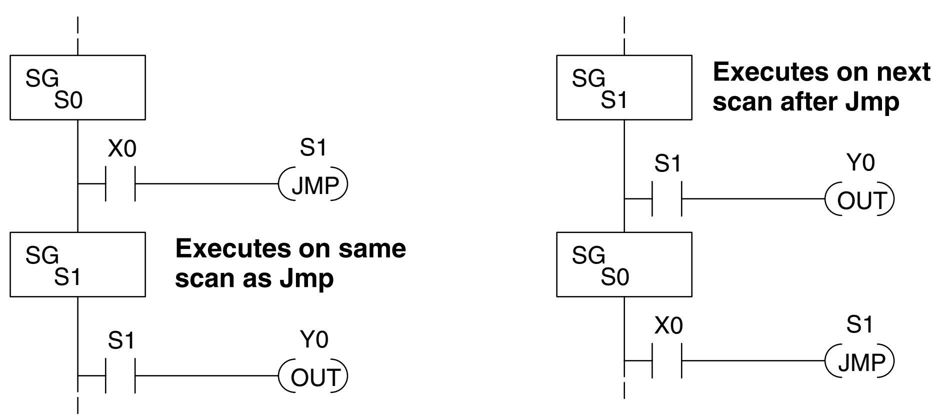
Stage Jump, Set, and Reset Instructions

The stage JMP instruction we have used deactivates the stage in which the instruction occurs, while activating the stage in the JMP instruction. Refer to the state transition shown below. When contact X0 energizes, the state transition from S0 to S1 occurs. The two stage examples shown below are equivalent. So, the stage Jump instruction is equal to a Stage Reset of the current stage, plus a Stage Set instruction for the stage to which we want to transition.



Please Read Carefully – The jump instruction is easily misunderstood. The “jump” does not occur immediately like a GOTO or GOSUB program control instruction when executed. Here’s how it works:

- The jump instruction resets the stage bit of the stage in which it occurs. All rungs in the stage still finish executing during the current scan, *even if there are other rungs in the stage below the jump instruction!*
- The reset will be in effect on the following scan, so the stage that executed the jump instruction previously will be inactive and bypassed.
- The stage bit of the stage named in the Jump instruction will be set immediately, so the stage will be executed on its next occurrence. In the left program shown below, stage S1 executes during the *same scan* as the JMP S1 occurs in S0. In the example on the right, Stage S1 executes on the *next scan* after the JMP S1 executes, because stage S1 is located *above* stage S0.

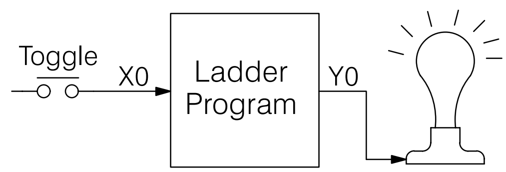


Note: Assume we start with Stage 0 active and stage 1 inactive for both examples.

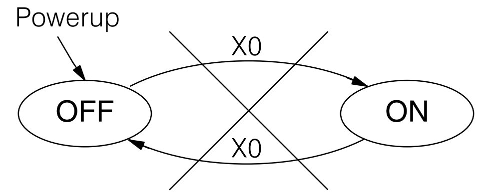
Stage Program Example: Toggle On/Off Lamp Controller

A 4–State Process

In the process shown to the right, we use an ordinary momentary pushbutton to control a light bulb. The ladder program will latch the switch input, so that we will push and release to turn on the light, push and release again to turn it off (sometimes called toggle function). Sure, we could just buy a mechanical switch with the alternate on/off action built in... However, this example is educational and also fun!



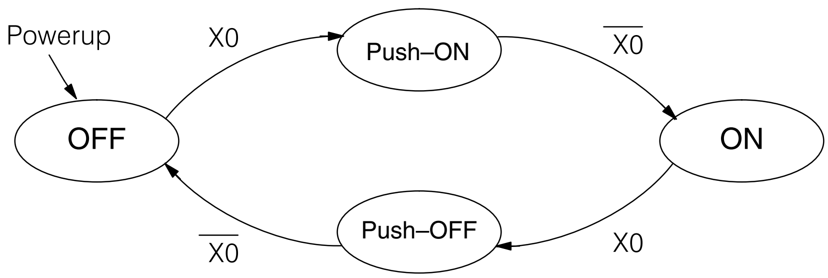
Next we draw the state transition diagram. A typical first approach is to use X0 for both transitions (like the example shown to the right). However, *this is incorrect* (please keep reading).



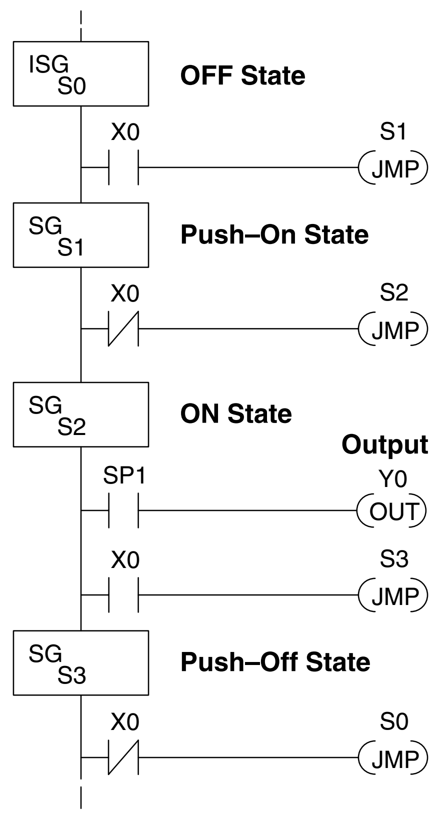
Output equation: Y0 = ON

Note that this example differs from the motor example, because now we have just one pushbutton. When we press the pushbutton, both transition conditions are met. We would just transition around the state diagram at top speed. If implemented in stage, this solution would flash the light on or off each scan (obviously undesirable)!

The solution is to make the the push and the release of the pushbutton separate events. Refer to the new state transition diagram below. At powerup we enter the OFF state. When switch X0 is pressed, we enter the Press-ON state. When it is released, we enter the ON state. Note that X0 with the bar above it denotes X0 NOT.



Output equation: Y0 = ON



When in the ON state, another push and release cycle similarly takes us back to the OFF state. Now we have two unique states (OFF and ON) used when the pushbutton is released, which is what was required to solve the control problem.

The equivalent stage program is shown to the right. The desired powerup state is OFF, so we make S0 an initial stage (ISG). In the ON state, we add special relay contact SP1, which is always on.

Note that even as our programs grow more complex, it is still easy to correlate the state transition diagram with the stage program!

Four Steps to Writing a Stage Program

By now, you've probably noticed that we follow the same steps to solve each example problem. The steps will probably come to you automatically if you work through all the examples in this chapter. It's helpful to have a checklist to guide us through the problem solving. The following steps summarize the stage program design procedure:

1. Write a Word Description of the application.

Describe all functions of the process in your own words. Start by listing what happens first, then next, etc. If you find there are too many things happening at once, try dividing the problem into more than one process. Remember, you can still have the processes communicate with each other to coordinate their overall activity.

2. Draw the Block Diagram.

Inputs represent all the information the process needs for decisions, and outputs connect to all devices controlled by the process.

- Make lists of inputs and outputs for the process.
- Assign I/O point numbers (X and Y) to physical inputs and outputs.

3. Draw the State Transition Diagram.

The state transition diagram describes the central function of the block diagram, reading inputs and generating outputs.

- Identify and name the states of the process.
- Identify the event(s) required for each transition between states.
- Ensure the process has a way to re-start itself, or is cyclical.
- Choose the powerup state for your process.
- Write the output equations.

4. Write the Stage Program.

Translate the state transition diagram into a stage program.

- Make each state a stage. Remember to number stages in octal. Up to 256 total stages are available in the DL205, numbered 0 to 377 in octal.
- Put transition logic inside the stage which originates each transition (the stage each arrow points *away* from).
- Use an initial stage (ISG) for any states that must be active at powerup.
- Place the outputs or actions in the appropriate stages.

You'll notice that Steps 1 through 3 just *prepare* us to write the stage program in Step 4. However, the program virtually writes itself because of the preparation beforehand. Soon you'll be able to start with a word description of an application and create a stage program in one easy session!

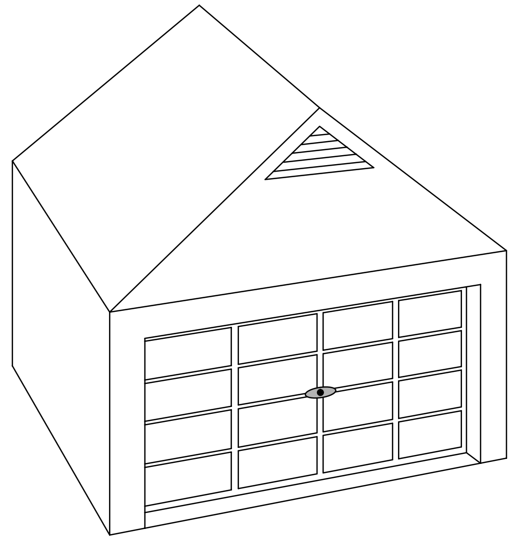
Stage Program Example: A Garage Door Opener

Garage Door Opener Example

In this next stage programming example we'll create a garage door opener controller. Hopefully most readers are familiar with this application, and we can have fun besides!

The first step we must take is to describe how the door opener works. We will start by achieving the basic operation, waiting to add extra features later. Stage programs are very easy to modify.

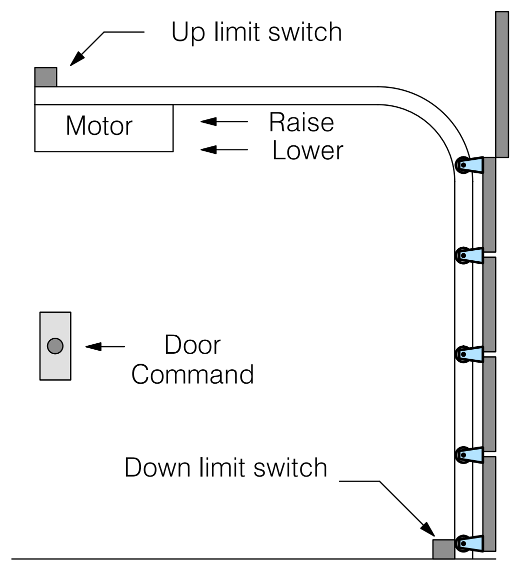
Our garage door controller has a motor which raises or lowers the door on command. The garage owner pushes and releases a momentary pushbutton once to raise the door. After the door is up, another push-release cycle will lower the door.



In order to identify the inputs and outputs of the system, it's sometimes helpful to sketch its main components, as shown in the door side view to the right. The door has an up limit and a down limit switch. Each limit switch closes only when the door has reach the end of travel in the corresponding direction. In the middle of travel, neither limit switch is closed.

The motor has two command inputs: raise and lower. When neither input is active, the motor is stopped.

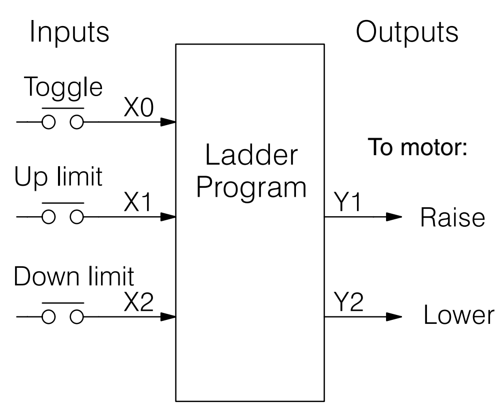
The door command is just a simple pushbutton. Whether wall-mounted as shown, or a radio-remote control, all door control commands logical OR together as one pair of switch contacts.



Draw the Block Diagram

The block diagram of the controller is shown to the right. Input X0 is from the pushbutton door control. Input X1 energizes when the door reaches the full up position. Input X2 energizes when the door reaches the full down position. When the door is positioned between fully up or down, both limit switches are open.

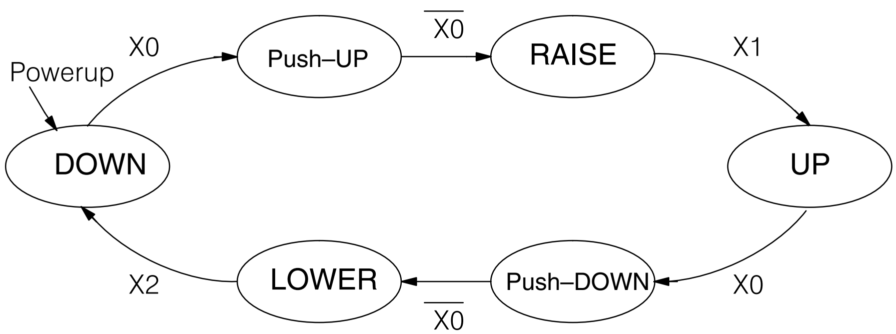
The controller has two outputs to drive the motor. Y1 is the up (raise the door) command, and Y2 is the down (lower the door) command.



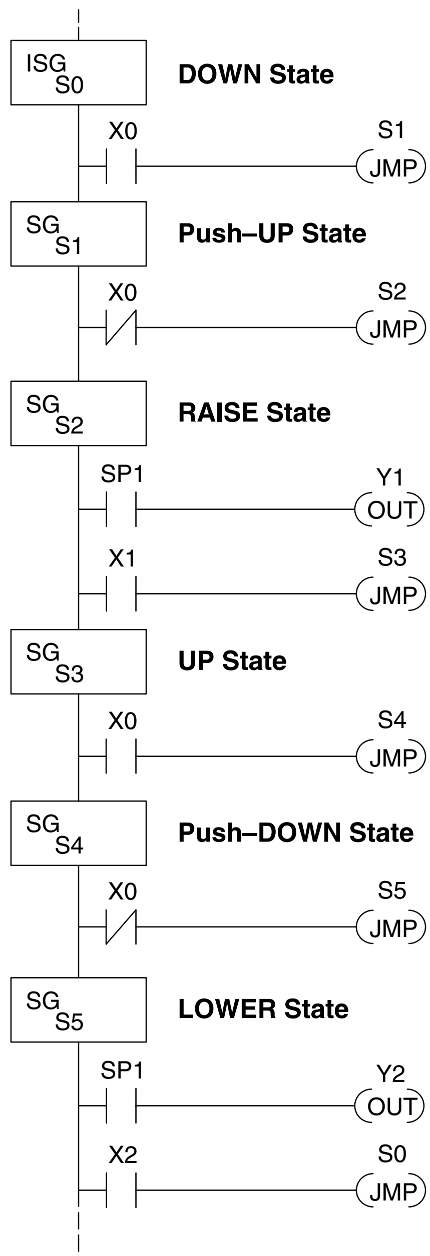
Draw the State Diagram

Now we are ready to draw the state transition diagram. Like the previous light bulb controller example, this application also has just one switch for the command input. Refer to the figure below.

- When the door is down (DOWN state), nothing happens until X0 energizes. Its push and release brings us to the RAISE state, where output Y1 turns on and causes the motor to raise the door.
- We transition to the UP state when the up limit switch (X1) energizes, and turns off the motor.
- Then nothing happens until another X0 press-release cycle occurs. That takes us to the LOWER state, turning on output Y2 to command the motor to lower the door. We transition back to the DOWN state when the down limit switch (X2) energizes.



Output equations: Y1 = RAISE Y2 = LOWER



The equivalent stage program is shown to the right. For now, we will assume the door is down at powerup, so the desired powerup state is DOWN. We make S0 an initial stage (ISG). Stage S0 remains active until the door control pushbutton activates. Then we transition (JMP) to Push-UP stage, S1.

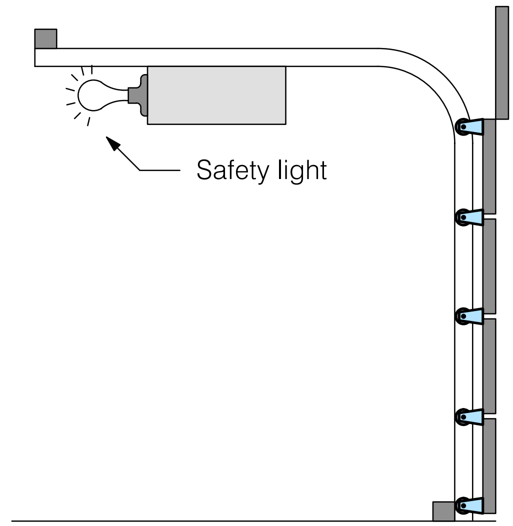
A push-release cycle of the pushbutton takes us through stage S1 to the RAISE stage, S2. We use the always-on contact SP1 to energize the motor's raise command, Y1. When the door reaches the fully-raised position, the up limit switch X1 activates. This takes us to the UP Stage S3, where we wait until another door control command occurs.

In the UP Stage S3, a push-release cycle of the pushbutton will take us to the LOWER Stage S5, where we activate Y2 to command the motor to lower the door. This continues until the door reaches the down limit switch, X2. When X2 closes, we transition from Stage S5 to the DOWN stage S0, where we began.

NOTE: The only special thing about an initial stage (ISG) is that it is automatically active at powerup. Afterwards, it is just like any other.

Add Safety Light Feature

Next we will add a safety light feature to the door opener system. It's best to get the main function working first as we have done, then adding the secondary features.

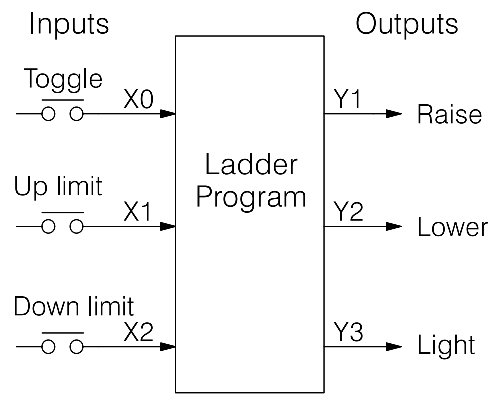


The safety light is standard on many commercially-available garage door openers. It is shown to the right, mounted on the motor housing. The light turns on upon any door activity, remaining on for approximately 3 minutes afterwards.

This part of the exercise will demonstrate the use of parallel states in our state diagram. Instead of using the JMP instruction, we'll use the set and reset commands.

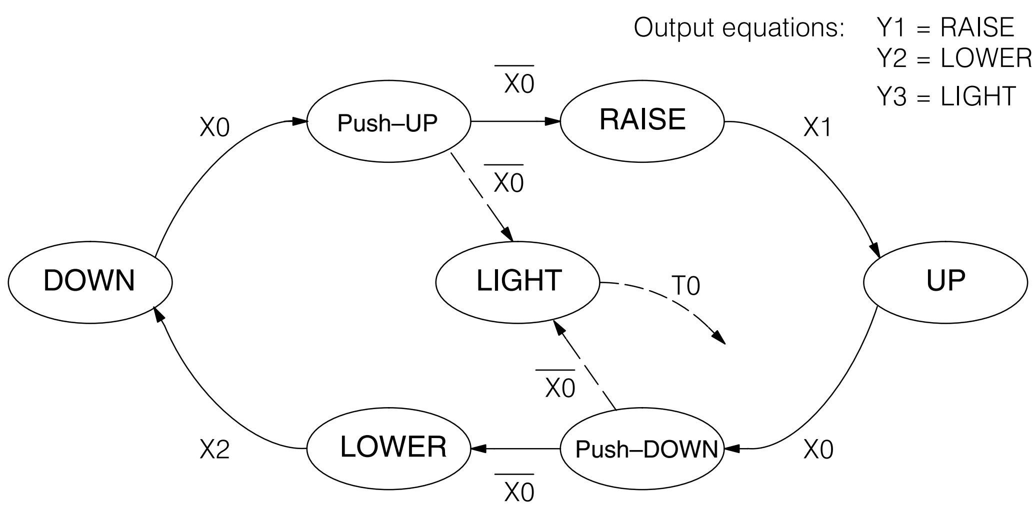
Modify the Block Diagram and State Diagram

To control the light bulb, we add an output to our controller block diagram, shown to the right, Y3 is the light control output.



In the diagram below, we add an additional state called "LIGHT". Whenever the garage owner presses the door control switch and releases, the RAISE or LOWER state is active *and the LIGHT state is simultaneously active.* The line to the Light state is dashed, because it is not the primary path.

We can think of the Light state as a parallel process to the raise and lower state. The paths to the Light state are not a transition (Stage JMP), but a State Set command. In the logic of the Light stage, we will place a three-minute timer. When it expires, timer bit T0 turns on and resets the Light stage. The path out of the Light stage goes nowhere, indicating the Light stage just becomes inactive, and the light goes out!



Using a Timer Inside a Stage

The finished modified program is shown to the right. The shaded areas indicate the program additions.

In the Push-UP stage S1, we add the Set Stage Bit S6 instruction. When contact X0 opens, we transition from S1 and go to two new active states: S2 and S6. In the Push-DOWN state S4, we make the same additions. So, any time someone presses the door control pushbutton, the light turns on.

Most new stage programmers would be concerned about where to place the Light Stage in the ladder, and how to number it. The good news is that it doesn't matter!

- Just choose an unused stage number, and use it for the new stage and as the reference from other stages.
- Placement in the program is not critical, so we place it at the end.

You might think that each stage has to be directly under the stage that transitions to it. While it is good practice, it is not required (that's good, because our two locations for the Set S6 instruction make that impossible). Stage numbers and how they are used determines the transition paths.

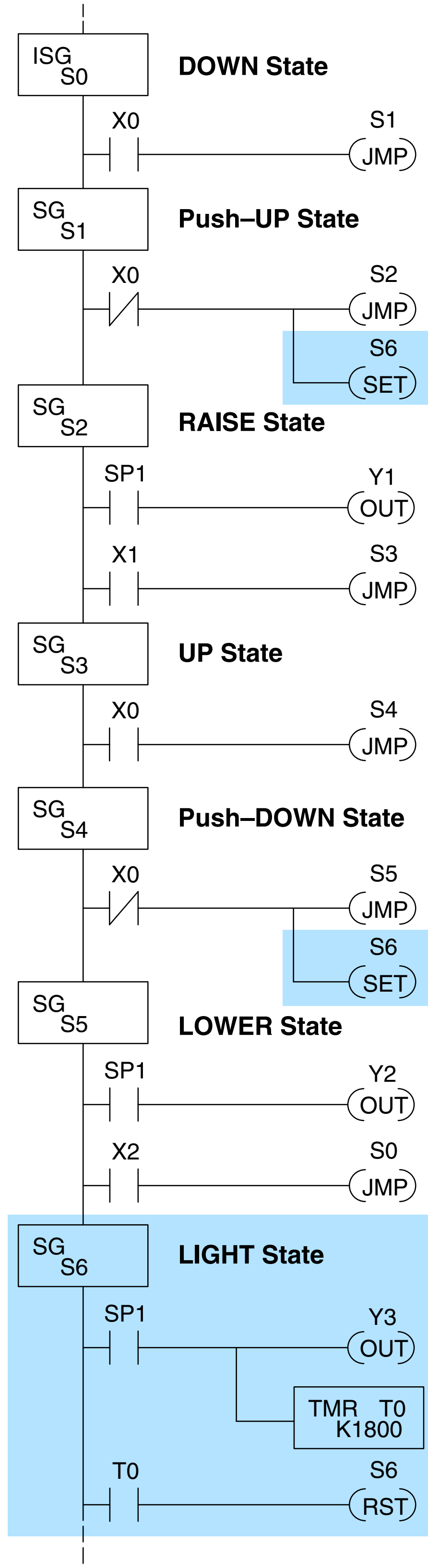
In stage S6, we turn on the safety light by energizing Y3. Special relay contact SP1 is always on. Timer T0 times at 0.1 second per count. To achieve 3 minutes time period, we calculate:

$$K= \frac{3 \text{ min. x } 60 \text{ sec/min}}{0.1 \text{ sec/count}}$$

K=1800 counts

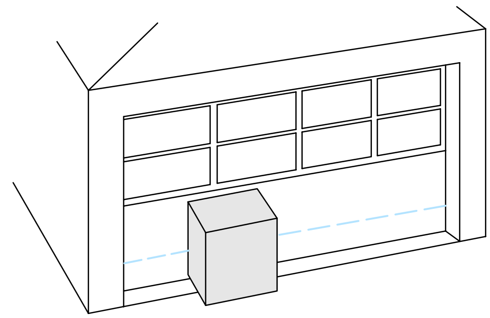
The timer has power flow whenever stage S6 is active. The corresponding timer bit T0 is set when the timer expires. So three minutes later, T0=1 and the instruction Reset S6 causes the stage to be inactive.

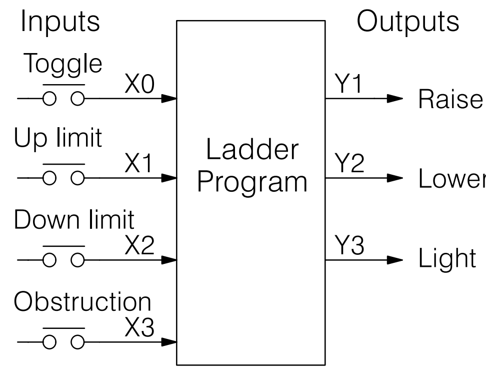
While Stage S6 is active and the light is on, stage transitions in the primary path continue normally and independently of Stage 6. That is, the door can go up, down, or whatever, but the light will be on for precisely 3 minutes.



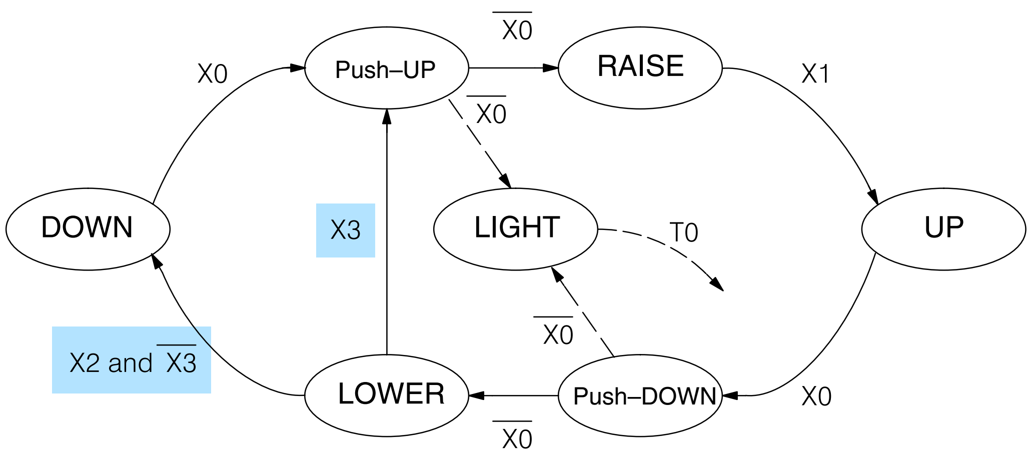
Add Emergency Stop Feature

Some garage door openers today will detect an object under the door. This halts further lowering of the door. Usually implemented with a photocell (“electric-eye”), a door in the process of being lowered will halt and begin raising. We will define our safety feature to work in this way, adding the input from the photocell to the block diagram as shown to the right. X3 will be on if an object is in the path of the door.





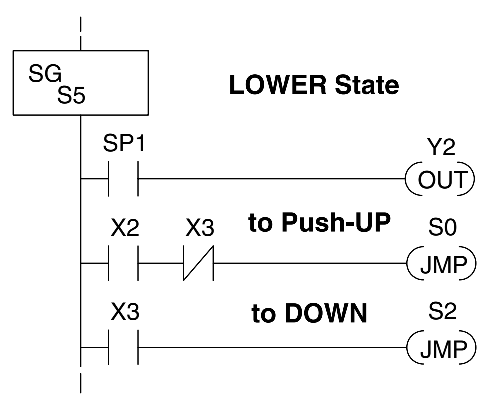
Next, we make a simple addition to the state transition diagram, shown in shaded areas in the figure below. Note the new transition path at the top of the LOWER state. If we are lowering the door and detect an obstruction (X3), we then jump to the Push-UP State. We do this instead of jumping directly to the RAISE state, to give the Lower output Y2 one scan to turn off, before the Raise output Y1 energizes.



Exclusive Transitions

It is theoretically possible that the down limit (X2) and the obstruction input (X3) could energize at the same moment. In that case, we would “jump” to the Push-UP and DOWN states simultaneously, which does not make sense.

Instead, we give priority to the obstruction by changing the transition condition to the DOWN state to [X2 AND NOT X3]. This ensures the obstruction event has the priority. The modifications we must make to the LOWER stage (S5) logic are shown to the right. The first rung remains unchanged. The second and third rungs implement the transitions we need. Note the opposite relay contact usage for X3, which ensures the stage will execute only one of the JMP instructions.

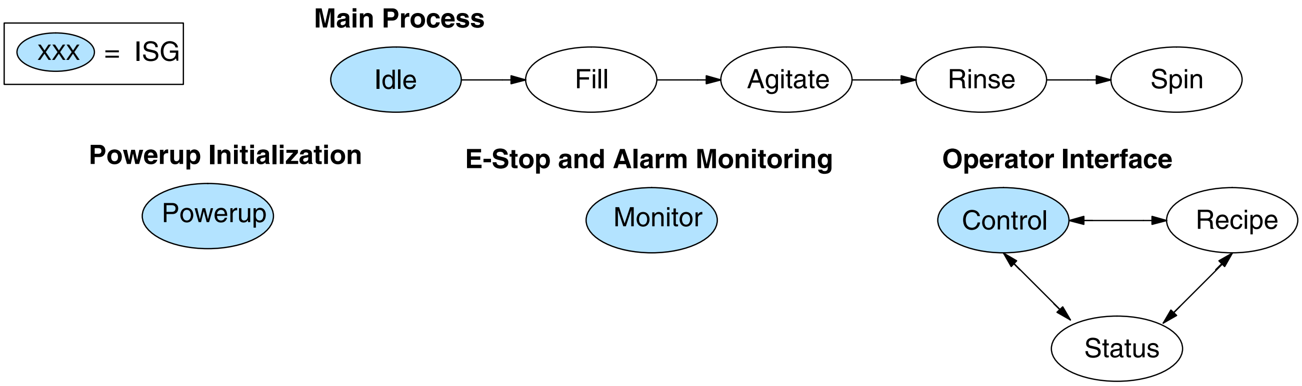


Stage Program Design Considerations

Stage Program Organization

The examples so far in this chapter used one self-contained state diagram to represent the main process. However, we can have multiple processes implemented in stages, all in the same ladder program. New stage programmers sometimes try to turn a stage on and off each scan, based on the false assumption that only one stage can be on at a time. For ladder rungs that you want to execute each scan, just put them in a stage that is always on.

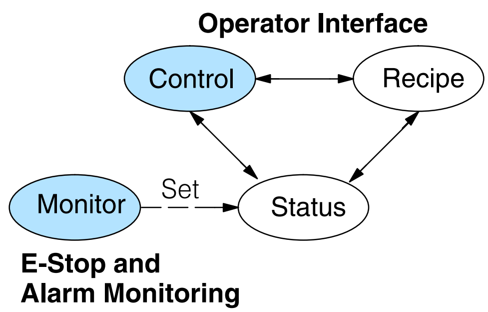
The following figure shows a typical application. During operation, the primary manufacturing activity Main Process, Powerup Initialization, E-Stop and Alarm Monitoring, and Operator Interface are all running. At powerup, three initial stages shown begin operation.



In a typical application, the separate stage sequences above operate as follows:

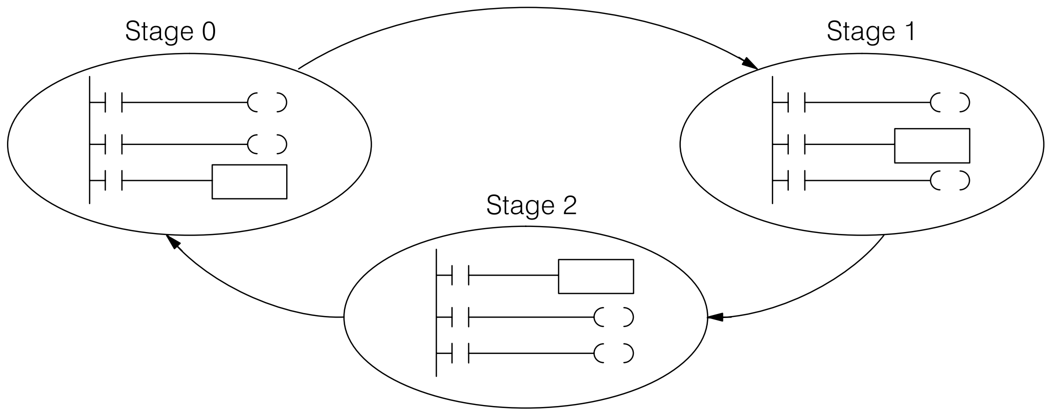
- **Powerup Initialization** – This stage contains ladder rung tasks done just once at powerup. Its last rung resets the stage, so this stage is only active for one scan (or only as many scans that are required).
- **Main Process** – this stage sequence controls the heart of the process or machine. One pass through the sequence represents one part cycle of the machine, or one batch in the process.
- **E-Stop and Alarm Monitoring** – This stage is always active because it is watching for errors that could indicate an alarm condition or require an emergency stop. It is common for this stage to reset stages in the main process or elsewhere, in order to initialize them after an error condition.
- **Operator Interface** – this is another task that must always be active and ready to respond to an operator. It allows an operator interface to change modes, etc. independently of the current main process step.

Although we have separate processes, there can be coordination among them. For example, in an error condition, the Status Stage may want to automatically switch the operator interface to the status mode to show error information as shown to the right. The monitor stage could set the stage bit for Status and Reset the stages Control and Recipe.



How Instructions Work Inside Stages

We can think of states or stages as simply dividing up our ladder program as depicted in the figure below. Each stage contains only the ladder rungs which are needed for the corresponding state of the process. The logic for transitioning out of a stage is contained within that stage. It's easy to choose which ladder rungs are active at powerup by using an "initial" stage type (ISG).



Most all instructions work just like they do in standard RLL. You can think of a stage just like a miniature RLL program which is either active or inactive.

Output Coils – As expected, output coils in active stages will turn on or off outputs according to power flow into the coil. However, note the following:

- Outputs work as usual, provided each output reference (such as "Y3") is used in only one stage.
- An output can be referenced from more than one stage, as long as only one of the stages is active at a time.
- If an output coil is controlled by more than one stage simultaneously, the active stage nearest the bottom of the program determines the final output status during each scan. Therefore, use the OROUT instruction instead when you want multiple stages to have a logical OR control of an output.

One-Shot or PD coils – Use care if you must use a Positive Differential coil in a stage. Remember that the input to the coil must make a 0–1 transition. If the coil is already energized on the first scan when the stage becomes active, the PD coil will not work. This is because the 0–1 transition did not occur.

PD coil alternative: If there is a task which you want to do only once (on 1 scan), it can be placed in a stage which transitions to the next stage on the same scan.

Counter – In using a counter inside a stage, the stage must be active for one scan before the input to the counter makes a 0–1 transition. Otherwise, there is no real transition and the counter will not count.

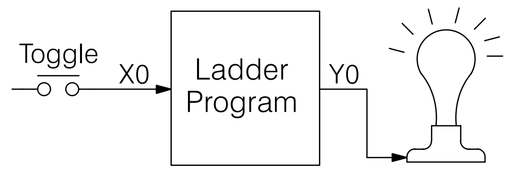
The ordinary Counter instruction does have a restriction inside stages: it may not be reset from other stages using the RST instruction for the counter bit. However, the special Stage Counter provides a solution (see next paragraph).

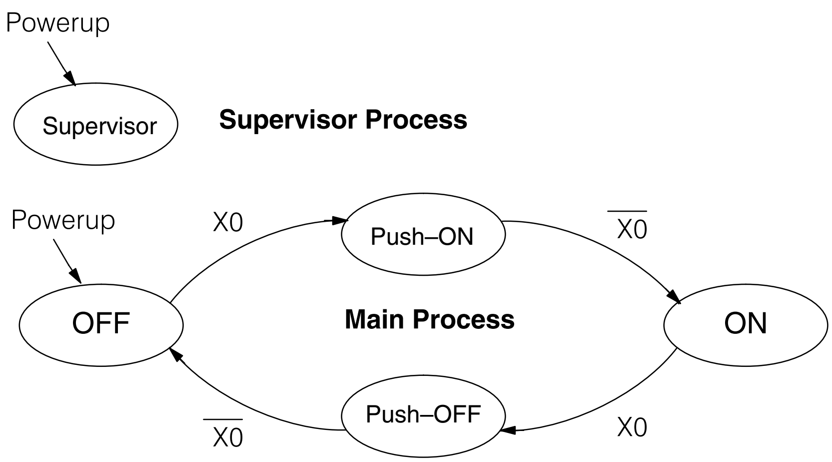
Stage Counter – The Stage Counter has the benefit that its count may be globally reset from other stages by using the RST instruction. It has a count input, but no reset input. This is the only difference from a standard counter.

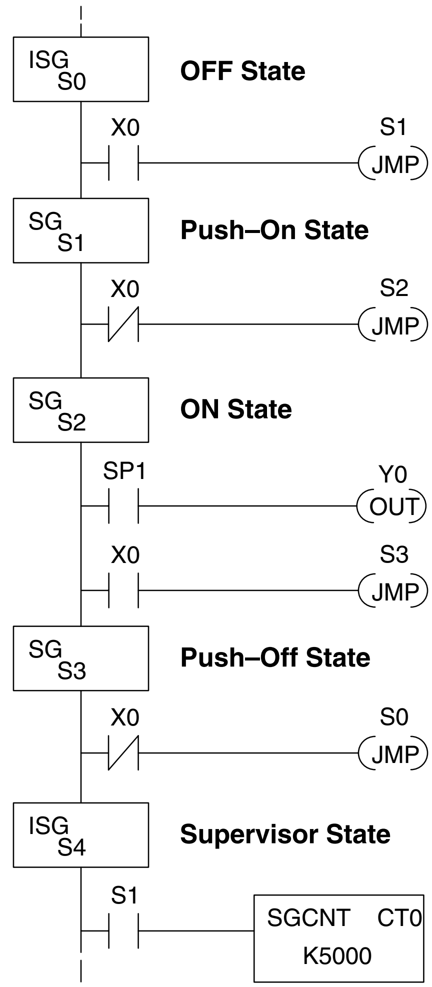
Drum – Realize that the drum sequencer is its own process, and is a different programming method than stage programming. If you need to use a drum with stages, be sure to place the drum instruction in an ISG stage that is always active.

Using a Stage as a Supervisory Process

You may recall the light bulb on-off controller example from earlier in this chapter. For the purpose of illustration, suppose we want to monitor the "productivity" of the lamp process, by counting the number of on-off cycles which occurs. This application will require the addition of a simple counter, but the key decision is in where to put the counter.







New stage programming students will typically try to place the counter inside one the the stages of the process they are trying to monitor. The problem with this approach is that the stage is active only part of the time. In order for the counter to count, the count input must transition from off to on at least one scan after its stage activates. Ensuring this requires extra logic that can be tricky.

In this case, we only need to add another supervisory stage as shown above, to "watch" the main process. The counter inside the supervisor stage uses the stage bit S1 of the main process as its count input. *Stage bits used as a contact let us monitor a process!*

Note that both the Supervisor stage and the OFF stage are initial stages. The supervisor stage remains active indefinitely.

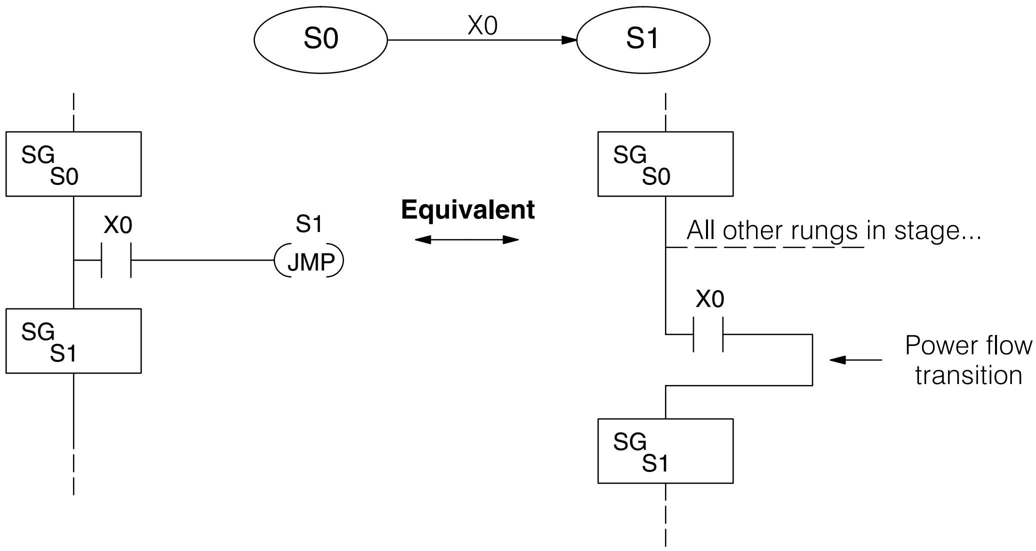
Stage Counter

The counter in the above example is a special Stage Counter. Note that it does not have a reset input. The count is reset by executing a Reset instruction, naming the counter bit (CT0 in this case). The Stage Counter has the benefit that its count may be globally reset from other stages. The standard Counter instruction does not have this global reset capability. You may still use a regular Counter instruction inside a stage... however, the reset input to the counter is the only way to reset it.

Power Flow Transition Technique

Our discussion of state transitions has shown how the stage JMP instruction makes the current stage inactive and the next stage (named in the JMP) active. As an alternative way to enter this in ***Direct***SOFT32, you may use the power flow method for stage transitions.

The main requirement is that the current stage be located directly above the next (jump-to) stage in the ladder program. This arrangement is shown in the diagram below, by stages S0 and S1, respectively.

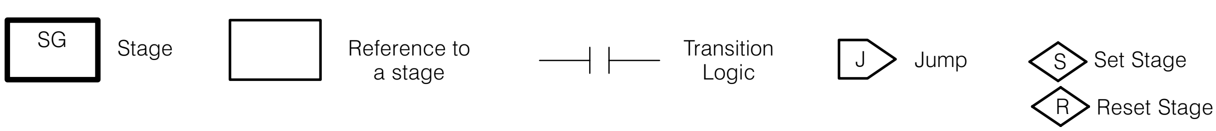


Recall that the stage JMP instruction may occur anywhere in the current stage, and the result is the same. However, power flow transitions (shown above) must occur as the last rung in a stage. All other rungs in the stage will precede it. The power flow transition method is also achievable on the handheld programmer, by simply following the transition condition with the stage instruction for the next stage.

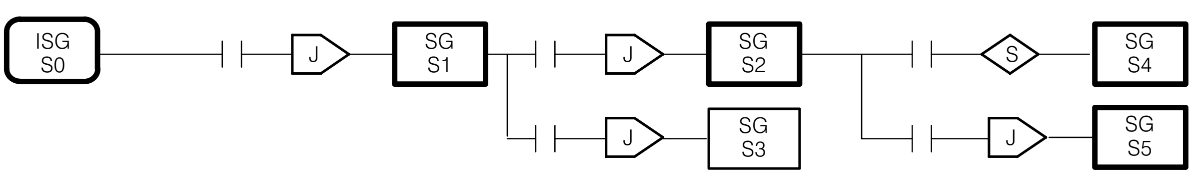
The power flow transition method does eliminate one stage JMP instruction, its only advantage. However, it is not as easy to make program changes as using the stage JMP. Therefore, we advise using stage JMP transitions for most programmers.

Stage View in DirectSOFT32

The stage View option in ***Direct***SOFT32 will let you view the ladder program as a flow chart. The figure below shows the symbol convention used in the diagrams. You may find the stage view useful as a tool to verify that your stage program has faithfully reproduced the logic of the state transition diagram you intend to realize.



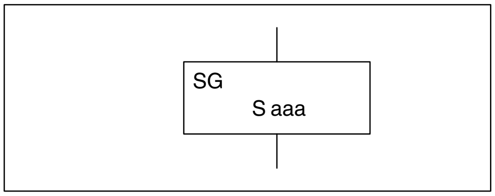
The following diagram is a typical stage view of a ladder program containing stages. Note the left-to-right direction of the flow chart.



RLL^{PLUS} Stage Instructions

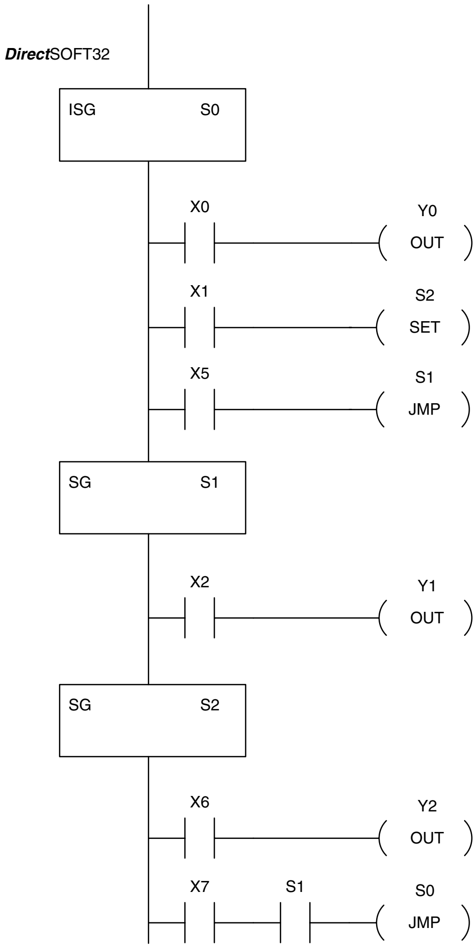
Stage (SG)

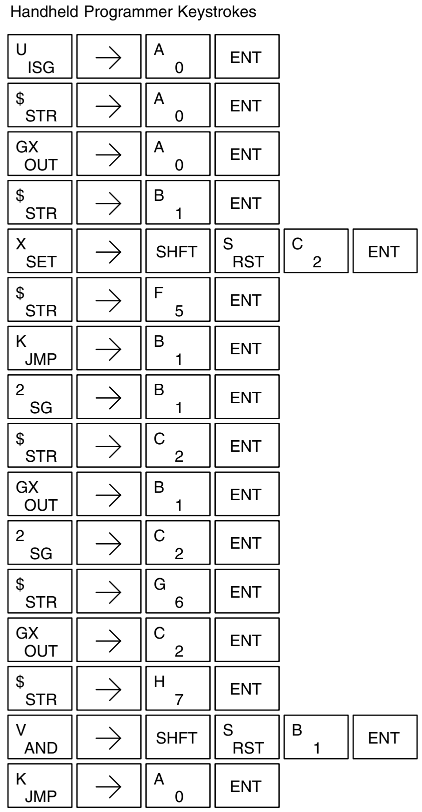
The Stage instructions are used to create structured RLL^{PLUS} programs. Stages are program segments which can be activated by transitional logic, a jump or a set stage that is executed from an active stage. Stages are deactivated one scan after transitional logic, a jump, or a reset stage instruction is executed.



Operand Data Type		DL130 Range
		aaa
Stage	S	0–377

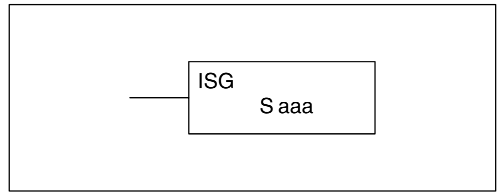
The following example is a simple RLL^{PLUS} Stage program. This program utilizes an initial stage, and jump instructions to create a structured program.





Initial Stage (ISG)

The Initial Stage instruction is normally used as the first segment of an RLL *PLUS* Stage program. Multiple Initial Stages are allowed in a program. They will be active when the CPU enters the Run mode allowing for a starting point in the program.

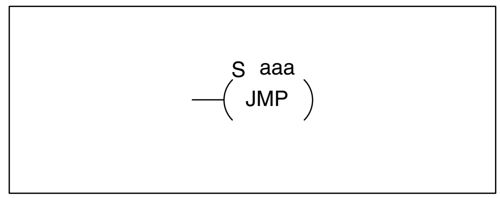


Operand Data Type		DL130 Range
		aaa
Stage	S	0–377

Initial Stages are also activated by transitional logic, a jump or a set stage executed from an active stage.

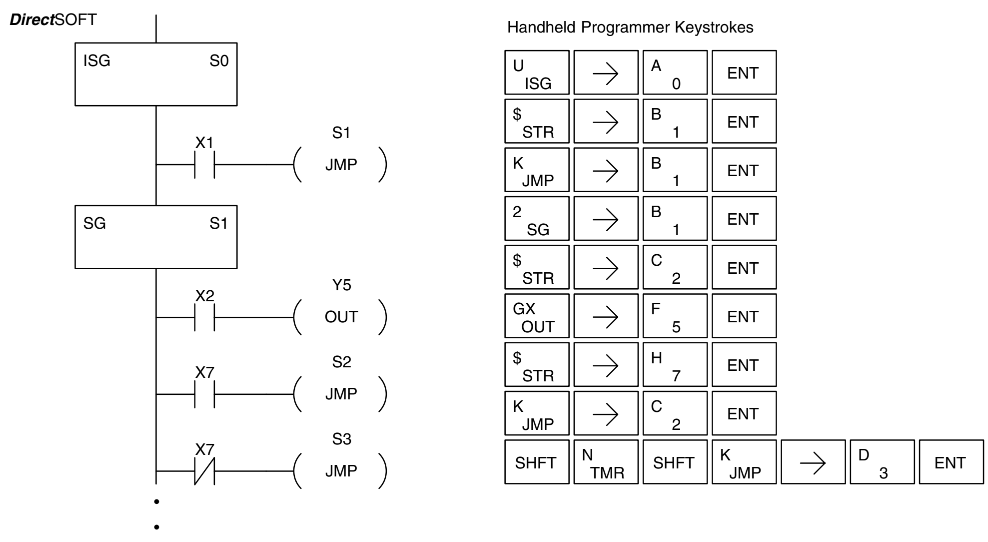
JUMP (JMP)

The Jump instruction allows the program to transition from an active stage containing the jump instruction to another stage (specified in the instruction). The jump occurs when the input logic is true. The active stage containing the Jump will deactivate 1 scan later.



Operand Data Type		DL130 Range
		aaa
Stage	S	0–377

In the following example, only stage ISG0 will be active when program execution. begins. When X1 is on, program execution will jump from Initial Stage 0 to Stage 1.



NOTE: The F1–130 CPU does not have the Not Jump instruction (as does other PLC families). You may still achieve the same result by using the Jump instruction, while inverting the sense of contact logic that activates that instruction.

Questions and Answers about Stage Programming

We include the following commonly-asked questions about Stage Programming as an aid to new students. All question topics are covered in more detail in this chapter.

Q. What does stage programming do that I can't do with regular RLL programs?

A. Stages allow you to identify all the states of your process before you begin programming. This approach is more organized, because you divide up a ladder program into sections. As stages, these program sections are active only when they are actually needed by the process. Most processes can be organized into a sequence of stages, connected by event-based transitions.

Q. Isn't a stage really just like a software subroutine?

A. No, it is very different. A subroutine is called by a main program when needed, and executes just once before returning to the point from which it was called. A stage, however, is part of the main program. It represents a state of the process, so an active stage executes on every scan of the CPU until it becomes inactive.

Q. What are Stage Bits?

A. A stage bit is just a single bit in the CPU's image register, representing the active/inactive status of the stage in real time. For example, the bit for Stage 0 is referenced as "S0". If S0 = 0, then the ladder rungs in Stage 0 are bypassed (not executed) on each CPU scan. If S0 = 1, then the ladder rungs in Stage 0 are executed on each CPU scan. Stage bits, when used as contacts, allow one part of your program to monitor another part by detecting stage active/inactive status.

Q. How does a stage become active?

A. There are three ways:

- If the Stage is an initial stage (ISG), it is automatically active at powerup.
- Another stage can execute a stage JMP instruction naming this stage, which makes it active upon its next occurrence in the program.
- A program rung can execute a Set Stage Bit instruction (such as Set S0).

Q. How does a stage become inactive?

A. There are three ways:

- Standard Stages (SG) are automatically inactive at powerup.
- A stage can execute a stage JMP instruction, resetting its Stage Bit to 0.
- Any rung in the program can execute a Reset Stage Bit instruction (such as Reset S0).

Q. What about the power flow technique of stage transitions?

A. The power flow method of connecting adjacent stages (directly above or below in the program) actually is the same as the stage Jump instruction executed in the stage above, naming the stage below. Power flow transitions are more difficult to edit in ***Direct***SOFT32, we list them separately from two preceding questions.

Q. Can I have a stage which is active for only one scan?

A. Yes, but this is not the intended use for a stage. Instead, just make a ladder rung active for 1 scan by including a stage Jump instruction at the bottom of the rung. Then the ladder will execute on the last scan before its stage jumps to a new one.

Q. Isn't a stage JMP just like a regular GOTO instruction used in software?

A. No, it is very different. A GOTO instruction sends the program execution immediately to the code location named by the GOTO. A stage JMP simply resets the stage Bit of the current stage, while setting the stage Bit of the stage named in the JMP instruction. Stage bits are 0 or 1, determining the inactive/active status of the corresponding stages. A stage JMP has the following results:

- When the JMP is executed, the remainder of the current stage's rungs are executed, even if they reside past(under) the JMP instruction. On the following scan, that stage is not executed, because it is inactive.
- The stage named in the stage JMP instruction will be executed upon its next occurrence. If located past (under) the current stage, it will be executed on the same scan. If located before (above) the current stage, it will be executed on the following scan.

Q. How can I know when to use stage JMP, versus a Set Stage Bit or Reset Stage Bit?

A. These instructions are used according to the state diagram topology you have derived:

- Use a stage JMP instruction for a state transition... moving from one state to another.
- Use a Set Stage Bit instruction when the current state is spawning a new parallel state or stage sequence, or when a supervisory state is starting a state sequence under its command.
- Use a Reset Bit instruction when the current state is the last state in a sequence and its task is complete, or when a supervisory state is ending a state sequence under its command.

Q. What is an initial stage, and when do I use it?

A. An initial stage (ISG) is automatically active at powerup. Afterwards, it works just like any other stage. You can have multiple initial stages, if required. Use an initial stage for ladder that must always be active, or as a starting point.

Q. Can I have place program ladder rungs outside of the stages, so they are always on?

A. It is possible, but it's not good software design practice. Place ladder that must always be active in an initial stage, and do not reset that stage or use a stage JMP instruction inside it. It can start other stage sequences at the proper time by setting the appropriate stage Bit(s).

Q. Can I have more than one active stage at a time?

A. Yes, and this is a normal occurrence for many programs. However, it is important to organize your application into separate processes, each made up of stages. And a good process design will be mostly sequential, with only one stage on at a time. However, all the processes in the program may be active simultaneously.

8

Maintenance and Troubleshooting

In This Chapter. . . .

Hardware System Maintenance

Standard Maintenance

No regular or preventative maintenance is required for this product (there are no internal batteries); however, a routine maintenance check (about every one or two months) of your PLC and control system is good practice, and should include the following items:

- **Air Temperature** – Check the air temperature in the control cabinet, so the operating temperature range of any component is not exceeded.
- **Air Filter** – If the control cabinet has an air filter, clean or replace it periodically as required.
- **Fuses or breakers** – verify that all fuses and breakers are intact.
- **DL105 Air Vents** – check that all air vents are clear. If the exterior case needs cleaning, disconnect the input power, and carefully wipe the case using a damp cloth. Do not let water enter the case through the air vents and do not use strong detergents because this may discolor the case.

Diagnostics

Diagnostics

Your DL105 Micro PLC performs many pre-defined diagnostic routines with every CPU scan. The diagnostics can detect various errors or failures in the PLC. The two primary error classes are *fatal* and *non-fatal*.

Fatal Errors

Fatal errors are errors which may cause the system to function improperly, perhaps introducing a safety problem. The CPU will automatically switch to Program Mode if it is in Run Mode. (Remember, in Program Mode all outputs are turned off.) If the fatal error is detected while the CPU is in Program Mode, the CPU will not allow you to transition to Run Mode until the error has been corrected.

Some examples of fatal errors are:

- Power supply failure
- Parity error or CPU malfunction
- Particular programming errors

Non-fatal Errors

Non-fatal errors are errors that need your attention, but should not cause improper operation. They do not cause or prevent any mode transitions of the CPU. The application program can use special relay contacts to detect non-fatal errors, and even take the system to an orderly shutdown or switch the CPU to Program Mode if desired. An example of a non-fatal error is:

- Particular programming errors

Finding Diagnostic Information

The programming devices will notify you of an error if one occurs while online.

- ***Direct***SOFT32 provides the error number and an error message.
- The handheld programmer displays error numbers and short descriptions of the error.

Appendix B has a complete list of error messages in order by error number.

Many error messages point to supplemental V-memory locations which contain related information. Special relays (SP contacts) also provide error indications.

V-memory Error Code Locations

The following table names the specific memory locations that correspond to certain types of error messages.

Error Class	Error Category	Diagnostic V-memory
User-Defined	Error code used with FAULT instruction	V7751
System Error	Fatal Error code	V7755
	Major Error code	V7756
	Minor Error code	V7757
Grammatical	Address where syntax error occurs	V7763
	Error Code found during syntax check	V7764
CPU Scan	Number of scans since last Program to Run Mode transition	V7765
	Current scan time (ms)	V7775
	Minimum scan time (ms)	V7776
	Maximum scan time (ms)	V7777

Special Relays (SP) Corresponding to Error Codes

The special relay table also includes status indicators which can indicate errors. For a more detailed description of each of these special relays refer to Appendix D.

CPU Status Relays	
SP12	Terminal Run mode
SP16	Terminal Program mode
SP20	STOP instruction was executed
SP22	Interrupt enabled
System Monitoring Relays	
SP40	Critical error
SP41	Non-critical error
SP44	Program memory error
SP50	Fault instruction was executed
SP51	Watchdog timeout
SP52	Syntax error
SP53	Cannot solve the logic

Accumulator Status Relays	
SP60	Acc. is less than value
SP61	Acc. is equal to value
SP62	Acc. is greater than value
SP63	Acc. result is zero
SP64	Half borrow occurred
SP65	Borrow occurred
SP66	Half carry occurred
SP67	Carry occurred
SP70	Result is negative (sign)
SP71	Pointer reference error
SP73	Overflow
SP75	Data is not in BCD
SP76	Load zero

DL105 Micro PLC Error Codes

These errors can be generated by the CPU or by the Handheld Programmer, depending on the actual error. Appendix B provides a more complete description of the error codes.

The errors can be detected at various times. However, most of them are detected at power-up, on entry to Run Mode, or when a Handheld Programmer key sequence results in an error or an illegal request.

Error Code	Description
E003	Software time-out
E004	Invalid instruction (RAM parity error in the CPU)
E099	Program memory exceeded
E151	Invalid command
E155	RAM failure
E210	Power fault
E312	Communications error 2
E313	Communications error 3
E316	Communications error 6
E320	Time out
E321	Communications error
E501	Bad entry
E502	Bad address
E503	Bad command
E504	Bad reference / value
E505	Invalid instruction
E506	Invalid operation
E520	Bad operation – CPU in Run
E524	Bad operation – CPU in Program

Error Code	Description
E526	Unit is offline
E527	Unit is online
E528	CPU mode
E540	CPU locked
E541	Wrong password
E542	Password reset
E601	Memory full
E602	Instruction missing
E604	Reference missing
E620	Out of memory
E621	EEPROM Memory not blank
E622	No Handheld Programmer EEPROM
E624	V memory only
E625	Program only
E627	Bad write operation
E628	Memory type error (should be EEPROM)
E640	Mis-compare
E650	Handheld Programmer system error
E651	Handheld Programmer ROM error
E652	Handheld Programmer RAM error

Program Error Codes

The following table lists program syntax and runtime error codes. Error detection occurs during a Program-to-Run mode transition, or when you use AUX 21 – Check Program. The CPU will also turn on SP52 and store the error code in V7755. Appendix B provides a more complete description of the error codes.

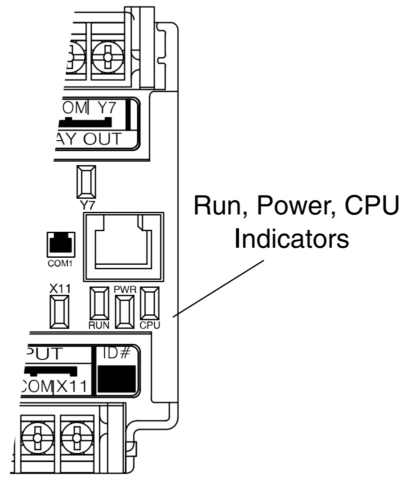
Error Code	Description
E4**	No Program in CPU
E401	Missing END statement
E402	Missing LBL
E406	Missing IRT
E421	Duplicate stage reference
E422	Duplicate SBR/LBL reference
E431	Invalid ISG/SG address
E436	Invalid INT address
E438	Invalid IRT address
E440	Invalid Data Address
E441	ACON/NCON
E451	Bad MLS/MLR

Error Code	Description
E452	X input used as output coil
E453	Missing T/C
E454	Bad TMRA
E455	Bad CNT
E456	Bad SR
E461	Stack Overflow
E462	Stack Underflow
E463	Logic Error
E464	Missing Circuit
E471	Duplicate coil reference
E472	Duplicate TMR reference
E473	Duplicate CNT reference

CPU Indicators

The DL105 Micro PLCs have indicators on the front to help you diagnose problems with the system. In normal runtime operation only the RUN and PWR indicators are on. The table below is a quick reference to potential problems.

Indicator Status	Potential Problems
PWR (LED off)	1. System voltage incorrect 2. PLC power supply faulty
RUN (LED off)	1. CPU programming error 2. (CPU in program mode)
CPU (LED on)	1. Electrical noise interference 2. Internal CPU defective

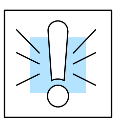


PWR Indicator

In general there are three reasons for the CPU power status LED (PWR) to be OFF:

1. Power to the unit is incorrect or is not applied.
2. PLC power supply is faulty.
3. Other component(s) have the power supply shut down.

If the voltage to the power supply is not correct, the PLC may not operate properly or may not operate at all. Use the following guidelines to correct the problem.



WARNING: To minimize the risk of electrical shock, always disconnect the system power before inspecting the physical wiring.

1. First, disconnect the external power.
2. Verify that all external circuit breakers or fuses are still intact.
3. Check all incoming wiring for loose connections. If you’re using a separate termination block, check those connections for accuracy and integrity.
4. If the connections are acceptable, reconnect the system power and verify the voltage at the DL105 power input is within specification. If the voltage is not correct shut down the system and correct the problem.
5. If all wiring is connected correctly and the incoming power is within the specifications, the PLC internal supply may be faulty.

The best way to check for a faulty PLC is to substitute a known good one to see if this corrects the problem. The removable connectors on the DL105 make this relatively easy. If there has been a major power surge, it is possible the PLC internal power supply has been damaged. If you suspect this is the cause of the power supply damage, consider installing an AC line conditioner to attenuate damaging voltage spikes in the future.

RUN Indicator

If the CPU will not enter the Run mode (the RUN indicator is off), the problem is usually in the application program, unless the CPU has a fatal error. If a fatal error has occurred, the CPU LED should be on. (You can use a programming device to determine the cause of the error.)

Both of the programming devices, Handheld Programmer and ***Direct***SOFT32, will return an error message describing the problem. Depending on the error, there may also be an AUX function you can use to help diagnose the problem. The most common programming error is “Missing END Statement”. All application programs require an END statement for proper termination. A complete list of error codes can be found in Appendix B.

CPU Indicator

If the CPU indicator is on, a fatal error has occurred in the CPU. Generally, this is not a programming problem but an actual hardware failure. You can power cycle the system to clear the error. If the error clears, you should monitor the system and determine what caused the problem. You will find this problem is sometimes caused by high frequency electrical noise introduced into the CPU from an outside source. Check your system grounding and install electrical noise filters if the grounding is suspected. If power cycling the system does not reset the error, or if the problem returns, you should replace the CPU.

Communications Problems

If you cannot establish communications with the CPU, check these items.

- The cable is disconnected.
- The cable has a broken wire or has been wired incorrectly.
- The cable is improperly terminated or grounded.
- The device connected is not operating at the correct baud rate (9600 baud).
- The device connected to the port is sending data incorrectly.
- A grounding difference exists between the two devices.
- Electrical noise is causing intermittent errors.
- The PLC has a bad communication port and should be replaced.

For problems in communicating with ***Direct***SOFT32 on a personal computer, refer to the ***Direct***SOFT32 manual. It includes a troubleshooting section that can help you diagnose PC problems in communications port setup, address or interrupt conflicts, etc.

I/O Point Troubleshooting

Possible Causes

If you suspect an I/O error, there are several things that could be causing the problem.

- High-Speed I/O configuration error
- A blown fuse in your machine or panel (the DL105 does not have internal I/O fuses)
- A loose terminal block
- The auxiliary 24 VDC supply has failed
- The Input or Output Circuit has failed

Some Quick Steps

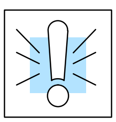
When troubleshooting the DL105 Micro PLCs there are a few facts you should be aware of. These facts may assist you in quickly correcting an I/O problem.

- HSIO configuration errors are commonly mistaken for I/O point failure during program development. If the I/O point in question is in X0–X3, or Y0–Y2, check all parameter locations listed in Chapter 3 that apply to the HSIO mode you have selected.
- The output circuits cannot detect shorted or open output points. If you suspect one or more faulty points, measure the voltage drop from the common to the suspect point. Remember when using a Digital Volt Meter, leakage current from an output device such as a triac or a transistor must be considered. A point which is off may appear to be on if no load is connected the point.
- The I/O point status indicators are logic-side indicators. This means the LED which indicates the on or off status reflects the status of the point with respect to the CPU. On an output point the status indicators could be operating normally while the actual output device (transistor, triac etc.) could be damaged. With an input point, if the indicator LED is on the input circuitry is probably operating properly. Verify the LED goes off when the input signal is removed.
- Leakage current can be a problem when connecting field devices to an I/O point. False input signals can be generated when the leakage current of an output device is great enough to turn on the connected input device. To correct this install a resistor in parallel with the input or output of the circuit. The value of this resistor will depend on the amount of leakage current and the voltage applied but usually a 10K to 20KΩ resistor will work. Verify the wattage rating of the resistor is correct for your application.
- Because of the removable terminal blocks on the DL105, the easiest method to determine if an I/O circuit has failed is to replace the unit if you have a spare. However, if you suspect a field device is defective, that device may cause the same failure in the replacement PLC as well. As a point of caution, you may want to check devices or power supplies connected to the failed I/O circuit before replacing the unit with a spare.

Testing Output Points

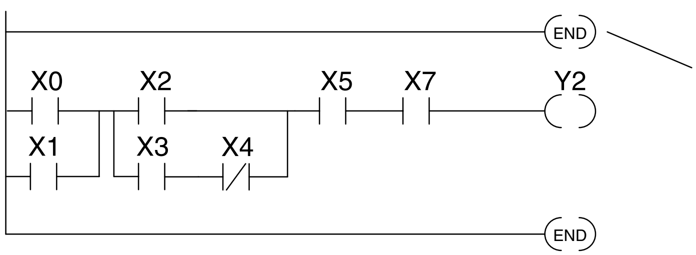
Output points can be set on or off in the DL105 series CPUs. If you want to do an I/O check out independent of the application program, follow the procedure below:

Step	Action
1	Use a handheld programmer or ***Direct***SOFT32 to communicate online to the PLC.
2	Change to Program Mode.
3	Go to address 0.
4	Insert an “END” statement at address 0. (This will cause program execution to occur only at address 0 and prevent the application program from turning the I/O points on or off).
5	Change to Run Mode.
6	Use the programming device to set (turn) on or off the points you wish to test.
7	When you finish testing I/O points delete the “END” statement at address 0.



WARNING: Depending on your application, forcing I/O points may cause unpredictable machine operation that can result in a risk of personal injury or equipment damage. Make sure you have taken all appropriate safety precautions prior to testing any I/O points.

Handheld Programmer Keystrokes Used to Test an Output Point



Insert an END statement at the beginning of the program. This disables the remainder of the program.

From a clear display, use the following keystrokes

STAT ENT

```
16P STATUS
BIT REF   X
```

Use the PREV or NEXT keys to select the Y data type

NEXT A 0 ENT

```
  Y  10   Y   0
□□□□□□□□□□□□□□□□
```

Y2 is now on

Use arrow keys to select point, then use ON and OFF to change the status

← ← SHFT ON INS

```
  Y  10   Y   0
□□□□□□□□□□□□□■□□
```

Noise Troubleshooting

Electrical Noise Problems

Noise is one of the most difficult problems to diagnose. Electrical noise can enter a system in many different ways and they fall into one of two categories, conducted or radiated. It may be difficult to determine how the noise is entering the system but the corrective actions for either of the types of noise problems are similar.

- Conducted noise is when the electrical interference is introduced into the system by way of a attached wire, panel connection ,etc. It may enter through an I/O circuit, a power supply connection, the communication ground connection, or the chassis ground connection.
- Radiated noise is when the electrical interference is introduced into the system without a direct electrical connection, much in the same manner as radio waves.

Reducing Electrical Noise

While electrical noise cannot be eliminated it can be reduced to a level that will not affect the system.

- Most noise problems result from improper grounding of the system. A good earth ground can be the single most effective way to correct noise problems. If a ground is not available, install a ground rod as close to the system as possible. Ensure all ground wires are single point grounds and are not daisy chained from one device to another. Ground metal enclosures around the system. A loose wire can act as a large antenna, introducing noise into the system. Therefore, tighten all connections in your system. Loose ground wires are more susceptible to noise than the other wires in your system. Review Chapter 2 Installation, Wiring, and Specifications if you have questions regarding how to ground your system.
- Electrical noise can enter the system through the power source for the PLC and I/O circuits. Installing an isolation transformer for all AC sources can correct this problem. DC sources should be well-grounded good quality supplies.
- Separate input wiring from output wiring. Never run low-voltage I/O wiring close to high voltage wiring.

Machine Startup and Program Troubleshooting

The DL105 Micro PLCs provide several features that can help you debug your program before and during machine startup. This section discusses the following topics which can be very helpful.

- Program Syntax Check
- Duplicate Reference Check
- Special Instructions
- Run Time Edits
- Forcing I/O Points

Syntax Check

Even though the Handheld Programmer and ***Direct***SOFT32 provide error checking during program entry, you may want to check a program that has been modified. Both programming devices offer a way to check the program syntax. For example, you can use AUX 21, CHECK PROGRAM to check the program syntax from a Handheld Programmer, or you can use the PLC Diagnostics menu option within ***Direct***SOFT32. This check will find a wide variety of programming errors. The following example shows how to use the syntax check with a Handheld Programmer.

Use AUX 21 to perform syntax check

CLR C 2 B 1 AUX ENT

```
AUX 21 CHECK PRO
1:SYN 2:DUP REF
```

Select syntax check (default selection)

ENT

(You may not get the busy display if the program is not very long.)

```
BUSY
```

One of two displays will appear

Error Display (example)

```
$00050 E401
MISSING END
```

(shows location in question)

Syntax OK display

```
NO SYNTAX ERROR
?
```

See the Error Codes Section for a complete listing of programming error codes. If you get an error, just press CLR and the Handheld will display the instruction where the error occurred. Correct the problem and continue running the Syntax check until the NO SYNTAX ERROR message appears.

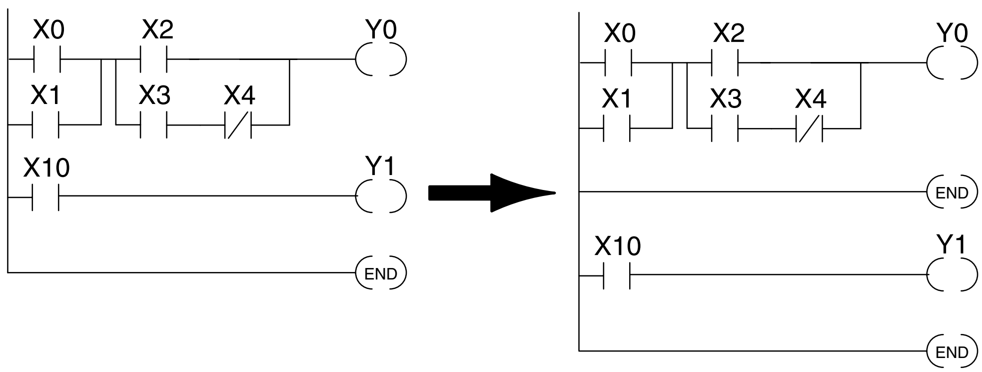
Special Instructions

There are several instructions that can be used to help you debug your program during machine startup operations.

- END
- PAUSE
- STOP

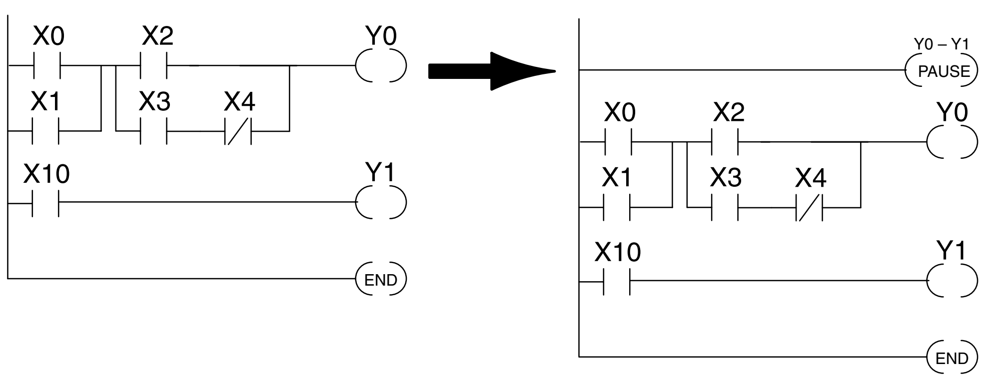
END Instruction: If you need a way to quickly disable part of the program, just insert an END statement prior to the portion that should be disabled. When the CPU encounters the END statement, it assumes that is the end of the program. The following diagram shows an example.

Normal Program | New END disables X10 and Y1



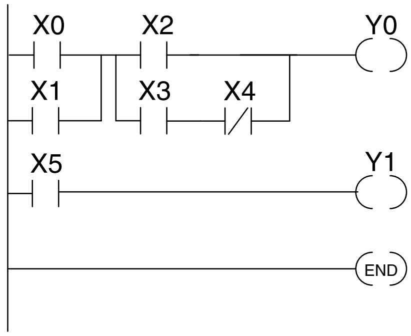
PAUSE Instruction: This instruction provides a quick way to allow the inputs (or other logic) to operate while disabling selected outputs. The output image register is still updated, but the output circuits are not. For example, you could make this conditional by adding an input contact or CR to control the instruction with a switch or a programming device. Or, you could just add the instruction without any conditions so the selected outputs would be disabled at all times.

Normal Program | PAUSE disables Y0 and Y1

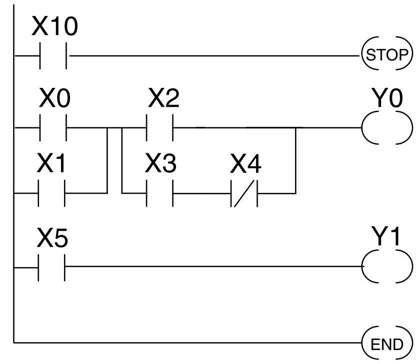


STOP Instruction: Sometimes during machine startup you need a way to quickly turn off all the outputs and return to Program Mode. You can use the STOP instruction. When this instruction is executed the CPU automatically exits Run Mode and enters Program Mode. Remember, all outputs are turned off during Program Mode. The following diagram shows an example of a condition that returns the CPU to Program Mode.

Normal Program



STOP puts CPU in Program Mode



In the example shown above, you could trigger X10 which would execute the STOP instruction. The CPU would enter Program Mode and all outputs would be turned off.

Duplicate Reference Check

You can also check for multiple uses of the same output coil. Both programming devices offer a way to check for this condition.. For example, you can AUX 21, CHECK PROGRAM to check for duplicate references from a Handheld Programmer, or you can use the PLC Diagnostics menu option within ***Direct***SOFT32. The following example shows how to perform the duplicate reference check with a Handheld Programmer.

Use AUX 21 to perform syntax check

CLR | C 2 | B 1 | AUX | ENT

```
AUX 21 CHECK PRO
1:SYN 2:DUP REF
```

Select duplicate reference check

→ | ENT (You may not get the busy display if the program is not very long.)

```
BUSY
```

One of two displays will appear

Error Display (example)
(shows location in question)

```
$00024 E471
DUP COIL REF
```

Syntax OK display

```
NO DUP REFS
?
```

If you get an error, just press CLR and the Handheld will display the instruction where the error occurred. Correct the problem and continue running the Duplicate Reference check until no duplicate references are found.

NOTE: You can use the same coil in more than one location, especially in programs containing Stage instructions and / or OROUT instructions. The Duplicate Reference check will find occurrences, even though they are acceptable.

Run Time Edits

The DL105 Micro PLC allows you to make changes to the application program during Run Mode. These edits are not “bumpless.” Instead, CPU scan is momentarily interrupted (and the outputs are maintained in their current state) until the program change is complete. This means if the output is off, it will remain off until the program change is complete. If the output is on, it will remain on.

WARNING: Only authorized personnel fully familiar with all aspects of the application should make changes to the program. Changes during Run Mode become effective immediately. Make sure you thoroughly consider the impact of any changes to minimize the risk of personal injury or damage to equipment. There are some important operational changes during Run Time Edits.

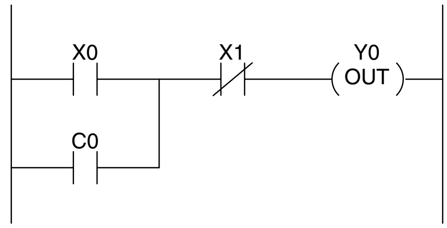
1. If there is a syntax error in the new instruction, the CPU *will not* enter the Run Mode.
2. If you delete an output coil reference and the output was on at the time, the output will remain on until it is forced off with a programming device.
3. Input point changes are not acknowledged during Run Time Edits. So, if you’re using a high-speed operation and a critical input comes on, the CPU may not see the change.

Not all instructions can be edited during a Run Time Edit session. The following list shows the instructions that can be edited.

Mnemonic	Description
TMR	Timer
TMRF	Fast timer
TMRA	Accumulating timer
TMRAF	Accumulating fast timer
CNT	Counter
UDC	Up / Down counter
SGCNT	Stage counter
STR, STRN	Store, Store not
AND, ANDN	And, And not
OR, ORN	Or, Or not
STRE, STRNE	Store equal, Store not equal
ANDE, ANDNE	And equal, And not equal
ORE, ORNE	Or equal, Or not equal
STR, STRN	Store greater than or equal Store less than
AND, ANDN	And greater than or equal And less than

Mnemonic	Description
OR, ORN	Or greater than or equal Or less than
LD	Load data (constant)
LDD	Load data double (constant)
ADDD	Add data double (constant)
SUBD	Subtract data double (constant)
MUL	Multiply (constant)
DIV	Divide (constant)
CMPD	Compare accumulator (constant)
ANDD	And accumulator (constant)
ORD	Or accumulator (constant)
XORD	Exclusive or accumulator (constant)
LDF	Load discrete points to accumulator
OUTF	Output accumulator to discrete points
SHFR	Shift accumulator right
SHFL	Shift accumulator left
NCON	Numeric constant

We'll use the program logic shown to describe how this process works. In the example, we'll change X0 to C10. Note, the example assumes you have already placed the CPU in Run Mode.



Use the MODE key to select Run Time Edits

MODE NEXT NEXT ENT

```
*MODE CHANGE*
RUN TIME EDIT?
```

Press ENT to confirm the Run Time Edits

ENT (Note, the RUN LED on the D2–HPP Handheld starts flashing to indicate Run Time Edits are enabled.)

```
*MODE CHANGE*
RUNTIME EDITS
```

Find the instruction you want to change (X0)

SHFT | X SET | A 0 | SHFT | FD REF FIND

```
$00000 STR X0
```

Press the arrow key to move to the X. Then enter the new contact (C10).

→ | → | SHFT | C 2 | B 1 | A 0 | ENT

```
RUNTIME EDIT?
STR C10
```

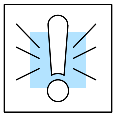
Press ENT to confirm the change

ENT (Note, once you press ENT, the next address is displayed.

```
OR C0
```

Forcing I/O Points

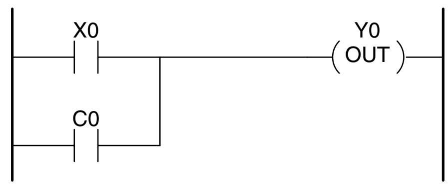
There are many times, especially during machine startup and troubleshooting, that you need the capability to force an I/O point to be either on or off. Before you use a programming device to force any data type it is important you understand how the DL105 CPUs process the forcing requests.



WARNING: Only authorized personnel fully familiar with the application should make program changes. Do thoroughly consider the impact of any changes to minimize the risk of personal injury or damage to equipment.

Bit Forcing — Bit forcing temporarily changes the status of a discrete bit. For example, you may want to force an input on even though the program has turned it off. This allows you to change the point status stored in the image register. The forced value will be valid until the CPU writes to the image register location during the next scan. This is useful you just need to force a bit on to trigger another event.

The following diagrams show a brief example of how you could use the D2–HPP Handheld Programmer to force an I/O point. The example assumes you have already placed the CPU into Run Mode.



From a clear display, use the following keystrokes

STAT ENT

```
16P STATUS
BIT REF   X
```

Use the PREV or NEXT keys to select the Y data type. (Once the Y appears, press 0 to start at Y0.)

NEXT A 0 ENT

```
  Y  10         Y    0
□ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □
```

Use arrow keys to select point, then use ON and OFF to change the status

← ← SHFT ON INS

Y2 is now on

```
  Y  10         Y    0
□ □ □ □ □ □ □ □ □ □ □ □ □ ■ □ □
```

Bit Forcing with Direct Access

From a blank display, use the following keystrokes to force Y7 ON

SHFT Y MLS H 7 SHFT ON INS

Solid fill indicates point is on.

```
BIT FORCE
Y7                    ■
```

From a blank display, use the following keystrokes to force Y7 OFF

SHFT Y MLS H 7 SHFT OFF DEL

No fill indicates point is off.

```
BIT FORCE
Y7                    □
```

Auxiliary Functions

A

In This Appendix. . . .

Introduction

Purpose of Auxiliary Functions

Many CPU setup tasks involve the use of Auxiliary (AUX) Functions. The AUX Functions perform many different operations, including clearing ladder memory, displaying the scan time, and copying programs to EEPROM in the handheld programmer. They are divided into categories that affect different system resources. You can access the AUX Functions from ***Direct***SOFT32 or from the D2–HPP Handheld Programmer. The manuals for those products provide step-by-step procedures for accessing the AUX Functions. Some of these AUX Functions are designed specifically for the Handheld Programmer setup, so they will not be needed (or available) with the ***Direct***SOFT32 package. Even though this Appendix provides many examples of how the AUX functions operate, you should supplement this information with the documentation for your choice of programming device. Note, the Handheld Programmer may have additional AUX functions that are not supported with the DL105 PLCs.

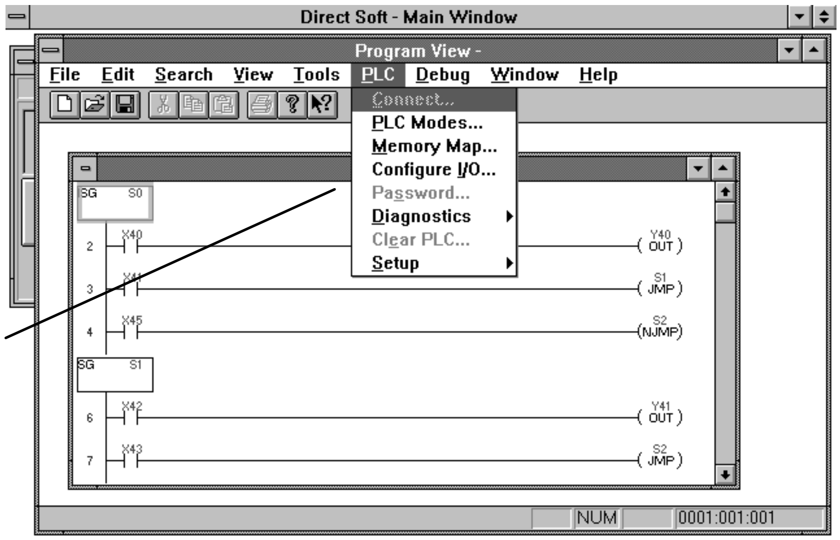
AUX Function and Description		DL105
AUX 2* — RLL Operations		
21	Check Program	❍
22	Change Reference	❍
23	Clear Ladder Range	❍
24	Clear All Ladders	❍
AUX 3* — V-Memory Operations		
31	Clear V Memory	❍
AUX 4* — I/O Configuration		
41	Show I/O Configuration	❍
AUX 5* — CPU Configuration		
51	Modify Program Name	❍
53	Display Scan Time	❍
54	Initialize Scratchpad	❍
55	Set Watchdog Timer	❍
57	Set Retentive Ranges	❍
58	Test Operations / Pause Override	❍
5B	HSIO Interface Configuration	❍

AUX Function and Description		DL105
AUX 6* — Handheld Programmer Configuration		
61	Show Revision Numbers	❍
62	Beeper On / Off	HP
65	Run Self Diagnostics	HP
AUX 7* — EEPROM Operations		
71	Copy CPU memory to HPP EEPROM	HP
72	Write HPP EEPROM to CPU	HP
73	Compare CPU to HPP EEPROM	HP
74	Blank Check (HPP EEPROM)	HP
75	Erase HPP EEPROM	HP
76	Show EEPROM Type (CPU and HPP)	HP
AUX 8* — Password Operations		
81	Modify Password	❍
82	Unlock CPU	❍
83	Lock CPU	❍

❍ — supported
HP — Handheld Programmer function

Accessing AUX Functions via *Direct*SOFT32

***Direct*SOFT32 provides various menu options during both online and offline programming. Some of the AUX functions are only available during online programming, some only during offline programming, and some during both online and offline programming. The following diagram shows and example of the PLC operations menu available within *Direct*SOFT32.



Menu Options

Accessing AUX Functions via the Handheld Programmer

You can also access the AUX functions by using a Handheld Programmer. Plus, remember some of the AUX functions are only available from the Handheld. Sometimes the AUX name or description cannot fit on one display. If you want to see the complete description, just press the arrow keys to scroll left and right. Also, depending on the current display, you may have to press CLR more than once.

CLR AUX

```
AUX FUNCTION SELECTION
AUX 2* RLL OPERATIONS
```

Use NXT or PREV to cycle through the menus

NEXT

```
AUX FUNCTION SELECTION
AUX 3* V OPERATIONS
```

Press ENT to select sub-menus

ENT

```
AUX 3* V OPERATIONS
AUX 31 CLR V MEMORY
```

You can also enter the exact AUX number to go straight to the sub-menu.

Enter the AUX number directly

CLR D 3 B 1 AUX

```
AUX 3* V OPERATIONS
AUX 31 CLR V MEMORY
```

AUX 2* — RLL Operations

RLL Operations auxiliary functions allow you to perform various operations on the ladder program.

AUX 21
Check Program

Both the Handheld and ***Direct***SOFT32 automatically check for errors during program entry. However, there may be occasions when you want to check a program that has already been in the CPU. Two types of checks are available:

- Syntax
- Duplicate References

The Syntax check will find a wide variety of programming errors, such as missing END statements. If you perform this check and get an error, see Appendix B for a complete listing of programming error codes. Correct the problem and then continue running the Syntax check until the message “NO SYNTAX ERROR appears.

Use the Duplicate Reference check to verify you have not used the same output coil reference more than once. Note, this AUX function will also find the same outputs even if they have been used with the OROUT instruction, which is perfectly acceptable.

This AUX function is available on the PLC Diagnostics sub-menu from within ***Direct***SOFT32.

AUX 22
Change Reference

There will probably be times when you need to change an I/O address reference or control relay reference. AUX 22 allows you to quickly and easily change all occurrences, (within an address range), of a specific instruction. For example, you can replace every instance of X5 with X10.

AUX 23
Clear Ladder Range

There have been many times when we’ve taken existing programs and added or removed certain portions to solve new application problems. By using AUX 23 you can select and delete a portion of the program. ***Direct***SOFT32 does not have a menu option for this AUX function, but you can just select the appropriate portion of the program and cut it with the editing tools.

AUX 24
Clear Ladders

AUX 24 clears the entire program from CPU memory. Before you enter a new program, you should always clear ladder memory. This AUX function is available on the PLC/Clear PLC sub-menu within ***Direct***SOFT32.

AUX 3* — V-memory Operations

AUX 31
Clear V Memory

AUX 31 clears all the information from the V-memory locations available for general use. This AUX function is available on the PLC/Clear PLC sub-menu within ***Direct***SOFT32.

AUX 4* — I/O Configuration

AUX 41
Show I/O Configuration

This AUX function allows you to display the current I/O configuration on the DL105. Both the Handheld Programmer and ***Direct***SOFT32 will show the I/O configuration is fixed at F1–130:10 DI / 8 DO.

AUX 5* — CPU Configuration

The following auxiliary AUX functions allow you to setup, view, or change the CPU configuration.

AUX 51 Modify Program Name

DL105 PLCs can use a program name for the CPU program or a program stored on EEPROM in the Handheld Programmer. (Note, you cannot have multiple programs stored on the EEPROM.) The program name can be up to eight characters in length and can use any of the available characters (A–Z, 0–9). AUX 51 allows you to enter a program name. You can also perform this operation from within ***Direct***SOFT32 by using the PLC/Setup sub-menu. Once you've entered a program name, you can only clear the name by using AUX 54 to reset the system memory. Make sure you understand the possible effects of AUX 54 before you use it!

AUX 53 Display Scan Time

AUX 53 displays the current, minimum, and maximum scan times. The minimum and maximum times are the ones that have occurred since the last Program Mode to Run Mode transition. You can also perform this operation from within ***Direct***SOFT32 by using the PLC/Diagnostics sub-menu.

AUX 54 Initialize Scratchpad

The CPU maintains system parameters in a memory area often referred to as the "scratchpad". In some cases, you may make changes to the system setup that will be stored in system memory. For example, if you specify a range of Control Relays (CRs) as retentive, these changes are stored.

NOTE: You may never have to use this feature unless you have made changes that affect system memory. Usually, you'll only need to initialize the system memory if you are changing programs and the old program required a special system setup. You can usually change from program to program without ever initializing system memory.

AUX 54 resets the system memory to the default values. You can also perform this operation from within ***Direct***SOFT32 by using the PLC/Setup sub-menu.

AUX 55 Set Watchdog Timer

DL105 PLCs have a "watchdog" timer that is used to monitor the scan time. The default value set from the factory is 200 ms. If the scan time exceeds the watchdog time limit, the CPU automatically leaves RUN mode and enters PGM mode. The Handheld displays the following message E003 S/W TIMEOUT when the scan overrun occurs.

Use AUX 55 to increase or decrease the watchdog timer value. You can also perform this operation from within ***Direct***SOFT32 by using the PLC/Setup sub-menu.

AUX 57 Set Retentive Ranges

DL105 CPUs provide certain ranges of retentive memory by default. Some of the retentive memory locations are backed up by a super-capacitor, and others are in non-volatile EEPROM. The EEPROM memory locations are V4000 to 4177, and V7630 to V7647. The default ranges are suitable for many applications, but you can change them if your application requires additional retentive ranges or no retentive ranges at all (see Appendix E).

The default settings are:

Memory Area	DL105	
	Default Range	Available Range
Control Relays	C300 – C377	C0 – C377
V Memory	V2000 – V7777	V0 – V7777
Timers	None by default	T0 – T77
Counters	CT0 – CT77	CT0 – CT77
Stages	None by default	S0 – S377

Use AUX 57 to change the retentive ranges. You can also perform this operation from within ***Direct***SOFT32 by using the PLC/Setup sub-menu.

WARNING: The DL105 CPUs do not have battery-backed RAM. The super-capacitor will retain the values in the event of a power loss, but only up to 3 weeks. (The retention time may be as short as 4 1/2 days in 60 degree C operating temperature.)

AUX 58
Test Operations

AUX 58 is used to override the output disable function of the Pause instruction. Use AUX 58 to program a single output or a range of outputs which will operate normally even when those points are within the scope of the pause instruction.

AUX 5B
Counter Interface Configuration

AUX 5B is used with the High-Speed I/O (HSIO) function to select the configuration. You can choose the type of counter, set the counter parameters, etc. See Chapter 3 for a complete description of how to select the various counter features.

AUX 6* — Handheld Programmer Configuration

The following auxiliary functions allow you to setup, view, or change the Handheld Programmer configuration.

AUX 61
Show Revision Numbers

As with most industrial control products, there are cases when additional features and enhancements are made. Sometimes these new features only work with certain releases of firmware. By using AUX 61 you can quickly view the CPU and Handheld Programmer firmware revision numbers. This information (for the CPU) is also available from within ***Direct***SOFT32 from the PLC/Diagnostics sub-menu.

AUX 62
Beeper On / Off

The Handheld has a beeper that provides confirmation of keystrokes. You can use Auxiliary (AUX) Function 62 to turn off the beeper.

AUX 65
Run Self Diagnostics

If you think the Handheld Programmer is not operating correctly, you can use AUX 65 to run a self diagnostics program. You can check the following items.

- Keypad
- Display
- LEDs and Backlight
- Handheld Programmer EEPROM check

AUX 7* — EEPROM Operations

The following auxiliary functions allow you to move the ladder program from one area to another and perform other program maintenance tasks.

Transferrable Memory Areas

Many of these AUX functions allow you to copy different areas of memory to and from the CPU and handheld programmer. The following table shows the areas that may be mentioned.

Option and Memory Type	DL105 Default Range
1:PGM — Program	$00000 – $02047
2:V — V memory	$00000 – $03777
3:SYS — System	Non-selectable copies system parameters
4:etc (All)— Program, System and *non-volatile* V-memory only	Non-selectable

AUX 71 CPU to HPP EEPROM

AUX 71 copies information from the CPU memory to an EEPROM installed in the Handheld Programmer.You can copy different portions of EEPROM (HP) memory to the CPU memory as shown in the previous table.

AUX 72 HPP EEPROM to CPU

AUX 72 copies information from the EEPROM installed in the Handheld Programmer to CPU memory in the DL105. You can copy different portions of EEPROM (HP) memory to the CPU memory as shown in the previous table.

AUX 73 Compare HPP EEPROM to CPU

AUX 73 compares the program in the Handheld programmer (EEPROM) with the CPU program. You can compare different types of information as shown previously.

AUX 74 HPP EEPROM Blank Check

AUX 74 allows you to check the EEPROM in the handheld programmer to make sure it is blank. It's a good idea to use this function anytime you start to copy an entire program to an EEPROM in the handheld programmer.

AUX 75 Erase HPP EEPROM

AUX 75 allows you to clear all data in the EEPROM in the handheld programmer. You should use this AUX function before you copy a program from the CPU.

AUX 76 Show EEPROM Type

You can use AUX 76 to quickly determine what size EEPROM is installed in the Handheld Programmer.

AUX 8* — Password Operations

There are several AUX functions available that you can use to modify or enable the CPU password. You can use these features during on-line communications with the CPU, or, you can also use them with an EEPROM installed in the Handheld Programmer during off-line operation. This will allow you to develop a program in the Handheld Programmer and include password protection.

- AUX 81 — Modify Password
- AUX 82 — Unlock CPU
- AUX 83 — Lock CPU

AUX 81 Modify Password

You can use AUX 81 to provide an extra measure of protection by entering a password that prevents unauthorized machine operations. The password must be an eight-character numeric (0–9) code. Once you've entered a password, you can remove it by entering all zeros (00000000). (This is the default from the factory.)

Once you've entered a password, you can lock the CPU against access. There are two ways to lock the CPU with the Handheld Programmer.

- The CPU is always locked after a power cycle (if a password is present).
- You can use AUX 82 and AUX 83 to lock and unlock the CPU.

You can also enter or modify a password from within ***Direct***SOFT32 by using the PLC/Password sub-menu. This feature works slightly differently in ***Direct***SOFT32. Once you've entered a password, the CPU is automatically locked when you exit the software package. It will also be locked if the CPU is power cycled.

WARNING: Make *sure* you remember the password *before* you lock the CPU. Once the CPU is locked you cannot view, change, or erase the password. If you do not remember the password, you have to return the CPU to the factory for password removal.

NOTE: The DL105 CPUs support multi-level password protection of the ladder program. This allows password protection while not locking the communication port to an operator interface. The multi-level password can be invoked by creating a password with an upper case “A” followed by seven numeric characters (e.g. A1234567).

AUX 82 Unlock CPU

AUX 82 can be used to unlock a CPU that has been password protected. ***Direct***SOFT32 will automatically ask you to enter the password if you attempt to communicate with a CPU that contains a password.

AUX 83 Lock CPU

AUX 83 can be used to lock a CPU that contains a password. Once the CPU is locked, you will have to enter a password to gain access. Remember, this is not necessary with ***Direct***SOFT32 since the CPU is automatically locked whenever you exit the software package.

B

DL105 Error Codes

In This Appendix. . . .

— Error Code Table

DL105 Error Code	Description
E003 SOFTWARE TIME-OUT	If the program scan time exceeds the time allotted to the watchdog timer, this error will occur. SP51 will be on and the error code will be stored in V7755. To correct this problem use AUX 55 to extend the time allotted to the watchdog timer.
E004 INVALID INSTRUCTION	The CPU attempted to execute an instruction code, but the RAM contents had a parity error. Performing a program download to the CPU in an electrically noisy environment can corrupt a program's contents. Clear the CPU program memory, and download the program again.
E099 PROGRAM MEMORY EXCEEDED	If the compiled program length exceeds the amount of available CPU RAM this error will occur. SP52 will be on and the error code will be stored in V7755. Reduce the size of the application program.
E151 BAD COMMAND	A parity error has occurred in the application program. SP44 will be on and the error code will be stored in V7755 .This problem may possibly be due to electrical noise. Clear the memory and download the program again. Correct any grounding problems. If the error returns replace the Micro PLC.
E155 RAM FAILURE	A checksum error has occurred in the system RAM. SP44 will be on and the error code will be stored in V7755. This problem may possibly be due to a low battery, electrical noise or a CPU RAM failure. Clear the memory and download the program again. Correct any grounding problems. If the error returns replace the CPU.
E210 POWER FAULT	A short duration power drop-out occurred on the main power line supplying power to the base.

DL105 Error Code	Description
E312 HP COMM ERROR 2	A data error was encountered during communications with the CPU. Clear the error and retry the request. If the error continues check the cabling between the two devices, replace the handheld programmer, then if necessary replace the CPU. The error code will be stored in V7756.
E313 HP COMM ERROR 3	An address error was encountered during communications with the CPU. Clear the error and retry the request. If the error continues check the cabling between the two devices, replace the handheld programmer, then if necessary replace the CPU. The error code will be stored in V7756.
E316 HP COMM ERROR 6	A mode error was encountered during communications with the CPU. Clear the error and retry the request. If the error continues replace the handheld programmer, then if necessary replace the CPU. The error code will be stored in V7756.
E320 HP COMM TIME-OUT	The CPU did not respond to the handheld programmer communication request. Check to insure cabling is correct and not defective. Power cycle the system if the error continues replace the CPU first and then the handheld programmer if necessary.
E321 COMM ERROR	A data error was encountered during communication with the CPU. Check to insure cabling is correct and not defective. Power cycle the system and if the error continues replace the CPU first and then the handheld programmer if necessary.
E4** NO PROGRAM	A syntax error exists in the application program. The most common is a missing END statement. Run AUX21 to determine which one of the E4** series of errors is being flagged. SP52 will be on and the error code will be stored in V7755.
E401 MISSING END STATEMENT	All application programs must terminate with an END statement. Enter the END statement in appropriate location in your program. SP52 will be on and the error code will be stored in V7755.
E402 MISSING LBL	A MOVMC or LDLBL instruction was used without the appropriate label. Refer to the Chapter 5 for details on these instructions. SP52 will be on and the error code will be stored in V7755.
E406 MISSING IRT	An interrupt routine in the program does not end with the IRT instruction. SP52 will be on and the error code will be stored in V7755.
E421 DUPLICATE STAGE REFERENCE	Two or more SG or ISG labels exist in the application program with the same number. A unique number must be allowed for each Stage and Initial Stage. SP52 will be on and the error code will be stored in V7755.
E422 DUPLICATE LBL REFERENCE	Two or more LBL instructions exist in the application program with the same number. A unique number must be allowed for each and label. SP52 will be on and the error code will be stored in V7755.
E431 INVALID ISG/SG ADDRESS	An ISG or SG instruction must not be placed after the end statement (such as inside a subroutine). SP52 will be on and the error code will be stored in V7755.

DL105 Error Code	Description
E436 INVALID INT ADDRESS	An INT must be programmed after the end statement, not in the main body of the program. SP52 will be on and the error code will be stored in V7755.
E438 INVALID IRT ADDRESS	An IRT must be programmed after the end statement, not in the main body of the program. SP52 will be on and the error code will be stored in V7755.
E440 INVALID DATA ADDRESS	Either the DLBL instruction has been programmed in the main program area (not after the END statement), or the DLBL instruction is on a rung containing input contact(s).
E441 ACON/NCON	An ACON or NCON must be programmed after the end statement, not in the main body of the program. SP52 will be on and the error code will be stored in V7755.
E451 BAD MLS/MLR	MLS instructions must be numbered in ascending order from top to bottom.
E452 X AS COIL	An X data type is being used as a coil output.
E453 MISSING T/C	A timer or counter contact is being used where the associated timer or counter does not exist.
E454 BAD TMRA	One of the contacts is missing from a TMRA instruction.
E455 BAD CNT	One of the contacts is missing from a CNT or UDC instruction.
E456 BAD SR	One of the contacts is missing from the SR instruction.
E461 STACK OVERFLOW	More than nine levels of logic have been stored on the stack. Check the use of OR STR and AND STR instructions.
E462 STACK UNDERFLOW	An unmatched number of logic levels have been stored on the stack. Insure the number of AND STR and OR STR instructions match the number of STR instructions.
E463 LOGIC ERROR	A STR instruction was not used to begin a rung of ladder logic.
E464 MISSING CKT	A rung of ladder logic is not terminated properly.
E471 DUPLICATE COIL REFERENCE	Two or more OUT instructions reference the same I/O point.
E472 DUPLICATE TMR REFERENCE	Two or more TMR instructions reference the same number.
E473 DUPLICATE CNT REFERENCE	Two or more CNT instructions reference the same number.

DL105 Error Code	Description
E501 BAD ENTRY	An invalid keystroke or series of keystrokes was entered into the handheld programmer.
E502 BAD ADDRESS	An invalid or out of range address was entered into the handheld programmer.
E503 BAD COMMAND	An invalid command was entered in the handheld programmer.
E504 BAD REF/VAL	An invalid value or reference number was entered with an instruction.
E505 INVALID INSTRUCTION	An invalid instruction was entered into the handheld programmer.
E506 INVALID OPERATION	An invalid operation was attempted by the handheld programmer.
E520 BAD OP–RUN	An operation which is invalid in the RUN mode was attempted by the handheld programmer.
E524 BAD OP–PGM	An operation which is invalid in the PROGRAM mode was attempted by the handheld programmer.
E526 OFF LINE	The handheld programmer is in the OFFLINE mode. To change to the ONLINE mode use the MODE the key.
E527 ON LINE	The handheld programmer is in the ON LINE mode. To change to the OFF LINE mode use the MODE the key.
E528 CPU MODE	The operation attempted is not allowed during a Run Time Edit.
E540 CPU LOCKED	The CPU has been password locked. To unlock the CPU use AUX82 with the password.
E541 WRONG PASSWORD	The password used to unlock the CPU with AUX82 was incorrect.
E542 PASSWORD RESET	The CPU powered up with an invalid password and reset the password to 00000000. A password may be re-entered using AUX81.

DL105 Error Code	Description
E601 MEMORY FULL	Attempted to enter an instruction which required more memory than is available in the CPU.
E602 INSTRUCTION MISSING	A search function was performed and the instruction was not found.
E604 REFERENCE MISSING	A search function was performed and the reference was not found.
E620 OUT OF MEMORY	An attempt to transfer more data between the CPU and handheld programmer than the receiving device can hold.
E621 EEPROM NOT BLANK	An attempt to write to a non-blank EEPROM in the handheld programmer was made. Erase the EEPROM and then retry the write.
E622 NO HPP EEPROM	A data transfer was attempted with no EEPROM (or possibly a faulty EEPROM) installed in the handheld programmer.
E623 SYSTEM EEPROM	A function was requested with an EEPROM in the handheld programmer which contains system information only.
E624 V-MEMORY ONLY	A function was requested with an EEPROM in the handheld programmer which contains V-memory data only.
E625 PROGRAM ONLY	A function was requested with an EEPROM in the handheld programmer which contains program data only.
E627 BAD WRITE	An attempt to write to a write-protected or faulty EEPROM in the handheld programmer was made. Check the write protect jumper and replace the EEPROM if necessary.
E628 EEPROM TYPE ERROR	The wrong size EEPROM is being used in the handheld programmer. This error occurs when the program size is larger than what the HPP can hold.
E640 COMPARE ERROR	A compare between the EEPROM handheld programmer and the CPU was found to be in error.
E650 HPP SYSTEM ERROR	A system error has occurred in the handheld programmer. Power cycle the handheld programmer. If the error returns replace the handheld programmer.
E651 HPP ROM ERROR	A ROM error has occurred in the handheld programmer. Power cycle the handheld programmer. If the error returns replace the handheld programmer.
E652 HPP RAM ERROR	A RAM error has occurred in the handheld programmer. Power cycle the handheld programmer. If the error returns replace the handheld programmer.

C

Instruction Execution Times

In This Appendix. . . .

Introduction

This appendix contains several tables that provide the instruction execution times for DL105 Micro PLCs. Many of the execution times depend on the type of data used with the instruction. Registers may be classified into the following types:

- Data (word) Registers
- Bit Registers

V-Memory Data Registers

Some V-memory locations are considered data registers, such as timer or counter current values. Standard user V memory is classified as a V-memory data register. Note that you can load a bit pattern into these types of registers, even though their primary use is for data registers. The following locations are data registers:

Data Registers	DL105
Timer Current Values	V0 – V77
Counter Current Values	V1000 – V1077
User Data Words	V2000 – V2377 V4000 – V4177

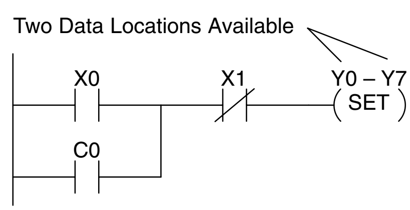
V-Memory Bit Registers

You may recall that some of the discrete points such as X, Y, C, etc. are automatically mapped into V memory (see Appendix E). The following bit registers contain this data:

Bit Registers	DL105
Input Points (X)	V40400 – V 40407
Output Points (Y)	V40500 – V40507
Control Relays (C)	V40600 – V40617
Timer Status Bits	V41100 – V41103
Counter Status Bits	V41140 – V41143
Stages	V41000 – V41017

How to Read the Tables

Some instructions can have more than one parameter. For example, the SET instruction shown in the ladder program to the right can set a single point or a range of points.



In these cases, execution times that depend on the amount and type of parameters. The execution time tables list execution times for both situations, as shown below:

SET	1st #:	X, Y, C, S		17.4 µs
	2nd #:	X, Y, C, S,	(N pt)	12.0µs+5.4µsxN
RST	1st #:	X, Y, C, S		19.5 µs
	2nd #:	X, Y, C, S,	(N pt)	10.5µs+5.2µsxN

Execution depends on numbers of locations and types of data used

Instruction Execution Times

Boolean Instructions

Boolean Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
STR	X, Y, C, T, CT,S, SP	3.3 μs	3.3 μs
STRN	X, Y, C, T, CT,S, SP	3.9 μs	3.9 μs
OR	X, Y, C, T, CT, S, SP	2.7 μs	2.7 μs
ORN	X, Y, C, T, CT,S, SP	3.3 μs	3.3 μs
AND	X, Y, C, T, CT, S, SP	2.1 μs	2.1 μs
ANDN	X, Y, C, T, CT, S, SP	2.7 μs	2.7 μs
ANDSTR	None	1.2 μs	1.2 μs
ORSTR	None	1.2 μs	1.2 μs
OUT	X, Y, C	3.4 μs	3.4 μs
OROUT	X, Y, C	8.6 μs	8.6 μs
PD	X, Y, C	13.5 μs	13.5 μs
SET	1st #: X, Y, C, S 2nd #: X, Y, C, S (N pt)	17.4 μs 12.0μs+5.4μsxN	6.8 μs 6.8 μs
RST	1st #: T, CT 2nd #: T, CT (N pt)	31.6 μs 17μs+14.6μsxN	6.8 μs 6.8 μs
PAUSE	1wd: Y 2wd: Y (N points)	19.0 μs 15μs+4μs x N	19.0 μs 15μs+4μs x N
RST	1st #: X, Y, C, S 2nd #: X, Y, C, S (N pt)	17.7 μs 10.5μs+5.2μsxN	6.8 μs 6.8 μs

Comparative Boolean Instructions

Comparative Boolean Instructions			DL105	
Instruction	Legal Data Types		Execute	Not Execute
STRE	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	77 μs 158 μs 57 μs	13.8 μs 13.8 μs 13.8 μs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 μs 240 μs 139 μs	13.8 μs 13.8 μs 13.8 μs
STRNE	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	77 μs 158 μs 57 μs	13.8 μs 13.8 μs 13.8 μs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 μs 240 μs 139 μs	13.8 μs 13.8 μs 13.8 μs

Comparative Boolean (cont.)			DL105	
Instruction	**Legal Data Types**		**Execute**	**Not Execute**
ORE	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 239 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
ORNE	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 239 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
ANDE	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 239 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
ANDNE	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 239 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
STR	1st	2nd		
	T, CT	V:Data Reg. V:Bit Reg. K:Constant	78 µs 158 µs 57 µs	13.8 µs 13.8 µs 13.8 µs
	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	78 µs 159 µs 57 µs	13.8 µs 13.8 µs 13.8 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	159 µs 241 µs 139 µs	13.8 µs 13.8 µs 13.8 µs
STRN	1st	2nd		
	T, CT	V:Data Reg. V:Bit Reg. K:Constant	78 µs 158 µs 57 µs	13.8 µs 13.8 µs 13.8 µs
	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	78 µs 159 µs 57 µs	13.8 µs 13.8 µs 13.8 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	159 µs 241 µs 139 µs	13.8 µs 13.8 µs 13.8 µs

Comparative Boolean (cont.)			DL105	
Instruction	**Legal Data Types**		**Execute**	**Not Execute**
OR	1st	2nd		
	T, CT	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 240 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
ORN	1st	2nd		
	T, CT	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 240 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
AND	1st	2nd		
	T, CT	V:Data Reg. V:Bit Reg. K:Constant	76 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	75 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 240 µs 137 µs	12.0 µs 12.0 µs 12.0 µs
ANDN	1st	2nd		
	T, CT	V:Data Reg. V:Bit Reg. K:Constant	76 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	1st	2nd		
	V: Data Reg.	V:Data Reg. V:Bit Reg. K:Constant	76 µs 158 µs 55 µs	12.0 µs 12.0 µs 12.0 µs
	V: Bit Reg.	V:Data Reg. V:Bit Reg. K:Constant	158 µs 240 µs 137 µs	12.0 µs 12.0 µs 12.0 µs

Immediate Instructions

Immediate Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
STRI	X	27 μs	9.8 μs
STRNI	X	26 μs	8.6 μs
ORI	X	27 μs	9.8 μs
ORNI	X	26 μs	8.6 μs
ANDI	X	25 μs	8.0 μs
ANDNI	X	24 μs	6.8 μs
OROUTI	Y	45 μs	45 μs
SETI	1st #: Y 2nd #: Y (N pt)	25.5 μs 5.5 μs+20 x N	6.8 μs 6.8 μs
RSTI	1st #: Y 2nd #: Y (N pt)	25.5 μs 5 μs+20.5 x N	6.8 μs 6.8 μs

Timer, Counter, Shift Register, EDRUM Instructions

Timer, Counter, Shift Register, and Drum Instructions			DL105	
Instruction	Legal Data Types		Execute	Not Execute
TMR	1st T	2nd V:Data Reg. V:Bit Reg. K:Constant	 75 μs 158 μs 66 μs	 31 μs 31 μs 31 μs
TMRF	1st T	2nd V:Data Reg. V:Bit Reg. K:Constant	 75 μs 158 μs 66 μs	 31 μs 31 μs 31 μs
TMRA	1st T	2nd V:Data Reg. V:Bit Reg. K:Constant	 94 μs 304 μs 95 μs	 56 μs 264 μs 45 μs
TMRAF	1st T	2nd V:Data Reg. V:Bit Reg. K:Constant	 98 μs 304 μs 95 μs	 54 μs 264 μs 49 μs
CNT	1st CT	2nd V:Data Reg. V:Bit Reg. K:Constant	 68 μs 148 μs 56 μs	 61 μs 141 μs 45 μs
SGCNT	1st CT	2nd V:Data Reg. V:Bit Reg. K:Constant	 57 μs 140 μs 46 μs	 64 μs 148 μs 53 μs

Timer, Counter, Shift Register, and Drum Instructions Cont'd		DL105	
Instruction	**Legal Data Types**	**Execute**	**Not Execute**
UDC	1st 2nd CT V:Data Reg. V:Bit Reg. K:Constant	 103 µs 310 µs 102 µs	 74 µs 281 µs 70 µs
SR	C (N points to shift)	30 µs+4.6 µs xN	17.2 µs
EDRUM	CT	320 µs	221 µs

Accumulator Data Instructions

Accumulator / Stack Load and Output Data Instructions		DL105	
Instruction	**Legal Data Types**	**Execute**	**Not Execute**
LD	V:Data Reg. V:Bit Reg. K:Constant P:Indir. (Data) P:Indir. (Bit)	68 µs 149 µs 62 µs 169 µs 256 µs	8.4 µs 8.4 µs 8.4 µs 8.4 µs 8.4 µs
LDD	V:Data Reg. V:Bit Reg. K:Constant P:Indir. (Data) P:Indir. (Bit)	72 µs 266 µs 64 µs 172 µs 373 µs	8.4 µs 8.4 µs 8.4 µs 8.4 µs 8.4 µs
LDF	1st 2nd X, Y, C, S K:Constant T, CT, SP (N pt)	77 µs+6.2 µs xN	10 µs
LDA	O: (Octal constant for address)	58 µs	8.4 µs
OUT	V:Data Reg. V:Bit Reg. P:Indir. (Data) P:Indir. (Bit)	60 µs 132 µs 162 µs 239 µs	8.4 µs 8.4 µs 8.4 µs 8.4 µs
OUTD	V:Data Reg. V:Bit Reg. P:Indir. (Data) P:Indir. (Bit)	68 µs 276 µs 196 µs 384 µs	8.4 µs 8.4 µs 8.4 µs 8.4 µs
OUTF	1st 2nd X, Y, C K:Constant (N pt)	36 µs+7.6 µs xN	8 µs
POP	None	55 µs	7.2 µs

Logical Instructions

Logical (Accumulator) Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
AND	V:Data Reg. V:Bit Reg.	63 µs 261 µs	10.4 µs 10.4 µs
ANDD	K:Constant	53 µs	8.4 µs
OR	V:Data Reg. V:Bit Reg.	59 µs 257 µs	10.4 µs 10.4 µs
ORD	K:Constant	49 µs	8.4 µs
XOR	V:Data Reg. V:Bit Reg.	60 µs 257 µs	10.4 µs 10.4 µs
XORD	K:Constant	49 µs	8.4 µs
CMP	V:Data Reg. V:Bit Reg.	59 µs 259 µs	10.4 µs 10.4 µs
CMPD	V:Data Reg. V:Bit Reg. K:Constant	63 µs 257 µs 54 µs	8.4 µs 8.4 µs 8.4 µs

Math Instructions

Math Instructions (Accumulator)		DL105	
Instruction	Legal Data Types	Execute	Not Execute
ADD	V:Data Reg. V:Bit Reg.	198 µs 397 µs	10.6 µs 10.6 µs
ADDD	V:Data Reg. V:Bit Reg. K:Constant	198 µs 397 µs 188 µs	8.4 µs 8.4 µs 8.4 µs
SUB	V:Data Reg. V:Bit Reg.	200 µs 397 µs	10.6 µs 10.6 µs
SUBD	V:Data Reg. V:Bit Reg. K:Constant	198 µs 392 µs 190 µs	8.4 µs 8.4 µs 8.4 µs
MUL	V:Data Reg. V:Bit Reg. K:Constant	497 µs 483 µs 487 µs	10.6 µs 10.6 µs 8.4 µs
DIV	V:Data Reg. V:Bit Reg. K:Constant	909 µs 1108 µs 899 µs	10.6 µs 10.6 µs 8.4 µs
INCB	V:Data Reg. V:Bit Reg.	83 µs 349 µs	10.4 µs 10.4 µs
DECB	V:Data Reg. V:Bit Reg.	82 µs 351 µs	10.4 µs 10.4 µs

Bit Instructions

Bit Instructions (Accumulator)		DL105	
Instruction	Legal Data Types	Execute	Not Execute
SHFR	V:Data Reg. (N bits) V:Bit Reg. (N bits) K:Constant (N bits)	44µs+14.6 x N 243µs+14.6 x N 34µs+14.6 x N	10.4 µs 10.4 µs 8.4 µs
SHFL	V:Data Reg. (N bits) V:Bit Reg. (N bits) K:Constant (N bits)	44µs+14.6 x N 243µs+14.6 x N 34µs+14.6 x N	10.4 µs 10.4 µs 8.4 µs
ENCO	None	62 µs	7.2 µs
DECO	None	34 µs	7.2 µs

Number Conversion Instructions

Number Conversion Instructions (Accumulator)		DL105	
Instruction	Legal Data Types	Execute	Not Execute
BIN	None	359 µs	7.2 µs
BCD	None	403 µs	7.2 µs
INV	None	27 µs	5.0 µs

Table Instructions

Table Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
MOV	Move V:data reg. to V:data reg. Move V:bit reg. to V:data reg. Move V:data reg to V:bit reg. Move V:bit reg. to V:bit reg. N= #of words	450µs+17 x N 430µs+244 x N 460µs+215 x N 490µs+448 x N	6.2µs 6.2µs 6.2µs 6.2µs
MOVMC	Move V:Data Reg. to E^2 Move V:Bit Reg. to E^2 Move from E^2 to V:Data Reg. Move from E^2 to V:Bit Reg. N= #of words	— — 250µs+201xN —	— — 6.2µs —
LDLBL	K	58µs	8.4µs

CPU Control Instructions

CPU Control Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
NOP	None	0 μs	0 μs
END	None	27 μs	27 μs
STOP	None	16 μs	5 μs

Program Control Instructions

Program Control Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
MLS	K (1–7)	12 μs	12 μs
MLR	K (0–6) N= 1 to 7	13 μs + 2.4 x N	13 μs + 2.4 x N

Interrupt Instructions

Interrupt Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
ENI	None	9 μs	5 μs
DISI	None	8 μs	5 μs
INT	O0	0 μs	0 μs
IRT	None	1.6 μs	—

Message Instructions

Message Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
FAULT	V:Data Reg. V:Bit Reg. K:Constant	171 μs 253 μs 2798 μs	8.4 μs 8.4 μs 8.4 μs
DLBL	K	0 μs	0 μs
NCON	K	0 μs	0 μs
ACON	K	0 μs	0 μs

RLL*PLUS* Instructions

RLL*PLUS* Instructions		DL105	
Instruction	Legal Data Types	Execute	Not Execute
ISG	S	31 μs	32 μs
SG	S	31 μs	32 μs
JMP	S	14 μs	8 μs

D

Special Relays

In This Appendix. . . .

DL105 PLC Special Relays

"Special Relays" are just contacts that are set by the CPU operating system to indicate a particular system event has occurred. These contacts are available for use in your ladder program. Knowing just the right special relay contact to use for a particular situation can save lot of programming time. Since the CPU operating system sets and clears special relay contacts, the ladder program only has to use them as inputs in ladder logic.

Startup and Real-Time Relays

SP0	First scan	on for the first scan after a power cycle or program to run transition only. The relay is reset to off on the second scan. It is useful where a function needs to be performed only on program startup.
SP1	Always ON	provides a contact to insure an instruction is executed every scan.
SP3	1 minute clock	on for 30 seconds and off for 30 seconds.
SP4	1 second clock	on for 0.5 second and off for 0.5 second.
SP5	100 ms clock	on for 50 ms. and off for 50 ms.
SP6	50 ms clock	on for 25 ms. and off for 25 ms.
SP7	Alternate scan	on every other scan.

CPU Status Relays

SP12	Terminal run mode	on when the CPU is in the run mode.
SP16	Terminal program mode	on when the CPU is in the program mode.
SP20	Forced stop mode	on when the STOP instruction is executed.
SP22	Interrupt enabled	on when interrupts have been enabled using the ENI instruction.

System Monitoring

SP40	Critical error	on when a critical error such as I/O communication loss has occurred.
SP41	Warning	on when a non critical error such as a low battery has occurred.
SP44	Program memory error	on when a memory error such as a memory parity error has occurred.
SP50	Fault instruction	on when a Fault Instruction is executed.
SP51	Watch Dog timeout	on if the CPU Watch Dog timer times out.
SP52	Grammatical error	on if a grammatical error has occurred either while the CPU is running or if the syntax check is run. V7755 will hold the exact error code.
SP53	Solve logic error	on if CPU cannot solve the logic.

Accumulator Status

SP60	Value less than	on when the accumulator value is less than the instruction value.
SP61	Value equal to	on when the accumulator value is equal to the instruction value.
SP62	Greater than	on when the accumulator value is greater than the instruction value.
SP63	Zero	on when the result of the instruction is zero (in the accumulator.)
SP64	Half borrow	on when the 16 bit subtraction instruction results in a borrow.
SP65	Borrow	on when the 32 bit subtraction instruction results in a borrow.
SP66	Half carry	on when the 16 bit addition instruction results in a carry.
SP67	Carry	when the 32 bit addition instruction results in a carry.
SP70	Sign	on anytime the value in the accumulator is negative.
SP71	Invalid octal number	on when an Invalid octal number was entered. This also occurs when the V-memory specified by a pointer (P) is not valid.
SP73	Overflow	on if overflow occurs in the accumulator when a signed addition or subtraction results in an incorrect sign bit.
SP75	Data error	on if a BCD number is expected and a non–BCD number is encountered.
SP76	Load zero	on when any instruction loads a value of zero into the accumulator.

HSIO Pulse Catch Relay

SP100	X0 is on	X0 — on for 1 scan after a pulse on X0 occurs.

Equal Relays for HSIO Mode 10 Counter Presets

SP540	Current = target value	on when the counter current value equals the value in V2320.
SP541	Current = target value	on when the counter current value equals the value in V2322.
SP542	Current = target value	on when the counter current value equals the value in V2324.
SP543	Current = target value	on when the counter current value equals the value in V2326.
SP544	Current = target value	on when the counter current value equals the value in V2330.
SP545	Current = target value	on when the counter current value equals the value in V2332.
SP546	Current = target value	on when the counter current value equals the value in V2334.
SP547	Current = target value	on when the counter current value equals the value in V2336.
SP550	Current = target value	on when the counter current value equals the value in V2340.
SP551	Current = target value	on when the counter current value equals the value in V2342.
SP552	Current = target value	on when the counter current value equals the value in V2344.
SP553	Current = target value	on when the counter current value equals the value in V2346
SP554	Current = target value	on when the counter current value equals the value in V2350.
SP555	Current = target value	on when the counter current value equals the value in V2352.
SP556	Current = target value	on when the counter current value equals the value in V2354.
SP557	Current = target value	on when the counter current value equals the value in V2356.
SP560	Current = target value	on when the counter current value equals the value in V2360.
SP561	Current = target value	on when the counter current value equals the value in V2362.
SP562	Current = target value	on when the counter current value equals the value in V2364.
SP563	Current = target value	on when the counter current value equals the value in V2366.
SP564	Current = target value	on when the counter current value equals the value in V2370.
SP565	Current = target value	on when the counter current value equals the value in V2372.
SP566	Current = target value	on when the counter current value equals the value in V2374.
SP567	Current = target value	on when the counter current value equals the value in V2376.

E

PLC Memory

In This Appendix. . . .

DL105 PLC Memory

When designing a PLC application, it is important for the PLC user to understand the different types of memory in the PLC. Two types of memory are used by the DL105 CPU, RAM and EEPROM. This memory can be configured by the PLC user as either retentive or non–retentive memory.

Retentive memory is memory that is configured by the user to maintain values through a power cycle or a PROGRAM to RUN transition. Non–retentive memory is memory that is configured by the PLC user to clear data after a power cycle or a PROGRAM to RUN transition. The retentive ranges can can be configured with either the handheld programmer using AUX 57 or ***Direct***SOFT32 (PLC Setup).

The contents of RAM memory can be written to and read from for an infinite number of times, but RAM requires a power source to maintain the contents of memory.The contents of RAM are maintained by the internal power supply (5VDC) only while the PLC is powered by an external source, normally 120VAC. When power to the PLC is turned off, the contents of RAM are maintained by a “Super–Capacitor”. If the Super–Capacitor ever discharges, the contents of RAM will be lost. The data retention time of the Super–Capacitor backed RAM is 3 weeks maximum, and 4 1/2 days minimum (at 60° C).

The contents of EEPROM memory can be read from for an infinite number of times but there is a limit to the number of times it can be written to (typical specification is 100,000 writes). EEPROM does not require a power source to maintain the memory contents. It will retain the contents of memory indefinately.

PLC user V–memory is stored in both volatile RAM and non–volatile EEPROM memory. Data being stored in RAM uses V2000–V2377. Data stored in EEPROM uses V4000–V4177 and V7630–V7647.

Data values that must be retained for long periods of time, when the PLC is powered off, should be stored in EEPROM based V–memory.

Data values that are continually changing or which can be initialized with program logic should be stored in RAM based V–memory.

F

European Union Directives (CE)

In This Appendix. . . .

— European Union (EU) Directives
— Basic EMC Installation Guidelines

European Union (EU) Directives

NOTE: The information contained in this section is intended as a guideline and is based on our interpretation of the various standards and requirements. Since the actual standards are issued by other parties and in some cases Governmental agencies, the requirements can change over time without advance warning or notice. Changes or additions to the standards can possibly invalidate any part of the information provided in this section.

This area of certification and approval is absolutely vital to anyone who wants to do business in Europe. One of the key tasks that faced the EU member countries and the European Economic Area (EEA) was the requirement to bring several similar yet distinct standards together into one common standard for all members. The primary purpose of a single standard was to make it easier to sell and transport goods between the various countries and to maintain a safe working and living environment. The Directives that resulted from this merging of standards are now legal requirements for doing business in Europe. Products that meet these Directives are required to have a CE mark to signify compliance.

Member Countries

As of January 1, 1997, the members of the EU are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, Sweden, and the United Kingdom. Iceland, Liechtenstein, and Norway together with the EU members make up the European Economic Area (EEA) and all are covered by the Directives.

Applicable Directives

There are several Directives that apply to our products. Directives may be amended, or added, as required.

- **Electromagnetic Compatibility Directive (EMC)** — this Directive attempts to ensure that products placed on the market do not generate electromagnetic disturbances that would affect other apparatus, including radio and/or telecommunications equipment.
- **Machinery Safety Directive** — this Directive covers the safety aspects of the equipment, installation, etc. There are several areas involved, including testing standards covering both electrical noise immunity and noise generation.
- **Low Voltage Directive** — this Directive is also safety related and covers electrical equipment that has voltage ranges of 50–1000VAC and/or 75–1500VDC.
- **Battery Directive** — this Directive covers the production, recycling, and disposal of batteries.

Compliance

Certain standards within each Directive already require mandatory compliance. The EMC Directive, which has gained the most attention, became mandatory as of January 1, 1996. The Low Voltage Directive became mandatory as of January 1, 1997.

Ultimately, we are all responsible for our various pieces of the puzzle. As manufacturers, we must test our products and document any test results and/or installation procedures that are necessary to comply with the Directives. As a machine builder, you are responsible for installing the products in a manner which will ensure compliance is maintained. You are also responsible for testing any combinations of products that may (or may not) comply with the Directives when used together.

The end user of the products must comply with any Directives that may cover maintenance, disposal, etc. of equipment or various components. *Although we strive to provide the best assistance available, it is impossible for us to test all possible configurations of our products with respect to any specific Directive. Because of this, it is ultimately your responsibility to ensure that your machinery (as a whole) complies with these Directives and to keep up with applicable Directives and/or practices that are required for compliance.*

As of July 1, 1997, the DL105 (F1–130DR–CE, F1–130DD–CE, F1–130DR–D, and F1–130DD–D versions only), DL205, DL305, and DL405 PLC systems manufactured by Koyo Electronics Industries or FACTS Engineering, when properly installed and used, conform to the Electromagnetic Compatibility (EMC), Low Voltage Directive, and Machinery Directive requirements of the following standards.

- **Emissions**
  EN50081–1 Generic domestic and light industrial environment
  EN50081–2 Generic heavy industrial environment
- **Immunity**
  EN50082–1 Generic domestic and light industrial environment
  EN50082–2 Generic heavy industrial environment
- **Low Voltage Directive**
  EN61131–2 PLC Product Standard
  EN61010–1 Installation Category 1
- **Machinery Directive**
  EN60204–1 Safety of Machinery

Special Installation Manual

The installation requirements to comply with the requirements of the Machinery Directive, EMC Directive and Low Voltage Directive are slightly more complex than the normal installation requirements found in the United States. To help with this, we have published a special manual which you can order:

- **DA–EU–M** – EU Installation Manual that covers special installation requirements to meet the EU Directive requirements. Order this manual to obtain the most up-to-date information.

Other Sources of Information

Although the EMC Directive gets the most attention, other basic Directives, such as the Machinery Directive and the Low Voltage Directive, also place restrictions on the control panel builder. Because of these additional requirements it is recommended that the following publications be purchased and used as guidelines:

- BSI publication TH 42073: February 1996 – covers the safety and electrical aspects of the Machinery Directive
- EN 60204–1:1992 – General electrical requirements for machinery, including Low Voltage and EMC considerations
- IEC 1000–5–2: EMC earthing and cabling requirements
- IEC 1000–5–1: EMC general considerations

It may be possible for you to obtain this information locally; however, the official source of applicable Directives and related standards is:

The Office for Official Publications of the European Communities
L–2985 Luxembourg; quickest contact is via the World Wide Web at
http://euro–op.eu.int/indexn.htm

Another source is:

British Standards Institution – Sales Department
Linford Wood
Milton Keynes
MK14 6LE
United Kingdom; the quickest contact is via the World Wide Web at
http://www.bsi.org.uk

Basic EMC Installation Guidelines

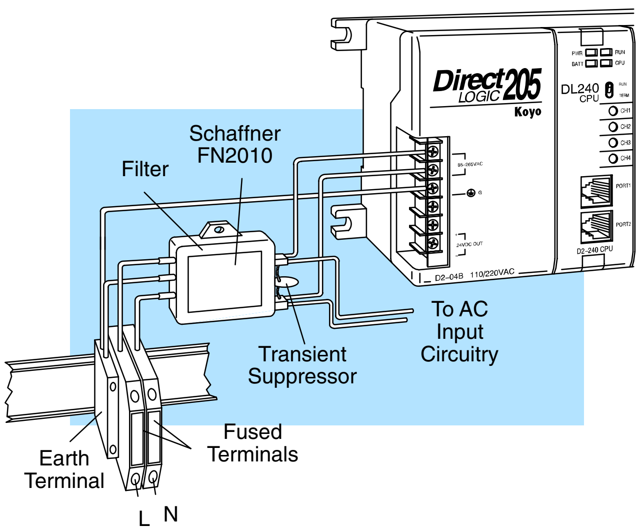
Enclosures

The simplest way to meet the safety requirements of the Machinery and Low Voltage Directives is to house all control equipment in an industry standard lockable steel enclosure. This has an added benefit because it will also help ensure that the EMC characteristics are well within the requirements of the EMC Directive. Although the RF emissions from the PLC equipment, when measured in the open air, are well below the EMC Directive limits, certain configurations can increase emission levels.

For example, where several identical DL305 or DL405 CPU and expansion rack power supplies are incorporated into one enclosure, small variations in the RF emission frequencies of the different supplies can add together to raise the total emission levels. Standard industrial steel enclosures without any special shielding measures will easily provide 30–50 dB attenuation which gives a wide margin for error. Holes in the enclosure, for the passage of cables or to mount operator interfaces, will only expose single PLC units, so no special precautions need to be taken. However, glass door enclosures should be avoided in situations where multiple units are housed in the control cubicle.

AC Mains Filters

DL105, DL205 and DL305 AC powered base power supplies require extra mains filtering to comply with the EMC Directive on conducted RF emissions. All PLC equipment has been tested with filters from Schaffner, which reduce emissions to negligible levels if the filters are properly grounded (earth ground). A filter with a current rating suitable to supply all PLC power supplies and AC input modules should be selected. We suggest the FN2010 for DL105/DL205 systems and the FN2080 for DL305 systems. DL405 systems do not require extra filtering.



Suppression and Fusing

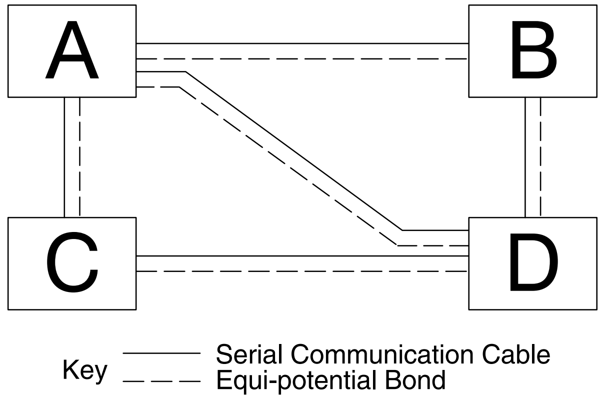
In order to comply with the fire risk requirements of the Low Voltage and Machinery Directive electrical standards EN 61010–1, and EN 60204–1, by limiting the power into “unlimited” mains circuits with power leads reversed, it is necessary to fuse both AC and DC supply inputs. You should also install a transient voltage suppressor across the power input connections of the PLC. Choose a suppressor such as a metal oxide varistor, with a rating of 275VAC working voltage for 230V nominal supplies (150VAC working voltage for 115V supplies) and high energy capacity (eg. 140 joules).

Transient suppressors must be protected by fuses and the capacity of the transient suppressor must be greater than the blow characteristics of the fuses or circuit breakers to avoid a fire risk. A recommended AC supply input arrangement for Koyo PLCs is to use twin 3 amp TT fused terminals with fuse blown indication, such as DINnectors DN–F10L terminals, or twin circuit breakers, wired to a Schaffner FN2010 filter or equivalent, with high energy transient suppressor soldered directly across the output terminals of the filter. PLC system inputs should also be protected from voltage impulses by deriving their power from the same fused, filtered, and surge-suppressed supply.

Internal Enclosure Grounding

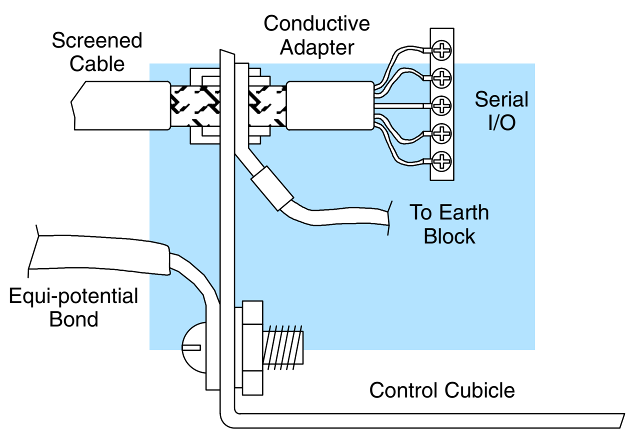
A heavy-duty star earth terminal block should be provided in every cubicle for the connection of all earth ground straps, protective earth ground connections, mains filter earth ground wires, and mechanical assembly earth ground connections. This should be installed to comply with safety and EMC requirements, local standards, and the requirements found in IEC 1000–5–2.The Machinery Directive also requires that the common terminals of PLC input modules, and common supply side of loads driven from PLC output modules should be connected to the protective earth ground terminal.

Equi–potential Grounding



Adequate site earth grounding must be provided for equipment containing modern electronic circuitry. The use of isolated earth electrodes for electronic systems is forbidden in some countries. Make sure you check any requirements for your particular destination. IEC 1000–5–2 covers equi-potential bonding of earth grids adequately, but special attention should be given to apparatus and control cubicles that contain I/O devices, remote I/O racks, or have inter-system communications with the primary PLC system enclosure. An equi-potential bond wire must be provided alongside all serial communications cables, and to any separate items of the plant which contain I/O devices connected to the PLC. The diagram shows an example of four physical locations connected by a communications cable.

Communications and Shielded Cables



Good quality 24 AWG minimum twisted-pair shielded cables, with overall foil and braid shields are recommended for analog cabling and communications cabling outside of the PLC enclosure. To date it has been a common practice to only provide an earth ground for one end of the cable shield in order to minimize the risk of noise caused by earth ground loop currents between apparatus. The procedure of only grounding one end, which primarily originated as a result of trying to reduce hum in audio systems, is no longer applicable to the complex industrial environment. Shielded cables are also efficient emitters of RF noise from the PLC system, and can interact in a parasitic manner in networks and between multiple sources of interference.

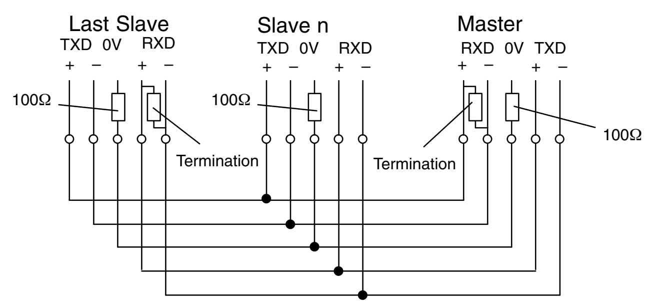
The recommendation is to use shielded cables as electrostatic "pipes" between apparatus and systems, and to run heavy gauge equi-potential bond wires alongside all shielded cables. When a shielded cable runs through the metallic wall of an enclosure or machine, it is recommended in IEC 1000–5–2 that the shield should be connected over its full perimeter to the wall, preferably using a conducting adapter, and not via a pigtail wire connection to an earth ground bolt. Shields must be connected to every enclosure wall or machine cover that they pass through.

Analog and RS232 Cables

Providing an earth ground for both ends of the shield for analog circuits provides the perfect electrical environment for the twisted pair cable as the loop consists of signal and return, in a perfectly balanced circuit arrangement, with connection to the common of the input circuitry made at the module terminals. RS232 cables are handled in the same way.

Multidrop Cables

RS422 twin twisted pair, and RS485 single twisted pair cables also require a 0V link, which has often been provided in the past by the cable shield. It is now recommended that you use triple twisted pair cabling for RS422 links, and twin twisted pair cable for RS485 links. This is because the extra pair can be used as the 0V inter-system link. With loop DC power supplies earth grounded in both systems, earth loops are created in this manner via the inter-system 0v link. The installation guides encourage earth loops, which are maintained at a low impedance by using heavy equi-potential bond wires. **To account for non–European installations using single-end earth grounds, and sites with far from ideal earth ground characteristics, we recommend the addition of 100 ohm resistors at each 0V link connection in network and communications cables.**



Shielded Cables within Enclosures

When you run cables between PLC items within an enclosure which also contains susceptible electronic equipment from other manufacturers, remember that these cables may be a source of RF emissions. There are ways to minimize this risk. Standard data cables connecting PLCs and/or operator interfaces should be routed well away from other equipment and their associated cabling. You can make special serial cables where the cable shield is connected to the enclosure's earth ground at both ends, the same way as external cables are connected.

Network Isolation

For safety reasons, it is a specific requirement of the Machinery Directive that a keyswitch must be provided that isolates any network input signal during maintenance, so that remote commands cannot be received that could result in the operation of the machinery. The FA–ISONET does not have a keyswitch! Use a keylock and switch on your enclosure which when open removes power from the FA–ISONET. To avoid the introduction of noise into the system, any keyswitch assembly should be housed in its own earth grounded steel box and the integrity of the shielded cable must be maintained.

Again, for further information on EU directives we recommend that you get a copy of our EU Installation Manual (DA–EU–M). Also, if you are connected to the World Wide Web, you can check the EU Commision's official site at: http://eur–op.eu.int/

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FIVE STAR
AUTOMATION, INC.

Operating Instructions

For TDS-5 PLC Control Panel

Velcon Systems
Colorado Springs, Colorado

Velcon Systems ORDER NO# 34719

1 General Notes

We reserve the rights to this operating manual and other technical documentation, including any cases where protected rights may be assigned.

The designated drawings and technical documents must not be reproduced, made accessible to a third party or inappropriately used in any other way without our prior agreement. Any contravention of this obligation will result in a liability for damages.

1.1 Purpose of operating instructions

These operating instructions are intended to familiarize the operators of the **TDS-5 with the following**:

- The operating method
- The controls
- The safety instructions
- maintenance

1.2 Operating Personal

The TDS-5 may only be operated by personal who have been provided with the necessary training by Velcon Systems.

This training is to be recorded on the hand over certificate.

Additional requirements, qualifications and fields of responsibility are indicated in every chapter.

1.3 Additional Documentation

The subassembly suppliers operating instructions are contained in the manual.

1.4 Filing

The operating instructions must always be kept with the system.

These instructions must be accessible at all times.

1.5 Identification data

Machine data	Model: Order No: Year of manufacture:	TDS-5 PLC Control Panel 34719 2001
Customer entries	Equipment No: Location:	
Manufacturers address	Company name: Street: Town: Telephone: Fax: E-mail:	Five Star Automation, Inc 24 A. North Research Drive Pueblo, Colorado Springs 719-547-1852 719-547-1849 info@fivestarautomation.com
Product support	Address: Telephone: Fax: E-mail:	Five Star Automation, Inc 24 A. North Research Drive Pueblo, Colorado Springs 719-547-1852 719-547-1849 info@fivestarautomation.com
Documentation data	Date of publication: Last amendment:	2/19/2001

2 Safety instructions

2.1 General safety instructions

Please observe the following instructions in particular:

- The TDS-5 is designed with the latest state of the art equipment and is reliable. However, this system may represent a hazard if used by untrained personal, improperly or for purposes for which it is not intended

- Any person involved in operating and maintaining the TDS-5 on the plant premises (inspection, maintenance and repair) shall have read and understood the operating manual, and in particular the chapter "Safety instructions". The operator is advised to confirm this in writing.

- Intended application of the system also included compliance with the manufactures operating and maintenance regulations.

- The system may only be maintained and repaired by authorized and trained personal. Such personal shall be instructed about the possible hazards.

- In the interests of safety, the responsibilities relating to the operation and maintenance shall be clearly defined and observed to avoid any un-clarity.

- The shutdown procedures specified in the operating instructions shall be followed before carrying out any operation, conversion, modification or maintenance work.

- It is prohibited to use any working method, which may impair the safety and function of the system.

- That operator shall insure that no work is carried out on the system by untrained personal.

- The operator is obliged to provide immediate notification of any changes in the performance of the system, which may impair its safety.

- The operator shall only operate the system when it is in perfect working order.

- Unauthorized conversions and modifications, which impair the safety of the system, are prohibited.

- Before any work is carried out on the system, its drives and other equipment shall be secured against accidental startup.

- After carrying out repair work, insure that all protective devices are reinstalled and tested before starting the system.

- The system shall always be operated in accordance with local safety and health directives.

The individual sections of this operating manual contain further safety instructions and descriptions, which shall be observed before the system is started.

2.2 Safety systems

Safety systems provide protection against damage due to:

- High Pressure
- High Level
- Low Flow
- Low Transformer Level
- Blocked Filter

The measuring point designations (see flow chart and Chapter) and the measures to be implemented in case of a failure are contained in **Chapter**. All faults occurring in the safety system are indicated by Alarm Lights.

- The safety systems are automatically checked before each system start and during operation for efficiency and functional capability. The measuring and control systems (MCS) are installed in easily accessible positions and protected against contamination.
- The electrical safety systems are, largely, connected using the zero voltage principle; i.e. the control system evaluates a missing signal as a fault.
- Safety system malfunctions are signaled by Alarm Lights.
- Maintenance and repair of the safety systems may only be executed by persons commissioned by the manufacturer or fully trained expert personal.

Restart of the plant after a fault-initiated shutdown, is only permissible after completion of fault rectification by experienced personnel.

The safety systems may not be disabled, bridged or otherwise manipulated. Changing of the safety system can lead to failure of the system.

2.3 Safety circuits

The TDS-5 system is equipped with safety circuits. These serve to check the conditions required before every start of the unit and to monitor them during operation.

In case of failures, the hardware and software safety circuits open immediately and interrupt the operation of the Pump.

Malfunctions are indicated by Alarm indicator Lights at the control panel and must be acknowledged via the control panel reset button.

2.3.1 Hardware Safety Circuit

The following conditions must be met before the Cabinet Fan will start:

- Thermo Switch must be in its normal state

If any of these conditions are not met, the Cabinet Fan will not start. The hardware safety circuit is checked continuously during operation. In case of a malfunction, the Cabinet Fan is immediately de-energized.

2.3.2 Software Safety Circuit

The TDS-5 also has a software safety circuit in addition to the hardware safety circuit.

The following conditions must be met before The Pump motor will start.

- High Pressure Switch must be in its normal state
- High Level Switch must be in its normal state
- Flow switch must reach its normal state within 30 seconds of the Pump starting
- The Transformer level must be in its normal range
- The filter must not be blocked or plugged

If any of these conditions are not met, the Pump motor will not start and a malfunction signal will be initiated. The software safety circuit is checked continuously during operation. In case of a malfunction, the Pump motor is immediately de-energized and the system shifts to a malfunction mode.

3 Description

3.1 Operating principle

The TDS-5 PLC Control Panel operates as the central Control Panel for the TDS-5 system. It contains an Automation Direct PLC which uses an input and output card to process input signals to effect the output to the Pump motor and various Alarm Indicator Lights.

3.1.1 Operation mode: Start-up

Before the start-up of the system, all safeties are checked by the PLC. If all are found normal all Alarm Lights will be off. At this time the Start Push Button may be depressed to start the Pump Motor. If no flow is detected within 30 seconds the Pump Motor will shutdown and the Low Flow Alarm light will illuminate.

3.1.2 Operation mode: Normal operation

If after starting the Pump Motor, flow is detected within the 30 second time limit the unit will operate normally until the Pump Motor is manually shutdown or a fault (alarm) condition occurs.

3.1.3 Operation mode: System shut-down

The shutdown of the system from normal operation is accomplished by manually pushing the Pump Motor Stop Push Button on the main control panel.

By pushing the Pump Motor Stop Push Button, the shutdown process is initiated.

The Shutdown process will Stop the Pump Motor.

4 Instrument and equipment list

A list of your system components can be found in your manual

4.1 Programmable control system

The purpose of the programmable control system (PLC) is to ensure that all the important functions of the system are carried out and to provide the necessary link with the system components.

These include:

- Starting circuit control
- Monitoring of Flows and Levels

The programmable control system (PLC) consists of various modules, which are installed, in the main control cabinet.

- Central processing with plug in memory (EPROM)
- Input modules with isolated or non-isolated inputs (110V or 24V)
- Output modules with isolated or non-isolated outputs (110V or 24V)

5 Maintenance and care

5.1 General

These rules of maintenance and care are valid for all TDS-5 systems.

To guarantee a correct function of the system, the user has to observe the following points:

- The system is to be used only for the purpose of
- According to our maintenance instructions, the system is to be checked and maintained at regular interval by competent personnel
- When carrying out maintenance operations, compliance with the manufacturers operating and maintenance instructions is mandatory.

For documentation of all checks and maintenance, we suggest you keep a logbook. So all results of commissioning, measurements and maintenance can be recorded. Also all malfunctions and the remedial measure taken to correct them.

The following points must be observed for all work done on TDS-5 systems:

The main breaker shall be shut off and locked out.

NOTE: The Main Breaker to Shutoff the TDS-5 PLC Control Panel is Remotely Located on the TDS-5 Unit.

6 Troubleshooting

All the faults are shown as Red Alarm Lights.

It should be noted that only those faults associated with the conditions laid down in the safety sequence result in the automatic shutdown of the system.

These faults lead to the shutting down of the Pump Motor. They are indicated by Red Alarm Lights

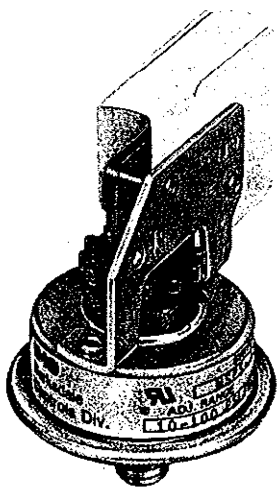
Troubleshooting must only be carried out by suitably trained personnel who are familiar with the applicable safety regulations.

After the fault has been rectified, the Pump Motor must be restarted. First, the fault reset push button on the main panel must be pushed to clear the fault. Then the Pump Motor Start Push Button Shall be pressed to initiate normal operation.

7 Circuit diagram

Please refer to the electrical drawings.

MSPS Models
Little General™



EE05 0.5-5.0 psi
EE15 1.5-15.0 psi
EE100 10.0-100.0 psi

FF05 0.5-5.0 psi
FF15 1.5-15.0 psi
FF100 10.0-100.0 psi

DD05 0.5-5.0 psi
DD15 1.5-15.0 psi
DD100 10.0-100.0 psi

JJ05 0.5-5.0 psi
JJ15 1.5-15.0 psi
JJ100 10.0-100.0 psi

OPERATING CHARACTERISTICS • ORDERING DATA

PRESSURE SWITCHES—All values given in P.S.I. (Gauge)

Proof (Test) Pressure (psig)	Adjustable Range				Approx.[1] Actuation Value (Differential)	Limit Switch Class[2]	Switch Catalog No.
	Decreasing		Increasing				
	Min.	Max.	Min.	Max.			
100	.5	4.5	1.0	5.0	.2 to .5	EE	MSPS-EE05SS
100	1.5	14.2	2.3	15.0	.3 to .8	EE	MSPS-EE15SS
150	10.0	92.1	17.9	100.0	2.0 to 7.9	EE	MSPS-EE100SS
100	.5	4.5	1.0	5.0	.2 to .5	FF	MSPS-FF05SS
100	1.5	14.2	2.3	15.0	.3 to .8	FF	MSPS-FF15SS
150	10.0	92.1	17.9	100.0	2.0 to 7.9	FF	MSPS-FF100SS
100	.5	4.3	1.2	5.0	.2 to .7	DD	MSPS-DD05SS
100	1.5	14.0	2.5	15.0	.3 to 1.0	DD	MSPS-DD15SS
150	10.0	91.0	19.0	100.0	2.6 to 9.0	DD	MSPS-DD100SS
100	.5	4.3	1.2	5.0	.2 to .7	JJ	MSPS-JJ05SS
100	1.5	14.0	2.5	15.0	.3 to 1.0	JJ	MSPS-JJ15SS
150	10.0	91.0	19.0	100.0	2.6 to 9.0	JJ	MSPS-JJ100SS

1-Fixed at any pressure; varies as shown from lowest to highest setting.
2-Class DD and EE switches: single pole, single throw, normally open.
Class FF and JJ switches: single pole, double throw, may be wired normally open or normally closed.
WETTED MATERIALS: 300 series stainless steel and Buna N; plus brass for pressure connections P1 thru P4.

DETAIL DATA

ELECTRICAL CHARACTERISTICS: All models incorporate Underwriters Laboratories (UL) Inc. listed miniature snap-action switches available in SPST normally open, or SPDT normally open or normally closed switch logic. Automatically reset by switch snap action.

ELECTRICAL RATING: Class EE and FF switches 3 amps (inductive) 125 or 250 VAC; Class DD and JJ switches 15 amps (inductive) 125 or 250 VAC; .5 amps 125 VDC, .25 amps 250 VDC.

ELECTRICAL CONNECTION: .250" wide x .032" thick quick-connect switch terminals.

PRESSURE CONNECTION: 1/8" NPT stainless steel male, standard.

TEMPERATURE RANGE: +20°F to +165°F (−7°C to +74°)

ADJUSTMENT INSTRUCTIONS: Turn adjusting knob clockwise (CW) to increase and counterclockwise (CCW) to decrease pressure setting.

OPTIONAL MODIFICATIONS: 25 amp switching in SPST configuration available. Consult factory. Various pressure connections available. See below.

ORDERING DATA: When ordering, specify switch part number, service and pressure setting required.

SWITCH PART NUMBER **MSPS-XXXXSSXX**

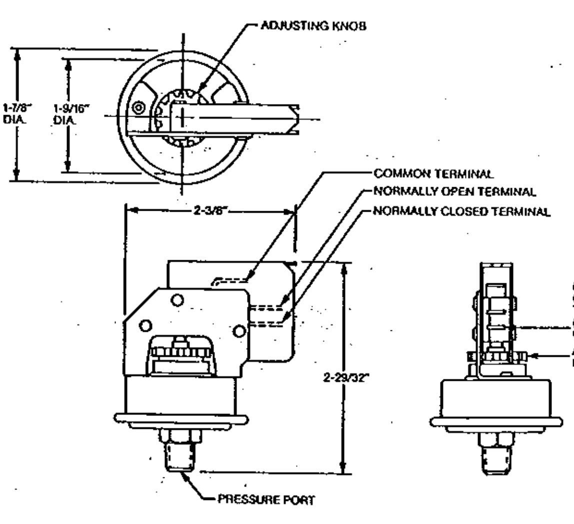
Basic Model

Switch Class
DD and EE = SPST N.O.; JJ and FF = SPDT N.O. or N.C.

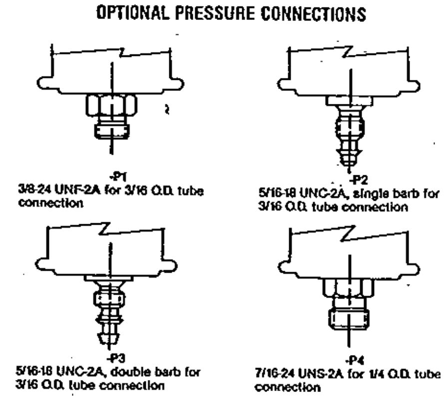
Adjustable Pressure Range in PSIG
05 = .5 to 5 psig; 15 = 1.5 to 15 psig; 100 = 10 to 100 psig

Pressure Connection Material
Omit if ordering brass; Example: MSPS-EE05

Pressure Connection Option
Standard is brass. "SS" must be omitted from order number; Example: MSPS-EE05-P1. To order stainless steel, leave "SS" in order number; Example: MSPS-EE05SS-P1



OPTIONAL PRESSURE CONNECTIONS



All models and modifications shown are Underwriters' Laboratories listed in the Recognized Component Directory under Industrial Control Equipment, Motor Controllers Float and Pressure Operated (NKPZ2) File MH8147, E42816, and Canadian Standards Association listed under Class 3231 02, File LR 22355.

Platinum™ Series Vacuum Pumps

OPERATING INSTRUCTIONS & PARTS MANUAL

2-Stage, Direct Drive

Specifications

DV-42N, DV-85N,
DV-142N, DV-200N & DV-285N

MOTOR
1/2 HP, 50HZ, 230 Volt; Capacitor start; Automatic thermal overload protected.

INTAKE

DV-42N	1/4 Male Flare
DV-85N	1/4 x 3/8 Male Flare
DV-142N, DV-200N & DV-285	3/8 x 1/4 x 3/8 Male Flare

FREE AIR DISPLACEMENT

	CFM	Liters Per Minute
DV-42N	1.5	42
DV-85N	3	85
DV-142N	5	142
DV-200N	7	200
DV-285N	10	285

-250 Series CE

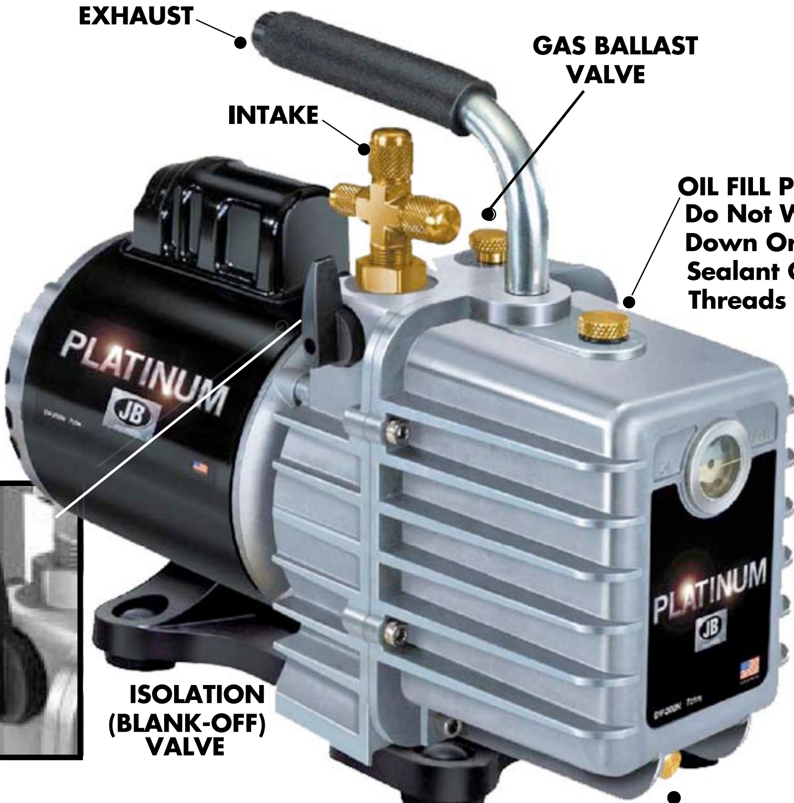
MOTOR
1/2 HP, 50 HZ, 230 Volt; Capacitor start; Automatic thermal overload protected.

INTAKE PORT
See Above

FREE AIR DISPLACEMENT

	CFM	50 HZ Liters Per Minute
DV-42N-250	1.25	35
DV-85N-250	2.5	71
DV-142N-250	4.2	119
DV-200N-250	5.8	167
DV-285N-250	8.3	237

Dual voltage motors available upon request

In order to make the best use of your investment, familiarize yourself with the new features and operating instructions before starting pump. With just routine care your ***Platinum*** will give you years of reliable service by following proper maintenance guidelines. ***Platinum* pumps are designed for deep vacuum work in refrigeration systems only.**

Each **Platinum** pump has been factory tested to guarantee 25 micron or better and listed CFM performance. The serial number has been recorded. Complete and mail the Warranty Registration Card within10 days of purchase to validate your warranty. You will be notified of any technical updates.

25,400 Microns = 1"

IMPORTANT: Use oil specifically refined for deep vacuum pumps. Using oil not refined for deep vacuum pumps and/or operating with contaminated oil will void warranty.

IMPORTANT
This unit has been drained for shipment.
DO NOT ATTEMPT TO OPERATE WITHOUT ADDING OIL.

OIL

CAPACITY

DV-42N
30 oz. (865 cc)

DV-85N
27 oz. (785 cc)

DV-142N
23 oz. (660 cc)

DV-200N
23 oz. (660 cc)

DV-285N
24 oz. (705 cc)

Being just a teaspoon low affects the ultimate vacuum.

Slowly add oil until oil level rises to the top of OIL LEVEL line. Replace oil fill plug.

If oil is too low, you will hear the exhaust baffle chatter. If the oil level is too high, excess oil will be blown out the exhaust.

Pump oil should be changed after each use. If system is heavily contaminated, oil may have to be changed several times during evacuation.

OPERATION

IMPORTANT

DO NOT START PUMP BEFORE ADDING OIL

The following procedures will prevent oil from being drawn into cartridge and creating hard start-up.

START-UP

Open one intake port and isolation valve, close gas ballast valve and start pump. Make vacuum connections.

Crack gas ballast valve for the first part of the evacuation procedure. After pump quiets down from initial volume of air, close valve and continue evacuating. Failure to close valve will result in poor pump performance.

SHUT-DOWN

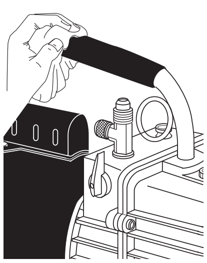
Close isolation valve and crack gas ballast valve. Continue running pump for 2-3 seconds. With gas ballast valve still cracked, stop pump and then close valve.

Remove hose connections and cap intakes.

CHANGING OIL

To reach deep vacuum, Platinum pumps need clean, moisture-free oil throughout evacuation.

Care should be taken to avoid contact on skin and clothing when changing oil. Used oil should be disposed of in a leakproof corrosive-resistant container.



1. After every evacuation while pump is warm and oil is thin, place pump on level surface and open oil drain. Oil can be forced from the pump by opening one intake and partially blocking the exhaust with a cloth while the pump is running. Do not operate the pump for more than 20 seconds using this method.
2. Close drain. Remove oil fill cap and fill to top of OIL LEVEL line with *Black Gold* Pump Oil. Replace oil fill cap.

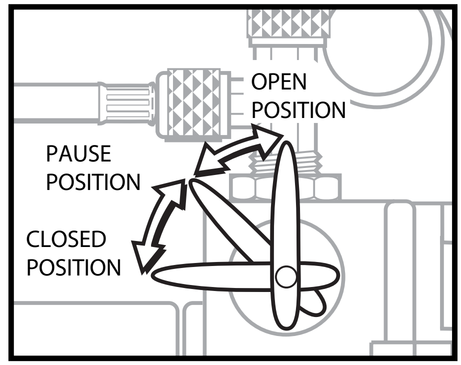
FLUSHING

If the oil is badly contaminated, flushing may be necessary. Slowly pour 1/3-1/2 cup *Black Gold* oil into the intake connection while pump is running. Repeat as required until contamination is removed from oil resevoir, pump rotors, vanes and housing.

Dispose of all oil used in flushing of pump.

After Evacuation, Oil Contains Rust Forming Water and Corrosive Acids. Drain Immediately While Pump Is Warm.

ISOLATION (BLANK-OFF) VALVE



Quarter-turn on/off. No additional valve needed to isolate system.

When checking pressure rise, slowly turn handle counter-clockwise. Pause at 45 °. Valve completely closed at 90°.

PUMP MOTOR

Pump and oil must be above 30°F. Line voltage must be equal to motor nameplate ±10%. Normal operating temperature is approximately 160°F, which is hot to the touch. Line voltage and ambient conditions will affect this somewhat. Motor has automatic resetting thermal overload protection. ***Platinum*** is designed for continuous duty and will run for extended periods without overheating.

DIGITAL VACUUM GAUGES

DV-22N
Battery

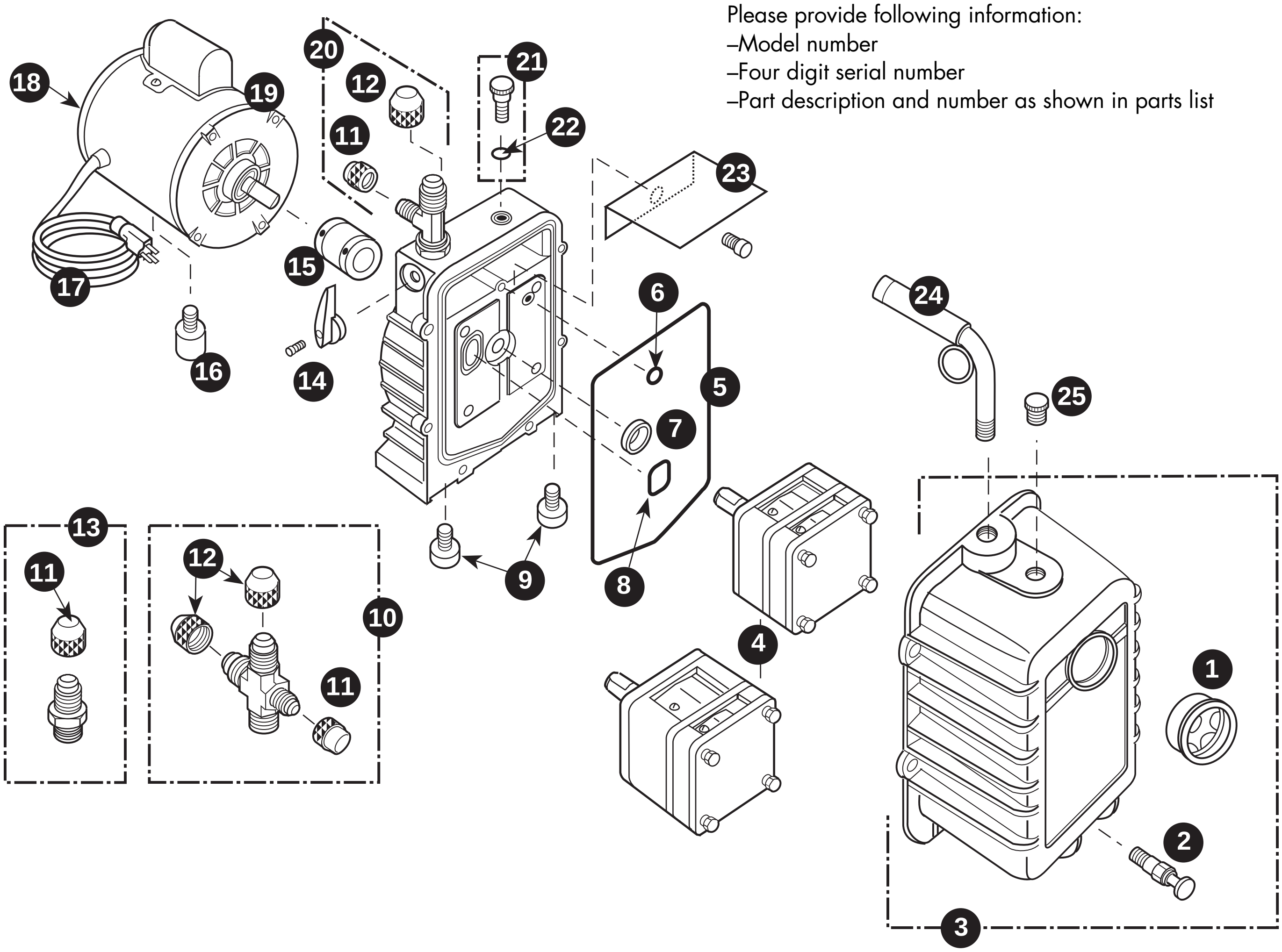
- **Reads Vacuum In 7 International Units: Microns, PSIA, InHg, MBars, Pascals, Torr, MTorr**

DV-20
Battery/Electric

Both Gauges Feature

- **Digital Display With Solid State Circuitry**
- **+32° F to +120°F (0° C to 48.9 °C) Ambient Temperature**
- **NIST Traceable**
- **Solid State Design – No Adjustment Necessary For Temperature**
- **Automatic Power Off Battery Saver**
- **Saves Last Vacuum Readout After Shutdown**
- **Low Battery Indicator**

Please provide following information:
–Model number
–Four digit serial number
–Part description and number as shown in parts list



Ref. No.	Part No.	Description
1	PR-1	Sight Glass
2	PR-2	Drain Valve
3	PR-300	DV-42N through DV-200N Cover Assy. w/Sight Glass and Drain Valve
	PR-301	DV-285N Cover Assy. w/Sight Glass and Drain Valve
4	PR-305	DV-42N Cartridge w/O-Rings and Cover Seal
	PR-302	DV-85N Cartridge w/O–Rings and Cover Seal
	PR-303	DV-142N Cartridge w/O–Rings and Cover Seal
	PR-304	DV-200N Cartridge w/O–Rings and Cover Seal
	PR-314	DV-285N Cartridge w/O–Rings and Cover Seal
5	PR-311	Cover Seal
6	PR-211	Trap O-Ring, Gas Ballast
7	PR-3	Shaft Seal
8	PR-315	Trap O-Ring, Intake
9	PR-4	Rubber Foot & Screw Assy. (1 per pkg.)
10	PR-24	Intake Cross with Caps
11	NFT5-4	1/4" O-Ring Cap
12	NFT5-6	3/8" O-Ring Cap
13	PR-32	1/4" Intake with Cap
14	PR-209	Plastic Isolation Valve Handle & Screw

Ref. No.	Part No.	Description
15	PR-208	Flexible Coupler
16	PR-42	Motor Foot & Screw
17	PR-31	6' Line Cord, 115V (Emerson before 1201)
	PR-58	6' Line Cord w/M & Fe Ends, 115V (Marathon)
18	PR-35	Rocker Switch, 115V (Marathon)
	PR-54	Rocker Switch, 115V (Emerson before 1201)
19	PR-206	1/2 HP, 115V, 60HZ Motor w/Line Cord and Switch (Marathon)
	PR-207	1/2 HP, 115/230V, 50/60 HZ Motor w/Line Cord and Switch (Marathon)
20	PR-5	Intake Tee with Caps
21	PR-7	Gas Ballast Valve w/O-Ring
22	P90009	O-Ring, Gas Ballast Valve
23	PR-40	Splash Guard and Screw
24	PR-205	Cushioned Handle w/Lift Loop
25	PR-22	Oil Fill Plug w/O-Ring
Not Shown		
	PR-18	Cartridge Valve Repair Kit (Excluding 285N)
	PR-52	DV-285N Cartridge Valve Repair Kit
	PR-45	Pump Repair Kit: PR-1, PR-2, PR-4(2), PR-42, PR-208

TROUBLESHOOTING CHART

Symptom	Possible Cause(s)	Corrective Action
Pump won't start.	1. Power cord not plugged in securely. 2. Motor switch not on. 3. Pump temp. below 30°F. 4. Inconsistent line voltage.	1. Plug power cord in securely. 2. Turn motor switch to ON position. 3. Warm up pump to 30°F & turn motor switch on. 4. Line voltage must be within 10% of 115 volt.
Pump won't pull deep vacuum.	1. Contaminated oil. 2. Oil level too low. 3. Air leak in system being evacuated. 4. Pump inlet fittings missing or not tightened. 5. Coupler slipping	1. Change oil. 2. Add oil. 3. Locate & repair leaks. 4. Clean or replace O-ring. 5. Tighten coupler setscrews to flats of cartridge and motor.
Oil drips from point where shaft enters the pump housing.	Damaged oil seal.	Replace.
Pump shuts down and will not start.	Thermal overload may be open.	Disconnect pump from system. Wait about 15 minutes for motor to cool and turn it on again. If it cycles off again, return pump to factory for repair.
Pump cycles on and off from a completely cold start and then runs smoothly.	Oil backed up into cartridge and was being cleared out. Pump has not been shutdown properly.	1. Remove 1/4" cap. 2. Turn pump on.

PUMP MOTOR

Pump and oil must be above 30 °F. Line voltage must be equal to motor nameplate ±10%. Normal operating temperature is approximately 160°F, which is hot to the touch. Line voltage and ambient conditions will affect this somewhat. Motor has automatic resetting thermal overload protection. *Platinum*™ is designed for continuous duty and will run for extended periods without overheating.

WARRANTY

Platinum™ pumps are warranted against defects in materials and workmanship for 2 years. All JB products are guaranteed when used in accordance with our directions and recommendations, and we limit this warranty to the repair, replacement, or credit at invoice price (our option) of products which in our opinion are defective due to defects in workmanship and/or materials. In no case will we allow charges for labor, expense or consequential damage. Repairs performed on items out of warranty will be invoiced on a nominal basis. Contact you wholesaler for details.

Should you need further assistance, write our Home Office or contact your nearest J/B Service Center.

MAIN WAREHOUSE
JB INDUSTRIES, INC.
P.O. Box 1180–Dept. 85
Aurora, Illinois 60507-1180 USA
E-mail: sales@jbind.com
Visit our web site at: www.jbind.com
Toll Free Technical Service Number 1-800-323-0811

CANADA
ALLTEMP PRODUCTS CO., LTD.
827 Brock Road South
Pickering, Ont., Canada L1W 3J2
Phone: (905) 831-3311
Fax: (905) 831-1864

Form 10185-308
Printed in U.S.A.

JB INDUSTRIES INC.
Aurora, Illinois 60505 USA

TM

Please read and save these instructions. Read carefully before attempting to assemble, install, operate or maintain the product described. Protect yourself and others by observing all safety information. Failure to comply with instructions could result in personal injury and/or property damage! Retain instructions for future reference.

Dayton® Temperature Controls

Description

The single stage Models 2E206 (SPDT) and 2E728 (SPST) and the two stage Model 2E207 (SPDT) are designed to control automatic ventilation or heating systems. The 30° to 110°F temperature range permits use for many space applications.

NOTE: Not for use where a National Electrical Code Article 547 approved control is required.

The switches are enclosed and protected. A compact helical temperature element, treated to minimize corrosion, is firmly attached to the exterior of the case and when the thermostat is mounted with bulb pointed down, it is protected from falling objects, dirt, etc.

948

E29357

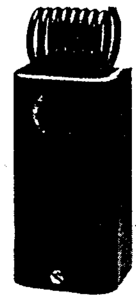


Figure 1

ENGLISH

Specifications

MODEL 2E728: One SPST switch (one set of contacts opens on temperature drop).

MODEL 2E206: One SPDT switch (one set of contacts opens on temperature rise as the other set closes simultaneously).

MODEL 2E207: Two SPDT switches, with one stage operating 3°F higher than the other stage.

Range: 30° to 110°F. (140°F maximum overrun temperature).

Differential: Approximately 3½°F. (Each switch has this differential on Model 2E207).

Temperature between stage: (Model 2E207) This difference is fixed; the low stage makes contacts R to Y at the dial setting while the high stage makes contact approximately 3°F above the dial setting.

Case: .062" cold rolled steel. Gray baked enamel finish.

Cover: .025" cold rolled steel. Gray baked enamel finish.

Contact Unit: Snap acting contacts in dust protected enclosure.

ESPAÑOL

ELECTRICAL RATINGS

MODELS 2E206 & 2E728

AC Voltage		120	208	240	277
Full load amps		16.0	9.2	8.0	—
Locked rotor amps		96.0	55.2	48.0	—
Model 2E728 SPST: Non-inductive or resistance load amps (SPST Rating) (not lamp loads)		22.0	22.0	22.0	22.0
Model 2E206:					
Non-Ind.	When connected—SPST	22.0	22.0	22.0	22.0
	When connected—SPDT	16.0	9.2	8.0	7.2
Pilot duty		125 VA, 24/600 VAC			

MODEL 2E207

AC Voltage	120	208	240
Full load amps	16.0	9.2	8.0
Locked rotor amps	96.0	55.2	48.0
Non-inductive or resistance load amps (not lamp loads)	16.0	9.2	8.0
Pilot duty	125 VA, 24/600 VAC		

NOTE: When used as a two circuit switch, the total connected load must not exceed 2000 VA.

FRANÇAIS

General Safety Information

1. Make certain that the electrical ratings of the thermostat conform to the power source and to the load(s) being controlled. Loads exceeding the rating of the thermostat should be handled with a suitably rated relay or motor starter.
2. Disconnect all power before installing or servicing. If the power disconnect is out of sight, lock it in the open position and tag it to prevent unexpected application of power. Failure to do so could result in fatal electric shock.

⚠WARNING ***Do not depend upon the thermostat as the sole means of disconnecting power when installing or servicing the product it is controlling. Always disconnect power at the main circuit breaker as described above. Failure to do so could result in fatal electric shock.***

3. Special attention must be given to any grounding information pertaining to this thermostat and to any other equipment associated with its installation and use. To ensure a proper ground, the grounding means must be checked by a qualified electrician.

Form 5S1421

997-486-10

Printed in U.S.A.
06881
0996/294/VCPVP

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Dayton® Temperature Controls

General Safety Information (Continued)

4. This thermostat is intended ONLY for permanent installation in accordance with the United States National Electrical Code (NEC), all applicable local codes and ordinances, and all sections of this manual. All wiring should be done by a qualified electrician, using copper wire only.
5. This thermostat is intended for general heating or cooling ONLY. It must NOT be used in potentially dangerous locations such as flammable, explosive, chemical-laden or wet atmospheres.
6. These thermostats are designed for use only as operating controls. Where an operating control failure would result in personal injury and/or loss of property, it is the responsibility of the installer to add devices (safety, limit controls) or systems (alarm, supervisory systems) that protect against, or warn of, control failure.
7. Use this thermostat as an operating control only.
8. In cases in which property damage may result from malfunction of the thermostat, a backup system should be used. Where critical or high value products are to be maintained, an approved temperature limit should be wired in series with this thermostat. In less critical applications, a second thermostat with alarm contacts can be used to provide redundancy.

Installation

LOCATION

Mount control 5 to 6 feet above the floor where it will be exposed to the average temperature of the controlled space. Do not mount control where it will be affected by unusual heat or cold such as directly exposed to body heat or in sunlight. Avoid locations near a door, window or other opening. Do not mount on an outside wall

MOUNTING

⚠ CAUTION ***Do not dent or deform the sensing bulb of this control. A dent or deformation will change the calibration and cause the control to cycle at a temperature lower than the dial setting.***

⚠ CAUTION ***On rough mounting surface use top two mounting holes only. When you mount this control on an uneven surface and pull all four mounting screws down tight, you can twist the case enough to affect thermostat calibration and operation.***

Dimensions

Performance specifications appearing herein are nominal and are subject to accepted manufacturing tolerances and application variables.

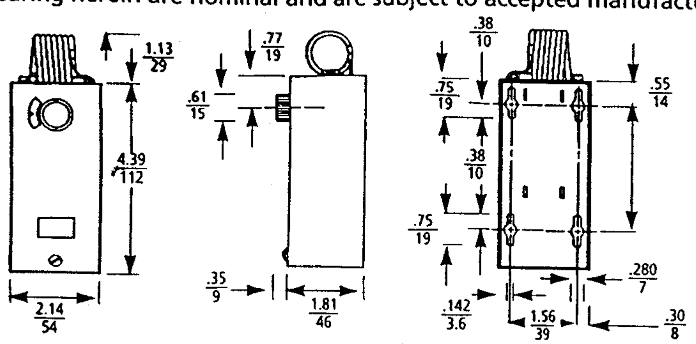

Figure 2 - Dimensions in inches/milimeters

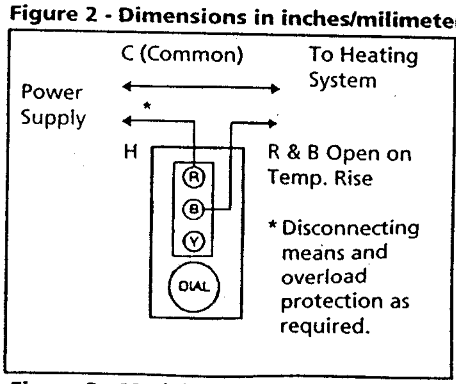

Figure 3 - Model 2E206 in Typical Heating Control Circuit

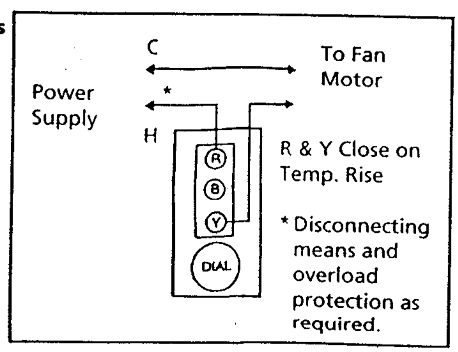

Figure 4 - Models 2E206 & 2E728 in Typical Ventilating or Cooling Control Circuit. (Terminal B is not used on Model 2E728).

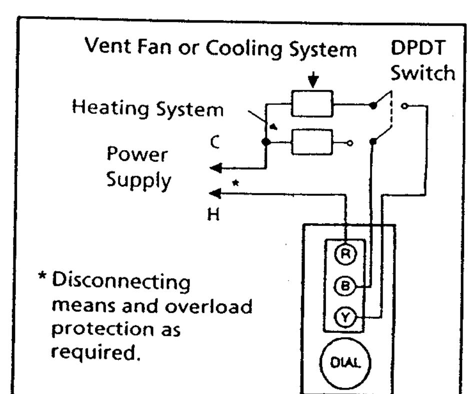

Figure 5 - Model 2E206 in Control of Heating and Ventilating Systems.

Models 2E206, 2E207 and 2E728

Installation (Continued)

WIRING

All wiring should be done in accordance with applicable codes, ordinances and regulations. Figures 3, 4 and 5 illustrate typical wiring of Models 2E206 and 2E728 for control of heating, cooling and combination heating-cooling control systems (copper conductors only).

NOTE: Letters R, B and Y (red, blue and yellow) refer to color of paint dots near terminals. Numbers 1, 2 and 3 appear on the terminals themselves.

Figure 6 shows typical wiring for the control of a two speed ventilating fan. When control temperature element reaches the dial settings of Model 2E207, the low temperature switch starts the fan on low speed. If the space temperature continues to rise, the high temperature switch supplies power to the high speed motor winding while disconnecting the low speed winding.

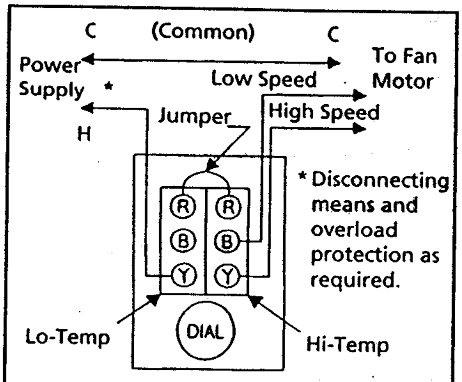

Figure 6 - Model 2E207 in Typical Two-Speed Ventilating Fan Control Circuit

Figure 7 shows Model 2E207 in a typical hook-up for a two-volume fan application. The fan will start when the temperature element reaches the dial setting. If the temperature continues to rise, the damper motor will be energized by the high temperature switch.

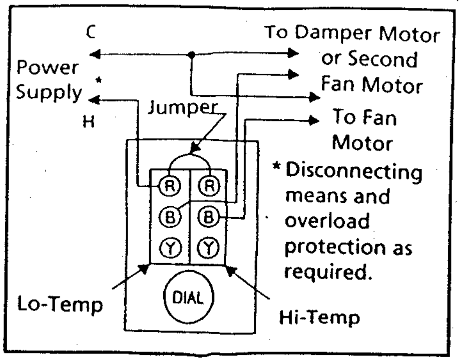

Figure 7 - Model 2E207 in Control of Single Speed Ventilating Fan and Volume-Increase Damper Motor.

Model 2E207 can also be used to control a combination heating and ventilating or cooling system, as shown in Figure 8. A temperature increase to the dial setting will turn off the heating system when the R-B contacts of the low temperature switch break. An increase in temperature of about 3°F will turn on the fan or cooling system through the R-Y contacts of the high temperature switch.

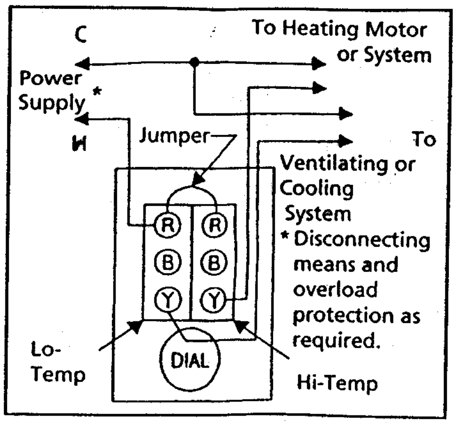

Figure 8 - Typical Wiring of Heating and Cooling Devices to Model 2E207 Two-Stage Thermostat (Automatic Changeover).

Figure 9 illustrates typical wiring of Model 2E207 for control of two stages of heating. As the space temperature decreases to the dial setting, the high temperature switch will make R-B turning on the first stage of heating. If the temperature continues to drop (about 3°F). the low temperature switch will make R-B turning on the second stage of heating.

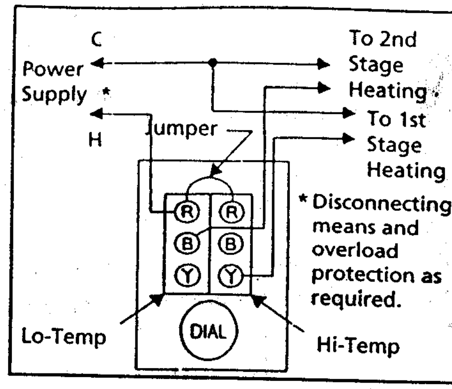

Figure 9 - Typical Wiring of two-Stage Heating.

CHECKOUT PROCEDURE

Before leaving the installation, a complete operating cycle should be observed to see that all components are functioning properly.

Check for correct operation in the following manner:

1. Models 2E206 & 2E728 — Ventilating or Cooling System: Turn dial clockwise to a setting above space temperature. Fan or cooling system should be off. When dial is turned counterclockwise, the fan or cooling system should turn on approximately at the dial setting.

   Model 2E206 — Heating System: Turn dial clockwise above the space temperature; the heating unit should be on. When dial is turned counterclockwise, the heating unit should turn off approximately at the dial setting.
2. Model 2E207 — If hook-up is similar to Figure 6, fan should start at approximately space temperature and should change to high speed as the dial is turned counterclockwise to a lower temperature setting. If wiring is similar to Figure 7, the damper should open as the dial is turned counterclockwise. The devices should act in reverse sequence when the dial is turned clockwise.

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Operation

Figure 10 illustrates the operation of Model 2E207. On a temperature increase to the dial setting, the circuit between R and Y of the low stage switch (RYL) closed. Simultaneously the circuit between R and B (RBL) opens. On a further increase in temperature the high stage switch operates and closes (RYH) while simultaneously opening (RBH). The reverse sequencing takes place on a temperature fall.

NOTE: No Replacement Parts Available.

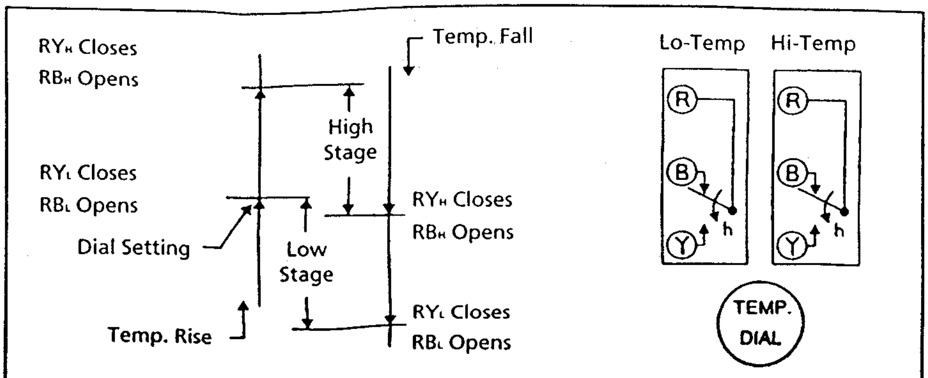

Figure 10 — Operational Diagrams of Model 2E207

Troubleshooting Chart

Symptom	Possible Cause(S)	Corrective Action
Models 2E206 & 2E728		
Cooling or fan does not operate	1.Improper wiring 2.Thermostat dial set above space temperature	1.Check wiring 2.Set dial to lower temperature
Cooling or fan runs continuously	1.Improper wiring 2.Thermostat dial set below space temperature	1.Check wiring 2.Set dial to higher temperature
Model 2E206		
System operates in reverse	Improper wiring	Check wiring
Heating unit does not operate	1.Improper wiring 2.Thermostat dial set below space temperature	1.Check wiring 2.Set dial to higher temperature
Heating unit runs continuously	1.Improper wiring 2.Dial set above space temperature	1.Check wiring 2.Set dial to lower temperature
Model 2E207		
Cooling or fan does not operate	1.Improper wiring 2.Thermostat dial set too high	1.Check wiring 2.Adjust dial to lower setting
Cooling or fan runs continuously	1.Improper wiring 2.Thermostat set too low	1.Check wiring 2.Adjust to higher setting
Heating does not operate (Figure 9)	1.Improper wiring 2.Thermostat set too low	1.Check wiring 2.Adjust thermostat to higher setting. First stage of heating should come on when dial setting equals space temp. As dial is adjusted to higher temp. (3°F) second stage of heating unit should come on
Heating system runs continuously	1.Improper wiring 2.Thermostat set too high	1.Check wiring 2.Adjust to lower setting
System runs in reverse	Improper wiring	Check wiring

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Dayton® Temperature Controls

Limited Warranty

Dayton One-Year Limited Warranty. *Dayton® Temperature Controls, Models covered in this manual, are warranted by Dayton Electric Mfg. Co. (Dayton) to the original user against defects in workmanship or materials under normal use for one year after date of purchase. Any part which is determined to be defective in material or workmanship and returned to an authorized service location, as Dayton designates, shipping costs prepaid, will be, as the exclusive remedy, repaired or replaced at Dayton's option. For limited warranty claim procedures, see PROMPT DISPOSITION below. This limited warranty gives purchasers specific legal rights which vary from jurisdiction to jurisdiction.*

Limitation of Liability. *To the extent allowable under applicable law, Dayton's liability for consequential and incidental damages is expressly disclaimed. Dayton's liability in all events is limited to and shall not exceed the purchase price paid.*

Warranty Disclaimer. *Dayton has made a diligent effort to provide product information and illustrate the products in this literature accurately; however, such information and illustrations are for the sole purpose of identification, and do not express or imply a warranty that the products are merchantable, or fit for a particular purpose, or that the products will necessarily conform to the illustrations or descriptions.*

Except as provided below, no warranty or affirmation of fact, expressed or implied, other than as stated in the "LIMITED WARRANTY" above is made or authorized by Dayton.

Product Suitability. *Many jurisdictions have codes and regulations governing sales, construction, installation, and/or use of products for certain purposes, which may vary from those in neighboring areas. While Dayton attempts to assure that its products comply with such codes, it cannot guarantee compliance, and cannot be responsible for how the product is installed or used. Before purchase and use of a product, review the product applications, and all applicable national and local codes and regulations, and be sure that the product, installation, and use will comply with them.*

Certain aspects of disclaimers are not applicable to consumer products; e.g., (a) some jurisdictions do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you; (b) also, some jurisdictions do not allow a limitation on how long an implied warranty lasts, consequently the above limitation may not apply to you; and (c) by law, during the period of this limited warranty, any implied warranties of implied merchantability or fitness for a particular purpose applicable to consumer products purchased by consumers, may not be excluded or otherwise disclaimed.

Prompt Disposition. *Dayton will make a good faith effort for prompt correction or other adjustment with respect to any product which proves to be defective within limited warranty. For any product believed to be defective within limited warranty, first write or call dealer from whom the product was purchased. Dealer will give additional directions. If unable to resolve satisfactorily, write to Dayton at address below, giving dealer's name, address, date, and number of dealer's invoice, and describing the nature of the defect. Title and risk of loss pass to buyer on delivery to common carrier. If product was damaged in transit to you, file claim with carrier.*

Manufactured for Dayton Electric Mfg. Co., 5959 W. Howard St., Niles, Illinois 60714 U.S.A.

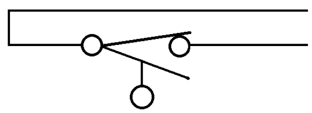
Manufactured for Dayton Electric Mfg. Co.
Niles, Illinois 60714 U.S.A.

Dayton®

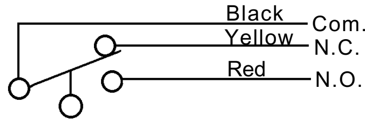
Electrical Data . . .

Standard snap-action switch is a 20VA, SPST, hermetically sealed,magnetically actuated, make-and-break type. Normally open or normally closed operation is selectable by inverting floats on unit stem. A level station with SPDT 3-wire switch is available as a separate component if required.

Typical Wiring Diagrams



SPST Switch N.O. or N.C. (Dry).
Selectable by Inverting Float.



SPDT Switch in N.C. (Dry) Position

Switch Ratings . . . Max. Resistive Load

VA	Volts	Amps AC	Amps DC
20	0-30	.4	.3
	120	.17	.13
	240	.08	.06

Important Points!

Product must be maintained and installed in strict accordance with the National Electrical Code and GEMS product catalog and instruction bulletin. Failure to observe this warning could result in serious injuries or damages.

An appropriate explosion-proof enclosure or intrinsically safe interface device must be used for hazardous area applications involving such things as *(but not limited to)* ignitable mixtures, combustible dust and flammable materials.

Pressure and temperature limitations shown on individual catalog pages and drawings for the specified level switches must not be exceeded. These pressures and temperatures take into consideration possible system surge pressures/temperatures and their frequencies.

Selection of materials for compatibility with the media is critical to the life and operation of GEMS level switches. Take care in the proper selection of materials of construction; particularly wetted materials.

Life expectancy of switch contacts varies with applications. Contact GEMS if life cycle testing is required.

Ambient temperature changes do affect switch set points, since the specific gravity of a liquid can vary with temperature.

Level switches have been designed to resist shock and vibration; however, shock and vibration should be minimized.

Liquid media containing particulate and/or debris should be filtered to ensure proper operation of GEMS products.

Electrical entries and mounting points may require liquid/vapor sealing if located in an enclosed tank.

Level switches must not be field repaired.

Physical damaged sustained by the product may render it unserviceable.

P/N 72946
Rev. L

Gems Sensors Inc.
One Cowles Road
Plainville, CT
06062.1198

tel 860.747.3000
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Fabri-Level Switch Kit

Instruction Bulletin No. 72946

Fabri-Level Kits contain all components for complete assembly of a 1- or 2-station level switch unit for pipe-plug mounting in your tank. Each kit contains: 1 Tube Connector, 1 Mounting Plug, 2 Level Stations (Switch, Tube, Float), 2 Extension Tubes, 1 Tube End Fitting, 3 Tube Unions.

Specifications . . .

Conduit Thread: 1/2" NPT-F
Tube/Fitting Size: 1/2" O.D.
Max. No. Levels per Stem: 6
Mounting Attitude: Vertical ± 30°
Fitting Ferrule:
Buna N Floats: Nylon
Stainless Floats: 316 Stainless Steel

N.O. or N.C. operation of the SPST switch is selectable by inverting the float(s) on the unit stem. **Note: SPDT circuits must have "N.O." toward lead wires. SPDT floats are not reversible.** Two 10" lengths of tube are furnished to space level stations as desired.

Switch	Material	Oper. Temp.		Min. Sp. Gr.	Pres. (Max.PSI)	Mtg. NPT	Part Number
		Water	Oil				
SPST 20 VA	Brass Fittings, Buna N Floats	To 180°F (82.2°C)	-40°F to +230°F	.55	150	2"	24576
				.75		1-1/4"	26128
	316 SS Fittings, Buna N Floats		(-40°C to +110°C)	.75		1-1/4"	26130
				55		2"	26675
	All 316 SS	-40°F to +275°F (-40°C to +135°C)		.80	750	2"	24577

This product is suitable for Class I and Class II applications only, per the requirements of standard EN60730 and any additional specific requirements for a particular application or medium being sensed. Class I compliance of metal bodied units requires a ground connection between the metal body and the earthing system of the installation. Class I compliance of plastic bodied units in contact with a conductive medium requires that the medium be effectively earthed so as to provide an earthed barrier between the unit and accessible areas. For Class III compliance, a supply at safety extra-low voltage (SELV) must be provided. Please consult the Factory for compliance information on specific part numbers.

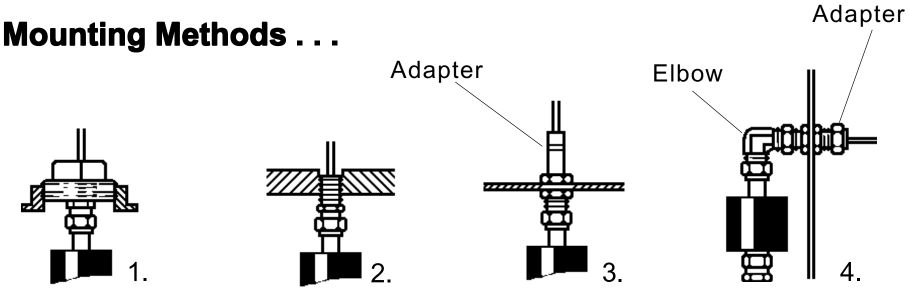
Installation and Maintenance . . .

Installation can be from top, bottom or side of tank, as shown below. Usually installed as nearly vertical as possible, units will operate reliably as much as 30o from the vertical. Only two wrenches are needed to assemble. From one to six level stations may be spaced as desired on a single unit. You merely follow **"Assembly Instructions"**, install in tank, connect electrical leads and your "tailor-made" unit is ready for use . . . in any media compatible with Brass and Buna N or 316 Stainless Steel - the two material options available.

Installation and Maintenance (Cont.)

Maintenance requirements are minimal and usually limited to occasional clean-up of scum or scale accumulation.

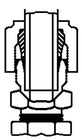
Mounting Methods . . .



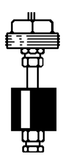
1. 1-1/4" or 2" NPT pipe plug. Top or bottom mount, boss or thickwall tank. Permits unit insertion from outside.

2. 3/8" NPT-M tube connector. Top or bottom mount from inside. Boss or thickwall tank.

3, 4. Top-mount through sheet metal cover, or with 90° elbow for mounting unit from inside of tank.



Pressure-type fittings form positive seal. Tube cannot turn, wires cannot twist during tightening. Nylon ferrule for brass units, SS ferrule for stainless units. 13/16" and 7/8" HEX fittings.



2" NPT mounting plug permits entire unit to be inserted in tank from outside. 1/2" NPT-F provides direct electrical conduit connection. A 1-1/4" NPT mounting plug is also available.

Assembly Instructions . . .

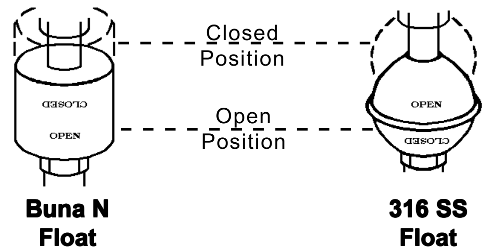
1. Assemble unit, observing the following sketches and information.

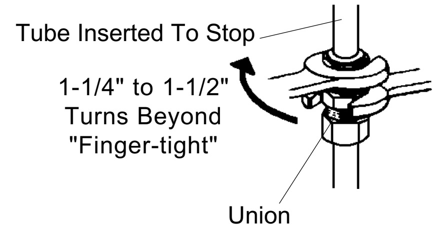
a/ Extension Tubes (When Required): Cut to proper length. Tubes 36" long are available as components, or use any 1/2" tubing of suitable non-magnetic material.

b/ Level Stations: Assemble floats on switch tubes for desired switch operation, as shown. Feed level station wires through switch tubes of each level station, toward mounting plug. **Note: Floats are shown in normally open (dry) position. To reverse operation, invert floats.** (See next page)

Note

SPDT circuits must have "N.O." towards lead wire end of switch tube. SPDT floats are not reversible.



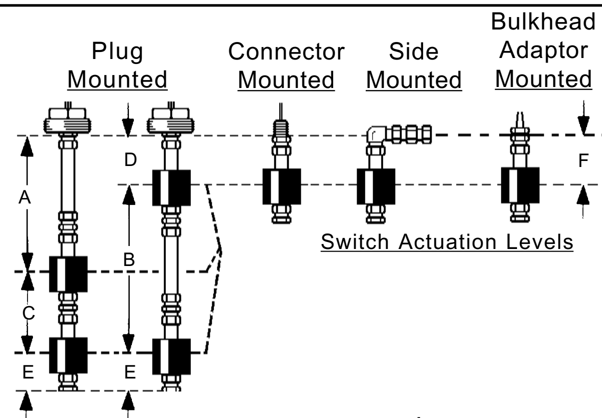


c/ **Coupling Components Together:** Insert tubes to limit in fittings and tighten "finger-tight". After checking entire unit, wrench-tighten as illustrated. **Important: Always assemble entire unit "finger-tight" first, then check level locations and switch operation (N.O. or N.C.) before final tightening.**

2. **Install Unit in Tank:** Fabri-Level units with 1 1/4" or 2" NPT mounting plugs are installed through a boss or tapped hole from outside of tank. Units with alternate mountings are installed from the inside.

3. **Electrical Leads:** Leads are readily identified for connection; i.e., switch leads nearest mounting end of unit project the farthest, etc. **CAUTION: See "Switch Ratings" before connecting power to Fabri-Level unit.**

Actuation Level Dimensional Data . . .



Note:
Buna N floats shown.

When two or more extension tubes are coupled together for greater length, assemble coupling unions before cutting to length per "A" or "B" (In illustration at left).

For Units with Buna N Floats . . .

A. Min. with tube extension: 4-3/4"
Cut tube to length: "A" minus 2-7/8"
B. Min. with tube extension: 6-5/16"
Cut tube to length: "B" minus 4-15/16"
C. 4-1/4": Closest that levels can be.
D. 2-5/8": Highest possible level.
E. 2-1/8": Lowest possible level.
F. 2-7/8": Minus tank wall thickness.

For Units with 316 Stainless Floats . . .

A. Min. with tube extension: 4-1/2"
Cut tube to length: "A" minus 2-5/8"
B. Min. with tube extension: 6-5/8"
Cut tube to length: "B" minus 4-11/16"
C. 4-1/2": Closest that levels can be.
D. 2-3/8": Highest possible level.
E. 2-5/8": Lowest possible level.
F. 2-5/8": Minus tank wall thickness.

Shuttle-Type Flow Switches
Series FS-200/400
Instruction Bulletin No. 45523

Gems Sensors
An Ino Industries Business

Installation

Install FS-200 or FS-400 Series units in piping system using standard pipe fitting procedures. Be careful to keep sealing compound out of the unit. Be sure to observe direction of flow - marked "IN" and "OUT" on housing. See chart below for port and wrench hex. sizes.

Unless otherwise specified, standard FS-200 and FS-400 units are factory-calibrated with water. FS-200 and FS-200 Adjustable units are installed horizontally, in line, with lead wires up. FS-400 and FS-400 Adjustable units are installed vertically; lead wires up, as shown. 150 micron filtration is suggested for use with all units.

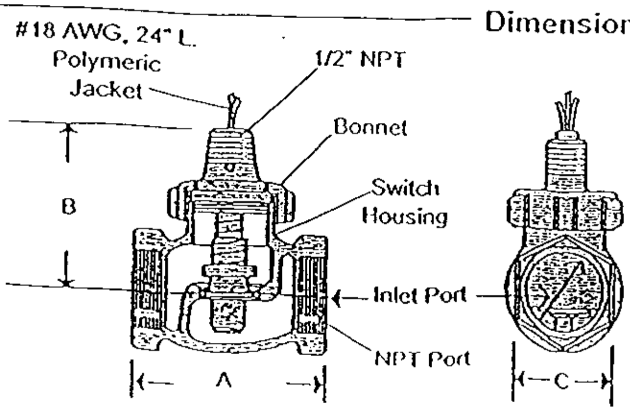
Specifications (FS-200 Series)

Wetted Materials	
Housing	
FS-200	Bronze or 316 Stainless Steel
FS-200 Adj.	Bronze
Shuttle	Teflon®
Bonnet	Bronze or Stainless Steel
Spring	316 Stainless Steel
Other Wetted Parts	Viton®, Ceramic
Pressure Rating	
Operating	400 PSIG @ 100°F (37.8°C)
Proof	800 PSIG @ 100°F (37.8°C)
Operating Temperature	
FS-200	-20°F to +300°F (-29°C to +148.9°C)
FS-200 Adj.	-20°F to +200°F (-29°C to +93.3°C)
Repeatability	1% Maximum Deviation
Set Point Accuracy	±10%
Set Point Differential	15% Maximum
Switch*	SPDT, 20 VA
Electrical Termination	No. 18 AWG, 24" L., Polymeric Lead Wires

Note: Bonnet and shuttle assembly should be removed from unit during welding or brazing. (See bonnet assembly removal under "Maintenance" on back of sheet.)

*See "Electrical Data" on inside pages

Dimensions (FS-200 Series)



Model	Port Size NPT	"A" Dim.	"B" Dim.	"C" Dim. (HEX)
FS-200 and FS-200 Adjustable	1"	3-1/4"	3"	1-25/32"
	1-1/4"	4"	3-3/16"	2-3/16"
	1-1/2"	4-1/2"	3-1/2"	2-1/2"
	2"	5-3/8"	4"	3-3/32"
	2-1/2"	6-5/16"	4-1/2"	3-5/8"
	3"	7-3/8"	5-5/32"	4-3/8"

Adjustable versions available in 1" port sizes only.

Specifications (FS-400 Series) . . .

Wetted Materials	
Housing	Bronze
Shuttle	Delrin®
Spring	316 Stainless Steel
O-Ring	Viton®
Other Wetted Parts	Ceramic
Pressure Rating, Max.	
Operating	400 PSI @ 100°F (+37.8°C)
Proof	800 PSI @ 100°F (+37.8°C)
Operating Temperature	-20°F to +180°F (-29°C to +82.2°C)
Repeatability	1% Maximum Deviation
Set Point Accuracy	±10%
Set Point Differential	15% Maximum
Switch*	SPDT, 20 VA
Inlet/Outlet Ports	3/4" NPT
Electrical Termination	No. 18 AWG, 24" L., Polymeric Lead Wires

*See "Electrical Data" below.

CE

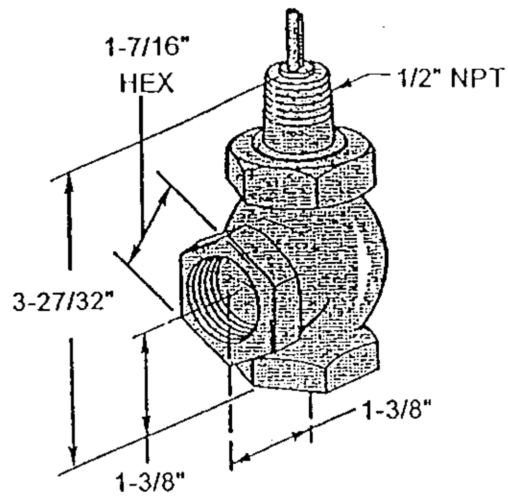
This product is suitable for Class I and Class II applications only, per the requirements of standard EN60730 and any additional specific requirements for a particular application or medium being sensed. Class I compliance of metal bodied units requires a ground connection between the metal body and the earthing system of the installation. Class I compliance of plastic bodied units in contact with a conductive medium requires that the medium be effectively earthed so as to provide an earthed barrier between the unit and accessible areas. For Class III compliance, a supply at safety extra-low voltage (SELV) must be provided. Please consult the Factory for compliance information on specific part numbers.

Electrical Data

Switch Ratings - Maximum Resistive Load

VA	Volts	Amps AC	Amps DC
10 General Use	0-50	.2	.13
	120	.08	N.A.
	100	N.A.	.3
20 Pilot Duty	0-30	.4	.3
	120	.17	.13
	240	.08	.06
50 General Use	0-50	0.5	0.5
	120	.4	.4
	240	.2	.2

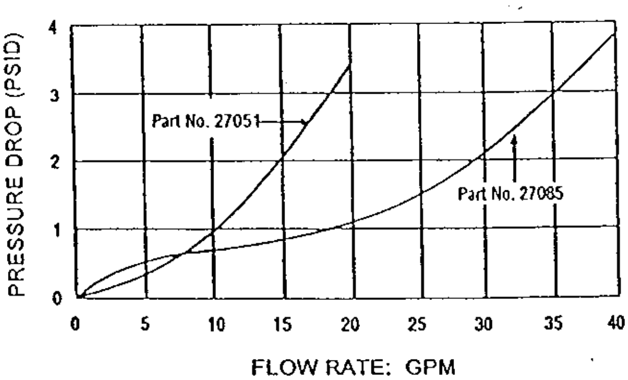
Dimensions (FS-400 Series)



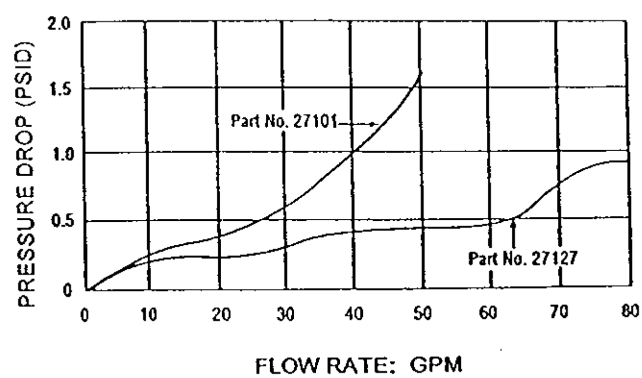
Pressure Drop Charts - Typical

FS-200 Series

1" NPT and 1-1/2" NPT Ports

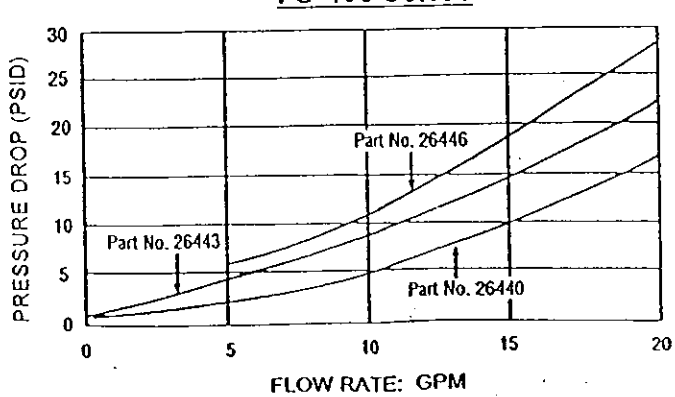


2" NPT and 3" NPT Ports



Note: Tests conducted with units in horizontal position (lead wires up) with water at +70°F (21°C).

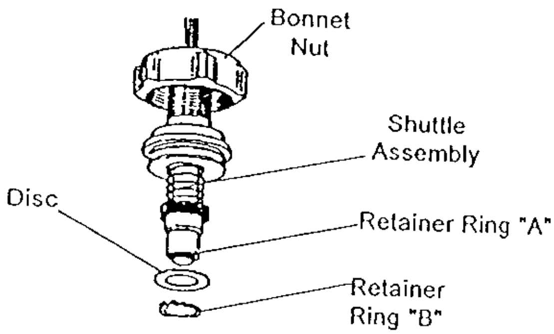
FS-400 Series



Note: Tests conducted with units in vertical position (lead wires up) with water at +70°F (21°C).

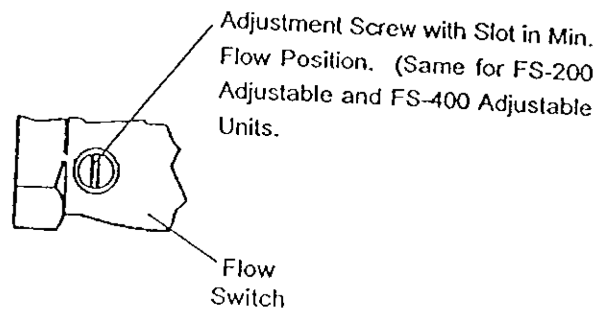
Electrical Connection . . .
Lead wires and 1/2" NPT or junction box with 1/2" NPT.

Maintenance . . .
Occasional cleaning when excessive contamination is present in the liquid is the only maintenance normally required. With system shut-down and no liquid in piping, remove bonnet nut to disassemble unit for cleaning. **It is not necessary to remove unit body from the system.** Remove retainer ring "A" for complete shuttle disassembly. Remove ring "B" to disassemble disc only.



Flow Setting Adjustment . . .
(FS-200/400Adjustable and FS-400 Units.)

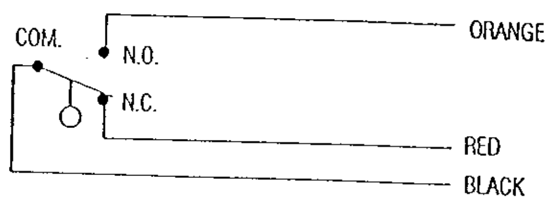
Standard units are normally supplied with adjustment set at "minimum flow" - adjustment screw slot (and vane within unit) in vertical position, as shown below. Adjustment may be made with unit on test stand or installed in system. With liquid flowing at desired rate, adjust screw in side of housing until unit just actuates. (Switch closes or opens, as desired.)



Typical Wiring Diagram . . .

SPDT, Shown Dry

FS-200/400 Series
(Fixed & Adjustable)



Important Points!

Product must be maintained and installed in strict accordance with the National Electrical Code and GEMS technical brochure and instruction bulletin. Failure to observe this warning could result in serious injuries or damages.

An appropriate explosion-proof enclosure or intrinsically safe interface device must be used for hazardous area applications involving such things as *(but not limited to)* ignitable mixtures, combustible dust and flammable materials.

Pressure and temperature limitations shown on individual catalog pages and drawings for the specified flow switches must not be exceeded. These pressures and temperatures take into consideration possible system surge pressures/temperatures and their frequencies.

Selection of materials for compatibility with the media is critical to the life and operation of GEMS flow switches. Take care in the proper selection of materials of construction; particularly wetted materials.

Life expectancy of switch contacts varies with applications. Contact GEMS if life cycle testing is required.

Ambient temperature changes do affect switch set points, since the specific gravity of a liquid can vary with temperature.

Flow switches have been designed to resist shock and vibration; however, shock and vibration should be minimized.

Liquid media containing particulate and/or debris should be filtered to ensure proper operation of GEMS products.

Electrical entries and mounting points may require liquid/vapor sealing if located in an enclosed tank.

Flow switches must not be field repaired.

Physical damage sustained by the product may render it unserviceable.

P/N 45523
Rev. K

Gems Sensors — An Imo Industries Business

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Installation & Maintenance Instructions

SERIES 8210 8211

2-WAY INTERNAL PILOTED-OPERATED SOLENOID VALVES
NORMALLY CLOSED OPERATION — GENERAL SERVICE
3/4" NPT

Form No.V5427R1

NOTICE: See separate solenoid installation and maintenance instructions for information on: Wiring, Solenoid Temperature, Cause of Improper Operation, Coil or Solenoid Replacement.

DESCRIPTION

Series 8210 valves are 2-way normally closed internal pilot-operated solenoid valves designed for general service. Valves are made of rugged forged brass. Series 8210 valves are provided with a general purpose solenoid enclosure.
Series EF8210 and 8211 are the same as Series 8210 except they are provided with an explosionproof or explosionproof/watertight solenoid enclosure.

OPERATION

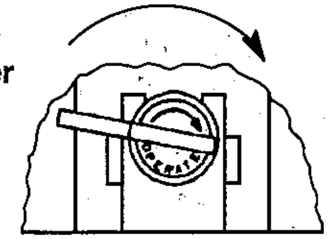
Normally Closed: Valve is closed when solenoid is de-energized; open when energized.

IMPORTANT: Minimum operating pressure differential is 5 psi.

Manual Operator (optional feature)

Manual operator allows manual operation when desired or during an electrical power outage. To engage manual operator (open the valve), turn lever clockwise until it hits a stop. Valve will now be in the same position as when the solenoid is energized. To disengage manual operator (close the valve) turn lever counterclockwise until it hits a stop.

To engage, turn lever clockwise until it hits a stop.



Partial view of Manual Operator

⚠ CAUTION: For valve to operate electrically, manual operator lever must be fully rotated counterclockwise.

INSTALLATION

Check nameplate for correct catalog number, pressure, voltage, frequency, and service. Never apply incompatible fluids or exceed pressure rating of the valve. Installation and valve maintenance to be performed by qualified personnel.

Future Service Considerations

Provision should be made for performing seat leakage, external leakage, and operational tests on the valve with a nonhazardous, noncombustible fluid after disassembly and reassembly.

Temperature Limitations

For maximum valve ambient and fluid temperatures, refer to chart below. Check catalog number and watt rating on nameplate.

Watt Rating AC/DC	Catalog Number Prefix	Solenoid Class	Maximum Ambient Temp.	Maximum Fluid Temp.
6 AC	None or DF	F	122°F (50°C)	180°F (82°C)
	HT	H	140°F (60°C)	180°F (82°C)
6.1 AC	None, KF, SF, or SC	F	125°F (54°C)	180°F (82°C)
	HT, KH, ST or SU	H	140°F (60°C)	180°F (82°C)
11.2 DC	None or HT	F or H	77°F (25°C)	150°F (65°C)
11.6 DC	None, HT, KF, KH, SC, SF or ST	F or H	104°F (40°C)	150°F (65°C)

Positioning

This valve is designed to perform properly when mounted in any position. However, for optimum life and performance, the solenoid should be mounted vertically and upright to reduce the possibility of foreign matter accumulating in the solenoid base sub-assembly area.

Mounting

For mounting bracket (optional feature) dimensions, refer to Figure 1.

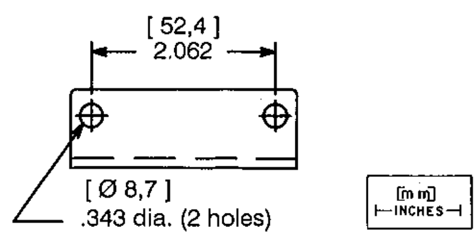


Figure 1. Mounting bracket dimensions

Piping

Connect piping to valve according to markings on valve body. Apply pipe compound sparingly to male pipe threads only. If applied to valve threads, the compound may enter the valve and cause operational difficulty. Avoid pipe strain by properly supporting and aligning piping. When tightening the pipe, do not use valve or solenoid as a lever. Locate wrenches applied to valve body or piping as close as possible to connection point.

⚠ CAUTION: To protect the solenoid valve, install a strainer or filter suitable for the service involved in the inlet side as close to the valve as possible. Clean periodically depending on service conditions. See ASCO Series 8600, 8601 and 8602 for strainers.

ASCO Valves Automatic Switch Co. 50-60 Hanover Road, Florham Park, New Jersey 07932

MAINTENANCE

⚠ WARNING: To prevent the possibility of personal injury or property damage, turn off electrical power, depressurize valve, and vent fluid to a safe area before servicing the valve.

NOTE: It is not necessary to remove the valve from the pipeline for repairs.

Cleaning

All solenoid valves should be cleaned periodically. The time between cleanings will vary depending on the medium and service conditions. In general, if the voltage to the coil is correct, sluggish valve operation, excessive noise or leakage will indicate that cleaning is required. In the extreme case, faulty valve operation will occur and the valve may fail to open or close. Clean strainer or filter when cleaning the valve.

Preventive Maintenance

- Keep the medium flowing through the valve as free from dirt and foreign material as possible.
- While in service, the valve should be operated at least once a month to insure proper opening and closing.
- Depending on the medium and service conditions, periodic inspection of internal valve parts for damage or excessive wear is recommended. Thoroughly clean all parts. If parts are worn or damaged, install a complete ASCO Rebuild Kit.

Causes of Improper Operation

- **Incorrect Pressure:** Check valve pressure. Pressure to valve must be within range specified on nameplate.
- **Excessive Leakage:** Disassemble valve and clean all parts. If parts are worn or damaged, install a complete ASCO Rebuild Kit.

Valve Disassembly

1. Disassemble valve in an orderly fashion using exploded views for identification and placement of parts. Refer to Figure 1 for AC construction; Figure 2 for DC construction.
2. Remove solenoid enclosure. See separate instructions.

- For valves supplied with optional manual operator, see section on *Disassembly of Manual Operator*.

3. Unscrew solenoid base sub-assembly from valve body. Then remove core assembly with core spring and bonnet gasket. For AC construction (Figure 1) core spring is a loose piece.
4. Remove bonnet screws, valve bonnet, diaphragm spring, diaphragm assembly, body gasket, body passage eyelet and body passage gasket.
5. All parts are now accessible for cleaning or replacement. If parts are worn or damaged, install a complete ASCO Rebuild Kit.

– Service Notice –

When installing a new ASCO Rebuild Kit, the parts supplied are new, improved and a direct replacement for the present parts providing all new parts are installed.

⚠ CAUTION: To ensure proper valve operation, install all parts supplied in ASCO Rebuild Kit. Do not mix old and new parts.

Valve Reassembly

1. Lubricate body gasket, body passage gasket, bonnet gasket and solenoid base gasket with DOW CORNING® 200 Fluid lubricant or an equivalent high-grade silicone fluid.
2. Install body passage gasket, body passage eyelet, diaphragm assembly, diaphragm spring, valve bonnet and bonnet screws. Hand thread screws as far as possible. Then torque bonnet screws in a crisscross manner to 144 ± 15 in-lbs [16,3 ± 1,7 Nm].

- For valves supplied with optional manual operator, see section on *Reassembly of Manual Operator*.

3. For AC construction (Figure 1), install core spring in core assembly. Wide end of core spring in core first, closed end protrudes from top of core.
4. Install solenoid base gasket, core assembly with core spring and solenoid base sub-assembly in valve body. Torque solenoid base sub-assembly to 175 ± 25 in-lbs [19,8 ± 2,8 Nm].
5. Install solenoid. See separate instructions.

⚠ WARNING: To prevent the possibility of personal injury or property damage, check valve for proper operation before returning to service. Also perform internal seat and external leakage tests with a nonhazardous, noncombustible fluid.

6. Restore line pressure and electrical power supply to valve.
7. After maintenance is completed, operate the valve a few times to be sure of proper operation. A metallic *click* indicates the solenoid is operating.

Disassembly of Manual Operator

1. Unscrew solenoid base sub-assembly from manual operator body.
2. Unscrew manual operator body from valve body. Then remove stem retainer from base of manual operator body and stem/spacer sub-assembly.
3. Pull stem/spacer sub-assembly with stem gasket from side of manual operator body. Then remove core assembly with core spring, solenoid base gasket and manual operator bonnet gasket.
4. For further disassembly refer to section on ***Valve Disassembly*** step 4.

Reassembly of Manual Operator

1. Lubricate manual operator stem gasket with DOW CORNING® 111 Compound lubricant or an equivalent high-grade silicone grease.
2. For AC construction (Figure 1), install core spring in core assembly. Wide end of core spring in core first, closed end protrudes from top of core.
3. Holding the manual operator body in a vertical position, install core assembly with core spring from the bottom end.
4. Insert the stem/spacer sub-assembly with the stem gasket into the side hole of the manual operator body. Rotate the lever of the stem/spacer sub-assembly to the 12 o'clock position.
5. Install stem retainer on base of manual operator body and simultaneously engage it into the slot provided on the stem/spacer sub-assembly.

IMPORTANT: The spacer on the stem/spacer sub-assembly *must be inside* of the stem retainer for AC construction (Figure 1) and *outside* of the stem retainer for DC construction (Figure 2).

6. Install bonnet gasket and manual operator body with preassembled parts into valve body. Torque manual operator body to 175 ± 25 in-lbs [19,8 ± 2,8 Nm].
7. Replace solenoid base gasket and solenoid base sub-assembly. Torque solenoid base sub-assembly to 175 ± 25 in-lbs [19,8 ± 2,8 Nm].
8. For further reassembly, refer to ***Valve Reassembly*** step 5.

Torque Chart

Part Name	Torque Value Inch–Pounds	Torque Value Newton–Meters
Solenoid base sub–assembly	175 ± 25	19,8 ± 2,8
Manual operator body	175 ± 25	19,8 ± 2,8
Bonnet screws	144 ± 15	16,3 ± 1,7

ORDERING INFORMATION FOR ASCO REBUILD KITS

Parts marked with an asterisk (*) in the exploded view are supplied in Rebuild Kits. When Ordering Rebuild Kits for ASCO valves, order the Rebuild Kit number stamped on the valve nameplate. If the number of the kit is not visible, order by indicating the number of kits required, and the Catalog Number and Serial Number of the valve(s) for which they are intended.

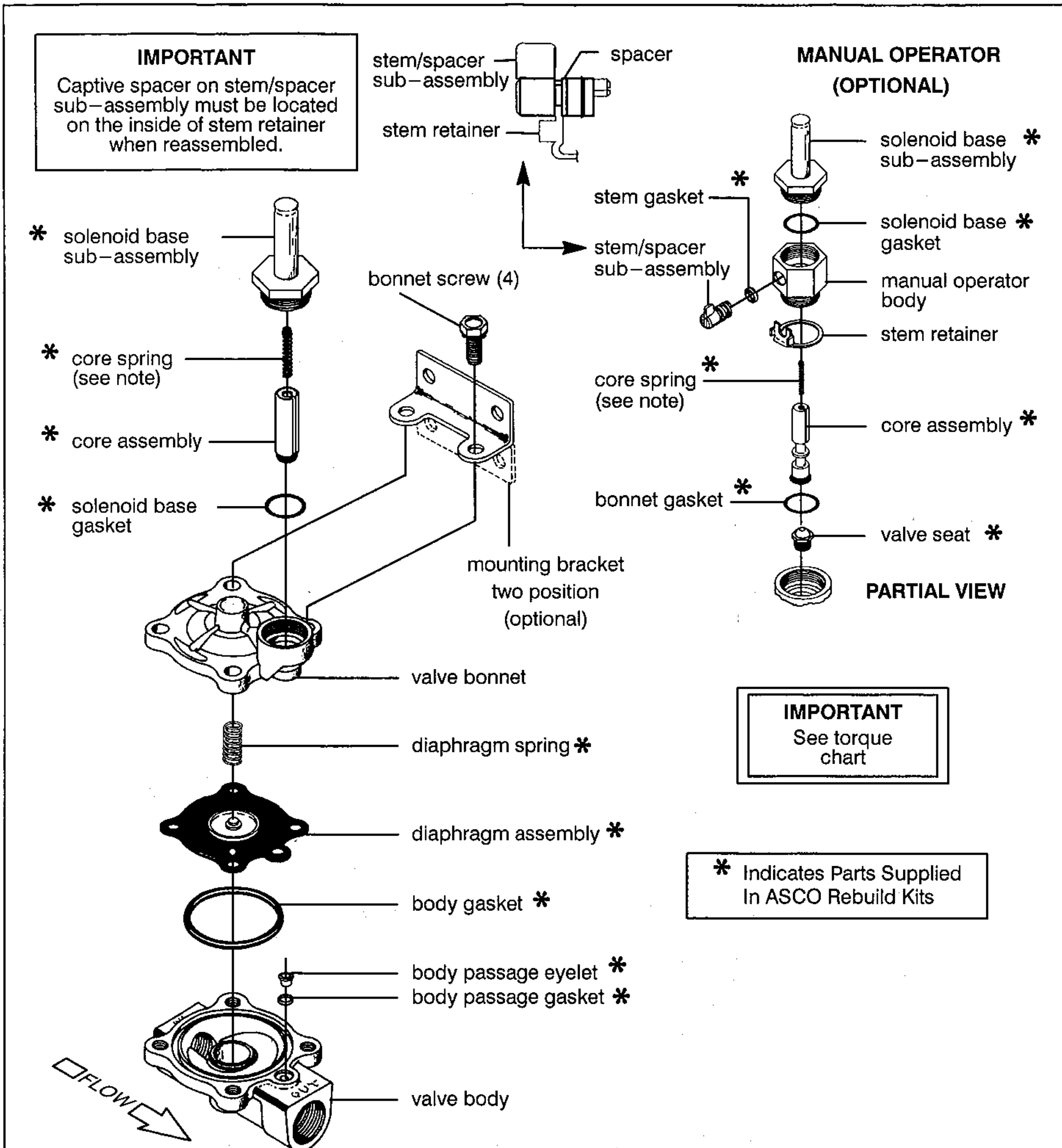


Figure 2. Series 8210 valve without solenoid, AC construction shown.

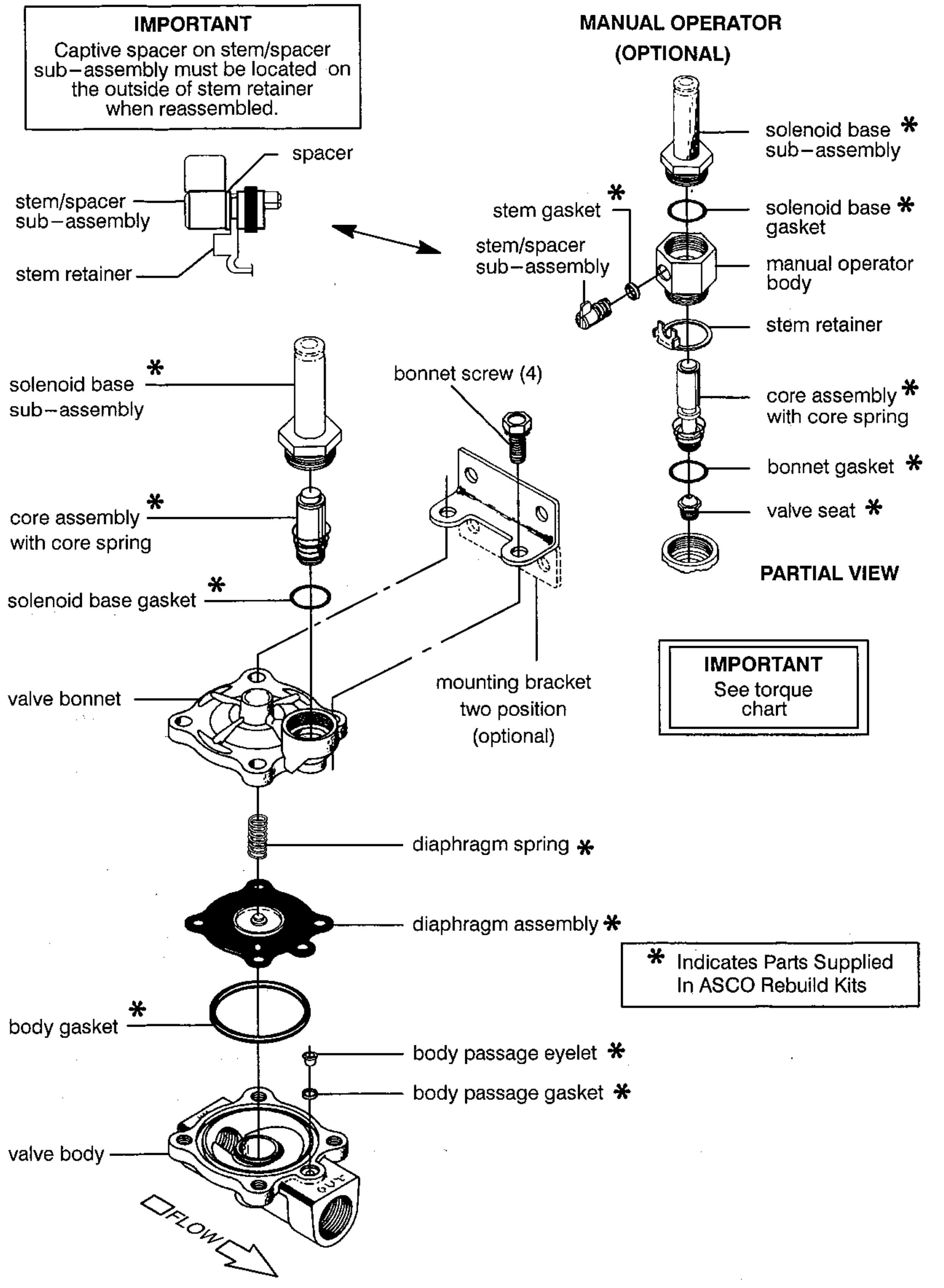


Figure 3. Series 8210 without solenoid, DC construction shown.

Installation & Maintenance Instructions

2-WAY INTERNAL PILOT-OPERATED SOLENOID VALVES
NORMALLY CLOSED OPERATION — SOFT CLOSING
3/8", 1/2", OR 3/4" NPT — 9/16" OR 3/4" ORIFICE

SERIES 8221

Form No.V6489R1

IMPORTANT: See separate solenoid installation and maintenance instructions for information on: Wiring, Solenoid Temperature, Causes of Improper Operation, Coil or Solenoid Replacement.

DESCRIPTION

Series 8221 valves are 2-way normally closed, internal pilot-operated solenoid valves designed for soft closing. Valves are made of forged brass with internal parts of brass or stainless steel and elastomers of Buna N or ethylene propylene depending upon service requirements. Valves may be provided with a general purpose or explosionproof/watertight solenoid enclosure.

OPERATION

Normally Closed: Valve is closed when solenoid is de-energized; open when energized.

IMPORTANT: Minimum operating pressure differential required is 5 psi. Valve will remain open down to 3 psi differential.

INSTALLATION

Check nameplate for correct catalog number, pressure, voltage, frequency, and service. Never apply incompatible fluids or exceed pressure rating of the valve. Installation and valve maintenance to be performed by qualified personnel.

Future Service Considerations

Provision should be made for performing seat leakage, external leakage, and operational tests on the valve with a nonhazardous, noncombustible fluid after disassembly and reassembly.

Temperature Limitations

For maximum valve ambient and fluid temperatures, refer to chart. Check catalog number prefix and suffix on nameplate to determine the maximum temperatures. See example following chart.

Construction AC or DC	Catalog Number Prefix	Catalog Number Suffix	Maximum Temperature °F	
			Ambient	Fluid
AC	None	None	125	180
	HT	None	140	180
	None	HW	125	210
	HT	HW	140	210
DC	None, or HT	None	104	150

EXAMPLES: For Catalog No. HT8221G3, AC construction the maximum ambient temperature is 140° F with a maximum fluid temperature of 180°F. For Catalog No. 8221G1HW, AC construction the maximum ambient temperature is 125° F with a maximum fluid temperature of 210°F.

Positioning

This valve is designed to perform properly when mounted in any position. However, for optimum life and performance, the solenoid should be mounted vertically and upright to reduce the possibility of foreign matter accumulating in the solenoid base sub-assembly area.

Piping

Connect piping to valve according to markings on valve body.

⚠ CAUTION: Valves with suffix "HW" in the catalog number are equipped with ethylene propylene elastomers which can be attacked by oils and greases. Wipe the pipe threads clean of cutting oils.

Apply pipe compound sparingly to male pipe threads only. If applied to valve threads, the compound may enter the valve and cause operational difficulty. Avoid pipe strain by properly supporting and aligning piping. When tightening the pipe, do not use valve or solenoid as a lever. Locate wrenches applied to valve body or piping as close as possible to connection point.

IMPORTANT: To protect the solenoid valve, install a strainer or filter suitable for the service involved, in the inlet side as close to the valve as possible. Clean periodically depending on service conditions. See ASCO Series 8600, 8601 and 8602 for strainers.

MAINTENANCE

Note: It is not necessary to remove the valve from the pipeline for repairs.

⚠ WARNING: To prevent the possibility of personal injury or property damage, turn off electrical power, depressurize valve, and vent fluid to a safe area before servicing the valve.

Cleaning

All solenoid valves should be cleaned periodically. The time between cleanings will vary depending on the medium and service conditions. In general, if the voltage to the coil is correct, sluggish valve operation, excessive noise or leakage will indicate that cleaning is required. In the extreme case, faulty valve operation will occur and the valve may fail to open or close. Clean strainer or filter when cleaning the valve.

Preventive Maintenance

- Keep the medium flowing through the valve as free from dirt and foreign material as possible.
- While in service, the valve should be operated at least once a month to ensure proper opening and closing.
- Depending on the medium and service conditions, periodic inspection of internal valve parts for damage or excessive wear is recommended. Thoroughly clean all parts. If parts are worn or damaged, install a complete ASCO Rebuild Kit.

Causes of Improper Operation

- **Incorrect Pressure:** Check valve pressure. Pressure to valve must be within range specified on nameplate.
- **Excessive Leakage:** Disassemble valve and clean all parts. If parts are worn or damaged, install a complete ASCO Rebuild Kit.

Valve Disassembly

Note: Refer to Figure 1 for AC construction and Figure 2 for DC construction.

1. Disassemble valve in an orderly fashion using exploded views for identification of parts.
2. Remove solenoid, see separate instructions.
3. Unscrew solenoid base sub–assembly and remove core assembly, core spring and bonnet gasket.
4. Remove bonnet screws and valve bonnet from valve body. Then remove the following parts: piston spring, lip seal, support, piston, disc, snubber, body gasket, bleed gasket, flow control, and pilot gasket.
5. All parts are now accessible to clean or replace. Replace worn or damaged parts with a complete ASCO Rebuild Kit.

Valve Reassembly

1. Reassemble valve using exploded views for identification and placement of parts.
2. Lubricate the disc and all gaskets with DOW CORNING® 111 Compound lubricant or an equivalent high–grade silicone grease.
3. Position flow control in valve body with concave end outward; facing valve bonnet.
4. Position bleed gasket, pilot gasket, and body gasket in valve body.
5. Preassemble snubber, disc and piston to form piston assembly. Install snubber into recessed side of disc and press this assembly into the piston.
6. Position lip seal, flanged end up, onto piston. Position support in valve body and install piston with snubber, disc, and lip seal into support.

⚠ WARNING: To prevent the possibility of personal injury or property damage, the valve bonnet and valve body must be in proper alignment. When assembling, be sure that either the letters *MB* (if present) on the valve bonnet line up with *IN* on the valve body, or that the word *OUT* (where applicable) lines up with *OUT* on the valve body. Both *MB* and the word *OUT* may be present on the same valve bonnet.

7. Replace piston spring, valve bonnet, and bonnet screws. Torque bonnet screws in a crisscross manner to 95 ± 10 in–lbs [10,7 ± 1,1 Nm].
8. Replace solenoid base gasket, core assembly, core spring, and solenoid base sub–assembly.

Note: For AC construction, position wide end of core spring in core first, closed end protrudes from top of core.

9. Torque solenoid base sub–assembly to 175 ± 25 in–lbs [19,8 ± 2,8 Nm].
10. Install solenoid, see separate solenoid instructions. Then make electrical hookup to solenoid.

⚠ WARNING: To prevent the possibility of personal injury or property damage, check valve for proper operation before returning to service. Also perform internal seat and external leakage tests with a nonhazardous, noncombustible fluid.

11. Restore line pressure and electrical power supply to valve.
12. After maintenance is completed, operate the valve a few times to be sure of proper operation.

ORDERING INFORMATION

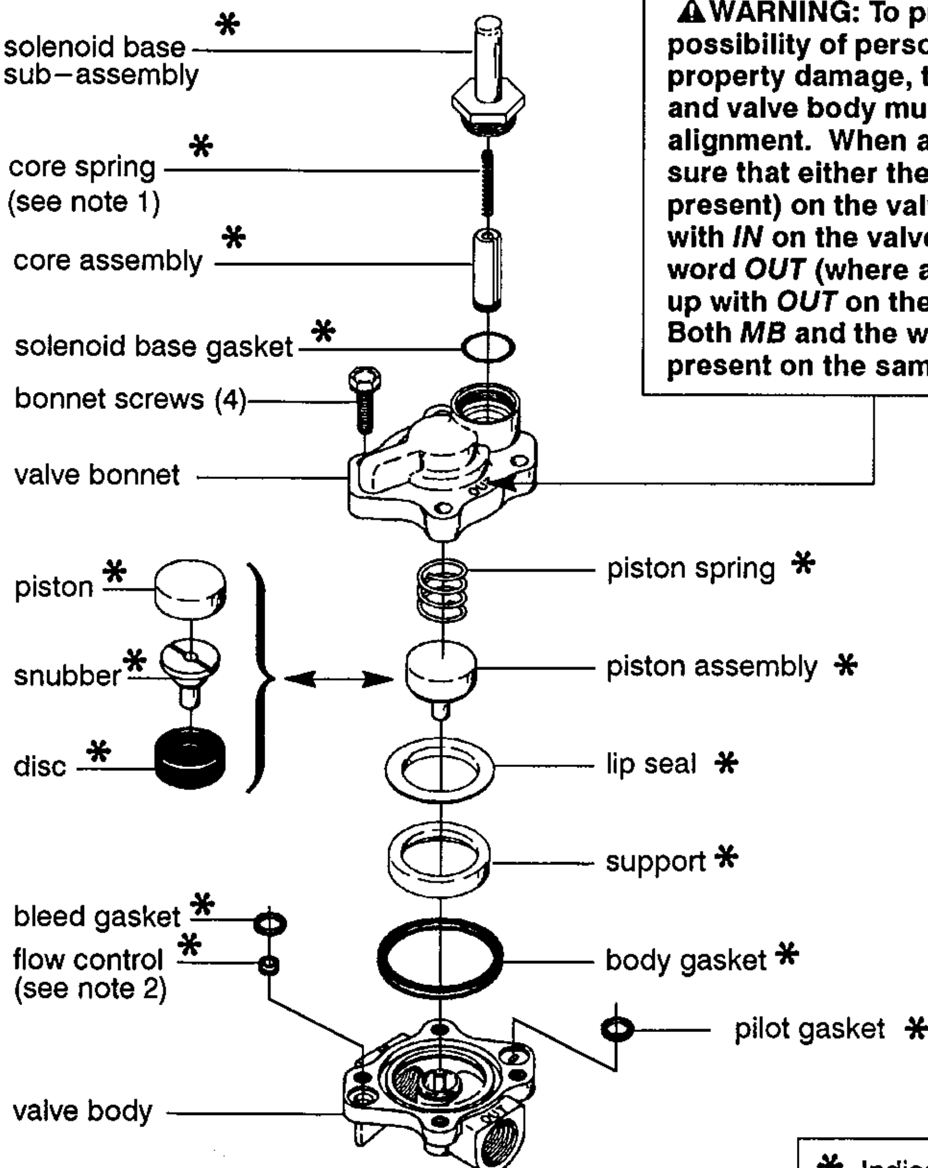
FOR ASCO REBUILD KITS

Parts marked with an asterisk (*) in the exploded view are supplied in Rebuild Kits. When Ordering Rebuild Kits for ASCO valves, order the Rebuild Kit number stamped on the valve nameplate. If the number of the kit is not visible, order by indicating the number of kits required, and the Catalog Number and Serial Number of the valve(s) for which they are intended.

Torque Chart

Part Name	Torque Value In–lbs	Torque Value Nm
solenoid base sub–assembly	175 ± 25	19,8 ± 2,8
bonnet screws	95 ± 10	10,7 ± 1,1

⚠WARNING: To prevent the possibility of personal injury or property damage, the valve bonnet and valve body must be in proper alignment. When assembling , be sure that either the letters *MB* (if present) on the valve bonnet line up with *IN* on the valve body, or that the word *OUT* (where applicable) lines up with *OUT* on the valve body. Both *MB* and the word *OUT* may be present on the same valve bonnet.



* Indicates Parts Supplied In ASCO Rebuild Kits

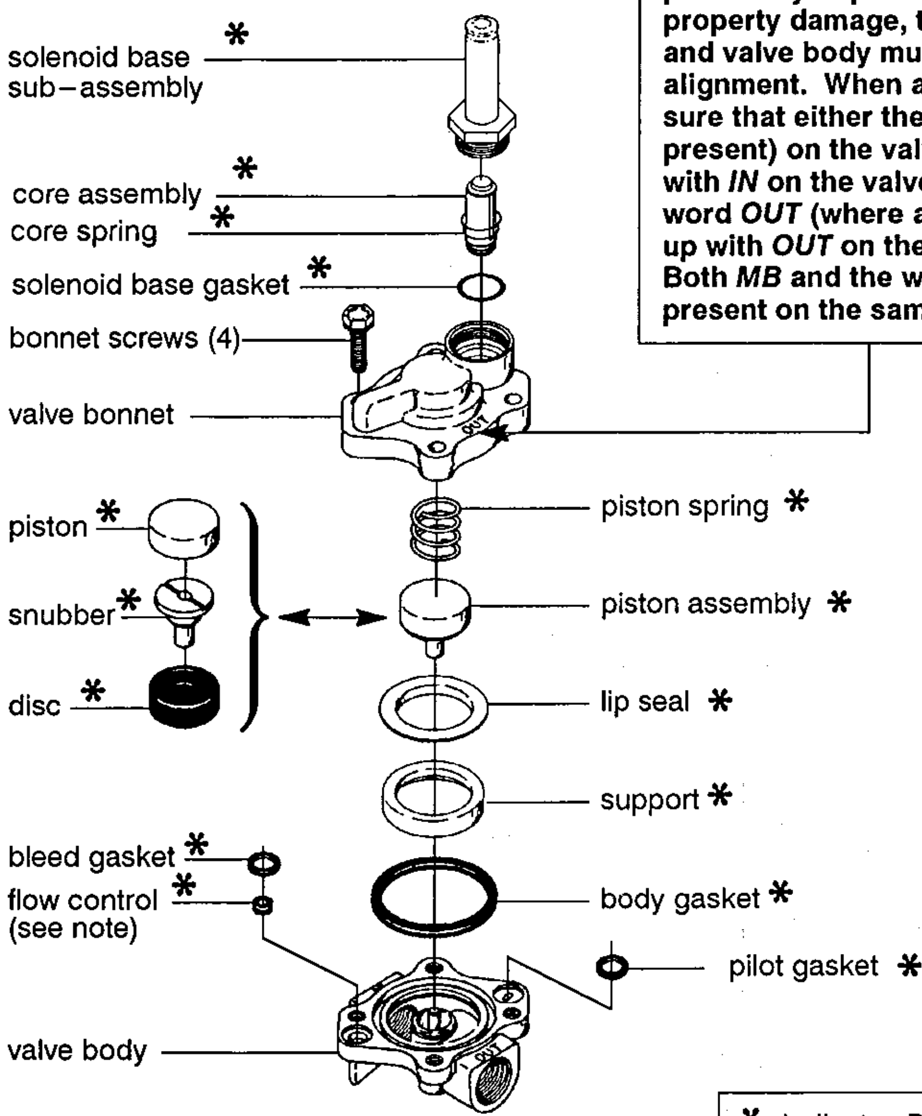
Notes:

1. Wide end of core spring in core first closed end protrudes from top of core.
2. Concave end of flow control to face valve bonnet.

Figure 1. Series 8221 valve without solenoid, AC construction shown.

Torque Chart

Part Name	Torque Value In–lbs	Torque Value Nm
solenoid base sub–assembly	175 ± 25	19,8 ± 2,8
bonnet screws	95 ± 10	10,7 ± 1,1



⚠WARNING: To prevent the possibility of personal injury or property damage, the valve bonnet and valve body must be in proper alignment. When assembling , be sure that either the letters *MB* (if present) on the valve bonnet line up with *IN* on the valve body, or that the word *OUT* (where applicable) lines up with *OUT* on the valve body. Both *MB* and the word *OUT* may be present on the same valve bonnet.

* Indicates Parts Supplied In ASCO Rebuild Kits

Note:

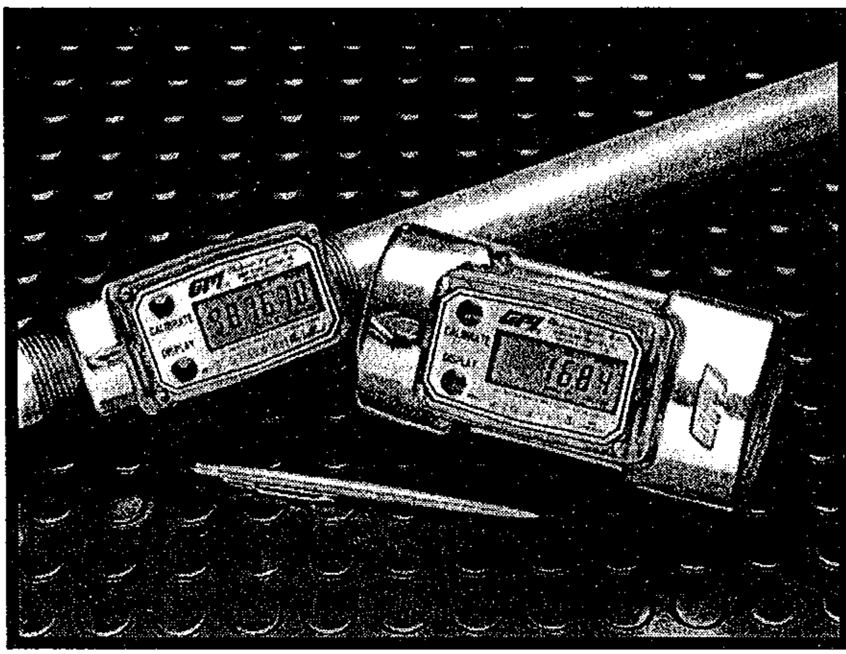
Concave end of flow control to face valve bonnet.

Figure 2. Series 8221 valve without solenoid, DC construction shown.

Manual No. 920685-6

Electronic Digital Meter

Owner's Manual



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CE

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To the owner . . .

Congratulations on receiving your GPI Electronic Digital Meter. We are pleased to provide you with a meter designed to give you maximum reliability and efficiency.

Our business is the design, manufacture, and marketing of liquid handling, agricultural, and recreational products. We succeed because we provide customers with innovative, reliable, safe, timely, and competitively-priced products. We pride ourselves in conducting our business with integrity and professionalism.

We are proud to provide you with a quality product and the support you need to obtain years of safe, dependable service.

Grant Nutter

President
Great Plains Industries, Inc.

TABLE OF CONTENTS

GENERAL INFORMATION

This manual will assist you in operating and maintaining your meter. It is designed and written with you in mind. Please take a few moments to acquaint yourself with the information contained here.

If you need assistance, contact the dealer from whom you purchased your meter.

If You Measure in Liters!

This manual commonly refers to "gallons." If your meter is factory calibrated in liters, consider all references to "gallons" apply equally to "liters." The model number of your meter specifies "GM" for gallon Factory Calibration and "LM" for liter Factory Calibration.

NOTE: If your meter is factory calibrated in gallons, you can field calibrate in liters, and vise-versa.

This symbol is used throughout the manual to call your attention to safety messages.

Warnings alert you to the potential for personal injury.

Cautions call your attention to practices or procedures which may damage your meter.

Notes give you information that can improve efficiency of operations.

It is your responsibility to make sure that all operators have access to adequate instructions about safe operating and maintenance procedures.

Read Me!

For your safety, review the major warnings and cautions below before operating your meter.

1. This meter is approved to handle only fluids which are compatible with the meter's housing material.
2. When metering flammable liquids, observe precautions against fire or explosion.
3. When handling hazardous liquids, always follow the liquid manufacturer's safety precautions.
4. Always dispose of used cleaning solvents in a safe manner according to the solvent manufacturer's instructions.

5. During meter removal, liquid may spill. Follow the liquid manufacturer's safety precautions to clean up minor spills.
6. Do not blow compressed air through the meter.
7. Do not submerge the meter.
8. Do not allow liquids to dry inside the meter.
9. Do not use a wrench to install plastic meters. Hand tighten only.
10. For best results, always verify calibration before use.

INTRODUCTION

Your Electronic Digital Meter (EDM) is designed for measuring liquids. The meter translates pulse data from the turbine into calibrated flow units shown on the meter's readout. Field replaceable batteries provide power.

All meters are tested and factory calibrated before shipping.

This manual refers to three families of meters: Low Flow, One Inch, and Two Inch. To further identify your particular model, refer to the Specifications Section at the end of this manual.

BEFORE INSTALLATION

Upon receipt, examine your meter for visible damage. Remove protective plugs and caps for a thorough inspection. If any items are damaged or missing, contact your distributor.

Make sure the meter model meets your specific needs. Refer to the Specification Section and confirm the following:

1. Your flow rate is within the limits of your model.
2. Your liquid is compatible with your meter's material.
3. Your system's pressure does not exceed the meter's maximum pressure rating.

QUICK START

If your installation is relatively simple and you have installed our EDM meters before, you may use this section to quickly install and operate your meter. This section is especially helpful to those measuring thin viscosity fluids dispensed through a hose and nozzle.

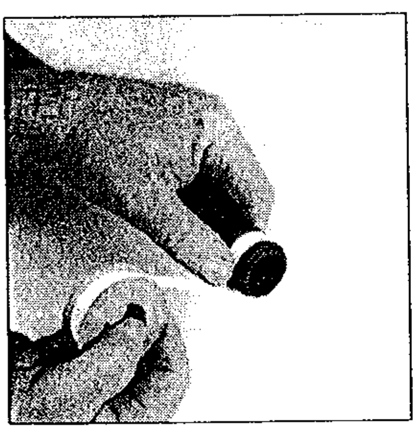
If you complete this section and encounter difficulties, please refer to other sections, as necessary.

NOTE: To accommodate different installations, the faceplate can be rotated 180 degrees. To do this, remove the four corner screws from the face of the meter and lift the computer assembly from the turbine. Rotate the computer assembly 180 degrees. Place on the turbine ensuring the gasket or O-ring is fully seated. Secure the four screws.

Connections

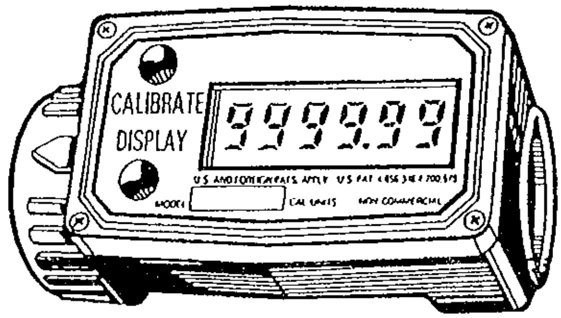
1. To protect against leakage, make sure all threads are sealed with two or three turns of Teflon® tape or a sealing compound compatible with the liquid being metered. (Figure 1)

Figure 1



2. Make sure the Teflon® tape or sealing compound does not interfere with flow.
3. Make sure the arrow on the outlet is pointing in the direction of the flow. (Figure 2)

Figure 2



4. Tighten the meter onto the fittings. Use a wrench only on metal meters. Hand tighten plastic meters.

CAUTION: Using a wrench on plastic meters could damage the meter.

Verify Meter Accuracy

Before using, you should check the meter's accuracy and verify calibration.

1. Make sure there is no air in the system by starting the flow until it runs steadily. Then, stop the flow using a valve or nozzle.
2. If desired, hold down DISPLAY for three seconds to zero the meter's Batch Total. When zeros appear, release the button.
3. Meter an exact known volume into an accurate container. For best results, meter with one continuous full stream.
4. Check the readout. If the amount metered is accurate, field calibration is not necessary. If not, refer to the Calibration Section for further instructions.

Using the Meter

The meter turns on automatically when fluid flow starts and, to conserve power, turns off automatically a few minutes after flow stops.

The meter can also be turned on manually by pressing and releasing the DISPLAY button.

If you wish to know the exact volume measured with each use, use the Batch Total function. You can zero the Batch Total before measuring and monitor volume as it flows through the meter, just like the gas pump at the service station as you fill up your tank.

To zero the Batch Total, make sure the meter is on. Hold down the DISPLAY button for three seconds until zeros appear. Release the button, start the flow, and watch the volume on the readout.

NOTE: If LOCKED appears on the readout, the Cumulative Total is displayed. It cannot be manually zeroed. To select the Batch Total, press and release DISPLAY until LOCKED does not appear on the bottom line.

If the numbers in the readout are dim or fading, the batteries need replacement. Refer to the Maintenance Section for more details.

INSTALLATION

Review the Before Installation and Quick Start Sections above. Also consider the following recommendations, especially if you are installing your meter in a piping system. These suggestions will help maximize performance of your meter.

The meter can be mounted either vertically or horizontally. It should be field calibrated in the same orientation in which it is mounted.

Avoid installing the meter in electrically "noisy" environments. If installed within six inches (15.2cm) of large motors, relays, vehicle ignition systems, or transformers, the meter's accuracy can be adversely affected.

To avoid pulsation or swirl, use the following recommendations.

For Low Flow or One Inch Meters, install with
- 20 inches (51cm) of straight pipe upstream and
- 5 inches (13cm) of straight pipe downstream.

For Two Inch Meters, install with
- 40 inches (102cm) of straight pipe upstream and
- 10 inches (26cm) of straight pipe downstream.

Flow straightening vanes installed upstream from the meter can reduce the upstream pipe length.

Flow control valves upstream from the meter and within the straight pipe distances given above can adversely effect meter accuracy. This is especially true when measuring liquids with low vapor pressures such as fuels, oils, and solvents.

If cavitation effects meter accuracy, a flow control valve on the downstream side of the meter can provide a back pressure of 5 to 50 PSI (0.3 to 3.4 bar) to minimize the problem.

Foreign material in liquid can clog the meter's rotor. If the problem affects meter accuracy or material coats the rotor, install screens to filter the incoming flow.

- For Low Flow Meters use a 25 micron or .001 inch screen.
- For One Inch or Two Inch Meters use a 350 micron or .015 inch screen.

For maximum accuracy, the velocity profile of the flow entering the meter must be uniform throughout the cross section of the pipe.

OPERATIONS

All meter operations are reflected in the readout on the face of the meter.

The readout contains three lines of information. They are generally defined as follows:

- the top line identifies the calibration curve,
- the middle line reflects flow information, and
- the bottom line shows information from the totalizer.

The words or "flags" that display on the top and bottom line further identify specific information.

Turn On
The meter is on when any display is present. It turns on automatically when liquid flows through the meter. It can be turned on manually by pressing and releasing the DISPLAY button.

Turn Off
The meter turns off automatically approximately four minutes after flow stops. When the meter is off, the readout is blank.

Batch and Cumulative Totals
Total flags are displayed on the bottom line. There are two types of totals: Batch Total and Cumulative Total.

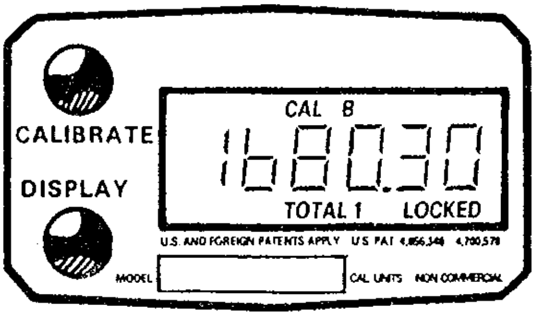
A Batch Total indicates flow during a single use. It is the total liquid metered since the last manual clearing of this total. For example, the Batch Total indicates when you have metered 20 gallons of diesel into your truck's tank (like the pump at the gas station).

Batch Total is labeled with TOTAL followed by a number. On most models this is TOTAL 2.

The Cumulative Total is the total of all liquid measured since the meter's power supply was connected. At your first use, the Cumulative Total is not zero because of calibration at the factory.

The Cumulative Total is labeled with TOTAL followed by a number and **always** flagged with the word LOCKED indicating that this total is locked and cannot be manually zeroed. (Figure 3)

Figure 3



Select Totals
To change between totals, press and release DISPLAY.

NOTE: Generally, readout displays change when buttons are **released**.

Clear Batch Total
Make sure the Batch Total is displayed. To clear, press and hold DISPLAY for three seconds or until the readout changes to zeros.

Clear Cumulative Total
Cumulative Totals are zeroed only when batteries are removed or go dead or when the Cumulative Total reaches the maximum value of 999,999.

Calibration Curves
Calibration Curve information is shown on the top line of the readout. There are two types of calibration curves: Field Calibration and Factory Calibration.

A Field Calibration Curve is set by the user. It can be changed or modified at any time using procedures given in the Calibration Section.

If a Field Calibration has not been completed, the meter uses the Factory Calibration.

A Factory Calibration Curve is "preset" by the manufacturer and stored permanently in the meter's computer. Factory Calibration curves display PRESET on the top line.

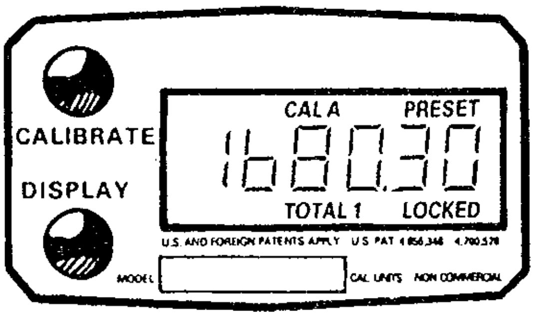
Select Calibration Curves
To change between a Field Calibration curve and a Factory Calibration curve, hold CALIBRATE down while pressing and releasing DISPLAY. When the desired calibration curve appears, release both buttons.

NOTE: In this case, the CALIBRATE button acts like a "Shift" key on a typewriter, shifting the operations of the DISPLAY button to change the top line of the readout.

Field Calibration is labeled with CAL followed by a letter. On most models this is CAL B.

Factory Calibration is CAL followed by a letter and **always** flagged with the word PRESET. In most models, Factory Calibration appears as CAL A PRESET. (Figure 4)

Figure 4



Flow Rate Feature

Some models include a Rate of Flow display, as opposed to the usual flow volume.

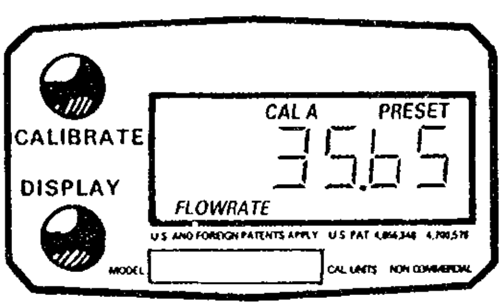
When this feature is activated, the word FLOWRATE displays to the left on the bottom line.

When FLOWRATE is displayed, the numbers on the middle line reflect the rate of flow, for example, the current gallons per minute (GPM) or liters per minute (LPM).

Display FLOWRATE

To use this feature, press and release DISPLAY until FLOWRATE appears to the left of the bottom line. (Figure 5)

Figure 5

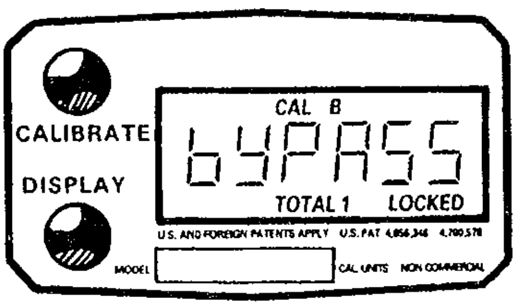


Bypass Feature

Some models contain a Bypass feature for those instances when the meter has continuous flow and power conservation is important. When Bypass is activated the flow is not monitored and totaled by the computer.

When activated, the word BYPASS displays on the middle line. (Figure 6)

Figure 6



When Bypass is activated, the meter no longer senses the flow and the readout goes off after a few minutes. Push the DISPLAY button to activate the readout and check proper operation. Activate Bypass again to conserve battery power.

Propeller

Any time liquid flows through the meter, a small propeller displays.

"NO" Flag

The NO flag displays on the left of the top line when particular conditions have not been met during calibration procedures. Full definition of this flag is given in the Calibration Section.

While the NO flag displays, normal flow does not register on the meter. To resume normal flow counting, either exit Calibration mode or complete a successful Field Calibration as detailed in the Calibration Section.

Normal Precautions

Check the following items frequently to insure proper operation and measurement.

1. Make sure there are no leaks in the connections. To seal leaks, remove and inspect the meter and replace the Teflon® tape or sealant. Refer to the Troubleshooting Section.
2. A dim or fading readout indicates loss of power. To restore power, replace the batteries and check for corrosion on the battery terminals. Refer to the Maintenance Section.

3. Verify meter accuracy before use. To do this, measure a known quantity of liquid into a calibration container and compare the volume measured against the readout. If necessary, field calibrate the meter. Refer to the Calibration Section.

4. To ensure accurate measurement, remove all air from the system before use. To purge the system of air:
   a. Open the discharge valve or nozzle and allow fluid to completely fill the system. Make sure the stream is full and steady and no air is present.
   b. Close the discharge valve or nozzle. Leave the system on.
   c. Start normal operations. If necessary, zero the Batch Total.

⚠ ! ! ! WARNING ! ! !

If handling hazardous liquids, always follow the liquid manufacturer's safety precautions. Wear protective clothing such as goggles, gloves, and respirators as instructed.

⚠ ! ! ! WARNING ! ! !

When metering flammable liquids, observe precautions against fire or explosion. Do not meter in the presence of any source of ignition including running or hot engines, lighted cigarettes, or gas or electric heaters.

CALIBRATION

The two types of calibration are Field Calibration and Factory Calibration. These are defined in the Operations Section directly above. This section deals with the Field Calibration specifics and procedures. It also gives more specific information about Factory Calibration.

Field Calibration is necessary when Factory Calibration accuracy is not acceptable.

Factory Calibration is completed with thin viscosity liquid. If you are dispensing liquid which has a different uniform viscosity, a one-point Field Calibration can improve meter accuracy.

Up to five points can be calibrated on each calibration curve. This "multi-point" Field Calibration improves accuracy when operating characteristics (usually flow rate) are not uniform, for example, if you plan to measure a flow rate which varies from 5 GPM to 25 GPM.

Calibration Container

The desired calibration container should be uniformly dependable and constructed with a graduated neck. The container's volume indicator should be clearly and precisely marked. It is helpful if the container's material allows a window through which the level of liquid can be viewed. The factory has designed a calibration container for calibrations of five gallon or five liter quantities recommended for Low Flow and One Inch Meters.

Two Inch Meter Field Calibration

Due to high flow rate and large minimum volume requirements, the Field Calibration of Two Inch Meters should be considered carefully.

The minimum calibration volume required for these meters is 50 gallons or 200 liters. It is difficult to stop flow of a two inch stream flowing at the minimum calibration rate of 30 GPM (114 LPM).

It is strongly recommended that Field Calibration of Two Inch Meters be completed with a combination of volume and weight. Only fine resolution scales should be used.

Before Beginning Field Calibration

For successful Field Calibration, please review the following before beginning.

For most accurate results, dispense at full flow. Quickly start and stop a full flow as many times as necessary to reach the exact designated volume. Do not "choke" or "trickle" the flow to reach the exact volume.

Use an accurate calibration container.

Meet the meter's minimum requirements for calibration volume.

- Low Flow Meters require 5 gallons or 5 liters of minimum volume.
- One Inch Meters require 5 gallons or 50 liters of minimum volume.
- Two Inch Meters require 50 gallons or 200 liters of minimum volume.

Meet the meter's minimum requirements for flow rate.

- Low Flow minimum calibration flow rate is 0.3 GPM (1.5 LPM).
- One Inch minimum calibration flow rate is 3 GPM (12 LPM).
- Two Inch minimum calibration flow rate is 30 GPM (114 LPM).

If the meter's minimum volume and flow rate requirements are not met during the Field Calibration procedures, the meter blinks "NO" when you try to exit Calibration Mode and you must calibrate again.

Use the correct button sequence during the calibration procedure.

Install your meter on your system according to the Installation instructions given earlier in this manual.

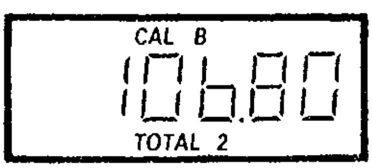
Immediately prior to calibration, purge the system of air by turning on the system and dispensing until the flow stream is full and steady. Stop the flow, but leave the system running.

Calibration Procedure

These Field Calibration procedures are recommended when the Factory Calibration is not appropriate for your measurement needs.

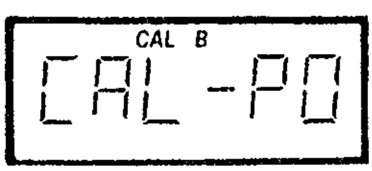
Your Action	Troubleshooting

1. Select the Field Calibration curve you wish to calibrate. Hold down CALIBRATE while you press and release DISPLAY until a CAL displays without the PRESET flag.



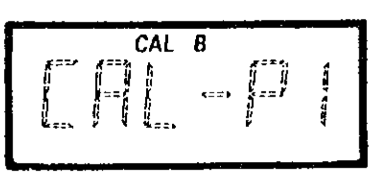
2. Enter Calibration mode by holding down CALIBRATE. Then hold down DISPLAY for approximately three seconds until CAL-P0 appears on the readout.

If CAL-P0 does not appear after a few seconds, you're probably in a Factory Calibration curve. Try Step 1. Remember, PRESET denotes a Factory Calibration curve which you cannot calibrate.

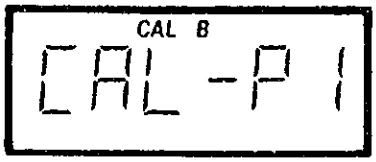


3. Release both buttons. CAL-P1 blinks on the readout.

If you wish to exit Calibration Mode now, hold down CALIBRATE and press and release DISPLAY once. You will return to the normal readout and the old calibration curve information is retained in your meter.

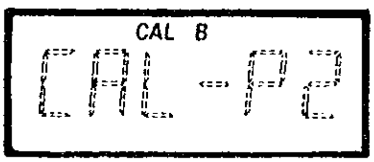


4. To calibrate the first or only point, press and release CALIBRATE. CAL-P1 stops blinking and remains on the readout.



5. Dispense the appropriate volume into a calibration container using a full flow technique. When the calibration container is full, quickly stop the flow.

6. Press and release CALIBRATE once to complete calibration of the first point. The meter responds by blinking CAL-P2.

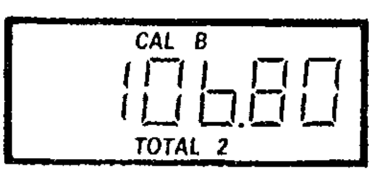


If you are doing a one-point calibration curve, you are finished with the calibration procedure and need to continue with Step 7 below.

The blinking CAL-P2 indicates the meter is prompting you for the second point in this curve. If you want to calibrate additional points, return to Step 4 above and calibrate up to five points. Use a different flow rate with each calibration point. After the fifth point is accepted, the meter automatically returns to normal operations.

7. To accept this one calibration point and return to normal operations, hold down CALIBRATE while you press and release DISPLAY once.

   If the calibration was completed successfully, the meter will return to the normal display with a TOTAL flag on the bottom line.



If NO is blinking on the left side of the top line, the calibration point was not accepted by the computer. Try again starting with Step 2 above. Increase flow rate or volume as necessary. Make sure to use the correct button sequence.

If the readout flashes NO and you do not wish to try again, go back to Step 2 above and continue to the exit option in Step 3.

Factory Calibration

Factory Calibration curves are set at the factory for measuring liquids in gallons or liters and always display PRESET on the readout. This calibration is permanently stored in the meter's computer and provides calibration information for the meter unless Field Calibration is completed.

MAINTENANCE

During daily use, these meters are virtually maintenance-free.

It is important, however, that the meters be kept free of liquids when not in use for extended periods of time to prevent drying of liquids on the internal components. If liquids have dried and caked on the rotor, see the Cleaning instructions below.

Beware of a dim or fading readout. This condition indicates potential battery failure. See the Battery instructions below.

Batteries

Your meter is equipped with field replaceable lithium batteries which provide power for at least 4,000 hours of actual use. Replacement batteries can be ordered from the factory.

If the meter's readout should become dim or blank, it is an indication that the batteries should be replaced.

When batteries are disconnected or fail, the Batch and Cumulative Totals return to zero.

Factory and Field Calibrations are *not* lost when batteries are replaced or power is lost. They are saved in the meter's computer and are available after new batteries are installed. You do not need to repeat Field Calibration.

Check the batteries and terminals at least every year to ensure proper operation. It is strongly recommended that terminals be cleaned annually.

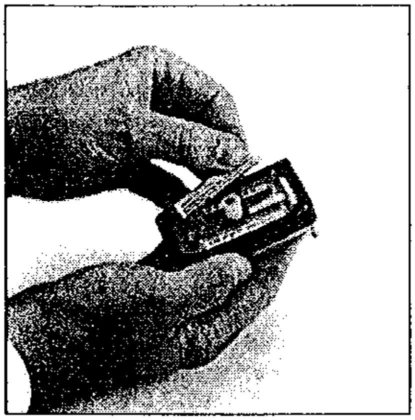
NOTE: Batteries can be replaced without removing the meter from the hose or pipe.

To replace batteries or clean terminals:

1. Remove the corner screws from the face of the meter and lift the computer assembly from the turbine.

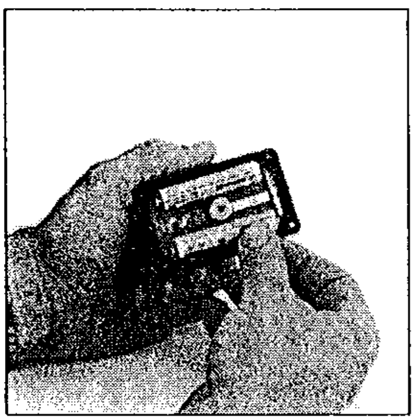
2. Remove the batteries. (Figure 7)

Figure 7



3. If necessary, clean any corrosion from the battery terminals.
4. Place the batteries in position, ensuring the positive posts are positioned correctly. (Figure 8)

Figure 8



When the batteries are installed correctly, the computer powers on automatically. Check the readout to make sure normal meter functions have resumed before assembling again. If necessary, seat the batteries again.

5. Place the computer assembly on the turbine. Make sure the gasket or O-ring is fully seated to avoid moisture damage. Secure with the four screws.

To Remove

⚠ ! ! ! WARNING ! ! !

During meter removal, liquid may spill. Follow the liquid manufacturer's safety precautions for clean up of minor spills.

1. Ensure all liquid is drained from the meter. This could include draining the hose, meter, nozzle, or pipe.
2. Wearing protective clothing as necessary, loosen both ends of the meter. Use a wrench only on the meter's flat metal surfaces.

CAUTION: Using a wrench on plastic meters could damage the meter.

3. If the meter is not immediately installed again, cap the hose end or pipe to prevent spills.

To Clean

During use, the meter should be kept full of liquid to ensure that drying does not occur inside the meter. If drying or caking should occur, the rotor will stick or drag, affecting accuracy. In this circumstance, cleaning is required.

To determine if the rotor is stuck or dragging, gently blow air through the meter and listen for the quiet whir of the rotor.

CAUTION: Never blow compressed air through the meter. It could damage the rotor.

To clean a stuck or dragging rotor, follow the procedures below.

1. Remove the meter from the hose or pipe following the directions above.
2. Apply a penetrating lubricant such as WD-40 or a recommended cleaning solvent on the turbine's rotor, shaft, and bearings. Allow it to soak for 10 to 15 minutes.

CAUTION: Do not submerge the meter.

3. Carefully remove residue from the rotor using a soft brush or small probe such as a screwdriver. Be careful not to damage the rotor and support.

⚠ ! ! ! WARNING ! ! !

Follow the liquid manufacturer's instructions for the disposal of contaminated cleaning solvents.

4. When the rotor turns freely, install it again following the Installation instructions given earlier in this manual.

To Store

After thoroughly cleaning the meter, store it in a dry location.

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
A. METER IS NOT ACCURATE	1. Field Calibration not performed properly	Field calibrate again or select Factory Calibration.
	2. Factory Calibration not suitable for liquid being measured	Perform a Field Calibration according to Calibration Section.
	3. Meter operated below minimum flow rate	Increase flow rate. See Specifications Section.
	4. Meter partially clogged with dried liquid	Remove meter. Clean carefully with WD-40 or similar penetrating lubricant. Make sure rotor spins freely.
	5. Turbine bearings partially clogged with dried liquid	Remove meter. Lubricate bearings with WD-40 or similar penetrating lubricant through small holes in turbine supports. Make sure rotor spins freely.
	6. Teflon® tape or other material wrapped around rotor	Remove meter. Clear material from rotor. Make sure rotor spins freely.
	7. Installed too close to fittings	Install correctly. See Installation Section.
	8. Installed too close to motors or electrically "noisy" environment	Install correctly. See Installation Section.
B. READOUT FADED OR BLANK	1. Batteries weak, dead, or not connected	Remove computer and replace batteries. Install computer again, making sure that the gasket or O-ring seats evenly around the computer and turbine housing.
	2. Computer defective	Contact the factory.
C. NORMAL FLOW RATE BUT METER DOES NOT COUNT (Meter comes on when DISPLAY button pushed.)	1. Field Calibration not performed correctly	Field Calibrate again or select Factory Calibration.
	2. Rotor stuck or damaged	Remove meter. Lubricate turbine bearings with WD-40 or similar penetrating lubricant through small holes in turbine supports. Make sure rotor spins freely. If rotor cannot be loosened, contact the factory.
	3. Teflon® tape or other material wrapped around rotor.	Remove meter. Clear material from rotor. Make sure rotor spins freely.
	4. Computer defective	Contact the factory.

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
D. REDUCED FLOW RATE AND METER DOES NOT COUNT (Meter comes on when DISPLAY button pushed.)	1. Meter clogged with dried liquids	Remove meter. Clean carefully with WD-40 or similar penetrating lubricant. Make sure rotor spins freely.
E. CANNOT GET METER INTO FIELD CALIBRATION	1. Factory Calibration (PRESET) curve active	Hold down CALIBRATE and push and release DISPLAY until PRESET flag goes off. Proceed with calibration according to the Calibration Section.
	2. Button push sequence incorrect	Make sure PRESET flag on readout is off. Make sure CALIBRATE is held down *before* DISPLAY is pushed. Hold for three seconds. Readout will then show CAL-P0. Release both buttons. Computer face will then blink CAL-P1. Proceed with calibration according to Calibration Section.
	3. Computer circuit board defective	Replace computer. Contact the factory.
F. COMPUTER BLINKS "NO" AFTER FIELD CALIBRATION	1. Calibration sample too small	Try again and dispense minimum volume. See Calibration Section.
	2. Flow rate too low	Try again and increase flow rate to minimum calibration rate. See Calibration Section.
	3. Button push sequence incorrect	Make sure PRESET flag on readout is off. Make sure CALIBRATE is held down *before* DISPLAY is pushed. Hold for three seconds. Readout will then show CAL-P0. Release both buttons. Computer face will then blink CAL-P1. Proceed with calibration according to Calibration Section.
	4. Rotor not spinning freely	Remove meter. Clean carefully with WD-40 or similar penetrating lubricant. Make sure rotor spins freely.
G. METER CONNECTIONS LEAK	1. Meter installed without thread sealant	Remove meter. Wrap male connections with 3 to 4 wraps of Teflon® tape or compatible sealing compound. Install again.
	2. Connecting threads damaged	Remove meter and inspect threads. Replace damaged connections. If meter threads are damaged, contact the factory.
	3. Meter housing cracked	Inspect housing for cracks. If cracks present, contact the factory.

SPECIFICATIONS

The following specifications apply to all models and materials.

Power Source:
Two lithium batteries which provide power for at least 4,000 hours of actual use.

Operating Temperature:
+5 to +140 degrees F (-15 to +60 degrees C).

Storage Temperature:
-40 to +150 degrees F (-40 to +70 degrees C).

Accuracy:
Factory Calibration with non-viscous liquids to ±1.5%.
Field Calibration with non-viscous liquids to ±1.0%.

Wetted Parts:
In all models, wetted parts include the retainer rings, shaft, bearings, signal generators, and rotor. These parts are always the same materials.

Signal Generators:	Ferrite
Shaft:	Tungsten Carbide
Bearings:	Ceramic
Retainer Rings:	Stainless Steel

The following specifications are dependent upon housing materials.

Pressure Rating:

Aluminum:	300 PSIG (20.7 bar).
Nylon:	150 PSIG (10.3 bar).
Stainless Steel:	800 PSIG (55.1 bar).

Recommended Chemicals:
Aluminum is recommended for use with petroleum products.
Nylon is recommended for use with water or non-aggressive chemicals.
Stainless Steel is recommended for use with water and chemicals compatible with stainless steel.

U.S. Measurement

Model Family	Low Flow	One Inch	Two Inch
Units*	Gallons	Gallons	Gallons
Flow Range in GPM	0.3 to 3	3 to 50	30 to 300
Threads*	NPT	NPT	NPT
Inlet and Outlet	1 inch	1 inch	2 inch
Internal Diameter	1/4 inch	1 inch	2 inch
Design Type	Paddlewheel	Turbine	Turbine
Readout Totals			
Minimum	.01	.01	.01
Maximum	999,999	999,999	999,999
Pressure Drop at Maximum Flow Rate	2 PSIG at 3 GPM.	5 PSIG at 50 GPM.	7 PSIG at 300 GPM.
Dimensions			
Length	4 inch	4 inch	6 inch
Height	2.5 inch	2.5 inch	4.25 inch
Width	2 inch	2 inch	3 inch

Metric Measurement

Model Family	Low Flow	One Inch	Two Inch
Units*	Liters	Liters	Liters
Flow Range in LPM	1 to 10	10 to 190	100 to 1,000
Threads*	ISO	ISO	ISO
Inlet and Outlet	1 inch	1 inch	2 inch
Internal Diameter	1/4 inch	1 inch	2 inch
Design Type	Paddlewheel	Turbine	Turbine
Readout Totals			
Minimum	.01	.01	.01
Maximum	999,999	999,999	999,999
Pressure Drop at Maximum Flow Rate	.14 bar at 10 LPM.	.35 bar at 190 LPM.	.48 bar at 1,000 LPM.
Dimensions			
Length	10.2cm	10.2 cm	15.2cm
Height	6.4cm	6.4cm	10.8cm
Width	5.1cm	5.1cm	7.6cm

*Models are also available in liter measurement with NPT threads.

A1 Commercial Grade Modular Model Numbers

A1 03 GM S 100 N A1

Product Identifier
A1 Electronic Digital Meter

Computer Assembly

01	Special, 1 button
02	Special, 2 button
03	2 Totals, 2 Cals
04	2 Totals, 2 Cals, Rate
05	3 Totals, 3 Cals, Bypass
06	2 Totals, 1 Cal
07	3 Totals, 3 Cals, Bypass, Rate
08	2 Cals, Rate
XX	No Computer

Factory Calibration Units

GM	Gallons per minute
LM	Liters per minute
XX	No Computer
OO	Special

Turbine Housing/Support Materials

A	Aluminum/Nylon
N	Nylon/Nylon
S	Stainless Steel/PVDF
X	No Turbine
O	Special

Flow Rate

025	1/4 inch Low Flow - 0.3 to 3 GPM (1 to 10 LPM)
100	1 inch - 3 to 50 GPM (10 to 190 LPM)
200	2 inch - 30 to 300 GPM (100 to 1,000 LPM)

Fitting

N	Female NPT
I	Female ISO
X	No Turbine
O	Special

Packaging

A1	Standard 1 inch
A2	Standard 2 inch
B1	1 inch Turbine only
B2	2 inch Turbine only
B3	Computer only
C1	Generic Low Flow and 1 inch
C2	Generic 2 inch
C3	Generic Computer Only
XX	No Packaging
OO	Special

FM APPROVED

Model 03 Number Chart

Sample Model Number: 03 N 31 G M

Computer Assembly — 03
(Most contain automatic on and off.)
03 includes a Batch Total, Cumulative Total, Factory Calibration, and Field Calibration.

Housing/Turbine Material — N
- A = Aluminum/Nylon
- N = Nylon/Nylon
- S = Stainless Steel/PVDF

Thread and Flow Range — 31
- 11 = ISO Low Flow
- 12 = ISO One Inch
- 13 = ISO Two Inch
- 30 = NPT Low Flow
- 31 = NPT One Inch
- 32 = NPT Two Inch

Factory Calibration Units — G
- G = Gallons
- L = Liter

Time per Unit — M
- M = Minutes

PARTS

Replacement Kits and Accessories

Replacement Kits are available for turbine assemblies and computer assemblies. Individual components within these assemblies, such as rotors, signal generators, and buttons are not available. The factory will determine the exact Turbine Assembly or Computer Assembly you need when given your model number and serial number.

Other replacement kits and accessories can be ordered with the part numbers below.

Part Number	Description
113520-1	Battery Replacement Kit
901002-52	O-Ring
116000-1	Large (5 gallon) Calibration Container
116004-6	Small (5 liter) Calibration Container
116004-5	Small (5 quart) Calibration Container

Patent Numbers

U.S. Patent 4,856,348; 4,700,579; 5,046,370; D 302,396; D 282,448; D 309,272; D 309,188. Australian Patent 572,494. Canadian Patent 1,223,464. European Patent 0147004. Japanese Patent Pending.

SERVICE

For warranty consideration, parts, or other service information, please contact your local distributor. If you need further assistance, call the GPI Customer Service Department in Wichita, Kansas, during normal business hours.

1-800-835-0113 (except Kansas)
In Kansas, call 1-316-686-7361

To obtain prompt, efficient service, always be prepared with the following information:

1. The model number of your meter.
2. The serial number or manufacturing date code of your meter.
3. Specific information about part numbers and descriptions.

For warranty work always be prepared with your original sales slip or other evidence of purchase date.

Returning Parts

Please contact the factory before returning any parts. It may be possible to diagnose the trouble and identify needed parts in a telephone call or letter. GPI can also inform you of any special handling requirements you will need to follow covering the transportation and handling of equipment which has been used to transfer hazardous or flammable liquids.

CAUTION: Do not return meters without specific authority from the GPI Customer Service Department. Due to strict regulations governing transportation, handling, and disposal of hazardous or flammable liquids, GPI will not accept meters for rework unless they are completely free of liquid residue.

CAUTION: Meters not flushed before shipment can be refused and returned to sender.

Manual No. 920685-6

Great Plains Industries, Inc. Limited Warranty Policy

Great Plains Industries, Inc., 5252 East 36th Street North, Wichita, Kansas 67220-3205, hereby provides a limited one year warranty against defects in material and workmanship on all products manufactured by Great Plains Industries, Inc. This warranty shall extend to the purchaser of this product and to any person to whom such product is transferred during the warranty period.

The warranty period shall begin on the date of the original new equipment purchase. Warrantor's obligation hereunder shall be limited to repairing defective workmanship or replacing or repairing any defective part or parts. This warranty shall not apply if:

a.) the product has been altered or modified outside the warrantor's duly appointed representative;

b.) the product has been subjected to neglect, misuse, abuse or damage or has been installed or operated other than in accordance with the manufacturer's operating instructions.

To make a claim against this warranty, notice of claim must be given in writing to the company at its above address no later than 30 days after the expiration of the warranty period. Such notice shall identify the defect in the product. The company shall, within 14 days of receipt of such notice, notify the customer to either send the product, transportation prepaid, to the company at its office in Wichita, Kansas, or to a duly authorized service center. The company shall perform all obligations imposed on it by the terms of this warranty within 60 days of receipt of the defective product.

GREAT PLAINS INDUSTRIES, INC. EXCLUDES LIABILITY UNDER THIS WARRANTY FOR DIRECT, INDIRECT, INCIDENTAL AND CONSEQUENTIAL DAMAGES INCURRED IN THE USE OR LOSS OF USE OF THE PRODUCT WARRANTED HEREUNDER.

The company herewith expressly disclaims any warranty of merchantability or fitness for any particular purpose other than for which it was designed.

This warranty gives you specific rights and you may also have other rights which vary from U.S. state to U.S. state.

NOTE: In compliance with MAGNUSON MOSS CONSUMER WARRANTY ACT - Part 702 (governs the resale availability of the warranty terms).

GPI®

5252 East 36th Street North
Wichita, KS USA 67220-3205
TEL: 316-686-7361
FAX: 316-686-6746

GREAT PLAINS INDUSTRIES, INC.

1-800-835-0113

10/96

ELECTRONIC DIGITAL FLOWMETER/TOTALIZER

QUICK REFERENCE INSTRUCTION SHEET

TURN ON

The meter is on when any display is present. It turns on automatically when liquid flows through the meter. It can be turned on manually by pressing and releasing the DISPLAY button.

DISPLAY FLOW RATE

Press and release **DISPLAY** button until "*FLOWRATE*" appears to the left on the bottom line. Flow in gallons per minute will be displayed.

DISPLAY TOTALS

CUMULATIVE TOTAL

Press and release **DISPLAY** button until "*TOTAL 1   LOCKED*" appears on the bottom line. Cumulative totals are zeroed only when batteries are removed or go dead or when the cumulative total reaches the maximum value of 999,999.

BATCH TOTAL

Press and release **DISPLAY** button until "*TOTAL 2*" appears on the bottom line. The batch total is cleared by pressing and holding the **DISPLAY** button for three (3) seconds or until the readout changes to zeros.

TURN OFF

The meter turns off automatically approximately four minutes after flow stops. When the meter is off, the readout is blank.

REPLACE BATTERIES

Batteries should provide at least 4000 hours of actual use. If the meter's readout is dim or blank, the batteries should be replaced. Remove the corner screws from the face of the meter and lift the computer assembly from the turbine. Remove the batteries and clean any corrosion from the terminals. Place new batteries in position ensuring that positive posts are positioned correctly. Check the readout to make sure normal meter functions have resumed before assembling again. Calibration of the unit is not lost when batteries are replaced or power is lost.

Replacement Battery Model Number: Sanyo Lithium CR12600SE (3v)
(or equal) 2 ea required

ELECTRONIC DIGITAL FLOWMETER/TOTALIZER

QUICK REFERENCE INSTRUCTION SHEET

TURN ON

The meter is on when any display is present. It turns on automatically when liquid flows through the meter. It can be turned on manually by pressing and releasing the **DISPLAY** button.

DISPLAY FLOW RATE

Press and release **DISPLAY** button until "***FLOWRATE***" appears to the left on the bottom line. Flow in gallons per minute will be displayed.

DISPLAY TOTALS

CUMULATIVE TOTAL

Press and release **DISPLAY** button until "***TOTAL 1   LOCKED***" appears on the bottom line. Cumulative totals are zeroed only when batteries are removed or go dead or when the cumulative total reaches the maximum value of 999,999.

BATCH TOTAL

Press and release **DISPLAY** button until "***TOTAL 2***" appears on the bottom line. The batch total is cleared by pressing and holding the **DISPLAY** button for three (3) seconds or until the readout changes to zeros.

TURN OFF

The meter turns off automatically approximately four minutes after flow stops. When the meter is off, the readout is blank.

REPLACE BATTERIES

Batteries should provide at least 4000 hours of actual use. If the meter's readout is dim or blank, the batteries should be replaced. Remove the corner screws from the face of the meter and lift the computer assembly from the turbine. Remove the batteries and clean any corrosion from the terminals. Place new batteries in position ensuring that positive posts are positioned correctly. Check the readout to make sure normal meter functions have resumed before assembling again. Calibration of the unit is not lost when batteries are replaced or power is lost.

Replacement Battery Model Number:	Sanyo Lithium CR12600SE (3v) (or equal) 2 ea required

DOMINO® Moisture-In-Oil (MIO) Instruments

USER´S GUIDE

Doble Document XXXXXXX
Doble Part No.:500-0687
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CHAPTER 1
GENERAL INFORMATION

This chapter provides general notes for the manual and the *DOMINO*® family of moisture-in-oil (MIO) instruments.

About This Manual

This manual provides information for installing, operating, and maintaining *DOMINO*® family of moisture-in-oil instruments. It covers all models provided by Doble. Some features may not apply to the instrument that you purchased.

Contents of This Manual

This manual consists of the following chapters:

- Chapter 1, General Information, provides general notes for the manual and the
- Chapter 2, Product Overview, introduces the features, advantages, and the product nomenclature
- Chapter 3, installation, provides you with information to aid in installing the product.
- Chapter 4, operation, contains information that is needed to operate this product.
- Chapter 5, ppm conversion, contains information on conversion models.
- Chapter 6, maintenance, provides information that is needed in basic maintenance of the product.

Trademarks

Microsoft®, Windows®, Windows NT®, and Windows® 2000 are registered trademarks of Microsoft Corporation in the United States and/or other countries.

Warranties

Equipment Limited Warranty

Doble Engineering Company (DOBLE) warrants the products that it manufactures to be free from defects in material and workmanship for a period of one year from the date shipped from the factory.

During the one-year warranty period, DOBLE will repair or replace, at its option, any defective products or components thereof at no additional charge, provided that the product or component is returned, shipping prepaid, to DOBLE. The Purchaser is responsible for insuring any product or component so returned and assumes the risk of loss during shipment. All replaced products and components become the property of DOBLE.

THIS LIMITED WARRANTY DOES NOT EXTEND TO ANY PRODUCTS WHICH HAVE BEEN DAMAGED AS A RESULT OF NORMAL WEAR AND TEAR, ACCIDENT, ABUSE, NEGLIGENCE INCLUDING BUT NOT LIMITED TO FAILURE TO SERVICE THE PRODUCT OR OTHERWISE FOLLOW DOBLE'S SERVICE INSTRUCTIONS, MISUSE INCLUDING BUT NOT LIMITED TO UNSUITABLE OR UNAUTHORIZED USE OF THE PRODUCT OR INCORRECT INSTALLATION OR ASSEMBLY OR ERROR IN STORING, MAINTAINING OR IN HANDLING THE PRODUCT OR ANY EQUIPMENT THEREOF, OR AS A RESULT OF MODIFICATION BY ANYONE OTHER THAN DOBLE OR AN AUTHORIZED DOBLE REPRESENTATIVE.

EXCEPT AS EXPRESSLY SET FORTH ABOVE, NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, ARE MADE WITH RESPECT TO THE PRODUCT INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. DOBLE EXPRESSLY DISCLAIMS ALL WARRANTIES NOT STATED HEREIN. IN THE EVENT THE PRODUCT IS NOT FREE FROM DEFECTS AS WARRANTED ABOVE, THE PURCHASER'S

SOLE REMEDY SHALL BE REPAIR OR REPLACEMENT AS PROVIDED ABOVE. DOBLE 'S LIABILITY SHALL UNDER NO CIRCUMSTANCES EXCEED THE INVOICE PRICE OF ANY PRODUCT FOR WHICH A WARRANTY CLAIM IS MADE. UNDER NO CIRCUMSTANCES WILL DOBLE BE LIABLE TO THE PURCHASER OR ANY USER FOR ANY DAMAGES, INCLUDING WITHOUT LIMITATION, PERSONAL INJURY OR PROPERTY DAMAGE CAUSE BY THE PRODUCT, ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, LOST PROFITS, LOST SAVINGS, OR OTHER DAMAGES ARISING OUT OF THE USE OF OR INABILITY TO USE THIS PRODUCT.

Software Limited Warranty

THIS SOFTWARE PRODUCT IS PROVIDED “AS IS” WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THIS SOFTWARE PRODUCT IS WITH PURCHASER SHOULD THE PRODUCT PROVE DEFECTIVE. PURCHASER (AND NOT DOBLE OR AN AUTHORIZED DEALER) ASSUMES THE ENTIRE COST OF ALL NECESSARY SERVICING, REPAIR, OR CORRECTION.

Some states do not allow the exclusion of implied warranties, so the above exclusion may not apply. This warranty gives the purchaser specific legal rights and you may also have other rights which vary from state to state.

DOBLE warrants the disks on which the software product is furnished to be free from defects in materials and workmanship under normal use for a period of one hundred and twenty (120) days from the date of shipment from DOBLE.

Limitations of Remedies

DOBLE’s entire liability and Purchaser’s exclusive remedy shall be:

1. The replacement of any disks not meeting DOBLE’s "Limited Warranty" which are returned to Doble.

2. If DOBLE is unable to deliver replacement disks that are free from defects in materials and workmanship, Purchaser may terminate this agreement. By returning the software product and all copies thereof in any form and affirming compliance with this requirement in writing, DOBLE will refund the purchase price.

IN NO EVENT WILL DOBLE BE LIABLE TO PURCHASER FOR ANY DAMAGES, INCLUDING ANY LOST PROFITS, LOST SAVINGS OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE SUCH SOFTWARE PRODUCT, EVEN IF DOBLE OR AN AUTHORIZED DEALER HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, OR FOR ANY CLAIM BY ANY OTHER PARTY.

SOME STATES DO NOT ALLOW THE LIMITATION OR EXCLUSION OF LIABILITY FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATION OR EXCLUSION MAY NOT APPLY.

In-Warranty Repairs

United States: Ten (10) day turnaround is guaranteed from the date the instrument is received. All shipping charges <u>from Doble</u> are paid by Doble. All shipping charges <u>to Doble</u> are paid by the customer.

International: Ten (10) day turnaround is guaranteed from the date the instrument is received on repair of the instrument only. The ten day turnaround does not include shipping time. All shipping charges and customs brokerage fees <u>from Doble</u> are paid by Doble. All shipping charges and customs brokerage fees <u>to Doble</u> are paid by the customer.

Out-of-Warranty Repairs

United States: Within one week of receipt of instrument the customer will be notified of the repairs and the cost of those repairs. Repairs will be completed within 10 days after authorization is received to proceed with the repairs. All shipping charges, <u>both to and from Doble</u>, are paid by the customer.

International: Within one week of receipt of instrument the customer will be notified of the repairs and the cost of those repairs. Repairs will be completed within 10 days after authorization is received to proceed with the repairs. The ten day turnaround does not include shipping time. All shipping charges and customs brokerage fees, <u>both to and from Doble</u>, are paid by the customer.

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CHAPTER 2

PRODUCT OVERVIEW

This chapter introduces the features, advantages, and the product nomenclature of the *DOMINO*® Moisture-In-Oil (MIO) unit.

Introduction to the *DOMINO*® MIO

The *DOMINO*® MIO unit is a microprocessor based instrument for the measurement of moisture in terms of relative saturation and temperature in transformer mineral oils, other dielectric liquids and certain lubricating and hydraulic oils. A calculation for ppm is then made in the instrument and outputted to the local display, digital and/or analog outputs. The MIO unit incorporates a capacitive thin film sensor for moisture determination and an RTD for temperature determination. The operation of the sensor is based on changes in its capacitance as the thin polymer film absorbs and desorbs water molecules.

The transmitter portion (electronics, display and keypad in housing) of the MIO unit can be configured in many ways. It can have either a blank cover or a cover with a local display and keypad with which the user can operate the transmitter. The power supply voltage can be selected from three alternatives. Two analog output signals can be scaled and the measurement ranges changed within certain limits. The MIO unit can be supplied with two, five or ten meter sensor head cable.

The *DOMINO*® Moisture-In-Oil instruments provide reliable moisture measurements in a wide range of applications. Analog outputs can be chosen between current and voltage signals. Alternatively, digital outputs RS-232 (standard) or RS-422/485 (optional) can be selected.

Basic Features and Options

- user friendly display
- different probe cable lengths
- transmitter mounting kit
- optional modules: power supply module, RS-422/485-module, additional analog output module and relay module

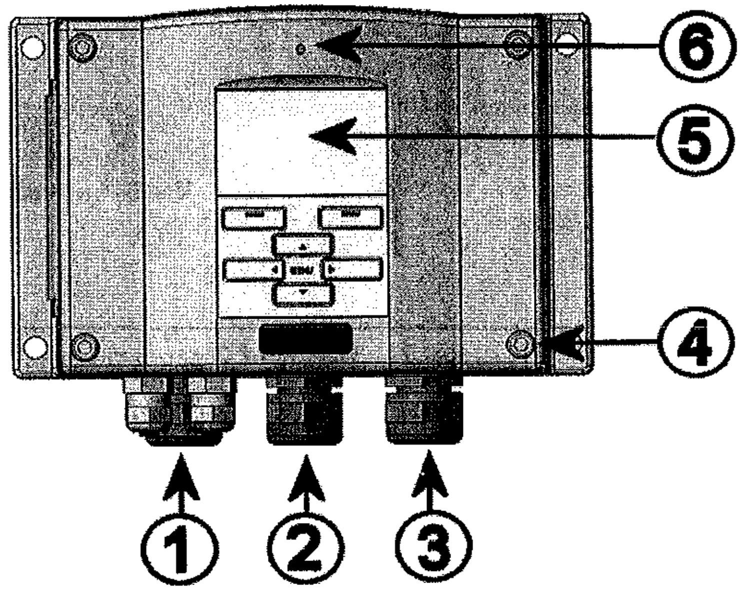

FIGURE 1 Transmitter Body

The following numbers refer to

FIGURE 1 above:

1	=	Signal + powering cable gland
2	=	Cable gland for optional module
3	=	Cable gland for optional module
4	=	Cover screw (4 pcs)
5	=	Display with keypad (optional)
6	=	Cover LED

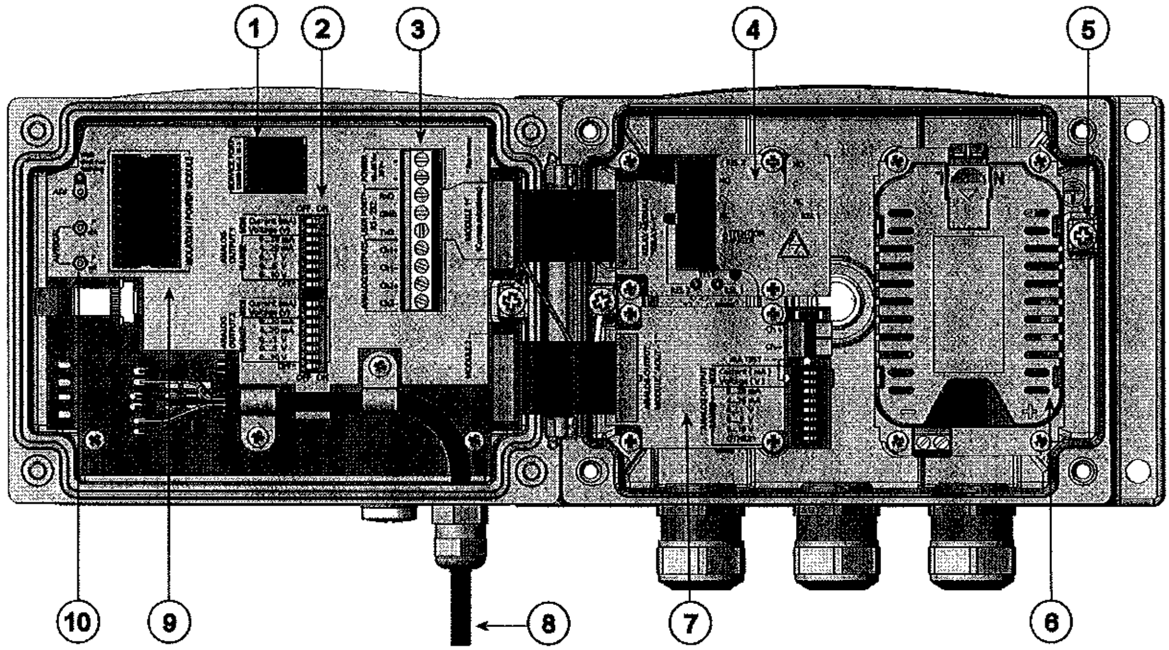

FIGURE 2 Inside of Open Transmitter

The following numbers refer to FIGURE 2 above:

1	=	Service port (RS-232)
2	=	DIP switches for analog output settings
3	=	Power supply and signal wiring screw terminals
4	=	Relay/RS-422/485 module (optional)
5	=	Grounding connector
6	=	Power supply module (model dependent)
7	=	Analog output relay module (model dependent)
8	=	Humidity probe cable
9	=	Output isolation module (optional)
10	=	Adjustment buttons with indicator led. Purge is not available.

Probe

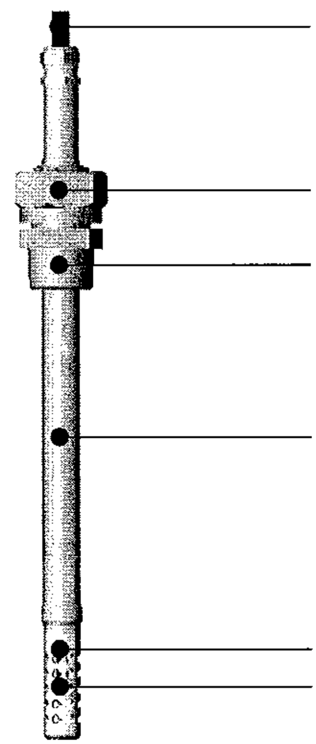

FIGURE 3 Probe

Probe cable lengths are 2 m, 5 m and 10 m.

General Theory of Operation

Method Used for Measuring Moisture in Oil

The *DOMINO*® Moisture-In-Oil unit is used to determine the dissolved moisture content of dielectric liquids in transformers, other electric apparatus, processing equipment, and lubricating and hydraulic systems. The sensor measures the capacitance of a thin polymer film. The capacitance changes proportionally to the change in relative saturation of water in the oil. Relative saturation (RS), expressed in units of percent, is the concentration of water (W_c) in the oil relative to the solubility (S) or concentration of water the oil can hold at the measurement temperature. An example of this is shown in Equation 1.

(Equation 1) $RS = W_c / S\ (100\%)$

Where: RS is relative saturation in percent

W_c is in ppm wt./wt.

S is in ppm wt./wt.

The instrument converts the measured RS to a concentration, parts per million in mg/kg (ppm wt./wt.). This output can be locally displayed or is available through the RS232 serial bus and analog outputs. To be able to perform this calculation the instrument measures both the capacitance of the thin-film polymer and converts it to RS, and the temperature.

The default value used in the *DOMINO*® MIO is for new and service aged transformer mineral oil. Equation 2 is the algorithim that Doble incorporates into the unit for calculation of the ppm value:

(Equation 2) $\text{Log } S_o = -1567/K + 7.0895$

Where:

S_o is the solubility of water in mineral oil

K is the temperature in Kelvin (°C + 273)

Knowing the solubility of water in oil and the RS, the water content can be easily calculated by rearranging Equation 1. Equation 2 will apply to many transformer mineral oils, but may require changes for some very aged mineral oils, other types of dielectric liquids (silicones, natural esters, synthetic esters, lubrication oils, hydraulic oils, etc). The instrument is user configurable to change the constants for these liquids, which have very different solubility characteristics for water then transformer mineral oil. Doble has developed over 30 develop more as the need arises. In many cases a sample of the liquid will be needed to test to determine the solubility coefficients. If you require an algorithim for a special application please e-mail your requirements to: domino@doble.com.

The structure of the moisture sensor is shown in Figure 4.

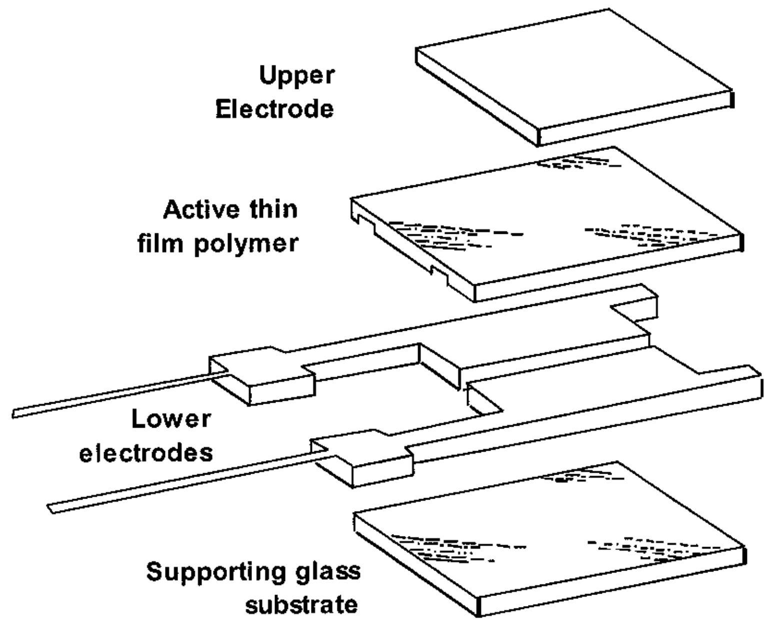

FIGURE 4. Structure of Relative Saturation Sensor

The moisture and temperature sensors are mounted on the end of a probe, which is placed directly in the oil. A signal cable transmits the capacitance changes from the probe to a NEMA 4 weather-proof transmitter housing which contains the electronics. The moisture sensor is composed of an upper and lower electrode, a thin film polymer and a support base (Figure 4). Water vapor penetrates the upper electrode and reaches the thin-film polymer. The amount of water vapor absorbed is dependent on the relative saturation of water in the oil. The polymer used for this application is dispersive, that is, its dielectric constant changes with changing water content. The capacitance of the polymer, which is the dielectric constant of the material divided by the dielectric constant of vacuum (which is 1), is used to determine the relative saturation of water in the dielectric liquid.

Because the sensor relies on the movement of water molecules to and from the thin film polymer, oil flow around the sensor greatly facilitates this process. Little or no oil flow around the sensor will give low readings below the true water content.

This sensor is stable in an oil environment for many years and can operate over the full range of oil temperatures in transformers (up to 180°C). The sensors are quite accurate and even more chemically stable than the previous generation. The calibration includes low moisture contents where the sensors will operate much of the time.

The most important feature which distinguishes the measurement of realtive saturation from the traditional measurement of absolute water content (in ppm) is that the saturation point remains stable regardless exceeds 90% RS in any system, there is a risk for separation of the water from the oil (emulsified or free water). This is especially true if the temperature decreases. The most important advantages of this system are the fact that relative saturation is immune to the aging of oil and to additives, and that the *DOMINO*® MIO unit can be used for continuous on-line measurements. In addition, the *DOMINO*® can be calibrated against salt solutions and no reference oils are needed.

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CHAPTER 3

INSTALLATION

This chapter provides you with information to aid in installing the product.

Mounting the Housing

Standard Mounting

Mount the housing by fastening the *DOMINO*® transmitter to the wall with 4 screws, for example M6 or XXXX (not provided).

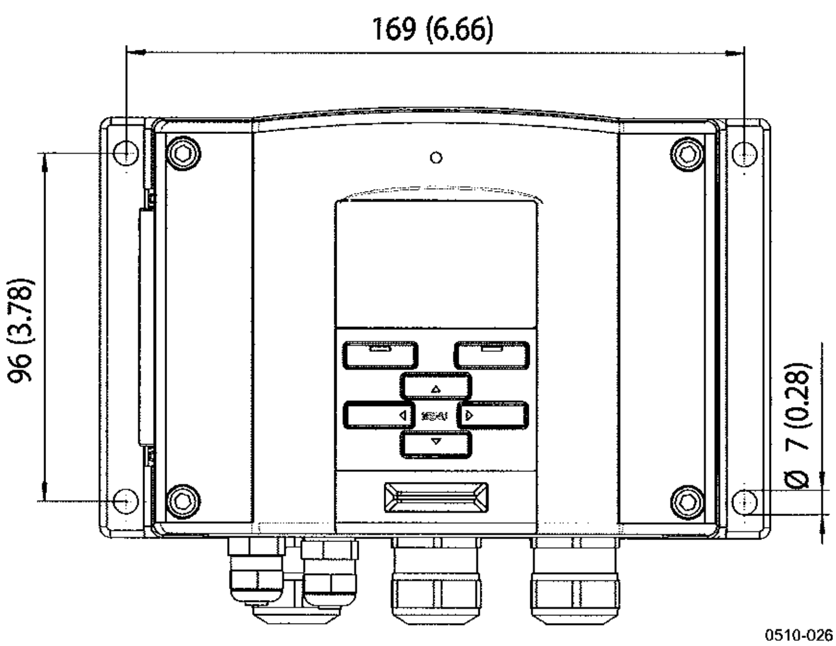


Figure 4 Standard Mounting Dimensions (in mm/inch)

Transformer Tank Mounting with Mounting Kit

THIS SECTION NOT YET INPUTTED.

Wiring

Cable Bushings

A single electrical cable with a screen and three to ten wires is recommended for power and analog/serial connections. The cable diameter should be 8...11 mm (0.31...0.43 inch). The number of cable bushings depends on the transmitter options. See the following recommendations for the cable bushings:

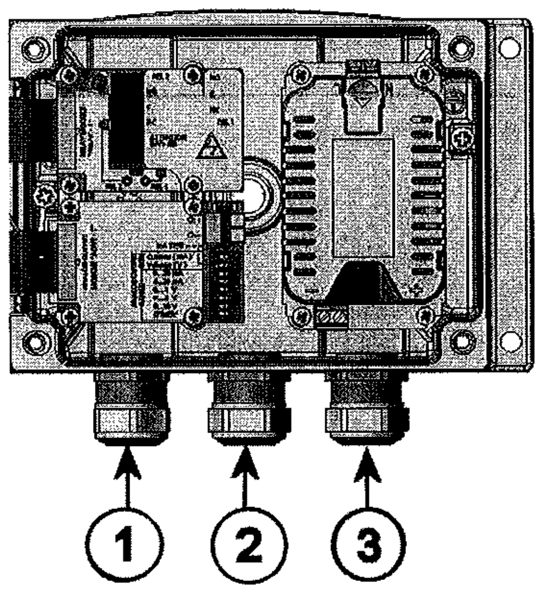


Figure 5 Cable Bushings

The following numbers refer to Figure 5 above:

1 = Cable for signal/powering Ø8 ... 11 mm (0.31...43 inch)
2 = Cable for optional module Ø8 ... 11 mm (0.31...43 inch)
3 = Cable for optional power supply module Ø8 ... 11 mm (0.31...43 inch)

NOTE	When there is high electric noise level (for example, near transformers and large electric motors) in the operating environment it is recommended to use shielded cable or take care that the signal cables are separated from other cables.

Grounding the Cables

Ground the screen of the electrical cable properly to achieve the best possible EMC performance.

Fig. 1

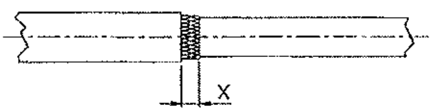


Fig. 2

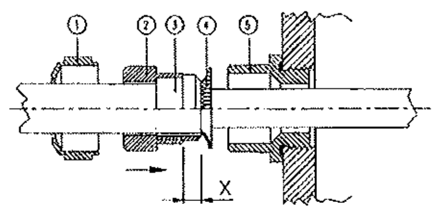
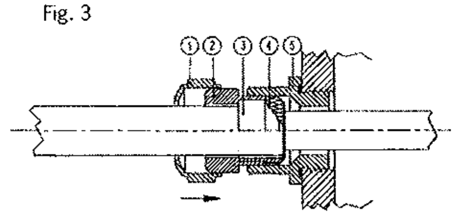


Fig. 3



0504-049

Figure 6 Grounding the Screen of Electrical Cable

1. Cut back outer sheath to desired length.
2. Cut back screen braiding or screen foil to dimension X (see figure 3).
3. Push the domed cap nut (item 1) and the seal insert with contact socket of the gland (item 2+3) onto the cable as shown in the diagram.
4. Bend over the screen braiding or screen foil by about 90° (item 4).
5. Push the seal insert with the contact socket of the gland (item 2+3) up to the screen braiding or screen foil.
6. Mount lower part (item 5) on the housing.
7. Push the seal with the contact socket of the gland and (item 2+3) flush into the lower part (item 5).
8. Screw the domed cap nut (item 1) onto the lower part (item 5).

Grounding the Transmitter Housing

In case you need to ground the transmitter housing, the grounding connector is found inside the housing, see FIGURE 2 on page 16.

Note that the probe head is connected to the same potential as the transmitter housing. Make sure that different groundings are made to the same potential. Otherwise harmful ground currents may be generated.

If it is needed to have galvanic isolation of the power supply line from the output signals, *DOMINO*® MIO units can be ordered with optional output isolation module. This module prevents harmful grounding loops.

Signal and Power Supply Wiring

When connecting transmitter with 8-pin connector, refer to section 8-Pin Connector on page 45. When wiring the power supply module, refer to the the next section, Power Supply Module.

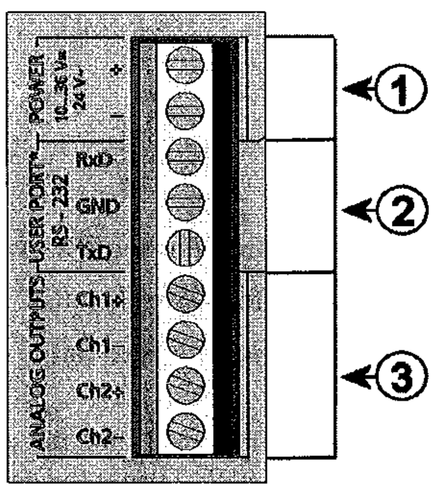


Figure 7 Screw Terminal Block on Motherboard

The following numbers refer to Figure 7 above:

1 = Power supply terminals 10 ... 35 VDC, 24 VAC
2 = User port (RS-232 terminals)
3 = Analog signal terminals

WARNING	Make sure that you connect only de-energized wires.

1. Open the transmitter cover by taking out the four cover screws.
2. Insert the power supply wires and signal wires through the cable bushing in the bottom of the transmitter; see the grounding instructions in the previous sections.
3. Connect the analog output cables to terminals: **Ch1 +, Ch1-, Ch2+, Ch2-**. Connect the RS-232 user port cables to terminals RxD, GND and TxD. For more information about the RS-232 connection refer to section Serial Line Communication on page 52.
4. When wiring to the RS-485 module, relay module or additional analog output module, see section RS-422/485 Interface on page 42 section Relays on page 40 and section Third Analog Output on page 38 on page
5. Connect the power supply wires to the connectors: **POWER 10...35V+ 24V~** (+) and (-) terminals. If you are using 24 VAC power supply, see the note below before connecting the supply wires.
6. Turn on the power. The indicator led on the cover lit continuously during normal operation.
7. Close the cover and replace the cover screws. The transmitter is ready for use.

Connections to 24 VAC Power Supply

Separate floating supply for each transmitter is recommended (see upper Figure 8 on page 28 above.) If you have to connect several transmitters to one AC supply, the phase (~) must always be connected to (+) connector of each transmitter (see lower Figure 8 on page 28 below).

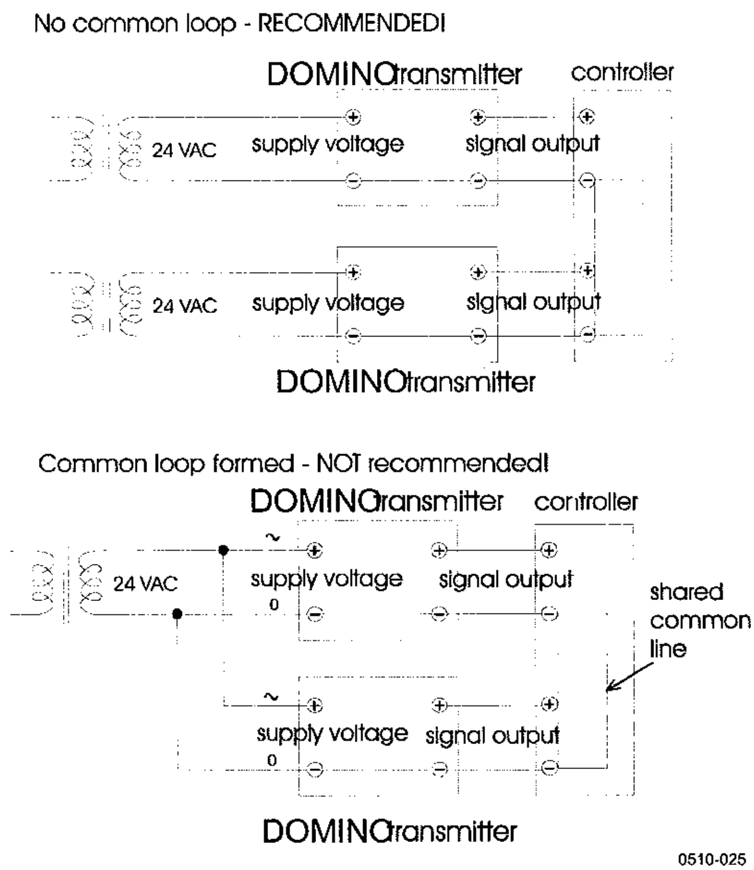


Figure 8 Connections to 24 VAC Power Supply

CAUTION	In case you have only one AC supply, never connect same wire to the + connector of a transmitter and to the - connector of another one. This will short-circuit the transformer.

Power Supply Module

The AC (mains) power connection may be connected to the power supply module only by an authorized electrician. A readily accessible disconnect device shall be incorporated in the fixed wiring.

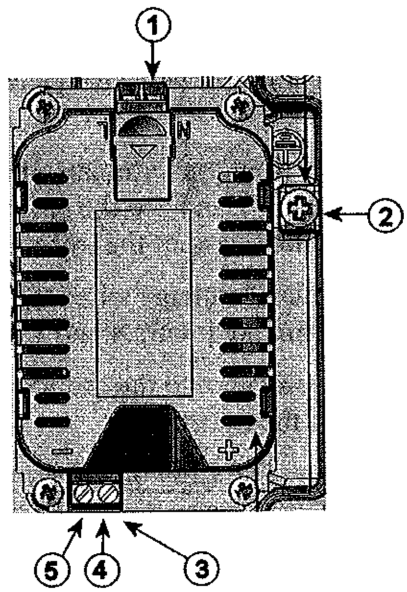


Figure 9 Power Supply Module

The following numbers refer to Figure 9 above:

1 = Connect AC (mains) voltage wires to these terminals
2 = Grounding terminal
3 = In case the module is not installed in the factory, connect wires from these terminals to the power supply 10...36V= 24V~ terminals in the screwterminal of the mother board.
4 = +
5 = -

Installation

1. Disconnect the power and open the transmitter cover.
2. Remove the protective plug from the cable gland and thread the wires. In case the power supply module is installed in the factory, continue with the step 5.
3. To attach the module fasten the power module to the bottom of the housing with four screws. See the position in FIGURE 2 on page 16.
4. Connect the wires from the terminals of the power supply module marked with + and - to the terminals **POWER 10... 35 V** 24V on the motherboard of the transmitter.
5. Connect the AC mains voltage wires to the power supply module terminals marked with **N** and **L**.
6. Attach the grounding wire to the grounding terminal on the right-hand side of the transmitter.
7. Connect the power. The LED on the cover of the transmitter is lit continuously during normal operation.

WARNING	Do not detach the power supply module from the transmitter when the power is on.

WARNING	Do not connect the mains power to power supply module when it is not installed in the transmitter.

WARNING	Always connect protective ground terminal.

Warnings

Dieses Produkt entspricht der Niederspannungsrichtlinie (73/23 EWG).

- Das Netzmodul darf nur von einem dazu befugten Elektriker angeschlossen werden.
- Trennen Sie das Netzmodul nicht vom Messwertgeber, wenn der Strom eingeschaltet ist.
- Verbinden Sie das Netzmodul nur mit der Spannungsquelle, wenn es im Messwertgeber MMT330 montiert ist.
- Das Erdungskabel muss zum Schutz immer angeschlossen sein.

Ce produit est conforme à la Directive relative à la Basse Tension (73/23 EEC).

- Seul un électricien compétent est habilité à raccorder le module d'alimentation au secteur.
- Ne pas détacher le module d'alimentation du transmetteur lorsqu'il est en service.
- Ne pas raccorder le secteur au module d'alimentation lorsque celui-ci n'est pas installé dans le transmetteur MMT330.
- Toujours raccorder un bornier de protection à la terre.

Tämä tuote on pienjännitedirektiivin (73/23 EEC) mukainen.

- Vaihtovirtaliitännän saa kytkeä tehonsyöttömoduuliin ainoastaan valtuutettu sähköasentaja
- Älä irrota tehonsyöttömoduulia lähettimestä, kun virta on kytkettynä.
- Älä kytke verkkovirtaa tehonsyöttömoduuliin, jos kyseistä moduulia ei ole asennettu MMT330 lähettimeen.
- Kytke aina maadoitusliittimet.

Denna produkt uppfyller kraven i direktivet om lågspänning (73/23 EEC).

- Nätanslutningen (växelströmsanslutningen) får bara anslutas till strömförsörjningsmodulen av en behörig elektriker.
- Ta inte loss strömförsörjningsmodulen från mätaren när strömmen är på.
- Anslut inte strömförsörjningsmodulen till nätet när den inte är installerad i MMT330-mätaren
- Anslut alltid en skyddande jordningsplint.

Questo prodotto é conforme alla Direttiva sul basso voltaggio (73/23 CEE).

- La conduttura elettrica puó essere collegata al modulo di alimentazione elettrica soltanto da un elettricista autorizzato.
- Non staccare l´alimentazione elettrica dal trasmettitore quando é acceso.
- Non collegare la corrente elettrica al modulo di alimentazione elettrica se non é installato nel trasmettitore MMT330.
- Collegare sempre il morsetto protettivo a terra!

Dette produkt er i overensstemmelse med direktivet om lavspænding (73/23 EØS).

- Netstrømskoblingen til må kun tilsluttes strømforsyningsmodulet af en autoriseret elinstallatør
- Strømforsyningsmodulet må ikke løsgøres fra senderen, mens spændingen er sluttet til.
- Slut ikke netspændingen til strømforsyningsmodulet, når det ikke er installeret i MMT330- senderen
- Forbind altid den beskyttende jordklemme!

Dit product voldoet aan de eisen van de richtlijn 73/23 EEG (Laagspanningsrichtlijn).

- De stroom kan aan de stroomtoevoer module aangesloten worden alleen door een bevoegde monteur.
- Het is niet toegestaan de stroomtoevoer module van de transmitter los te koppelen wanneer de stroom aan is.
- Het is niet toegestaan de stroom aan de stroomtoevoer module aan te sluiten als deze niet in een MMT330-transmitter is gemonteerd.
- Altijd beschermend aardcontact aansluiten!

Este producto cumple con la directiva de bajo voltaje (73/23 EEC).

- La conexión de la alimentación principal al módulo de alimentación sólo puede realizarla un electricista autorizado.
- No desenchufe el módulo de alimentación del transmisor cuando esté encendido.
- No conecte la alimentación principal al módulo de alimentación cuando no esté instalado en el transmisor MMT330.
- Conecte siempre el terminal de protección de conexión a tierra.

See toode vastab madalpinge direktiivile (73/23 EEC).

- Voolukaabli võib vooluallika mooduli külge ühendada ainult volitatud elektrik.
- Ärge ühendage vooluallika moodulit saatja küljest lahti, kui vool on sisse lülitatud.
- Ärge ühendage voolukaablit vooluallika mooduli külge, kui seda pole MMT330-tüüpi saatjasse paigaldatud.
- Ühendage alati kaitsev maandusklemm!

Ez a termék megfelel a Kisfeszültségű villamos termékek irányelvnek (73/23/EGK).

- A hálózati feszültséget csak feljogosított elektrotechnikus csatlakoztathatja a tápegységmodulra.
- A bekapcsolt távadóról ne csatolja le a tápegységmodult.
- Ne csatlakoztassa a hálózati feszültséget a tápegységmodulhoz, ha az nincs beépítve a MMT330 távadóba.
- Feltétlenül csatlakoztasson földelő védőkapcsot!

Šis produktas atitinka direktyvą dėl žemos įtampos prietaisų (73/23/EB).

- Elektros tinklą su energijos tiekimo moduliu sujungti gali tik įgaliotas elektrikas.
- Niekada neišimkite energijos tiekimo modulio iš siųstuvo, kai maitinimas yra įjungtas.
- Jei energijos tiekimo modulis nėra įmontuotas MMT330 siųstuve, nejunkite jo į elektros tinklą.
- Visada prijunkite prie apsauginės įžeminimo jungties!

Šis produkts atbilst Zemsprieguma direktīvai (73/23 EEC).

- Strāvas pieslēgumu var pieslēgt pie barošanas avota moduļa tikai autorizēts elektriķis.
- Neatvienot barošanas avota moduli no raidītāja, kad pieslēgta strāva.
- Nepievienot strāvu barošanas avota modulim, ja tas nav uzstādīts MMT330 raidītājā
- Vienmēr pievienot aizsargājošu iezemētu terminālu !

Ten produkt spełnia wymogi Dyrektywy niskonapięciowej (73/23 EEC).

- Napięcie zasilające powinno zostać podłączone do modułu zasilacza tylko przez wykwalifikowanego elektryka.
- Nie wolno odłączać modułu zasilacza od nadajnika, kiedy zasilanie jest włączone.
- Nie wolno podłączać napięcia zasilającego do modułu zasilacza, kiedy nie jest on zamontowany w nadajniku MMT330.
- Zawsze należy podłączać zabezpieczający zacisk uziemiający!

Tento výrobek vyhovuje Směrnici pro nízké napětí (73/23 EEC).

- Připojení síťového napájení k napájecímu modulu smí provádět pouze oprávněný elektrikář.
- Neodpojujte napájecí modul od snímače při zapnutém napájení.
- Nepřipojujte síťové napájení k napájecímu modulu, pokud není instalován ve snímači MMT330.
- Vždy zapojte ochrannou zemnící svorku!

DOMINO® Probe Installation

Due to the sliding fit the *DOMINO®* probe is easy to install into and remove from a pressurized process. The probe is especially suitable for the measurements in transformer radiators, coolers, tank walls through fittings or valves or in pipelines. The probe is adjustable, with two length options.

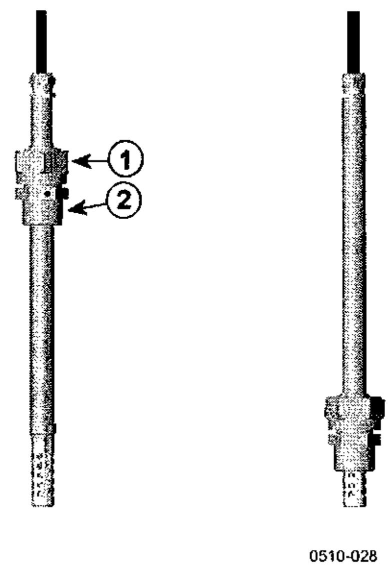


Figure 10 ***DOMINO®*** **Probe**

The following numbers refer to Figure 10 above:

1 = Clasp nut, 24 mm hex nut
2 = Fitting body, 27 mm hex head, ½ inch MNPT threads

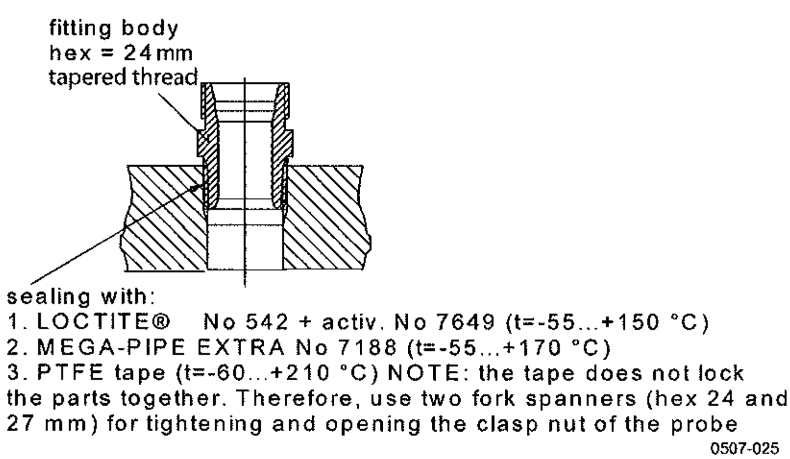


Figure 11 Sealing of Fitting Body into Process

Ball Valve Installation Kit for the *DOMINO®* Probe

The stainless steel ball valve and nipple installation kit are preferred when connecting the probe to a pressurized process or pipeline.

½ inch FNPT stainless steel ball valve	Doble Part No.: 230-0172
½ inch MNPT stainless steel nipple	Doble Part No.: 09B-0761-01

Use the Doble supplied ball valve or a ball valve with a through hole of Ø14 mm (0.55 inch) or more. If you install the sensor head (Ø 12 mm) in a process pipe, please note that the nominal size of the pipe must be at least 1 inch (2.54 cm). Use the manual press handle to press the sensor head into the pressurized (< 10 bar) process or pipeline.

1. Shut down the process if the process pressure is more than 10 bars. If the pressure is lower there is no need to shut down the process.
2. Make the installation according to the figure below. Install the sensor head transversely against the direction of the process flow.

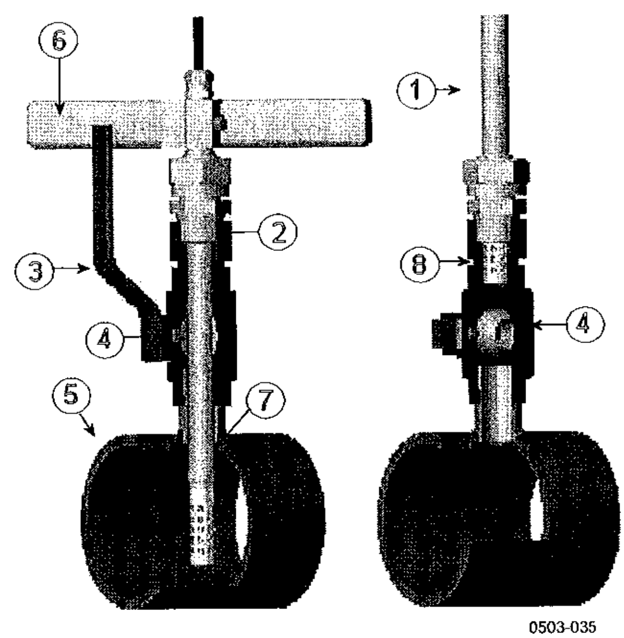


Figure 12 Installing the Sensor Head Through the Ball Valve Assembly

The following numbers refer to Figure 12 above:

1 = Probe

The following numbers refer to Figure 12 above:

2 = Tighten clasp nut first manually; probe is then sliding easily. Finally tighten with a fork spanner about 60° to have a stable installation. Do not overtighten this nut.
3 = Handle of the ball valve
4 = Ball of the ball valve
5 = Process chamber/pipeline
6 = Manual press handle
7 = The groove on the sensor head indicates the upper adjustment limit
8 = Filter

You can not close the valve if the groove (7) is not in sight. When installing the sensor head through the Ball Valve Assembly it is not necessary to empty or shut down the process for installing or removing the sensor head.

1. Mount the probe with the ball valve assembly closed; tighten the clasp nut manually. Add tape or other sealing according to instructions, see Figure 11 on page 34.
2. Open the ball valve assembly.
3. Push the probe head through the ball valve assembly into the process. If the pressure is high, use a manual press handle. Note that the sensor head must be pushed so deep that the filter is completely inside the process flow.
4. Tighten the clasp nut a further 50-60°.

NOTE	The probe can be installed in the process through the ball valve assembly provided that the process pressure is less than 10 bars. This way, the process does not have to be shut down when installing or removing the probe. However, if the process is shut down before removing the probe, the process pressure can be max. 40 bars.

Tightening the Clasp Nut

1. Adjust the probe to a suitable depth according to the type of installation.
2. Tighten the clasp nut first manually.
3. Mark the fitting body and the clasp nut.

4. Tighten the nut a further 50 -60° (ca. 1/6 turn) with a wrench. If you have suitable torque spanner, tighten the nut to max 45 ± 5 Nm (33 ± 4 ft-lbs).

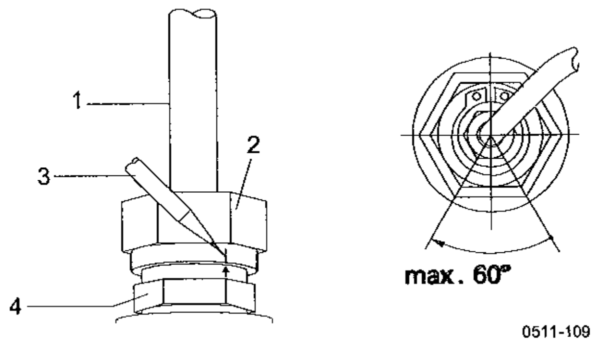


Figure 13 Tightening the Clasp Nut

The following numbers refer to Figure 13 above:

1 = Probe
2 = Clasp nut
3 = Pen
4 = Fitting body

NOTE	Take care not to over tighten the clasp nut to avoid difficulties when opening it.

CAUTION	Take care not to damage the probe body. A damaged body makes the probe head less tight and may prevent it from going through the clasp nut.

CAUTION	In pressurized processes it is essential to tighten the supporting nuts and screws very carefully to prevent loosening of the probe by the action of pressure.

Optional Modules

Galvanic Isolation for Output

If galvanic isolation of the power supply line from the output signals is needed, the *DOMINO*® can be ordered with optional output isolation module. This module prevents harmful grounding loops.

NOTE	Output isolation module is not needed when using the power supply module.

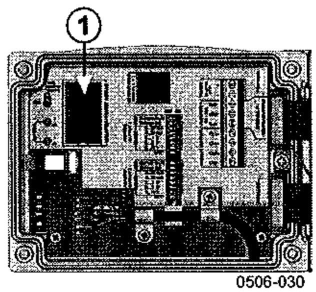


Figure 14 Galvanic Output Isolation Module

Number refers to Figure 14 above:

1 = Output isolation module

Third Analog Output

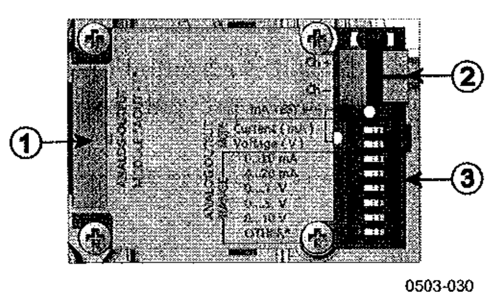


Figure 15 Third Analog Output

The following numbers refer to Figure 15 above:

1 = Flat cable pins
2 = Screw terminals for signal line

The following numbers refer to Figure 15 above:

3 = DIP switches to select the output mode and range

Installation and Wiring

1. Disconnect the power. In case the analog output module is installed in the factory, continue with the step 4.
2. To attach the module, open the transmitter cover and fasten the analog output module to the bottom of the housing with four screws. See the position from the picture on page 11.
3. Connect the flat cable between the analog output module and the motherboard's pins MODULE 2.
4. Take out the protective plug from the cable gland and thread the wires.
5. Connect the wires to the screw terminals marked with **Ch+** and **Ch-** .
6. Select the current/voltage output by setting ON either of the switches 1 or 2.
7. Select the range by setting ON one of the switches 3...7.

NOTE Only one of the switches 1 and 2 can be ON at a time.

Only one of the switches 3...7 can be ON at a time.

Channel 3

	OFF	ON	Selection
1			Current output selection, ON=Current output selected
2			Voltage output selection, ON=Voltage output selected
3			0...20 mA selection, ON= 0...20 mA selected
4			4... 20 mA selection, ON= 4... 20 mA selected
5			0...1 V selection, ON=0...1 V selected
6			0...5 V selection, ON=0...5 V selected
7			0...10 V selection, ON= 0...10 V selected.
8			For service use only, keep always in OFF position.

8. Connect the power.
9. Select the quantity and scale the channel via the serial line or display/keypad, see section Analog Output Quantities on page 74. For testing the analog output, see Section Analog Output Tests on page 76. For fault indication setting, see section Analog Output Fault Indication Setting on page 77.

Relays

The *DOMINO*® that you purchased may have already come relay modules or may be equipped with one or two configurable relay modules. Each module contains two configurable relays. See the contact ratings in section Technical Specifications of Optional Modules on page 109.

Installation and Wiring

1. Disconnect the power and open the transmitter cover. In case the relay-module is installed in the factory, continue with step 5.
2. To attach the module fasten the relay module to the bottom of the housing with four screws. See the position in FIGURE 2 on page 16.
3. When the mains power is in use attach the grounding wire to the grounding terminal.
4. Connect the flat cable between the relay module and the **MODULE 1** or **MODULE 2** pins of the motherboard.
5. Take out the protective plug from the cable gland and thread the relay wires.
6. Connect the wires to the screw terminals: NO, C, NC.

Selecting the Activation State of the Relay

The middlemost C terminal and either one of the terminals NO/NC must be connected. The polarity can be freely selected.

NO Normally open
C Common relay
NC Normally closed

Relay NOT activated: C and NC outputs are closed, NO is open
Relay IS activated: C and NO outputs are closed, NC is open.
Connect the power and close the cover.

NOTE	For instructions on how to operate the relay (for example, select quantity for the relay output and set the relay setpoints) see section Operation of Relays on page 78.

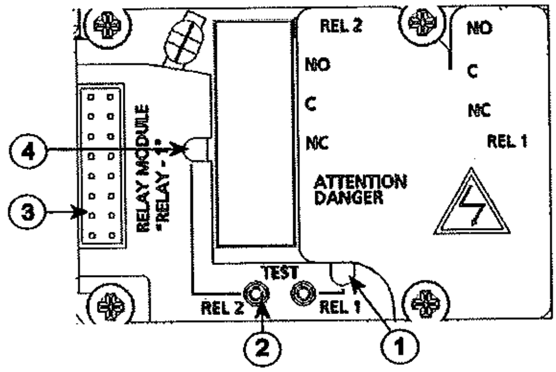


Figure 16 Relay Module

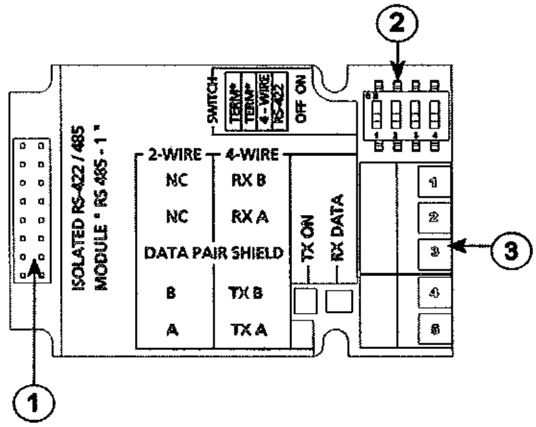
The following numbers refer to Figure 16 above:

1 = Indication led for the relay 1 or 3
2 = Relay test buttons
3 = Flat cable pins
4 = Indication led for relay 2 or 4

WARNING	The relay module may contain dangerous voltages even if the transmitter power has been disconnected. Before opening the transmitter you must switch off **both** the transmitter **and** the voltage connected to the relay terminals.

WARNING	Do not connect the mains power to relay unit without grounding the transmitter.

RS-422/485 Interface



0503-029

Figure 17 RS-485 Module

The following numbers refer to Figure 17 above:

1 = Flat cable pins
2 = Selection switches
3 = Screw terminals for wiring

Installation and Wiring

1. Disconnect the power. In case the RS-485-module is installed in the factory, continue with the item 4.

2. To attach the module, open the transmitter cover and fasten the RS-485 module to the bottom of the housing with four screws.

3. Connect the flat cable between the RS-485 module and the motherboard's pins **MODULE1 (Communications)**.

4. Pull the network wirings through the cable gland.

5. Connect the twisted pair wires (1 or 2 pairs) to the screw terminals as presented in Table 1 on page 42:

Table 1 Connecting the Twisted Pair Wires to the Screw Terminals

Screw terminal	Data line (2-wire RS-485)	Data line (4-wire RS-485/422)
1	(not connected)	RxB
2	(not connected)	RxA
3	Data pair shield	Data pair shield
4	B	TxB
5	A	TxA

6. If you use RS-485 (or RS-422) to connect just one *DOMINO*® to a master computer, enable the internal termination of *DOMINO*® by switching switches 1 and 2 ON. Make sure that the master's end of the line is also terminated (by using master's internal termination or with a separate terminator).

If you are connecting many transmitters to the same RS-485 bus, make sure that switches 1 and 2 are OFF and terminate the bus with separate terminators at both ends. This allows removing any transmitter without blocking the bus operation.

NOTE If you use the internal termination of the transmitter at the end of the RS-485 bus (instead of using separate terminators) removing that transmitter will block the bus operation.

7. Use the bus type (4-wire/2-wire) to select the selection switch 3.

In 4-wire mode RS-485 master sends data to the *DOMINO*® through terminals RxA and RxB and receives data from *DOMINO*® through terminals TxA and TxB.

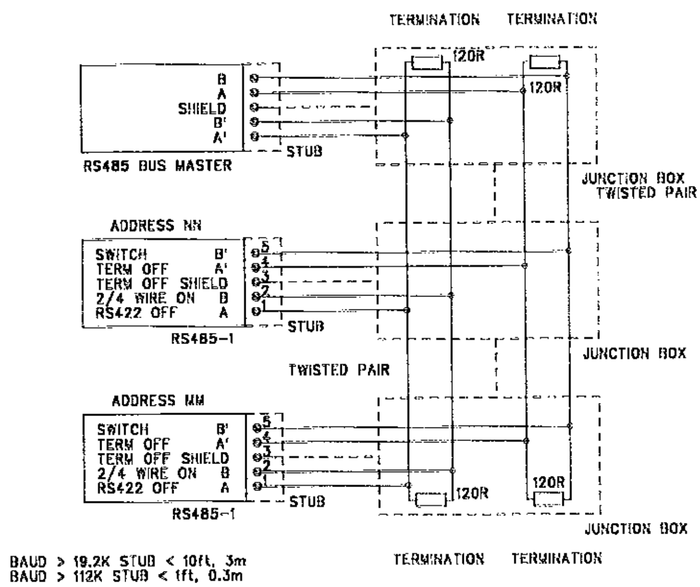


Figure 18 4-Wire RS-485 Bus

Table 2 4-Wire (Switch 3:On)

RS-485 master	Data	MMT330
TxA	→	RxA
TxB	→	RxB
RxA	←	TxA
RxB	←	TxB

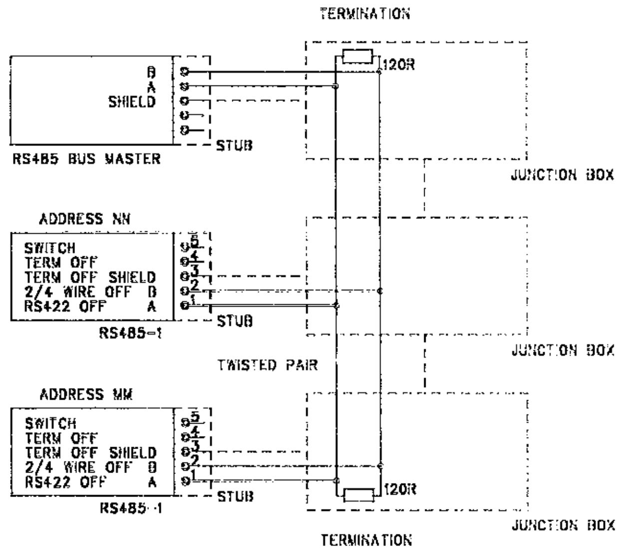


Table 3 2-Wire (Switch 3:Off)

RS-485 master	Data	MMT330
A	↔	A
B	↔	B

8. When operating in communication mode RS-422, set both switches 3 and 4 to ON position (4-wire wiring is required for RS-422 mode).

9. Connect the power and close the cover.

8-Pin Connector

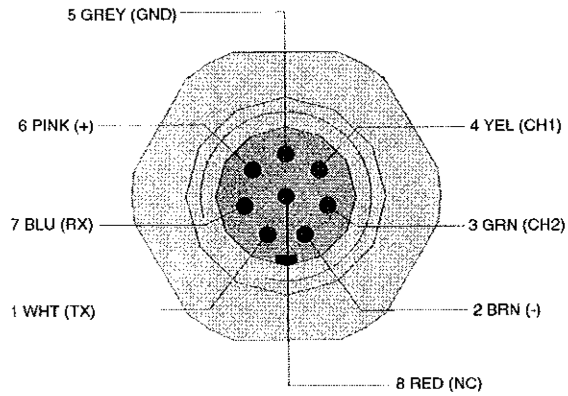


Figure 19 Wiring of Optional 8-Pin Connector

Table 4 Wiring of 8-Pin Connector

PIN/Terminal	Wire	Serial Signal		Analog Signal
		RS-232 (EIA-232)	**RS-485 (EIA-485)**	
1	White	Data out TX	A -	-
2	Brown	(serial GND)	(serial GND)	Signal GND (for both channels)
3	Green	-	-	Ch 2+
4	Yellow	-	-	Ch 1 +
5	Grey	Supply -	Supply -	Supply -
6	Pink	Supply +	Supply +	Supply +
7	Blue	Data in RX	B -	-
8	Shield/Red	Cable shield	Cable shield	Cable shield

CHAPTER 4

OPERATION

This chapter contains information that is needed to operate this product.

Getting Started

Within a few seconds after power-up the led on the cover of the transmitter is lit continuously indicating normal operation. When using the optional display and turning the transmitter on the first time, the language selection menu window opens. Select the language with the arrow buttons and press the SELECT button.

Display/Keypad (Optional)

Basic Display

Display shows you the measurement values of the selected quantities in the selected units. You can select 1... 3 quantities for the numerical basic display (see section Changing Quantities and Units on page 60.)

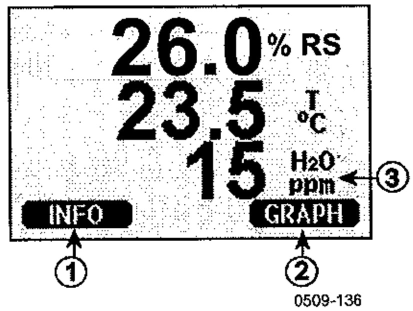


Figure 20 Basic Display

The following numbers refer to Figure 20 above:

1 = The Info shorcut button, see section Device Information on page 66.
2 = The Graph shortcut button, see section Graphic History on page 47.
3 = Quantities selected for display

NOTE	From any view, a four-second press on the right-hand function button takes you directly to the basic display.

Graphic History

The graphical display shows the data trend of the selected quantities, one at a time. The graph is updated automatically while measuring. Use the following functions in the graphical display:

- Press the **NEXT** button to have the trend graph and max/min graph in turns and browse through the quantities selected for display.
- Press the **EXIT** button to get back the basic display.

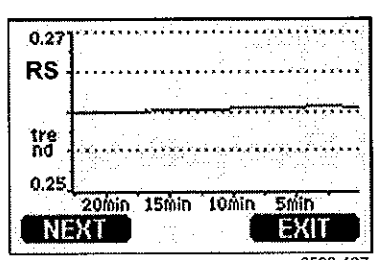


Figure 21 Graphical Display

Trend graph: Shows you a curve of average values. Each value is a calculated average over a period. See Table 5 on page 48.

Max/min graph: Shows you the minimum and maximum values in a form of curve. Each value is max/min over a time period. See Table 5 on page 48 below.

Table 5 Periods for Trend and Max/Min Calculations

Observation Period	Period for Trend/Max/Min Calculations (Resolution)
20 minutes	10 seconds
3 hours	90 seconds
1 day	12 minutes
10 days	2 hours
2 months	12 hours
1 year	3 days

- Press the □□ arrow buttons to zoom in and out the time in the graph window.
- Press the □□ arrow buttons to have the cursor mode where you can observe individual measuring points. Press an arrow button to move the cursor (vertical bar) along the time axis. The numerical value at the cursor position is shown at the left upper corner. Time from the present to the chosen moment is shown at the right upper corner.

Table 6 Graph Information Messages in Cursor Mode

Message	Interpretation
Power outage	Power failure (marked also with dashed vertical line)
No data	Quantity has not been selected for the display
Device failure	General device failure
T meas. failure	Temperature measurement/sensor failure
RH meas. failure	Moisture measurement/sensor failure
Adj. mode active	Adjustment mode active (data recorded in the adjustment mode is not displayed)

A question mark after time tells you that at least one power failure (dashed vertical line) has occurred after the chosen moment. In this case, the exact time difference between the present and the cursor position is not exactly known.

Menus and Navigation

You can change settings and select functions in the menus.

1. Open the **MAIN MENU** by pressing any of the □□□□ arrow buttons in the basic (numeric) display mode.
2. Move in the menus by using the □□ arrow buttons.

3. Open a submenu with □ button.
4. Press □ to return to the previous level.
5. Function button **EXIT** returns you back to the basic display.

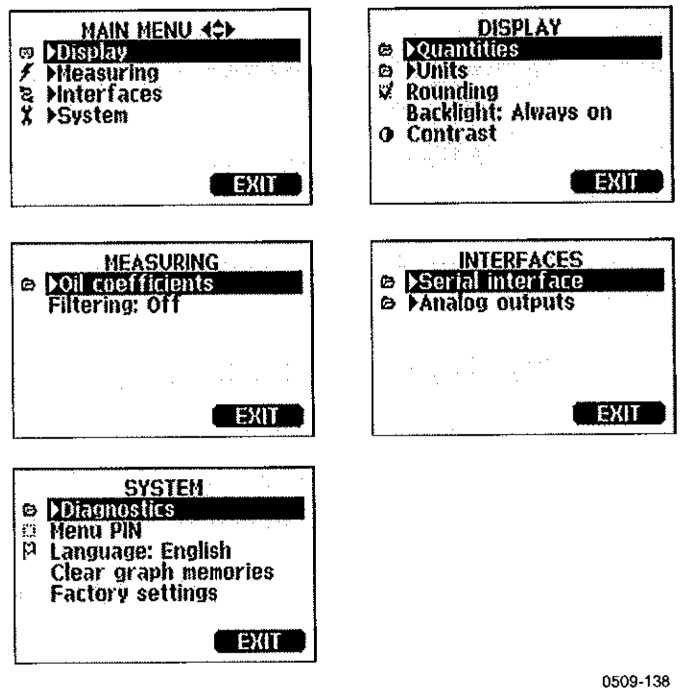


Figure 22 Main Menus

Language Setting

1. Go back to the basic display by keeping the right-hand □ button pressed for four seconds.
2. Open the **MAIN MENU** by pressing any of the □□□□ buttons.
3. Select □**System** (the lowest row), press □button.
4. Select **Language: ...** (the third row marked with a flag icon), press **SELECT** button (left-hand □ button).
5. Select the menu language with □□ buttons and press **SELECT** button (left-hand □ button).
6. Press **EXIT** to return to the basic display.

Rounding Setting

Round off one decimal by using the Rounding function . The default setting is rounding on. Rounding has no effect on quantities without decimals.

1. Open the **MAIN MENU** by pressing any of the □□□□ arrow buttons.
2. Select □**Display** and confirm by pressing the □arrow button.
3. Select **Rounding** and press **ON/OFF** button.
4. Press **EXIT** to return to the basic display.

Display Backlight Setting

As a default the display backlight is always on. In the automatic mode the backlight stays on for 30 seconds from the last press of any button. When pressing any button, the light turns on again.

1. Open the **MAIN MENU** by pressing any of the □□□□ arrow buttons.
2. Select □**Display**, press the □arrow button.
3. Select **Backlight**, press the **CHANGE** button.
4. Select **On/Off/Automatic**, press the **SELECT** button.
5. Press **EXIT** to return to the basic display.

Display Contrast Setting

1. Open the **MAIN MENU** by pressing any of the □□□□ arrow buttons.
2. Select □**Display**, press the □arrow button.
3. Select **Contrast**, press the **ADJUST** button.
4. Adjust the contrast by pressing the □□ arrow buttons.
5. Press **OK** and **EXIT** to return to the basic display.

Keypad Lock (Keyguard)

This function locks the keypad and prevents unintentional key presses.

1. Keep pressing the left-hand function button for 4 seconds to lock the keypad (at any display).
2. To unlock the keypad, press the **OPEN** button for 4 seconds.

Menu PIN Lock

You can prevent unauthorized changes of the device settings by activating the menu PIN lock. When this function is activated, the basic display and graphical view are available but access to the menus is locked. The key symbol indicates the activation of this feature.

1. Open the **MAIN MENU** by pressing any of the □□□□ arrow buttons.
2. Select □**System**, press the □arrow button.
3. Select **Menu PIN**, press the **ON** button.
4. Enter a PIN code by using the □□arrow buttons. Press **OK** to confirm the setting. Now the PIN lock is on and a key symbol is shown in a display.
5. Press **EXIT** to return to the basic display. Returning to the menu is possible only by entering the correct PIN code.

When you want to turn off the PIN lock, go to the menu by giving the PIN code and select □**System, Menu PIN,** press **OFF** button.

In case you have forgotten the PIN code, open the transmitter cover and press the **ADJ** button once. Wait for a few seconds and the adjustment menu opens. Select **Clear menu PIN**, press □ **CLEAR.**

NOTE	You can also disable the keypad completely with serial command **LOCK**.

Factory Settings

Use the display/keypad to restore the factory settings. This operation does not affect the adjustments. Only settings available in the menus are restored.

1. Press any of the arrow buttons to open the **MAIN MENU**.
2. Select **System** by pressing the ▶ arrow button.
3. Select **Factory settings** and press the **REVERT** button to confirm your selection. Press the **YES** button to reset all settings to the factory defaults.

See section General Settings on page 60 for a description of the other menu options.

Serial Line Communication

Connect the serial interface by using either the user port or the service port.

For permanent interfacing to host system, use the user port.You can change the serial settings and operate in RUN, STOP and POLL modes.

For temporary RS-232 connections use the service port. Service port is always available with fixed serial settings.

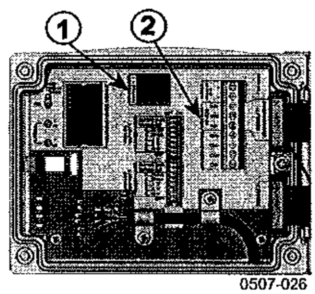


Figure 23 Service Port Connector and User Port Terminal on Mother Board

The following numbers refer to Figure 23 above:

1 = Service port connector
2 = User port terminals

User Port Connection

Use suitable serial cable between the user port RxD, GND and TxD screw terminals and the PC serial port, see Figure 24 on page 53 below.

Table 7 Default Serial Communication Settings for the User Port

Parameter	Value
Bauds	4800
Parity	Even
Data bits	7
Stop bits	1
Flow control	None

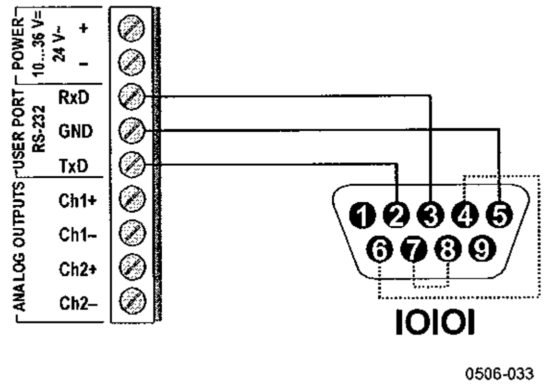


Figure 24 Connection Example Between PC Serial Port and User Port

Connections to pins 4,6,7 and 8 on PC serial port are required only if you are using software requiring hardware handshaking.

NOTE	User port cannot be used when RS-485 module is connected.

Service Port Connection

1. Connect the serial interface cable (optional accessory, order code: 19446ZZ) between the serial port of your PC and the service port connector on the motherboard, see Figure 23 on page 52 above.

Table 8 Fixed Communication Settings for Service Port

Parameter	Value
Bauds	19200
Parity	No
Data bits	8
Stop bits	1
Flow control	None

2. Open a terminal program and set the communication settings (see the following section for more detailed instructions).

3. Power-up the *DOMINO*®.

After power-up the transmitter (in STOP-mode) outputs the software version and the command prompt.

```
MMT330/2.04
>
```

In RUN mode a measurement output starts immediately after power-up.

Terminal Program Settings

The following instructions show a connection example with HyperTerminal program (included in the Microsoft Windows).

Follow the instructions below to open a HyperTerminal program:

1. Start HyperTerminal. To get help for starting HyperTerminal, click "Start", select "Help" to open Windows help, and search for "HyperTerminal".

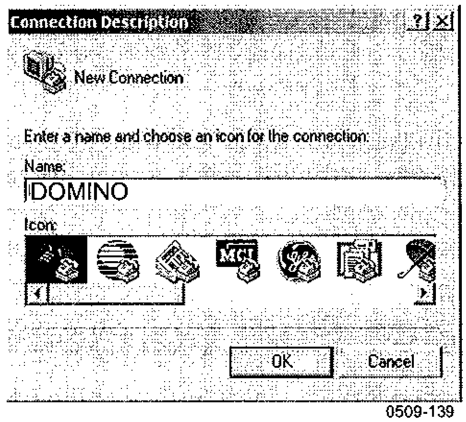


Figure 25 Starting HyperTerminal Connection

2. In the "New Connection"window of the HyperTerminal, define a name for *DOMINO*® serial connection, for example "DOMINO". Click OK.
3. In "Connect using" box, select the PC communications port where the serial cable is connected. (If your computer has only one COM port, it is called "COM1"). Click OK.

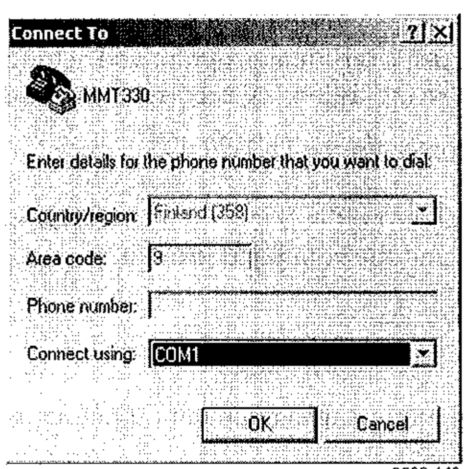


Figure 26 Connecting to HyperTerminal

4. Set the port settings in the "Properties" window to match the settings of your *DOMINO®* *user port/service port.* For *DOMINO®*, "Flow control" must always be set to "None". Finally click OK to start using the serial connection.

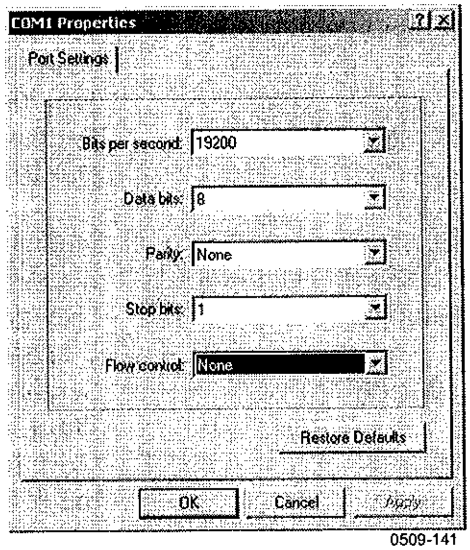


Figure 27 HyperTerminal Serial Port Settings

5. Select "File" → "Save" in the HyperTerminal main window to save the serial port settings. To use the saved settings later, start HyperTerminal, click cancel in the "New Connection" window, and select "File" → "Open".

List of Serial Commands

The bold text in the brackets is the default setting. Enter commands by typing them on your computer and pressing the Enter key.

Measurement commands	
R	Start the continuous outputting
S	Stop the continuous outputting
INTV [**0**...255 S/MIN/H]	Set the continuous output interval (for RUN mode)
SEND [0...99]	Output the reading once
SMODE [**STOP**/RUN/POLL]	Set the serial interface
SERI [baud p d s]	User port settings (default: 4800 E 7 1) baud: 300...115200
ADDR [**0**...99]	Set the transmitter address (for POLL mode)
OPEN [0...99]	Open temporarily connection to the POLL-mode device
CLOSE	Close the connection (back to POLL mode)
Formatting commands	
FORM	Set the output format of SEND and R commands
TIME	Set the time
DATE	Set the date
FTIME [ON/**OFF**]	Add time to output to SEND and R outputs
FDATE [ON/**OFF**]	Add date to R and SEND outputs
UNIT	Select the metric or non-metric output units
Data recording commands	
DSEL	Select data recording and display quantities.
PLAY [0...17]	Output recorded data file
DIR	Display recorded files
DELETE	Delete the graph files
UNDELETE	Recovers the deleted files
Calibration and adjustment commands	
CRH	Relative humidity calibration
CT	Temperature calibration
FCRH	Relative humidity calibration after sensor change
CTEXT	Give the text to calibration information field
CDATE	Set the calibration date

ACAL	Analog output calibration
Setting and testing the analog outputs	
AMODE	View the analog output modes
ASEL	Select the parameters for the analog outputs
ITEST	Test the analog outputs
AERR	Change the analog error output values
Setting and testing the relays	
RSEL	Set and view the relays
RTEST	Test the relays
Other commands	
?	Output the information about the device
??	Output the information about the device in POLL-state
ECHO [ON/OFF]	Turn the serial interface echo ON/OFF
FIND	All devices in POLL mode are sent their addresses
HELP	List the most common commands
ERRS	List present transmitter errors
FILT	Set the result filtering
VERS	Display the software version information
LOCK	Lock the menu/disable keypad
OIL	Set oil-specific parameters for ppm conversion

Getting Measurement Message from Serial Line

Enter the **R** command to start output of measurements. Enter the **S** command, press the Esc button or reset the transmitter to stop outputting. See command **SMODE** to change the default (power-up) operation mode.

Format the output by using the following commands:

- outputting interval can be changed with the **INTV** command.
- output message format can be changed with a command **FORM.**

- status of chemical purge and probe heating can be added with a command **FST**.
- date and time information can be added with commands **FDATE** and **FTIME**

Examples:

```
>r
RS=   26.1% T= 23.8 'C H2O=    15 ppm
>
```

Stopping Continuous Outputting

S

Use the S command to end the RUN mode. After this command all other commands can be used.

Outputting Reading Once

SEND

Use the SEND command to output the reading once in STOP mode.

The output format depends on which parameters the transmitter can output.

Examples:

```
>SEND
RS=   26.1% T= 23.8 'C H2O=    15 ppm
>
```

If there is an error in outputting the quantity, value is displayed with stars '*'.

The output mode can be changed with the commands: **FORM, FST, FDATE, TIME.**

Formatting Serial Line Message

TIME and DATE

To set time enter the **TIME** command. To set date enter the **DATE** command.

TIME

DATE

These time and date settings are shown on the timestamps of **PLAY** command. When you want to include time and date in the **R** and **SEND** commands, use the **FTIME** and **FDATE** commands.

Example:

```
>TIME
Current time is 04:12:39
Enter new time (hh:mm:ss) ? 12:24:00
>DATE
Current date is 2000-01-01
Enter new date (yyyy-mm-dd) ? 2005-10-22
>
```

NOTE	Time and date are cleared to 2000-01-01 00:00:00 at reset or at power failure.

FTIME and FDATE

FTIME and **FDATE** commands will enable/disable output of time and date to the serial line. To add time to R and SEND outputs enter:

FTIME [*x*]

To add date to **R** and **SEND** outputs enter:

FDATE [*x*]

where

x = ON or OFF

Example:

```
>send
RS=   27.7% T= 23.5 'C H2O=    16 ppm
>ftime on
Form. time      : ON
>send
00:16:07 RS=   27.7% T= 23.5 'C H2O=    16 ppm
>fdate on
Form. date      : ON
>send
2000-01-01 00:16:15 RS=   27.7% T= 23.5 'C H2O=    16
ppm
>
```

General Settings

Changing Quantities and Units

To change quantities and units use serial commands or the optional display/keypad. The *DOMINO*® measures the following quantities:

- Relative saturation (%RS)
- temperature (T) (metric unit: °C, non metric unit:°F)
- ppm for transformer oil only (H_2O)

NOTE	Only the quantities selected when ordering the device can be selected as a display output quantity.

Using Display/Keypad

Use display/keypad to select the display output quantities.

1. Press any of the arrow buttons to open the **MAIN MENU**.
2. Press the ► arrow button to select **Display**.
3. Press ► arrow button to select **Quantities.**
4. Select the quantity by using the ▲ ▼ arrow buttons. Confirm the selection by pressing **SELECT**. You can select 1 ... 3 display quantities at a time.
5. Press **EXIT** to return to the basic display.

To select display units:

1. Press any of the arrow buttons to open the MAIN MENU.
2. Press the ► arrow button to select **Display**.
3. Use the ▲ ▼arrow buttons to select Units. Confirm the selection by pressing the right-hand arrow button.
4. Use the ▲ ▼ arrow buttons to select display units. Confirm the selection by pressing **CHANGE**. The unit changes from metric to non-metric or the other way round.
5. Press **EXIT** to return to the basic display.

NOTE	Changing the display quantities/units (by using the display/keypad) has no effect on the serial output data.

Using Serial Line

Use the serial line command **FORM** to change the format or select a certain quantities for the output commands **SEND** and **R**.

FORM [*x*]

where

x = Formatter string

Formatter string consists of quantities and modifiers. The *DOMINO®* measures the following quantities:

- relative saturation (%RS)
- temperature (T) (metric unit: °C, non metric unit:°F)
- ppm for transformer oil only (H_2O)

When selecting the quantity, use the abbreviations of the quantities. The modifiers are presented in Table 9 on page 61 below.

Table 9 The modifiers

Modifier	Description
x.y	Length modifier (number of digits and decimal places)
#t	Tabulator
#r	Carriage-return
#n	Line feed
""	String constant
#xxx	Special character, code "xxx" (decimal), for example #027 for ESC
U5	Unit field and length (optional)

Example:

```
>form "RS=" 6.4 rs #t "t=" 6.2 t #r#n
>

>send
rs=     0.2644t=    25.50
>

>form "Oil ppm= " h2o " " u3 #r#n
>send
Oil ppm=    16.6 ppm
>
```

Command '**FORM** /' will return the default output format. The default output format depends on the device configuration.

```
>form /
>send
rs=   0.087 T= 24.0 'C
>
```

UNIT

Use the **UNIT** command to select metric or non-metric output units:

UNIT [*x*]

where

x = M or N

where

M = Metric units
N = Non-metric units

NOTE	This command changes both the serial output and display units to either metric or non-metric units. When you want to output both metric and non-metric units simultaneously on the serial line and display, select the display units later by using the display/keypad.

User Port Serial Settings

Using Display/Keypad

The communication settings for the user port can be changed via the serial line or by using the optional display/keypad. The communication settings for the service port are fixed and not changeable.

1. Press any of the arrow buttons to open the MAIN MENU.
2. Select **Interfaces** and press the ► arrow button to confirm your selection.
3. Select **Serial interface** and press the ► arrow button to confirm your selection.
4. Select **Bit rate/Serial format/Comm. mode** by pressing the **CHANGE** button. Use the ▲ ▼ arrow buttons to select and press **SELECT** to confirm your selection.

5. If you selected RUN communication mode, select **RUN** interval for and press **SET** to confirm your selection.
6. Use the arrow buttons to set the measuring interval and the unit. Press **OK** to confirm your settings.
7. If you selected POLL communication mode, select POLL address and press **SET** to confirm your selection.
8. Use the arrow buttons to set the transmitter address. Press **OK** to confirm the setting.
9. Use the arrow buttons to select **ECHO**. Press **ON** to turn to it on. Press **OFF** to turn it off.
10. Press **EXIT** to return to the basic display.

The new user port settings set using the display/keypad are effective immediately.

Using Serial Line

SERI

Use the serial line command **SERI** [*b p d s*] to set communication settings for the user port.

SERI [*b p d s*]

where

b	=	Bit rate (110, 150, 300, 600, 1200, 2400, 4800, 9600,19200, 38400, 57600, 115200)
p	=	Parity (n = none, e = even, o = odd)
d	=	Data bits (7 or 8)
s	=	Stop bits (1 or 2)

Example:

```
>SERI 600 N 8 1
600 N 8 1
>
```

You need to reset the transmitter to activate the new communication settings set with command SERI.

The settings can be changed one parameter at a time or all parameters at once:

```
>SERI O               changing parity only
4800 O 7 1
>SERI 600 N 8 1       changing all parameters
600 N 8 1
>
```

You can use the SERI command to change/view the user port settings even if you are currently connected to the service port.

SMODE

Use the command **SMODE** to set the user port start-up operating mode.

SMODE [*xxxx*]

where

xxx = STOP, RUN or POLL

Table 10 Selection of Output Modes

Mode	Output	Available Commands
STOP	Only with the **SEND** command	All (default mode)
RUN	Automatic output	Only command S
POLL	Only with the **SEND** [*addr*] command	Use with RS-485 buses, see Operation of RS-485 Module on page 83.

Selected output mode will be activated after power outages.

INTV

Use the command **INTV** to set the outputting interval for the RUN mode.

INTV [*xxx yyy*]

where

xxx = Output inverval (0 ... 255). 0: the fastest possible output rate.
yyy = Unit (s, min or h)

Example:

```
>INTV 10 min
Output intrv. :  10 min
>
```

ECHO

Use the command **ECHO** to set the user port echo. The command either enables or disables echo of characters received.

ECHO [*x*]

where

x = ON (default) or
= OFF

NOTE	You can use the SERI, SMODE, INTV and ECHO commands to change/view the user port settings even if you are currently connected to the service port.

Data Filtering

The averaging data filter calculates a average over a certain period of time. The lowest measurement noise is achieved with the extended filtering. There are three filtering levels available.

Table 11 Filtering Levels

Setting	Filtering level
OFF (default)	No filtering
ON	Standard = short filtering (approximately 15 s moving average)
EXTENDED	Extended filtering (default: approximately 1 min average)

Use display/keypad to set the filtering level.

1. Press any of the arrow buttons to open the **MAIN MENU**.
2. Select **Measuring** by pressing the ▶ arrow button.
3. Select **Filtering** and press **CHANGE** to confirm your selection.
4. Select **Off/Standard/Extended** and press **SELECT** to confirm your selection.
5. Press **EXIT** to return to the basic display.

FILT

Use the serial line command **FILT** [*xxx*] to set the filtering level.

FILT [*xxx*]

where

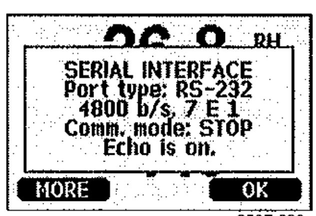
xxx = OFF, ON or EXT (default = ON)

Device Information

Use the display/keypad or the serial line to display the device information.

Press the **INFO** button in the basic display to see the following information:

- present or past unacknowledged errors, if any
- device information
- adjustment information fed by the user
- measuring settings
- serial interface information
- analog output information
- relay output information (when applicable)



0507-030

Figure 28 Device Information on Display

Proceed in the information views by pressing the **MORE** button as many times as you get the desired information. You can browse through the information displays also with arrow buttons. Press **OK** to return to the basic display.

?

Use the serial line command **?** to check the current transmitter configuration. Command **??** is similar but can also be used if the transmitter is in POLL mode.

Example:

```
>?
MMT330 / 2.04
Serial number   : A3420002
Batch number    : A3210034
Adjust. date    : 2005-08-07
Adjust. info    : Pre-adjustment Vaisala/HEL
Date            : 2000-01-01
Time            : 02:32:27
Serial mode     : STOP
Baud P D S      : 4800 E 7 1
Output interval: 0 s
Address         : 0
Echo            : ON
Pressure        : 1013.25 hPa
Filter          : OFF
Ch1 output      : 4...20mA
Ch2 output      : 4...20mA
Ch3 output      : 4...20mA
Ch1 RS    low   : 0.00
Ch1 RS    high  : 100.0
Ch2 T     low   : -40.00 'C
Ch2 T     high  : 60.00 'C
Ch3 H2O   low   : 0.00 ppm
Ch3 H2O   high  : 500.00 ppm
Module 1        : not installed
Module 2        : AOUT-1
>
```

HELP

Use the command **HELP** to list the commands.

Example:

```
>help
?         ACAL      ADDR      AERR      ASCL
ASEL      CDATE     CLOSE     CODE      CRH
CT        CTA       CTEXT     DATE      DELETE
DIR       DSEL      DSEND     ECHO      ERRS
FCRH      FDATE     FILT      FORM      FST
FTIME     HELP      INTV      ITEST     MODS
OPEN      PLAY      PRES      R         RESET
SEND      SERI      SMODE     TEST      TIME
UNDELETE  UNIT      VERS      XPRES
>
```

ERRS

Use the command **ERRS** to display transmitter error messages, see Table 14 on page 96.

Example:

```
>ERRS
No errors
>
```

VERS

Use the command **VERS** to display software version information.

Example:

```
>vers
MMT330 / 2.04
>
```

Resetting Transmitter By Using Serial Line

RESET

Resets the device. The user port switches to start-up output mode selected with command SMODE.

Locking Menu/Keypad by Using Serial Line

LOCK

Use the **LOCK** command to turn on the menu lock with 4-digit PIN code, for example 4444.

LOCK [*x yyyy*]

where

x = 1 (Menu locked)
yyyy = 4-digit PIN code

Example:

```
>lock 1 4444
Keyboard lock  : 1 [4444]
>
```

Use the **LOCK** command to turn on the menu lock without PIN code access possibility.

LOCK [*x*]

where

x = 1 (Menu locked)

Example:

```
>lock 1
Keyboard lock  : 1
>
```

Use the **LOCK** command to disable the keypad completely.

LOCK [*x*]

where

x = 2 (Keypad disabled)

Example:

```
>lock 2
Keyboard lock  : 2
>
```

NOTE	Open the locks with the serial command **LOCK 0**. You can open the menu lock also by using the keypad, if a PIN code has been set.

Data Recording

Data recording function is always on and collects data automatically into the memory of the device. Recorded data do not disappear from the memory when the power is switched off. Collected data can be observed in a form of a graph in the graphical view of the display.

Selecting Data Recording Quantities

If the device is provided with the optional display, the recorded quantities are always those selected for the display. Up to three quantities can be recorded at a time. See section Changing Quantities and Units on page 60 for instructions on how to select the display quantities with the keypad.

DSEL

Use the serial line command **DSEL** to select the quantities to be recorded if the transmitter is not equipped with display/keypad. The *DOMINO*® measures the following quantities:

- relative saturation (%RS)
- temperature (T) (metric unit: °C, non metric unit:°F)
- ppm for transformer oil only (H_2O)

DSEL [*xxx*]

where

xxx = Data recording quantity.
Example:

```
>dsel rs t
 rs T
>
```

Enter the command without parameters and press **ENTER** to display current recording parameters.

View Recorded Data

If the device is provided with the optional display, the graphical display shows the data of the selected quantities, one at a time. See section Graphic History on page 47 for details about graphical display.

You may also dump the logged data to the serial line in numeric form with the following commands.

DIR

Use the serial line and enter the **DIR** command to check the available files.

The device records six files (six observation periods) for each selected quantity. Thus, total amount of the files depends on the amount of the selected quantities being at minimum 6 and at maximum 18. See Table 5 on page 48.

Select, for example, three quantities (RS, T and H_2O). The last two columns illustrate software information that is not essential for the user.

Example:

```
>dir
0  RS  latest 20 minutes    00-01-01 02:12:49  135  020A
1  RS  latest 3 hours       99-12-31 23:12:49  135  025A
2  RS  latest 1 day         99-12-30 23:35:19  135  040C
3  RS  latest 10 days       99-12-20 20:35:19  135  0802
4  RS  latest 2 months      99-10-25 14:35:19  135  080C
5  RS  latest 1 year        98-11-22 02:35:19  135  1003
6  T   latest 20 minutes    00-01-01 02:12:49  135  020A
7  T   latest 3 hours       99-12-31 23:12:49  135  025A
8  T   latest 1 day         99-12-30 23:35:19  135  040C
9  T   latest 10 days       99-12-20 20:35:19  135  0802
10 T   latest 2 months      99-10-25 14:35:19  135  080C
11 T   latest 1 year        98-11-22 02:35:19  135  1003
12 H2O latest 20 minutes    00-01-01 02:12:49  135  020A
13 H2O latest 3 hours       99-12-31 23:12:49  135  025A
14 H2O latest 1 day         99-12-30 23:35:19  135  040C
15 H2O latest 10 days       99-12-20 20:35:19  135  0802
16 H2O latest 2 months      99-10-25 14:35:19  135  080C
17 H2O latest 1 year        98-11-22 02:35:19  135  1003
>
```

PLAY

Use the **PLAY** command to output the selected file to the serial line. Data in the output is <TAB> limited. This is compatible with most spreadsheet programs. Before giving the command, set the correct date and time with **TIME** and **DATE** commands, if needed.

PLAY [*x*]

where

x = 0 ... 17

Example:

```
>play 2
rs  latest 1 day       05-10-22 21:17:58       135  040C
Date      Time       trend      min       max
yy-mm-dd hh:mm:ss
05-10-22 21:17:58  27.01     27.00     27.05
05-10-22 21:29:58  27.11     27.02     27.18
05-10-22 21:41:58  27.08     27.08     27.10
05-10-22 21:53:58  27.10     27.02     27.20
>
```

The <**ESC**> key can be used to interrupt the output listing.

The **PLAY** -1 command can be used to output all files.

NOTE	Output of large amounts of recorded data can take a long time. If you are using the user port, select the highest serial baud supported to reduce the time required for output.

Deleting the Recorded Files

Use the keypad/display to delete the recorded files. Note that the transmitter automatically overwrites the old data when the memory gets full, so manual deletion of the recorded files is not necessary.

1. Press any of the arrow buttons to open the **MAIN MENU.**
2. Select **System** by pressing the ► arrow button.
3. Select **Clear graph memories** by pressing the **CLEAR** button. Press the **YES** button to confirm the selection.

CAUTION	This function clears all the data history from the memory, all graphs included.

DELETE/UNDELETE

Use the serial line to delete or undelete data files. Use the **DELETE** command to delete all data files. Use the **UNDELETE** command to recover the deleted files.

NOTE	The **UNDELETE** command will only recover the part of the deleted data that has not been recorded over yet.

Analog Output Settings

The analog outputs are set in the factory according to the order form. In case you want to change the settings, follow these instructions. See section Third Analog Output on page 38.

Changing Output Mode and Range

Both output channels have their own DIP switch module with 8 switches, see the position in FIGURE 2 on page 16 (DIP switches for analog output settings).

1. Select the current/voltage output, switch ON either of the switches, 1 or 2.
2. Select the range, switch ON one of the switches from 3 to 7.

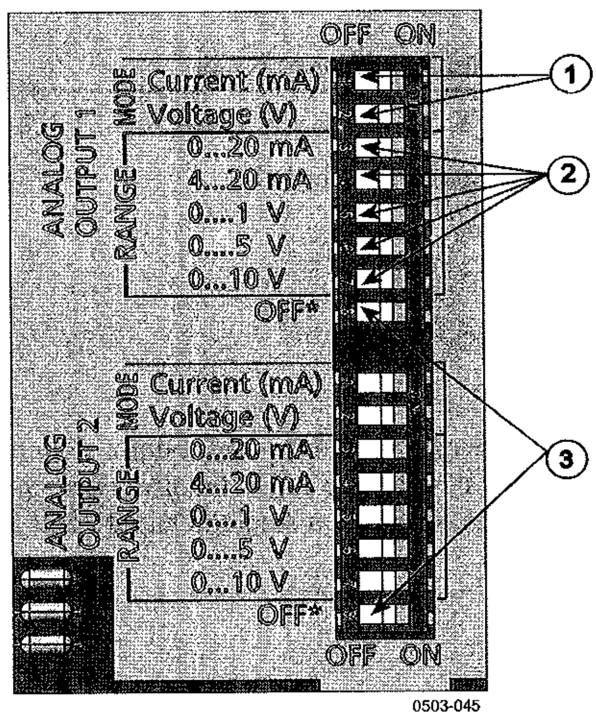


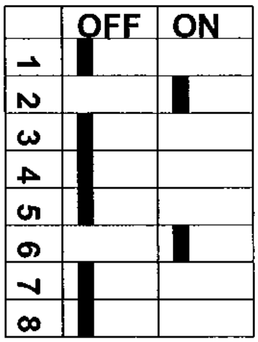
Figure 29 Current/Voltage Switches of Output Modules

The following numbers refer to Figure 29 above:

1 = Current/voltage selection output switches (from 1 to 2)
2 = Current/voltage range selection switches (from 3 to 7) in analog output 1 and 2.
3 = Switches for service use only. Keep in OFF position always.

NOTE	
	Only one of the switches 1 or 2, must be ON at a time.
	Only one of the switches 3 to 7, must be ON at a time.

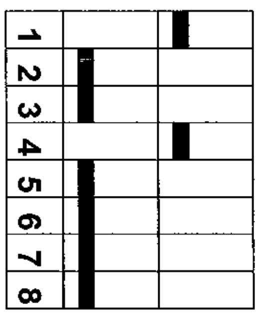
Example: 0 ... 5 V voltage output selected for channel 1 and 4...20 mA selected for channel 2.



Selection

Voltage output selected

0...5 V selected



Current output selected

4... 20 mA selected

NOTE	
	If you have customized the error output setting (**AERR**), check that the set error values are still valid after changing the output mode/range, see section Analog Output Fault Indication Setting on page 77.

Analog Output Quantities

Use the display/keypad to change and scale the analog output quantities.

1. Press any of the arrow buttons to open the **MAIN MENU.**
2. Select **Interfaces** by pressing the ▶ arrow button.
3. Select **Analog outputs** by pressing the ▶ arrow button.

4. Select **Output 1/2/3** by pressing the ► arrow button.
5. Select **Quantity** by pressing the ▲▼ arrow buttons. Confirm your selection by pressing **CHANGE**.
6. Select the quantity by using the arrow buttons. Press **SELECT** to confirm your selection.
7. Select **Scale,** lower limit, by pressing the ▲▼arrow buttons. Press **SET** to confirm your selection. Press **OK** to confirm your setting.
8. Select the upper limit by pressing the ▲▼arrow buttons. Use the arrow buttons to set the upper limit value. Press **SET** to confirm your selection. Press **OK** to confirm your setting.
9. Press **EXIT** to return to the basic display.

AMODE/ASEL

Use the serial line to select and scale the analog output quantities. Connect the transmitter to the PC. Open the terminal connection between your PC and the transmitter.

1. Check the analog output modes with the **AMODE** command.

Example:

```
>amode
Ch1 output     : 0...1V
Ch2 output     : 0...1V
>
```

2. Select and scale the quantities for the analog outputs with the command **ASEL**. Note that the optional quantities can be selected only if they have been selected when ordering the device.

ASEL [*xxx yyy zzz*]

where

xxx = Quantity of channel 1
yyy = Quantity of channel 2
zzz = Quantity of the optional analog output channel 3

Enter always all the quantities for all outputs. The *DOMINO*® measures the following quantities:

- relative saturaion (%RS)
- temperature (T) (metric unit: °C, non metric unit:°F)
- ppm for transformer oil only (H_2O)

Use the command **ASEL** [*xxx yyy*] as shown in the example below when using a device with two analog outputs.

Example:
```
>asel rs t
Ch1 RS    low  : 0.00
Ch1 RS    high : 100.0
Ch2 T     low  : -40.00 'C
Ch2 T     high : 60.00 'C
>
```

Analog Output Tests

Use the display/keypad for testing to test the operation of the analog by forcing the outputs to known values. Measure then the outputs with a current/voltage meter.

1. Press any of the arrow buttons to open the **MAIN MENU.**
2. Select **System** by pressing the ▶ arrow button.
3. Select **Diagnostics** by pressing the ▶ arrow button.
4. Select **Analog output tests** by pressing the ▶ arrow button.
5. Select one of the testing options **Force 0%/50%/100% of scale.** Press **TEST** to confirm your selection. All outputs are tested simultaneously. The actual output value depends on the selected range.
6. Press **OK** to stop testing. Press **EXIT** to return to the basic display.

ITEST

Use the serial line to test the operation of the analog outputs. Use the command **ITEST** to force the analog outputs to entered values. The set values remain valid until you enter the command ITEST without parameters or RESET the transmitter.

ITEST [*aa.aaa bb.bbb*]

where

aa.aaa = Current or voltage value to be set for channel 1 (mA or V)
bb.bbb = Current or voltage value to be set for channel 2 (mA or V)

Example:
```
>itest 20 5
Ch1 (rs  )     :          *        20.000 mA   H'CCDA
Ch2 (T   )     :          *         5.000 mA   H'34B9
>
```

Analog Output Fault Indication Setting

Factory default state for analog outputs during error condition is 0 V/ 0 mA. Please be careful when selecting the new error value. The error state of the transmitter should not cause unexpected problems in process monitoring.

Use the display/keypad to set the analog output fault indication.

1. Press any of the arrow buttons to open the **MAIN MENU.**
2. Select **Interfaces** by pressing the ► arrow button.
3. Select **Analog Outputs** by pressing the ► arrow button.
4. Select **Output 1/2/3** by pressing the ► arrow button.
5. Select Fault indication. Press **SET** to confirm your selection. Enter the fault indication value by using the arrow buttons. Press **OK** to confirm your setting. This value is outputted if a transmitter error occurs.
6. Press **EXIT** to return to the basic display.

AERR

Use the serial line **AERR** command to change the error output.

AERR

Example:

```
>aerr
Ch1 error out   : 0.000V ? 5.0
Ch2 error out   : 0.000V ? 5.0
>
```

NOTE	The error output value must be within a valid range of the output mode.

NOTE	The error output value is displayed only when there are minor electrical faults such as a humidity sensor damage. When there is a severe device malfunction, the error output value is not necessarily shown.

Operation of Relays

Quantity for Relay Output

A relay monitors the quantity chosen for the relay output. Any of the quantities available can be chosen.

Relay Setpoints

When the measured value is in between the "above" and "below" values, the relay is passive. When choosing lower value as "above" value and higher value as "below" value, the relay is passive when the measured value is not between the setpoints.

You can also set only one setpoint.

Hysteresis

Hysteresis function is to prevent the relay switching back and forth when the measured value is near to the setpoint values.

Relay is activated when the measured value passes the exact value of the setpoint. When returning and passing the setpoint again relay is not released before the value reaches the setpoint increased/decreased by the hysteresis value.

Hysteresis should be smaller than difference of the setpoints.

Example: When the 'active above' value RS is 60.0 and the hysteresis value is 5.0, relay activates when the RS reaches 60.0. As the humidity decreases, relay releases at 55.0.

NOTE	If both setpoints are specified and "above" setpoint is lower than "below" setpoint, the hysteresis works in the opposite direction, that is, relay is **released** when the measured value passes the exact value of the setpoint.

Relay Indicating Transmitter Error Status

You can set a relay to follow the operation status of the device. By selecting FAULT/ONLINE STATUS for output quantity a relay changes state on the basis of the operation status as follows:

FAULT STATUS
Normal operation: relay active (C and NO outputs are closed)
Not measuring state (error state or power off): relay released (C and NC outputs are closed)

ONLINE STATUS
Live measurement (data available): relay active (C and NO outputs are closed)
No live data (for example: error state or adjustment mode): relay released (C and NC outputs are closed)

Enabling/Disabling Relays

You can deactivate the relay outputs for example for service purposes of your system.

Setting Relay Outputs

NOTE	When having only one relay module installed, its relays are called 'relay 1' and 'relay 2'. When having two relay modules, the relays of the the module connected to slot **MODULE 1** are called 'relay 1' and relay 2' and relays connected to slot **MODULE 2** are called 'relay 3' and 'relay 4'

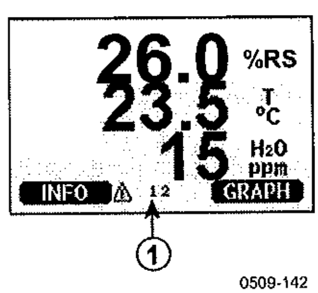


Figure 30 Relay Indicators on Display

The following number refers to Figure 30 above:

1 = Lists enabled relays. Activation state shown in black. Disabled relays are not shown.

Use the display/keypad to set the relay outputs.

1. Press any of the arrow buttons to open the **MAIN MENU**.
2. Select **Interfaces**, confirm by pressing the ▶ arrow button.
3. Select **Relay outputs**, confirm by pressing the ▶ arrow button.
4. Select **Relay 1/2/3/4**, confirm by pressing the ▶ arrow button.
5. Select the **Quantity**, confirm by pressing **Change**. Select the Quantity by using the arrow buttons. Confirm your selection by pressing **Select**.
6. Select **Act. above / Act**. below. Press **SET** to confirm your selection. (If asked, select **MODIFY** if you want to set the setpoint by using the arrow buttons. Select **REMOVE** if you want to remove the setpoint.)
7. Select **Hysteresis** by using the arrow buttons. Press **SET** to set the hysteresis. Press **OK**.
8. Select **Relay enable** by using the arrow buttons, press **ON/OFF** to enable/disable the relay.

RSEL

Use the serial line to select the quantity, setpoints and hysteresis or enable/disable the relay outputs. Enter the **RSEL** command.

RSEL [*q1 q2 q3 q4*]

where

q1	=	quantity for the relay 1 or Fault/Online
q2	=	quantity for the relay 2 or Fault/Online
q3	=	quantity for the relay 3 or Fault/Online
q4	=	quantity for the relay 4 or Fault/Online

Factory setting: all relays disabled.

The *DOMINO*® measures the following quantities:

- relative saturation (%RS)
- temperature (T) (metric unit: °C, non metric unit:°F)
- ppm for transformer oil only (H_2O)

Table 12 Quantities Measured by *DOMINO®*

Quantity	Abbreviation	Metric Unit	Non Metric Unit
Relative Saturation	RS	%	%
Temperature (T)	T	°C	°F

Table 13 Optional Quantity

Quantity	Abbreviation	Metric Unit	Non Metric Unit
ppm for transformer oil only	H2O	ppm	ppm

Example of window limit switch: Selecting relay 1 to follow aw measurement and relay 2 to follow temperature measurement. Two relay setpoints are set for both relays.

```
rsel RS t
Rel1 RS   above: 0.00   ? 30.0
Rel1 RS   below: 0.00   ? 40.0
Rel1 RS   hyst : 0.00   ? 2.0
Rel1 RS   enabl: OFF ? on
Rel2 T    above: 0.00 'C ? 30
Rel2 T    below: 0.00 'C ? 40
Rel2 T    hyst : 0.00 'C ? 3
Rel2 T    enabl: OFF ? on
>
```

- **Example of normal limit switch**: Selecting relay 1 to follow H_2O, relay 2 to follow temperature, relay 3 to follow online status and relay 4 to follow fault status.

```
rsel h2o t online fault
Rel1 H2O  above: 0.00 ppm ?
Rel1 H2O  below: 0.00 ppm ? 200
Rel1 H2O  hyst : 0.00 ppm ? 10
Rel1 H2O  enabl: ON ?
Rel2 T    above: 0.00 'C ? 30
Rel2 T    below: 0.00 'C ? 60
Rel2 T    hyst : 0.00 'C ? 2
Rel2 T    enabl: ON ?
Rel3 ONLI above: -
Rel3 ONLI below: -
Rel3 ONLI hyst : -
Rel3 ONLI enabl: ON ?
Rel4 FAUL above: -
Rel4 FAUL below: -
Rel4 FAUL hyst : -
Rel4 FAUL enabl: ON ?
```

Example of using relay 1 as fault alarm: selecting relay 1 to follow the fault status and relay 2 to follow the temperature measurement.

```
>rsel fault t
Rel1 FAUL above: -
Rel1 FAUL below: -
Rel1 FAUL hyst : -
Rel1 FAUL enabl: ON ?
Rel2 T    above: 0.00 'C ? 30
Rel2 T    below: 0.00 'C ? -
Rel2 T    hyst : 0.00 'C ? 2
Rel2 T    enabl: OFF ? ON
>
```

Testing Operation Of Relays

Testing activates relays even if they are disabled.

Use the module push buttons to activate the relays. Press the **REL 1** or **REL 2** button to activate the corresponding relay.

Relay is activated:	led is lit
Relay is not activated:	led is not lit

RTEST

Use the serial line command **RTEST** to test the operation of the relays.

RTEST [*x1 x2 x3 x4*]

where

x = ON/OFF

Example: Activate and then release all four relays.

```
>rtest on on on on
 ON ON ON ON
>
>rtest off off off off
 OFF OFF OFF OFF
>
```

Enter the command **RTEST** without parameters to stop testing.

Operation of RS-485 Module

RS-485 interface enables communication between RS-485 network and MMT330 transmitter. The RS-485 interface is isolated and offers a maximum communications rate of 115 200 bits/s. (For maximum bus length of 1 km, use bit rate 19200 b/s or less.)

When selecting an RS-232-RS-485 converters for the network, avoid self powered converters as they don't necessarily support the needed power consumption.

Echo function shall be always disabled (OFF) when using the 2-wire connection. When using the 4-wire connection you can disable/enable the echo setting.

NOTE	User port on *DOMINO®* main board cannot be used and connected when RS-485 module is connected. Service port is operating normally.

Networking Commands

Set the RS-422/485 interface by using the following commands. The other serial line commands are presented in section List of Serial Commands on page 56.

RS-485 configuration commands **SERI; ECHO; SMODE; INTV** and **ADDR** may be entered by using either the service port or RS-422/485 port. Also the optional display/keypad can be used, see section User Port Serial Settings on page 62.

SERI

Use the **SERI** command to input RS-485 bus settings.

SERI [*b p d s*]

where

b	=	bit rate (300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200)
p	=	parity (n = none, e = even, o = odd)
d	=	data bits (7 or 8)
s	=	stop bits (1 or 2)

ECHO

Use the **ECHO** command to enable/disable echo of characters received over the serial line.

ECHO [*x*]

where

x = ON/OFF (default = OFF)
When using 2-wire connection, echo must be always disabled.

SMODE

Use the **SMODE** command to set the default serial interface mode.

SMODE [*xxxx*]

where

xxxx = STOP, RUN or POLL

In STOP mode:	measurements output only by command SEND, all commands can be used
In RUN mode:	outputting automatically, only command S can be used to stop.
In POLL mode:	measurements output only with command SEND [*addr*].

When several transmitters are connected to the same line, each transmitter must be entered an own address in the initial configuration, and POLL mode must be used.

INTV

Use the **INTV** command to set the RUN mode output interval.

INTV [*n xxx*]

where

n = 0 - 255
xxx = S, MIN or H

Sets the RUN mode output interval. The time interval is used only when the RUN mode is active. For example, the output interval is set to 10 minutes.

```
>INTV 10 min
Output intrv. :    10 min
>
```

Setting RUN output interval to zero enables the fastest possible output rate.

ADDR

Addresses are required only for POLL mode (see serial line command SMODE on page 64.) Use the **ADDR** command to input the RS-485 transmitter address.

OPEN [*aa*]

where

aa = address (0 ... 99) (default = 0)

Example: the transmitter is configured to address 99.

```
>ADDR
Address : 2 ?  99
>
```

SEND

Use the SEND command to output the reading once in POLL mode:

SEND [*aa*]

where

aa = address of the transmitter

OPEN

When all transmitters on the RS-485 bus are in POLL mode the **OPEN** command sets one transmitter temporarily to STOP mode so that other commands can be entered.

OPEN [*aa*]

where

aa = address of the transmitter (0 ... 99)

CLOSE

The **CLOSE** command switches the transmitter back to the POLL mode.

Example:

```
>OPEN 2   (opens the line to transmitter 2, other
          transmitters stay in POLL mode)
>CRH      (for example, calibration performed)
...
>CLOSE    (line closed)
```

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CHAPTER 5

ppm conversion

DOMINO® ppm conversion for Transformer Oils

Traditionally, moisture in transformer oil is measured by using ppm-units. The ppm-output shows the average *mass concentration of water* in oil. Doble has this conversion readily available for mineral transformer oils and it comes in all *DOMINO®* units.

Conversion Model with Oil-specific Coefficients

For additional accuracy, oil-specific conversion model can be used both for mineral, silicone, synthetic and natural ester based oils. An oil sample has to be sent to Doble for modeling. As a result, the specific coefficients (A and B) for the transformer oil are determined by Doble. For additional information, please contact the Doble materials Laboratory in Watertown, Massachusetts, USA.

The determined coefficients of the transformer oil can be programmed to the *DOMINO®* by Doble or by a user according to the instructions presented in this chapter.

NOTE	Models equipped Oil-specific Coefficients are always needed for **all other applications** besides new and slighlty aged transforer mineral oils.

Setting Oil Coefficients Using Serial Line

If the ppm conversion and oil-specific coefficients have been programmed at Doble, the user does not have to set the conversion coefficients.

If a user has defined the coefficients or separately received from Doble the oil-specific coefficients A and B, related to his own oil type, the coefficients can be set to the software of Doble by using a serial bus or through an RS 485/422 serial module or through keypad/display.

OIL

Use the serial line command OIL to set oil-specific parameters for ppm conversion.

Example:

```
>OIL
Oil[0]          : -1567.0 ?
Oil[1]          : 7.0895 ?
>
```

where

Oil [0]   corresponds to parameter A
Oil [1]   corresponds to parameter B

Using Display/Keypad

1. Press any of the arrow buttons to open the **MAIN MENU.**
2. Select **Measuring** by pressing the ▶ arrow button.
3. Select **Oil coefficients** by pressing the ▶ arrow button.

4. Press **SET**. Set the upper value A by using the ▲ ▼buttons. Confirm by pressing OK.
5. Use the ▼ button to choose B. Press **SET**. Set the lower value B by using the ▲ ▼buttons. Confirm by pressing **OK**.
6. Press **EXIT** to return to the basic display.

Determination of Oil-Specific Coefficients

The equation of the Ppm calculation is:

$$\mathbf{ppm = aw{*}10^{(B+A/T)}}$$

With the following procedure the coefficients A and B can be defined for the equation:

$$\mathrm{LOG}(\mathrm{PPM}_{sat}) = B + A/T$$

Equipment needed:

- Apparatus for determining water content (for example, coulometric titrator and e.g. magnetic stirrer.)
- Oil test station:
    - a temperature test chamber
    - for example, a conical flask (1L) sealed by PTFE stopper with an inlet for a moisture probe
    - *DOMINO*®
    - magnetic stirrer.

Procedure:

1. Define the water content of the oil sample with the titration. Use the oil moisture level that is close to real conditions in the process.
2. Measure the water activity of this sample with *DOMINO*® at two temperatures that differ at least 20 °C. Follow the measurement stabilization illustrated by the graph.

NOTE	The sample has to be sealed very carefully i.e. not to be in contact with ambient air, which would change the water content.

NOTE	If the oil sample is very dry and the temperatures are close to each other, it may cause inaccuracy to the calculation model. In order to get the best possible performance it is recommended to use oil conditions that represent real conditions in application. Recommended values for samples are relative saturation of approximately 50% at 20°C.

3. Define the correlation between RS, T and PPM (w/w) from the measured values. Calculate A and B according to the following example.

$$A = \frac{LOG(PPM_{sat}[T2]) - LOG(PPM_{sat}[T1])}{1/(T2) - 1/(T1)}$$

$$B = LOG(PPM_{sat}[T1]) - A/T1$$

Example:

measured water content 213 ppm

T (°C)	aw	$ppm_{saturation}$
24.1	0.478	213/0.478 = 445.6067
57.6	0.188	213/0.188 = 1132.979

A = (LOG(1132.98)-LOG(445.607))/(1/(57.6+273.16)-1/(24.1+273.16)) = -1189.4581

B= LOG(445.607)-(-1189.4581)/(24.1 + 273.16) = 6.6503583

Assumptions:

The isoterm of water activity versus water concentration is linear and the solubility curve has the form of the given equation.

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CHAPTER 6
MAINTENANCE

This chapter provides information that is needed in basic maintenance of the product.

Periodic Maintenance

Cleaning

Clean the transmitter enclosure with a soft, lint-free cloth moistened with mild detergent.

Clean the sensor before storing the *DOMINO*® probe and before calibration. For cleaning of the probe you need instrument air and heptane (C_7H_{16}), hexan or pentane liquid. Dry with instrument air to prevent oxidation of the oil on the sensor. The oxidation of the oil on the sensor can cause extended response times or drifting.

1. Blow the probe head (with filter) with instrument air to remove the remains of the oil.
2. Immerse the probe head into heptane liquid and rinse out the oil (for 1 minute maximum).
3. Dry the probe head with instrument air. In case you are going to calibrate the probe, remove the filter and dry the sensor with instrument air. Check that the sensor looks clean.

Changing the Probe Filter

1. Unscrew the filter from the probe head.
2. Screw a new filter on the probe head. When using the stainless steel filter, take care to tighten the filter properly (recommended force 130 Ncm).

New filters can be ordered from Vaisala, see section Options and Accessories on page 111.

Changing the Sensor

The user can change *DOMINO*® sensors.

1. Unscrew the filter from the probe head. See the instructions in section Changing the Probe Filter on page 94.
2. Remove the damaged sensor and insert a new one. Handle the new sensor by the plastic socket. DO NOT TOUCH THE SENSOR PLATE.
3. After sensor change the humidity calibration must be made according to the instructions, see section Relative Humidity Adjustment After Sensor Change on page 102.
4. Screw a new filter on the probe head. When using the stainless steel filter, take care to tighten the filter properly (recommended force 130 Ncm).

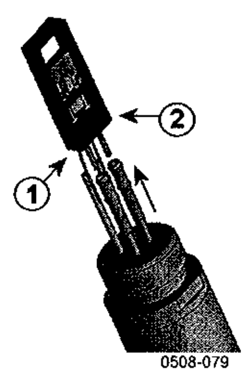


Figure 31 Changing the Sensor

The following numbers refer to Figure 31 above:

1 = Pull out the sensor
2 = Plastic socket

Error States

In error state the quantity is not measured and the output is shown as follows:

- analog channel outputs 0 mA or 0 V (you can use the serial line command **AERR** or display/keypad to change this fault indication value, see section Analog Output Fault Indication Setting on page 77.
- the serial port outputs stars (***)
- the cover LED is blinking
- optional display: error indicator is lit.

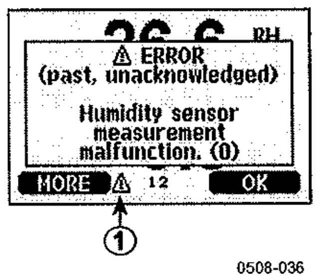


Figure 32 Error Indicator and Error Message

The following number refers to Figure 32 above:

1 = Error Indicator

- The error indicator disappears when the error state is over and you have checked the error message. Press the **INFO** button to display the error message.

You can also check the error message via the serial interface by using the command **ERRS**. In case of constant error, please contact Doble, see Doble Customer Service on page 117.

Table 14 Error Messages

Error Message	Action
Humidity sensor measurement malfunction.	Check the integrity of the humidity probe and the probe cable. Clean the probe from dirt, water, ice or other contaminants.
Humidity sensor short circuit	Check the integrity of the humidity probe and the probe cable. Clean the probe from dirt, water, ice or other contaminants.
Humidity sensor open circuit	Check the integrity of the humidity probe and the probe cable.
Temperature sensor open circuit.	Check the integrity of the humidity probe and the probe cable.
Temperature sensor short circuit.	Check the integrity of the humidity probe and the probe cable. Clean the probe from dirt water, ice or other contaminants.
Temperature measurement malfunction	Check the integrity of the humidity probe and the probe cable. Clean the probe from dirt water, ice or other contaminants.
Temperature sensor current leak.	Check the integrity of the humidity probe and the probe cables. Clean the probes from dirt, water, ice or other contaminants.
Internal ADC read error	Internal transmitter failure. Remove the transmitter and return the faulty unit to Doble Customer Service.
Internal EEPROM read error	Internal transmitter failure. Remove the transmitter and return the faulty unit to Doble Customer Service.
Internal EEPROM write error	Internal transmitter failure. Remove the transmitter and return the faulty unit to Doble Customer Service.
Add-on module 1 (or 2) connection failure	Turn off the power and check the module connection. Turn on the power.
Device internal temperature out of range	Ensure that the operating temperature is within the valid range.
Operating voltage out of range	Ensure that the operating voltage is within the valid range.
Internal analog voltage out of range	Internal transmitter failure. Remove the transmitter and return the faulty unit to Doble Customer Service.
Internal system voltage out of range	Internal transmitter failure. Remove the transmitter and return the faulty unit to Doble Customer Service.
Internal ADC reference voltage out of range	Internal transmitter failure. Remove the transmitter and return the faulty unit to Doble Customer Service.
Internal analog output reference voltage out of range	Internal transmitter failure. Remove the transmitter and return the faulty unit to Doble Customer Service.
Configuration switches for analog output 1/2/3 set incorrectly	Check and re-set the switches, see Figure 29 on page 73 and Figure 15 on page 38.
EEPROM failure on add-on module 1 (or 2)	Disconnect the power and check the analog output module connection.
Communication module installed in incorrect add-on module slot	Disconnect the power and change the communication module to another module slot.
Unknown/incompatible module installed in add-on module slot 1(or 2)	Ensure that the module is compatible with the *DOMINO*®.

CHAPTER 7
CALIBRATION AND ADJUSTMENT

This chapter provides information that is needed in calibration and adjustment of the product.

The *DOMINO*® is fully calibrated and adjusted as shipped from factory. The calibration interval depends on the application. It is recommended that calibration is done always when there is a reason to believe that the device is not within the accuracy specifications.

The user can calibrate the *DOMINO*® or send it to Doble for calibration. Calibration and adjustment is carried out either by using the push-keys on the motherboard, through the serial port or with the optional display/keypad.

Before the calibration the used sensor should be cleaned with instrument air to blow out existing oil or gently first flush with hepthane (C_7H_{16}), hexane or pentane and dry with instrument air to decrease response time.

The cleaning must be done as the oily sensor can contamine the salt bath and change the reference condition.

NOTE	It is important to clean the sensor before calibration as the oily sensor can contamine the salt bath and change the reference condition.

Cleaning the Sensor

Clean the sensor before storing the *DOMINO*® probe and before calibration. For cleaning of the probe you need instrument air and heptane, heaxane or pentane liquid. Dry with instrument air to prevent oxidation of the oil on the sensor. The oxidation of the oil on the sensor can cause extended response times or drifting.

1. Blow the probe head (with filter) with instrument air to remove the remains of the oil.
2. Immerse the probe head into heptane liquid and rinse out the oil.
3. Dry the probe head with instrument air. In case you are going to calibrate the probe, remove the filter and dry the sensor with instrument air. Check that the sensor looks clean.

Opening And Closing the Adjustment Mode

1. Open the transmitter cover. The buttons needed in adjustment are on the left-hand side of the motherboard.
2. Press the **ADJ** key to open the adjustment mode.
3. Press the **ADJ** key again to close the adjustment mode.

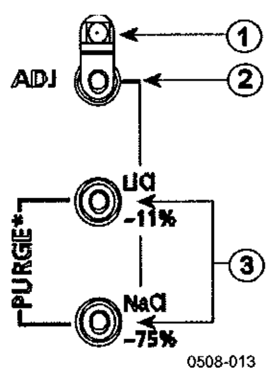
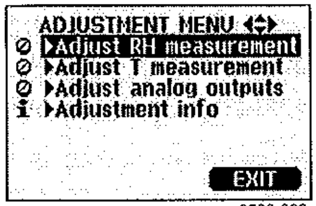


Figure 33 Adjustment and Purge Buttons

The following numbers refer to Figure 33 above:

1 = Indicator led
2 = Adjustment button
3 = Salt adjustment buttons. Note: purge is not available.

Adjustment menu is displayed only when **ADJ** button (on the motherboard inside the transmitter) is pressed.



0508-033

Figure 34 Adjustment Menu

Table 15 Indicator Led Functions

Indicator Led Function	Description
LED off	adjustment locked
LED on	adjustment available
LED blinking evenly	measurement not stabilized

Relative Humidity Adjustment

Using Push-Buttons

A simple push-button adjustment is carried out by using two relative humidity references: 11 % RH (LiCl) and 75 % RH (NaCl).

LiCl reference

1. Press the **ADJ** button (see Figure 33 on page 98) on the motherboard to open the adjustment mode. The indicator led starts flashing.
2. Remove the filter from the probe and insert the probe head into a measurement hole of the 11 % RH (LiCl) in the Humidity Calibrator or similar type device. Use the adapter fitting for the *DOMINO*® probe.
3. Wait at least 30 minutes for the sensor to stabilize (the indicator led is lit continuously). Adjustment cannot be done if the conditions are not stabilized (indicator led is flashing).
4. When the indicator led is lit continuously press the button LiCl~11% to adjust the 11 % RH condition. After adjustment transmitter returns to normal operation mode (indicator led is unlit).

NaCl reference

5. When adjusting in the second reference 75 % RH, press the **ADJ** button to open the adjustment mode. The indicator led starts flashing.

6. Insert the probe head into a measurement hole of the 75 % RH (NaCl) reference chamber of the humidity calibrator or similar type device. Use the adapter fitting for the *DOMINO*® probe.
7. Wait at least 30 minutes for the sensor to stabilize (the indicator led is lit continuously). Adjustment cannot be done if the conditions are not stabilized (indicator led is flashing).
8. Press the button **NaCl 75 %** to adjust the 75 % RH condition. After adjustment transmitter returns to normal operation mode (indicator led is unlit).

Using Display/Keypad

Note that the difference between the two humidity references must be at least 50% RH.

1. Press the **ADJ** button (opens the **ADJUSTMENT MENU**).
2. Select **Adjust RH measurement**, press □ button.
3. Select **1-point/ 2-point adjustment,** press. Press **START**.
4. Select the reference as guided by the display, press **SELECT**.

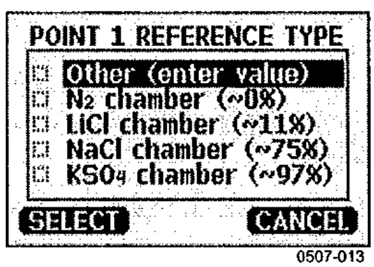


Figure 35 Selecting Point 1 Reference Type

5. Remove the filter from the probe and insert the probe head into a measurement hole of the dry end reference chamber (for example, LiCl: 11 % RH in the humidity calibrator or similar type device.) Use the adapter fitting for the *DOMINO*® probe.
6. Wait at least 30 minutes for the sensor to stabilize. Follow the stabilization from the **GRAPH** display.
7. Press **READY** when stabilized. If you have chosen the **Other** reference value, enter now the reference value by using the arrow keys.

   When carrying out the 2-point adjustment proceed to the next adjustment point and carry out the procedure as described in the previous items.

8. Answer **YES** to confirm the adjustment. Press **OK** to return to the adjustment menu.
9. Press **EXIT** to close the adjustment mode and return to the basic display. Before closing the adjustment mode, feed the adjustment information into the device, see section Feeding Adjustment Information on page 106.

Using Serial Line

Note that the difference between the two humidity references must be at least 50% RH.

1. Connect the *DOMINO*® to a PC. See section Serial Line Communication on page 52. Open a terminal program.
2. Press the **ADJ** button.
3. Remove the filter from the probe and insert the probe head into a measurement hole of the dry end reference chamber (for example, LiCl: 11 % RH in the humidity calibrator or smilar type device). Use the adapter fitting for the *DOMINO*® probe.
4. Enter the **CRH** command and press **ENTER.**

CRH

5. Wait at least 30 minutes for the sensor to stabilize.
6. Type **C** and press **ENTER** a few times to check if the reading is stabilized.
7. When the reading is stabilized, give the reference humidity after the question mark and press **ENTER.**

```
>crh

RH  :     11.25  Ref1 ? c
RH  :     11.25  Ref1 ? c
RH  :     11.25  Ref1 ? c
RH  :     11.24  Ref1 ? c
RH  :     11.24  Ref1 ? 11.3
Press any key when ready ...
```

8. Now the device is waiting for the high end reference. Insert the probe head into a measurement hole of the high end reference chamber (for example,. NaCl: 75 % RH chamber in the humidity calibrator or smilar type device). Use the adapter fitting for the *DOMINO*® probe. Press any key when ready.

9. Let the probe stabilize for about 30 minutes. You can follow the stabilization by typing C and pressing **ENTER**.
10. When stabilized, type the high end reference value after the question mark and press **ENTER**.

```
>crh

RH  :    11.25  Ref1 ? c
RH  :    11.24  Ref1 ? c
RH  :    11.24  Ref1 ? 11.3
Press any key when ready ...

RH  :    75.45  Ref2 ? c
RH  :    75.57  Ref2 ? c
RH  :    75.55  Ref2 ? c
RH  :    75.59  Ref2 ? 75.5
OK
>
```

11. OK indicates that the adjustment has succeeded and the new calibration coefficients are calculated and stored.Enter the adjustment information (date and text) to the memory of the transmitter, see the commands **CTEXT** and **CDATE**.
12. Press the **ADJ** button on the motherboard to close the adjustment mode.
13. Take the probe out of the reference conditions and replace the filter.

Relative Humidity Adjustment After Sensor Change

Using Display/Keypad

When using the optional display/keypad, follow the instructions on Using Display/Keypad on page 100 but select **Adj. for new RH sensor** (instead of **1-point/ 2-point adjustment**).

Using Serial Line

After sensor change, carry out the procedure as described in previous sections. Just replace the **CRH** command with the **FCRH** command.

FCRH

Example:

```
>FCRH
```

```
RH   :    1.82 1. ref    ?    0
Press any key when ready...
RH   :    74.22     2. ref    ? 75
OK
>
```

The OK indicates that the calibration has succeeded.

Temperature Adjustment

Using Display/Keypad

1. Press the **ADJ** button on the motherboard to open the **ADJUSTMENT MENU**. If using a warmed probe for measuring, probe heating will be interrupted when **ADJ** key is pressed. Wait some time for the probe to reach ambient temperature.
2. Select □**Adjust T measurement**, press □key.
3. Select **1-point/ 2-point adjustment**, press. Press **START**.
4. Remove the filter from the probe and insert the probe head into the reference temperature.
5. Wait at least 30 minutes for the sensor to stabilize. Follow the stabilization from the **GRAPH** display.
6. Press **READY** when stabilized. Give the reference temperature by using the arrow keys.

When carrying out the 2-point adjustment proceed to the next adjustment point and carry out the procedure as described in the previous item. Please, note that the difference between the two temperature references must be at least 30 °C.

7. Press **OK.** Press **YES** to confirm the adjustment.
8. Press **OK** to return to the adjustment menu.
9. Press **EXIT** to close the adjustment mode and return to the basic display.

Using Serial Line

1. Press the **ADJ** key on the motherboard to open the adjustment mode.
2. Remove the probe filter and insert the probe head into the reference temperature.
3. Enter the command **CT** and press **ENTER**.

CT

4. Type **C** and press **ENTER** a few times to check if the reading is stabilized. Let the reading stabilize, give the reference temperature after the question mark and press **ENTER** three times.

When having another reference temperature (2-point calibration) press **ENTER** only twice and insert the probe to the second reference. When the reading is stabilized, give the second reference temperature after the question mark and press **ENTER**. Please, note that the difference between the two temperature references must be at least 30 °C.

Example (1-point adjustment):

```
>ct
T   :    16.06  Ref1 ? c
T   :    16.06  Ref1 ? c
T   :    16.06  Ref1 ? c
T   :    16.06  Ref1 ? c
T   :    16.06  Ref1 ? c
T   :    16.06  Ref1 ? 16.0
Press any key when ready ...
T   :    16.06  Ref2 ?
OK
>
```

5. **OK** indicates that the calibration has succeeded.Give the calibration information (date and text) to the transmitter's memory, see the serial commands **CTEXT** and **CDATE**.
6. Press the **ADJ** button on the motherboard to close the adjustment mode.
7. Take the probe out of the reference conditions and replace the filter.

Analog Output Adjustment

In the analog output calibration the analog output is forced to the following values:

- current output: 2 mA and 18 mA

- voltage output: 10 % and 90 % of the range

Connect *DOMINO*® to a calibrated current/voltage meter in order to measure either current or voltage depending on the selected output type.

Using Display/Keypad

1. Press the **ADJ** button to open the **ADJUSTMENT MENU**.
2. Select □Adjust analog outputs, press □key.
3. Select the output to be adjusted **Adjust analog output 1/2**, press **START**.
4. Measure the first analog output value with a multimeter. Give the measured value by using the arrow buttons. Press **OK.**
5. Measure the second analog output value with a multimeter. Give the measured value by using the arrow buttons. Press **OK.**
6. Press **OK** to return to the adjustment menu.
7. Press **EXIT** to close the adjustment mode and to return to the basic display.

Using Serial Line

Enter the **ACAL** command and type the multimeter reading for each case. Continue by pressing **ENTER**.

ACAL

Example (current outputs):

```
>ACAL
Ch1  I1   (mA) ?    2.046
Ch1  I2   (mA) ?    18.087
Ch2  I1   (mA) ?    2.036
Ch2  I2   (mA) ?    18.071
>
```

Feeding Adjustment Information

This information is shown on the device information fields (see section Device Information on page 66.)

Using Display/Keypad

1. If you are not in the adjustment menu, press the **ADJ** button on the motherboard (opens the **ADJUSTMENT MENU**).
2. Select □**Adjustment info,** press the arrow □ button.
3. Select **Date**, press **SET**. Give the date by using the arrow buttons. Press **OK**.
4. Select **i,** press **SET.** Enter information text including 17 characters at maximum by using the arrow buttons. Press **OK.**
5. Press **EXIT** to return to the basic display.

Using Serial Line

CTEXT

Use the CTEXT command to enter text to the adjustment information field.

Example:

```
>ctext
Adjust. info   : (not set) ? HMK15
>
```

CDATE

Use the CDATE command to enter date to adjustment information field. Set the adjustment date in format YYYY-MM-DD.

Example.

```
>cdate
Adjust. date   : (not set) ? 2004-05-21
>
```

CHAPTER 8
TECHNICAL DATA

This chapter provides the technical data of the product.

Specifications

Measured Values

Water activity	
Measurement range	0...100 %RS
Accuracy (including non-linearity, hysteresis and repeatability)	
0...90%	±1.0%
90...100%	±2.0%
Response time (90%) at +20 °C	
in still oil (with stainless steel filter)	10 min.
Sensor	*DOMINO*® capacitive type

Performance

Temperature

Measurement range	-40...+180 °C (-40...+356 °F)
Accuracy at +20 °C (+68 °F)	± 0.2 °C

Operating Environment

Operating temperature	
for probes	same as measurement ranges
for transmitter body	-40...+60 °C (40...+140°F)
with display	0...+60 °C (+32...+140°F)
Pressure range for probes	See probe specifications
Complies with EMC standard	EN61326-1:1997+ Am1:1998 + Am2:2001 Industrial environment

Probe Specifications

Pressure range	0..40 bar / 0..580 psia
Mechanical durability	up to 40 bar /580 psia
Adjustable length	41..149/371 mm / 1.61..5.87/14.6 inch
Installation	
Fitting Body	R1/2" ISO
Fitting Body	NPT 1/2"
Ball Valve	

Inputs and Outputs

Operating voltage	10...35 VDC, 24 VAC
with optional power supply module	100...240 VAC, 50/60 Hz
Power consumption @ 20 °C (U_{in} 24VDC)	
RS-232	max 25 mA
U_{out} 2 x 0...1V / 0...5V / 0...10V	max 25 mA
I_{out} 2 x 0...20 mA	max 60 mA
display and backlight	+ 20 mA
Analog outputs (2 standard, 3rd optional)	
current output	0...20 mA, 4...20 mA
voltage output	0...1 V, 0...5 V, 0...10 V
Accuracy of analog outputs at 20 °C	± 0.05 % full scale
Temperature dependence of the analog outputs	± 0.005 %/°C full scale
External loads	
current ouputs	R_L < 500 ohm
0... 1V output	R_L > 2 kohm
0... 5V and 0... 10V outputs	R_L > 10 kohm
Max wire size	0.5 mm^2 (AWG 20) stranded wires recommended
Digital outputs	RS-232, RS-485 (optional)
Relay outputs (optional)	0.5 A, 250 VAC, SPDT (optional)
Display	LCD with backlight, graphic trend display of any parameter
Display menu languages	English, French, Spanish, German, Japanese, Russian, Swedish, Finnish

Mechanics

Cable bushing	M20x1.5 for cable diameter 8...11mm/0.31..0.43"
Conduit fitting	1/2"NPT
Interface cable connector (optional)	M12 series 8-pin (male)
option 1	with plug (female) with 5 m / 16.4 ft black cable
option 2	with plug (female) with screw terminals
Probe cable diameter	5.5 mm
Probe cable lengths	2 m, 5 m or 10 m
Housing material	G-AlSi 10 Mg (DIN 1725)
Housing classification	IP 65 (NEMA 4)

Technical Specifications of Optional Modules

Power Supply Module

Operating voltage	100...240 VAC 50/60 Hz
Connections	screw terminals for 0.5...2.5 mm^2 wire (AWG 20...14)
Bushing	for 8...11 mm diameter cable
Operating temperature	-40...+60 °C (-40...+140 °F)
Storage temperature	-40...+70°C (-40...+158 °F)

Analog Output Module

Outputs	0...20 mA, 4...20 mA, 0...1 V, 0...5 V, 0...10 V
Operating temperature range	-40...+60 °C (-40...+140 °F)
Power consumption	
U_{out} 0...1 V	max 30 mA
U_{out} 0...5V/0...10V	max 30 mA
I_{out} 0... 20 mA	max 60 mA
External loads	
current outputs	R_L< 500 ohms
Max load + cable loop resistance	540 ohms
0....1 V	R_L> 2000 ohms
0...5 V and 0... 10 V	R_L> 10 000 ohms
Storage temperature range	-55...+80 °C (-67...+176 °F)
3-pole screw terminal	
Max wire size	1.5 mm^2 (AWG16)

Relay Module

Operating temperature range	-40...+60 °C (-40...+140 °F)
Operating pressure range	500...1300 mHg
Power consumption @24 V	max 30 mA
Contacts SPDT (change over), for example,	
Contact arrangement Form C	
Imax	0.5 A 250 VAC
Imax	0.5 A 30 VDC
Safety standard for the relay component	IEC60950 UL1950
Storage temperature range	-55...+80 °C (-67...+176 °F)
3-pole screw terminal / relay	
Max wire size	2.5 mm2 (AWG14)

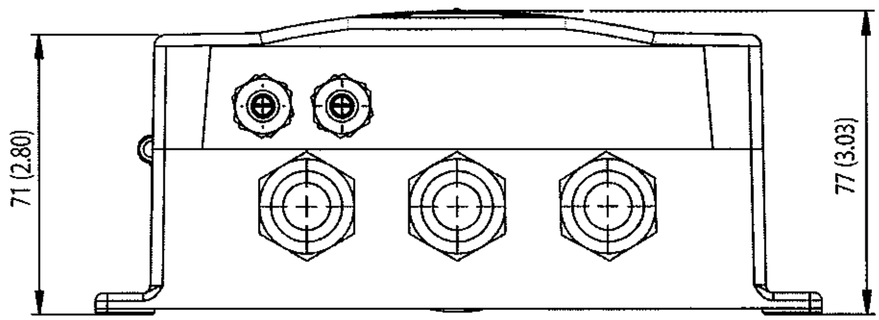
RS-485 Module

Operating temperature range	-40...+60 °C (-40...+140 °F)
Operating modes	2-wire (1-pair) half duplex 4-wire (2-pair) full duplex
Operating speed max	115.2 kbaud
Bus isolation	300VDC
Power consumption	
@ 24V	max 50 mA
External loads	
standard loads	32 RL> 10kohm
Storage temperature range	-55...+80 °C (-67...+176 °F)
Max wire size	1.5 mm2 (AWG16)

Options and Accessories

Description	Item code
MODULES	
Relay module	
Analog Output Module	
Isolated RS485 Module	
Power Supply Module	
Galvanic Isolation Module	
SENSORS	
Moisture Sensor	
Temperature Sensor	
FILTERS	
Stainless Steel Filter	
TRANSMITTER MOUNTING ACCESSORIES	
Tank Wall Mounting Kit	
PROBE MOUNTING ACCESSORIES	
Fitting Body ISO1/2 Solid Structure	
Fitting Body NPT1/2 Solid Structure	
Ball Valve ISO1/2	
½ MNPT short nipple	
Manual Press	
CONNECTION CABLES	
Serial Interface Cable	
OUTPUT CABLES FOR 8-PIN CONNECTOR	
Connection Cable 5m 8-pin M12 Female, Black	
Connector 8-pin M12 with Screw Terminals	
Male Connector 8-pin M12 with Cable and Adapter	
CABLE BUSHINGS	
Cable Gland M20x1.5 for 8...11mm Cable	
Cable Gland M20x1.5 for 11...14mm Cable	
Conduit Fitting M20x1.5 for NPT1/2 Conduit	
Dummy Plug M20x1.5	

Dimensions (in mm)



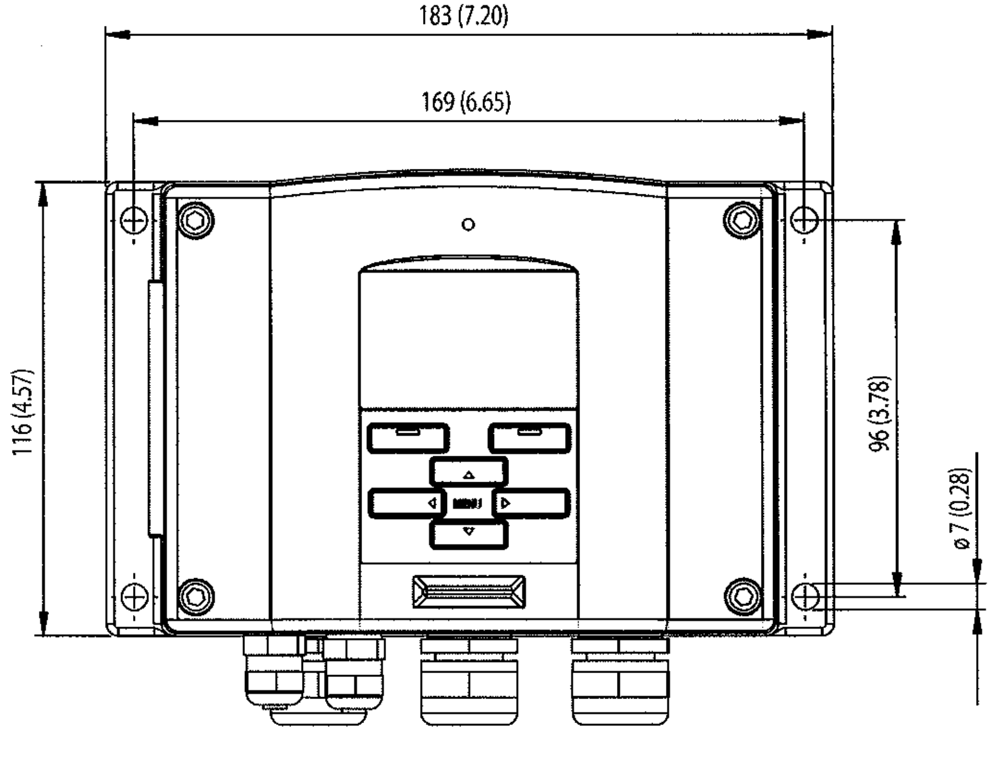


Figure 36 Transmitter Body Dimensions

DOMINO® Probe

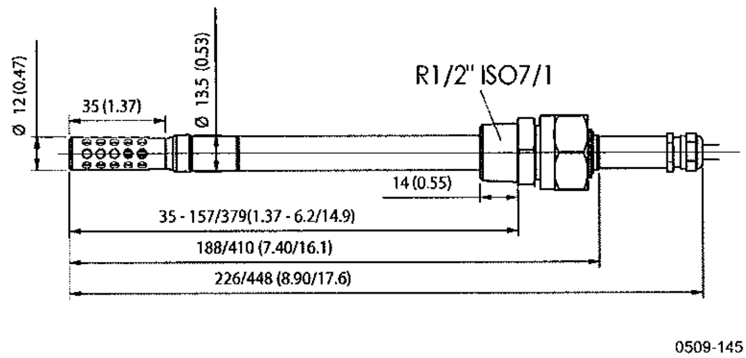


Figure 38 ***DOMINO*® Probe with RST-filter (Oil Filter), Dimensions**

Applications

Lubrication Oil in Paper Machines

Typically, a paper machine contains two or three separate lubrication systems. Usually, one is located at the wet end and the other at the dry end. There is a certain amount of free moisture constantly present which means that there is a risk of this moisture becoming into contact with the machine bearings. The most common reasons for the entrance of water are an inadequate sealing of the housing and cleaning with high pressure. However, accidental leakages from oil coolers and other equipment may also cause damage. In paper machines, the oil should absorb water while lubricating the bearings and then release this water when collected into the reservoir. It is to be noted that bearings should never be exposed to oils that have a high water content; this is especially important during standstill because the risk for corrosion process increases as the oil temperature decreases. It is essential to monitor the water content and keep it on a suitable level.

When measuring the water content of oil in paper machines, it would be useful to measure the realtive saturation before an oil reservoir and from a pressure line flow. This way, the performance of dehumidifiers can be kept under control to ensure that no free water reaches the bearings.

Transformer Oil

The determination of moisture in oil is an essential part of a comprehensive transformer maintenance program. Aging and deterioration increase the capacity of oil to absorb water. The primary interest in transformers is to measure the water in the oil and especially in the cellulosic insulation around the transformer windings. Heating and cooling have a considerable effect on moisture levels in oil. While temperature raises, the paper insulation of transformers tends to loose moisture which is absorbed by the oil surrounding it. Saturation level is thus a true indicator of moisture present. The *DOMINO*® method provides for a reliable detection of the aging of oil and possible leakages.

Oil immersed transformers rely on the oil for cooling, protection from corrosion and as an important component of their insulation. Excessive moisture contents in oil causes accelerated ageing of the insulation materials and reduces their dielectric strength. In extreme cases this can result in arcing and short circuits within the windings.

Accurate moisture measurements can also warn about leaks in the oil system, as water is absorbed from the surrounding air.

Heating and cooling of a transformer effect moisture levels in oil. This is due to the fact that the water solubility of oil is temperature dependent. In general, water solubility increases as temperature raises, see Figure 37 on page 115 below. Changes in temperature affect also on water desorption of the paper insulation around the transformer windings. Desorption of water from the solidinsulation increases as temperature raises and the surrounded oil absorbs desorbed water. Moisture level in oil is thus a true indicator of moisture present in the paper insulation.

In addition, it must be noted that capacity of oil to absorb water depends both on the chemical structure of the oil and the additives.

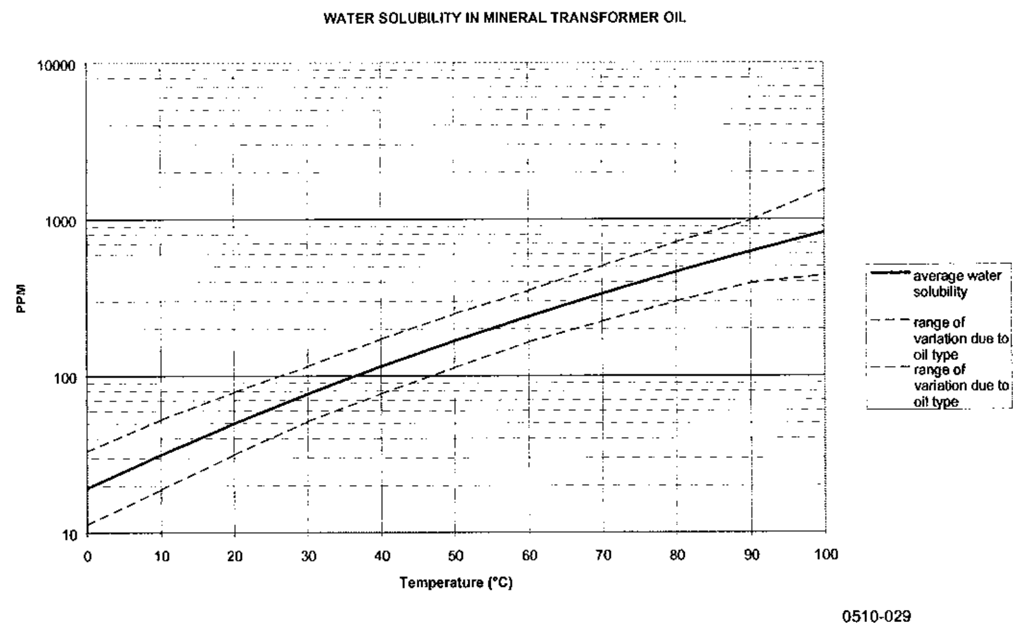


Figure 37 **The Water Solubility of Transformer Oils versus Temperature**

The margins show the range of variation of water solubility found in mineral oils.

Technical Support

For technical questions, contact the Doble technical support:

E-mail domino@doble.com

Fax 1.617.393.2918 or 1.617.393.2981

If the product needs repair, please follow the instructions below to speed up the process and to avoid extra costs to you.

Return Instructions

If the product needs repair, please follow the instructions below to speed up the process and avoid extra costs.

1. Read the warranty information.
2. Write a Problem Report with the name and contact information of a technically competent person who can provide further information on the problem.
3. On the Problem Report, please explain:
   - What failed (what worked / did not work)?
   - Where did it fail (location and environment)?
   - When did it fail (date, immediately / after a while / periodically / randomly)?
   - How many failed (only one defect / other same or similar defects / several failures in one unit)?
   - What was connected to the product and to which connectors?
   - Input power source type, voltage and list of other items (lighting, heaters, motors etc.) that were connected to the same power output.
   - What was done when the failure was noticed?

4. Include a detailed return address with your preferred shipping method on the Problem Report.
5. Pack the faulty product using an ESD protection bag of good quality with proper cushioning material in a strong box of adequate size. Please include the Problem Report in the same box.
6. Send the box to:
   Doble Engineering Company
   Customer Service Department
   85 Walnut Street
   Watertown, MA 02472
   USA

   RMA#

Doble Customer Service

Doble Engineering Company

Customer Service Department

85 Walnut Street

Watertown, MA 02472 USA

1.617.393.2918

www.doble.com

WELLS CARGO

Owner's Manual

ABOUT YOUR NEW WELLS CARGO TRAILER

Now is the right time to complete the information below for your permanent record. Use a typewriter or print clearly. You will also need this Quick Reference when contacting Wells Cargo or a Wells Cargo Dealership regarding your Warranty, Service, Repair, or Replacement parts.

(Feed this side if using a typewriter)

DATE PURCHASED ____________ **20** ______

SERIAL NUMBER ____________

MODEL NUMBER ____________

KEY LOCK NUMBER ____________

HITCH SIZE ____________

AXLE SIZE ____________

TIRE SIZE ____________

DEALERSHIP NAME ____________

ADDRESS ____________

CITY ____________

STATE ________ **ZIP** ____________

PHONE (   ) ____________

TABLE OF CONTENTS

REPORTING SAFETY DEFECTS

If you believe that your vehicle has a defect which could cause a crash or could cause injury or death, you should immediately inform the National Highway Traffic Safety Administration (NHTSA) in addition to notifying Wells Cargo, Inc. If NHTSA receives similar complaints, it may open an investigation, and if it finds that a safety defect exists in a group of vehicles, it may order a recall and remedy campaign. However, NHTSA cannot become involved in individual problems between you, your dealer, or Wells Cargo, Inc. To contact NHTSA, you may either call the Vehicle Safety Hotline toll-free at 1-888-327-4236 (TTY: 1-800-424-9153); go to *http://www.safercar.gov*, or write to: Administrator, NHTSA, 1200 New Jersey Avenue S.E., Washington, DC 20590. You can also obtain other information about motor vehicle safety from *http://www.safercar.gov*.

LABELS - INSTRUCTIONS - WARNINGS

Check your new Wells Cargo trailer for Instructional & Warning Labels like the ones listed below. Many are mandated by the Federal Government and others will help you in proper and safe operation. If decals become faded or damaged to the point where they are unreadable, please contact Wells Cargo for replacement. The information below is included in the event a label is missing.

Located At Lift-Up Nose Cone®

NOTICE
LUBRICATE ALL PIVOT POINTS WITH SAE 30 WEIGHT OIL A MINIMUM OF TWO TIMES PER YEAR

At Propane or Natural Gas Appliance

WARNING
BE SURE TO
Connect Appliance First
and check before you
connect gas bottles to line.
APPLIANCES ARE NOT CONNECTED AT FACTORY
Law requires that an authorized competent service man ONLY can complete this installation.

At Ride-In Entry i.e. Snowmobiles, Motorcycles

CAUTION - LOW CLEARANCE

At Transfer Switch or Junction Box

GENERATOR CIRCUIT. THIS CONNECTION IS FOR GENERATORS RATED 110-125 VOLT AC, 60HZ ______AMPERES MAXIMUM.

At Transfer Switch or Junction Box

AIR COND. CIRCUIT. THIS CONNECTION IS FOR AIR CONDITIONER RATED 110-125 VOLT AC. 60HZ ______AMPERES MAXIMUM

LABELS - INSTRUCTIONS - WARNINGS

At Ramp Doors

CAUTION
DO NOT STAND UNDER DOOR WHEN RAISING & LOWERING

At Outside Power Supply Connection

THIS CONNECTION FOR 120/240 VOLT, 3-POLE, 4 WIRE, 60 HERTZ, ______ AMPERE SUPPLY

At Outside Power Supply Connection

FOR 110/125 VOLT, AC 60 HZ. ______ AMPERE SUPPLY.

Located at Breakaway Switch Test Light

PULL PIN TO TEST
LIGHT INDICATES BATTERY O.K.

Located with Customer Information Papers

WARNING — EXTREME — DANGER
The "RAMP-HEISTER" torsion spring assembly has been carefully selected and installed by the manufacturer of this trailer. It has been designed to counterbalance the weight transferred when opening and closing the entrance ramp. The entire torsion spring assembly, mounting hardware and cables are loaded with tremendous energy. Repairs or adjustments by inexperienced persons or without proper tools is hazardous and could cause severe personal injury or death. Do not attempt to remove or repair any door components, hardware or the structure that these components are attached to. Periodic inspection or the entire assembly, to include but not be limited to, cable wear, fastener integrity and proper lubrication, is required. ALL REPAIRS OR ADJUSTMENTS MUST BE PERFORMED BY EXPERIENCED DOOR SERVICE PERSONNEL ONLY!
WARNING — EXTREME — DANGER

LABELS - INSTRUCTIONS - WARNINGS

Federal I.D. Plate - Mounted Road Side Lower Front Corner

MANUFACTURED BY/FABRIQUE PAR: Wells Cargo, Inc. Date: 8/17/2005
MODEL/MODELE: TW141-V Elkhart, IN 1-800-348-7553
GVWR/PNVB: 1356 KG (2990 LB)
GAWR (EACH AXLE) PNBE (CHAQUE ESSIEU): 7718KG (3500LB)
TIRES/PNEU: RIMS/JANTE: 15 x 5/38.1x12.7
COLD INFL PRESS/PRESS DE GONFL.A.FROID 50
THIS VEHICLE CONFORMS TO ALL APPLICABLE U.S. FEDERAL MOTOR VEHICLE SAFETY STANDARDS in EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE. THIS VEHICLE CONFORMS TO ALL APPLICABLE STANDARDS PRESCRIBED UNDER THE CANADIAN MOTOR VEHICLE SAFETY REGULATIONS IN EFFECT ON THE DATE OF MANUFACTURE. CE VEHICULE EST CONFORME A TOUTES LES NORMES QUI LUI SONT APPLICABLES EN VERTU DU REGLEMENT SUR LA SECURITE DES VEHICULES AUTOMOBILES DU CANADA EN VIGUEUR A LA DATE DE SA FABRICATION
V.I.N./N.I.V. 1WC200G1761114312 TYPE/TYPE: TRAILER/REMORQUE

Tire Placard - Mounted Road Side Lower Front Corner

TIRE AND LOADING INFORMATION

THE WEIGHT OF THE CARGO SHOULD NEVER EXCEED 667 KG 1470 LB

TIRE	SIZE	COLD TIRE PRESSURE	SEE OWNER'S MANUAL FOR ADDITIONAL INFORMATION
FRONT	ST205/75RR15	345 KPA or 50 PSI	
REAR			
SPARE			

FD-S80 1WC200G1761114312

Manufacturers I.D. Plate - Mounted Road Side Lower Front Corner

SINCE 1954

WELLS CARGO TM

DESIGN PROTECTED BY TRADEMARK LAW

ELKHART, IN
WAYCROSS, GA
WACO, TX
OGDEN, UT
PHOENIX, AZ
CARBONDALE, PA
TELEPHONE: 1-800-348-7553

LABELS - INSTRUCTIONS - WARNINGS

Aluminum Roof Rack Cross Bars

MAXIMUM WEIGHT 50 LBS

For trailers with rear spotting hitches. Primarily for Cable Splicing trailers.

REAR HITCH ASSEMBLY NOT TO BE USED FOR TOWING PURPOSES. FOR PLACEMENT ONLY!

At Trailer Sidewall above Corner Post Jacks

STABILIZING JACK
2000 LB. STATIC LOAD

STABILIZING JACK
3000 LB. STATIC LOAD

Ball Hitch Instruction and Warnings

ATTENTION MANUFACTURERS, DISTRIBUTORS, AND DEALERS THIS INFORMATION MUST BE PASSED ON TO THE CONSUMER

⚠ WARNING
PERSONAL INJURY

- Safe towing practice requires the proper use of safety chains used in accordance with instructions provided by the trailer manufacturer.
- Check that the ball has been completely inserted into the coupler ball socket and the ball clamp (inside the coupler) is closed around the underside of the tow ball and the handle is in the closed position.
- The loaded weight of the trailer must never exceed the least capacity marked on the coupler, tow ball, hitch, trailer or vehicle.
- Check coupler, hitch and ball for damage or wear before each use. Assure all parts operate freely. Replace any component if worn or damaged.
- Failure to follow warnings and instructions could result in separation of tow vehicle and trailer which can result in death, personal injury and property damage.

INSTALLATION INSTRUCTIONS

Request Atwood Bulletin for complete instructions on coupler installation, operation and maintenance.

DO NOT ATTEMPT INSTALLATION WITHOUT BULLETIN.

Request MPD 87984 bulletin

Atwood Mobile Products, Rockford, IL 61103
815-877-5700

MARVEL FLIP LATCH COUPLER 2/14/01 MPD 88552

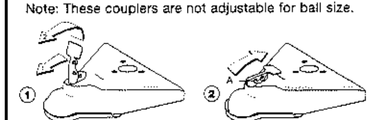
⚠ WARNING
PERSONAL INJURY

- Always open latch handle before inserting ball.

LATCHING INSTRUCTIONS

1. To open, slide forward and pull up open latch before inserting ball FIG 1.
2. Place coupler on ball of same diameter as coupler ball socket size and of same or greater capacity than trailer GVW.
   88555/88600 2" 88007/88010 2-5/16"
3. When ball is completely nested in socket, push top of latch handle rearward until handle snaps into closed position FIG 2.
4. Extend jack to ground and lift car/trailer combination 2"-4" to insure coupler is securely attached to tow ball. Retract jack completely before towing.
5. Insert padlock through hole in handle FIG 2-A for theft protection.

Note: These couplers are not adjustable for ball size.

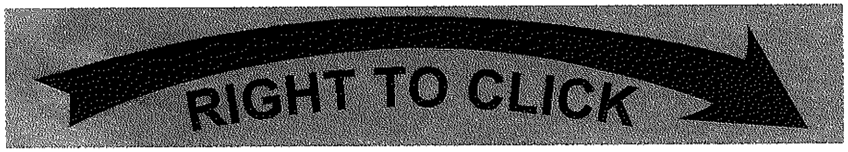


MAINTENANCE INSTRUCTIONS

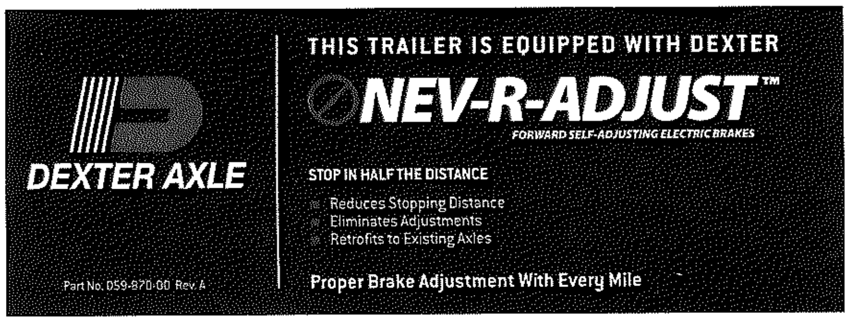
Lubricate ball socket with extreme pressure grease.
Lubricate moving parts with SAE 30 oil.

LABELS - INSTRUCTIONS - WARNINGS

Located above lock assembly on MPT models only.



On Wells Cargo and Road Force trailers with 3,500 lb. to 8000 lb. axles. Located behind fender/fenderette as low as possible.



NOTES

BEFORE YOUR 1ST TRIP - CHECK LIST

CHECK POINT:	
Tire Pressure & Tire Condition	X
Wheel Lugs*	X
Bearing Lube & Tightness	X
Burnish Brakes	X
Brakes/Brake Controllers	X
Breakaway Battery Charge	X
Hitch	X
Safety Chains	X
12V Running Lights	X
Doors/Windows/Roof Vents Locked	X
Distribution & Security	X
All Jacks "Up" in Travel Position	X
Level Trailer *(Parallel with ground & tow vehicle)*	X

***Check Lug Nuts for tightness before initial trip, at 10 miles, 25 miles and 50 miles. Recheck at least every 3 months or 3000 miles.**

Your Wells Cargo Dealer, in all probability, checked each of these Points before you took delivery. However, these are key things you should re-check before taking your trailer on the road for the first time.

A complete description of how to properly check these Points starts on Page 10.

ROUTINE MAINTENANCE CHECK LIST

CHECK:	WHAT TO DO:	EVERY TRIP	EVERY 3000 Mi. or 3 Mo.	EVERY 6000 Mi. or 6 Mo.	See Page # for Details
Tire Air Pressure	Inflate to Proper Pressure Indicated on Sidewall	●			10
Wheel Lugs Bolts & Nuts	Tighten to Proper Torque Specifications		●*		11
Wheel	Check for Damage and/or Out of Round			●	11
Coupler Ball or 5th Wheel & Pin	Check for Sufficient Lube. Check Lock Mechanism. Check for Unusual Wear.	●			12
Coupler	Check for proper fastening & Hitch Pin in position and secure	●			12

***Check Lug Nuts for tightness before initial trip, at 10 miles, 25 miles and 50 miles. Recheck at least every 3 months or 3000 miles.**

AXLES • HUBS • BRAKES: Your Wells Cargo trailer is equipped with Dexter Axles. The Dexter Operation Maintenance Service Manual, along with additional reference materials, can be found inside your trailer's service packet. Replacement copies are available from your Wells Cargo dealer. You can also find useful axle related information by visiting the Dexter Axle On-line Trailer Resource Library at:

www.dexteraxle.com/resource_library

Maintenance for Axles, Hubs and Brakes is extremely important. It is critical for protecting the longevity of your trailer. It is also vital for your personal safety and the protection of others. Follow the Dexter service recommendations exactly as described.

Please, never shortcut Axle • Hub • Brake service and maintenance.

ROUTINE MAINTENANCE CHECK LIST

CHECK:	WHAT TO DO:	EVERY TRIP	EVERY 3000 Mi. or 3 Mo.	EVERY 6000 Mi. or 6 Mo.	See Page # for Details
Safety Chains	Check for abrasion, distortion and general integrity of links	●			14
Brakes	Check for proper adjustment & operation	●			19
Breakaway Switch	Test Switch Operation and Connections	●			19
Breakaway Battery	Pull Switch Pin, Check Charge Indicator Light	●			19 - 20
Doors, Windows & Roof Vents	Check all Windows/Doors/ Roof Vents. Make sure all are closed & locked	●			21
Load Distribution	Check Load Distribution & Security	●			21
Leveling Jacks	Check Fastenings. Lube.	●			21
Welds	Check All Weld Beads for Cracks or Separations.			●	22
Hinges	Grease zerks with a Lithium complex grease.		●		22
Tie-Down Devices	Check for fracturing, distortion and improper anchoring.		●		22
Electrical: Lights & Signals	Check to make sure all are working properly. Replace burned out bulbs	●			23 - 25

TIRE PRESSURE: Proper air pressure for your tires is printed on the sidewall. Check pressure while tires are cold. Do not raise or lower pressure to meet load. Pressure other than recommended pressure will lead to excessive tire wear or tire failure. _Balancing recommended._ Preferred Balancing Method is to center off of stud holes, since 13" thru 17.5" wheels are not hub piloted.

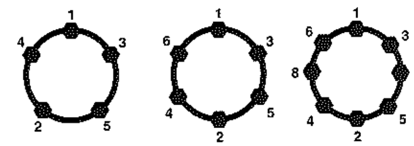
WHAT TO CHECK . . . HOW TO CHECK

WHEELS: Check Wheels for hole elongation or "out of round". This condition can be caused by Lug Nuts not being tight, or too tight. Trailer wheels can be damaged by chuck holes or curb jumping. You may not be aware of the road shock to the wheels without periodic checks. Replace any wheel that is bent. Replace any wheel if you see elongation of the bolt holes.

WHEEL LUGS: Wheel Lug Nuts must be tightened with a torque wrench. Refer to the chart below for proper torque for your trailer. _Check Lug Nut tightness before initial trip, at 10 miles, 25 miles and 50 miles. Recheck at least every 3 months or 3000 miles._

TORQUE STAGES

1st Stage	2nd Stage	3rd Stage
20/25 ft. lbs.	40/50 ft. lbs.	Full Torque



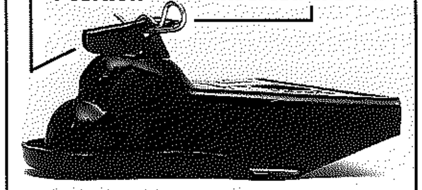
5 BOLT 6 BOLT 8 BOLT

Note: Warranties on trailer and axle do not apply to damage or injuries caused by loose or improperly tightened lug nuts or broken studs.

AXLE SIZE	WHEEL SIZE	STUD SIZE	STEEL WHEEL TORQUE	ALUMINUM WHEEL TORQUE
2000#	13"	1/2"	50# - 75#	N/A
2000#	14"	1/2"	90# - 120#	N/A
2000#	15"	1/2"	90# - 120#	90# - 120#
2500#	15"	1/2"	90# - 120#	90# - 120#
3500#	13"	1/2"	50# - 75#	N/A
3500#	15"	1/2"	90# - 120#	90# - 120#
5000#	15"	1/2"	90# - 120#	90# - 120#
6000#	15"	1/2"	90# - 120#	90# - 120#
6000#	16"	1/2"	90# - 120#	90# - 120#
7000#	16"	1/2"	90# - 120#	90# - 120#
7000#	16"	9/16"	90# - 120#	90# - 120#
7000#	16"	5/8"	275# - 325#	275# - 325#
7200#	16"	9/16"	90# - 120#	90# - 120#
7200#	16"	5/8"	275# - 325#	275# - 325#
8000#	17.5"	5/8"	275# - 325#	275# - 325#

WHAT TO CHECK . . . HOW TO CHECK

BALL COUPLER HITCHES:
Coupler Assembly includes a Latch Lever, and Latch Lever Safety Pin or Hitch Pin. Be sure the Latch Lever is locked and the Pin properly secured before moving your trailer. The Pin can be engaged fully only if the Ball is properly seated in the Coupler.

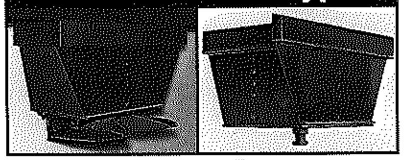


Ball Hitch Assembly

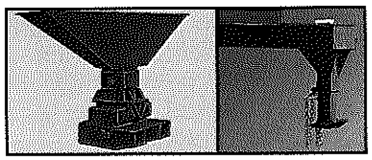
HITCH BALLS come in a variety of diameters and capacities. The GVWR capacity is always stamped on the Ball. Wells Cargo trailers use either a 2" Ball or a 2$^{5}/_{16}$" Ball depending on the GVWR of the trailer. *Always* be sure the Hitch Ball at least matches the GVWR of your trailer. *Always* be sure the diameter of the Hitch Ball matches the Coupler diameter. *Never* attempt to tow your trailer with improper size Ball. *Always* keep Ball greased to avoid excessive wear. Replace worn Hitch Balls or Locking Dogs promptly.

GOOSENECK HITCHES: Your Wells Cargo Gooseneck Trailer will be equipped with one of four hitch types pictured below. Be sure the King Pin or 5th Wheel on tow vehicle is rated for at least as much weight as the GVWR of the Trailer. Hitches (A, B & C pictured below) require a SAE 2" King Pin or 5th Wheel. Hitch D, (the Adjustable Height Ball Coupler Goose Neck) requires a 2 $^{5}/_{16}$" Hitch Ball with a rating equal to the GVWR of the unit.

Gooseneck Hitch Types



A. Inverted 5th Wheel **B.** Adjustable Hgt. King Pin



C. Articulating 5th Wheel **D.** Adjustable Hgt. Ball Coupler *

*Note: Ball Coupler Hitch (**D.**) requires Safety Chains

Recommended: Mount King Pin or 5th Wheel Hitch on the bed of the tow vehicle. This lowers the center of gravity for easier and safer handling. Replace worn Hitch Pins and 5th Wheel Jaws promptly.

Check with Tow Vehicle Manufacturer, Owners Manual or Local Dealership for any Hitch installation requirements. Hitches installed otherwise may void your tow vehicle warranty.

SAFETY CHAINS: Your Wells Cargo Trailer is equipped with Safety Chains that meet the requirements of *D.O.T. Regulations 393.70.*

Always attach the Chains by crossing them, forming a "cradle". If your Coupler disengages for any reason, the "cradle" will keep the Hitch from dragging the ground. You'll be able to make an easier and safer stop.

NEVER LOOK BACK WARRANTY PROGRAM

WELLS CARGO, INC. LIMITED WARRANTY

DURATION OF WARRANTY
Your Wells Cargo equipment, which has been manufactured, tested and inspected in accordance with carefully specified engineering requirements, is warranted to the original owner to be free from defects in material and workmanship for the period of **six (6) or four (4) or three (3) or two (2) years** depending on the brand/model*, except as herein limited, from date of purchase. The obligation of this Warranty shall be limited to repairing or replacing any part or parts which, in the opinion of the Company shall be proved defective in materials or workmanship under normal use and service during the appropriate year(s) period commencing with the date of purchase. Jack rams, electrical wiring, glass sealants, doors, seals, locks, paint, plumbing, couplers and jacks are warranted for a period of one (1) year from the date of purchase. The D.O.T. Wet Cell Battery (Breakaway System) is warranted for a period of six (6) months from the date of purchase.

This Warranty gives you specific legal rights, and you may also have other rights which vary from State to State.

**Length of Warranty by brand/model:*

6-Year Warranty

3-Year Warranty

4-Year Warranty

MT1000 — 3-Year Warranty
MT2000 & MT4000 — 6-Year Warranty

2-Year Warranty

3-Year Warranty

NEVER LOOK BACK WARRANTY PROGRAM

LIMITATIONS AND EXCLUSIONS

This Warranty shall not extend to:

1) Wells Cargo equipment which has been modified, repaired, or altered in any way without the express written consent of Wells Cargo.
2) Unreasonable use (including failure to provide reasonable and necessary maintenance.)
3) Tires, wheels, axles, axle assemblies, suspension components, ranges, heaters, refrigerators, air conditioners or all other appliances or components of the Wells Cargo equipment which are warranted separately by the respective manufacturers of said components. These warranties are contained in the owner's packet.
4) Any consequential damages for breach of this or any other warranty expressed or implied whatsoever. Repair or replacement under this Warranty is the exclusive remedy of the customer. Some States do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.
5) Parts not supplied by Wells Cargo.
6) Certain parts which require replacement in the ordinary course of use due to normal wear.

PROCEDURE

To secure repair of a trailer or any warranted parts under this Warranty, the unit or warranted part must be delivered, charges prepaid, to the nearest Wells Cargo Dealer or Wells Cargo manufacturing facility or as directed by the Company.

Your Wells Cargo dealer from whom you purchased your unit is responsible for the registration of your warranty with the factory. We ask that you cooperate with your dealer in supplying the necessary information on the warranty card so that we may better serve you.

Please Note: Should equipment not supplied by Wells Cargo fail, (e.g. the hitch you have installed on your tow vehicle), the result may be an accident, damage or injury beyond our control.

Wells Cargo, Inc. Warranty Registration

Please complete & return card promptly.

NAME: ____________

COMPANY: ____________

ADDRESS: ____________

CITY: ____________ STATE: ____________

ZIP CODE: ____________ COUNTRY: ____________

PHONE: (____) ____________ FAX: (____) ____________

EMAIL: ____________

SERIAL NUMBER: ____________

MODEL NUMBER: ____________

DATE PURCHASED: ____________

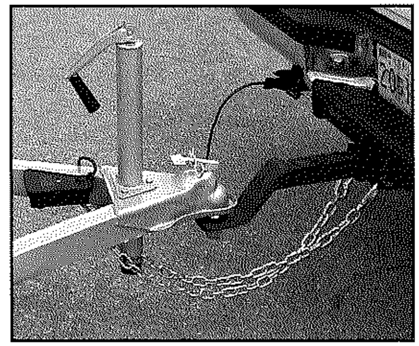
DEALER NAME and/or NUMBER: ____________

Where have you seen Wells Cargo Advertised? ____________

Please check the planned use of your Wells Cargo trailer:

☐ Motorcycles	☐ Auto Racing	☐ Moving/Relocating	☐ Manufacturer	☐ Moving Company	☐ Construction (Gen.)	☐ Concessionaire
☐ Snowmobiling	☐ Auto Collector	☐ Marching Band	☐ Distributor	☐ HAZMAT Response	☐ Mechanical Contractor	☐ Catering
☐ ATV	☐ Karting	☐ Mobile DJ	☐ Retailer	☐ Fire/Police/Medical	☐ Electrical Contractor	☐ Restaurant
☐ Bicycles	☐ Camping/RV	☐ Musician/Band	☐ Public Utility	☐ Landscape	☐ Painting Contractor	☐ Delivery Service
☐ BMX	☐ Scouting	☐ Photography/Video	☐ Government Agency	☐ Ground Maintenance	☐ Remodeling Contractor	☐ Misc. Service
☐ RC Models	☐ Arts & Crafts	☐ Radio/TV	☐ School/College	☐ Nursery	☐ Roofing/Siding/Gutter	☐ Rental/Leasing
☐ Ballooning	☐ Antiques	☐ Hunting	☐ Church/Service Group	☐ Sales/Display	☐ Insulation	☐ Utility Companies
☐ Living Quarters	☐ Toy Hauler	☐ ____________	☐ Agricultural/Animal	☐ Restroom Trailers	☐ Furniture/Cabinets	☐ ____________

WHAT TO CHECK . . . HOW TO CHECK



Safety Chain Hook-Up

Abrasion (possibly from dragging on the ground) or unusual stress (like the situation described above) can weaken the links, making them unsafe for trailering. If you detect any of these conditions, *replace the Safety Chains immediately!* If safety chains are too long, shorten to prevent dragging. **DO NOT TWIST!**

BRAKES: Your Wells Cargo Trailer is equipped with one of several Brake type options. Complete service and repair information for each available type brake is found in the Dexter Service Manual that is furnished with your Trailer. *It is important to strictly adhere to the Dexter instructions for brake service and repair. In this way, you are protecting the validity of all applicable Warranties.*

BURNISHING BRAKES: Brakes on a new trailer may tend to "grab", or pulsate. This is normal. To correct the situation, pull the trailer with the trailer brake control slightly engaged a short distance. This action smooths down the brake bands. Do not lock up the wheels.

BREAKAWAY SWITCH & D.O.T. WET CELL BATTERY: After hitching to Tow Vehicle, pull the Safety Pin on the Breakaway Switch to the first position (no need to completely remove pin). If the Test Light appears, battery is charged and the system is operational. Push Safety Pin back in to its original position. Check Battery fluid level every 60-90 days. Remove Cover. There are two Fill Caps. Refill with distilled water, only. Your Breakaway assembly is equipped with a Charge Line. (See Wire Diagrams, Page 20-21) Tow vehicle must also be wired for a charge line to keep Breakaway Battery charged. During long periods of idleness, keep wet cell battery charged using a trickle charger. *A discharged battery can freeze and crack in winter.*

BATTERY STORAGE: Before storing your battery, you should:

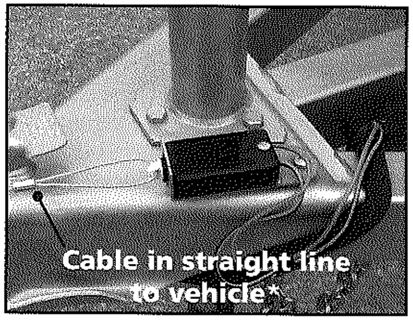
1.) Clean the battery case and terminals with baking soda and water
2.) Check the water level and add water if needed
3.) Test your battery with a hydrometer and/or voltmeter to ensure the battery is fully charged.
4.) If needed, charge your battery.

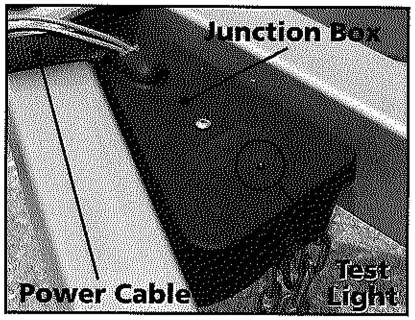
Batteries stored in a discharged state are susceptible to freezing, sulfation and an increased rate of discharge. A fully charged battery will not freeze unless the temperature reaches approximately 80ºF below zero. But if discharged, it can freeze at 32ºF.

Store your battery in a dry, cool, well-ventilated area—the cooler the better without going below 32ºF—out of reach of children and pets. Check the water level and state of charge every 45-60 days. If needed, add distilled water and charge.

WHAT TO CHECK . . . HOW TO CHECK

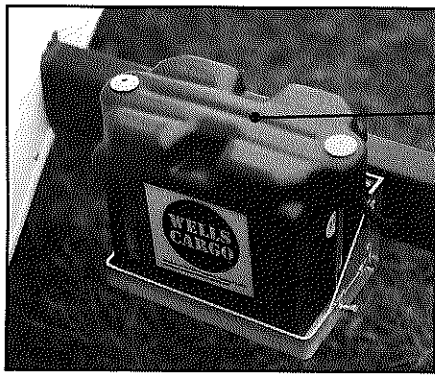
Breakaway Switch & Test Light - Mounted on A-Frame





* Attach Breakaway Switch Cable securely to tow vehicle. Locate attachment so little "slack" is left in the Cable; but enough slack to allow for turning without disengaging Pin. Thus, the Cable will activate brakes the instant a trailer becomes disengaged. _Brake adjustment is critical to stopping a disengaged trailer._

Breakaway Battery on A-Frame



Two Fill Caps Underneath Cover

CHECK BREAKAWAY SYSTEM & BRAKES BEFORE EACH TRIP

1. Disconnect 12V Plug from tow vehicle
2. Pull Breakaway Pin. If RED Test Light appears, there is adequate charge for battery to function.
3. While Pin is pulled, move tow vehicle forward. Brake should be on & wheels locked.
4. Replace Pin and secure to tow vehicle. Do not loop over Hitch Ball.
5. Plug 12V Connector into tow vehicle receptacle.
6. Test Brakes with Brake Controller.

NOTE: When disconnecting trailer from tow vehicle, make sure to replace Safety pin on the Brakeaway Switch. Failure to replace Safety Pin will drain battery and render the Brakeaway System useless. The Breakaway System should ***NEVER*** be used as a parking brake. Also, the wet cell battery is dedicated to the Brakeaway system only. **DO NOT** run any other charges (i.e., dome lights) from this battery.

WHAT TO CHECK . . . HOW TO CHECK

DOORS, WINDOWS & VENTS: Before towing your trailer, check that all doors, windows and roof vents are closed and latched. Make sure all closing mechanisms are functioning properly and are secured. Cam Lock Door Closures should be fully engaged. Single Doors with Flush Locks should be locked. _Using padlocks on all doors is added insurance against accidental opening from road shock._ Taking the above measures means you can travel without danger of doors and windows accidentally opening.

DOOR HOLD BACKS: These devices are intended to hold a door open in grade deviations only. _Do not_ rely on them to hold door open in windy conditions or in travel.

LOAD DISTRIBUTION: The total weight of the load you put in or on your trailer, plus the empty weight of the trailer itself, must not exceed the trailer's Gross Vehicle Weight Rating (GVWR). In addition, you must distribute the load in the trailer such that the load on any tire or axle does not exceed the tire load rating or the Gross Axle Weight Rating or GAWR.

Uneven load distribution can cause tire, wheel, axle or structural failure. Be sure your trailer is properly loaded. A proper weight distribution is equal, right to left; and creates a hitch weight that is in the proper range for stable trailer handling. In the table that follows, the second column notes the "rule of thumb" percentage of total weight of the trailer plus its cargo (GVW) that should appear on the hitch of the trailer. Consider these percentages as guidelines for Ball Hitch, V-Front and Gooseneck trailers respectively. Actual percentages may vary. Many factors including optional equipment, trailer configuration, towing angle, and load factor can and will affect hitch weight. Never exceed the hitch weight rating stamped on your tow vehicles coupler.

TYPE OF HITCH	HITCH WEIGHT %
Ball Hitch	10% to 15%
V-Front	10% to 15%
Gooseneck	25%

Overloading, uneven load distribution, and improper hitch weight can result in dangerous driving conditions resulting in loss of control of the trailer.

STABILIZER/LEVELING JACKS: Always block tires before and while using Leveling Jacks! Failure to block tires can result in failure of the Jacks or Stabilizers. This, in turn, can cause property damage and/or personal injury. Stabilizer Jacks (Cornerpost or Swing-Down) installed as original equipment by Wells Cargo have static load capacities ranging from 650 to 3000 lbs. *(See label affixed near jack for exact capacity.)* Consult individual Manufacturer's Owners Manual for capacity and rating for all Manual and Electric Leveling Jacks.

WHAT TO CHECK . . . HOW TO CHECK

WELDS: Every 6 months or 6,000 miles, check all welds for fractures or cracks. Also, check steel surfaces around the welds for any sign of cracking. If you do detect any of these conditions, *immediately* contact your Wells Cargo Dealer, or call Wells Cargo.

HINGES: Keep Hinges clean and clear of salt and road dirt. Proper maintenance will keep hinges from binding or freezing. Newer models: Steel hinges with a free flow pin and a grease zerks require greasing every 3 months. A Lithium complex grease is adequate for this routine maintenance. Older models: Lubricate with WD 40 or equivalent light oil.

TIE-DOWN DEVICES (ALL): Check regularly for any signs of fracturing, distortion and improper anchoring. Replace as needed.

TRAILER BODY: Keep your trailer clean, both interior and exterior. The exterior metal skin, roof caps, and wheels (standard, chrome, and aluminum) should be waxed at least once a year — more often if needed. Any anodized aluminum including the roof cove and trim accents should be cleaned with a mild detergent, rinsed thoroughly, and waxed as well. Do not use excessive abrasive cleaners as it may mar the protective finish. Make sure to touch up scratches. Scratches on the A-Frame and any exposed steel parts should be sanded, primed, and painted. Regular attention to these simple details will maintain the attractive appearance of your trailer. It will also help increase the service life and resale value already inherent in your Wells Cargo trailer.

GENERAL APPEARANCE: Just like an automobile, your trailer's exterior skin will look better longer if washed regularly. Dirt, road salt, acid rain, and air pollution can cause unsightly stains. If caught early, stains can be cleaned with a mild detergent. If left unattended, stain removal may require a commercial grade cleaner; or worse cause permanent damage. Call the Wells Cargo Parts Department at 1-800-348-7553 for cleaner recommendations.

SNOW LOAD ON TRAILER ROOF: Remove excess snow from the roof of your trailer. Units that sit for an extended period of time can accumulate an excessive amount of snow and ice. This can cause your roof to collapse.

SNOW MELT AND WATER DAMAGE: Do not allow water to accumulate and pool inside trailer. (Example: snow melt off snowmobile.) Over time, this could cause interior floor damage and shorten the life of your trailer. Open the rear door(s) and "jack-up" the front of your trailer. This allows the water to drain out the rear.

12 VOLT ELECTRICAL SYSTEMS - 4, 6 & 7 CIRCUIT CONNECTORS

RACEWAY: Your Wells Cargo Trailer *may* be equipped with a two-piece, molded snap-a-part wiring Raceway mounted inside, at the roof line. The Power Cable enters the Raceway at the front wall, and supplies connection for all internal and external 12 Volt Lighting. There are *NO* under carriage splices or taps in the lighting circuits. If you wish to add other lighting in the future, all connections can be made within the snap-a-part Raceway.

TROUBLE SHOOTING: The Raceway provides easy access for trouble shooting should you develop any problems. Circuits can be individually connected or disconnected for testing purposes. *Example*: Should a Tail Light Fuse blow and continues to blow, disconnect all Brown wires from the Main Cable. Replace Fuse. Reconnect one Brown wire at a time until Fuse blows again. This last wire, then, is the problem. Disconnect it. Reconnect all other wires, and check for lights that are not lit .The problem will be a malfunctioning fixture, or a grounded wiring. Use the same procedure to trouble shoot any other circuit. Some trailer models are not equipped with the Raceway. Instead, they have a Junction Box located at the interior, road side rear. The main 12V power cable feeds through the road side Frame Rail and through the Rear Corner Post to the Junction Box. All distribution for 12V, interior and exterior lighting feeds through the Junction Box.

All checks and trouble shooting can be done at the Junction Box. There are no under carriage splices or taps.

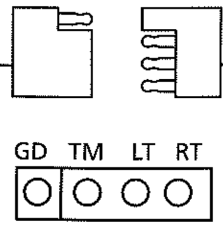
A NOTE ABOUT WIRING YOUR TOW VEHICLE: The electrical system for your trailer is protected by the circuit protection system in your tow vehicle. When "hot lines" are added for brakes and accessories, this wiring should be fused in the tow vehicle. Never use existing tow vehicle wiring for these lines. Run new wiring directly to the Plus (+) side of the tow vehicle battery. Never use circuit breakers for circuit protection when installing these lines. Use 12 gage wire (minimum) for both the brake and accessory wires. Do not exceed a 30 amp fuse on the brake line and a 20 amp fuse on the accessory line.

TOW VEHICLES (Foreign makes): Most foreign made tow vehicles have amber turn signals with separate brake and turn signal wiring. In order for the trailer's lights to work properly, one must install a special tail light converter to the tow vehicle. This converter allows the different wiring configurations of the tow vehicle and trailer to be compatible. Most RV and trailer parts supply stores carry this special converter.

4 TERMINAL CONNECTOR

TOW VEHICLE ⟷ TRAILER

Common Ground
Tail, Running, License & Aux. Lts.
Left - Stop & Turn
Right - Stop & Turn



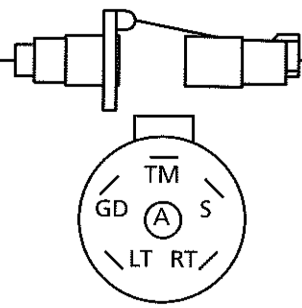
WHITE - Ground to Frame
BROWN -Tail, Running, & License Lights
- BROWN - Tail, Running & License Lts.
- BLACK - Dome & Other Aux. Lts.

YELLOW - Left Stop & Turn
GREEN - Right Stop & Turn

6 TERMINAL CONNECTOR

TOW VEHICLE ⟷ TRAILER

GD - Common Ground
S - Electric Brake
TM -Tail, Running, & License Lts.
A - Aux, Charge Line
LT - Left - Stop & Turn
RT - Right - Stop & Turn



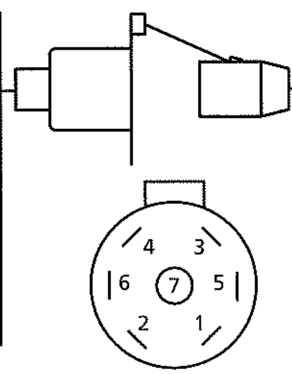
WHITE - (GD) - Common Ground to Frame
BLUE - (S) - Electric Brake
BROWN - (TM) - Tail, Running & License Lights
BLACK - (A) - Auxiliary - Dome, Charge Line etc.
YELLOW - (LT) - Left Stop & Turn Lights
GREEN - (RT) - Right Stop & Turn Lights

SAE WIRING CODE: The wire colors indicated above are according to this Code. Additional Code Colors: PURPLE - Optional, ORANGE - D.O.T. Breakaway (Wire running from Breakaway Switch thru Junction Box to D.O.T. Battery)

7 TERMINAL CONNECTOR

TOW VEHICLE ⟷ TRAILER

No. 1 - Common Ground
No. 2 - Electric Brake
No. 3 - Tail, Running & License Lts.
No. 4 - Battery Charge
No. 5 - Left Stop & Turn
No. 6 - Right Stop & Turn
No. 7 - Auxiliary



WHITE - (1) Common Ground to Frame
BLUE - (2) Electric Brake
BROWN - (3) To Tail, Running & License Light
BLACK - (4) Auxiliary, Dome Light, Charge Line etc.
YELLOW - (5) Left - Stop & Turn
GREEN - (6) Right - Stop & Turn
PURPLE - (7) Not Used

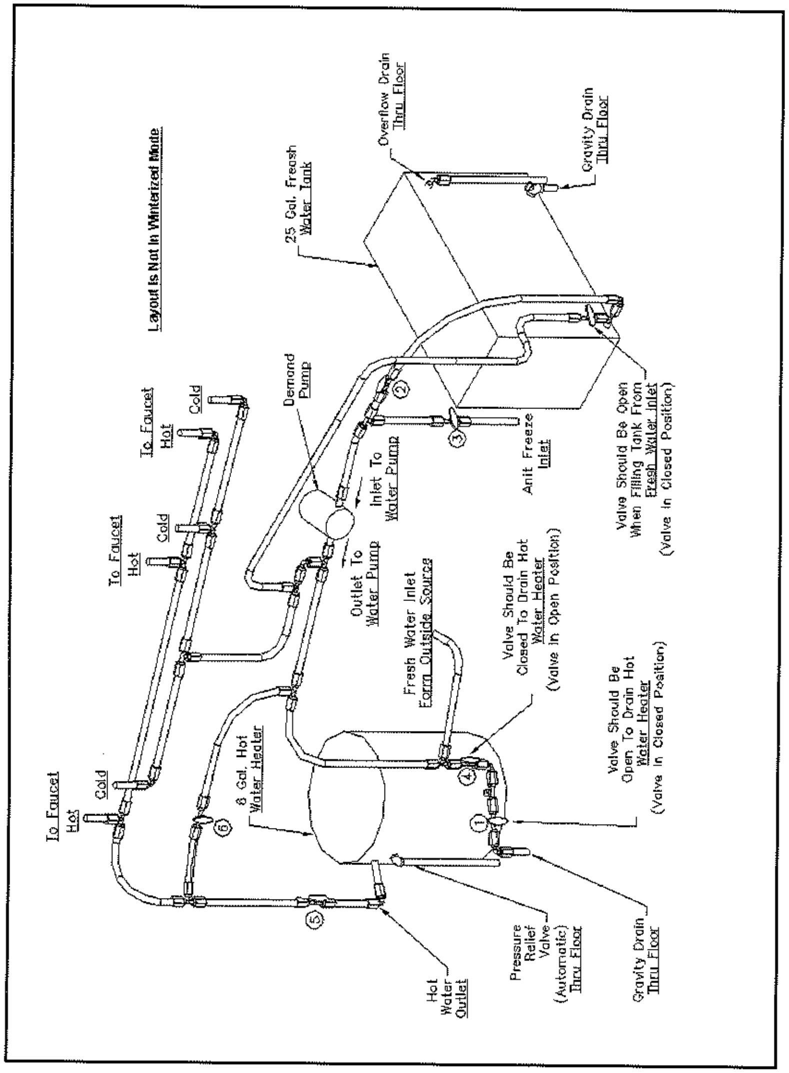
12 VOLT WIRING SYSTEM: All 12V Electrical Power is supplied from the tow vehicle to your trailer through one of the Circuit Connectors diagrammed at the left. All wiring is color coded according to SAE Code. The trailer half of the connector is attached to a flexible, jacketed Power Cable running to a Junction Box. (see upper, right hand illustration - Page 16). From the Junction Box, the Cable then runs through the road side frame channel.

CABLE WIRING CODE:
Yellow and Green - 18 gauge
Brown - 16 gauge
Black - 12 gauge

The Brake Line exits the Frame at the Axle, and connects to the Axle Wire via a water tight boot. Wire and boot are anchored to the Frame with Ring Clamp and Fastener.

WARNING: FOR TRAILERS WITH BREAKAWAY SYSTEM!
Tow vehicle _must_ be equipped with a fused, 20 Amp Charge Line connected to Pin 4 of the trailer Connector.

PLUMBING



WINTERIZING PLUMBING: After draining the system, close all of the drain valves, except the one that drains the water heater. (See ①) Leave that one open. We have added five shut off valves to our water piping to accommodate RV Non-Toxic antifreeze. Two of the valves are located on the suction side of the water pump. The first one disconnects the water storage tank. (See ②) It is normally open. Turn it off. The second valve on the suction side of the water pump opens the siphon tube (See ③) and can be opened up after the siphon tube is

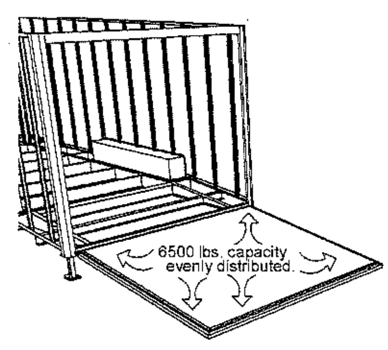
MISC. INFORMATION

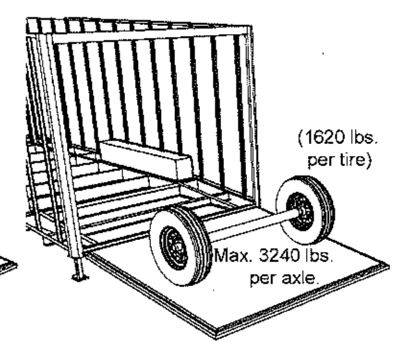
WINTERIZING PLUMBING *(con't)*: dipped into a gallon of RV Non-Toxic antifreeze. The other three valves are located right at the water heater and make it possible to leave the water heater full of air, while the hot and cold lines are filled with RV Non-Toxic antifreeze. Shut off the valve that fills the water heater with cold water. (See ④) Shut off the valve that is located on the hot water line off the water heater (See ⑤) Open the valve that joins the hot water lines and the cold water lines (See ⑥) This allows you to bypass the water heater and still fill both the hot and cold water lines. NOW YOU ARE READY. Slip the dip tube into a gallon of RV Non-Toxic antifreeze, with the valve open (See ③), and turn on the water pump. Open one faucet or toilet at a time until you see RV Non-Toxic antifreeze. When finished, the lines are full. Be sure to flush enough RV Non-Toxic antifreeze into the sinks so that the traps are protected as well.

SPECIALIZED PLUMBING: If you have a trailer with a specialized plumbing application, unlike the one shown on the previous page, these types of plumbing systems will need to be drained and winterized properly as well.

PROPER TRAILER LIFTING PROCESS: Make sure that the trailer is properly blocked or the brakes are applied to prevent the trailer from moving while the trailer is being jacked up. A Torflex® Axle should have the lifting jack of proper capacity placed under the axle mounting bracket when lifting the trailer. A Sprung Axle should have the lifting jack of proper capacity placed as close to the axles hangers on the main frame when lifting the trailer. Lift unit only high enough to do the work required. When working under a trailer, make sure that the trailer is supported properly by using proper capacity jack stands. **CAUTION:** Failure to comply may result in serious injury or death. **CAUTION:** Be sure to wear safety glasses. Failure to comply may result in serious injury.

RAMP DOOR CAPACITY: Two weight ratings (capacities) have been established for standard ramp doors. Ratings do not apply to special built ramp doors or front ramp doors on "V-Front" trailers. Note: Corner Post Jacks should be in the down position when loading and unloading. See illustration below.





MISC. INFORMATION

TORSION SPRING ASSEMBLY: Most* Wells Cargo brand trailer that features a ramp style door also includes a torsion spring assembly. The torsion spring assembly is designed to counterbalance the weight transferred when opening and closing the ramp door. This makes the ramp door easier and safer to operate. The torsion spring assembly is under a great amount of tension — especially in the open (or down) position. Do not use the wire cables as handrails. This puts added tension on the torsion spring assembly and increases the likelihood of a torsion spring assembly failure which could result in serious personal injury or death. Just like any other mechanical apparatus, the torsion spring assembly requires periodic inspection; and with repetitive use replacement. Industry standards state that one should consider replacing the entire spring assemble after 8,500 to 10,000 duty cycles. Opening and closing the door equals one (1) duty cycle. Inspection, repair, adjustment, and replacement of the torsion spring assembly must be performed by an experienced and qualified door service professional only. Never attempted to service or replace the torsion spring assembly yourself.

SLIPPERY WHEN WET: Some styles of flooring (and ramp door decking material) may become slippery when wet. This includes, but not limited to, Aluminum Tread Plate, Steel Tread Plate, Linoleum, Painted, and Plastic. Please exercise caution on any wet floor.

ALUMASPORT ALUMINUM WHEELS: The wheel's protective clear-coating may be permanently damaged by caustic material used in some car washes and by abrasives, chemicals, or steel wool. Use a mild soap and water solution to wash wheels. Rinse thoroughly with clean water and wipe dry. Use of any harsh or acid-based products will void all warranty claims.

**There is an option to install a rear ramp door on 4' and 5' wide models without a torsion spring assembly. Most customers prefer (and we recommend) a torsion spring assembly on any size ramp door.*

MISC. INFORMATION

E-TRACK: The following warnings have been provided by the E-Track manufacturer to assure proper and safe usage.

- *Webbing straps must be protected when used on rough or sharp objects. Straps that are cut, worn or damaged shall not be used and shall be replaced immediately. All strap assemblies shall be inspected prior to each use.*
- *The use of cheater bars (extenders) or other means of increasing leverage on a ratchet buckle handle or winch, other than a manufacturer approved device, can cause serious injury to the user and/or bystanders.*
- *When "Series F" bars are used in the vertical position, the spring end of the bar must be up to avoid bouncing out of the track. Shoring bars shall not be used in decking applications, unless otherwise specified.*
- *Cargo bars are not intended for use with cargo on wheels. Overtensioning of ratchet mechanism may cause damage to trailer sidewalls. NOTE: Cargo bars do not have load ratings due to varying conditions of trailer sidewalls.*
- *Do not overload or create a top-heavy, unstable trailer.*
- *Welding galvanized material may create toxic fumes. Welding shall be done with adequate ventilation.*
- *E-Track and related accessories may be subjected to dirt, mud, snow, ice, road salt, cleaning solution, etc., and therefore require inspection, cleaning, and lubricating to ensure that they are in proper operating condition.*
- *It is the owner's responsibility to evaluate the suitability of any cargo securing product for their particular application. Failure to comply with recommended usage guidelines may result in personal injury or cargo damage.*

TIRE SAFETY INFORMATION

TIRE AND LOADING INFORMATION

THE WEIGHT OF THE CARGO SHOULD NEVER EXCEED 667 KG 1470 LB

TIRE	SIZE	COLD TIRE PRESSURE	SEE OWNER'S MANUAL FOR ADDITIONAL INFORMATION
FRONT	ST205/75RR15	345 KPA or 50 PSI	
REAR			
SPARE			

FD-S90

1WC200G1761114312

TIRE SAFETY INFORMATION ***(For trailers with a GVWR of 10,000 lbs. or less)*:**

1) Locate the statement "The weight of cargo should never exceed XXX kg. Or XXX lbs.," on your vehicle's placard. (See placard above.)
2) This figure equals the available amount of cargo and luggage capacity.
3) Determine the combined weight of cargo being loaded on the vehicle. That weight may not safely exceed the available cargo capacity calculated in Step #2.

GLOSSARY OF TIRE TERMINOLOGY:

Bias ply tire
A pneumatic tire in which the ply cords that extend to the beads are laid at alternate angles substantially less than 90 degrees to the centerline of the tread.

Cold inflation pressure
The pressure in the tire before you drive.

Curb weight
The empty weight of the trailer.

Gross Vehicle Weight Rating
The maximum weight of the fully loaded trailer, as published on the Certification / VIN label. Actual weight determined by weighing trailer on a public scale, without being attached to the towing vehicle.

TIRE SAFETY INFORMATION

Hitch Weight
The downward force exerted on the hitch ball by the trailer coupler.

Light truck (LT) tire
A tire designated by its manufacturer as primarily intended for use on lightweight trucks or multipurpose passenger vehicles.

Maximum load rating
The load rating for a tire at the maximum permissible inflation pressure for that tire.

Maximum permissible inflation pressure
The maximum cold inflation pressure to which a tire may be inflated.

Maximum loaded vehicle weight
The sum of curb weight, accessory weight, vehicle capacity weight, and production options weight.

Outer diameter
The overall diameter of an inflated new tire.

Overall width
The linear distance between the exteriors of the sidewalls of an inflated tire, including elevations due to labeling, decorations, or protective bands or ribs.

Ply
A layer of rubber-coated parallel cords.

Radial ply tire
A pneumatic tire in which the ply cords that extend to the beads are laid at substantially 90 degrees to the centerline of the tread.

Recommended inflation pressure
This is the inflation pressure provided by the vehicle manufacturer on the Tire Information label and on the Certification / VIN tag.

Rim
A metal support for a tire or a tire and tube assembly upon which the tire beads are seated.

Rim diameter
This means the nominal diameter of the bead seat.

TIRE SAFETY INFORMATION

Rim width
This means the nominal distance between rim flanges.

Sidewall
That portion of a tire between the tread and bead.

Special Trailer (ST) tire
The "ST" is an indication the tire is for trailer use only.

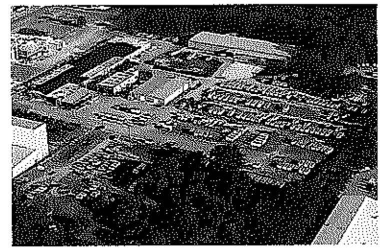
Tread
That portion of a tire that comes into contact with the road.

Treadwear indicators (TWI)
The projections within the principal grooves designed to give a visual indication of the degrees of wear of the tread.

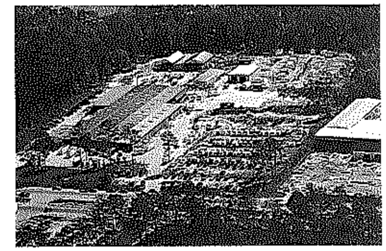
TIRE SAFETY – EVERYTHING RIDES ON IT
The National Traffic Safety Administration (NHTSA) has published a brochure (DOT HS 809 361) that discusses all aspects of Tire Safety, as required by CFR 575.6. It can be obtained and downloaded from NHTSA, free of charge, from the following web site:
[http://www.nhtsa.dot.gov/cars/rules/TireSafety/ridesonit/tires_index.html]

6 PLANTS WITH SERVICE FACILITIES

Toll-free: (800) 348-7553 **Web: www.wellscargo.com**



ELKHART, INDIANA
Corporate Offices
1503 McNaughton Ave.
PO Box 728
Elkhart, IN 46515-0728
Phone: (574) 264-9661
Fax: (574) 264-5938

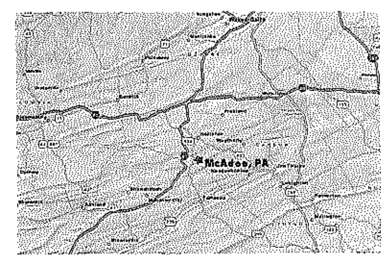


WAYCROSS, GEORGIA
South Division
2250 Industrial Blvd.
Waycross, GA 31503-6968
Phone: (912) 285-8132
Fax: (912) 287-0018

WACO, TEXAS
Texas Division
600 Texas Central Parkway
Waco, TX 76712-6514
Phone: (254) 772-1740
Fax: (254) 772-7673

OGDEN, UTAH
Wells Industries, Inc. (Subsidiary)
1741 W 2550 S
PO Box 1619
Ogden, UT 84402-1619
Phone: (801) 621-3637
Fax: (801) 392-5443

PHOENIX, ARIZONA
Arizona Division
6902 West Hadley St.
Phoenix, AZ 85043-4300
Phone: (623) 936-8150
Fax: (623) 936-5808



McADOO, PENNSYLVANIA
Pennsylvania Division
6 Banks Ave.
McAdoo, PA 18237-2507
Phone: (570) 282-3726
Fax: (570) 929-2141

Addendum

Wells Cargo Owner's Manual
Replacement for page 15
Please note the length of warranty for the
FastTrac model line is **two (2) years.**

WELLS CARGO, INC. LIMITED WARRANTY

DURATION OF WARRANTY

Your Wells Cargo equipment, which has been manufactured, tested and inspected in accordance with carefully specified engineering requirements, is warranted to the original owner to be free from defects in material and workmanship for the period of **six (6) or four (4) or three (3) or two (2) years** depending on the brand/model*, except as herein limited, from date of purchase. The obligation of this Warranty shall be limited to repairing or replacing any part or parts which, in the opinion of the Company shall be proved defective in materials or workmanship under normal use and service during the appropriate year(s) period commencing with the date of purchase. Jack rams, electrical wiring, glass sealants, doors, seals, locks, paint, plumbing, couplers and jacks are warranted for a period of one (1) year from the date of purchase. The D.O.T. Wet Cell Battery (Breakaway System) is warranted for a period of six (6) months from the date of purchase.

This Warranty gives you specific legal rights, and you may also have other rights which vary from State to State.

**Length of Warranty by brand/model:*

6-Year Warranty

3-Year Warranty

4-Year Warranty

MT1000 — 3-Year Warranty
MT2000 & MT4000 — 6-Year Warranty

2-Year Warranty

3-Year Warranty

Tire Warranty

Tires are warranted by their Manufacturer.

If you should have any problems with or require additional information regarding the tires installed on your unit, please contact the manufacturer of the specific tire brand. Those numbers are supplied in this pamphlet along with a picture of a tire with the information indicated which you will need when calling.

Tire brand
Tire size
Tire load range

DOT number
Manufacturing date

Do not discard your defective tire before contacting the Manufacturer.

Tire Manufacturer Phone List

Duro Tire:	(866) 788-2060
Goodyear:	(800) 321-2136
Winland:	(866) 420-6315
Taskmaster with DOT OU ____:	(866) 481-9554
Canada :	(573) 481-9554
Taskmaster with DOT KH ____:	(866) 443-9907
Tireco: Nanco, Mission, Nankang, Milestar, Freestar, Highlife	(800) 937-9433
Hercules:	(800) 677-9535
Uniroyal:	(800) 847-8475
H188ST Tire:	(800) 443-9907
TBC: Triangle, TowMax, Road Rider, Sailun	(800) 739-7698

If you are unable to receive service to your satisfaction, please contact Tredit Tire Warranty Department for more information and assistance at:

(866)443-9907

Tire & Wheel Information

Your trailer has been equipped with premium quality tires and wheels distributed by:

Tredit Tire & Wheel Co.
57941 Charlotte Ave.
Elkhart IN. 46517

www.tredittire.com

Safety Warning

Any tire and wheel, no matter how well constructed has the possibility of failure due to improper maintenance or service factors. To help in preventing risk of property damage or risk of serious injury, please note the following:

- **Tire failure may occur due to a variety of factors, including under inflation, over Inflation, punctures, overloading, or misapplication.**
- **Follow owner`s manual or tire placard on vehicle for instructions.**
- **Explosion of tire/rim assembly due to improper mounting may occur. Only specially trained persons should mount tires.**
- **Check inflation pressure regularly with accurate pressure gauge.**
- **Verify fitment before mounting to ensure safety.**
- **For best performance and longer possible life, routine care and maintenance is required.**

Tire & Wheel Care

OVERLOADING / ABUSE

If your trailer is over loaded, tire failure can occur very quickly. Care must be taken to see that the weight of your unit does not exceed the load capacity of the tires, or trailer manufacturer's Gross Vehicle Weight rating (GVW).
Care must also be taken to avoid tire damage due to cuts, abrasions or impact with curbs, potholes, etc.

INFLATION

The tire load rating branded on the tire sidewall is valid only when the tire is inflated to the specified pressure. Tire inflation pressure will vary due to changes in temperature, altitude, and normal air loss over time. To ensure adequate load carrying capacity and durability the inflation pressure of each tire (including spare) should be checked frequently when the tires are cool and adjusted to match the rating shown on the tire side wall.

WHEEL LUG TORQUE

All lug nuts (or bolts) must be checked and torqued to the vehicle manufacturer's specifications after the first 25, 50, and 75 miles. Retorquing must be done periodically and every time that the wheel lug nuts are removed for any reason.

WHEEL ISSUES

Wheels are subject to manufacturer`s warranties which vary. Tredit Tire will attempt to assist you with your warranty claim. If you are having issues with your wheels please contact Tredit Tire Warranty Department at (866) 443-9907.

When calling, you must have the following information available:

- Style or description
- Wheel size
- Paint or finish type
- Wheel Stamp (located on back side of rim)
- Number of lug nuts
- VIN Number
- Date manufactured
- Date of Purchase
- Vehicle manufacturer
- Model
- Credit Card information

No warranty will be honored without original wheel available for inspection. Most wheel manufacturers carry a one year warranty replacement policy.

White Spoke

Silver Mod

Chrome Mod

Aluminum Mod

DEXTER AXLE

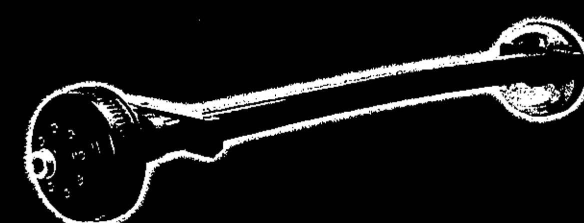
www.dexteraxle.com
2900 Industrial Parkway East • Elkhart, IN 46516
Fax: 574-295-8666 • Ph. 574-295-7888

3/04

LIT-001-00

OPERATION MAINTENANCE SERVICE MANUAL

600 - 8,000 lb. Axles & Related Components



DEXTER AXLE

www.dexteraxle.com

Introduction

This manual is designed to provide information for you to understand, use, maintain, and service your trailer running gear system. Your axles are manufactured by Dexter Axle. The Dexter product line, the most complete in the industry, is the result of over 30 years of experience in the design, testing and manufacturing of trailer axles. The Dexter running gear system consists of spindles, hubs, drums, brakes, and wheels which are engineered to provide you the finest towing and stopping performance currently available in the industry today.

Two Dexter philosophies are at work to provide you the best product available and have enabled us to maintain our position of leadership. First, we operate on the theory that "there is always a better way" for a product to operate, to be manufactured, and/or to be serviced. We are constantly striving to find that better way.

Secondly, we maintain wall-to-wall production control so that all the major components of your running gear system are manufactured in Dexter facilities under our strict quality control standards. These manufactured components include the axle beam, hubs, drums, spindles, brakes, magnets, rims, wheels and most of the steel stampings used in the attachment of your axle to your trailer. Dexter has the most complete, state-of-the-art manufacturing facilities which enable us to provide you, the trailer owner, with the finest product possible.

For all your running gear needs...

Look first to Dexter!

Now visit us at our web site
www.dexteraxle.com

Table of Contents

Important Safety Notice

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all running gear as well as the personal safety of the individual doing the work. This manual provides general directions for performing service and repair work with tested, effective techniques. Following these guidelines will help assure reliability.

There are numerous variations in procedures, techniques, tools, parts for servicing axles, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Anyone who departs from the instructions provided in this manual must first establish that they neither compromise their personal safety nor the vehicle integrity by their choice of methods, tools, or parts.

Refer to your vehicle manufacturer's owners manual for additional procedures, techniques, and warnings prior to performing any maintenance or repairs.

⚠ CAUTION

This is the safety alert symbol. It is used to alert you to potential injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

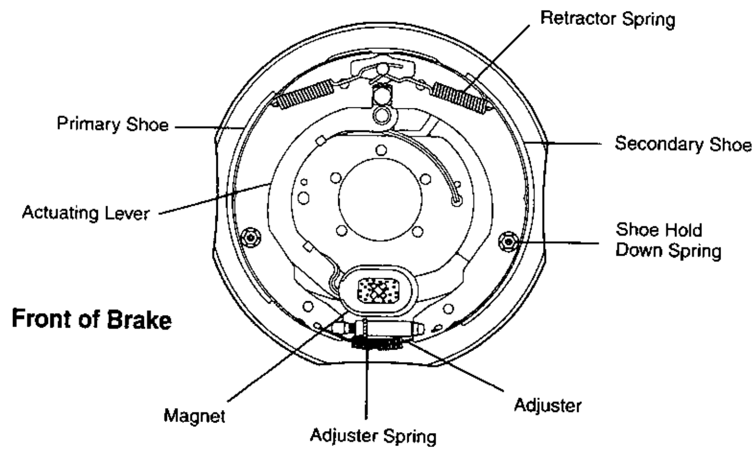
Getting Started - Setup and Adjustment

For proper performance, all new axles should have the following checked at the specified intervals:

- *Wheel Nut Torque:* at 10, 25, and 50 miles
- *Brake Adjustment:* at 200 and 3,000 miles
- *Tire pressure:* to manufacturer's requirements
- *Brake synchronization*: set brake controller per controller manufacturer's directions

Electric Brakes

The electric brakes on your trailer are similar to the drum brakes on your automobile. The basic difference is that your automotive brakes are actuated by hydraulic pressure while your electric trailer brakes are actuated by an electromagnet. With all of the brake components connected into the system, the brake will operate as follows:



Front of Brake

When the electrical current is fed into the system by the controller, it flows through the electromagnets in the brakes. The high capacity electromagnets are energized and are attracted to the rotating armature surface of the drums which moves the actuating levers in the direction that the drums are turning.

The resulting force causes the actuating cam block at the shoe end of the lever to push the primary shoe out against the inside surface of the brake drum. The force generated by the primary shoe acting through the adjuster link moves the secondary shoe out into contact with the brake drum.

Increasing the current flow to the electromagnet causes the magnet to grip the armature surface of the brake drum more firmly. This results in increasing the pressure against the shoes and brake drums until the desired stop is accomplished.

Features

Electrically actuated brakes have several advantages over other brake actuation systems.

1. They can be manually adjusted at the controller to provide the correct braking capability for varying road and load conditions.
2. They can be modulated to provide more or less braking force, thus easing the brake load on the towing vehicle.
3. They have very little lag time from the moment the tow vehicle's brakes are actuated until the trailer brakes are actuated.
4. In an emergency situation, they can provide some braking independent of the tow vehicle.

Parking Brake Option *(not available on all sizes)*

Dexter electric brakes with parking brake option are mechanically operated by a cable. Cable force applied to the parking lever creates a torque through the pivot pin and cam assembly. Torque transferred to the parking cam results in a spreading force between the primary and secondary shoes. The shoes, in turn, move towards the drum until contact is made. Friction generated between the drum and lining contact surface keeps the drum from rotating under normal loading conditions.

Self Adjusting Feature *(12¼" brakes series only)*

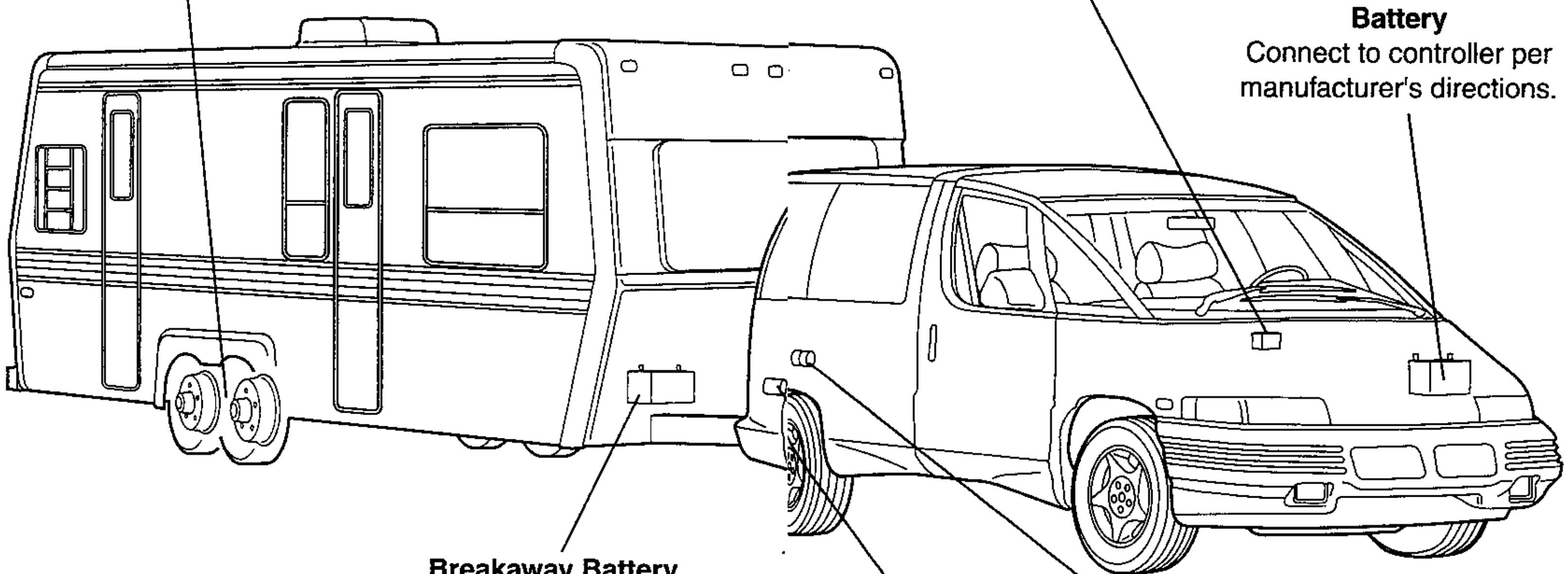
Forward self adjust electric brakes were introduced in October of 1996. This feature adjusts the brakes on both forward and reverse stops. Brake adjustment occurs when lining wear results in enough gap between the shoes and the brake drum surface. This added clearance will allow the adjuster mechanism to rotate the screw assembly at the bottom of the brake. That action expands the distance between the shoes and thus closes the gap to the drum surface.

Braking Systems - Electric

Brake Controllers

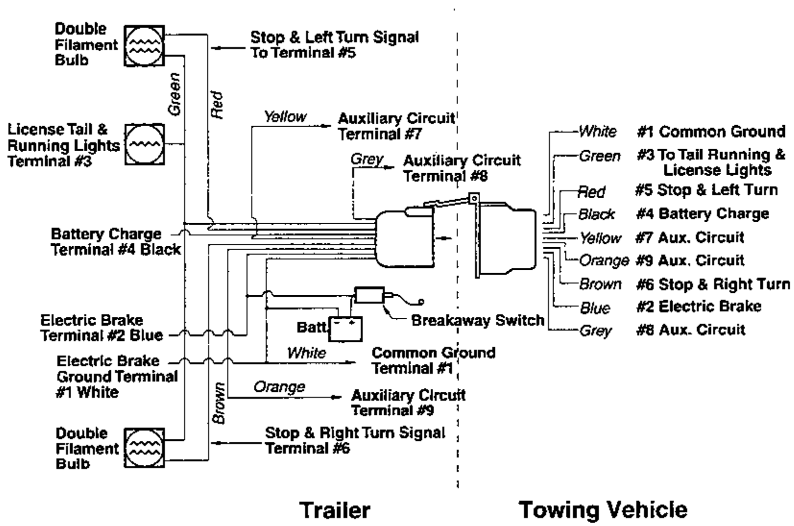
Electric brake controllers provide power to the magnets to actuate the trailer brakes. Dexter Axle offers a state-of-the-art inertial controller called the Predator Series™ DX2. This controller features a patented pendulum design which senses the deceleration of the towing vehicle and sends a proportional voltage to the electric trailer brakes. Other features include a visual gain setting for quick and easy adjustment and a digital LED display to show the voltage output. A manual override sends full voltage to the trailer brakes, regardless of gain setting, for emergency conditions and also illuminates the brake lights to warn of an impending stop.

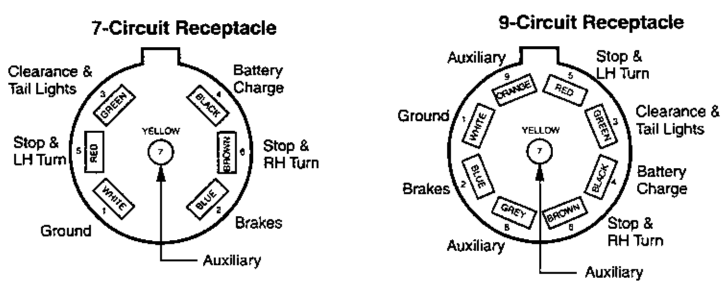
Most electric brake controllers provide a modulation function that varies the current to the electric brakes with the pressure on the brake pedal or amount of deceleration of the tow vehicle. Electronic or timing controllers do not provide proportional modulation. These controllers tend to be inexpensive but not the best choice for optimum braking. It is important that your brake controller provide approximately 2 volts to the braking system when the brake pedal is first depressed and gradually increases the voltage to 12 volts as brake pedal pressure is increased. If the controller "jumps" immediately to a high voltage output, even during a gradual stop, then the electric brakes will always be fully energized and will result in harsh brakes and potential wheel lockup.



Braking Systems - Electric

Typical Trailer Wiring





View Looking into Tow Vehicle Receptacle

How to Use Your Electric Brakes Properly

Your trailer brakes are designed to work in synchronization with your tow vehicle brakes. Never use your tow vehicle or trailer brakes alone to stop the combined load.

Your brake controller must be set up according to the manufacturer's recommendations to ensure proper synchronization between the tow vehicle and the trailer. Additionally, you may have to make small adjustments occasionally to accommodate changing loads and driving conditions.

Proper synchronization of tow vehicle to trailer braking can only be accomplished by road testing. Brake lockup, grabbiness, or harshness is quite often due to the lack of synchronization between the tow vehicle and the trailer being towed, too high of a threshold voltage (over 2 volts), or under adjusted brakes.

Before any synchronization adjustments are made, your trailer brakes should be burnished-in by applying the brakes 20-30 times with approximately a 20 m.p.h. decrease in speed, e.g. 40 m.p.h. to 20 m.p.h. Allow ample time for brakes to cool between application. This allows the brake shoes and magnets to slightly "wear-in" to the drum surfaces.

Trailer Wire Size Chart

Number of Brakes	Hitch-to-Axle Distance In Feet	Recommended Minimum Hookup Wire Size (Copper)
2		12 AWG
4	Under 30	12 AWG
4	30-50	10 AWG
6	Under 30	10 AWG
6	30-50	8 AWG

Synchronizing Your Trailer Brakes

To insure safe brake performance and synchronization, *read the brake controller manufacturer's instructions completely before attempting any synchronization procedure.*

> **⚠ CAUTION**
>
> **Before road testing, make sure the area is clear of vehicular and pedestrian traffic. Failure to brake safely could result in an accident and personal injury to yourself and/or others.**

Make several hard stops from 20 m.p.h. on a dry paved road free of sand and gravel. If the trailer brakes lock and slide, decrease the gain setting on the controller. If they do not slide, slightly increase the gain setting. Adjust the controller just to the point of impending brake lockup and wheel skid.

Note: Not all trailer brakes are capable of wheel lockup. Loading conditions, brake type, wheel and tire size can all affect whether a brake can lock. It is not generally considered desirable to lock up the brakes and slide the tires. This can cause unwanted flat spotting of the tires and could also result in a loss of control.

If the controller is applying the trailer brakes before the tow vehicle brakes, then the controller adjustments should be made so the trailer brakes come on in synchronization with the tow vehicle brakes. For proper braking performance, it is recommended that the controller be adjusted to allow the trailer brakes to come on just slightly ahead of the tow vehicle brakes. When proper synchronization is achieved there will be no sensation of the trailer "jerking" or "pushing" the tow vehicle during braking.

General Maintenance - Electric Brakes

Brake Adjustment

Brakes should be adjusted (1) after the first 200 miles of operation when the brake shoes and drums have "seated," (2) at 3,000 mile intervals, (3) or as use and performance requires. The brakes should be adjusted in the following manner:

1. Jack up trailer and secure on adequate capacity jack stands. Follow trailer manufacturer's recommendations for lifting and supporting the unit. Make sure the wheel and drum rotates freely.

> **⚠ CAUTION**
>
> **Do not lift or support the trailer on any part of the axle or suspension system. Never go under any trailer unless it is properly supported on jack stands which have been rated for the load. Improperly supported vehicles can fall unexpectedly and cause serious injury.**

2. Remove the adjusting hole cover from the adjusting slot on the bottom of the brake backing plate.
3. With a screwdriver or standard adjusting tool, rotate the starwheel of the adjuster assembly to expand the brake shoes. Adjust the brake shoes out until the pressure of the linings against the drum makes the wheel very difficult to turn.
   ***Note:** For drop spindle axles, a modified adjusting tool may be necessary.*
4. Then rotate the starwheel in the opposite direction until the wheel turns freely with a slight lining drag.
5. Replace the adjusting hole cover and lower the wheel to the ground.
6. Repeat the above procedure on all brakes. For best results, the brakes should all be set at the same clearance.

Brake Cleaning and Inspection

Your trailer brakes must be inspected and serviced immediately if a loss of performance is indicated. With normal use, servicing at one year intervals is usually adequate. With increased usage, this work should be done more frequently as required. Magnets and shoes must be changed when they become excessively worn or scored, a condition which can reduce vehicle braking.

Clean the backing plate, magnet arm, magnet, and brake shoes. Make certain that all the parts removed are replaced in the same brake and drum assembly. Inspect for any loose or worn parts, stretched or deformed springs and replace as necessary.

⚠ CAUTION

POTENTIAL ASBESTOS DUST HAZARD!
Some older brake linings may contain asbestos dust, which has been linked to serious or fatal illnesses. Certain precautions need to be taken when servicing brakes:

1. **Avoid creating or breathing dust.**
2. **Avoid machining, filing or grinding the brake linings.**
3. **Do not use compressed air or dry brushing for cleaning (dust can be removed with a damp brush).**

Brake Lubrication

Before reassembling, apply a light film of grease or anti-seize compound on the brake anchor pin, the actuating arm bushing and pin, and the areas on the backing plate that are in contact with the brake shoes and magnet lever arm. Apply a light film of grease on the actuating block mounted on the actuating arm.

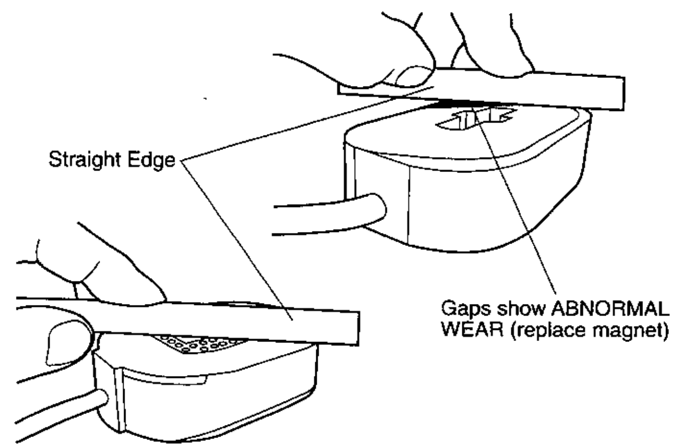
CAUTION

Do not get grease or oil on the brake linings, drums or magnets.

Magnets

Your electric brakes are equipped with high quality electromagnets that are designed to provide the proper input force and friction characteristics. Your magnets should be inspected and replaced if worn unevenly or abnormally. As indicated below, a straightedge should be used to check magnet condition. For best results, the magnet should be flat.

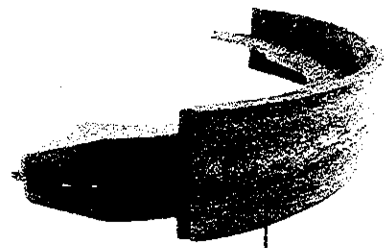
Even if wear is normal as indicated by your straightedge, the magnets should be replaced if any part of the magnet coil has become visible through the friction material facing of the magnet. It is also recommended that the drum armature surface be refaced when replacing magnets (see section on Brake Drum Inspection). Magnets should also be replaced in pairs - both sides of an axle. Use only genuine Dexter replacement parts when replacing your magnets.



Braking Systems - Electric

Shoes and Linings

A simple visual inspection of your brake linings will tell if they are usable. Replacement is necessary if the lining is worn (to within $^{1}/_{16}$" or less), contaminated with grease or oil, or abnormally scored or gouged. Hairline heat cracks are normal in bonded linings and should not be cause for concern. When replacement is necessary, it is important to replace both shoes on each brake and both brakes of the same axle. This will help retain the "balance" of your brakes.



Acceptable Hairline Cracks

⚠ CAUTION

POTENTIAL ASBESTOS DUST HAZARD!
Some older brake linings may contain asbestos dust, which has been linked to serious or fatal illnesses.
Certain precautions need to be taken when servicing brakes:

1. **Avoid creating or breathing dust.**
2. **Avoid machining, filing or grinding the brake linings.**
3. **Do not use compressed air or dry brushing for cleaning (dust can be removed with a damp brush).**

After replacement of brake shoes and linings, the brakes must be re-burnished to seat in the new components. This should be done by applying the brakes 20 to 30 times from an initial speed of 40 m.p.h., slowing the vehicle to 20 m.p.h. Allow ample time for brakes to cool between applications. This procedure allows the brake shoes to seat in to the drum surface.

Introduction to Troubleshooting

Proper brake function is critical to the safe operation of any vehicle. If problems are encountered with your trailer braking system, the following guide can be used to find the causes and remedies for some of the more common problems. If you are unsure or unable to resolve the problem, please contact your nearest repair facility for professional assistance.

Troubleshooting

Most electric brake malfunctions, that cannot be corrected by either brake adjustments or synchronization adjustments, can generally be traced to electrical system failure. Voltmeters and ammeters are essential tools for proper troubleshooting of electric brakes.

Mechanical causes are ordinarily obvious, i.e. bent or broken parts, worn out linings or magnets, seized lever arms or shoes, scored drums, loose parts, etc. Replace defective parts with genuine Dexter replacements.

Please consult the following troubleshooting charts to determine the causes and solutions for common problems found in trailer braking systems.

⚠ CAUTION

Best braking performance is achieved with a controller setting that is just short of wheel lock up or slide. Overly aggressive braking which results in wheel lock up and sliding, can cause a dangerous loss of control and result in personal injury or death.

Braking Systems - Electric

Troubleshooting

SYMPTOM	CAUSES	REMEDIES
No Brakes	Open Circuits	Find & Correct
	Severe Underadjustment	Adjust Brakes
	Faulty Controller	Test & Correct
	Short Circuits	Find & Correct
Weak Brakes	Grease or Oil on Magnets or Linings	Clean or Replace
	Corroded Connections	Clean & Correct Cause of Corrosion
	Worn Linings or Magnets	Replace
	Scored or Grooved Brake Drums	Machine or Replace
	Improper Synchronization	Correct
	Underadjustment	Adjust Brakes
	Glazed Linings	Reburnish or Replace
	Overloaded Trailer	Correct
Locking Brakes	Underadjustment	Adjust
	Improper Synchronization	Correct
	Faulty Controller	Test & Correct
	Loose, Bent or Broken Brake Components	Replace Components
	Out-of-Round Brake Drums	Machine or Replace
	Insufficient Wheel Load	Adjust System Resistor and Synchronize
Intermittent Brakes	Faulty Controller	Test & Correct
	Broken Wires	Repair or Replace
	Loose Connections	Find & Repair
	Faulty Ground	Find & Repair

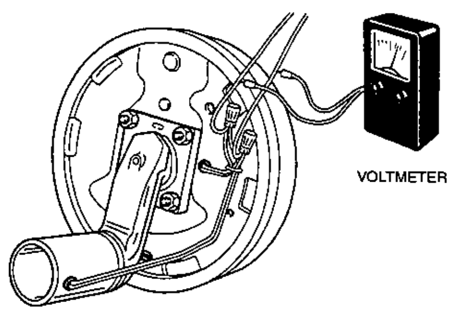
Troubleshooting

SYMPTOM	CAUSES	REMEDIES
Brakes Pull to One Side	Wrong Magnet Lead Wire Color	Correct
	Incorrect Adjustment	Adjust
	Grease or Oil on Linings or Magnets	Clean or Replace
	Broken Wires	Find & Repair
	Bad Connections	Find & Repair
Harsh Brakes	Underadjustment	Adjust
	Improper Synchronization	Correct
	Improper Controller	Change
	Faulty Controller	Test & Correct
Noisy Brake	Underadjustment	Adjust
	Lack of Lubrication	Lubricate
	Broken Brake Components	Replace Component
	Incorrect Brake Components	Correct
Surging Brakes	Grease or Oil on Linings or Magnet	Clean or Replace
	Out-of-Round or Cracked Brake Drums	Machine or Replace
	Faulty Controller	Test & Correct
Dragging Brakes	Overadjustment	Readjust
	Out-of-Round Brake Drums	Machine or Replace
	Incorrect Brake Components	Replace
	Loose, Bent or Broken Brake Components	Replace
	Faulty Breakaway Switch	Repair or Replace
	Loose Wheel Bearing Adjustment	Adjust
	Bent Spindle	Replace Axle

How to Measure Voltage

System voltage is measured at the magnets by connecting the voltmeter to the two magnet lead wires at any brake. This may be accomplished by using a pin probe inserted through the insulation of the wires. The engine of the towing vehicle should be running when checking the voltage so that a low battery will not affect the readings.

Voltage in the system should begin at 0 volts and, as the controller bar is slowly actuated, should gradually increase to about 12 volts. If the controller does not produce this voltage control, consult your controller manual.



The threshold voltage of a controller is the voltage applied to the brakes when the controller first turns on. Lower threshold voltage will provide for smoother braking. If the threshold voltage is too high, the brakes may feel grabby and harsh.

How to Measure Amperage

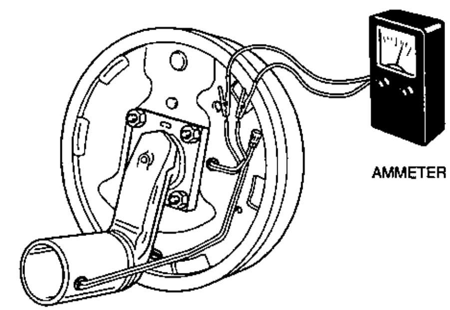
System amperage is the current flowing in the system when all the magnets are energized. The amperage will vary in proportion to the voltage. The engine of the tow vehicle should be running with the trailer connected when checking the trailer braking system.

One place to measure system amperage is at the BLUE wire of the controller which is the output to the brakes. The BLUE wire must be disconnected and the ammeter put in series into the line. System amperage draw should be as noted in the following table. Make sure your ammeter has sufficient capacity and note polarity to prevent damaging your ammeter.

Magnet Amperes Chart

Brake Size	Amps/ Magnet	Two Brakes	Four Brakes	Six Brakes	Magnet Ohms
7 x 1¹/₄	2.5	5.0	10.0	15.0	3.9
10 x 1¹/₂	3.0	6.0	12.0	18.0	3.2
10 x 2¹/₄	3.0	6.0	12.0	18.0	3.2
12 x 2	3.0	6.0	12.0	18.0	3.2
12¹/₄ x 2¹/₂	3.0	6.0	12.0	18.0	3.2
12¹/₄ x 3³/₈	3.0	6.0	12.0	18.0	3.2

If a resistor is used in the brake system, it must be set at zero or bypassed completely to obtain the maximum amperage reading. Individual amperage draw can be measured by inserting the ammeter in the line at the magnet you want to check. Disconnect one of the magnet lead wire connectors and attach the ammeter between the two wires. Make sure that the wires are properly reconnected and sealed after testing is completed.



The most common electrical problem is low or no voltage and amperage at the brakes. Common causes of this condition are:

1. Poor electrical connections
2. Open circuits
3. Insufficient wire size
4. Broken wires
5. Blown fuses (fusing of brakes is not recommended)
6. Improperly functioning controllers or resistors

Another common electrical problem is shorted or partially shorted circuits (indicated by abnormally high system amperage).

Braking Systems - Electric

Possible causes are:

1. Shorted magnet coils
2. Defective controllers
3. Bare wires contacting a grounded object

Finding the cause of a short circuit in the system is done by isolating one section at a time. If the high amperage reading drops to zero by unplugging the trailer, then the short is in the trailer. If the amperage reading remains high with all the brake magnets disconnected, the short is in the trailer wiring.

All electrical troubleshooting procedures should start at the controller. Most complaints regarding brake harshness or malfunction are traceable to improperly adjusted or non-functioning controllers. See your controller manufacturer's data for proper adjustment and testing procedures. For best results, all the connection points in the brake wiring should be sealed to prevent corrosion. Loose or corroded connectors will cause an increase in resistance which reduces the voltage available for the brake magnets.

Hydraulic Drum Brakes

The hydraulic brakes on your trailer are much like those on your automobile or light truck. The hydraulic fluid from a master cylinder is used to actuate the wheel cylinder which, in turn, applies force against the brake shoes and drum. The main difference between automotive hydraulic brakes and hydraulic trailer brakes is the trailers' actuation system. These systems respond to the braking signal from the tow vehicle and supply the required brake fluid volume and pressure to the trailer brakes.

CAUTION

The operating pressure required for Dexter brakes:

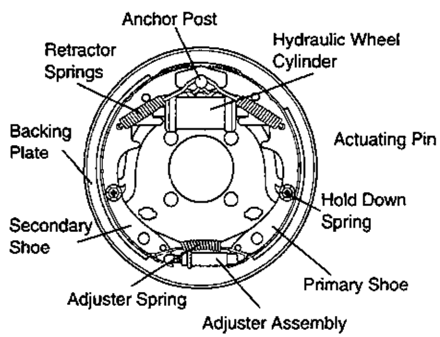
- **7" diameter brakes**
  maximum operating pressure is 750 PSI
- **10" diameter and larger**
  maximum operating pressure is 1,000 PSI

Hydraulic Brake Operation

Duo-Servo

The duo-servo brake uses a dual piston wheel cylinder to apply the brakes. This type of brake is typically used in a vacuum/hydraulic, electric/hydraulic or air/hydraulic system. A description of operation of this brake is as follows:

When the brakes are applied, the double-acting wheel cylinder moves the primary and secondary shoes towards the drum. The frictional force between the brake drum and lining attempts to turn the primary shoe into the secondary shoe. The secondary shoe is forced onto the anchor pin and from this point, the secondary and primary shoes attempt to "wrap around". In essence, the brake has utilized frictional force to help the applying force on both shoes.

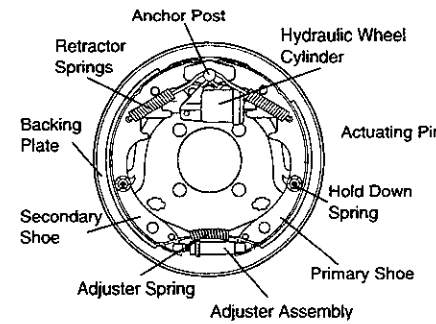


If the brakes are applied while the vehicle is backing, the shoes rotate in the direction of the drum rotation. This causes the secondary shoe to leave the anchor and causes the primary shoe to move against the anchor. Action of the brake is the same in reverse as forward.

Uni-Servo

This type of hydraulic brake utilizes a single acting cylinder. Upon actuation, the primary shoe is pressed against the brake drum, which causes the shoe to move in the direction of rotation. This movement in turn actuates the secondary shoe through the adjuster link assembly. Braking in reverse is significantly less effective than in the forward direction.

Another variation is called a "free backing" brake which is commonly used on trailers with a surge hitch system. When backing with a surge brake hitch, normal brakes are applied through the surge mechanism and if there is more brake force on the trailer than the tow vehicle can override, no backing is possible. The free backing brake was developed to allow backing in this application. This brake has a primary shoe on a pivot which allows normal application in the forward direction, but allows the primary shoe to rotate away from the drum surface when backing.



Self Adjusting Mechanism for 12¼" Hydraulic Brakes

Forward self-adjust hydraulic brakes were introduced in March, 1997. This feature adjusts the brakes on both forward and reverse stops. Brake adjustment occurs only when lining wear results in enough gap between the shoes and the drum surface. This added clearance will allow the adjuster mechanism to rotate the screw assembly at the bottom of the brake. That action expands the distance between the shoes and thus closes the gap to the drum surface.

Hydraulic Parking Brake Option

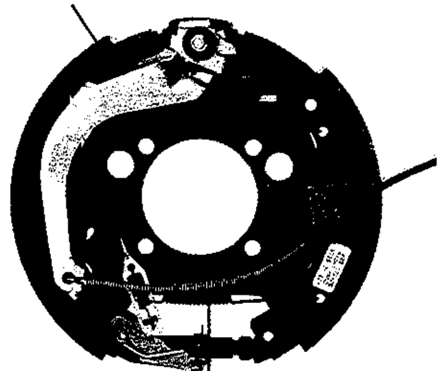
The parking feature on Dexter hydraulic brakes is cable operated. On the 10" and 12" brakes, the parking cable body is mounted to the brake backing plate. The cable end is attached to the internal parking brake lever to actuate the brake. On Dexter 12¼" brakes manufactured before February 2002, the parking cable body mounts to a support plate which is attached to the brake mounting flange. The cable end is routed through the dust shield and the brake spider to attach to the internal parking brake lever.

Braking Systems - Hydraulic

For 12¼" brakes produced after February 2002, a short cable is installed directly into the backing plate to provide a convenient means for the trailer manufacturer to attach an appropriate operating system.

The internal parking brake lever of 10" and 12" Dexter brakes, which is mounted to the secondary shoe, transfers applied cable force through a parking strut which is attached to the primary shoe. This transferred load generates a spreading force between the primary and secondary shoes. The shoes move toward the drum until contact is made. Friction generated between the drum and lining contact surface results in parking brake capability.

The internal parking brake lever of Dexter 12¼" brakes transfers the applied cable force through a cam mechanism. The cam mechanism generates a spreading force between the primary and secondary shoes. The shoes move toward the drum until contact is made. Friction generated between the drum and lining contact surface results in parking brake capability.

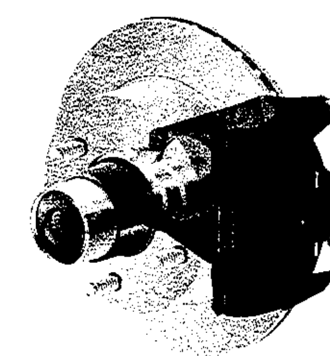


Disc Brakes

Dexter Axle manufactures two types of disc brakes, the floating caliper and the fixed caliper brake. With both styles, the disc brake uses friction pads astride a ventilated rotor which is attached to the wheel hub. When the brake is actuated, the pads are pressed against the sides of the rotor causing drag to slow the rotating disc. This action converts the kinetic energy (motion) into heat. The heat is dissipated rapidly by the ventilated disc.

The floating caliper brake uses piston(s) situated on one side of the brake rotor. Hydraulic fluid pressure pushes against the piston(s) to apply the inboard brake pad. As the inboard pad exerts force against the rotating rotor surface, the caliper moves laterally towards the trailer frame and in turn applies an equivalent force to the outboard brake pad against the rotor surface. As the lining material wears, the caliper will automatically maintain the proper lining to rotor clearance. The floating caliper design is used on Dexter 3,500, 10,000, and 12,000 lb. axle models.

The fixed caliper method uses pistons situated on both sides of the rotor. During actuation, hydraulic pressure pushes against the pistons to apply the inboard and outboard brake pads equally to decelerate the rotating rotor. The caliper is fixed and stays stationary during brake actuation and brake adjustment. Brake pad to rotor clearance is maintained as lining wear occurs via the brake piston and internal caliper seal. The fixed caliper design is used on the Dexter 6,000 lb. and 8,000 lb. axle models.



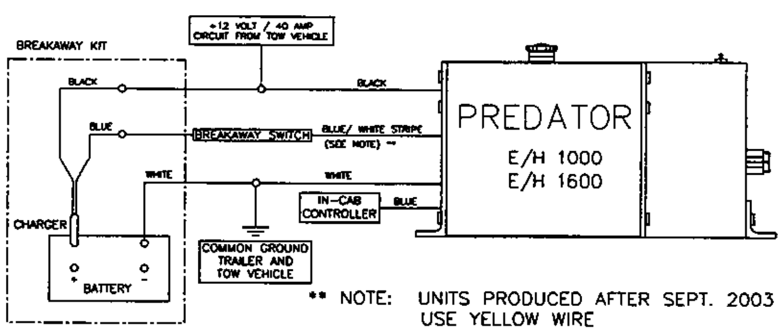
Disc brake effectiveness is the same going either in a forward or reverse direction. All Dexter disc brakes should be actuated with a braking system that is capable of providing a maximum hydraulic pressure of 1,600 psi.

Actuation Systems

To effectively operate your hydraulic trailer brakes, Dexter recommends the Predator E/H™ electrohydraulic actuator, powered by the Predator series DX2™ electronic brake controller. These high performance hydraulic power modules will supply pressurized brake fluid to your trailer brakes in proportion to the amount of braking effort called for by the towing vehicles' deceleration rate.

The Predator E/H 1000™ will supply 1000 psi for your drum brakes and the E/H 1600™ will generate 1600 psi for maximum output from your Dexter disc brakes. The sealed, watertight housing contains the electronics necessary to control the high pressure piston pump and proportioning valve for smooth, efficient braking.

ELECTRICAL SCHEMATIC



** NOTE: UNITS PRODUCED AFTER SEPT. 2003 USE YELLOW WIRE

Troubleshooting Guide

Brakes are slow to respond

1. Re-bleed the trailer brakes and actuator.
2. If the trailer is equipped with drum brakes, readjust the drum brakes to the trailer manufacture's recommended running clearance.

3. Slow response can be caused by trailer wiring that is too small.
4. For trailers where the Predator E/H™ is located less than 10 feet from the tow vehicle, 12 gage wire is recommended for the black and white wires between the tow vehicle and the Predator E/H™ unit. All other wires should be a minimum of 16 gauge.
5. For trailers where the Predator E/H™ is located more than 10 feet from the tow vehicle, 10 gage wire is recommended for the black and white wires between the tow vehicle and the Predator E/H™ unit. All other wires should be a minimum of 16 gauge.
6. Slow response can be caused by improper adjustment of the brake controller. On inertia-based electronic brake controls, adjust the pendulum (inertia sensor) to a more aggressive setting and/or increase the gain setting.

Unit will not run when the ignition is on and the brake pedal is depressed

1. Verify that the trailer and tow vehicle are wired as detailed on the electrical schematic.
2. With the ignition switch on and the brakes not applied, you should have 12-13 volts between the black and white wires on the Predator E/H™ unit.
3. Clean and replace the ground between the trailer and the Predator E/H™ actuator.
4. Test operation of the unit using the breakaway test procedure.

Breakaway test procedure - do not leave the breakaway switch pulled for more than two minutes during any of the steps outlined below

1. Pull the breakaway switch on the trailer.
2. If the unit runs and builds pressure, that indicates the actuator is functioning properly. The problem most likely is a defective electronic brake controller in the tow vehicle or defective wiring between the tow vehicle and the Predator E/H™ unit.
3. If the unit runs but will not build pressure, the problem most likely is a defective solenoid valve in the Predator E/H™ unit and the actuator should be returned for repair.

Braking Systems - Hydraulic

4. If the unit still does not run after the breakaway battery is fully charged, verify that the voltage between the white wire and blue with white stripe wire (or yellow wire) is at least 12 volts.
5. If the voltage is less than 12 volts, either the breakaway switch or the breakaway wiring is defective.
6. If the voltage is greater than 12 volts, the Predator E/H™ actuator should be returned for repair.

Trailer brakes too aggressive

1. Reduce the gain setting on the in-cab electronic brake controller.

Braking Systems - Hydraulic

General Maintenance - Hydraulic Brakes

Drum Brake Adjustment - Manual

Brakes should be adjusted (1) after the first 200 miles of operation when the brake shoes and drums have "seated," (2) at 3,000 mile intervals, (3) or as use and performance requires. The brakes should be adjusted in the following manner:

1. Jack up trailer and secure on adequate capacity jack stands. Follow trailer manufacturer's recommendations for lifting and supporting the unit. Make sure the wheel and drum rotates freely.

⚠ CAUTION

Do not lift or support the trailer on any part of the axle or suspension system. Never go under any trailer unless it is properly supported on jack stands which have been rated for the load. Improperly supported vehicles can fall unexpectedly and cause serious injury or death.

2. Remove the adjusting hole cover from the adjusting slot on the bottom of the brake backing plate.
3. With a screwdriver or standard adjusting tool, rotate the starwheel of the adjuster assembly to expand the brake shoes. Adjust the brake shoes out until the pressure of the linings against the drum makes the wheel very difficult to turn.
   Note: *For drop spindle axles, a modified adjusting tool may be necessary.*
4. Then rotate the starwheel in the opposite direction until the wheel turns freely with a slight lining drag.
5. Replace the adjusting hole cover and lower the wheel to the ground.
6. Repeat the above procedure on all brakes. For best results, the brakes should all be set at the same clearance.

Most of the brake components are very similar to those used in electric brakes, and maintenance is comparable for the hub and drum, shoes and linings, and bearings. Specific maintenance activities are as follows:

Wheel Cylinders

Inspect for leaks and smooth operation. Clean with brake cleaner and flush with fresh brake fluid. Hone or replace as necessary.

Brake Lines

Check for cracks, kinks, or blockage. Flush with fresh brake fluid. Bleed system to remove all air. Replace as necessary.

Shoes and Linings

A simple visual inspection of your brake linings will tell if they are usable. Replacement is necessary if the lining is worn (to within $1/16$" or less), contaminated with grease or oil, or abnormally scored or gouged. Hairline heat cracks are normal in bonded linings and should not be cause for concern. When replacement is necessary, it is important to replace both shoes on each brake and both brakes of the same axle. This will help retain the "balance" of your brakes.

⚠ CAUTION

POTENTIAL ASBESTOS DUST HAZARD!
Some older brake linings may contain asbestos dust, which has been linked to serious or fatal illnesses. Certain precautions need to be taken when servicing brakes:
1. **Avoid creating or breathing dust.**
2. **Avoid machining, filing or grinding the brake linings.**
3. **Do not use compressed air or dry brushing for cleaning (dust can be removed with a damp brush).**

After replacement of brake shoes and linings, the brakes must be re-burnished to seat in the new components. This should be done by applying the brakes 20 to 30 times from an initial speed of 40 m.p.h., slowing the vehicle to 20 m.p.h. Allow ample time for brakes to cool between applications. This procedure allows the brake shoes to seat in to the drum surface.

Hardware

Check all hardware. Check shoe return spring, hold down springs, and adjuster springs for stretch or wear. Replace as required. Service kits are available.

Instructions for Brake Caliper Kit 3.5K Disc Hydraulic Brakes

Notice to Buyer
It is recommended that all brakes be replaced at the same time to insure balanced braking performance.

Remove the old brake caliper
1. Jack up trailer and secure on adequate capacity jack stands. Follow trailer manufacturers recommendations for lifting and supporting the unit.

⚠ CAUTION

Do not lift or support the trailer on any part of the axle or suspension system. Never go under any trailer unless it is properly supported on jack stands which have been rated for the load. Improperly supported vehicles can fall unexpectedly and cause serious injury or death.

2. Remove the wheel from the hub, leaving the brake exposed.
3. Disconnect the brake actuation system. Check that the hydraulic system has zero pressure and that the hub and rotor rotates freely.

4. Remove the hose from the caliper. Then remove the two caliper mounting bolts. Do not allow the caliper to hang from the hose.

Installing the new brake caliper

1. First inspect the brake assembly for grooves, flaking, cracks, heat checking, thickness variation, insufficient rotor thickness, and look to see that the mounting hardware is straight. Replace any component as needed (or desired) per manufacturer recommendations.
2. Install the new caliper assembly. Make sure that the bleed screw points up.
3. Remount the caliper assembly onto the caliper attaching bracket. Ensure that there is thread locking compound on the threads of the new mounting bolts. Torque mounting bolts to **40-50 Ft. Lbs.** *Note: Use two lug nuts to secure rotor against the hub face when reassembling the caliper. After the caliper is assembled remove the lug nuts.*
4. Reconnect the hose to the elbow adapter on the back of the caliper and torque to **10-12 Ft. Lbs.**
5. Reconnect the brake actuation system. Refer to your actuation systems *Operation Maintenance Service Manual* for proper operation.
6. Bleed and flush brake system per your actuation systems *Operation Maintenance Service Manual.*
7. Remount the wheel. Refer to your *Operation Maintenance Service Manual* for proper wheel nut torque procedures.

Instructions for Brake Rotor Kit 3.5K Disc Hydraulic Brakes

Notice to Buyer
It is recommended that all brakes be replaced at the same time to insure balanced braking performance.

Remove the old brake rotor
1. Jack up trailer and secure on adequate capacity jack stands. Follow trailer manufacturers recommendations for lifting and supporting the unit.

⚠ CAUTION

Do not lift or support the trailer on any part of the axle or suspension system. Never go under any trailer unless it is properly supported on jack stands which have been rated for the load. Improperly supported vehicles can fall unexpectedly and cause serious injury or death.

2. Remove the wheel from the hub, leaving the brake exposed.
3. Disconnect the brake actuation system. Check that the hydraulic system has zero pressure and that the hub and rotor rotates freely.
4. Remove the two caliper mounting bolts. Do not allow the caliper assembly to hang from the hose. Do not disconnect the hose or allow air into the hydraulic system.
5. With the caliper assembly out of the way remove the brake rotor. Save the brake mounting hardware for reinstalling the brake calipers.

Installing the new brake rotor

1. First inspect the brake assembly for grooves, flaking, cracks, heat checking, thickness variation, insufficient rotor thickness, and look to see that the mounting hardware is straight. Replace any component as needed (or desired) per manufacturer recommendations.
2. Install the new brake rotor by fitting it onto the hub flush with the hubface.
3. Remount the caliper assembly onto the caliper attaching bracket. Place thread locking compound on threads of mounting bolts. Torque mounting bolts to **40-50 Ft. Lbs.** *Note: Use two lug nuts to secure rotor against the hub face when reassembling the calipers. After the calipers are assembled remove the lug nuts.*
4. Reconnect the brake actuation system. Refer to your *Operation Maintenance Service Manual* for proper operation.
5. Remount the wheel. Refer to your *Operation Maintenance Service Manual* for proper wheel nut torque procedures.

Instructions for Brake Rotor Kit 6K or 8K Disc Hydraulic Brakes

Notice to Buyer
It is recommended that all brakes be replaced at the same time to insure balanced braking performance.

Remove the old brake rotor
1. Jack up trailer and secure on adequate capacity jack stands. Follow trailer manufacturers recommendations for lifting and supporting the unit.

⚠ CAUTION

Do not lift or support the trailer on any part of the axle or suspension system. Never go under any trailer unless it is properly supported on jack stands which have been rated for the load. Improperly supported vehicles can fall unexpectedly and cause serious injury or death.

2. Remove the wheel from the hub, leaving the brake exposed.
3. Disconnect the brake actuation system. Check that the hydraulic system has zero pressure and that the hub and rotor rotates freely.
4. Remove the four caliper mounting bolts. <u>Do not allow the caliper assembly to hang from the hose.</u> <u>Do not disconnect the hose or allow air into the hydraulic system.</u>
5. With the caliper assembly out of the way remove the brake rotor. Save the brake mounting hardware for reinstalling the brake calipers.

Installing the new brake rotor

1. First inspect the brake assembly for grooves, flaking, cracks, heat checking, thickness variation, insufficient rotor thickness, and look to see that the mounting hardware is straight. Replace any component as needed (or desired) per manufacturer recommendations.

2. Install the new brake rotor by fitting it onto the hub flush with the hubface. *Note: Use two lug nuts to secure rotor against the hub face when reassembling the calipers. After the calipers are assembled remove the lug nuts.*
3. Remount the caliper assembly onto the caliper attaching bracket. It may be necessary to push the piston into the calipers to obtain enough clearance. Torque mounting bolts to **25-50 Ft. Lbs.**
4. Spin the rotor to ensure that there is enough clearance between the rotor and the crossover brake line.
5. Reconnect the brake actuation system. Refer to your *Operation Maintenance Service Manual* for proper operation.
6. Remount the wheel. Refer to your *Operation Maintenance Service Manual* for proper wheel nut torque procedures.
7. Spin the wheel to ensure that there is enough clearance between the wheel, crossover brake line, and rotor.

Instructions for Brake Pad Kit 6K or 8K Disc Hydraulic Brakes

Notice to Buyer
It is recommended that all brakes be replaced at the same time to insure balanced braking performance.

Remove the old brake pads
1. Jack up trailer and secure on adequate capacity jack stands. Follow trailer manufacturers recommendations for lifting and supporting the unit.

⚠ CAUTION

Do not lift or support the trailer on any part of the axle or suspension system. Never go under any trailer unless it is properly supported on jack stands which have been rated for the load. Improperly supported vehicles can fall unexpectedly and cause serious injury or death.

2. Remove the wheel from the hub, leaving the brake exposed.
3. Disconnect the brake actuation system. Check that the hydraulic system has zero pressure and that the hub and rotor rotates freely.
4. Remove the brake pad retaining bolt.
5. Remove the old pads from the caliper assembly. Save the brake pad retaining hardware for reinstalling the new pads onto the caliper.

⚠CAUTION

POTENTIAL ASBESTOS DUST HAZARD!
Some older brake linings may contain asbestos dust, which has been linked to serious or fatal illnesses. Certain precautions need to be taken when servicing brakes:
1. **Avoid creating or breathing dust.**
2. **Avoid machining, filing or grinding the brake linings.**
3. **Do not use compressed air or dry brushing for cleaning (dust can be removed with a damp brush).**

Installing the new brake pads

1. First inspect the brake assembly for grooves, flaking, cracks, heat checking, thickness variation, insufficient rotor thickness, and look to see that the mounting hardware is straight. Replace any component as needed (or desired) per manufacturer recommendations.
2. Press the caliper pistons into the calipers until enough clearance is available to fit the new pads between the pistons and the rotor. *Note: Use two lug nuts to secure rotor against the hub face when reassembling the new pads. After the pads are assembled remove the lug nuts.*
3. Install the new brake pads by sliding them in one at a time between the caliper pistons and the rotor. The pads are the same for the inner and outer side of the rotor. <u>Make sure the brake lining side of the pad faces the rotor, and the steel backing faces the caliper pistons.</u>

4. Align the brake pad mounting holes with the holes in the caliper. Insert the brake pad retaining bolt and torque to **15-25 Ft. Lbs.**
5. Reconnect the brake actuation system. Refer to your *Operation Maintenance Service Manual* for proper operation.
6. Remount the wheel. Refer to your *Operation Maintenance Service Manual* for proper wheel nut torque procedures.

Instructions for Brake Caliper Kit 6K or 8K Disc Hydraulic Brakes

Notice to Buyer
It is recommended that all brakes be replaced at the same time to insure balanced braking performance.

Remove the old brake pads
1. Jack up trailer and secure on adequate capacity jack stands. Follow trailer manufacturers recommendations for lifting and supporting the unit.

⚠CAUTION

Do not lift or support the trailer on any part of the axle or suspension system. Never go under any trailer unless it is properly supported on jack stands which have been rated for the load. Improperly supported vehicles can fall unexpectedly and cause serious injury or death.

2. Remove the wheel from the hub, leaving the brake exposed.
3. Disconnect the brake actuation system. Check that the hydraulic system has zero pressure and that the hub and rotor rotates freely.
4. Remove the hose from the caliper, then remove the four caliper mounting bolts. <u>Do not allow the caliper to hang from the hose.</u>

Installing the new brake caliper

1. First inspect the brake assembly for grooves, flaking, cracks, heat checking, thickness variation, insufficient rotor thickness, and look to see that the mounting hardware is straight. Replace any component as needed (or desired) per manufacturer recommendations.
2. Assemble the new caliper assembly. *Note: Use two lug nuts to secure rotor against the hub face when reassembling the calipers. After the brake is assembled remove the lug nuts.*
3. One caliper will be used on the inboard side, with the hydraulic line fitting adapter installed on the top side of the piston boss. The other caliper will be used on the outboard side with the bleed screw installed at the top of the piston boss. Install both of these calipers onto the attaching bracket. Make sure that the bleed screw points up and is located on the outboard caliper. Torque bolts to **25-25 Ft. Lbs.**
4. Connect the new crossover brake line on the bottom sides of the piston boss on both calipers. *Note: Make sure the crossover line fits snug around the calipers and rotor without touching the rotor.* Spin the rotor to ensure there is proper clearance. Torque the crossover line to **12-15 Ft. Lbs.** Torque the bleed screw and the hydraulic line fitting adapter to **60-76 Inch Lbs.**
5. Reassemble the brake pads into the disc brake. Make sure to locate the brake lining side of the pads toward the rotor surface, and the steel side of the pads toward the calipers. Align the holes in the brake pads with the ones in the calipers. Insert the brake pad retaining bolt and torque to **15-25 Ft. Lbs.**
6. Reconnect the brake actuation system. Refer to your *Operation Maintenance Service Manual* for proper operation.
7. Bleed and flush brake system per your actuation systems *Operation Maintenance Service Manual.*
8. Remount the wheel. Refer to your *Operation Maintenance Service Manual* for proper wheel nut torque procedures.
9. Spin wheel to ensure proper clearance between the wheel, crossover brake line, and the rotor.

Introduction to Troubleshooting

Proper brake function is critical to the safe operation of any vehicle. A properly installed vacuum/hydraulic, electric/hydraulic or air/hydraulic system should not require any special attention with the exception of routine maintenance as defined by the manufacturer. If problems occur, the entire tow vehicle/trailer braking system should be analyzed by a qualified mechanic. Typical problems in a hydraulic braking system are:

- Air or vacuum leaks
- Hydraulic system leaks
- Air in brake lines
- Water or other impurity in brake fluid
- Rusted or corroded master or wheel cylinders
- Actuation system malfunction

Please consult the following troubleshooting charts to determine the causes and solutions for common problems found in trailer braking systems.

CAUTION

The operating pressure required for Dexter brakes:

- **7" diameter brakes**
  maximum operating pressure is 750 PSI
- **10" diameter and larger**
  maximum operating pressure is 1,000 PSI

Troubleshooting

SYMPTOM	CAUSES	REMEDIES
Noisy Brakes	Underadjustment	Adjust
	Lack of Lubrication	Lubricate
	Broken Brake Components	Replace Components
	Incorrect Brake Components	Correct
Locking Brakes	Loose, Bent or Broken Brake Components	Replace Components
	Underadjustment	Adjust
	Out-of-Round Drums	Machine or Replace
Pulls to One Side	Incorrect Tire Pressure	Inflate Evenly on Both Sides to Req. Pressures
	Unmatched Tires on Same Axle	Match Tires on Axle
	Restricted Brake Lines or Hoses	Repair or Replace
	Malfunctioning Cylinder Assembly	Check for Stuck or Sluggish Pistons
	Defective or Damaged Shoe and Lining	Install New Shoe and Lining-Complete Axle
	One Side Out-of-Adjustment	Adjust
Dragging	Improper Fluid	Replace Rubber Parts Fill with DOT4 Fluid
	Blocked Master Cylinder	Open with Compressed Air or Replace Cylinder
	Parking Brake Cable Frozen	Free Cable and Lubricate
	Improper Lining Thickness or Location	Install New Shoes and Linings

Troubleshooting

SYMPTOM	CAUSES	REMEDIES
No Brakes	Broken or Kinked Brake Line	Repair or Replace
	Severe Underadjustment	Adjust Brakes
	Malfunctioning Actuation System	Troubleshoot System
Weak Brakes	Brake Adjustment Not Correct	Manual-Adjust Brakes Automatic-Make Several Reverse Stops
	Excessively Worn Brake Linings	Replace Shoe and Lining
	Incorrect Lining	Install Correct Shoe and Lining
	Grease or Fluid Soaked Lining	Repair Grease Seal or Wheel Cylinder. Install New Shoe and Lining.
	Frozen Master Cylinder or Wheel Cylinder Pistons	Recondition or Replace All Cylinders, Brake Fluid
	Glazed Lining	Reburnish or Replace
	Excessive Drum Wear	Replace
	Trapped Air in Lines	Bleed System
	Overloaded Trailer	Correct
	Malfunctioning Actuating System	Troubleshoot System
Harsh Brakes	Brake Adjustment Not Correct	Manual-Adjust Brakes Automatic-Make Several Reverse Stops
	Grease or Fluid on Linings	Replace Shoes and Linings
Surging Brakes	Grease or Oil on Linings	Clean or Replace
	Out of Round Drums or Cracked Drums	Machine or Replace

Hubs/Drums/Bearings

Dexter Axle offers several types of bearing arrangements and lubrications methods.

- Dexter's standard wheel bearing configuration consists of opposed tapered roller bearing cones and cups, fitted inside of a precision machined cast hub. This method of using tapered roller bearings requires that a minimal amount of axial end play be provided at assembly. This end play is essential to the longevity of the bearings service life. This design is typically lubricated with grease, packed into the bearings. Oil lubrication is another method which is available in some of the larger axle capacities.

- E-Z Lube™ is another option chosen by some trailer manufacturers. If your axle is equipped with the Dexter E-Z Lube™ feature, the bearings can be periodically lubricated without removing the hubs from the axle. This feature consists of axle spindles that have been specially drilled and assembled with grease fittings in their ends. When grease is pumped into the fitting, it is channeled to the inner bearing and then flows back to the outer bearing and eventually back out the grease cap hole.

- Nev-R-Lube™ option is the latest innovation from Dexter. Nev-R-Lube™ bearings are comprised of opposed tapered roller bearing cones sealed inside of a precision ground, one piece double cup arrangement. These bearings are designed with a small amount of axial end play. This end play is essential to the longevity of the bearings service life. They are lubricated, assembled and sealed at the factory. No further lubrication is ever needed.

Before attempting any disassembly of your Dexter axle, make sure you read and follow the instructions for the appropriate axle type.

Hub Removal - Standard Bearings

Whenever the hub equipment on your axle must be removed for inspection or maintenance the following procedure should be utilized.

1. Elevate and support the trailer unit per manufacturers' instructions.

⚠ CAUTION

You must follow the maintenance procedures to prevent damage to important structural components. Damage to certain structural components such as wheel bearings can cause the wheel end to come off of the axle. Loss of a wheel end while the trailer is moving can cause you to lose control and lead to an accident, which can result in serious injury or death.

2. Remove the wheel.
3. Remove the grease cap by carefully prying progressively around the flange of the cap. If the hub is an oil lube type, then the cap can be removed by unscrewing it counterclockwise while holding the hub stationary.
4. Remove the cotter pin from the spindle nut or, in the case of E-Z Lube™ versions, bend the locking tang to the free position.
   For E-Z Lube™ axles produced after February 2002, a new type of retainer is used. Gently pry off retainer from the nut and set aside.
5. Unscrew the spindle nut (counterclockwise) and remove the spindle washer.
6. Remove the hub from the spindle, being careful not to allow the outer bearing cone to fall out. The inner bearing cone will be retained by the seal.
7. For 7,200 lb. and 8,000 lb. axles, a hub puller should be used to assist in drum removal.

Brake Drum Inspection

There are two areas of the brake drum that are subject to wear and require periodic inspection. These two areas are the drum surface where the brake shoes make contact during stopping and the armature surface where the magnet contacts (only in electric brakes).

The drum surface should be inspected for excessive wear or heavy scoring. If worn more than .020" oversized, or the drum has worn out of round by more than .015", then the drum surface should be re-machined. If scoring or other wear is greater than .090" on the diameter, the drum must be replaced. When turning the drum surface, the maximum rebore diameter is as follows:

- 7" Brake Drum-7.090" diameter
- 10" Brake Drum-10.090" diameter
- 12" Brake Drum-12.090" diameter
- 12 1/4" Brake Drum-12.340" diameter
- 6K and 8K Rotor-1.03" minimum thickness
- 3.5K Rotor-.85" minimum thickness

The machined inner surface of the brake drum that contacts the brake magnet is called the armature surface. If the armature surface is scored or worn unevenly, it should be refaced to a 120 micro inch finish by removing not more than .030" of material. To insure proper contact between the armature face and the magnet face, the magnets should be replaced whenever the armature surface is refaced and the armature surface should be refaced whenever the magnets are replaced.

Note: *It is important to protect the wheel bearing bores from metallic chips and contamination which result from drum turning or armature refacing operations. Make certain that the wheel bearing cavities are clean and free of contamination before reinstalling bearing and seals. The presence of these contaminants will cause premature wheel bearing failure.*

Bearing Inspection

Wash all grease and oil from the bearing cone using a suitable solvent. Dry the bearing with a clean, lint-free cloth and inspect each roller completely.

CAUTION

Never spin the bearing with compressed air.
THIS CAN DAMAGE THE BEARING.

If any pitting, spalling, or corrosion is present, then the bearing must be replaced. The bearing cup inside the hub must be inspected.

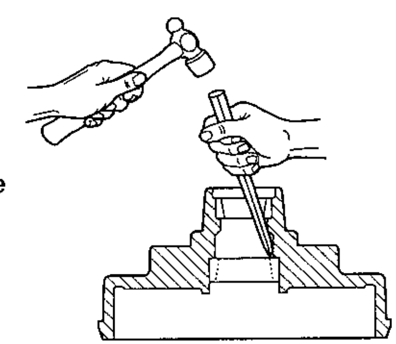
IMPORTANT: *Bearings must always be replaced in sets of a cone and a cup.*

⚠ CAUTION

Be sure to wear safety glasses when removing or installing force fitted parts. Failure to comply may result in serious eye injury.

When replacing the bearing cup proceed as follows:

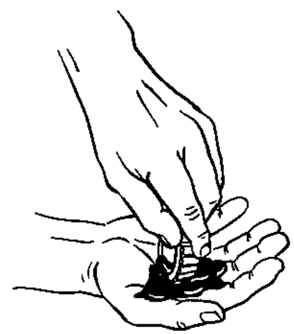
1. Place the hub on a flat work surface with the cup to be replaced on the bottom side.
2. Using a brass drift punch, carefully tap around the small diameter end of the cup to drive out.
3. After cleaning the hub bore area, replace the cup by tapping in with the brass drift punch. *Be sure the cup is seated all the way up against the retaining shoulder in the hub.*



Bearing Lubrication - Grease

Along with bearing adjustment, proper lubrication is essential to the proper function and reliability of your trailer axle. Bearings should be lubricated every 12 months or 12,000 miles. The method to repack bearing cones is as follows:

1. Place a quantity of grease into the palm of your hand.
2. Press a section of the widest end of the bearing into the outer edge of the grease pile closest to the thumb forcing grease into the interior of the bearing.
3. Repeat this while rotating the bearing from roller to roller.
4. Continue this process until you have the entire bearing completely filled with grease.
5. Before reinstalling, apply a light coat of grease on the bearing cup.



Bearing Lubrication - Oil

If your axles are equipped with oil lubricated hubs, periodically check and refill the hub as necessary with a high quality hypoid gear oil to the level indicated on the clear plastic oil cap. The oil can be filled from either the oil fill hole, if present, in the hub or through the rubber plug hole in the cap itself.

Recommended Wheel Bearing Lubrication Specifications

Grease:

Thickener Type .... Lithium Complex
Dropping Point .... 215°C (419°F) Minimum
Consistency .... NLGI No. 2
Additives .... EP, Corrosion & Oxidation Inhibitors
Viscosity Index .... 80 Minimum

Approved Sources:

Mobil Oil .... Mobilgrease HP, Mobilith AW2
Exxon/Standard .... Ronex MP
Kendall Refining Co. .... Kendall L-427
Ashland Oil Co. .... Valvoline Multipurpose GM
76 Lubricants .... 76 Multiplex EP
Citgo Petroleum .... Lithoplex MP#2
Mystik .... Mystik JT-6 Hi Temp Grease
Pennzoil Product Co. .. Premium Wheel Bearing Grease 707L

Oil:

SAE 90, SAE 80W-90, SAE 75W-90

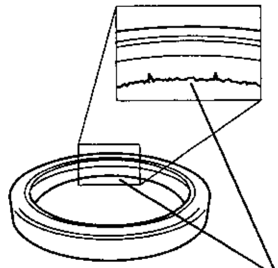
Approved Sources:

Union Oil Co. .... Unocal MP Gear Lube
Exxon Co. USA .... Gear Oil GX 80W-90
Mobil Oil Corp .... Mobilube SHC 75W-90
Pennzoil Prod. Co. .... Gear Plus 80W-90 GL-5
Gear Plus Super 75W-90

***Note:** The convenient lubrication provisions of the E-Z Lube™ and the oil lubrication must not replace periodic inspection of the bearings.*

Seal Inspection and Replacement

Whenever the hub is removed, inspect the seal to assure that it is not nicked or torn and is still capable of properly sealing the bearing cavity. If there is any question of condition, replace the seal. Use only the seals specified in the Seal Replacement Chart. To replace the seal:

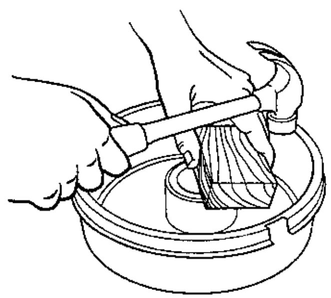


Bad Seal: Nicks and Tears (REPLACE SEAL)

1. Pry the seal out of the hub with a screwdriver. Never drive the seal out with the inner bearing as you may damage the bearing.
2. Apply a PERMATEX sealant to the outside of the new seal.

Note: *Permatex sealant should not be used on rubber encased seals.*

3. Tap the new seal into place using a clean wood block.



Bearing Adjustment and Hub Replacement

If the hub has been removed or bearing adjustment is required, the following adjustment procedure must be followed:

1. After placing the hub, bearings, washers, and spindle nut back on the axle spindle in reverse order as detailed in the previous section on hub removal, rotate the hub assembly slowly while tightening the spindle nut to approximately 50 lbs.-ft. (12" wrench or pliers with full hand force.)
2. Then loosen the spindle nut to remove the torque. *Do not rotate the hub.*
3. Finger tighten the spindle nut until just snug.
4. Back the spindle nut out slightly until the first castellation

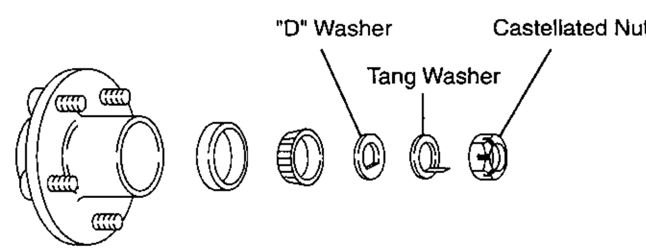
lines up with the cotter key hole and insert the cotter pin (or locking tang in the case of E-Z Lube™).

5. Bend over the cotter pin legs to secure the nut (or locking tang in the case of E-Z Lube™).
6. Nut should be free to move with only restraint being the cotter pin (or locking tang).

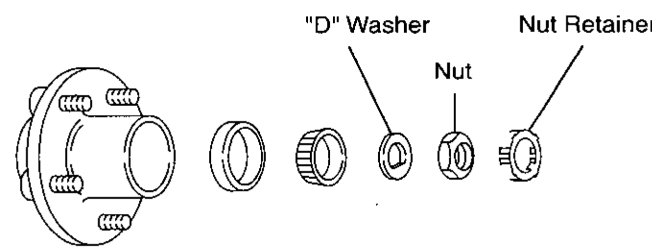
For axles using the new nut retainer:

1. Finger tighten the nut until just snug, align the retainer to the machined flat on the spindle and press the retainer onto the nut. The retainer should snap into place. Once in place, the retainer/nut assembly should be free to move slightly.
2. If the nut is too tight, remove the retainer and back the nut off approximately one twelfth of a turn and reinstall the retainer. The nut should now be free to move slightly.
3. Reinstall grease cap.

Typical E-Z Lube™ Prior to Spring 2002



Typical E-Z Lube™ After Spring 2002

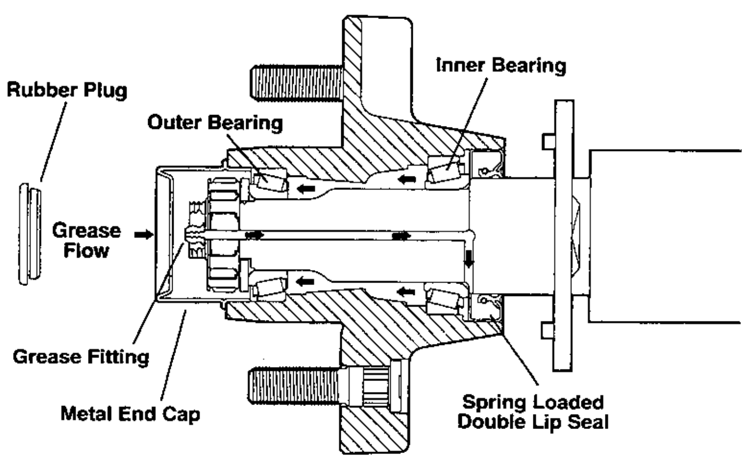


E-Z Lube™ Lubrication

The procedure is as follows:

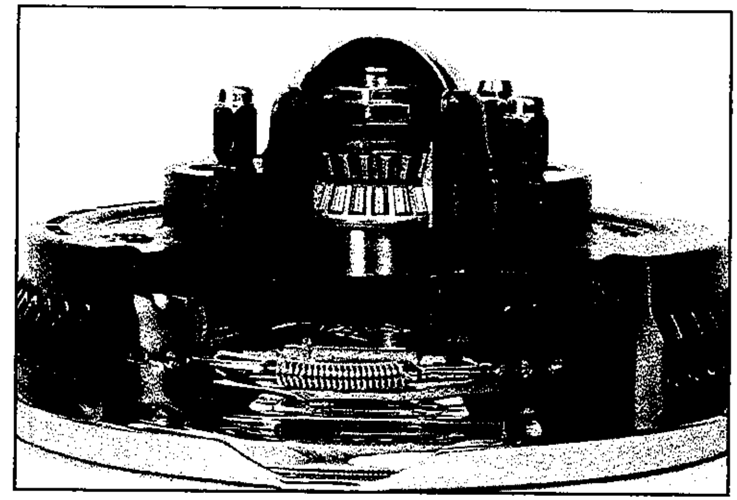
1. Remove the rubber plug from the end of the grease cap.
2. Place a standard grease gun onto the grease fitting located in the end of the spindle. Make sure the grease gun nozzle is fully engaged on the fitting.
3. Pump grease into the fitting. The old displaced grease will begin to flow back out the cap around the grease gun nozzle.
4. When the new clean grease is observed, remove the grease gun, wipe off any excess, and replace the rubber plug in the cap.
5. Rotate hub or drum while adding grease.

Note: The E-Z Lube™ feature is designed to allow immersion in water. Axles not equipped with E-Z Lube™ are not designed for immersion and bearings should be repacked after each immersion. If hubs are removed from an axle with the E-Z Lube™ feature, it is imperative that the seals be replaced BEFORE bearing lubrication. Otherwise, the chance of grease getting on brake linings is greatly increased.



Nev-R-Lube™ Drums/Bearings

Dexter's Nev-R-Lube™ bearings are comprised of opposed tapered roller bearing cones sealed inside of a precision ground, one piece double cup arrangement. These bearings are designed with a small amount of axial end play. This end play is essential to the longevity of the bearings service life.



Drum Removal

Whenever the hub equipment on your axle must be removed for inspection or maintenance, the following procedure should be utilized.

1. Elevate and support the trailer unit per manufacturer's instructions.

⚠ CAUTION

Do not lift or support the trailer on any part of the axle or suspension system. Never go under any trailer unless it is properly supported on jack stands which have been rated for the load. Improperly supported vehicles can fall unexpectedly and cause serious injury or death.

2. Remove the wheel.
3. Remove the grease cap from the hub by carefully prying progressively around the flange.
4. Remove snap ring on the end of the spindle. Remove "torque instruction" washer.
5. Unscrew the spindle nut (counterclockwise) and remove the spindle washer.
6. Carefully remove the hub from the spindle. The Nev-R-Lube™ bearing cartridge will remain in the hub.

Note: Do not remove cartridge bearing from the hub bore unless replacement of the bearing cartridge is intended. Special tools and techniques are required for removal of the old bearing.

Bearing Inspection

Important:

1. Elevate and support the trailer unit per manufacturer's instructions.

⚠ CAUTION

Do not lift or support the trailer on any part of the axle or suspension system. Never go under any trailer unless it is properly supported on jack stands which have been rated for the load. Improperly supported vehicles can fall unexpectedly and cause serious injury or death.

2. Check for excessive wheel end clearance by pulling the tire assembly towards you and by pushing the assembly away from you. Slight end play is acceptable.
3. Rotate tire slowly forwards and backwards. The wheel assembly should turn freely and smoothly.
4. Excessive wheel end play, restriction to rotation, noise, or "bumpy" rotation should be remedied by replacing the bearing unit.
5. Bearing units should be inspected every year or 12,000 miles whichever comes first.

Note: *A slight amount of grease weeping from the seal area is normal. Excessive leakage may indicate abnormal bearing operation.*

Nev-R-Lube™ Bearing End Play Inspection

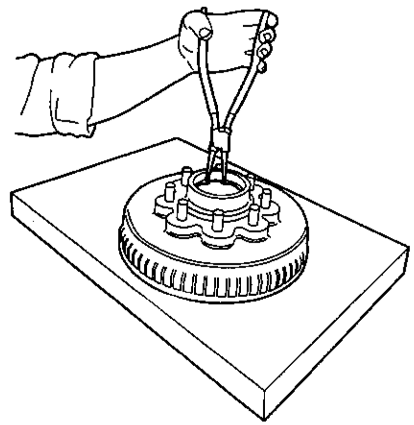
The following lists the maximum axial end play for each of the sizes of Nev-R-Lube™ bearings and the amount of tilt that can be expected. Since there are a large number of wheel and tire combinations in use on trailers, the tilt is expressed in inches per inch. The movement as measured at the tire tread can be found by the following method:

Example: if the tilt value is shown as .003" per inch and the tire measures 30" in diameter, simply multiply .003" X 30" = .090" which is the total expected movement at the tires' outer diameter.

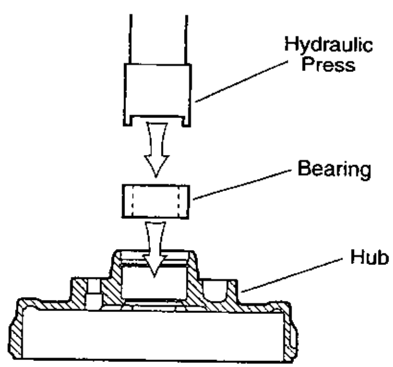
Bearing size	End play	Resultant tilt value
35 MM	.005" axial	.003"/ per inch
42 MM	.006" axial	.005"/ per inch
50 MM	.008" axial	.004"/ per inch

It is important to note that most mounted tires will deflect fairly easily when enough hand pressure is applied while shaking the tire. Excessive pressure will result in the perception that the bearings' tilt is greater than it actually is. This same phenomenon will occur when checking any wheel end, even those equipped with conventional bearing sets.

Bearing Replacement and Drum Installation



1. Once the drum and bearing assembly is removed from the axle, remove "internal" snap ring from the bearing bore that retains bearing.
2. Using an arbor press and mandrel, press the bearing out of the drum. Bearing will exit on the wheel side of the drum.
3. When replacing a Nev-R-Lube™ bearing pack, the bore in the hub should be cleaned and inspected for visual damage (replace as necessary).
4. Installing the new bearing should be conducted using an arbor press and a "hollow" or "stepped" mandrel to press only on the outer housing of the bearing assembly (failure to follow procedure will damage bearing and/or seals during installation). Press bearing until it seats against the backup shoulder machined into the hub.



5. Install "internal" snap ring into hub.
6. Clean and inspect spindle shaft. Apply a light coating of anti-seize lubricant to the spindle shaft prior to assembling drum.
7. Install drum assembly onto spindle (*Do Not Force*).
8. Install steel washer onto spindle end.
9. Start self-locking nut onto spindle thread by hand. Complete installation using a 1½" or 1 7/16" socket and torque wrench. Nut should be torqued to 145-155 lb.-ft. (this torque will set the internal bearing adjustment, no other adjustments are to be made).
10. Install "torque instruction" washer onto end of spindle.
11. Install "external" snap ring onto end of spindle to retain washer.
12. Inspect assembly for excessive end play, noise, and rotation restriction prior to mounting final wheel end hardware.

Hubs/Drums/Bearings

Suspension Systems

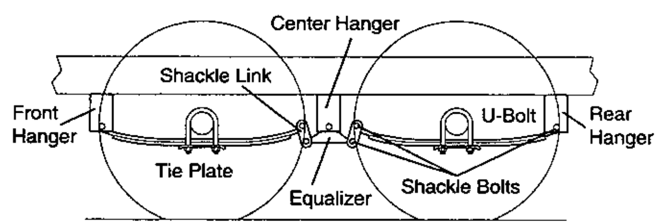
The suspension systems incorporated into Dexter axles are designed to provide the trailer owner three basic functions:

1. Attach the axle to the trailer
2. Dampen the effects of road shock
3. Cushion the cargo or load

All Dexter suspension systems are available in single and multiple axle configurations. The three types most commonly available are double eye leaf spring, slipper spring and Torflex®.

Double Eye Leaf Springs

Double eye springs have eyes formed in each end of the spring with anti-friction bushings fitted for wear resistance. The springs are held to the axle tube using a system of U-bolts and clamp plates and are attached to the trailer as shown.



Underslung Shown

Articulation of this suspension occurs when the spring becomes loaded and consequently lengthens. The double pivot action of the shackle links accommodates this articulation and allows the system to move freely.

In multiple axle installations, the action is the same with the additional movement of the equalizer assembly. This serves to transfer instantaneous loads from one axle to another in an effort to "equalize" the load between the axles.

Grease Lubricated Suspension Bushings

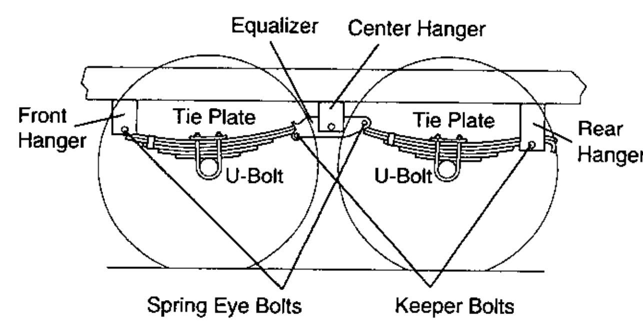
Dexter Axle offers an optional heavy duty attaching parts kit for double eye leaf spring suspensions up to 7,000 lb. axle capacity. The kit contains extra heavy shackle links, bronze bushings for the spring eyes and suspension bolts and equalizers equipped with grease fittings to provide a convenient means to lubricate all the pivot points. For availability, contact your nearest Dexter Axle facility or visit us on-line at **www.dexteraxle.com** for a complete listing of genuine repair parts.

Slipper Leaf Springs

Slipper springs have an eye formed in one end only with the other end formed into a reverse curve. The attachment of these springs is as follows:

1. The front eye is attached directly into the front hanger with a bolt and nut.
2. The rear end of the spring is captured in the rear hanger or equalizer with a "keeper bolt" that prevents the spring from coming out when the trailer is jacked up for service.

The articulation of this suspension occurs when the rear end of each slipper spring slides against the wear surfaces provided in the rear hangers or equalizers. This suspension is also available in single and multiple axle configurations.



Overslung Shown

Inspection and Replacement

All the components of your suspension system should be visually inspected at least every 6,000 miles for signs of excess wear, elongation of bolt holes, and loosening of fasteners. Whenever loose or replaced, the fasteners in your suspension system should be torqued as detailed in the charts below.

⚠ CAUTION

You must follow the maintenance procedures to prevent damage to important structural components. Damage to certain structural components such as wheel bearings can cause the wheel to come off of the axle. Loss of a wheel end while the trailer is moving can cause you to lose control and lead to an accident, which can result in serious injury or death.

Suspension Fastener Torque Values

Item	Torque (lbs.-ft.) Min	Max
$^3/_8$" U-Bolt	30	50
$^7/_{16}$" U-Bolt	45	70
$^1/_2$" U-Bolt	45	70
Non shoulder type with $^9/_{16}$" threads		
Shackle Bolt Spring Eye Bolt Equalizer Bolt	Snug fit only. Parts must rotate freely. Locking nuts or cotter pins are provided to retain nut-bolt assembly.	
Shoulder Type Shackle Bolt with $^7/_{16}$" threads	30	50

Worn spring eye bushings, sagging springs, or broken springs should be replaced using the following method.

1. Support the trailer with the wheels just off the ground.

⚠ CAUTION

Do not lift or support the trailer on any part of the axle or suspension system. Never go under any trailer unless it is properly supported on jack stands which have been rated for the load. Improperly supported vehicles can fall unexpectedly and cause serious injury or death.

2. After the unit is properly supported place a suitable block under the axle tube near the end to be repaired. This block is to support the weight of the axle only, so that suspension COMPONENTS can be removed.
3. Disassemble the U-bolts, nuts, and tie plates.
4. Remove the spring eye bolts and remove the spring and place on a suitable work surface.
5. If the spring eye bushings are to be replaced, drive out the old bushing using a suitable drift punch.

⚠ CAUTION

Be sure to wear safety glasses when removing or installing force fitted parts. Failure to comply may result in serious injury.

6. Drive the new bushing into the spring eye using a piloted drift punch or a close fitting bolt inserted through the bushing.
7. Reinstall repaired or replaced components in reverse order.

Note: *For multiple axle units, the weight of each axle must be supported as outlined in Step 2 before disassembly of any component of the suspension system.*

If the equalizer or equalizer bushings must be replaced, follow the instructions above for lifting and supporting the trailer unit and then proceed as follows:

1. With both axles blocked up, remove the spring eye bolt, shackle bolt, and equalizer bolt from the equalizer to be repaired or replaced.
2. Take the equalizer to suitable work surface and remove the worn bushings using a suitable drift punch.
3. Drive the new bushings into place using a piloted drift punch or a close fitting bolt through the bushing.
4. Reassemble in reverse order.

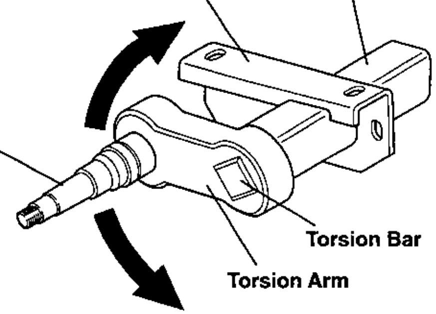
⚠ CAUTION

Be sure to wear safety glasses when removing or installing force fitted parts. Failure to comply may result in serious injury.

All of the pivot points on your standard suspension system have been fitted with anti-friction bearing materials which do not require routine lubrication. When otherwise servicing the unit, these pivot points may be lubricated if you so desire. If your trailer has been fitted with the Heavy Duty Attaching Parts Kit, you should lubricate periodically to ensure long component life.

Torflex® Suspension

The TORFLEX® suspension system is a torsion arm type suspension which is completely self contained within the axle tube. It attaches directly to the trailer frame using brackets which are an integral part of the axle assembly. The TORFLEX® axle provides improved suspension characteristics relative to leaf spring axles through the unique arrangement of a steel torsion bar



surrounded by four natural rubber cords encased in the main structural member of the axle beam.

The wheel/hub spindle is attached to a lever, called the torsion arm, which is fastened to the rubber encased bar. As load is applied, the bar rotates causing a rolling/compressive resistance in the rubber cords. This action provides the same functions as conventional sprung axles with several operating advantages including independent suspension.

Except for periodic inspection of the fasteners used to attach the TORFLEX® axle to the vehicle frame, no other suspension maintenance is required on TORFLEX® axles. They are, of course, subject to the maintenance and inspection procedures regarding brakes, hubs, bearings, seals, wheels, and tires as outlined in this manual.

CAUTION

DO NOT WELD ON THE TORFLEX® BEAM. It has rubber cords inside and the heat generated by welding could damage the cord.

Airflex™ Suspension

The Dexter ***AIRFLEX™*** suspension is a unique combination of Torflex® axle and conventional air suspension technology. This low maintenance suspension system carries the load on a cushion of air, usually supplied by an on-board compressor and storage tank. A load leveling valve maintains a constant ride height, regardless of load. As load is added to the trailer, the valve will automatically signal the compressor to supply more air. As loads are removed, the same valve will exhaust air to maintain the same height and ride characteristics.

The ***AIRFLEX™*** suspension can be supplied with a dump valve which allows the trailer to be lowered several inches to facilitate loading or leveling. Once loaded, the valve is reversed and the system is pressurized to raise the trailer back up to normal running height.

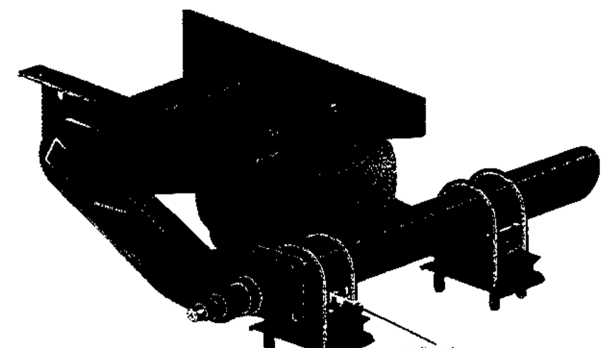
Axle Adjustment

1. Support the trailer frame on a level surface. If the wheels are already mounted, make sure they are clear of the ground. If the air actuation system has been installed, make sure the air pressure in the air bags is bled off before lifting the trailer. **CAUTION: Lifting the trailer with air system pressurized will overextend the air bags and can result in damage to the air bags.**

⚠CAUTION

Do not lift or support the trailer on any part of the axle or suspension system. Never go under any trailer unless it is properly supported on jack stands which have been rated for the load. Improperly supported vehicles can fall unexpectedly and cause serious injury or death.

2. Measure from king pin to spindle center on each side. To simplify this process, plumb lines may be dropped from the king pin and from the centerline of each spindle end. Measurements "A" and "B" can then be taped on the floor to eliminate any miss measurement due to sagging of the tape long measurements. Compare A and B measurements (see Figure 1).
3. Loosen all the U-bolt nuts slightly and move the axle assembly with the adjusting screws, located on the front and rear of the axle seat. Move front axle to correct alignment position based on previous findings of A and B measurements. Make sure both front and rear adjusting screws are snug after axle is realigned. Then, retighten the U-bolt nuts to 100 to 120 lb ft.



4. Re-measure A and B, as before, to assure that "A" and "B" dimensions are within 1/16" of each other. If dimensions are not to specification, then repeat adjustment procedure.

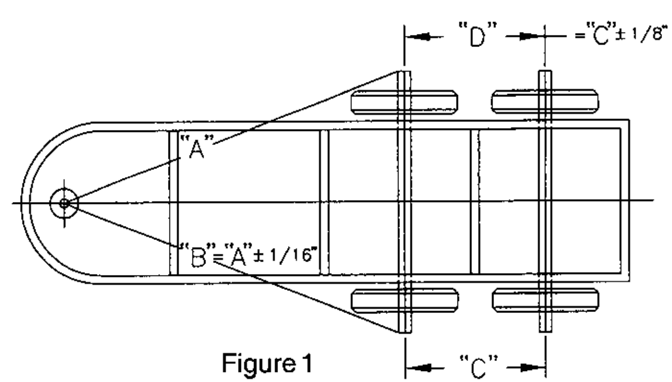


Figure 1

Tandem Axle Adjustment

1. Adjust the second axle using it's left hand spring seat adjusters to assure distances "C" and "D" are within tolerance.
2. Measure the distances "C" and "D" between the front and rear tandem axles. These distances must be within 1/8" of each other.
3. After alignment is completed make sure all nuts and bolts are tightened to their respective torque values.
4. The limits of 1/16" and 1/8" appear very small in comparison to the overall dimensions of the vehicle but they are recognized as the maximum permissible limit of misalignment. Also, the relatively small size of those limits makes accurate measurements important.

Wheels

Wheel Selection

Wheels are very important and critical components of your running gear system. When specifying or replacing your trailer wheels it is important that the wheels, tires, and axle are properly matched. The following characteristics are extremely important and should be thoroughly checked when replacement wheels are considered.

1. *Bolt Circle*. Many bolt circle dimensions are available. Some vary by so little that it might be possible to attach an improper wheel that does not match the axle hub. Be sure to match your wheel to the axle hub.
2. *Capacity*. Make sure that the wheels have enough load carrying capacity and pressure rating to match the rated load of the tire.
3. *Offset*. This refers to the relationship of the center line of the tire to the hub face of the axle. Care should be taken to match any replacement wheel with the same offset wheel as originally equipped. Failure to match offset can result in reducing the load carrying capacity of your axle.
4. *Rim Contour*.

⚠ CAUTION

Replacement tires must meet the same specifications as the originals. Mismatched tires and rims may come apart with explosive force and cause personal injury to yourself or others. Mismatched tires and rims can also blow out and cause you to lose control and have an accident which can result in serious injury or death.

⚠ CAUTION

Do not attempt to repair or modify a damaged wheel. Even minor modifications can cause a dangerous failure of the wheel and result in personal injury or death.

Torque Requirements

It is extremely important to apply and maintain proper wheel mounting torque on your trailer axle. Torque is a measure of the amount of tightening applied to a fastener (nut or bolt) and is expressed as length force. For example, a force of 90 pounds applied at the end of a wrench one foot long will yield 90 lbs.-ft. of torque. Torque wrenches are the best method to assure the proper amount of torque is being applied to a fastener.

⚠ CAUTION

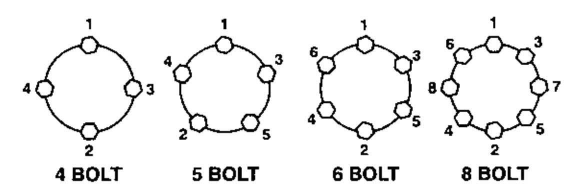
Wheel nuts or bolts must be tightened and maintained at the proper torque levels to prevent loose wheels, broken studs, and possible dangerous separation of wheels from your axle, which can lead to an accident, personal injuries or death.

Be sure to use only the fasteners matched to the cone angle of your wheel (usually 60° or 90°). The proper procedure for attaching your wheels is as follows:

1. Start all bolts or nuts by hand to prevent cross threading.
2. Tighten bolts or nuts in the sequence shown for Wheel Torque Requirements.
3. The tightening of the fasteners should be done in stages. Following the recommended sequence, tighten fasteners per wheel torque chart below.
4. Wheel nuts/bolts should be torqued before first road use and after each wheel removal. Check and re-torque after the first 10 miles, 25 miles, and again at 50 miles. Check periodically thereafter.

Wheel Torque Requirements

Wheel Size	Torque Sequence 1st Stage	2nd Stage	3rd Stage
12"	20-25	35-40	50-75
13"	20-25	35-40	50-75
14"	20-25	50-60	90-120
15"	20-25	50-60	90-120
16"	20-25	50-60	90-120
16.5" x 6.75"	20-25	50-60	90-120
16.5" x 9.75"	55-60	120-125	175-225
14.5" Demount.	Tighten sequentially to		85-95
17.5" Hub Pilot Clamp Ring & Cone Nuts	50-60	100-120	190-210
17.5" Hub Pilot 5/8" Flange Nuts	50-601	90-200	275-325



Tires

Before mounting tires onto the wheels, make certain that the rim size and contour is approved for the tire as shown in the Tire and Rim Association Yearbook or the tire manufacturers catalog. Also, make sure the tire will carry the rated load. If the load is not equal on all tires due to trailer weight distribution, use the tire rated for the heaviest wheel position.

Note: *The capacity rating molded into the sidewall of the tire is not always the proper rating for the tire if used in a trailer application. Use the following guidelines:*

1. LT and ST tires. Use the capacity rating molded into the tire.
2. Passenger Car Tires. Use the capacity rating molded into the tire sidewall **divided by 1.10** for trailer use.

Use tire mounting procedures as outlined by the Rubber Manufacturer's Association or the tire manufacturers.

Tire inflation pressure is the most important factor in tire life. Inflation pressure should be as recommended by the manufacturer for the load. Pressure should be checked cold before operation. Do not bleed air from tires when they are hot. Check inflation pressure weekly during use to insure the maximum tire life and tread wear. The following tire wear diagnostic chart will help you pinpoint the causes and solutions of tire wear problems.

CAUTION

Tire wear should be checked frequently because once a wear pattern becomes firmly established in a tire it is difficult to stop, even if the underlying cause is corrected.

Tire Wear Diagnostic Chart

Wear Pattern	Cause	Action
Center Wear	Over Inflation	Adjust pressure to particular load per tire catalog
Edge Wear	Under Inflation	Adjust pressure to particular load per tire catalog
Side Wear	Loss of camber or overloading	Make sure load doesn't exceed axle rating. Align at alignment shop.
Toe Wear	Incorrect toe-in	Align at alignment shop.
Cupping	Out-of-balance	Check bearing adjust-ment and balance tires.
Flat Spots	Wheel lockup & tire skidding	Avoid sudden stops when possible and adjust brakes.

Replacement Parts/Kits

Magnet Replacement Kits

Brake Size	Magnet Kit No. (one magnet per kit)	Wire Color	Nut Torque Brake Mounting
7 x 1¼	K71-057-00	White	45-70
10 x 2¼	K71-104-00	Green	45-70
12 x 2	K71-105-00	White	25-50
12 x 2	K71-125-00 (7K)	Black	25-50
12¼ x 2½	K71-441-00	Red	55-80
12¼ x 3⅜	K71-375-00 oval magnet	White	55-80

Brake Shoe Replacement Kits

Brake Size	Shoe and Lining Replacement (1 Brake)	
	Electric	*Hydraulic*
7 x 1¼	K71-045-00	N/A
7 x 1¾	N/A	K71-466-00
10 x 2¼	K71-047-00	K71-267-00
Free Backing		K71-393-00
Corrosion Resistant		K71-423 -00
12 x 2 (5.2K)	K71-048-00	K71-268-00
12 x 2 (7K)	K71-127-00	K71-269-00 LH K71-270-00 RH
Free Backing		K71-394-00 LH K71-395-00 RH
Free Backing, Corrosion Resistant		K71-427-00 LH K71-428-00 RH
12¼ x 2½	K71-497-00LH K71-496-00RH	N/A
12¼ x 3⅜	K71-499-00LH K71-498-00RH	K71-165-00 LH K71-166-00 RH
12¼ x 3⅜	K71-049 K71-050	Stamped Backing Plate (prior to April 2000)
3.5K Disc	N/A	K71-623-00 (1 axle set)
6.0K Disc	N/A	K71-629-00 (1 axle set)
8.0K Disc	N/A	K71-629-00 (1 axle set)

Replacement Parts/Kits

Bearing Replacement Chart

Brake Size	Hub Size	Bearings	Dexter Kit Number	Industry Part # Cup /Cone	Axle Capacity
7 x 1¼	4 or 5 Bolt	Inner	K71-306-00	L44610 / L44649	2K
		Outer	K71-306-00	L44610 / L44649	
10 x 1½	4 or 5 Bolt	Inner	K71-307-00	LM67010 / LM67048	2.8K
		Outer	K71-306-00	L44610 / L44649	
10 x 2¼	4 or 5 Bolt	Inner	K71-390-00	L68111 / L68149	3.5K
		Outer	K71-306-00	L44610 / L44649	
12 x 2	6 Bolt	Inner	K71-308-00	25520 / 25580	5.2K
		Outer	K71-307-00	LM67010 / LM67048	
12 x 2	5 Bolt Demount	Inner	K71-308-00	25520 / 25580	6K
		Outer	K71-309-00	15245 / 15123	
12 x 2	8 Bolt	Inner	K71-308-00	25520 / 25580	6K
		Outer	K71-310-00	14125A / 14276	
12 x 2 *	6 Bolt	Inner	K71-308-00	25520 / 25580	7K
		Outer	K71-309-00	15245 / 15123	
12¼ x 2½	8 Bolt	Inner	K71-308-00	25520 / 25580	7.2K
		Outer	K71-415-00	02420 / 02475	
12¼ x 3⅜	8 Bolt	Inner	K71-308-00	25520 / 25580	8K
		Outer	K71-415-00	02420 / 02475	

*Special Application

Seal Replacement Reference

Brake Size	Hub Size	Seal Part No. Std.	E-Z Lube™	Oil
7 x 1¼	4 or 5 Bolt	010-009-00	K71-301-00	NA
10 x 2¼	4, 5 or 6 Bolt	010-004-00	K71-303-00	NA
12 x 2**	5 Bolt Demount; 6 or 8 Bolt	010-054-00	K71-305-00	K71-305-00
12¼ x 2½	8 Bolt	K71-386-00	K71-386-00	K71-386-00
12¼ x 3⅜	8 Bolt	K71-386-00	K71-386-00	K71-386-00

**2.12" diameter seal journal prior to 10/97
**2.25" diameter seal journal after 10/97

Storage

Storage Preparation

If your trailer is to be stored for an extended period of time or over the winter, it is important that the trailer be prepared properly.

1. Remove the emergency breakaway battery and store inside, out of the weather. Charge the battery at least every 90 days.
2. Jack up the trailer and place jack stands under the trailer frame so that the weight will be off the tires. Follow trailer manufacturer's guidelines to lift and support the unit. Never jack up or place jack stands on the axle tube or on the equalizers.

⚠ CAUTION

Do not lift or support the trailer on any part of the axle or suspension system. Never go under any trailer unless it is properly supported on jack stands which have been rated for the load. Improperly supported vehicles can fall unexpectedly and cause serious injury or death.

3. Lubricate mechanical moving parts such as the hitch, and suspension parts, that are exposed to the weather.
4. Boat trailer axles are subject to repeated immersion. Before storing, remove brake drums; clean, dry and re-lubricate moving brake components; inspect bearings - clean and re-lubricate.
5. On oil lubricated hubs the upper part of the roller bearings are not immersed in oil and are subject to potential corrosion. For maximum bearing life, it is recommended that you revolve your wheels periodically (every 2-3 weeks) during periods of prolonged storage.

After Prolonged Storage - Inspection Procedures

Before removing trailer from jack stands:

1. Remove all wheels and hubs or brake drums. Note which spindle and brake that the drum was removed from so that it can be reinstalled in the same location.
2. Inspect suspension for wear.
3. Check tightness of hanger bolt, shackle bolt, and U-bolt nuts per recommended torque values.
4. Check brake linings, brake drums and armature faces for excessive wear or scoring.
5. Check brake magnets with an ohmmeter. The magnets should check 3.2 ohms. If shorted or worn excessively, they must be replaced.
6. Lubricate all brake moving parts using a high temperature brake lubricant (LUBRIPLATE or Equivalent).

CAUTION

Do not get grease or oil on brake linings or magnet face.

7. Remove any rust from braking surface and armature surface of drums with fine emery paper or crocus cloth. Protect bearings from contamination while so doing.
8. Inspect oil or grease seals for wear or nicks. Replace if necessary.
9. Lubricate hub bearings. Refer to procedure in manual.
10. Reinstall hubs and adjust bearings per instructions in manual.
11. Mount and tighten wheels per instructions in manual.

Trip Preparation Checklist

There are a number of simple rules to follow in caring for your trailer axle assembly that can add to its life and in the case of some of these rules, you may be protecting your own life as well. Using the following checklist before starting a trip with your trailer is highly recommended. Some of these items should be checked 2-3 weeks prior to a planned trip to allow sufficient time to perform maintenance.

1. Check your maintenance schedule and be sure you are up-to-date.
2. Check hitch. Is it showing wear? Is it properly lubricated?
3. Fasten safety chains and breakaway switch actuating chain securely. Make certain the breakaway battery is fully charged.
4. Inspect towing hookup for secure attachment.
5. Load your trailer so that approximately 10% of the trailers total weight is on the hitch. For light trailers this should be increased to 15%.
6. *Do Not Overload.* Stay within your gross vehicle rated capacity (consult your trailers identification plate).
7. Inflate tires according to manufacturer's specifications; inspect tires for cuts, excessive wear, etc.
8. Check wheel mounting nuts/bolts with a torque wrench. Torque, in proper sequence, to the levels specified in this manual.
9. Make certain brakes are synchronized and functioning properly.
10. Check tightness of hanger bolt, shackle bolt, and U-bolt nuts per torque values specified in manual.
11. Check operation of all lights.
12. Check that your trailer is towing in a level position and adjust hitch height if required.

Maintenance Schedule

Item	Function Required	Weekly	3 Months or 3000 Miles	6 Months or 6000 Miles	12 Months or 12000 Miles
Brakes	Test that they are operational.		*At Every Use*		
Brake Adjustment	Adjust to proper operating clearance.		●		
Brake Magnets	Inspect for wear and current draw.			●	
Brake Linings	Inspect for wear or contamination.				●
Brake Controller	Check for correct amperage & modulation.			●	
Brake Cylinders	Check for leaks, sticking.				●
Brake Lines	Inspect for cracks, leaks, kinks.				●
Trailer Brake Wiring	Inspect wiring for bare spots, fray, etc.				●
Breakaway System	Check battery charge and switch operation.		*At Every Use*		
Hub/Drum	Inspect for abnormal wear or scoring.				●
Wheel Bearings & Cups	Inspect for corrosion or wear. Clean & repack.				●
Seals	Inspect for leakage. Replace if removed.				●
Springs	Inspect for wear, loss of arch.				●
Suspension Parts	Inspect for bending, loose fasteners, wear.			●	
Hangers	Inspect Welds.				●
Wheel Nuts and Bolts	Tighten to specified torque values.		●		
Wheels	Inspect for cracks, dents or distortion.			●	
Tire Inflation Pressure	Inflate tires to mfg's. specifications.	●			
Tire Condition	Inspect for cuts, wear, bulging, etc.		●		

Dexter Axle Limited Warranty

WHAT PRODUCTS ARE COVERED

All Dexter trailer axles, wheels, and suspensions, excluding Dexter 6000 series Manufactured Housing Axles.

LIMITED 2 YEAR WARRANTY

Dexter Axle warrants to the original purchaser that its axles, wheels, suspension systems and Predator Series™ E/H hydraulic brake actuators shall be free from defects in material and workmanship for a period of two (2) years from the date of first sale of the trailer incorporating such components.

LIMITED 5 YEAR WARRANTY

Dexter Axle warrants to the original purchaser that its Nev-R-Lube™ bearings and the suspension components only of its Torflex® axles shall be free from defects in material and workmanship for a period of five years from the date of first sale of the trailer incorporating such components.

LIMITED 7 YEAR WARRANTY

Dexter Axle warrants to the original purchaser that its Predator Series™ electric brake controllers shall be free from defects in material and workmanship for a period of seven (7) years from the date of purchase.

EXCLUSIVE REMEDY

Dexter Axle will, at its option, repair or replace the affected components of any defective axle, repair or replace the entire defective axle, or refund the then-current list price of the axle. In all cases, a reasonable time period must be allowed for warranty repairs to be completed. Allowance will only be made for installation costs specifically approved by Dexter Axle.

WHAT YOU MUST DO

In order to make a claim under these warranties:

1. You must be the original purchaser of the vehicle in which the Spring Suspension Axles or Torflex® Axles were originally installed.
2. You must promptly notify us within the warranty period of any defect and provide us with any substantiation that we may reasonably request.

3. The axles, wheels, or suspensions must have been installed and maintained in accordance with good industry practice and any specific Dexter Axle recommendations, including those specified in Dexter Axle's publication "Operation, Maintenance Service Manual."

EXCLUSIONS

These warranties do not extend to or do not cover defects caused by:

1. The connecting of brake wiring to the trailer wiring or trailer wiring to the towing vehicle wiring.
2. The attachment of the running gear to the frame.
3. Hub imbalance, or any damage caused thereby.
4. Parts not supplied by Dexter Axle.
5. Any damage whatever caused by or related to any alteration of the axle including welding supplemental brackets to the axle.
6. Use of an axle on a unit other than the unit to which it was originally mounted.
7. Normal wear and tear.
8. Alignment.
9. Improper installation.
10. Unreasonable use (including failure to provide reasonable and necessary maintenance as specified in Dexter Axle's publication "Operation, Maintenance Service Manual" including required maintenance after "Prolonged Storage").
12. Improper wheel nut torque.
13. Cosmetic finish or corrosion.

LIMITATIONS

1. **In all cases, Dexter Axle reserves the right to fully satisfy its obligations under the Limited Warranties by refunding the then-current list price of the defective axle (or, if the axle has been discontinued, of the most nearly comparable current product).**
2. Dexter Axle reserves the right to furnish a substitute or replacement component or product in the event an axle or any component of the axle is discontinued or is otherwise unavailable.
3. These warranties are nontransferable.

GENERAL

THE FOREGOING WARRANTIES ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES EXCEPT THAT OF TITLE, WHETHER

Warranty

WRITTEN, ORAL OR IMPLIED, IN FACT OR IN LAW (INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE).

These warranties give you specific legal rights, and you may also have other rights which vary from state to state.

THE DURATION OF ANY IMPLIED WARRANTIES, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED TO THE DURATION OF THE EXPRESS WARRANTIES HEREIN. DEXTER AXLE HEREBY EXCLUDES INCIDENTAL AND CONSEQUENTIAL DAMAGES, INCLUDING LOSS OF TIME, INCONVENIENCE, LOSS OF USE, TOWING FEES, TELEPHONE CALLS OR COST OF MEALS, FOR ANY BREACH OF ANY EXPRESS OR IMPLIED WARRANTY, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

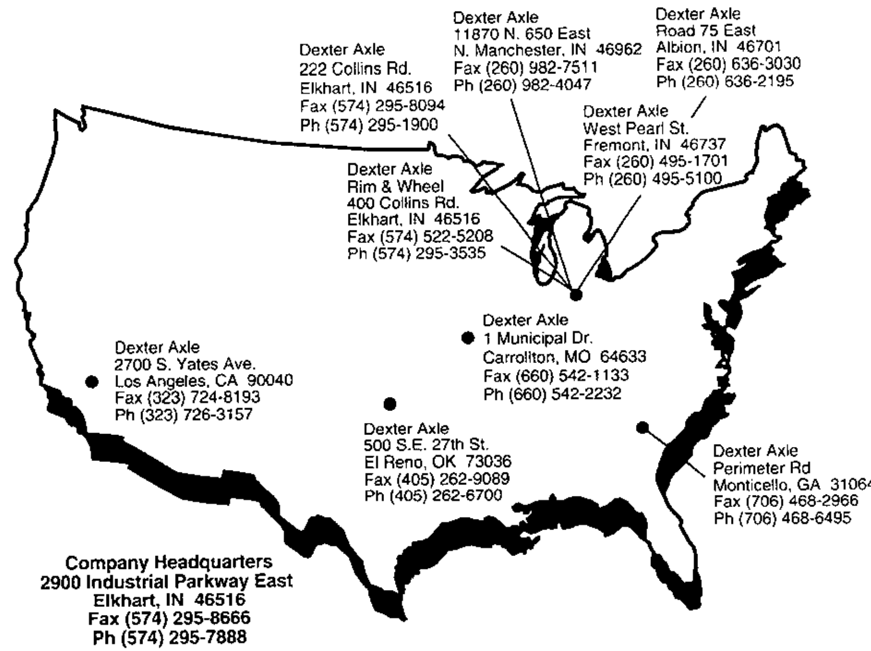
Some states do not allow limitations on how long an implied warranty lasts, or the exclusion or limitation of incidental or consequential damages, so the above exclusion or limitation may not apply to you.

Inquiries regarding these warranties should be sent to:

Dexter Axle
P.O. Box 250
Elkhart, Indiana 46515

Genuine Dexter axles and components are available nationwide from our plant locations listed below or through our network of distributors. Check our website for the distributor nearest you.

Visit us at our website: www.dexteraxle.com



DEXTER AXLE

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LIMITED 2 YEAR WARRANTY
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LIMITED 5 YEAR WARRANTY
Dexter Axle warrants to the original purchaser that its Nev-R-Lube™ bearings and the suspension components only of its Torflex® Axles shall be free from defects in material and workmanship for a period of five (5) years from the date of first sale of the trailer incorporating such components.

LIMITED 7 YEAR WARRANTY
Dexter Axle warrants to the original purchaser that its Predator Series™ electric brake controllers shall be free from defects in material and workmanship for a period of seven (7) years from the date of purchase.

EXCLUSIVE REMEDY
Dexter Axle will, at its option, repair or replace the affected components of any defective axle, repair or replace the entire defective axle, or refund the then-current list price of the axle. In all cases, a reasonable time period must be allowed for warranty repairs to be completed. Allowance will only be made for installation costs specifically approved by Dexter Axle.

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In order to make a claim under these warranties:

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6. Use of an axle on a unit other than the unit to which it was originally mounted.
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These warranties give you specific legal rights, and you may also have other rights which vary from state to state.

THE DURATION OF ANY IMPLIED WARRANTIES, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED TO THE DURATION OF THE EXPRESS WARRANTIES HEREIN. DEXTER AXLE HEREBY EXCLUDES INCIDENTAL AND CONSEQUENTIAL DAMAGES, INCLUDING LOSS OF TIME, INCONVENIENCE, LOSS OF USE, TOWING FEES, TELEPHONE CALLS OR COST OF MEALS, FOR ANY BREACH OF ANY EXPRESS OR IMPLIED WARRANTY, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Some states do not allow limitations on how long an implied warranty lasts, or the exclusion or limitation of incidental or consequential damages, so the above exclusion or limitation may not apply to you.

Inquiries regarding these warranties should be sent to:

Dexter Axle
P.O. Box 250
Elkhart, Indiana 46515

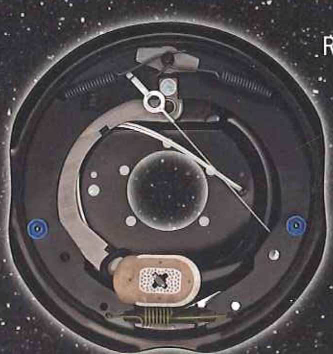
DEXTER AXLE

LIT-400-00

DEXTER AXLE

NEV-R-ADJUST™
FORWARD SELF-ADJUSTING ELECTRIC BRAKES

SUDDEN STOP AHEAD!
ARE YOUR TRAILER BRAKES ADJUSTED?



Road hazards have a tendency to suddenly appear without warning. Add a trailer behind you and there's no time to second guess your ability to stop. In order for trailer brakes to perform as designed, proper adjustment is crucial. Improperly adjusted trailer brakes can greatly sacrifice stopping distances, potentially putting you and your cargo in harm's way.

In the past, trailer owners had to ensure that time consuming manual adjustments were being routinely performed. Now there's no need to worry. Nev-R-Adjust™ brakes automatically adjust to proper clearances during travel allowing you to stop with confidence. Demand better braking for your travels. Demand that your trailer be equipped with Dexter's Nev-R-Adjust™ brakes.

DELIVERING COMPLETE TRAILER RUNNING GEAR SOLUTIONS FOR OVER 40 YEARS

PROPER BRAKE ADJUSTMENT WITH EVERY MILE.

✓ REDUCES STOPPING DISTANCE

When road hazards suddenly present themselves, every second counts. Dexter's Nev-R-Adjust™ brakes have been extensively tested and proven to reduce stopping distances up to 50% versus improperly adjusted brakes.

✓ ELIMINATES ADJUSTMENTS

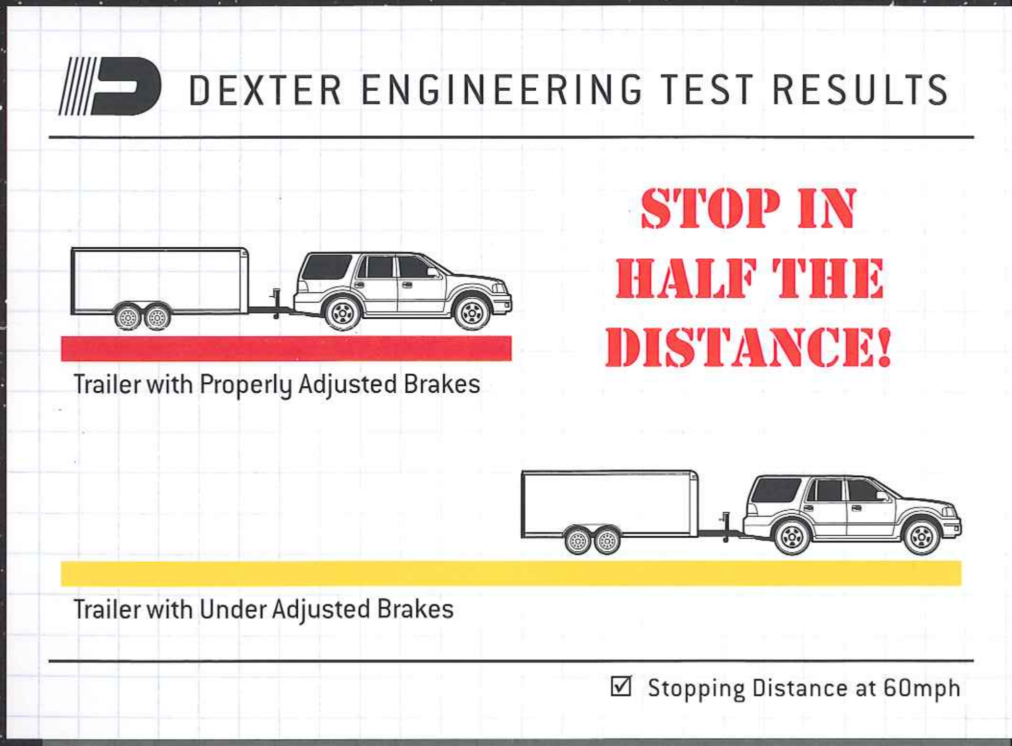
During travel, the brakes automatically rotate an adjuster assembly to close the gap caused by lining wear. This eliminates the need for manual brake adjustments while maintaining optimum performance and braking power.

✓ SAVES TIME & MONEY

Nev-R-Adjust™ brakes offer a convenient solution that saves trailer owners the time and expense of manual brake adjustments. Because proper adjustment leads to better efficiency from the trailer brakes, wear on the tow vehicle brakes is also greatly reduced.

✓ RETROFITS TO EXISTING AXLES

Available as a replacement or upgrade to 10" x 2¼" and 12" x 2" electric brakes. These Nev-R-Adjust™ brakes are CSA approved. Backed by a two year limited warranty from one of the most respected names in the industry.



2 Year Warranty
DEXTER AXLE COMPANY

THE DEXTER DIFFERENCE
QUALITY • SERVICE • INNOVATION

ØNEV-R-ADJUST™
FORWARD SELF-ADJUSTING ELECTRIC BRAKES

2900 Industrial Parkway East • Elkhart, IN 46516 • Customer Sales & Support: (574) 295-7888 • dexteraxle.com

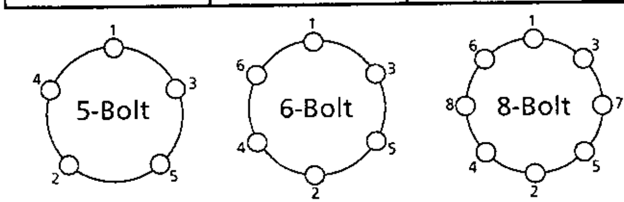
NOTICE
Driver - Dealer - Owner

CHECK WHEEL NUTS OR BOLTS

- **FIRST TRIP: Check Wheel Nuts/Bolts at Start, 10, 25, & 50 Miles.**
- **RECHECK: At Least Every 3 Months or 3000 Miles.**

TORQUE STAGES

1st Stage	2nd Stage	3rd Stage
20/25 ft. lbs.	40/50 ft. lbs.	Full Torque



TORQUE SETTINGS

WC-044

Axle Size	Wheel Size	Stud Size	Steel Wheel Torque	Aluminum Wheel Torque
2000#	13"	1/2"	50# - 75#	N/A
2000#	14"	1/2"	90# - 120#	N/A
2000#	15"	1/2"	90# - 120#	90# - 120#
3500#	13"	1/2"	50# - 75#	N/A
3500#	15"	1/2"	90# - 120#	90# - 120#
5000#	15"	1/2"	90# - 120#	90# - 120#
6000#	15"	1/2"	90# - 120#	90# - 120#
6000#	16"	1/2"	90# - 120#	90# - 120#
7000#	16"	1/2"	90# - 120#	90# - 120#
7000#	16"	9/16"	90# - 120#	90# - 120#
7000#	16"	5/8"	275# - 325#	275# - 325#
7200#	16"	9/16"	90# - 120#	90# - 120#
7200#	16"	5/8"	275# - 325#	275# - 325#
8000#	17.5"	5/8"	275# - 325#	275# - 325#

WARRANTY

The Company does not warrant conformity to any specifications. We guarantee freedom from defective material and workmanship, and title to products of its manufacture when such products are installed and operated in accordance with its instructions. These warranties shall terminate one year from date of invoice.

OUR WARRANTY DOES NOT EXTEND TO ARTICLES SUCH AS PUMPS, MOTORS, ELECTRICAL COMPONENTS, ETC. MANUFACTURED BY OTHERS. THIS RESPONSIBILITY RESTS ENTIRELY WITH THE MANUFACTURER OF THESE ARTICLES.

THE WARRANTIES ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Except in the respect to patent matters, the exclusive liability of the Company arising out of the supplying of its products, or their use, and any related services whether on warranties, negligence, or otherwise, shall be, at its option, to correct the defect, replace the products or repay the purchase price. In the event of correction or replacement, the purchaser will be responsible for all transportation and labor cost.

In no event shall the Company be liable for indirect, consequential or special damages.

No change in this warranty shall be binding upon the Company unless in writing and signed on its behalf by its President.

All orders, sales and contracts are subject to our standard conditions of sale in effect at the time of our acceptance.

(Velcon Systems (herein “Company”) is a division of Velcon Filters, Inc.)

SERVICE POLICY

The Company maintains a stock of repair parts and competent Service Engineers who are available for making repairs, maintenance or supervision of installations. A charge will be made for the Service Engineer’s time, material used, transportation costs, and all expenses.

All requests for service or repair parts should be directed to the Company at Colorado Springs, Colorado, or to one of its established authorized distributors, and full information should be given concerning the difficulty experienced and the part numbers of the equipment involved.

Accessories, for which there is no extra charge, are frequently shown in installation instructions for the purpose of indicating the proper way to install them or their function in connection with the equipment described by the installation instructions.

(Velcon Systems (herein “Company”) is a division of Velcon Filters, Inc.)

Velcon Filters, Inc. • 1210 Garden of the Gods Road • Colorado Springs, CO 80907-3410
Telephone: 719.531.5855 • Facsimile: 719.531.5690 • www.velcon.com
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