OP6225 Analog Sensor Module
User Guide

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ANALOG SENSOR MODULE

INTRODUCTION

The purpose of this section is to describe the Analog Sensor Module – an I/O signal conditioning module that is part of the TestDrive System. It includes an overview of the module's functions, it's specifications and features, technical details, and a description of the context of use.

This document is intended for run-time and development users to implement the ASM as part of TestDrive. Support engineers may also use the information from this document to troubleshoot technical issues.

The ASM is used to simulate analog sensor signals to an Electrical Control Unit (ECU). When used with the TestDrive system, it is capable of providing sensor functionalities required in all simulator applications for the automotive industry. Simulation results are strengthened by the ASM's ability to provide ratiometric outputs for user defined High and Low voltage references on each channel.

Figure 1 shows how, through the ASM, the user is able to control K so that the desired VOUT (between VREF_HI and VREF_LOW) is obtained. (Ranging from VREF_LOW to VREF_HI).

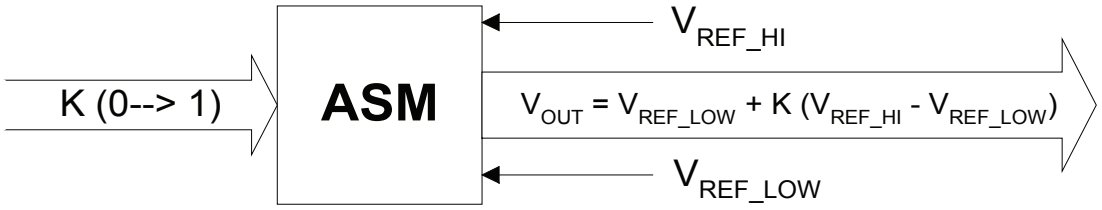


Figure 1: Analog Sensor Module Function

SPECIFICATIONS

Outputs	Characteristics (Per Channel)			
16 Channels	**Resolution**	12 bits	Accuracy	1%
	Voltage output (impedance > 100KΩ)	VO(min) 0V VO(max) 16V	Ratiometric: Linear output range between high & low references Linearization: possible for last 4 channels	
	Voltage Protection	VREF_L (min) VREF_H (max)	-1V 27V	
	Max. Current	200mA continuous		
	Frequency Protection	50KHz (1.6µsec/V slew rate; Rload = 1KΩ)		
		Over Current →Yes	Thermal Shutdown → Yes	

Table 1: ASM Electrical Specifications

FEATURES LIST

Feature	Details	
User defined HI/LOW reference for each channel	Individual external voltage references (0V to 16V range) are used for each channel. The reference. voltages (REF_Hx & REF_Lx) are routed through the 56-pin Elco connector.	
Common Reference Capability (Rev2 only)	Rev2 only – All output channels could can be configured to have a common high and low reference that is connected through the 56-pin Elco connector.	
Disabling faulty channels	Any faulty channel reported to the system is automatically disabled until the user acknowledges the error and the situation is corrected. The channel is then reenabled.	
Module Status **Error Reporting:**	Power (Green) LED: indicates that 5V and 3.3V digital power supplies are within validity range. Activity **(Yellow)** LED**:** - Steady flash if the TestDrive model accesses the card; (communication established.) - Blinks 2 times if the FPGA module is not programmed; (flash update operation required.) - Blinks 3 times if the FPGA firmware does not correspond to the module. Fault (**Red**) LED: indicates that a fault has been detected in the system or module.	On the front of the module
Individual Channel Status	Channel Over Current LED – reports an over current state on a specific channel. Channel Thermal Shutdown LED – reports if an amplifier thermal shutdown has occurred on a specific channel.	In the TestDrive GUI
Positive Cable ID	The module is able to report a bad or lost cable connection or a loss of/ or a change to a good cable connection occurs. This is done in the TestDrive GUI.	
Positive Module ID	The TestDrive system is able to report (on the TestDrive GUI) the identification of an inserted module. The ASM has module ProductMajorID 1. See the “Frequently asked questions” section.	
Firmware Update	The module supports a robust remote software update mechanism that It is capable of recovering from a failure to update the FPGA Configuration Data due to uncontrollable circumstances, such as a power failure. The module is also able to reprogram itself while the model is paused.	

Table 2: ASM Board Features

TECHNICAL DESCRIPTION

OVERVIEW

The ASM module allows the user to synchronously control up to16 channels of analog voltage, that is output to the ECU at every calculation step. Each output signal is able to sink or source a maximum of 200mA where the output voltage is proportional to the difference between the reference voltage signals (Ref HI X and Ref LO X) as shown in Figure 2. Ref HI X and Ref LO X are, respectively, the high and low reference voltages for each output channel where X is the identification number of the channel, number ranging from 0 to 15.

In addition to this, the module supports the Cable ID I/O process.

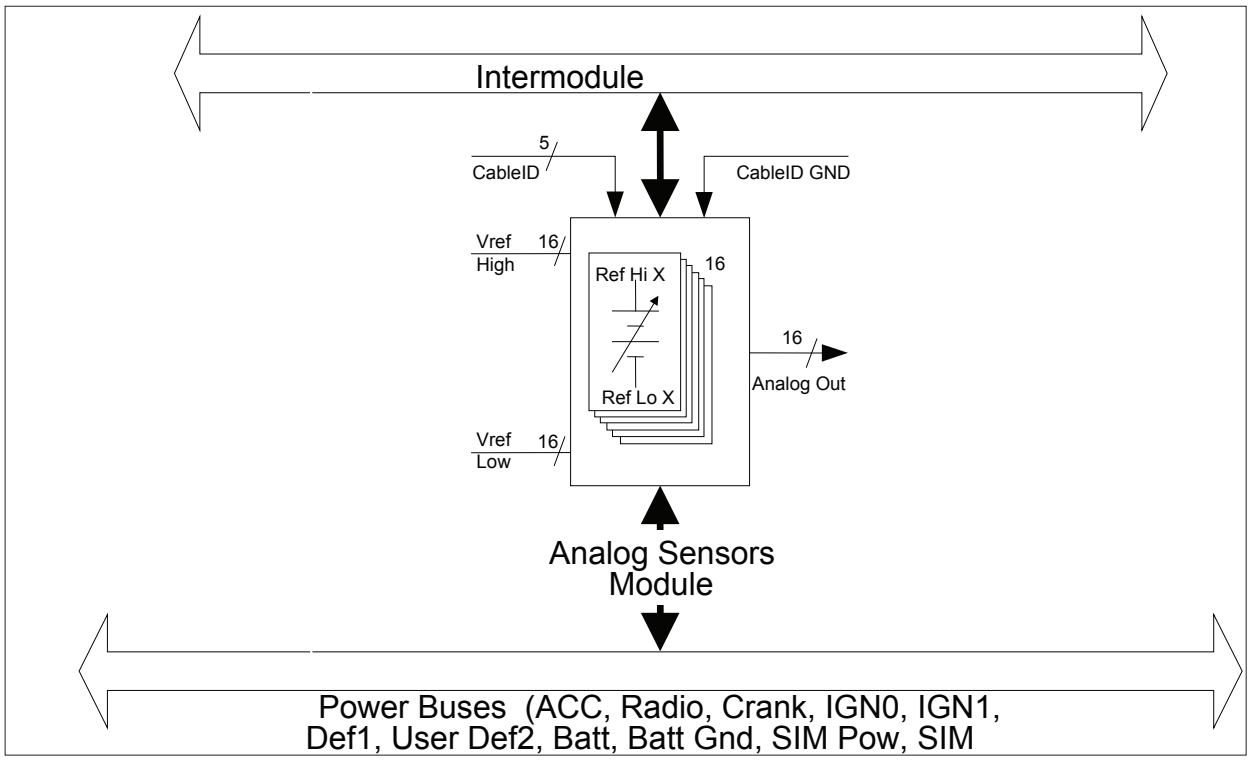


Figure 2: Analog Sensor Module Function Block Diagram

FUNCTIONAL DESCRIPTION

Figure 3 shows the block diagram for the Analog Sensor ModuleASM, it details the functionalities of the analog sensor channels and the FPGA engine. The ASM has 16 channels sharing share a common data bus, while having specific control lines for each channel.

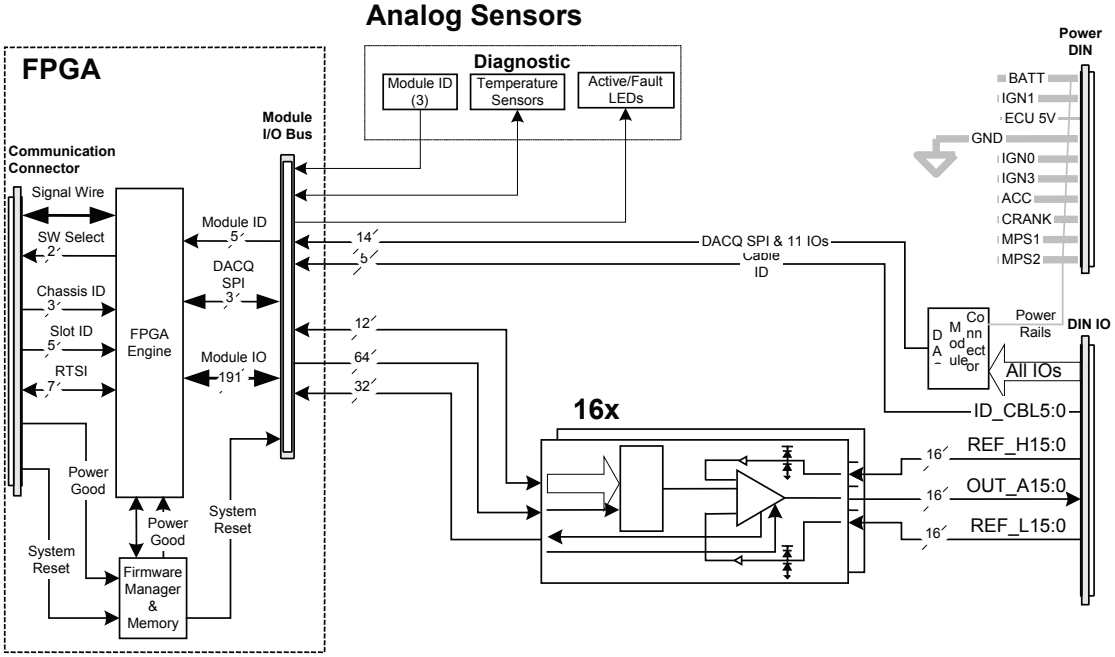


Figure 3: ASM and FPGA Engine Functional Block Diagram

The FPGA engine is used to perform the following tasks:

- Communicate with the RTU
- Enable the output stage for each channel's Analog analog Output output line
- Latch synchronously the digital value to the Digital to Analog Converter
- Disable all channels in fault because of an over current or thermal shutdown conditions
- Control the Activity & Fault LEDs
- Read the module identification and report the module status.

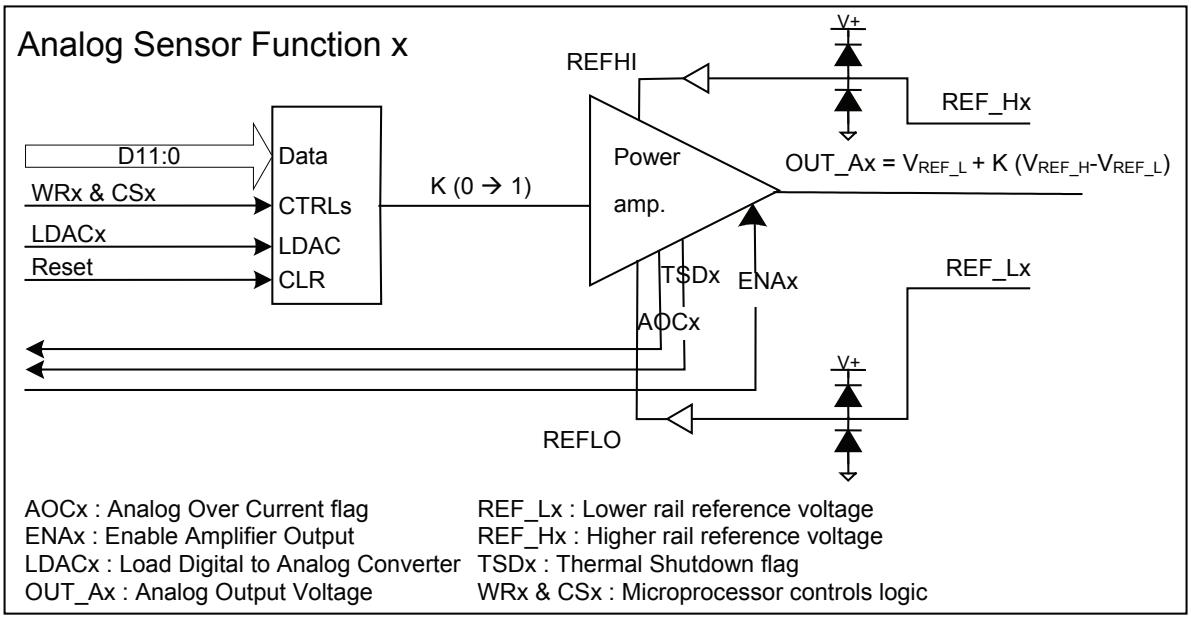


Figure 4: Further details the block diagram of the an Analog Sensor Channel.

The FPGA engine loads each channel's DACs through implementation of the LDACx, WRx and CSx lines. The FPGA engine also enables the output of the power amplifier. The DAC outputs a signal to the power amplifier that is ratiometric between REF_Hx and REF_Lx. When the DAC code field is set to 0x000, the output voltage is set to REF_Lx. Similarly, when the value of the DAC code field is set to 0xFFF, the output voltage is equivalent to REF_Hx.

The power amplifier outputs the analog sensor simulated signal on OUT_Ax. Should over current or thermal shutdown conditions occur, the power amplifier notifies the FPGA engine (through AOCx and TSDx respectively) to which disables the respective faulty channel.

The RTU updates the value of every DAC register at each calculation step.

ASM PIN-OUTS

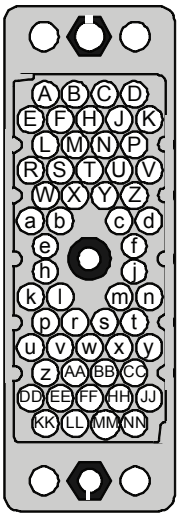
All 16 channels' reference voltages (REF_H15:0 and REF_L15:0) and analog output signals (OUT_ A15:0) are routed from through the ELCO-56 pin connector. Below, Table 3 provides the list of signals available on the external ELCO-56 connector sorted by pin numbers. The table shows also on which pin of the DIN 96 (DIN 96/ J7A) connector the signal is supplied to the module.

As can be seen from the table below, positive cable identification is also achieved through the ELCO-56 pin connector (Signals ID_CBL and ID_CBL4:0).

For Rev. 2 boards, signals COM_REF_L and COM_REF_H are used to connect common low and high references for the channels (see section 3.3 for more details). For Rev. 1 boards, signals PROTO0 and PROTO1 are not used.

Elco Eq. # (female)	Elco Pin name (female)	Signal Name in Analog Module Schematic (2003/10/07)	Input Line	Output Line	DIN 96/J7A
1	A	OUT_A0		x	A2
2	B	REF_L2	x		C1
3	C	REF_L0	x		B1
4	D	REF_H0			A1
5	E	REF_L4	x		C3
6	F	REF_H1	x		B3
7	H	OUT_A1		x	A3
8	J	PROTO0	x	x	C2
9	K	PROTO1	x	x	B2
10	L	OUT_A3		x	A5
11	M	REF_L5	x		C4
12	N	REF_H2	x		B4
13	P	OUT_A2		x	A4
14	R	REF_L7	x		C6
15	S	REF_H4	x		B6
16	T	OUT_A4		x	A6
17	U	REF_L6	x		C5
18	V	REF_H3	x		B5
19	W	OUT_A6		x	A8
20	X	REF_L8	x		C7
21	Y	REF_H5	x		B7
22	Z	OUT_A5		x	A7
23	a	REF_H7	x		B9
24	b	OUT_A7		x	A9
25	c	REF_L9	x		C8
26	d	REF_H6	x		B8
27	e	OUT_A8		x	A10
28	f	REF_L10	x		C9
29	h	REF_L11	x		C10
30	j	REF_H8	x		B10
31	k	OUT_A10		x	A12
32	l	REF_L12	x		C11
33	m	REF_H9	x		B11
34	n	OUT_A9		x	A11
35	p	REF_H11	x		B13
36	r	OUT_A11		x	A13
37	s	REF_L13	x		C12
38	t	REF_H10	x		B12

Female
ELCO Connector
56 pins



Elco Eq. # (female)	Elco Pin name (female)	Signal Name in Analog Module Schematic (2003/10/07)	Input Line	Output Line	DIN 96/J7A
39	u	OUT_A13		x	A15
40	v	REF_L15	x		C14
41	w	REF_H12	x		B14
42	x	OUT_A12		x	A14
43	y	REF_L14	x		C13
44	z	REF_H14	x		B16
45	AA	OUT_A14		x	A16
46	BB	REF_L1	x		C15
47	CC	REF_H13	x		B15
48	DD	ID_CBL0	x		A18
49	EE	ID_CBL		x	C17
50	FF	REF_H15	x		B17
51	HH	OUT_A15		x	A17
52	JJ	REF_L3	x		C16
53	KK	ID_CBL4	x		C20
54	LL	ID_CBL3	x		C19
55	MM	ID_CBL2	x		A19
56	NN	ID_CBL1	x		C18

Table 3: Signal list for for the ELCO-56 pin connector

NOTE: Artwork was done using Elco Male and female connector was used during assembly

TESTDRIVE ASM GUI

TestDrive provides a LabView based GUI that facilitates the use and configuration of the Analog Sensor Module's 16 channels. All functionalities required for to simulating an analog signal for the ECU are encompassed in the TestDrive's Analog Sensor Module GUI. Additionally, error detection tools are provided to ease troubleshooting of a system/module.

The following section details the highlighted features/functions of the graphic ASM GUI.

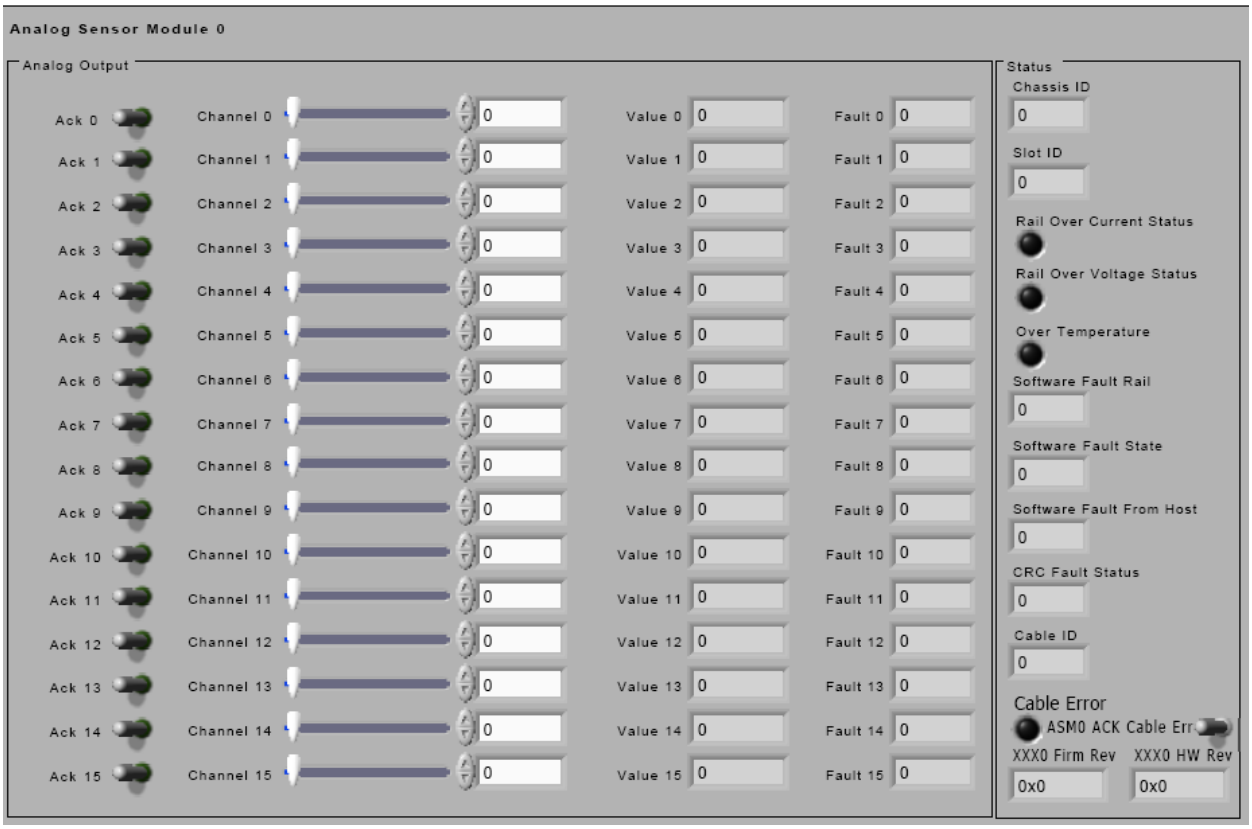


Figure 5: TestDrive Analog Sensor Module GUI

ASM GUI FEATURES & FUNCTIONALITIES

A. Channel Inputs: The GUI provides users with two means for the user to supply inputs to the 16 channels. Each channel provides has a slider bar and an incremental numerical control to input analog sensor values. Additionally, the incremental numerical control field can have any user-defined value directly entered.

B. Channel Output: The output being generated by the module for each channel can be seen in this field.

C. Fault Indicators: The 'Rail Over Current Status' and 'Over Temperature' LED indicators are used to alert the user that there is an Over Current or Thermal Shutdown error on one of the channels. The user can then refer to the fault monitoring fields of each channel to see which channel is experiencing the fault.

D. Fault Monitor: Analog Over Current (AOC) and Thermal Shutdown (TSD) faults for each channel are indicated in this field. The default value is zero (0), no faults. When an Over Current and/ or Thermal Shutdown occur, a one (1) is indicated in this field (NOTE: this applies only for rev 2 modules. Revision 1 module error reporting is as follows:

- Zero (0) No Error
- One (1) AOC fault
- Two (2) TSD fault
- Three (3) AOC & TSD fault

E. Fault Acknowledge: These toggle switches are used to acknowledge an error that may occur and to reactivate a particular channel. Note that the fault can only be acknowledged once the error condition has been corrected. If the situation hasn't been corrected the fault monitor will still show the fault and the channel won't be reactivated.

F. Software Faults: These fields report if a Software software based error has occurred on the module.

G. Chassis ID & Slot ID: These fields, respectively, report the TestDrive Chassis ID (between main and auxiliary) and the slot where the ASM has been inserted into the chassis.

H. Cable ID: The Cable ID is reported in the cable ID field. This feature must be enabled to function. and the ID for the proper cable is set from the ASM Configuration GUI (see 3.3). If a bad cable is connected or if a correct cable connection is changed or/removed, an error is indicated with the Cable Error LED. This error can be acknowledged by the Cable Error toggle switch.

I. HW & SW Revisions: The current firmware revision and hardware revisions are indicated in the XXX0 Firm Rev and XXX0 HW Rev fields (respectively).

ASM CONFIGURATION GUI

The ASM board's GUI provides a separate panel that allows the user to modify certain configurations for board operation. From selecting the 'Config' tab of the TestDrive interface, the user can access the configuration panels for all modules inserted into the system. Figure 6 details the ASM configuration panel.

From the configuration GUI the user can decide if each channel should use specific High & Low references or if they should use common references. Connection of the common references can be seen from "Table 3: Signal list for for the ELCO-56 pin connector" (this feature is exclusive to Rev2 modules).

Channels 12, 13, 14 and 15 can also be configured to have a linear, instead of ratiometric, output with respect to their references.

The user can also enable cable identification and set the desired cable value that the system should monitor for (see "Frequently asked questions" for more details).

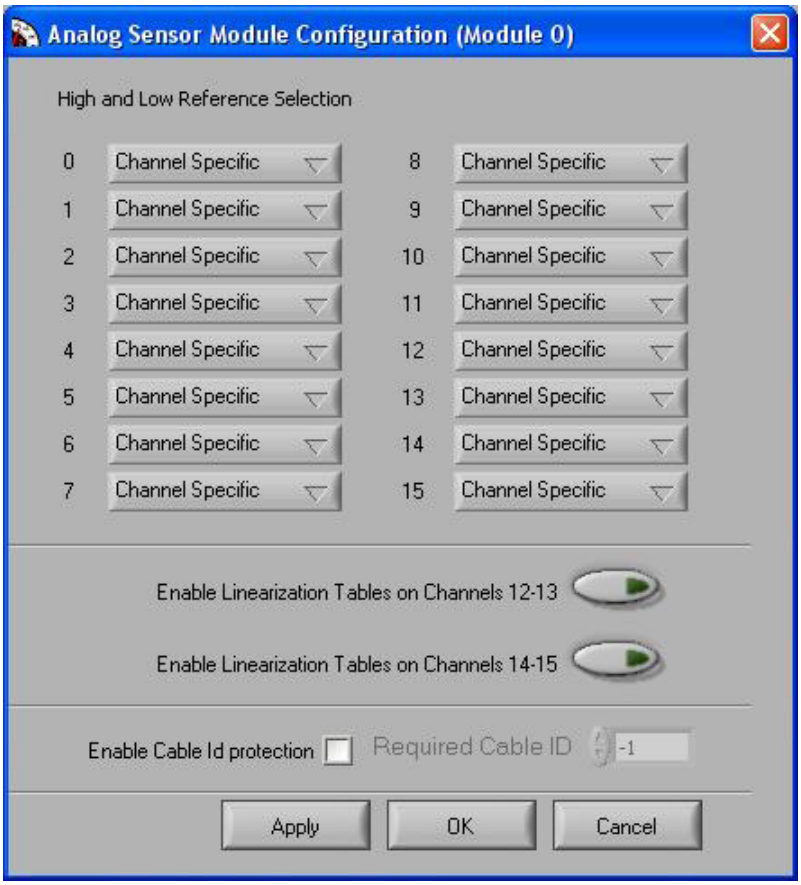


Figure 6: ASM Configuration GUI

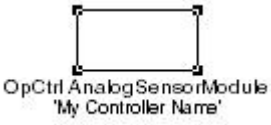
THE ASM SIMULINK MODEL

TD.mdl

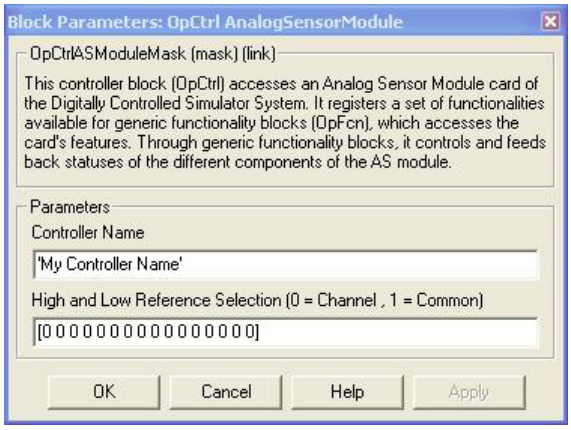
'TD.mdl' is a standard Simulink model provided with all TestDrive systems. The model is used to simulate automotive functions to the ECU. The Analog Sensor Module is a component of the overall model. The default version of 'TD.mdl' supports up to three ASMs in the TestDrive chassis (Note: the model may need to be modified to support more ASMs).

OpCtrl Analog Sensor Module

Block



Mask



Description

The "OpCtrl AnalogSensorModule" block accesses the Analog Sensor Module ASM of the same Controller Name.

The block enables the user to select the type of High and Low Reference for each channel. Each number in the High and Low Reference Selection field vector represents channels 0 to 15 from left to right. The user can modify the channel's specific number to '1' if common references are desired. The common reference values are connected externally through pins COM_REF_H and COM_REF_L (see Table 3). Note that this only applies for Rev.2 boards.

Parameters

Controller Name: The controller name specified in an OpCtrl block's Controller Name parameter enables the binding between a specific controller and it's generic functionalities.

High and Low Reference Selection: From left to right, each value of the vector represents channels 0 to 15. The user can select channel specific (0) or common (1) references for each channel by modifying the vector values.

Inputs: No Inputs.

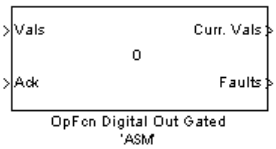
Outputs: No Outputs.

Characteristics and Limitations

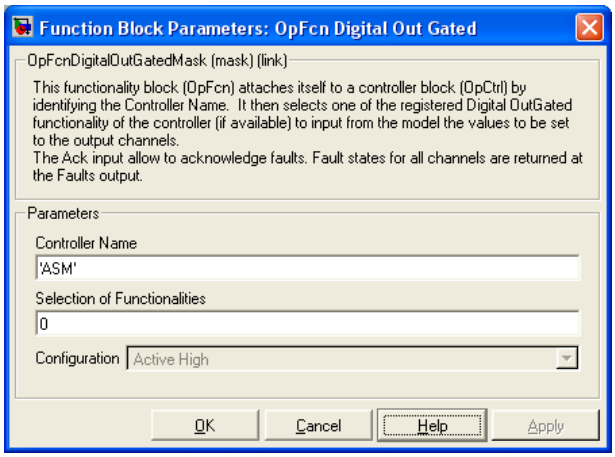
- Direct Feedthrough
- Discrete sample time
- XHP support
- Work offline

OpFcn Digital Out Gated

Block



Mask



Description

This block refers to one channel of the ASM. In such, there should be 16 entities to work with the 16 channels.

Parameters

Controller Name: Each functionality block such as the OpFcn Digital Out Gated block must refer to an OpCtrl block that will manage the data transfer with the IO board. The binding between OpFcn and OpCtrl blocks is performed via the use of the Controller name that each OpCtrl block uniquely defines. This binding is checked during the initialization phase of the model. If no OpCtrl block is found that defines the same Controller Name as this OpFcn Digital Out Gated block, the OpFcn Digital Out Gated block is simply disabled and returns 0s.

Selection of Functionalities: This field is used to determine which Analog analog output the OpFcn Digital Out Gated block is tied to. For example, to use this block to control OUT_A2, a 2 should be placed in this field. Note that if using 'td.mdl', the values of these fields default to the same corresponding switch (ex: OpFcn Digital Out Gated 0 ties to OUT_A0; OpFcn Digital Out Gated 1 ties to OUT_A1).

Inputs

Vals: This input is the value .

Ack: This input is to acknowledge faults. This means that if a fault has previously been flagged the channel receives this signal to confirm that it should stay deactivated.

Outputs

Curr. Vals: This output gives the value the hardware could approximate from the Vals input. Since the hardware as a 12 bits precision it is possible that the input field can differ slightly.

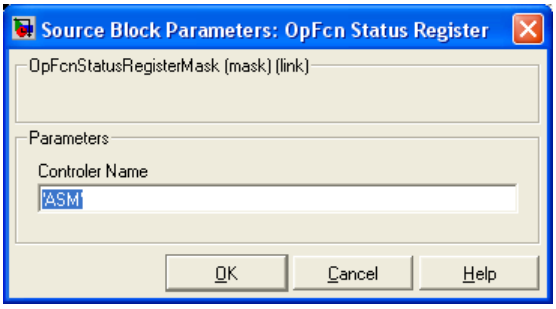
Faults: This field outputs if there was a fault detected on the channel. A fault can be due to over current overheating, etc.

Characteristics and Limitations

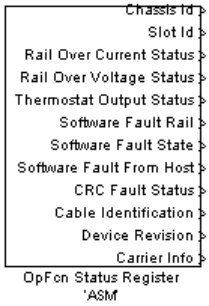
- Direct Feedthrough
- Discrete sample time
- XHP support
- Work offline

OpFcn Status Register

Block



Mask



Description

This generic Status Register functionality block, OpFcnStatusRegister, is designed to return status information from a TestDrive module board. All TestDrive boards define a similar status register that enables the user to get information regarding: board location (chassis, slot and cable identification), synchronization status and error status (over-current, over-voltage, over-temperature, software faults, communication faults). Although not all these parameters can be of interest for a given module board, the register mapping allows the use of the same OpFcnStatusRegister for all boards.

Parameters

Controller Name: The controller name uniquely specified in an OpCtrl block's parameter enables the binding between a specific controller block and the present functionality block. Binding between OpFcn and OpCtrl blocks that define the same Controller Name is performed during the initialization phase of the model. If no OpCtrl block is found that defines the same Controller Name as the OpFcnStatusRegister block, the OpFcnStatusRegister is simply disabled.

Inputs

This block has no inputs.

Outputs

Chassis Id: This output returns the number of the chassis where the board is installed. Typically this number is 0.

Slot Id: This output returns the number of the slot where the board is installed. Typically this number is 1 to 11 when the board is in a chassis, and 0 when the board is standalone.

Rail Over-Current Status: This output returns 1 when an over-current condition is detected on the board, and 0 otherwise. Acknowledgment of this error depends on the type of board.

Rail Over-Voltage Status: This output returns 1 when an over-voltage condition is detected on the board, and 0 otherwise. Acknowledgment of this error depends on the type of board.

Thermostat Output Status: This output returns 1 when an over-temperature condition is detected on the board, and 0 otherwise. Acknowledgment of this error depends on the type of board.

Software Fault Rail: This flag is more relevant for modules that support different power rail values. The flag is raised when 2 power rails are selected for the same output line.

Software Fault State: This flag is more relevant for modules that support different states values. The flag is raised when 2 states (high and low) are selected for the same output line.

Software Fault From Host: Function not available in this version.

CRC Fault Status: Function not available in this version.

Cable Identification: This output returns the state of the cable identification lines ID-CBL1-5 of the module board. The default value is 31.

Device revision: This output returns the revision number of the associated device.

Carrier Info: This output returns information about the IO card revision. This output has a size of 2 and will ultimately return the hardware revision and serial number of the board. Presently the first value is 1 if the driver detects that the card holds an EEPROM for storing revision and serial number information. The second value is presently fixed to 65535.

Characteristics and Limitations

Connector Pin Assignments:

Since the OpFcnStatusRegister block may attach itself to different boards that support the Status Register functionality, the user should refer to the documentation of his specific module board for connector pin assignments.

- Direct Feedthrough No
- Discrete sample time Yes
- XHP support Yes
- Work offline No
-

FREQUENTLY ASKED QUESTIONS

Q: What is the maximum number of ASMs that may be connected to the TestDrive System?

A: The maximum number of ASMs that can be used is dependant on the number of TestDrive chassis used. Up to 10 ASM modules can be inserted into each chassis. Note that the TestDrive model ('TD.mdl') must be modified to support this additional feature. The default model allows up to three ASMs in one TestDrive chassis.

Q: What is the module ID for the ASM and where can it be read?

A: The module ID for the ASM is 3. This is not directly visible on the default GUI of the ASM. A development level user can make modifications to the model and GUI to output the module ID.

Q: How does cable identification work?

A: Each module supports positive cable identification. Cable identification is enabled and set by the ASM Configuration GUI ("Cable Identifcation"). The user will define a value between 0 and 31. This value will be set in binary with the signals ID_CBL0 to ID_CBL4 (Table 3Table 3). The figure below depicts functionality of cable identification.

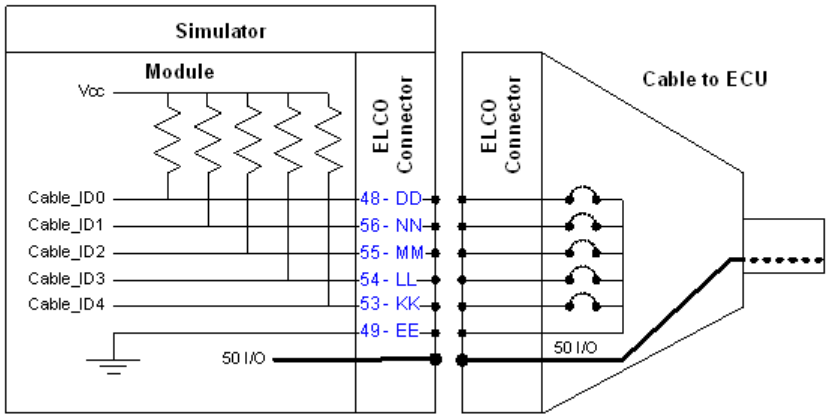


Figure 7: Cable Identifcation

The user will ground the necessary signals (Cable_ID0 to Cable_ID4) via Elco pin EE to achieve the binary equivalent of the decimal value set in the ASM Configuration panel.

A: How do I use common references for some/all of my ASM outputs?

A: This is a feature specific to Rev.2 ASM modules. The High and Low common reference can be connected to pins J and K of the Elco connector, respectively (Table 3). From the ASM Configuration panel (Figure 6), the user can select which channels can use the common references.

Q: Can I vary my output linearly instead of ratiometrically between the High and Low references?

A: ASM channels 12 to 15 allow for linearization of outputs. These options must be enabled from the ASM Configuration Panel (Figure 6). Note that this feature is only available on Rev. 2 ASMs.

Q: Is it possible to control the linear relation (gain and offset) of outputs 12 to 15?

A: Using RT-Lab, from td.mdl, the user can modify the gain and offset of channels 12 to 15 to any desired set of values. Note that the linearization option for these channels must be enabled for the changes to take effect.

Q: What is the relation between the rail voltages and the ASM? Is it necessary to power the rail to have the ASM working?

A: There is no implied relation between the rail and the ASM. It is not necessary to power the rail to operate the ASM. It is possible to use the rail voltages (ex: Batt and GND) as the high and low references for a specific channel.

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