## SIEMENS



Operating instructions

## SINAMICS

## G150 NEMA

Converter cabinet units
150 HP (110 kW) ... 800 HP (560 kW)

## SIEMENS

## Preface

Safety instructions

## SINAMICS

## SINAMICS G150 NEMA Converter cabinet units

Operating Instructions
Commissioning

## Operation

Setpoint channel and closed- ..... 7 loop control

## Electrical installation

Output terminalsFunctions, monitoring and protective functions ..... 9
Diagnostics / faults and alarms ..... 10
Maintenance and servicing ..... 11
Technical specifications12
Appendix

## Legal information

## Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

## ! DANGER

indicates that death or severe personal injury will result if proper precautions are not taken.

## WARNING

indicates that death or severe personal injury may result if proper precautions are not taken.

## CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

## NOTICE

indicates that property damage can result if proper precautions are not taken.
If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

## Qualified Personnel

The product/system described in this documentation may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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## Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

## Preface

## Structure of this documentation

The customer documentation comprises general and individual documentation.
The general documentation describes the topics that apply to all cabinet units:

- Operating Instructions

The Operating Instructions consist of the following sections:

- Device description
- Mechanical installation
- Electrical installation
- Commissioning guide
- Description of function
- Maintenance instructions
- Technical specifications
- List Manual

The List Manual consists of the following parts:

- Parameter list
- Function diagrams
- Fault / alarm list
- Documentation for Drive Control Chart (DCC)
- Programming and Operating Manual: DCC Editor description
- Function Manual: Description of the standard DCC blocks

The individual documentation describes a specific configured cabinet unit and contains the following:

- Dimension drawing

The dimension drawing documents the dimensions of the ordered cabinet unit.

- Layout diagram

The layout diagram shows the components installed in the ordered cabinet unit along with the equipment identifiers and location designations.

- Circuit diagram

The circuit diagram shows the electrical components installed in the ordered encoder unit with the equipment identifiers and location designations, their interconnections, and the customer interfaces.

## - Terminal diagram

The terminal diagram shows all the customer terminals in the ordered cabinet unit and the associated internal wiring in the cabinet unit. This diagram documents the line-side target wiring.

- Spare parts list

The spare parts list contains all the available spare parts for the ordered cabinet unit.

- Additional operating instructions

The instructions for supplier components installed in the ordered cabinet unit are included as original documentation.

## Technical support

Technical advice is available at the following address:

- Phone.: 1-800-333-7421 (within USA, toll free)

Tel.: +1(423)262-5710 (outside USA)

- Online request: www.siemens.com/automation/support-request


## Customer service, field service, spare parts and repair

- helpline.sii@siemens.com Tel.: 1-800-241-4453 (within USA, toll free) Tel.: +1(423)262-5711 (outside USA)


## Internet address

Information about SINAMICS can be found on the Internet at the following address: http://www.siemens.com/sinamics

## EMC limits for South Korea

```
이 기기는 업무용(A급) 전자파적합기기로서 퐌매자 또는 사용자는 이 점을 주의하시기 바라며,
가정외의 지역에서 사용하는 것을 목적으로 합니다.
For sellers or other user, please keep in mind that this device in an A-grade electromagnetic wave device. This device is intended to be used in areas other than home.
```

The EMC limits to be observed for Korea correspond to the limits of the EMC product standard for variable-speed electric drives EN 61800-3 of category C2 or the limit class A, Group 1 according to EN 55011.
By implementing appropriate additional measures, the limit values according to category C2 or limit value class A, Group 1, are complied with. Additional measures, such as the use of an additional RFI suppression filter (EMC filter), may be necessary. In addition, measures for proper plant design to meet EMC requirements are described in detail in this manual and the "SINAMICS Low Voltage Configuration Manual".

## Certification

The following manufacturing sites have a UL listing for the manufacture of Industrial Control Panels and Control Panel Enclosures:

- Siemens Industry Inc.

500 Hunt Valley Rd, New Kensington, PA 15068-7060, USA
UL file \# E83449

- Siemens AG

Vogelweiherstrasse 1-15, 90441 Nuremberg, Germany UL file \# E251147

Use of OpenSSL
This product contains software (https://www.openssl.org/) that has been developed by the OpenSSL project for use in the OpenSSL toolkit.

This product contains cryptographic software (mailto:eay@cryptsoft.com) created by Eric Young.

This product contains software (mailto:eay@cryptsoft.com) developed by Eric Young.

## Table of contents

Preface ..... 3
1 Safety instructions ..... 17
1.1 General safety instructions ..... 17
1.2 Handling the AOP30 backup battery ..... 22
$1.3 \quad$ Handling electrostatic sensitive devices (ESD) ..... 23
1.4 Industrial security ..... 24
1.5 Residual risks of power drive systems ..... 25
2 Device overview ..... 27
2.1 Chapter content ..... 27
2.2 Applications, Features ..... 27
2.2.1 Area of application ..... 27
2.2.2 Features, quality, service ..... 28
2.3 Design ..... 29
2.3.1 Enclosed drive type A ..... 30
2.3.2 Enclosed chassis type C ..... 31
2.4 Block diagram ..... 32
2.5 Nameplate ..... 34
3 Mechanical installation ..... 39
$3.1 \quad$ Content of this chapter ..... 39
3.2 Transportation and storage ..... 39
3.3 Installation ..... 41
3.3.1 Mechanical installation: Checklist ..... 42
3.3.2 Preparation ..... 43
3.3.2.1 Requirements for installation location ..... 43
3.3.2.2 Requirements on the levelness of the floor ..... 44
3.3.2.3 Shipping and handling indicators ..... 45
3.3.2.4 Unpacking ..... 47
3.3.2.5 Required tools ..... 47
3.3.3 Installation ..... 47
3.3.3.1 Lifting the enclosure off the transport pallet ..... 47
3.3.3.2 Disassembling the lifting hardware ..... 49
3.3.3.3 Connection to the foundation ..... 51
3.3.4 Changing the enclosure type, options M23 and M54 ..... 51
3.3.5 Motor connection from above (option M78) ..... 52
3.3.6 Mechanical door lock (option M39) ..... 53
4 Electrical installation ..... 55
4.1 Content of this chapter ..... 55
4.2 Checklist for electrical installation ..... 56
4.3 Important safety precautions ..... 61
4.4 Introduction to EMC ..... 62
4.5 EMC-compliant design ..... 64
$4.6 \quad$ Power connections ..... 66
4.6.1 Cable lugs ..... 67
4.6.2 Connection cross-sections, cable lengths ..... 68
4.6.3 Connection of shielded three-phase current cables ..... 69
4.6.4 Connecting the motor and power cables ..... 70
4.6.5 $\quad$ Adjusting the fan voltage ( - T1-T10) ..... 73
4.6.6 Adjusting the internal power supply (-A1 -T10, enclosed drive type A only) ..... 75
4.6.7 Removing the connection clip for the basic interference suppression module for operation on an ungrounded / IT power network ..... 76
4.7 External supply of the auxiliary supply from a secure line ..... 81
4.7.1 $\quad 115 \mathrm{~V} \mathrm{AC}$ auxiliary supply ..... 82
4.7.2 24 V DC auxiliary supply ..... 82
$4.8 \quad$ Signal connections ..... 82
4.8.1 Control Unit CU320-2 DP ..... 82
4.8.2 $\quad$ Customer terminal module ..... 97
4.8.2.1 Customer terminal block (-A60) (for types A and C) ..... 99
4.8.2.2 Customer terminal block ( -X65) (for type A with option G65) ..... 101
4.8.2.3 Terminal descriptions ..... 103
4.9 Other connections ..... 109
4.9.1 dv/dt filter plus Voltage Peak Limiter (option L10) ..... 110
4.9.2 Input contactor (option L13) ..... 113
4.9.3 Feeder for external auxiliaries / motor blower (option L17) ..... 114
4.9.4 3-contactor bypass (option L29) ..... 115
4.9.5 Soft starter bypass (option L30) ..... 117
4.9.6 Enclosure light with service socket (option L50) ..... 118
4.9.7 Enclosure space heater (option L55) ..... 119
4.9.8 ALL STOP, coast to stop (option N55) ..... 120
4.9.9 EMERGENCY OFF category 0; 115 V AC or 24 V DC (option N57) ..... 120
4.9.10 EMERGENCY STOP category 1; 115 V AC (option N59) ..... 122
4.9.11 EMERGENCY STOP category 1; 24 V DC (option L60) ..... 123
4.9.12 $25-\mathrm{kW}$ braking unit (option L61); 50-kW braking unit (option L62) ..... 124
4.9.12.1 Commissioning ..... 128
4.9.12.2 Diagnostics and duty cycles ..... 129
4.9.12.3 Threshold switch ..... 130
4.9.13 Line-side surge arrester (option L96) ..... 134
4.9.14 RTD monitor (option L97) ..... 134
4.9.15 Insulation monitor (option L87) ..... 135
4.9.16 Control power supply, 120 V AC, 5 A (option N70) ..... 137
4.9.17 CAN Communication Board CBC10 (option G20) ..... 139
4.9.1 PROFINET Communication Board CBE20 (option G33) ..... 142
4.9.19 Temperature sensor module TM150 (option G51) ..... 145
4.9.19.1 Description ..... 145
4.9.19.2 Connecting ..... 146
4.9.19.3 Connection examples ..... 149
4.9.20 Sensor Module Cabinet-Mounted SMC30 (option K50) ..... 151
4.9.20.1 Description ..... 151
4.9.20.2 Connection ..... 155
4.9.20.3 Connection examples ..... 158
4.9.21 Voltage Sensing Module for determining the actual motor speed and the phase angle (option K51) ..... 159
4.9.22 Additional SMC30 Sensor Module Cabinet-Mounted (option K52) ..... 160
4.9.23 Additional customer terminal block TM31 (option G61) ..... 161
4.9.24 TM31 wired to customer terminal block (option G65) ..... 161
4.9.25 Safety license for 1 axis (option K01) ..... 162
4.9.26 Terminal module for activation of "Safe Torque Off" and "Safe Stop 1" (option K82) ..... 163
4.9.27 TM54F Terminal Module (option K87) ..... 164
4.9.28 Safe Brake Adapter SBA 230 V AC (option K88) ..... 166
4.9.29 Control Unit CU320-2 PN (option K95) ..... 168
5 Commissioning ..... 181
$5.1 \quad$ Chapter content ..... 181
$5.2 \quad$ The STARTER commissioning tool ..... 182
5.2.1 Installing the STARTER commissioning tool ..... 184
5.2.2 Layout of the STARTER user interface ..... 184
5.3 Procedure for commissioning via STARTER ..... 185
5.3.1 Creating the project ..... 185
5.3.2 Configuring the drive unit ..... 193
5.3.3 Transferring the drive project ..... 218
5.3.4 Commissioning with STARTER via Ethernet ..... 220
5.4 Operator panel AOP30 ..... 226
5.5 First commissioning with the AOP30 ..... 227
5.5.1 Initial startup ..... 227
5.5.2 Basic commissioning ..... 229
5.6 Status after commissioning ..... 237
5.7 Commissioning an encoder with gear factor ..... 238
5.8 Parameter reset to factory settings ..... 239
6 Operation ..... 241
6.1 Chapter content ..... 241
6.2 General information about command and setpoint sources ..... 242
6.3 Basic information about the drive system ..... 243
6.3.1 Parameters ..... 243
6.3.2 Drive objects ..... 246
6.3.3 Data sets ..... 247
6.3.4 BICO technology: Interconnecting signals ..... 253
6.3.5 Propagation of faults ..... 259
6.4 Command sources ..... 260
6.4.1 "PROFIdrive" default setting ..... 260
6.4.2 "TM31 terminals" default setting ..... 262
6.5 Setpoint sources ..... 264
6.5.1 Analog inputs ..... 264
6.5.2 Motorized potentiometer ..... 266
6.5.3 Fixed speed setpoints ..... 267
6.6 Control via the operator panel ..... 269
6.6.1 Operator panel (AOP30) overview and menu structure ..... 269
6.6.2 Operation screen menu ..... 271
6.6.3 Parameterization menu ..... 272
6.6.4 Fault/alarm memory menu ..... 274
6.6.5 Commissioning/service menu ..... 275
6.6.5.1 Drive commissioning ..... 275
6.6.5.2 Device commissioning ..... 275
6.6.5.3 Drive diagnostics ..... 276
6.6.5.4 AOP settings ..... 277
6.6.5.5 AOP diagnostics. ..... 284
6.6.6 Language selection ..... 286
6.6.7 Operation via the operator panel (LOCAL mode) ..... 286
6.6.7.1 LOCAL/REMOTE key ..... 287
6.6.7.2 ON key / OFF key ..... 287
6.6.7.3 CCW/CW selection ..... 288
6.6.7.4 Jog ..... 288
6.6.7.5 Increase setpoint / decrease setpoint ..... 288
6.6.7.6 AOP setpoint ..... 289
6.6.7.7 Inhibit AOP LOCAL mode ..... 290
6.6.7.8 Acknowledge fault from the AOP ..... 290
6.6.7.9 CDS setting via AOP ..... 290
6.6.7.10 Operator input inhibit / Parameterization inhibit. ..... 291
6.6.8 Faults and alarms. ..... 292
6.6.9 Saving the parameters permanently ..... 294
6.6.10 Parameterization errors ..... 294
6.7 Communication according to PROFIdrive ..... 295
6.7.1 General information ..... 295
6.7.2 Application classes ..... 297
6.7.3 Cyclic communication ..... 298
6.7.3.1 Message frames and process data ..... 299
6.7.3.2 Structure of the message frames ..... 301
6.7.3.3 Overview of control words and setpoints ..... 302
6.7.3.4 Overview of status words and actual values. ..... 303
6.7.4 Acyclic communication ..... 303
6.7.4.1 Structure of requests and responses ..... 305
6.7.4.2 Determining the drive object numbers ..... 311
6.7.4.3 Example 1: Reading parameters ..... 311
6.7.4.4 Example 2: Writing parameters (multi-parameter request) ..... 313
6.7.5 Diagnostic channels ..... 317
6.7.5.1 Diagnostics via PROFINET ..... 318
6.7.5.2 Diagnostics via PROFIBUS ..... 320
6.7.6 Further information about PROFIdrive communication ..... 324
6.8 Communication via PROFIBUS DP ..... 325
6.8.1 PROFIBUS port ..... 325
6.8.2 Control via PROFIBUS ..... 330
6.8.3 Monitoring: Message frame failure ..... 332
6.8.4 Further information about communication via PROFIBUS DP ..... 333
6.9 Communication via PROFINET IO ..... 333
6.9.1 Activating online operation: STARTER via PROFINET IO ..... 333
6.9.2 General information about PROFINET IO ..... 337
6.9.2.1 General information about PROFINET IO for SINAMICS ..... 337
6.9.2.2 Real-time (RT) and isochronous real-time (IRT) communication ..... 338
6.9.2.3 Addresses ..... 339
6.9.2.4 Data transmission ..... 341
6.9.2.5 Communication channels ..... 342
6.9.3 Communication with CBE20 ..... 343
6.9.3.1 Selecting the CBE20 firmware ..... 343
6.9.3.2 EtherNet/IP ..... 344
6.9.4 PROFINET media redundancy ..... 344
6.9.5 PROFINET system redundancy ..... 345
6.9.5.1 Overview ..... 345
6.9.5.2 Design, configuring and diagnostics ..... 346
6.9.5.3 Faults, alarms and parameters ..... 347
6.9.6 PROFlenergy ..... 348
6.9.6.1 Description ..... 348
6.9.6.2 Tasks of PROFlenergy ..... 349
6.9.6.3 PROFlenergy - Properties of the drive system ..... 349
6.9.6.4 PROFlenergy - Commands ..... 350
6.9.6.5 PROFIenergy - Measurement values ..... 351
6.9.6.6 PROFIenergy - Energy-saving mode ..... 351
6.9.6.7 Transition to energy-saving mode from PROFIdrive Operation state (S4) ..... 352
6.9.6.8 Disabling PROFlenergy and pause time ..... 352
6.9.6.9 PROFIenergy applications ..... 353
6.9.6.10 Function diagrams and parameters ..... 353
6.9.7 Support of I\&M data sets 1... 4 ..... 353
6.9.8 Further information about communication via PROFINET IO ..... 356
6.10 Communication via SINAMICS Link ..... 356
6.10.1 Basic principles of SINAMICS Link ..... 356
6.10.2 Topology ..... 358
6.10.3 Configuring and commissioning ..... 360
6.10.4 Example ..... 365
6.10.5 Communication failure when booting or in cyclic operation ..... 367
6.10.6 Transmission times for SINAMICS Link ..... 368
6.10.7 Function diagrams and parameters ..... 369
6.11 Communication via EtherNet/IP ..... 370
6.11.1 Overview ..... 370
6.11.2 Connect drive device to Ethernet/IP ..... 370
6.11.3 Configuring communication ..... 371
6.11.4 Supported objects ..... 372
6.11.5 Integrate the drive device into the Ethernet network via DHCP ..... 381
6.11.6 Parameters, faults and alarms ..... 382
6.12 Communication via MODBUS TCP ..... 383
6.12.1 Overview ..... 383
6.12.2 Configuring Modbus TCP via interface X150 ..... 384
6.12.3 Configuring Modbus TCP via interface X1400 ..... 385
6.12.4 Mapping tables. ..... 386
6.12.5 Write and read access using function codes ..... 389
6.12.6 Communication via data set 47 ..... 391
6.12.6.1 Communication details ..... 392
6.12.6.2 Examples: Read parameters ..... 393
6.12.6.3 Examples: Write parameter ..... 394
6.12.7 Communication procedure. ..... 395
6.12.8 Parameters, faults and alarms ..... 396
6.13 Communication services and used port numbers ..... 397
6.14 Parallel operation of communication interfaces ..... 399
6.15 Engineering Software Drive Control Chart (DCC) ..... 403
7 Setpoint channel and closed-loop control ..... 405
7.1 Chapter content ..... 405
7.2 Setpoint channel ..... 406
7.2.1 Setpoint addition ..... 406
7.2.2 Direction reversal ..... 407
7.2.3 Skip frequency bands and minimum speed ..... 408
7.2.4 Speed limiting ..... 409
7.2.5 Ramp-function generator ..... 410
7.3 V/f (V/Hz) control ..... 414
7.3.1 Voltage boost ..... 417
7.3.2 Resonance damping ..... 420
7.3.3 Slip compensation ..... 421
7.4 Vector speed/torque control with/without an encoder ..... 423
7.4.1 Vector control without an encoder ..... 424
7.4.2 Vector control with encoder ..... 431
7.4.3 Actual speed value filter ..... 432
7.4.4 Speed controller ..... 433
7.4.4.1 Speed controller feedfoward control (integrated feedfoward control with balancing) ..... 436
7.4.4.2 Reference model ..... 438
7.4.4.3 Speed controller adaptation ..... 440
7.4.4.4 Droop ..... 442
7.4.4.5 Open actual speed value ..... 444
7.4.5 Torque control ..... 446
7.4.6 Torque limiting. ..... 448
7.4.7 Current setpoint filter ..... 450
7.4.8 Current controller adaptation ..... 451
7.4.9 Permanent-magnet synchronous motors ..... 452
8 Output terminals ..... 455
8.1 Chapter content ..... 455
8.2 Analog outputs ..... 456
8.2.1 List of signals for the analog signals ..... 457
8.3 Digital outputs ..... 459
9 Functions, monitoring and protective functions ..... 461
9.1 Content of this chapter ..... 461
9.2 Drive functions ..... 462
9.2.1 Motor data identification and automatic speed controller optimization ..... 462
9.2.1.1 Motor data identification ..... 463
9.2.1.2 Rotating measurement and speed controller optimization ..... 466
9.2.1.3 Shortened rotating measurement ..... 468
9.2.1.4 Parameters ..... 469
9.2.2 Efficiency optimization ..... 469
9.2.3 Fast magnetization for induction motors ..... 471
9.2.4 Vdc control ..... 473
9.2.5 Automatic restart function ..... 478
9.2.6 Flying restart ..... 481
9.2.6.1 Flying restart without an encoder ..... 482
9.2.6.2 Flying restart with an encoder ..... 485
9.2.6.3 Parameters ..... 486
9.2.7 Checking for a short-circuit/ground fault at a motor ..... 487
9.2.8 Motor changeover ..... 488
9.2.8.1 Description ..... 488
9.2.8.2 Example of changing over between two motors ..... 488
9.2.8.3 Function diagrams ..... 489
9.2.8.4 Parameters ..... 490
9.2.9 Friction Characteristic ..... 491
9.2.10 Armature short-circuit braking, DC braking ..... 493
9.2.10.1 General information ..... 493
9.2.10.2 External armature short-circuit braking ..... 493
9.2.10.3 Internal armature short-circuit braking ..... 495
9.2.10.4 DC braking ..... 496
9.2.11 Increasing the output frequency ..... 498
9.2.11.1 Description ..... 498
9.2.11.2 Default pulse frequencies ..... 499
9.2.11.3 Increasing the pulse frequency ..... 499
9.2.11.4 Maximum output frequency achieved by increasing the pulse frequency ..... 500
9.2.11.5 Parameters ..... 500
9.2.12 Derating behavior with increased pulse frequency ..... 501
9.2.13 Pulse frequency wobbling ..... 502
9.2.14 Runtime (operating hours counter) ..... 504
9.2.15 Simulation mode ..... 505
9.2.16 Direction reversal ..... 506
9.2.17 Switching unit systems (SI/US/\%) ..... 508
9.2.18 Simple brake control ..... 510
9.2.19 Synchronization ..... 513
9.2.20 Energy savings indicator for pumps, fans, and compressors ..... 514
9.2.21 Write protection ..... 517
9.2.22 Know-how protection ..... 519
9.2.22.1 Description ..... 519
9.2.22.2 Activating know-how protection ..... 521
9.2.22.3 Deactivating know-how protection ..... 522
9.2.22.4 Changing the know-how protection password ..... 523
9.2.22.5 OEM exception list ..... 523
9.2.22.6 Memory card copy protection ..... 524
9.2.22.7 Spare part replacement when know-how protection with copy protection is activated ..... 524
9.2.22.8 Overview of important parameters ..... 525
9.2.23 Emergency operation ..... 526
9.2.24 Web server ..... 530
9.2.24.1 Description ..... 530
9.2.24.2 Starting the Web server ..... 532
9.2.24.3 Web server configuration ..... 534
9.2.24.4 Display areas ..... 535
9.2.24.5 Overview of important parameters ..... 537
9.3 Extended functions ..... 537
9.3.1 Technology controller ..... 537
9.3.2 Bypass function. ..... 540
9.3.2.1 Synchronized bypass with overlap (p1260=1) ..... 541
9.3.2.2 Synchronized bypass without overlap (p1260 = 2) ..... 544
9.3.2.3 Bypass without synchronization (p1260 = 3) ..... 546
9.3.2.4 Function diagram ..... 548
9.3.2.5 Parameters. ..... 548
9.3.3 Extended brake control ..... 549
9.3.4 Extended monitoring functions ..... 554
9.3.5 Moment of inertia estimator ..... 556
9.4 Monitoring functions and protective functions ..... 562
9.4.1 Power unit protection, general ..... 562
9.4.2 Thermal monitoring and overload responses ..... 563
9.4.3 Blocking protection ..... 565
9.4.4 Stall protection (vector control only) ..... 566
9.4.5 Thermal motor protection. ..... 567
9.4.5.1 Description ..... 567
9.4.5.2 Temperature sensor connection to customer terminal module TM31 (option G60) ..... 567
9.4.5.3 Temperature sensor connection to a sensor module (option K50) ..... 568
9.4.5.4 Temperature sensor connection directly to the control interface module ..... 569
9.4.5.5 Temperature sensor evaluation ..... 570
9.4.5.6 Thermal motor models ..... 571
9.4.5.7 Function diagrams ..... 574
9.4.5.8 Parameters. ..... 574
9.4.6 Temperature measurement via TM150 (option G51) ..... 575
9.4.6.1 Description ..... 575
9.4.6.2 Measurement with up to 6 channels ..... 577
9.4.6.3 Measurement with up to 12 channels ..... 577
9.4.6.4 Forming groups of temperature sensors ..... 578
9.4.6.5 Evaluation of temperature channels ..... 579
9.4.6.6 Function diagrams ..... 580
9.4.6.7 Parameters. ..... 580
10 Diagnostics / faults and alarms ..... 581
10.1 Chapter content ..... 581
10.2 Diagnostics ..... 582
10.2.1 Diagnostics via LEDs ..... 582
10.2.2 Diagnostics via parameters ..... 589
10.2.3 Indicating and rectifying faults ..... 593
10.3 Overview of alarms and faults ..... 594
10.3.1 "External alarm 1" ..... 594
10.3.2 "External fault 1" ..... 595
10.3.3 "External fault 2" ..... 596
10.3.4 "External fault 3" ..... 596
11 Maintenance and servicing ..... 597
11.1 Chapter content ..... 597
11.2 Maintenance ..... 598
11.2.1 Cleaning ..... 598
11.3 Servicing ..... 599
11.3.1 Installation device ..... 600
11.3.2 Using lifting lugs to transport power blocks ..... 601
11.4 Replacing components ..... 603
11.4.1 Replacing the filter mats ..... 603
11.4.2 Replacing the Control Interface Module, frame size FX ..... 604
11.4.3 Replacing the Control Interface Module, frame size GX ..... 606
11.4.4 Replacing the Control Interface Module, frame size HX ..... 608
11.4.5 Replacing the Control Interface Module, frame size JX ..... 610
11.4.6 Replacing the power block, frame size FX ..... 612
11.4.7 Replacing the power block, frame size GX ..... 615
11.4.8 Replacing the power block, frame size HX ..... 618
11.4.9 Replacing the power block, frame size JX ..... 623
11.4.10 Replacing the fan, frame size FX ..... 628
11.4.11 Replacing the fan, frame size GX ..... 630
11.4.12 Replacing the fan, frame size HX ..... 632
11.4.13 Replacing the fan, frame size JX ..... 636
11.4.14 Replacing cylindrical fuses ..... 640
11.4.15 Replacing the LV HRC fuses ..... 641
11.4.16 Replacing the door-mounted operator panel ..... 643
11.4.17 Replacing the backup battery for the door-mounted operator panel ..... 643
11.5 Forming the DC link capacitors ..... 645
11.6 Messages after replacement of DRIVE-CLiQ components ..... 646
11.7 Upgrading the drive firmware ..... 647
11.8 Downloading new operator panel firmware from the PC ..... 648
12 Technical specifications ..... 649
12.1 Chapter content. ..... 649
12.2 General specifications ..... 650
12.2.1 Derating data ..... 651
12.2.1.1 Current derating as a function of the ambient temperature ..... 651
12.2.1.2 Installation altitudes over 6.600 ft and up to 16.500 ft above MSL ..... 652
12.2.1.3 Current derating as a function of the pulse frequency ..... 654
12.2.2 Overload capability ..... 655
12.3 Technical specifications ..... 657
12.3.1 Enclosed drive type A, 380 V-480 V 3 AC ..... 658
12.3.2 Enclosed chassis type C, $380 \mathrm{~V}-480 \mathrm{~V} 3 \mathrm{AC}$ ..... 661
12.3.3 Enclosed drive type A, 500 V-600 V 3 AC ..... 667
12.3.4 Enclosed chassis type C, $500 \mathrm{~V}-600 \mathrm{~V} 3 \mathrm{AC}$ ..... 670
A Appendix ..... 677
A. 1 Acronyms and abbreviations ..... 677
A. 2 Parameter macros ..... 679
Index ..... 691

## Safety instructions

### 1.1 General safety instructions

## DANGER

Lockout/Tagout is designed for your safety
Lockout/Tagout is a safety procedure that neutralizes and secures hazardous energy in a machine, device, or system so that employees can work on it safely. Lockout/Tagout rules and procedures are found in OSHA regulation - 29 CFR 1910.147- The Control of Hazardous Energy (Lockout/Tagout). You can read the regulation on the OSHA website: http://www.osha.gov.

These are the 6 steps for accomplishing lockout/tagout

1. Prepare for shutdown

This includes notifying team members who will be affected by the procedure.
2. Shut down the machine

This may involve reviewing the procedure to make sure that it was done correctly.
3. Identify all the hazardous energy sources

Electricity is just one source. Be sure to identify "hidden" sources of energy, these may be residual energy or stored energy sources.
4. Isolate or neutralize all hazardous energy sources

This includes closing switches, grounding or short-circuiting, closing valves, and other actions.
5. Lock the energy sources

This is usually done at the same time you perform step 4 . Be sure to neutralize the residual energy and stored energy sources.
6. Verify your lockout procedure

Make sure that the machine is completely locked out... and that you have the right machine!

## ! WARNING

Electric shock and danger to life due to other energy sources
Touching live components can result in death or serious injury.

- Only work on electrical equipment if you are appropriately qualified.
- Always observe the country-specific safety rules for all work.

Generally, the following steps apply when establishing safety:

1. Prepare for disconnection. Notify all those who will be affected by the procedure.
2. Isolate the drive system from the power supply and take measures to prevent it being switched back on again.
3. Wait until the discharge time specified on the warning labels has elapsed.
4. Check that there is no voltage between any of the power connections, and between any of the power connections and the protective conductor connection.
5. Check to determine whether any auxiliary circuits are de-energized.
6. Ensure that the motors cannot move.
7. Identify all other dangerous energy sources, e.g., compressed air, hydraulic, or water. Switch the energy sources to a safe state.
8. Check that the correct drive system is completely locked.

After you have completed the work, restore the operational readiness by following the above steps in the reverse order.


## ! WARNING

Electric shock due to connection to an unsuitable power supply
When equipment is connected to an unsuitable power supply, exposed components may carry a hazardous voltage that might result in serious injury or death.

- Only use power supplies that provide SELV (Safety Extra Low Voltage) or PELV (Protective Extra Low Voltage) output voltages for all connections and terminals of the electronics modules.


## ! WARNING

## Electric shock due to equipment damage

Improper handling may cause damage to equipment. In the case of damaged devices, hazardous voltages can be present at the enclosure or at exposed components. If touched, these can result in death or severe injury.

- Ensure compliance with the limits specified in the technical specifications during transport, storage, and operation.
- Do not use any damaged devices.



## A. warning

## Electric shock due to unconnected cable shield

Hazardous contact voltages can occur as a result of capacitive cross-coupling due to unconnected cable shields.

- Connect cable shields and unused cores of power cables (e.g. brake cores) at least on one end at the grounded enclosure potential.



## A. warning

Electric shock if there is no ground connection
When the ground connection of devices with protection class I is missing or incorrectly implemented, high voltages can be present at open, exposed parts, which when touched, can result in death or severe injury.

- Ground the device in compliance with the applicable regulations.



## ! WARNING

Arcing when a plug connection is opened during operation
Opening a plug connection when a system is in operation can result in arcing that may cause serious injury or death.

- Only open plug connections when the equipment is in a voltage-free state, unless it has been explicitly stated that they can be opened in operation.



## WARNING

Electric shock due to residual charges in power components
Because of the capacitors, a hazardous voltage is present for up to 5 minutes after the power supply has been switched off. Contact with live parts can result in death or serious injury.

- Wait for 5 minutes before you check that the unit really is in a no-voltage condition and start work.


## NOTICE

Property damage due to loose power connections
Insufficient tightening torques or vibration can result in loose power connections. This can result in damage due to fire, device defects or malfunctions.

- Tighten all power connections to the prescribed torque.
- Check all power connections at regular intervals, particularly after equipment has been transported.


## ! WARNING

Spread of fire from built-in devices
In the event of fire outbreak, the enclosures of built-in devices cannot prevent the escape of fire and smoke. This can result in serious personal injury or property damage.

- Install built-in units in a suitable metal cabinet in such a way that personnel are protected against fire and smoke, or take other appropriate measures to protect personnel.
- Ensure that smoke can only escape via controlled and monitored paths.


## ! WARNING

Failure of pacemakers or implant malfunctions due to electromagnetic fields
Electromagnetic fields (EMF) are generated by the operation of electrical power equipment, such as transformers, converters, or motors. People with pacemakers or implants in the immediate vicinity of this equipment are at particular risk.

- If you have a heart pacemaker or implant, maintain a minimum distance of 2 m from electrical power equipment.


## ! WARNING

Unexpected movement of machines caused by radio devices or mobile phones
When radio devices or mobile phones with a transmission power > 1 W are used in the immediate vicinity of components, they may cause the equipment to malfunction.
Malfunctions may impair the functional safety of machines and can therefore put people in danger or lead to property damage.

- If you come closer than around 2 m to such components, switch off any radio devices or mobile phones.
- Use the "SIEMENS Industry Online Support App" only on equipment that has already been switched off.


## ! WARNING

## Motor fire in the event of insulation overload

A ground fault in an IT system produces greater stress on the motor insulation. If the insulation fails, it is possible that death or severe injury can occur as a result of smoke and fire.

- Use a monitoring device that signals an insulation fault.
- Correct the fault as quickly as possible so that the motor insulation is not overloaded.


## WARNING

Fire due to inadequate ventilation clearances
Inadequate ventilation clearances can cause overheating of components with subsequent fire and smoke. This can cause severe injury or even death. This can also result in increased downtime and reduced service lives for devices/systems.

- Ensure compliance with the specified minimum clearance as ventilation clearance for the respective component.


## WARNING

Unrecognized dangers due to missing or illegible warning labels
Dangers might not be recognized if warning labels are missing or illegible. Unrecognized dangers may cause accidents resulting in serious injury or death.

- Check that the warning labels are complete based on the documentation.
- Attach any missing warning labels to the components, where necessary in the national language.
- Replace illegible warning labels.


## NOTICE

## Device damage caused by incorrect voltage/insulation tests

Incorrect voltage/insulation tests can damage the device.

- Disconnect the devices before carrying out a voltage/insulation test of the machine/system, because all drives and motors have been high voltage-tested at the manufacturer, and therefore it is not necessary to perform an additional test within the machine/system.


## WARNING

## Unexpected movement of machines caused by inactive safety functions

Inactive or non-adapted safety functions can trigger unexpected machine movements that may result in serious injury or death.

- Observe the information in the appropriate product documentation before commissioning.
- For safety-relevant functions, carry out a safety analysis of the entire system, including all safety-relevant components.
- Assign parameters appropriately to ensure that the utilized safety functions are adapted to your drives and automation tasks and are activated.
- Perform a function test
- Only put your plant into productive operation after you have ensure the correct sequence of the safety-relevant functions.


## Note

Important safety instructions for Safety Integrated functions
If you want to use Safety Integrated functions, you must observe the safety instructions in the Safety Integrated manuals.

### 1.2 Handling the AOP30 backup battery

4. Warning

Risk of explosion and release of harmful substances
Improper handling of lithium batteries can result in an explosion of the batteries.
Explosion of the batteries and the released pollutants can cause severe physical injury.
Note the following points when handling lithium batteries:

- Replace used batteries in good time; see the chapter "Replacing the backup battery".
- Only replace the lithium battery with an identical battery or with a type recommended by the manufacturer.
- Do not throw lithium batteries into a fire, do not recharge, do not open, do not shortcircuit, do not reverse the polarity, do not heat above $100^{\circ} \mathrm{C}$ and protect from direct sunlight, moisture and condensation.


### 1.3 Handling electrostatic sensitive devices (ESD)

Electrostatic sensitive devices (ESD) are individual components, integrated circuits, modules, or devices that may be damaged by either electrostatic fields or electrostatic discharges.

## NOTICE

Damage caused by electric fields or electrostatic discharge
Electric fields or electrostatic discharge can cause malfunctions due to damaged individual components, integrated circuits, modules, or devices.

- Only pack, store, transport, and deliver electronic components, modules, or devices in their original packaging or in other suitable materials, e.g., conductive foam rubber of aluminum foil.
- Only touch components, modules, and devices when you are grounded by one of the following methods:
- Wearing an ESD wrist strap
- Wearing ESD shoes or ESD grounding straps in ESD areas with conductive flooring
- Only place electronic components, modules, or devices on conductive surfaces (table with ESD surface, conductive ESD foam, ESD packaging, ESD transport container).

The necessary ESD protective measures are clearly illustrated in the following diagram:

- $a=$ conductive floor surface
- b = ESD table
- c = ESD shoes
- d = ESD overall
- e = ESD wristband
- $f=$ enclosure ground connection
- $g=$ contact with conductive flooring


Figure 1-1 ESD protective measures

### 1.4 Industrial security

## Note

## Industrial security

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement - and continuously maintain - a holistic, state-of-the-art Industrial Security concept. Siemens products and solutions only represent one component of such a concept.
The customer is solely responsible for preventing unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the company's network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about Industrial Security, please visit:

Industrial Security (http://www.siemens.com/industrialsecurity).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.
To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed at:

Industrial Security (http://www.siemens.com/industrialsecurity).

## A. warning

Unsafe operating states resulting from software manipulation
Software manipulation (e.g. viruses, trojans, malware or worms) can cause unsafe operating states in your system that may lead to death, serious injury, and property damage.

- Keep the software up to date.
- Incorporate the automation and drive components into a holistic, state-of-the-art industrial security concept for the installation or machine.
- Make sure that you include all installed products into the holistic industrial security concept.
- Protect files stored on exchangeable storage media from malicious software by applying suitable protection measures, e.g. virus scanners.


## Note

## Industrial Security Configuration Manual

You can find a Configuration Manual on the topic of Industrial Security at this address (https://support.industry.siemens.com/cs/ww/en/view/108862708).

### 1.5 Residual risks of power drive systems

When assessing the machine or system-related risk in accordance with the respective local regulations (e.g. EC Machinery Directive), the machine manufacturer or system installer must take into account the following residual risks emanating from the control and drive components of a drive system:

1. Unintentional movements of the driven machine or system components during commissioning, operation, maintenance, and repairs caused by, for example:

- Hardware and/or software errors in the sensors, control system, actuators and connection system
- Response times of the controller and drive
- Operation and/or environmental conditions outside the specifications
- Condensation/conductive pollution
- Parameter assignment, programming, cabling, and installation errors
- Use of wireless devices/mobile phones in the immediate vicinity of electronic components
- External influences/damage
- X-ray, ionizing radiation and cosmic radiation

2. Unusually high temperatures, including open flames, as well as the emission of light, noise, particles, gases, etc., can occur inside and outside the components under fault conditions caused by, for example:

- Component malfunctions
- Software errors
- Operation and/or environmental conditions outside the specifications
- External influences/damage

3. Hazardous shock voltages caused by, for example:

- Component malfunctions
- Influence of electrostatic charging
- Induction of voltages in moving motors
- Operation and/or environmental conditions outside the specifications
- Condensation/conductive pollution
- External influences/damage

4. Electric, magnetic, and electromagnetic fields generated during operation that can pose a risk to individuals with pacemakers, implants, or metal replacement joints if they fail to maintain sufficient distance
5. Release of environmental pollutants or emissions as a result of improper operation of the system and/or failure to dispose of components safely and correctly
6. Influence of network-connected communication systems, e.g. ripple-control transmitters or data communication via the network.

For more information about the residual risks of the power drive system components, see the relevant sections in the technical user documentation.

## Device overview

### 2.1 Chapter content

This chapter provides information on the following:

- Introduction to the enclosed drives
- The main components and features of the enclosed drives
- The drive wiring
- Explanation of the nameplate


### 2.2 Applications, Features

### 2.2.1 Area of application

SINAMICS G150 NEMA enclosed drives are specially designed to meet the requirements of drives for the North American market for loads with quadratic and constant torque characteristics, medium performance requirements, and no regenerative feedback. Applications include:

- Pumps and fans
- Compressors
- Extruders and mixers
- Grinders


### 2.2.2 Features, quality, service

## Features

The accuracy of sensorless vector control ensures that the system can be used for a wide variety of applications and, as a result, an additional speed sensor is normally not required.
Optionally, applications with system-specific requirements for an encoder can use a speed feedback encoder (requires optional interface module).
SINAMICS G150 NEMA takes this into account specifically and offers a low-cost drive solution tailored to the actual requirements.

In addition, other factors of course ensure easy handling of the drive from the planning and design phase through to operation. These include:

- Compact, modular, service-friendly design
- Straightforward planning/design and commissioning thanks to the SIZER and STARTER tools
- Ready to connect to facilitate the installation process
- Quick, menu-driven commissioning with no complex parameter assignment
- Clear and convenient drive monitoring/diagnostics, commissioning and operation via a user-friendly graphic operator panel with measured values displayed in plain text or in a quasi-analog bar display.
- SINAMICS is an integral part of Totally Integrated Automation (TIA). The TIA concept offers an optimized range of products for automation and drive technology. This concept is characterized by planning/design, communication, and data management procedures that are consistent throughout the product range. SINAMICS is totally integrated in the TIA concept.
Separate S7/PCS7 blocks and faceplates for WinCC are available.
- Integration in SIMATIC H systems is possible via a Y link.
- Drive Control Chart (DCC)

Drive Control Chart (DCC) expands the facility for the simplest possible configuring of technological functions for the SINAMICS drive system.
The block library encompasses a large selection of closed-loop, arithmetic and logic function blocks, as well as more comprehensive open-loop and closed-loop control functions. The user-friendly DCC editor enables easy graphical configuration and a clear representation of control loop structures as well as a high degree of reusability of existing diagrams. DCC is an add-on to the STARTER commissioning tool.

## Quality

SINAMICS G150 NEMA converter enclosed drives are manufactured to meet high standards of quality and exacting demands.

This results in a high level of reliability, availability, and functionality for our products.
The development, design, and manufacturing processes, as well as order processing and the logistics supply center have been independently certified to ISO 9001-2000.

## Service

Our worldwide sales and service network offers our customers consulting services tailored to their needs, provides support with planning and design, and offers a range of training courses.
For detailed contact information and the current link to our Internet pages, refer to chapter "Diagnostics/Faults and Alarms", section "Service and Support".

### 2.3 Design

The SINAMICS G150 handling indicators feature a compact, modular, and service-friendly design.

A wide range of electrical and mechanical options enable the drive system to be optimized for the appropriate requirements.
Two types are offered depending on the options that are chosen.

### 2.3.1 Enclosed drive type A

Standard features include circuit breakers (per NEC motor feeder protection requirements), line fuses, and line reactors. Additional line side and load side components can also be installed as required. These include an input contactor, output reactor or filter, and additional protection and monitoring devices.

The enclosed drive comprises to two cabinets with a total width of between 39.4 " ( 1000 mm ) and 63" (1600 mm).


Figure 2-1 Example of an enclosed drive type A (e.g., $200 \mathrm{HP}, 460 \mathrm{~V} 3 \mathrm{AC}$ ) (configuration and components shown may vary by type)

### 2.3.2 Enclosed chassis type C

This version is particularly compact in design an can be provided with an (optional) built-in line reactor.

It can be used, for example, when the power supply connection components, such as the input contactor and circuit-breaker disconnect as well as fuses for semi-conductor protection, are installed in an existing central low-voltage MCC.

Circuit breakers or line fuses are required as per NFPA 70: National Electrical Code® (NEC®). External circuit breakers (UL-listed) and line fuses are also required to ensure short-circuit strength (SCCR as per UL 508A) of the power converter.

The enclosed chassis simply comprises a single cabinet with a width of 15.8 " ( 400 mm ), 23.6" (600 mm), or 39.4" (1000 mm).


Figure 2-2 Example of an enclosed chassis type C (e.g., $250 \mathrm{HP}, 460 \mathrm{~V} 3 \mathrm{AC}$ ) (configuration and components shown may vary by type)

### 2.4 Block diagram

## Block diagram of enclosed drive type $A$



Figure 2-3 Block diagram of enclosed drive type A

## Note

## PE connection of the motor

The motor ground (PE) connection must be routed directly to the drive enclosure.

## Block diagram of enclosed chassis type C



Figure 2-4 Block diagram of enclosed chassis type C

## Note

PE connection of the motor
The motor ground (PE) connection must be routed directly to the drive enclosure.

### 2.5 Nameplate

## Rating plate specifications

SIEMENS
100 TECHNOLOGY DR, ALPHARETTA, GA, USA
Made in USA of U.S. and Imported Parts


Figure 2-5 Rating plate on the enclosed drive

## Rating plate specifications (from rating plate above)

Table 2-1 Rating plate specifications

| Item | Specification | Value | Description |
| :---: | :---: | :---: | :---: |
| (1) | Input | $\begin{gathered} 50 / 60 \mathrm{HZ} \\ 3 \mathrm{AC} \\ 380 . .480 \mathrm{~V} \\ 294 \mathrm{~A} \\ \hline \end{gathered}$ | Line frequency <br> 3-phase connection <br> Rated input voltage <br> Rated input current |
| (2) | Output | 0-300HZ 3AC 0 ... 480 V 260 A | Output frequency <br> 3-phase connection <br> Rated output voltage <br> Rated output curren |
| (3) | Temperature range | +0 ... $+40^{\circ} \mathrm{C}$ | Ambient temperature range within which the enclosed drive can operate under $100 \%$ load |
| (4) | Degree of protection | IP23 <br> UL TYPE 1 Enclosure | Enclosed drive degree of protection |
| (5) | Short-Circuit Current Rating | 65 kA@480 VAC | SCCR per UL 508A: <br> maximum permissible voltage for short circuit current |
| (6) | Duty class | 1 | I: Duty class I to IEC 60146-1-1 = $100 \%$ continuous (at the specified current values, the enclosed drive can operate continuously under $100 \%$ load) |
| (7) | Cooling method | AF | A: Cooling medium: air <br> F: Circulation method: forced cooling, blower inside drive enclosure |
| (8) | Weight | 600 kg | Weight of the enclosed drive |
| (9) | Output power | 200 HP | Type rating |

## Date of manufacture

The date of manufacture can be determined as follows:

Table 2-2 Production year and month

| Letter/number | Year of manufacture |  | Letter/number |
| :---: | :---: | :---: | :---: |
| C | 2012 |  | $1 \ldots 9$ |
| Month of manufacture |  |  |  |
| D | 2013 |  | O |
| E | 2014 |  | N |
| F | 2015 | D | October |
| H | 2016 |  | November |
| J | 2017 |  | December |
| K | 2018 |  |  |
| L | 2019 |  |  |
| M | 2020 |  |  |

## Explanation of the option codes

Table 2-3 Explanation of the option codes

|  |  | Enclosed drive type A | Enclosed chassis type C |
| :---: | :---: | :---: | :---: |
| Enclosure Options |  |  |  |
| M06 | Base (plinth), 4" (100 mm) high, RAL 7022 | $\checkmark$ | $\checkmark$ |
| M07 | Cable marshalling compartment 8" (200 mm) high, RAL 7035 | $\checkmark$ | $\checkmark$ |
| M23 | Enclosure NEMA 1 filtered | $\checkmark$ | $\checkmark$ |
| M39 | Mechanical door lock (slam latch) [doors without c/b operator] | $\checkmark$ | - |
| M43 | Enclosure IP43 | $\checkmark$ | $\checkmark$ |
| M54 | Enclosure NEMA 12 (ventilated) [derating, see Current derating as a function of the ambient temperature (Page 651)] | $\checkmark$ | $\checkmark$ |
| M78 | Motor-side top cable exit | $\checkmark$ | - |
| M90 | Crane transport aid / eyebolts [Recommended: required to lift the drive off pallet] | $\checkmark$ | $\checkmark$ |
| Y09 | Special enclosure paint color | $\checkmark$ | $\checkmark$ |
| Power options |  |  |  |
| L08 | Motor reactor | $\checkmark$ | - |
| L10 | Output dv/dt filter with VPL [Requires add-on options cabinet] | $\checkmark$ | - |
| L13 | Main contactor | $\checkmark$ | - |
| L22 | Input line reactor not included in scope of delivery | $\checkmark$ | - |
| L23 | Input line reactor uk = 3 \% | - | $\checkmark$ |
| L61 | Braking unit $25 \mathrm{~kW} / 125 \mathrm{~kW}$ | $\checkmark$ | - |
| L62 | Braking unit $50 \mathrm{~kW} / 250 \mathrm{~kW}$ | $\checkmark$ | - |
| Miscellaneous Options |  |  |  |
| L17 | Feeder for external auxiliaries / motor blower, 460 or $575 \mathrm{~V} 3 \mathrm{ph} . \mathrm{AC}$, max. 5 A | $\checkmark$ | - |
| L29 | 3-contactor bypass | $\checkmark$ | - |
| L30 | Soft starter bypass | $\checkmark$ | - |
| L50 | Cabinet lighting with power outlet, 120 V 1-ph. AC, 5 A | $\checkmark$ | - |
| L55 | Cabinet anti-condensation heating | $\checkmark$ | $\checkmark$ |
| U90 | UL listing per UL 508A [Requires M23, M43, or M54] | $\checkmark$ | $\checkmark$ |
| U91 | cUL listing per UL 508A [Requires M23, M43, or M54] | $\checkmark$ | $\checkmark$ |
| Safety Integrated |  |  |  |
| K01 | Safety license for 1 axis | $\checkmark$ | - |
| K52 | Additional SMC30 Sensor Module Cabinet-Mounted | $\checkmark$ | - |
| K82 | Terminal module for controlling the "Safe Torque Off" and "Safe Stop 1" safety functions | $\checkmark$ | - |
| K87 | TM54F Terminal Module | $\checkmark$ | - |
| K88 | Safe Brake Adapter SBA 230 V AC | $\checkmark$ | - |


|  |  | Enclosed drive type A | Enclosed chassis type C |
| :---: | :---: | :---: | :---: |
| Control options |  |  |  |
| G20 | CBC10 Communication Board (CANopen) | $\checkmark$ | $\checkmark$ |
| G22 | Interface converter MODBUS RTU (acc. to PROFIBUS) | $\checkmark$ | $\checkmark$ |
| G33 | CBE20 Communication Board with $4 \times$ RJ45 ports (SINAMICS Link, Profinet, Ethernet/IP) | $\checkmark$ | $\checkmark$ |
| G51 | TM150 Temperature Sensor Module | $\checkmark$ | $\checkmark$ |
| G61 | Additional TM31 customer terminal module | $\checkmark$ | - |
| G65 | TM31 wired to customer terminal block | $\checkmark$ | - |
| K50 | SMC30 Sensor Module Cabinet-Mounted for speed measurement | $\checkmark$ | $\checkmark$ |
| K51 | VSM10 Sensor Module Cabinet-Mounted | $\checkmark$ | - |
| K95 | CU320-2 PN Control Unit | $\checkmark$ | $\checkmark$ |
| L87 | Insulation monitor for ungrounded power networks | $\checkmark$ | - |
| L96 | Line-side surge arrester | $\checkmark$ | - |
| L97 | PT100 tripping unit (for 8 PT100) | $\checkmark$ | - |
| N55 | ALL STOP, coast to stop | $\checkmark$ | - |
| N57 | EMERGENCY OFF category $0,120 \mathrm{~V}$ AC or 24 V DC, coast to stop | $\checkmark$ | - |
| N59 | EMERGENCY STOP category 1, 120 V AC, controlled ramp-down | $\checkmark$ | - |
| N60 | EMERGENCY STOP category 1, 24 V DC, controlled ramp-down | $\checkmark$ | - |
| N70 | Control power supply, 120 V AC, 5 A | $\checkmark$ | - |
| Documentation \& Languages |  |  |  |
| D02 | Customer drawings in DXF format | $\checkmark$ | $\checkmark$ |
| D04 | Customer documentation in paper format, one set | $\checkmark$ | $\checkmark$ |
| D14 | Advance copy of customer documentation (PDF) | $\checkmark$ | $\checkmark$ |
| D58 | Documentation in: English / French | $\checkmark$ | $\checkmark$ |
| D76 | Documentation in English | $\checkmark$ | $\checkmark$ |
| D77 | Documentation in French | $\checkmark$ | $\checkmark$ |
| D78 | Documentation in Spanish | $\checkmark$ | $\checkmark$ |
| T58 | Rating plate data in English/French | $\checkmark$ | $\checkmark$ |
| Converter acceptance tests (not shown on the rating plate) |  |  |  |
| F03 | Visual acceptance test | $\checkmark$ | $\checkmark$ |
| F71 | Function test with no motor connected (with the customer present) | $\checkmark$ | $\checkmark$ |
| F72 | Function test with no motor connected (without the customer present) | $\checkmark$ | $\checkmark$ |
| F74 | Function test with test bay motor (without the customer present) | $\checkmark$ | $\checkmark$ |
| F75 | Function test with test bay motor (with the customer present) | $\checkmark$ | $\checkmark$ |
| F76 | Insulation test (without the customer present) | $\checkmark$ | $\checkmark$ |
| F77 | Insulation test (with the customer present) | $\checkmark$ | $\checkmark$ |
| F97 | Customer-specific acceptance inspections (on request) | $\checkmark$ | $\checkmark$ |

$\checkmark$ indicates that this option is available for that drive type.

- indicates that this option is not available for that drive type.


## Mechanical installation

### 3.1 Content of this chapter

This chapter provides information on the following:

- The conditions for transporting, storing, and installing the enclosed drives
- Preparing and installing the drives


### 3.2 Transportation and storage

## Transport

## A. warning

## Incorrectly transporting the device

The device can tip over if you transport it incorrectly or if you use non-approved transport equipment. Death, serious injury, and property damage can result.

- Ensure that only trained personnel transport the device with approved transport equipment and lifting tools.
- Comply with the information regarding the center of gravity. A label or stamp with exact information regarding the center of gravity of the cabinet is attached to each transport unit.
- Transport the unit only in the original marked upright position. Do not tilt the device.
- The forks of the forklift must protrude from the rear of the transport pallet. The floor panels of the transport units do not support loading.


## A. warning

## Using forklift trucks that are not approved

If the forks are too short, this can cause the transport unit/cabinet to tip over resulting in death, serious injury, or damage to the cabinet.

- The forks of the forklift must protrude from the rear of the transport pallet. The floor panels of the transport units do not support loading.
- Transport the units only with forklifts approved for this purpose.


## Note

## Shipping

- The devices are packaged by the manufacturer in accordance with the climatic conditions and stress encountered during transit and in the recipient country.
- The packaging instructions relating to transportation, storage, and proper handling must be observed.
- For transportation using forklifts, the devices must be set down on a wooden pallet.
- Once the devices are unpacked, they can be transported using the optional transport eyebolts or beams on the cabinet unit (option M90). The load must be distributed evenly for this. Strong shocks or impacts must be avoided during transit and when the devices are being set down, for example.
- Shock and tilt indicators affixed to the packaging will signal if the cabinet unit is subjected to impermissible shocks or tilting when in transit (see "Shipping and handling indicators").
- Permissible ambient temperatures:

Air cooling: $-13^{\circ} \mathrm{F}\left(-25^{\circ} \mathrm{C}\right)$ to $158^{\circ} \mathrm{F}\left(+70^{\circ} \mathrm{C}\right)$, class 2 K 3 acc. to IEC $60721-3-2$ Briefly done to $-40^{\circ} \mathrm{F}\left(-40^{\circ} \mathrm{C}\right)$ for max. 24 hours

## Note

## Damage in transit

- Carry out a thorough visual inspection of the device before accepting the delivery from the shipping company. Pay special attention to transport damage that is not readily apparent but indicated by the tilt and shock indicators.
- Check that you have received all the items specified on the delivery note.
- Notify the shipping company immediately of any missing components or damage.
- If you identify any hidden defects or damage, contact the shipping company immediately and ask them to examine the device.
- If you fail to contact the shipping company immediately, you may forfeit your right to claim compensation for the defects and damage.
- If necessary, you can request the support of your local Siemens office.


## Storage

The devices must be stored in clean, dry rooms. Temperatures between $-13^{\circ} \mathrm{F}\left(-25^{\circ} \mathrm{C}\right)$ and $131^{\circ} \mathrm{F}\left(+55^{\circ} \mathrm{C}\right)$ are permissible. Temperature fluctuations greater than 20 K per hour are not permitted.
If the cabinet unit is stored for a prolonged period once it has been unpacked, cover it or take other appropriate measures to ensure that it does not become dirty and that it is protected against environmental influences. If such measures are not taken, the warranty becomes invalid in the event of a claim for damages.

### 3.3 Installation

! WARNING
Failure to observe general safety instructions and residual risks
If the general safety instructions and residual risks are not observed, accidents can occur causing serious injuries or death.

- Observe the general safety instructions.
- Take into account residual risks when assessing risks.


## Protection against the spread of fire

The device may be operated only in closed enclosures or in control cabinets with protective covers that are closed, and when all of the protective devices are used. The installation of the device in a metal control cabinet or the protection with another equivalent measure must prevent the spread of fire and emissions outside the control cabinet.

## Protection against condensation or electrically conductive contamination

Protect the device, e.g. by installing it in a control cabinet with degree of protection IP54 according to IEC 60529 or NEMA 12. Further measures may be necessary for particularly critical operating conditions.

If condensation or conductive pollution can be excluded at the installation site, a lower degree of protection of the control cabinet is permitted.

### 3.3.1 Mechanical installation: Checklist

Use the following checklist to guide you through the mechanical installation procedure for the enclosed drive. Read the "Safety instructions" section at the start of these Operating Instructions before you start working on the device.

## Note

## Checking the checklist

Check the first box in the column on the right if the action applies to your enclosed drive. In the same way, check the boxes once you have finished the installation procedure to confirm that the activities are complete.

| Item | Action | Yes | Completed |
| :---: | :--- | :--- | :--- |
| 1 | Check the shipping and handling indicators prior to installation. Refer to "Mechanical <br> installation/Assembly/Preparatory steps/Shipping and handling indicators". | $\square$ | $\square$ |
| 2 | The environmental conditions must be permissible. See "Technical specifications, <br> General technical specifications". <br> The enclosed units must be firmly attached using the anchor points provided. <br> Enclosed chassis type C, 15.8" (400 mm) wide: The enclosed unit can be secured to <br> a non-flammable vertical surface, if necessary, by means of the wall support <br> supplied (see "Mechanical installation/preparation"). <br> The flow of cooling air is thus unobstructed. | $\square$ | $\square$ |
| 3 | The minimum ceiling height (for unobstructed air outlet) specified in the Operating <br> Instructions must be observed. The cooling air supply must be not be obstructed <br> (see "Mechanical installation/preparation"). | $\square$ | $\square$ |
| 4 | Components that are supplied separately for transport reasons (e.g., top hats) must <br> be fitted (see "Mechanical installation/Fitting top hats"). | $\square$ | $\square$ |
| 5 | The clearance around an open door (escape route) specified in the applicable <br> accident prevention guidelines must be observed. | $\square$ | $\square$ |
| 6 | Option M78: <br> Select the required metric screw connections or heavy-gauge threaded joints based <br> on the cable cross-section, and drill the required holes in the mounting plates. When <br> the cable is fed in from above, ensure that enough room is available if the cable has <br> to be bent because of the cable feeder and cross-sections. The cable entries should <br> be fed in vertically to minimize transverse forces on the entries (see "Mechanical <br> installation/Motor connection from above (option M78)"). | $\square$ | $\square$ |

### 3.3.2 Preparation

### 3.3.2.1 Requirements for installation location

The enclosed drives are designed for installation in closed, electrical operating areas in compliance with IEC 61800-5-1. A closed electrical operating area is a room or area containing electrical equipment that can be accessed by trained personnel only. Access is controlled by a door or other form of barricade that can be opened only by means of a key or other tool. The room or area is also clearly marked with appropriate warning notices.

The operating areas must be dry and free of dust. The air supplied must not contain any electrically conductive gas, vapors, or dust that could impair operation. It may be necessary to filter the air supplied to the installation room. If the air contains dust, filter mats (option M54) can be installed in front of the ventilation grills of the cabinet doors and also in front of the optional top hats. Option M54 offers additional protection against water sprayed against the enclosure from any direction and corresponds to enclosure type NEMA 12 ventilated (IP54).

The permissible values for climatic ambient conditions must be taken into account.
At temperatures above $104^{\circ} \mathrm{F}\left(40^{\circ} \mathrm{C}\right)$ or altitudes above $6600 \mathrm{ft}(2000 \mathrm{~m})$, the devices must be derated.

The basic versions of the enclosed drives have a NEMA 1 enclosure.
The enclosed drives are installed in accordance with the dimension drawings supplied. The clearance between the top of the cabinet and the ceiling is also specified on the dimension drawings.

The cooling air for the power module is drawn in from the front through the ventilation grills in the lower part of the cabinet doors. The heated air is released through the ventilation grills in the roof assembly. Cooling air can also be supplied from below through intermediate floors, air ducts, etc. To allow this, openings must be made in the 3 -section bottom panel or individual bottom panels must be removed.

In accordance with IEC 61800-3, the enclosed drive is not intended for use in public lowvoltage networks that supply residential buildings. High-frequency interference may occur if they are used in this type of power network.

### 3.3.2.2 $\quad$ Requirements on the levelness of the floor

The foundation at the installation location of the enclosed drives must be horizontal and level to ensure proper functioning of the enclosed drives.

- Care must be taken to ensure that the doors can be opened and closed and that the locking systems work properly.
- Flat sections (such as doors, side panels and top hats) must be sealed correctly to ensure compliance with the specified degree of protection.
- When cabinets are connected (e.g., transport units), air inlets caused by gaps must be prevented.


Figure 3-1 Requirements on the levelness of the floor
The following requirements must be met to ensure the full functionality of the cabinet units:

- The foundation must be horizontal and level.
- Irregularities must be leveled out.
- Gaps where air can enter, created when aligning (e.g.: (1) in the diagram) must be closed.


### 3.3.2.3 Shipping and handling indicators

The cabinet units are equipped with tilt and shock indicators to monitor for damage during transit.


Figure 3-2 Tilt indicator


Figure 3-3 Shock indicator

## Position of the shipping and handling indicators

The tilt indicators are affixed to the top of the cabinet unit, inside the doors.
The shock indicators are affixed to the bottom of the cabinet unit, inside the doors.

## Checking the shipping and handling indicators prior to commissioning

It is essential to check the shipping and handling indicators prior to commissioning the drive.


Figure 3-4 Tilt indicator tripped

The tilt indicator provides immediate visible evidence of whether the cabinet units have been transported and stored upright. When the unit is tipped, blue-colored quartz sand begins to flow into the arrow-shaped indicator area. The tilt indicator has tripped when the blue color extends beyond the middle line of the arrowhead.


Figure 3-5 Shock indicator tripped
The shock indicator shows if an acceleration has exceeded $98.1 \mathrm{~m} / \mathrm{s}^{2}(10 \times \mathrm{g})$ and indicates the direction of acceleration. The black color of the arrows indicates that an impermissible shock load has occurred in the direction of the arrow.

| ! WARNING |
| :--- |
| Damage to the device when shock or tilt indicators are tripped |
| When shock or tilt indicators have been tripped, safe operation of the device is not |
| guaranteed. |
| Death, serious injury, and property damage can result. |
| - Do not put the drive into operation if one of the shock or tilt indicators has been tripped. |
| - Contact Technical Support immediately for clarification. |

## Removing the shipping and handling indicators prior to commissioning

## NOTICE

Property damage caused by transport indicators remaining in the device during operation
If transport indicators are left in the device, property damage due to detachment of transport indicators or temperature damage can occur during operation.

- Remove the transport indicators before putting the drive into operation.

Ethyl alcohol can be used to remove any remains of adhesive after removing the transport indicators from the control cabinet.

### 3.3.2.4 Unpacking

Check the delivery against the delivery note to ensure that all the items have been delivered. Check that the cabinet is intact.

The packaging material must be discarded in accordance with the applicable country-specific guidelines and rules.

### 3.3.2.5 Required tools

You require the following tools for installation:

- Standard set of tools with screwdrivers, screw wrenches, socket wrenches, etc.
- Torque wrenches 1.5 Nm to 100 Nm
- 600 mm extension for socket wrenches


### 3.3.3 Installation

### 3.3.3.1 Lifting the enclosure off the transport pallet

## Lifting from the transport pallet

The applicable local guidelines for transporting the cabinet from the transport pallet to the installation location must be observed.

Crane transport aids (option M90) can also be fitted on the top of the cabinet.
The fixing screws of the transport pallets can be removed without having to lift the cabinet unit. The positions of the fixing screws are indicated by red markings on the outside of the pallets.


Figure 3-6 Lifting from the transport pallet (left: without base; right: with base)
For cabinet units without base (in the figure on the left), the fixing screws of the transport pallets must be removed from the underside of the pallet.
For cabinet units with base (in the figure on the right), the fixing screws of the transport pallet are accessible only after the cover is opened. They can then be loosened and removed directly from the front.

| ! WARNING |
| :--- |
| Failure to observe the weight and the center of gravity |
| Failure to observe the weight and center of gravity can cause death or serious injury during |
| lifting and transport activities. |
| - The weight specified on the packaging and the specified center of gravity must always |
| be taken into account when the cabinet is lifted and transported. |
| - Particular attention must be paid to this hazard potential after unscrewing the cabinet |
| units from the transport pallet. |

## Center of gravity of the cabinet

The diagram below shows the center of gravity of the cabinet (for all sizes), which must always be taken into account when lifting and installing the cabinet.


Figure 3-7 Center of gravity of the cabinet

## Note

## Center of gravity of the cabinet

A sticker with the precise position of the center of gravity of the cabinet is attached to all cabinets/transport units.

### 3.3.3.2 Disassembling the lifting hardware

With option M90 (crane transport aid), the cabinet units are equipped with either transport eyebolts or beams.


Figure 3-8 Option M90, transport beams

## Disassembling

The transport eyebolts can be unscrewed and removed. Depending on the length of the cabinet or transport unit, the transport beams can have a varying number of fastening screws. These must be unscrewed and removed before the beams can be removed.

## A. WARNING

Incorrect handling of the mounting rails
Improper handling of the heavy mounting rails during disassembly can cause injuries or property damage.

- Ensure careful handling of the mounting rails during disassembly.
- Prevent screws from falling into the device during disassembly and causing property damage during operation.


## Original roof screws



Figure 3-9 Original roof screws accessory kit

After removing the crane transport aid, the removed transport eyebolts or the fixing screws of the transport beam must be replaced by the original roof screws from the accessory kit supplied in order to ensure compliance with the degree of protection and proper grounding of the cabinet.


Figure 3-10 Factory state (left), original roof screws (right)

### 3.3.3.3 Connection to the foundation

## Connection to the foundation

Four holes for M12 screws are provided on each cabinet panel to secure the enclosure to the ground. The fixing dimensions are specified in the dimension drawings

Every cabinet panel must be attached to the ground using at least 2 opposing fixing points (1 screw each in the front and rear part of the cabinet panel).
If this is not possible for reasons of accessibility, the fixing points of the adjacent cabinet panels must be correspondingly raised.
Generally, as many fixing points as possible should be used
For 15.8" (400 mm) wide enclosures, the product package includes two wall supports (steel brackets) for attaching the top of the enclosure to the wall to provide extra security.

### 3.3.4 Changing the enclosure type, options M23 and M54

To change the type of enclosure from NEMA 1 (standard) to NEMA 1 filtered (IP23), IP43, or NEMA 12 ventilated (IP54), filter mats are fitted to the ventilation slots in the doors and top hats. The top hats are mounted after the enclosures have been installed.

## Description

## Enclosure NEMA 1 filtered

The ventilation slots of enclosed drives with a NEMA 1 filtered enclosure are fitted with foam filters in the air inlet (doors) and air outlet (top hats).

## Enclosure IP43

The ventilation slots of enclosed drives with an IP43 enclosure are fitted with foam filters and wire mesh in the air inlet (doors) and air outlet (top hats).

## Enclosure NEMA 12 ventilated

The ventilation slots of enclosed drives with a NEMA 12 ventilated enclosure are fitted with fine paper filters in the air inlet (doors) and air outlet (top hats).
Maintaining the integrity of the NEMA 12 ventilated enclosure requires an intact filter medium, which must be replaced on a regular basis according to environmental conditions. Filters can be easily fitted and replaced from outside the enclosure.

### 3.3.5 Motor connection from above (option M78)

## Description

With option M78, the busbar studs for connecting the power cables and the clamping bar for mechanically securing the cables are located within the top hat.
The busbars for connection from above are already installed when the system is delivered. For transport reasons, the top hats are delivered separately and must be installed at the plant. With options M23, M43, and M54, plastic ventilation grilles and filter mats are also supplied.

Based on the number of cables and the cable cross-sections used, holes must be drilled for attaching cable glands through which cables will be inserted.

## Note

Connecting the control cables
The control cable and optional brake resistors are still connected from below.

## Attaching the top hat

1. Remove the crane transport aids (if present).
2. Secure the contact surfaces of the top hat to the top of the cabinet using the sealing tape provided.
3. Fit the top hat to the top of the cabinet at the positions specified (fixing points of the crane transport aid).
4. To secure the power cables, remove the front panel of the top hat.


Figure 3-11 Attaching the top hat for M78

### 3.3.6 Mechanical door lock (option M39)

## Description

The door of the enclosure in which the circuit breaker is located (the Line Connection Module) provides the only mechanical interlock for the circuit breaker lever. All other enclosures of the cabinet unit have a door lock that uses a special key; these can be opened at any time, regardless of whether or not the drive is running.
Option M39 provides a mechanical door lock for all other enclosure doors in the form of a spring-loaded pin that is inserted into a plate. This prevents an enclosure door from being opened as long as the circuit breaker is On (provided the opening mechanism for the circuit breaker has not been overridden).


Figure 3-12 Mechanical door lock (slam latch): view from inside the enclosure, unlocked
With this option, the door to the Line Connection Module must first be opened, which requires the circuit breaker to be switched off (or overridden). After this, the spring-loaded pin must be pulled out to release the second door, which can then be opened if it is unlocked. If the cabinet unit has a third door, the second door must be opened first to access the pin that locks the third door.

The slam latch engages automatically when the door is closed. The door should then be locked with the key to engage the 3-point lock. The slam latch is merely an additional component for preventing access to the cabinet unit when the drive is running; it is not a substitute for the door lock or the 3-point lock.

## ! DANGER

## Open doors in operation

Open doors or a faulty door locks during operation and in the event of a fault can cause opening of the doors and exposure of any persons in the vicinity to an arc flash or flying parts. This can cause death or serious injury.

- Keep all cabinet doors locked during operation using the door lock and the 3-point lock.


### 4.1 Content of this chapter

This chapter provides information on the following:

- Establishing the electrical connections for the enclosed drive
- Adjusting the fan voltage and the internal power supply to local conditions (supply voltage)
- The customer terminal module and its interfaces
- The interfaces for additional options


### 4.2 Checklist for electrical installation

Use the following checklist to guide you through the electrical installation procedure for the cabinet unit. Read the "Safety instructions" section at the start of these Operating Instructions before you start working on the device.

## Note

## Checking the checklist

Check the first box in the column on the right if the action applies to your enclosed drive. In the same way, check the boxes once you have finished the installation procedure to confirm that the activities are complete.

| Item | Action | Yes | Completed |
| :---: | :--- | :--- | :--- |
| Power connections |  |  |  |
| 1 | The line-side and motor-side power cables must be dimensioned and routed in <br> accordance with the ambient and routing conditions. The maximum permissible <br> cable lengths between the drive and motor must be observed depending on the type <br> of cable used (see "Electrical installation/Power connections/Conductor cross- <br> sections and cable lengths"). <br> The protective ground connection to the motor must be fed back directly to the <br> cabinet unit. <br> The cables must be properly connected with a torque of 50 Nm to the terminals of <br> the cabinet unit. The cables for the motor and low-voltage switchgear must also be <br> connected with the required torques. |  |  |
| 2 | The cables between the low-voltage switchgear and the cabinet unit must be <br> protected in compliance with NFPA 70 (National Electric Code) guidelines for <br> conductor protection. With Type C, additional circuit breakers and fuses must be <br> used to ensure adequate short-circuit strength (SCCR). See "Technical <br> specifications" for the appropriate components. | $\square$ | $\square$ |
| 3 | For strain relief, the cables must be clamped to the cable C-type mounting bar. |  |  |
| 4 | When EMC-shielded cables are used, screwed glands that connect the shield to <br> ground with the greatest possible surface area must be provided on the motor <br> terminal box (see "Electrical installation/EMC-compliant installation"). | $\square$ | $\square$ |
| 5 | The cable shields must be properly applied and the cabinet properly grounded at the <br> points designated for that purpose (see "Electrical installation/EMC-compliant <br> installation"). | $\square$ | $\square$ |
| 6 | The voltage for the fan transformer (-T1-T10) for types A and C, and the internal <br> power supply (-A1-T10) for type A (option N70 only) must be adapted to the supply <br> voltage for the cabinet unit. Larger cabinet units have 2 fan transformers <br> (-T1 -T10/-T20), which must be set jointly (see "Electrical installation/Power <br> connections/Adjusting the fan voltage (-T 1-T10)" and "Electrical installation/Power <br> connections/Adjusting the internal power supply (-A1 -T10)"). | $\square$ |  |


| Item | Action |  | Yes | Completed |
| :---: | :---: | :---: | :---: | :---: |
| 7 | A yellow warning label is attached to each connection clip for the basic interference suppression module. <br> - The warning label must be removed from the connection clip (by pulling it off) if the connection clip is to remain in the unit (operation on a grounded power network). <br> - The warning label must be removed together with the connection clip if the unit is operated on an ungrounded / IT power network. <br> (See "Electrical installation/Power connections/Removing the connection clip for the basic interference suppression module for operation on an ungrounded / IT power network"). |  |  | $\square$ |
| 8 | The nameplate can be used to ascertain the date of manufacture. If the period from the date of manufacture to initial commissioning or the downtime of the cabinet unit is less than 2 years, the DC link capacitors do not have to be reformed. If the downtime period is longer than two years, reforming must be carried out (see "Maintenance and Servicing/Forming of DC Link Capacitors"). |  |  |  |
| 9 | With an external auxiliary supply, the cable for the 115 V AC supply must be connected to terminal -X40, while the cable for the 24 V DC supply must be connected to terminal -X9 (see "Electrical installation/Power connections/External supply of the auxiliary infeed from a fused power network"). |  | $\square$ |  |
| 10 | Option L10 dv/dt filter plus voltage peak limiter | During commissioning, the filter must be selected via STARTER or AOP30. You are advised to check the selection by ensuring that p0230 is set to 2. <br> The required parameters are set automatically (see "Electrical installation/Other connections/dv/dt filter plus voltage peak limiter (option L10)"). | $\square$ |  |
| 11 | Option L13 Main contactor | Wire the feedback signal contacts of the main contactor (see Chapter "Electrical installation/Additional connections/Main contactor (option L13)". | $\square$ | $\square$ |
| 12 | Option L17 <br> Connection for external auxiliaries (e.g., motor blower) | The external motor blower must be correctly connected to terminals -X155:1 (L1) to -X155:3 (L3). The supply voltage of the motor blower must match the input voltage of the cabinet unit. The load current must not exceed 5 A and must be set at -Q155 in accordance with the load connected (see "Electrical installation/Other connections/Connection for external devices (option L17)"). | Set value: |  |
| 13 | Option L50 <br> Cabinet light with service socket | The 115 V auxiliary supply for the cabinet light with an integrated service socket must be connected to terminal -X390 and protected with a fuse (max. 10 A ) on the line end (see "Electrical installation/Other connections/Cabinet light with service socket (option L50)"). | $\square$ |  |
| 14 | Option L55 Anticondensation heater | The 115 V auxiliary supply for the enclosure anti-condensation heater ( $115 \mathrm{~V} / 60 \mathrm{~Hz}, 100 \mathrm{~W}$, or $115 \mathrm{~V} / 60 \mathrm{~Hz} 2 \times 100 \mathrm{~W}$ for enclosure widths ranging from $31.5^{\prime \prime}(800 \mathrm{~mm})$ to $47.2^{\prime \prime}$ ( 1200 mm )) must be connected to terminals -X240: 1 to 3 connected and protected with fuses (max. 16 A) (see "Electrical installation/Other connections/Cabinet anti-condensation heater (option L55)"). | $\square$ | $\square$ |

### 4.2 Checklist for electrical installation

| Item | Action |  | Yes | Completed |
| :---: | :---: | :---: | :---: | :---: |
| Signal connections |  |  |  |  |
| 15 | Cabinet unit operation from higher-level controller/control room. The control cables must be connected in accordance with the interface assignment and the shield applied. Due to potential electrical interference, the digital and analog signals must be routed with separate cables, and an appropriate distance from power cables must be observed. <br> When the analog inputs on the customer terminal module are used as current or voltage inputs, selectors S5.0 and S5.1 must be set accordingly (see "Electrical installation/Signal connections/Customer terminal module (-A60)"). |  | $\square$ | $\square$ |
| 16 | Option K50 <br> Sensor Module <br> Cabinet- <br> Mounted <br> SMC30 | The SMC30 Sensor Module is used for determining the actual motor speed. <br> For SINAMICS G150 NEMA, the following encoders are supported by the SMC30 Sensor Module: <br> - TTL encoder <br> - HTL encoder <br> The motor temperature can also be detected using KTY84-130 or PTC thermistors. <br> In the factory state, an HTL encoder is bipolar with 1024 pulses per revolution (see "Electrical installation/Other connections/ Sensor Module Cabinet-Mounted SMC30 (option K50)"). | $\square$ |  |
| 17 | Option K52 <br> Additional SMC30 Sensor Module CabinetMounted | For reliable actual value acquisition when using the Safety Integrated Extended Functions, the additional SMC30 sensor module is used (see "Electrical installation/Other connections/ Additional SMC30 Sensor Module Cabinet-Mounted (option K52)"). | $\square$ |  |
| Connecting protection and monitoring devices |  |  |  |  |
| 18 | Option G51 <br> TM150 <br> Temperature Sensor Module | A maximum of 12 temperature sensors (PT100, PT1000, KTY84, PTC, bimetallic NC contact) can be be connected to the TM150 Terminal Module (see "Electrical installation/Other connections/ TM150 Temperature Sensor Module (option G51)"). | $\square$ | $\square$ |
| 19 | Option N57 <br> EMERGENCY OFF category 0 , 115 V AC or 24 V DC | EMERGENCY OFF category 0 stops the drive in an uncontrolled manner. When using the EMERGENCY OFF pushbutton, no additional wiring is required. <br> However, if the cabinet unit is integrated in an external safety circuit, then the contact must be looped in via terminal block -X120 (see "Electrical installation/Other connections/ EMERGENCY OFF Category 0; 115 V AC or 24 V DC (option N57)"). | $\square$ | $\square$ |
| 20 | Option N59 <br> EMERGENCY STOP category 1 , 115 V AC | EMERGENCY STOP category 1 stops the drive in a controlled manner. Based on the load characteristic and the required shutdown times, it may be necessary to use braking units with this option. No additional wiring is needed when using the EMERGENCY OFF pushbutton. <br> However, if the cabinet unit is integrated in an external safety circuit, then the contact must be looped in via terminal block X120. The timer relay at -A121 must be adapted to match system requirements ("Electrical installation/Other connections/ EMERGENCY STOP category 1, 115 V AC (option L59)"). | $\square$ | $\square$ |


| Item | Action |  | Yes | Completed |
| :---: | :---: | :---: | :---: | :---: |
| 21 | Option N60 <br> EMERGENCY <br> STOP <br> category 1, <br> 24 V DC | EMERGENCY STOP category 1 stops the drive in a controlled manner. Based on the load characteristic and the required shutdown times, it may be necessary to use braking units with this option. No additional wiring is needed when using the EMERGENCY OFF pushbutton. <br> If the cabinet unit is integrated in an external safety circuit, however, the contact must be looped in via terminal block -X120. The timer relay at -A120 must be adapted to match system requirements (see "Electrical installation/Other connections/ EMERGENCY STOP category 1, 24 V DC (option L60)"). | $\square$ |  |
| 22 | Option L61/L62 <br> 25 kW/125 kW <br> $50 \mathrm{~kW} / 250 \mathrm{~kW}$ <br> braking unit | The connecting cables and ground for the braking resistor must be connected to terminal block -X5: 1/2. A connection must be made between the braking resistor thermostatic switch and customer terminal module -A65. When commissioning via AOP30, the settings for evaluating "external fault 3" must be made. The settings for evaluating the thermostatic switch as "external fault 2" must be made (see "Electrical installation/Other connections/Braking unit 25 kW / 125 kW (option L61); braking unit 50 kW / 250 kW (option L62)"). | $\square$ | $\square$ |
| 23 | Option L87 <br> Insulation monitor for ungrounded supplies | The insulation monitor can be operated only on an ungrounded / IT power network. Only one insulation monitor can be used in an electrically-connected network. For plant-side control, the signaling relays must be connected accordingly or, with individual drives (cabinet unit is fed via a converter transformer assigned to the cabinet unit), integrated in the cabinet unit alarm circuit (see "Electrical installation/Other connections/Insulation monitoring (option L87)"). <br> The information in step 7 must also be noted: <br> "Before the drive is operated on an ungrounded / IT power network, the connection clip for the basic interference suppression module must be removed" (see "Electrical installation/Power connections/Removing the connection clip for the basic interference suppression module for operation on an ungrounded / IT power network"). | $\square$ | $\square$ |
| 24 | Option L97 <br> PT100 tripping unit | The PT100 RTDs must be connected to the monitoring units -B141, -B142, -B143 for the evaluation. A three-wire system can be used here to connect the PT100 sensors. The sensors are divided into three groups (see "Electrical installation/Other connections/PT100 tripping unit (option L97)"). This must be taken into account for the evaluation (factory setting). | $\square$ | $\square$ |

### 4.2 Checklist for electrical installation

| Item | Action | Yes | Completed |  |
| :---: | :--- | :--- | :--- | :---: |
| Safety Integrated | ( |  |  |  |
| 25 | Option K01 <br> Safety license <br> for 1 axis | For each axis, Safety Integrated Extended Functions require a <br> license <br> With Option K01, the safety license for 1 axis is contained and <br> activated on the CompactFlash card (see "Electrical installation/ <br> Other connections/Safety license for 1 axis (option K01)"). | $\square$ |  |
| 26 | Option K82 <br> "Safe Torque <br> Off" and "Safe <br> Stop 1" safety <br> functions | The terminal block -X41 must be connected at the plant end and <br> the safety functions must be activated prior to use via parameter <br> assignment. In addition, an acceptance test must be performed <br> and an acceptance report must be prepared (see "Electrical <br> installation/Other connections/Terminal module for activating <br> "Safe Torque Off" and "Safe Stop 1" safety functions (option <br> K82)"). | $\square$ | $\square$ |
| 27 | Option K87 <br> TM54F Terminal <br> Module | The terminal blocks of the TM54F Terminal Module must be <br> connected at the plant end, and the Safety Integrated Extended <br> Functions must be activated prior to use via parameter <br> assignment. In addition an acceptance test must be performed <br> and an acceptance report must be prepared (see "Electrical <br> installation/Other connections/TM54F Terminal Module (option <br> K87)"). | $\square$ | $\square$ |
| 28 | Option K88 <br> Safe Brake <br> Adapter <br> AC 230 V | To control the brake, a connection must be established between - <br> X14 on the Safe Brake Adapter and the holding brake (see <br> "Electrical installation/Other connections/Safe Brake Adapter SBA <br> 230 V AC (option K88)"). | $\square$ | $\square$ |

## Required tool

You require the following tools for the electrical installation:

- Standard set of tools with screwdrivers, screw wrenches, socket wrenches, etc.
- Torque wrenches 1.5 Nm up to 100 Nm
- 600 mm extension for socket wrenches


### 4.3 Important safety precautions

## WARNING

Failure to observe general safety instructions and residual risks
If the general safety instructions and residual risks are not observed, accidents can occur causing serious injuries or death.

- Observe the general safety instructions.
- Take into account residual risks when assessing risks.



## ! warning

## Electric shock when using unsuitable fuses

If unsuitable fuses are used, an electric shock can cause severe injury or death.

- Use only fuses recommended in the technical specifications.
- Observe the required minimum short-circuit current for the relevant fuse.



## A. warning

## Electric shock due to the residual charge of the DC link capacitors

Because of the DC link capacitors, a hazardous voltage is still present for a while after switching off the infeed voltage.

If live components are touched then this can result in severe injury or death.

- Open the unit only after the time specified on the warning label has elapsed.
- Before starting work, check the absence of voltage by an all-pole measurement, including to ground.


## NOTICE

Property damage resulting from switching on the device without forming of the DC link capacitors

After a storage duration exceeding two years, switching on the device without forming of the DC link capacitors can damage it.

- If the device has been stored for more than two years, form it before switching it on; see "Maintenance and service".


## Note

## Touch protection

When the cabinet door is opened, cabinet units have touch protection in compliance with DGUV Regulation 3 according to EN 50274.

These protective covers may need to be removed for installation and connection work. Once work has been completed, the protective covers must be properly refitted.

### 4.4 Introduction to EMC

## What is EMC?

Electromagnetic compatibility (EMC) describes the capability of an electrical device to function satisfactorily in an electromagnetic environment without itself causing interference unacceptable for other devices in the environment.
EMC therefore represents a quality feature for the

- Internal noise immunity: resistance to internal electrical disturbances
- External noise immunity: resistance to external electromagnetic disturbances
- Noise emission level: environmental effects caused by electromagnetic emissions

To ensure that the cabinet unit functions satisfactorily in the system, an environment subject to interference must not be neglected. For this reason, special EMC requirements exist for the system.

## Operational reliability and noise immunity

In order to achieve the greatest possible operational reliability and immunity to noise of a complete system (drive, automation, driven machines, etc.), measures must be taken by the drive manufacturer and the user. Only when all these measures are fulfilled, can the perfect functioning of the inverter be guaranteed and the specified legal requirements complied with (in the European Union: 2014/30/EU).

## Noise emissions

Product standard IEC 61800-3 describes the EMC requirements placed on "Variable-speed drive systems" (power drive systems). It specifies requirements for inverters with operating voltages of less than 1000 V . Different environments and categories are defined depending on where the drive system is installed.


Figure 4-1 Definition of the first and second environments

| First <br> environment | C 1 |  |
| :---: | :---: | :---: |
|  | C 2 | Second <br> environment |
|  | C 3 |  |
|  | C 4 |  |

Figure 4-2 Definition of categories C 1 to C 4

Table 4-1 Definition of the first and second environments

| Definition of the first and second environments |  |
| :--- | :--- |
| First environment | Residential buildings or locations in which the drive system is connected to <br> a public low-voltage supply network without a transformer. |
| Second environment | Industrial locations supplied by a medium-voltage network via a separate <br> transformer. |

Table 4-2 Definition of categories C1 to C4

| Definition of categories C1 to C4 |  |
| :--- | :--- |
| Category C1 | Rated voltage $<1000 \mathrm{~V}$; unrestricted use in the first environment. |
| Category C2 | Rated voltage for stationary drive systems $<1000 \mathrm{~V}$; for use in the second <br> environment. For use in the first environment only when sold and installed <br> by skilled personnel. |
| Category C3 | Rated voltage $<1000 \mathrm{~V}$; for use in the second environment only. |
| Category C4 | Rated voltage $\geq 1000 \mathrm{~V}$ or for rated currents $\geq 400 \mathrm{~A}$ in complex systems in <br> the second environment. |

### 4.5 EMC-compliant design

The following section provides some basic information and guidelines that will help you comply with the EMC and CE guidelines.

## Cabinet assembly

- Connect painted or anodized metal components using toothed self-locking screws or remove the insulating layer.
- Use unpainted, de-oiled mounting plates.
- Establish a central connection between ground and the protective earth system (ground).


## Shield gaps

- Bridge shield gaps (at terminals, circuit breakers, contactors, and so on) with minimum impedance and the greatest possible surface area.


## Use large cross-sections

- Use grounding wires or straps with large cross-sections or, better still, with finely stranded wires or flexible straps.


## Lay the motor supply cable separately

- The distance between the motor supply cable and signal cables should be $>20 \mathrm{~cm}$. Do not lay signal cables and motor cables parallel to each other.


## Laying the equipotential bonding cable

- It is recommended to lay an equipotential bonding cable with a minimum cross-section of $16 \mathrm{~mm}^{2}$ in parallel to the control lines.


## Use interference suppressors

- If relays, contactors, and inductive or capacitive loads are connected, the relays or contactors must be fitted with interference suppressors.


## Cable installation

- Cables that are subject to or sensitive to interference should be laid as far apart from each other as possible.
- All cables must be laid as close as possible to grounded enclosure parts such as mounting plates or cabinet frames. This reduces both noise radiation and interference injection.
- Reserve cores of signal and data cables must be grounded at both ends to achieve an additional shielding effect.
- Long cables should be shortened or laid in noise-resistant areas to avoid additional connecting points.
- If it is impossible to avoid crossing cables, conductors or cables that carry signals of different classes must cross at right angles, especially if they carry sensitive signals that are subject to interference.
- Class 1:

Unshielded cables for $\leq 60$ V DC
Unshielded cables for $\leq 25$ V AC
Shielded analog signal cables
Shielded bus and data cables
Operator panel interfaces, incremental/absolute encoder cables

- Class 2:

Unshielded cables for $>60 \mathrm{~V}$ DC and $\leq 230 \mathrm{~V}$ DC
Unshielded cables for $>25 \mathrm{~V}$ AC and $\leq 230 \mathrm{~V}$ AC

- Class 3:

Unshielded cables for > 230 V AC/DC and $\leq 1000$ V AC/DC

## Shield connection

- Shields must not be used to conduct electricity. In other words, they must not simultaneously act as neutral or ground (PE) conductors.
- Apply the shield so that it covers the greatest possible surface area. You can use ground clamps, ground terminals, or ground screw connections.
- Avoid extending the shield to the grounding point using a wire (pigtail) because this will reduce the effectiveness of the shield by up to $90 \%$.
- Attach the shield to a shield bar directly after its entry into the cabinet. Insulate the entire shielded cable and route the shield up to the device connection, but do not connect it again.


## I/O interfacing

- Create a low-impedance ground connection to other cabinets, system components, and distributed devices with the largest possible cross-section (at least $16 \mathrm{~mm}^{2}$ ).
- Ground unused lines at one end in the cabinet.
- Select the greatest possible distance between the power and signal cables, but at least 20 cm . The greater the distance over which the cables are routed in parallel, the greater the clearance must be. If a sufficient clearance cannot be maintained, you must install additional shields.
- Avoid unnecessarily long cable loops.


## Filtering cables

- Line supply cables and power supply cables for devices and modules may have to be filtered in the cabinet to reduce incoming or outgoing disturbances.
- To reduce emissions, the drive is equipped with a radio interference suppression filter as standard (in accordance with the limits defined in category C3). Optional filters can be fitted for use in the first environment (category C2).


## Protective ground conductors

- According to NFPA70 National Electrical Code Article 250, the minimum cross-section of the protective ground conductor must conform to the local safety regulations for protective ground conductors for equipment with a high leakage current.


### 4.6 Power connections

```
!\mp@code{WARNING}
Electric shock caused by interchanging or short-circuiting the device connections
Interchanging the power connections or short-circuiting of the DC link connections will
destroy the device, which can result in death or serious injuries.
- Do not interchange the input and output terminals of the device.
- Do not interchange or short-circuit the DC link terminals.
```


## Note

## Ground fault circuit interrupter

The device must not be operated via a ground fault circuit interrupter (EN 61800-5-1).

### 4.6.1 Cable lugs

## Cable lugs

The cable connections on the devices are designed for cable lugs according to DIN 46234 or DIN 46235.

For connection of alternative cable lugs, the maximum dimensions are listed in the table below.
These cable lugs are not to exceed these dimensions, as mechanical fastening and adherence to the voltage distances is not guaranteed otherwise.


Figure 4-3 Dimensions of the cable lugs

Table 4-3 Dimensions of the cable lugs

| Screw / bolts | Conductor cross-section <br> [AWG,MCM] ([mm $\left.{ }^{2}\right]$ | d2 <br> [inch] ([mm]) | b <br> [inch] ([mm]) | I <br> [inch] ([mm]) | c1 <br> [inch] ([mm]) | c2 <br> [inch] ([mm]) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| M8 | $2 / 0(70)$ | $0.33(8.4)$ | $0.94(24)$ | $2.17(55)$ | $0.51(13)$ | $0.39(10)$ |
| M10 | $350(185)$ | $0.41(10.5)$ | $1.46(37)$ | $3.23(82)$ | $0.59(15)$ | $0.47(12)$ |
| M10 | $500(240)$ | $0.51(13)$ | $1.65(42)$ | $3.62(92)$ | $0.63(16)$ | $0.51(13)$ |
| M12 | $4 / 0(95)$ | $0.51(13)$ | $1.10(28)$ | $2.56(65)$ | $0.63(16)$ | $0.51(13)$ |
| M12 | $350(185)$ | $0.51(13)$ | $1.46(37)$ | $3.23(82)$ | $0.63(16)$ | $0.51(13)$ |
| M12 | $500(240)$ | $0.51(13)$ | $1.65(42)$ | $3.62(92)$ | $0.63(16)$ | $0.51(13)$ |
| M16 | $500(240)$ | $0.67(17)$ | $1.65(42)$ | $3.62(92)$ | $0.75(19)$ | $0.63(16)$ |

### 4.6.2 Connection cross-sections, cable lengths

## Conductor cross-sections

The conductor cross-sections for the line connection, motor connection, and ground connection for your device are specified in the tables provided in the "Technical specifications" section.

## Cable lengths

The maximum permissible cable lengths are specified for standard cable types or cable types recommended by SIEMENS. Longer cables can only be used after consultation.

The listed cable length represents the actual distance between the drive and the motor, taking into account factors such as parallel laying, current-carrying capacity, and the laying factor.

- Unshielded cable (e.g., Protodur NYY): max. 1485 ft (450 m)
- Shielded cable (e.g., Protodur NYCWY, Protoflex EMV 3 Plus): max. 990 ft ( 300 m ).


## Note

## Cable lengths

The cable lengths specified are also valid if a motor reactor is used (option L08).

## Note

## Shielded cables

The PROTOFLEX-EMV-3 PLUS shielded cable recommended by Siemens has three symmetrically-arranged ground conductors. Each ground conductor must be fitted with cable lugs and connected to ground. The cable also has a concentric flexible braided copper shield. To comply with IEC 61800-3 regarding radio interference suppression, the shield must be contacted at both ends with the greatest possible surface area.

On the motor side, cable glands that contact the shield with the greatest possible surface area are recommended for the terminal boxes.

### 4.6.3 Connection of shielded three-phase current cables

A good shield connection is achieved by connecting the shields in the converter cabinet through a large surface area to the EMC shield rail using EMC shield clamps (PUK shield clamps). EMC shield clamps (PUK shield clamps) are provided in the accessories pack to connect to the shield rail.


Figure 4-4 Connecting shields in the converter at the EMC shield rail using EMC shield clamps (PUK shield clamps)

## Note

Detailed engineering information for connected shielded three-phase cables with concentrically arranged shields is provided in the "SINAMICS Low Voltage Configuration Manual" on the customer DVD supplied with the equipment.

### 4.6.4 Connecting the motor and power cables

Connecting the motor and power cables on the enclosed drive
Note
Position of the connections
For the location of the connections, see the layout diagrams.

## Enclosed drive type A

Connect the power cable according to the numbers in the following diagram.


Figure 4-5 Power cable connection for enclosed drive type A

1. Open the cabinet, remove any covers in front of the terminals for the motor cables (connections U2/T1, V2/T2, W2/T3; X2) and power cables (connections U1/L1, V1/L2, W1/L3; X1).
Remove or move the base plate under the terminals for inserting the power or motor cables.
Feed the power cable from the top or bottom into the enclosure and take it up as far as the circuit breaker terminals as indicated by the dashed line in the diagram (4).
Connect the protective ground to the ground terminal provided in the enclosure, marked with the ground symbol ( 50 Nm at M12).
2. Secure the power cable to the strain relief on the C-rails located inside the enclosure on the sides.
3. Lay the cable according to the permissible bending radius, and route it, if required, also through the tophat.
4. Connect the power cable with the prescribed torque to the circuit breaker (connections U1/L1, V1/L2, W1/L3; X1).

Then screw the motor cables onto the terminals.
Make sure that the conductors have been connected properly (U2/T1, V2/T2, W2/T3).

## Note

## Pay attention to the torque

The tightening torques for the supply system connections to the main switch -Q1 are specified in the respective technical data of the enclosed drive.

## Enclosed chassis type C

1. Open the cabinet, remove the covers (if necessary) in front of the motor cable (terminals U2/T1, V2/T2, W2/T3; X2) and power cable (terminals U1/L1, V1/L2, W1/L3; X1) terminals.
2. Move or remove the bottom plate below the terminals through which the motor cables are fed.
3. Connect the protective ground to the ground terminal provided in the enclosure, marked with the ground symbol ( 50 Nm at M12).
4. Connect the line and motor cables to the corresponding terminals.

Make sure that you connect the conductors in the correct sequence: U2/T1, V2/T2, W2/T3 and U1/L1, V1/L2, W1/L3!

## NOTICE

## Property damage due to loose power connections

Insufficient tightening torques or vibrations can result in faulty electrical connections. This can cause fire damage or malfunctions.

- Tighten all power connections with the specified tightening torques, e.g. power connection, motor connection, and DC link connections.
- Regularly check all power connections by retightening them with the prescribed tightening torque. This applies in particular after transport.


## Note

Protective ground connection of the motor
The protective ground connection of the motor must be fed back directly to the drive enclosure and connected there.

## Direction of motor rotation

IEC 60034-7 defines the two ends of an electric motor as follows:

- DE (Drive End): Usually the drive end of the motor
- NDE (Non-Drive End): Usually the non-drive end of the motor

An electric motor rotates clockwise if the shaft is turning clockwise when viewing the drive end (DE).

For electric motors with 2 shaft ends, the direction of rotation must be determined based on the shaft end specified as the drive end.

For clockwise rotation, the electric motor must be connected according to the following table.

Table 4-4 Enclosed drive and motor connection terminals

| Enclosed drive (connection terminals) | Motor (connection terminals) |
| :---: | :---: |
| U2/T1 | U |
| $\mathrm{V} 2 / \mathrm{T} 2$ | V |
| $\mathrm{~W} 2 / \mathrm{T} 3$ | W |

In contrast to the connection for the clockwise phase sequence, two phases have to be reversed with a counter-clockwise phase sequence (viewed from the drive shaft).

## Note

## Information on the phase sequence

If an incorrect phase sequence was connected when the motor was connected, p1821 (phase sequence direction reversal) can be used to correct the incorrect phase sequence without physically changing it over (see "Functions, monitoring and protective functions/ direction reversal").

For motors that can be star-connected or delta-connected, it must be ensured that the windings are interconnected consistent with the operating voltage indicated on the rating plate or in the motor documentation. Make sure that the winding insulation of the connected motor has sufficient insulation strength to meet the requirements for drive operation.

### 4.6.5 Adjusting the fan voltage (-T1-T10)

The power supply for the fan(s) ( 230 V 1 AC ) in the Power Module (-T1-T10) is taken from the main supply system using a transformer.
The position of the transformer is shown in the layout diagrams provided.
The transformer is equipped with taps on the primary side to finely adjust to the actual line voltage.
If necessary, the connection fitted in the factory, shown with a dashed line, must be reconnected to the actual line voltage.

## Note

Cabinet units with two transformers
Two transformers (-T1-T10, and -T1-T20) are installed in the following cabinet units. The two primary terminals of these devices must be connected in parallel.

- For 380 to 480 V 3 ph. AC: 6SL3710-1GE41-0_U3
- For 500 to 600 V 3 ph. AC: 6SL3710-1GF37-4_U3, 6SL3710-1GF38-1_U3


Figure 4-6 Setting terminals for the fan transformer ( 380 to $480 \vee 3 \mathrm{ph} . \mathrm{AC} / 500$ to $600 \vee 3 \mathrm{ph}$. AC)

The line voltage assignments for making the appropriate setting on the fan transformer are indicated in the following tables.

## ! WARNING

## Fire due to overheating resulting from insufficient equipment fan voltage

If the terminals are not reconnected to the actual line voltage, this can lead to overheating with a risk of personal injury due to smoke generation and fire.
This can also cause the fan fuses to blow due to overload.

- Set the terminals in accordance with the actual line voltage.


## Note

## Article numbers for fan fuses

The article numbers for fan fuses that have blown can be found in the spare parts list.

Table 4-5 Line voltage assignment for setting the fan transformer ( 380 to 480 V 3 ph . AC)

| Line voltage | Tap of the fan transformer (-T1 -T10) |
| :---: | :---: |
| $380 \mathrm{~V} \pm 10 \%$ | 380 V |
| $400 \mathrm{~V} \pm 10 \%$ | 400 V |
| $440 \mathrm{~V} \pm 10 \%$ | 440 V |
| $480 \mathrm{~V} \pm 10 \%$ | 480 V |

Table 4-6 Line voltage assignment for setting the fan transformer ( 500 to 600 V 3 ph . AC)

| Line voltage | Tap of the fan transformer (-T1 -T10) |
| :---: | :---: |
| $500 \mathrm{~V} \pm 10 \%$ | 500 V |
| $525 \mathrm{~V} \pm 10 \%$ | 525 V |
| $575 \mathrm{~V} \pm 10 \%$ | 575 V |
| $600 \mathrm{~V} \pm 10 \%$ | 600 V |

### 4.6.6 Adjusting the internal power supply (-A1 -T10, enclosed drive type A only)

A transformer (-A1-T10) is installed for the internal 115 V AC power supply of the cabinet. The location of the transformer is indicated in the layout diagrams supplied.
When delivered, the taps are always set to the highest level. The line-side terminals of the transformer may need to be reconnected according to the existing line voltage.
The line voltage assignments for making the appropriate setting on the transformer for the internal power supply are indicated in the following tables.

## NOTICE

Property damage due to voltage set too high
If the terminals are not reconnected to the actual line voltage, this can result in damage to the device when the voltage is set too high.

- Set the terminals in accordance with the actual line voltage.

Table 4-7 Line voltage assignment for the internal power supply ( 380 to 480 V AC, 3 phase)

| Line voltage range | Tap | Taps of matching transformer (-A1-T10) <br> LH1 - LH2 |
| :---: | :---: | :---: |
| $342 \ldots 390 \mathrm{~V}$ | 380 V | $1-2$ |
| $391 \ldots 410 \mathrm{~V}$ | 400 V | $1-3$ |
| $411 \ldots 430 \mathrm{~V}$ | 415 V | $1-4$ |
| $431 \ldots 450 \mathrm{~V}$ | 440 V | $1-5$ |
| $451 \ldots 470 \mathrm{~V}$ | 460 V | $1-6$ |
| $471 \ldots 528 \mathrm{~V}$ | 480 V | $1-7$ |

Table 4-8 Line voltage assignment for the internal power supply ( 500 to $600 \mathrm{VAC}, 3$ phase)

| Line voltage range | Tap | Taps of matching transformer (-A1-T10) <br> LH1-LH2 |
| :---: | :---: | :---: |
| $450 \ldots 515 \mathrm{~V}$ | 500 V | $1-8$ |
| $516 \ldots 540 \mathrm{~V}$ | 525 V | $1-9$ |
| $541 \ldots 560 \mathrm{~V}$ | 550 V | $1-10$ |
| $561 \ldots 590 \mathrm{~V}$ | 575 V | $1-11$ |
| $591 \ldots 670 \mathrm{~V}$ | 600 V | $1-12$ |

### 4.6.7 Removing the connection clip for the basic interference suppression module for operation on an ungrounded / IT power network

If the enclosed drive is operated on an ungrounded power network (IT power network), the connection clip to the basic interference suppression module of the drive (-T1) must be removed.

## Note

## Warning label on the connection clip

A yellow warning label is attached to each connection clip so that it is easier to find.

- The warning label must be removed from the connection clip (by pulling it off) if the connection clip is to remain in the unit (operation on a grounded power network).
- The warning label must be removed together with the connection clip if the unit is operated on an ungrounded / IT power network.


Figure 4-7 Warning label on the connection clip

## NOTICE

Device damage resulting from failure to remove the connection clip on an ungrounded power network

Failing to remove the connection clip for the basic interference suppression module on an ungrounded / IT power network can cause significant damage to the device.

- Remove the connection clip to the basic interference suppression module on an ungrounded power network (IT power network).


Figure 4-8 Removing the connection clip for the basic interference suppression module, frame size FX


Figure 4-9 Removing the connection clip for the basic interference suppression module, frame size GX


Figure 4-10 Removing the connection clip for the basic interference suppression module, frame size HX


Figure 4-11 Removing the connection clip for the basic interference suppression module, frame size JX

### 4.7 External supply of the auxiliary supply from a secure line

## Description

A secure external control power supply (for example, from a UPS) is always recommended if communication and closed-loop control are to be independent of the drive power supply. An external control power supply is particularly recommended for low-power lines susceptible to short-term voltage dips or power failures.

With a secure external supply independent of the main supply, alarms and fault codes can still be displayed on the operator panel and internal protection and monitoring devices if the main supply fails.
A. Warning

Dangerous voltage as a result of external auxiliary supply
When the external auxiliary supply is connected, dangerous voltages continue to be present in the cabinet unit even when the mains switch is open. Death or serious injury can result when live parts are touched.

- Observe the general safety instructions when working on the device.


## Note

## External auxiliary supply for automatic restart

An external auxiliary incoming supply must always be used when the automatic restart (WEA) function is to be used with integrated EMERGENCY OFF option (N57) or EMERGENCY STOP option (N59, N60). Otherwise, the automatic restart function does not work.

Table 4-9 Possible connections for the external auxiliary voltage based on selected options

| Cabinet unit option | External supply of auxiliary voltage independent of the main supply |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | 24 V DC <br> terminal -X9 | $\begin{aligned} & 115 \mathrm{~V} \mathrm{AC} \\ & \text { terminal -X40 } \end{aligned}$ | $\begin{array}{\|l} \hline 24 \mathrm{~V} \text { DC } \\ \text { (terminal-X9) } \\ 115 \mathrm{~V} \mathrm{AC} \\ \left(\text { terminal -X40) }^{1}\right. \text { ) } \\ \hline \end{array}$ | 115 V AC <br> (terminal -X40) <br> in conjunction with option L13 |
| - With no further options <br> - Enclosed chassis type C | X |  |  |  |
| N70 |  | X |  |  |
| L87 |  |  | X | X |
| L97 |  |  | X | X |

${ }^{1)}$ This is required not only when the open and closed-loop control but also when $115-\mathrm{V}-\mathrm{AC}$ loads (PT100 evaluation or insulation monitor) are to remain in operation if the main supply fails.

### 4.7. 115 V AC auxiliary supply

The fuse must not exceed 10 A .
The connection is protected inside the cabinet with a 10 A fuse.

## Connecting

- On terminal block -X40, remove the jumpers between terminals 1 and 2 as well as 5 and 6.
- Connect the external 115 V AC supply to terminals $2(\mathrm{~L} 1)$ and $6(\mathrm{~N})$.

Maximum connectable cross-section: \#12 AWG (4 mm²)

### 4.7.2 24 V DC auxiliary supply

The fuse must not exceed 10 A .
The maximum current demand is 5 A .

## Connecting

Connect the external 24 V DC supply to terminals 1 ( P 24 V ) and 2 ( $\mathrm{Mext}^{\text {et }}$ ) of terminal block -X9.

Maximum connectable cross-section: \#14 AWG ( $2.5 \mathrm{~mm}^{2}$ )

### 4.8 Signal connections

### 4.8.1 Control Unit CU320-2 DP

In the standard version, the cabinet unit contains a CU320-2 DP control unit, which handles the communication and open-loop/closed-loop control functions.

A PROFIBUS interface is available for higher-level communication.

## Connection overview



Figure 4-12 Connection overview of the CU320-2 DP Control Unit (without cover)


Figure 4-13 Interface X140 and measuring sockets T0 to T2 - CU320-2 DP (view from below)

## NOTICE

Malfunctions or damage to the Option Board by pulling and plugging it during operation
Pulling and plugging the Option Board during operation can damage it or cause it to malfunction.

- Only pull and plug the Option Board when the Control Unit is de-energized.


## Connection example



Figure 4-14 Connection example for CU320-2 DP

## X100 to X103: DRIVE-CLiQ interface

Table 4-10 DRIVE-CLiQ interface X100 - X103

|  | Pin | Signal name | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | TXP | Send data + |
|  | 2 | TXN | Send data - |
|  | 3 | RXP | Receive data + |
|  | 4 | Reserved, do not use |  |
|  | 5 | Reserved, do not use |  |
|  | 6 | RXN | Receive data - |
|  | 7 | Reserved, do not use |  |
|  | 8 | Reserved, do not use |  |
|  | A | + (24 V) | Power supply |
|  | B | $\mathrm{M}(0 \mathrm{~V})$ | Electronics ground |
| Connector Blanking pla | e: RJ45 s for DRIV | iQ interfaces (50 pcs.) A | r: 6SL3066-4CA00-0AA0 |

## X122: Digital inputs/outputs

Table 4-11 Terminal block X122

${ }^{1)}$ DI: Digital input; DI/DO: Bidirectional digital input/output; M: Electronics ground; M1: Reference potential
2) The fast inputs can be used as probe inputs or as inputs for the equivalent zero mark.
3) Data for: $\mathrm{V}_{\mathrm{cc}}=24 \mathrm{~V}$; load $48 \Omega$; high ("1") $=90 \% \mathrm{~V}_{\text {out; }}$ low ("0") $=10 \% \mathrm{~V}_{\text {out }}$

The maximum cable length that can be connected is 30 m .

## Note

## Ensuring the function of digital inputs

An open input is interpreted as "low".
Terminal M1 must be connected so that the digital inputs (DI) can function.
This is achieved through one of the following measures:

1. Provision of the ground reference of the digital inputs.
2. A jumper to terminal $M$. (Note: This removes the electrical isolation for these digital inputs.)

## Note

If the 24 V supply is briefly interrupted, then the digital outputs are deactivated during this time.

## X132: Digital inputs/outputs

Table 4-12 Terminal block X132

${ }^{1)}$ DI: Digital input; DI/DO: Bidirectional digital input/output; M: Electronics ground; M2: Reference potential
2) The fast inputs can be used as probe inputs or as inputs for the equivalent zero mark
3) Data for: $\mathrm{V}_{\mathrm{cc}}=24 \mathrm{~V}$; load $48 \Omega$; high ("1") $=90 \% \mathrm{~V}_{\text {out; }}$ low ("0") $=10 \% \mathrm{~V}_{\text {out }}$

The maximum cable length that can be connected is 30 m .

## Note

## Ensuring the function of digital inputs

An open input is interpreted as "low".
To enable the digital inputs (DI) to function, terminal M2 must be connected.
This is achieved through one of the following measures:

1. Provision of the ground reference of the digital inputs.
2. A jumper to terminal M . (Note: This removes the electrical isolation for these digital inputs.)

## Note

If the 24 V supply is briefly interrupted, then the digital outputs are deactivated during this time.

## X126: PROFIBUS connection

PROFIBUS is connected using a 9-pin sub D socket (X126); the terminals are isolated.

Table 4-13 PROFIBUS interface X126

|  | Pin | Signal name | Meaning | Range |
| :---: | :---: | :---: | :---: | :---: |
|  | 1 | - | Not assigned |  |
|  | 2 | M24_SERV | Power supply for teleservice, ground | 0 V |
|  | 3 | RxD/TxD-P | Receive/transmit data P (B) | RS485 |
|  | 4 | CNTR-P | Control signal | TTL |
|  | 5 | DGND | PROFIBUS data reference potential |  |
|  | 6 | VP | Supply voltage plus | $5 \mathrm{~V} \pm 10$ \% |
|  | 7 | P24_SERV | Power supply for teleservice, + (24 V) | 24 V (20.4 to 28.8 V ) |
|  | 8 | RxD/TxD-N | Receive/transmit data N (A) | RS485 |
|  | 9 | - | Not assigned |  |

A teleservice adapter can be connected to the PROFIBUS interface for remote diagnostics. The power supply for the teleservice (terminals 2 and 7 ) can have a load of up to 150 mA .

## NOTICE

Damage to the Control Unit or other PROFIBUS nodes due to high leakage currents
If a suitable equipotential bonding conductor is not used, significant leakage currents can flow along the PROFIBUS cable and destroy the Control Unit or other PROFIBUS nodes.

- An equipotential bonding conductor with a cross-section of at least $25 \mathrm{~mm}^{2}$ must be used between components in a system that are located at a distance from each other.


## NOTICE

Damage to the Control Unit or other CAN bus nodes due to the connection of a CAN cable If a CAN cable is connected to the X126 interface, this can destroy the Control Unit or other CAN bus nodes.

- Do not connect a CAN cable to the X126 interface.


## PROFIBUS connector

The terminating resistors must be inserted for the first and last nodes in a line; otherwise, data transmission will not function correctly.
The bus terminating resistors are activated in the connector.
The cable shield must be connected at both ends and over a large surface area.

## Connectors

Cables must be connected via PROFIBUS connectors because they have the necessary bus terminating resistors.

The figure below shows the correct PROFIBUS connector with and without a PG/PC connector.


PROFIBUS connector without PG/PC connection 6ES7972-0BA42-0XA0


PROFIBUS connector with PG/PC connection 6ES7972-0BB42-0XA0

## Bus terminating resistor

The bus terminating resistor must be switched on or off depending on its position in the bus, otherwise the data will not be transmitted properly.

The terminating resistors for the first and last nodes in a line must be switched on; the resistors must be switched off at all other connectors.

The cable shield must contact at both ends with the greatest possible surface area.

## Note

## Connector type

The proper connector assignment (IN/OUT) in conjunction with the terminating resistor must be observed according to the connector type.

First bus node Last bus node


Figure 4-15 Position of the bus terminating resistors

## PROFIBUS address switches

The PROFIBUS address is set as a hexadecimal value via two rotary coding switches. Values between $0_{\text {dec }}\left(00_{\text {hex }}\right)$ and $127_{\text {dec }}\left(7 \mathrm{~F}_{\text {hex }}\right)$ can be set as the address. The upper rotary coding switch $(H)$ is used to set the hexadecimal value for $16{ }^{1}$, and the lower rotary coding switch ( L ) is used to set the hexadecimal value for $16^{\circ}$.

Table 4-14 PROFIBUS address switches

| Rotary coding switches | Significance | Examples |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | 21 dec | 35 dec | 126dec |
|  |  | $15_{\text {hex }}$ | 23 hex | 7Enex |
|  | $16^{1}=16$ | 1 | 2 | 7 |
|  | $16^{0}=1$ | 5 | 3 | E |

## Setting the PROFIBUS address

The factory setting for the rotary coding switches is 0 dec ( $00_{\text {hex }}$ ).
There are two ways to set the PROFIBUS address:

1. Via p0918

- To set the bus address for a PROFIBUS node using STARTER, first set the rotary code switches to $0_{\text {dec }}\left(00_{\text {hex }}\right)$ and $127_{\text {dec }}\left(7 F_{\text {hex }}\right)$.
- Then use parameter p0918 to set the address to a value between 1 and 126.

2. Via the PROFIBUS address switches on the Control Unit

- The address is set manually to values between 1 and 126 using the rotary coding switches. In this case, p0918 is only used to read the address.


## Note

The rotary coding switches used to set the PROFIBUS address are located beneath the cover.

## Note

Address 126 is intended for commissioning. Permitted PROFIBUS addresses are 1 ... 126.
When several Control Units are connected to a PROFIBUS line, you set the addresses differently compared to the factory setting. Each PROFIBUS address in a PROFIBUS line can only be assigned once. Either set the PROFIBUS address in absolute terms using the rotary coding switches - or selectively in parameter p0918. Each change made to the bus address is effective only after a POWER ON.
The currently set address of the rotary coding switch is displayed in parameter r2057.

## X127: LAN (Ethernet)

Table 4-15 X127 LAN (Ethernet)

|  | Pin | Designation | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | TXP | Ethernet transmit data + |
|  | 2 | TXN | Ethernet transmit data - |
| - | 3 | RXP | Ethernet receive data + |
|  | 4 | Reserved, do not use |  |
|  | 5 | Reserved, do not use |  |
|  | 6 | RXN | Ethernet receive data - |
|  | 7 | Reserved, do not use |  |
|  | 8 | Reserved, do not use |  |
| Connector type: RJ45 socket |  |  |  |

## Note

The LAN (Ethernet) interface does not support Auto MDI(X). If the LAN interface of the communication partner also cannot handle auto-MDI(X), then a crossover cable must be used to establish the connection.

For diagnostic purposes, the X127 LAN interface features a green and a yellow LED. These LEDs indicate the following status information:

Table 4-16 LED states for the X127 LAN interface

| LED | Color | Status | Description |
| :--- | :--- | :--- | :--- |
| Link port | - | Off | Missing or faulty link |
|  | Green | Continuous light | 10 or 100 Mbit link available |
| Activity port | - | Off | No activity |
|  | Yellow | Flashing light | Sending or receiving |

## X140: Serial interface (RS232)

The AOP30 operator panel for operating/configuring the device can be connected via the serial interface. The interface is located on the underside of the Control Unit.

Table 4-17 Serial interface (RS232) X140


## Note

## Connecting cable to the AOP30

The connection cable to AOP30 may only contain the three contacts which are shown in the drawing; a completely allocated cable may not be used.

## T0, T1, T2: Measuring socket contacts

Table 4-18 Measuring socket contacts T0, T1, T2

|  | Socket | Function | Technical specifications |
| :---: | :---: | :---: | :---: |
| M T0 T1 T2 | M | Ground | Voltage: $0 . . .5 \mathrm{~V}$ <br> Resolution: 8 bits <br> Load current: max. 3 mA <br> Sustained short-circuit-proof <br> The reference potential is terminal M |
|  | T0 | Measuring socket contact 0 |  |
|  | T1 | Measuring socket contact 1 |  |
|  | T2 | Measuring socket contact 2 |  |
|  |  |  |  |
| PCB plug connector from Phoenix Contact, type: ZEC 1.0/ 4-ST-3.5 C1 R1.4, order number: 1893708 |  |  |  |

## Note

## Cable cross-section

The measuring socket contacts are only suitable for cable cross-sections of $0.2 \mathrm{~mm}^{2}$ to $1 \mathrm{~mm}^{2}$.

## Note

## Use of the measuring socket contacts

The measuring socket contacts are used to support commissioning and diagnostics. Connection during operation is not permitted.

## DIAG button

The DIAG pushbutton is reserved for service functions.

## Slot for the memory card



Figure 4-16 Slot for the memory card

## Note

Plant standstill by withdrawing or inserting the memory card during operation
If the memory card is withdrawn or inserted during operation, then data can be lost, possibly resulting in a plant standstill.

- Pull and plug the memory card only when the Control Unit is de-energized.


## Note

Insertion direction of the memory card
Only insert the memory card as shown in the photo above (arrow at top right).

## NOTICE

Damage to memory card due to electric fields or electrostatic discharge
Electrical fields or electrostatic discharge may result in damage to the memory card and therefore malfunctions.

- When removing and inserting the memory card, always observe the ESD regulations.


## Note

## Data loss when the Control Unit with memory card is returned

When a defective Control Unit is returned, the data on the memory card (parameters, firmware, licenses, etc.) may be lost during repair and testing.

- Do not return the memory card with the Control Unit. Instead, keep it in a safe place so that it can be inserted in the replacement unit.


## Note

Please note that only SIEMENS memory cards can be used to operate the Control Unit.

### 4.8.2 Customer terminal module

## Note

## Preassignment and position of the customer terminal block

The factory setting and description of the customer terminal module can be found in the circuit diagrams.

The location of the customer terminal module in the enclosed drive is indicated in the layout diagram.

## Types A and C

In the Type C enclosed chassis, the TM31 Terminal Module is used as the customer terminal module; the external signals must be connected to it.

## Type A with option G65

For Type A enclosed drives with option G65, the connections of the TM31 Terminal Module are routed to an intermediate terminal block (-X65), which can be used for customer connections with a larger conductor cross-section.

## Shield connection

The shield connection of shielded control cables on the customer terminal module (-A60 or -X65) is established in the immediate vicinity of the terminal module. For this purpose, the customer terminal module -A60 and the mounting plates have cut-out sections which are used to snap the enclosed shield springs into place. The shields of incoming and outgoing cables must be applied directly to these shield connections. It is important here to establish the greatest possible area of contact and a good conductive connection.

## Note

## Shield springs

These shield springs can be used for all control cables in the enclosed drive because all the shield connections are identical in design.


Figure 4-17 Shield connection

### 4.8.2.1 Customer terminal block (-A60) (for types A and C)

## Overview



Figure 4-18 TM31 customer terminal module


Figure 4-19 Connection overview of TM31 customer terminal module

### 4.8.2.2 Customer terminal block ( -X65) (for type A with option G65)

Overview


Figure 4-20 Customer terminal module


Figure 4-21 Connection overview of customer terminal module

### 4.8.2.3 Terminal descriptions

## X520: 4 digital inputs

Table 4-19 Terminal block X520

|  | Terminal | Designation ${ }^{1)}$ | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | DI 0 | Voltage: - $3 \ldots+30 \mathrm{~V}$ <br> Current consumption typical: 10 mA at 24 V DC <br> Input delay: <br> For "0" to "1": typ. $50 \mu \mathrm{~s}$, max. $100 \mu \mathrm{~s}$ <br> For "1" to "0": typ. $130 \mu \mathrm{~s}$, max. $150 \mu \mathrm{~s}$ <br> Electrical isolation: <br> Reference potential is terminal M1 <br> Signal level (including ripple) <br> High level: $15 \ldots 30 \mathrm{~V}$ <br> Low level: $-3 \ldots+5 \mathrm{~V}$ |
|  | 2 | DI 1 |  |
|  | 3 | DI 2 |  |
|  | 4 | DI 3 |  |
|  | 5 | M1 |  |
|  | 6 | M |  |
|  |  |  |  |
| Max. connectable cross-section: <br> - Version A and C: \#16 AWG (1.5 mm²) <br> - Version A with option G65: \#14 AWG ( $2.5 \mathrm{~mm}^{2}$ ) |  |  |  |

${ }^{1)}$ DI: Digital input; M1: Ground reference; M: Electronics ground

## Note

## Ensuring the function of digital inputs

An open input is interpreted as "low".
Terminal M1 must be connected so that the digital inputs (DI) can function.
This is achieved through one of the following measures:

1. Provision of the ground reference of the digital inputs.
2. A jumper to terminal M . (Note: This removes the electrical isolation for these digital inputs.)

## X530: 4 digital inputs

Table 4-20 Terminal block X530

|  | Terminal | Designation ${ }^{1)}$ | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | DI 4 | Voltage: $-3 \ldots+30 \mathrm{~V}$ <br> Current consumption typical: 10 mA at 24 V DC <br> Input delay: <br> For "0" to "1": typ. $50 \mu \mathrm{~s}$, max. $100 \mu \mathrm{~s}$ <br> For "1" to "0": typ. $130 \mu \mathrm{~s}$, max. $150 \mu \mathrm{~s}$ <br> Electrical isolation: <br> Reference potential is terminal M2 <br> Signal level (including ripple) <br> High level: $15 \ldots 30 \mathrm{~V}$ <br> Low level: -3 ... +5 V |
|  | 2 | DI 5 |  |
|  | 3 | DI 6 |  |
|  | 4 | DI 7 |  |
|  | 5 | M2 |  |
|  | 6 | M |  |
|  |  |  |  |

Max. connectable cross-section:

- Version A and C: \#16 AWG (1.5 mm²)
- Version A with option G65: \#14 AWG (2.5 mm²)

1) DI: Digital input; M2: Ground reference; M: Electronics ground

## Note

Ensuring the function of digital inputs
An open input is interpreted as "low".
To enable the digital inputs (DI) to function, terminal M2 must be connected.
This is achieved through one of the following measures:

1. Provision of the ground reference of the digital inputs.
2. A jumper to terminal M . (Note: This removes the electrical isolation for these digital inputs.)

## X521: 2 analog inputs (differential inputs)

Table 4-21 Terminal block X521

|  | Terminal | Designation ${ }^{1)}$ | Technical specifications |
| :---: | :---: | :---: | :---: |
| $\rightarrow \square$ | 1 | Al 0+ | The analog inputs can be toggled between current and voltage input using switches S5.0 and S5.1. <br> As voltage input: $-10 \ldots+10 \mathrm{~V} ; \mathrm{R}_{\mathrm{i}}>100 \mathrm{k} \Omega$ <br> Resolution: 11 bits + sign <br> As current input: $-20 \ldots+20 \mathrm{~mA} ; \mathrm{R}_{\mathrm{i}}=250 \mathrm{k} \Omega$ <br> Resolution: 10 bits + sign |
| N | 2 | Al 0- |  |
| $\omega$ | 3 | Al 1+ |  |
| 0 | 4 | Al 1- |  |
|  |  |  |  |
|  | 5 | P10 | Auxiliary voltage: $\begin{aligned} & P 10=10 V \\ & N 10=-10 V \end{aligned}$ <br> Sustained short-circuit-proof |
|  | 6 | M |  |
|  | 7 | N10 |  |
|  | 8 | M |  |
| Max. connectable cross-section: <br> - Version A and C: \#16 AWG (1.5 mm²) <br> - Version A with option G65: \#14 AWG ( $2.5 \mathrm{~mm}^{2}$ ) |  |  |  |

${ }^{1)} \mathrm{Al}$ : Analog input; P10/N10: Auxiliary voltage, M: Ground reference

## NOTICE

## Damage or malfunction due to impermissible voltage values

If a current exceeding $\pm 35 \mathrm{~mA}$ flows through the analog current input, then the component could be destroyed.
The common mode range must not be violated in order to avoid incorrect analog-digital conversion results.

- The input voltage may only be in the range between -30 V and +30 V (destruction limit).
- The common mode voltage may only be in the range between -10 V and +10 V (error limit).
- The back EMF at the auxiliary voltage outputs may only be in the range between -15 V and +15 V .


## Note

The voltage supply for the analog inputs can be taken internally or from an external voltage source.

## S5: Selector for voltage/current AIO, Al1

## Note

## Position of the selector

The selector is located on the customer terminal block TM31 (-A60), a selector setting also has to be made on TM31 for enclosed drives of type A with option G65.

Table 4-22 Selector for voltage/current S5

|  | Switch | Function |
| :--- | :--- | :--- |
| V V | S5.0 | S5.0 |
|  | S5.1 | Selects voltage (V) / current (I) AIO |
|  | S5.1 | Selects voltage (V) / current (I) AI1 |

## Note

## Factory state

The factory state for both switches is current measurement (switch set to "I").

## X522: 2 analog outputs, temperature sensor connection

Table 4-23 Terminal block X522

|  | Terminal | Designation ${ }^{1)}$ | Technical specifications |
| :---: | :---: | :---: | :---: |
| $\rightarrow \square$ | 1 | AO 0V+ | You can set the following output signals using parameters: |
| N | 2 | AO 0- |  |
| $\omega$ | 3 | AO 0C+ | Voltage: $-10 \ldots+10 \mathrm{~V}$ (max. 3 mA ) Current 1: 4 ... 20 mA (max. load resistance $\leq 500 \Omega$ ) |
|  | 4 | AO 1V+ |  |
|  | 5 | AO 1- | Current 2: -20 ... +20 mA (max. load resistance $\leq 500 \Omega$ ) |
|  | 6 | AO 1C+ |  |
|  |  |  | Current 3: 0 ... 20 mA (max. load resistance $\leq 500 \Omega$ ) |
|  |  |  | Resolution: 11 bits + sign |
|  |  |  | Sustained short-circuit-proof |
|  | 7 | +Temp ${ }^{2)}$ | Temperature sensor KTY84-1C130/PT1000/PTC Measuring current via temperature sensor connection: 2 mA |
|  | 8 | -Temp ${ }^{2)}$ |  |

Max. connectable cross-section:

- Version A and C: \#16 AWG (1.5 mm²)
- Version A with option G65: \#14 AWG (2.5 mm²)

1) $\mathrm{AO} \times \mathrm{V}$ : Analog output voltage; AO xC : Analog output current
2) Accuracy of the temperature measurement:

- KTY: $\pm 7^{\circ} \mathrm{C}$ (including evaluation)
- PT1000: $\pm 5^{\circ} \mathrm{C}$ (PT1000 tolerance class B according to EN 60751 including evaluation)
- PTC: $\pm 5^{\circ} \mathrm{C}$ (including evaluation)


## A. warning

Electric shock in the event of voltage flashovers at the temperature sensor
Voltage flashovers in the signal electronics can occur in motors without safe electrical separation of the temperature sensors.

- Use temperature sensors that fully comply with the specifications of the safety isolation.


## NOTICE

Damage or malfunction due to impermissible voltage values
If the back EMF is impermissible, the components may be damaged or malfunction.

- The back EMF at the outputs may only be in the range between -15 V and +15 V .


## NOTICE

Damage to motor when KTY temperature sensor is connected incorrectly
If a KTY temperature sensor is connected with incorrect polarity, it is not possible to detect when the motor overheats. Overheating can cause damage to the motor.

- Connect a KTY temperature sensor with the correct polarity.


## X540: Joint auxiliary voltage for the digital inputs

Table 4-24 Terminal block X540

|  | Terminal | Designation | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 8 | +24 V | Voltage: +24 V DC <br> Max. total load current of +24 V auxiliary voltage for terminals X540 and X541 combined: 150 mA <br> Sustained short-circuit-proof |
|  | 7 | +24 V |  |
|  | 6 | +24 V |  |
|  | 5 | +24V |  |
|  | 4 | +24V |  |
|  | 3 | +24 V |  |
|  | 2 | +24 V |  |
|  | 1 | +24 V |  |
| Version <br> Version | able cross d C: \#16 th option | $\begin{aligned} & \left.1.5 \mathrm{~mm}^{2}\right) \\ & 14 \mathrm{AWG}(2.5 \end{aligned}$ |  |

## Note

## Use of the voltage supply

This voltage supply is used only for supplying the digital inputs.

## X541: 4 non-floating digital inputs/outputs

Table 4-25 Terminal strip X541

|  | Terminal | Designation ${ }^{1)}$ | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 6 | M | Auxiliary voltage: <br> Voltage: +24 V DC <br> Max. total load current of +24 V auxiliary voltage for terminals X540 and X541 combined: 150 mA <br> As input: <br> Voltage: -3 ... 30 V <br> Power consumption, typical: 10 mA at 24 V DC <br> Input delay: <br> - for "0" to "1": Typ. $50 \mu \mathrm{~s}$ <br> - For "1" to "0". Typ. $100 \mu \mathrm{~s}$ <br> As output: <br> Voltage: 24 V DC <br> Max. load current per output: 500 mA <br> Max. total current of outputs (including currents to the inputs): $100 \mathrm{~mA} / 1 \mathrm{~A}$ (assignable) <br> Sustained short-circuit-proof <br> Output delay: <br> - For "0" to "1": Typ. $150 \mu \mathrm{~s}$ at 0.5 A resistive load ( $500 \mu \mathrm{~s}$ maximum) <br> - For "1" to "0": typ. $50 \mu \mathrm{~s}$ at 0.5 A resistive load <br> Switching frequency: <br> - For resistive load: Max. 100 Hz <br> - For inductive load: Max. 0.5 Hz <br> - For lamp load: max. 10 Hz <br> Maximum lamp load: 5 W |
|  | 5 | DI/DO 11 |  |
|  | 4 | DI/DO 10 |  |
|  | 3 | DI/DO 9 |  |
|  | 2 | DI/DO 8 |  |
|  | 1 | +24 V |  |
|  |  |  |  |
|  |  |  |  |
| Max. connectable cross-section: <br> - Version A and C: \#16 AWG (1.5 mm²) <br> - Version A with option G65: \#14 AWG (2.5 mm²) |  |  |  |

1) DI/DO: Digital input/output: M: Electronics ground

## Note

Open input
An open input is interpreted as "low".

## Note

If the 24 V supply is briefly interrupted, then the digital outputs are deactivated during this time.

## X542: 2 relay outputs (two-way contact)

Table 4-26 Terminal block X542

|  | Terminal | Designation ${ }^{1)}$ | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | DO 0.NC | Contact type: Change-over contact max. load current: 8 A <br> Max. switching voltage: $250 \mathrm{~V}_{\mathrm{AC}} 30 \mathrm{~V}_{\mathrm{DC}}$ <br> Max. switching capacity at 250 VAc: 2000 VA $(\cos \phi=1)$ <br> Max. switching capacity at $250 \mathrm{~V}_{\mathrm{AC}}: 750 \mathrm{VA}(\cos \phi=0.4)$ <br> Max. switching capacity at 30 VDC : 240 W (resistive load) <br> Required minimum current: 100 mA <br> Output delay: $\leq 20 \mathrm{~ms}^{2)}$ <br> Overvoltage category: Class II acc. to EN 60664-1 |
|  | 2 | DO 0.COM |  |
|  | 3 | DO 0.NO |  |
|  | 4 | DO 1.NC |  |
|  | 5 | DO 1.COM |  |
|  | 6 | DO 1.NO |  |
|  |  |  |  |
| Max. connectable cross-section: <br> - Version A and C: \#14 AWG (2.5 mm²) <br> - Version A with option G65: \#12 AWG (4.0 mm²) |  |  |  |

1) DO: Digital output, NO: Normally-open contact, NC: Normally-closed contact, COM: Mid-position contact
2) Depending on the parameter assignment and the supply voltage (P24) of the TM31

## Note

## Additional protective ground

If 115 V AC is applied to the relay outputs, the terminal module (-A60) must also be grounded via a \#14 AWG ( $2.5 \mathrm{~mm}^{2}$ ) ground conductor.

### 4.9 Other connections

Depending on the options installed, further connections may need to be established, for example, dv/dt filter plus Voltage Peak Limiter, input contactor, sine-wave filter, connection for external auxiliary equipment, enclosure light with service socket, enclosure space heater, safety relay combination (EMERGENCY OFF / EMERGENCY STOP), braking unit, RTD monitor, insulation monitor, communication modules, or speed encoder module.
More detailed information on how to interconnect individual options with interfaces is provided on customer DVD supplied with the unit.

### 4.9.1 dv/dt filter plus Voltage Peak Limiter (option L10)

## Description

The dv/dt filter plus voltage peak limiter comprises two components: the dv/dt reactor and the Voltage Peak Limiter, which limits transients and returns the energy to the DC link.

The dv/dt filters plus voltage peak limiter must be used for motors for which the dielectric strength of the insulation system is unknown or insufficient. Standard Siemens 1LA5, 1LA6, and 1LA8 series motors only require these for supply voltages $>500 \mathrm{~V}+10 \%$.

The dv/dt filter plus Voltage Peak Limiter limits the rate of voltage rise to values < $500 \mathrm{~V} / \mu \mathrm{s}$ and the typical voltage peaks to the values below (with motor cable lengths of $<150 \mathrm{~m}$ ):

- < 1000 V at $\mathrm{U}_{\text {line }}<575 \mathrm{~V}$

Option L10 requires an additional cabinet with a width as shown in the table below.

Table 4-27 Accommodating the voltage limiting network in an additional cabinet

| Voltage range | Installation of the voltage limiting <br> network in an additional cabinet <br> Width = 23.6" (600 mm | Installation of the voltage limiting <br> network in an additional cabinet <br> Width = 15.8" (400 mm) |
| :---: | :---: | :---: |
| 380 ... 480 V AC 3-ph. | 6SL3710-1GE32-1AU3 | 6SL3710-1GE36-1AU3 |
|  | 6SL3710-1GE32-6AU3 | 6SL3710-1GE37-5AU3 |
|  | 6SL3710-1GE33-1AU3 | 6SL3710-1GE38-4AU3 |
|  | 6SL3710-1GE33-8AU3 | 6SL3710-1GE41-0AU3 |
| 6SL3710-1GE35-0AU3 |  |  |
| 600 ... 600 V AC 3-ph. | 6SL3710-1GF31-8AU3 | 6SL3710-1GF34-1AU3 |
|  | 6SL3710-1GF32-2AU3 | 6SL3710-1GF34-7AU3 |
|  | 6SL3710-1GF32-6AU3 | 6SL3710-1GF35-8AU3 |
|  | 6SL3710-1GF33-3AU3 | 6SL3710-1GF37-4AU3 |
|  |  | 6SL3710-1GF38-1AU3 |

## Restrictions

The following restrictions should be noted when a dv/dt filter plus voltage peak limiter is used:

- The output frequency is limited to a maximum of 150 Hz .
- Maximum permissible motor cable lengths:
- Shielded cable: max. $980 \mathrm{ft}(300 \mathrm{~m})$
- Unshielded cable: max. 1480 ft (450 m)


## NOTICE

## Damage to the dv/dt filter from exceeding the maximum output frequency

The maximum permissible output frequency when using a dv/dt filter is 150 Hz . The dv/dt filter can be damaged if the output frequency is exceeded.

- Operate the dv/dt filter with a maximum output frequency of 150 Hz .


## NOTICE

## Damage to the dv/dt filter from exceeding the maximum pulse frequency

The maximum permissible pulse frequency when using a dv/dt filter is 2.5 kHz or 4 kHz . The dv/dt filter can be damaged if the pulse frequency is exceeded.

- When using the dv/dt filter, operate the Power Module with a maximum pulse frequency of 2.5 kHz or 4 kHz .


## NOTICE

Damage to the dv/dt filter if it is not activated during commissioning
The dv/dt filter may be damaged if it is not activated during commissioning.

- Activate the dv/dt filter during commissioning via parameter p0230 $=2$.


## NOTICE

Damage to the dv/dt filter when a motor is not connected
$\mathrm{dv} / \mathrm{dt}$ filters that are operated without a motor being connected can be damaged or destroyed.

- Never operate a dv/dt filter connected to the Power Module without a connected motor.


## Note

## Setting of pulse frequencies

It is permissible to set pulse frequencies in the range between the rated pulse frequency and the relevant maximum pulse frequency when a dv/dt filter plus voltage peak limiter is used. When doing so, take into account the "Current derating as a function of the pulse frequency"; refer to the Technical specifications.

Table 4-28 Max. pulse frequency when a dv/dt filter plus voltage peak limiter is used in units with a rated pulse frequency of 2 kHz

| Article no. <br> 6SL3710-... | Unit rating <br> [HP / kW] | Output current for a pulse <br> frequency of 2 kHz [A] | Max. pulse frequency when a dv/dt <br> filter is used |
| :---: | :---: | :---: | :---: |
| Supply voltage 3-phase 380 VAC ... 480 VAC |  |  |  |
| 1GE32-1AU3 | $150 / 110$ | 210 | 4 kHz |
| 1GE32-6AU3 | $200 / 132$ | 260 | 4 kHz |
| 1GE33-1AU3 | $250 / 160$ | 310 | 4 kHz |
| 1GE33-8AU3 | $300 / 200$ | 380 | 4 kHz |
| 1GE35-0AU3 | $400 / 250$ | 490 | 4 kHz |

Table 4-29 Max. pulse frequency when a dv/dt filter plus voltage peak limiter is used in units with a rated pulse frequency of 1.25 kHz

| Article no. <br> 6SL3710-.. | Unit rating <br> [HP / kW] | Output current for a pulse <br> frequency of 1.25 kHz [A] | Max. pulse frequency when a dv/dt <br> filter is used |  |
| :---: | :---: | :---: | :---: | :---: |
| Supply voltage 3-phase $380 \mathrm{VAC} \ldots 480 \mathrm{VAC}$ |  |  |  |  |
| 1GE36-1AU3 | $500 / 315$ | 605 | 2.5 kHz |  |
| 1GE37-5AU3 | $600 / 400$ | 745 | 2.5 kHz |  |
| 1GE38-4AU3 | $700 / 450$ | 840 | 2.5 kHz |  |
| 1GE41-0AU3 | $800 / 560$ | 985 | 2.5 kHz |  |
| Supply voltage 3-phase $500 \mathrm{VAC} \ldots 600 \mathrm{VAC}$ |  |  |  |  |
| 1GF31-8AU3 | $150 / 110$ | 175 | 2.5 kHz |  |
| 1GF32-2AU3 | $200 / 132$ | 215 | 2.5 kHz |  |
| 1GF32-6AU3 | $250 / 160$ | 260 | 2.5 kHz |  |
| 1GF33-3AU3 | $300 / 200$ | 330 | 2.5 kHz |  |
| 1GF34-1AU3 | $400 / 250$ | 410 | 2.5 kHz |  |
| 1GF34-7AU3 | $500 / 315$ | 465 | 2.5 kHz |  |
| 1GF35-8AU3 | $600 / 400$ | 575 | 2.5 kHz |  |
| 1GF37-4AU3 | $700 / 500$ | 735 | 2.5 kHz |  |
| 1GF38-1AU3 | $800 / 560$ | 810 | 2.5 kHz |  |

## Commissioning

During commissioning, the dv/dt filter plus Voltage Peak Limiter must be logged on using STARTER or the AOP30 operator panel (p0230 = 2).

## Note

Reset when establishing the factory setting
When the factory settings are restored, parameter p0230 is reset.
The parameter must be reset if the system is commissioned again.

### 4.9.2 Input contactor (option L13)

## Description

The enclosed drive is designed as standard without an input contactor. Option L13 (input contactor) is needed if a switching element is required for disconnecting the drive from the supply (necessary with EMERGENCY OFF). The contactor is controlled and powered from within the cabinet.

## Connecting

Table 4-30 Terminal block X50 - checkback contact "input contactor closed"

| Terminal | Designation ${ }^{1)}$ | Technical specifications |
| :---: | :---: | :--- |
| 4 | NO | Max. load current: 10 A |
| 5 | NC | Max. switching voltage: 250 V AC |
| 6 | COM | Max. switching capacity: 250 VA <br> Required minimum load: $\geq 1 \mathrm{~mA}$ |
| Max. connectable cross-section: \#12 AWG $\left(4 \mathrm{~mm}^{2}\right)$ |  |  |

${ }^{1)}$ NO: Normally-open contact, NC: Normally-closed contact, COM: Mid-position contact

## Keep main contactor closed

Via binector input p0870 it is possible to control whether the main contactor should always remain closed even if the required enables are missing or there is a fault.
p0870 $=1$ prevents the main contactor from being opened when the enables are canceled.
This enables a faster restart.

### 4.9.3 Feeder for external auxiliaries / motor blower (option L17)

## Description

This option includes a switched three-phase output at line voltage for an external device such as a motor blower which is fused at max. 5 A . The voltage is tapped at the drive input upstream of the input contactor/circuit breaker and, therefore, has the same level as the supply voltage. The outgoing circuit can be switched within the drive or externally.

## Connecting

Table 4-31 Terminal block X155 - Connection for external device/motor blower

| Terminal | Designation ${ }^{1)}$ | Technical specifications |
| :---: | :---: | :---: |
| 1 | L1 | 380 to 480 V 3 ph . AC |
| 2 | L2 | 500 to $600 \vee 3 \mathrm{ph}$. AC |
| 3 | L3 |  |
| 11 | Contactor control | 115 V AC |
| 12 |  |  |
| 13 | NO: Checkback | 115 V AC / 0.5 A |
| 14 | motor circuit breaker | 24 V DC / 2 A |
| 15 | NO | NO contact for checkback signal for 115 V AC / 6 A contactor |
| 16 | COM | Mid-position contact for terminals 15 and 17 |
| 17 | NC | NC contact for checkback signal for 115 V AC / 6 A contactor |
| Protective ground | Protective ground | Protective ground |
| Max. connectable cross-section: \#12 AWG (4 mm²) |  |  |

1) NO: Normally-open contact, NC: Normally-closed contact, COM: Mid-position contact

## Note

## Protection setting

The connection for external device/motor blower must be set in accordance with the load connected (-Q155).

## Circuit proposal for controlling the auxiliary contactor from within the drive

The following circuit, for example, can be used if the auxiliary contactor is to be controlled from within the drive. The "Operation" message is then no longer available for other purposes.


Figure 4-22 Circuit proposal for controlling the auxiliary contactor from within the drive

## Note

Additional protective conductor
If 115 V AC is applied to the relay outputs, the customer terminal module must also be grounded via a \#14 AWG ( $2.5 \mathrm{~mm}^{2}$ ) ground conductor.

### 4.9.4 3-contactor bypass (option L29)

## Description

The 3-contactor bypass circuit with allows the motor to be switched from the drive to the bypass circuit in the event of a drive fault, for example. The switchover to the bypass or to the drive takes place manually, as does the motor startup (direct line operation (DOL Start)).
The option includes:

- Contactor disconnectors at the drive input and output
- Bypass contactor
- Mechanical interlock on the output contactor and bypass contactor, in addition to the electrical interlock on all three contactors
- Electronic overload relay in the bypass circuit
- Changeover switch for VFD OFF bypass
- Pushbuttons for bypass ON and bypass OFF
- Indicator lights for bypass READY (green) and RUN (yellow)

The principle of operation is as follows:

- Under normal circumstances, the motor operates in drive mode (VFD):
- The selector is in the "VFD" position.
- The contactor at the drive output is closed.
- On receiving a starting signal, the drive closes the input contactor to connect the line to the drive circuit.
- If the selector is switched to the "OFF" position:
- The drive receives an "OFF2" signal, disconnecting the line supply and causing the motor to coast down.
- Neither drive mode nor bypass mode is possible in this position. The bypass contactor and the contactors at the drive input and output are open.
- If the selector is switched to the "Bypass" position, and the electronic overload relay does not trip:
- The "Bypass READY" indicator lights up.
- The contactors at the drive input and output are open.
- The "Bypass ON" command closes the bypass contactor, connecting the motor directly to the line:
- The motor starts up.
- The "Bypass RUN" indicator lights up.
- The "Bypass OFF" command opens the bypass contactor:
- The motor coasts down.
- The "Bypass RUN" indicator goes dark, and the "Bypass READY" indicator lights up.
- If the electronic overload relay trips:
- The bypass contactor is opened, and the motor coasts down.
- The "Bypass READY" and "Bypass RUN" indicators go dark.
- After the electronic overload relay is reset, the "Bypass READY" indicator lights up, and the motor can be switched on again.


### 4.9.5 Soft starter bypass (option L30)

## Description

The soft starting bypass circuit allows the motor to be switched from the drive to the bypass circuit in the event of a drive fault, for example. The switchover to the bypass or to the drive takes place manually, as does the motor startup with a soft starter (RVSS).

The option includes:

- Contactor disconnectors at the drive input and output
- Contactor disconnectors at the soft starter input and output
- Mechanical interlock on the output contactor and soft starter contactor, in addition to the electrical interlock on all four contactors
- Siemens soft starter model 3RW44 with an internal bypass contactor and electronic motor overload protection
- Changeover switch for VFD OFF bypass
- Pushbuttons for bypass ON and bypass OFF
- Indicator lights for bypass READY (green), RUN (yellow), and FAULT (red)

The principle of operation is as follows:

- Under normal circumstances, the motor operates in drive mode (VFD):
- The selector is in the "VFD" position.
- The contactors at the soft starter input and output are open.
- The output contactor on the drive is closed.
- On receiving a starting signal, the drive closes the input contactor to connect the line to the drive circuit.
- If the selector is switched to the "OFF" position:
- The drive receives an "OFF2" signal, disconnecting the line supply and causing the motor to coast down.
- Neither drive mode nor bypass mode is possible in this position. The soft starter contactor and the contactors at the drive input and output are open.
- If the selector is switched to the "Bypass" position, and the soft starter has no error messages:
- The "Bypass READY" indicator lights up.
- The contactors at the drive input and output are open.
- The contactors at the soft starter input and output are closed.

Please consult the Soft Starter 3RW44 System Manual for information on the soft starter functions and commissioning procedure.

## General:

- The "Bypass ON" command activates the soft starter to start the motor:
- The motor starts up.
- The "Bypass RUN" indicator lights up.
- The "Bypass OFF" initiates the procedure for stopping the motor:
- The motor decelerates on a ramp or coasts down, depending on the soft starter settings.
- The "Bypass RUN" indicator goes dark, and the "Bypass READY" indicator lights up.
- If a soft starter monitor trips:
- The "Bypass FAULT" indicator lights up, and the motor coasts down.
- The "Bypass READY" and "Bypass RUN" indicators go dark.
- After the soft starter is reset, the "Bypass FAULT" indicator goes dark, the "Bypass READY" indicator lights up, and the motor can be switched on again.


### 4.9.6 Enclosure light with service socket (option L50)

## Description

With this option, a universal lamp with an integrated service socket is installed in the enclosure. The power supply for the enclosure light and socket must be provided externally and fused at max. 10 A . The light is switched on manually with a slide switch.

## Connecting

Table 4-32 Terminal block X390 - connection for enclosure light with service socket

| Terminal | Designation | Technical specifications |  |
| :---: | :---: | :---: | :---: |
| 1 | L 1 | 115 V AC <br> power supply |  |
| 2 | N |  | Protective conductor |
| 3 | Protective ground |  |  |
| Max. connectable cross-section: \#12 AWG $\left(4 \mathrm{~mm}^{2}\right)$ |  |  |  |

### 4.9.7 Enclosure space heater (option L55)

## Description

The enclosure space heater is used at low ambient temperatures and high levels of humidity to prevent condensation from forming.

For enclosure widths 15.8 " ( 400 mm ) and 23.6 " ( 600 mm ), one $100-\mathrm{W}$ heater is used. For enclosure widths ranging from $31.5^{\prime \prime}(800 \mathrm{~mm})$ to $47.2^{\prime \prime}(1200 \mathrm{~mm})$, two heaters, 100 W each, are installed. The power supply for the heating ( $115 \mathrm{~V} A C$ ) must be provided externally and protected with a fuse (max. 10 A ).

## WARNING

Dangerous voltage as a result of external auxiliary supply
When an external supply voltage for the cabinet anti-condensation heating is connected, dangerous voltages continue to be present in the cabinet unit even when the mains switch is open. Death or serious injury can result when live parts are touched.

- Observe the general safety instructions when working on the device.


## A.caution

Burns caused by hot cabinet anti-condensation heating surfaces
During operation, the cabinet anti-condensation heating can reach high temperatures and cause burns if touched.

- Allow the cabinet anti-condensation heating to cool down before starting any work.
- Use the appropriate personnel protection equipment, e.g. gloves.


## Note

Providing supply voltage with temperature control
The supply voltage can be provided by means of a temperature control, to avoid unnecessary operation of the anti-condensation heating at higher ambient temperatures.

## Connecting

Table 4-33 Terminal block X240 - connection for enclosure space heater

| Terminal | Designation | Technical specifications |
| :---: | :---: | :---: |
| 1 | L 1 | 115 V AC <br> Power supply |
| 2 | N | Protective conductor |
| 3 | Protective ground |  |
| Max. connectable cross-section: \#12 AWG $\left(4 \mathrm{~mm}^{2}\right)$ |  |  |

### 4.9.8 ALL STOP, coast to stop (option N55)

## Description

### 4.9.9 EMERGENCY OFF category 0; 115 V AC or 24 V DC (option N57)

## Description

The mushroom pushbutton with protective collar and interlock is mounted in the door of the enclosed drive and its contacts are wired to the OFF2 terminal of the Control Unit. After the pushbutton is actuated, the motor coasts to a stop.

The enclosed drive is disconnected from the supply system in conjunction with the L13, L29 and L30 options.

ERGENCY OFF category 0 for uncontrolled stop according to IEC 60204-1. This function includes the interruption of the energy supply of the enclosed drive via the line contactor by bypassing the electronics by means of a safety relay according to IEC 60204-1. The motor coasts down. To prevent the input contactor from switching under load, an OFF2 is triggered simultaneously.

No additional wiring is needed when using the EMERGENCY OFF pushbutton.
The operational status and the function are indicated by three LEDs (-K120).
In the factory state, the type with 115 V AC button circuit is set.

## Note

## Pressing the EMERGENCY OFF button

When the EMERGENCY OFF pushbutton is pressed, an uncontrolled stop of the motor takes place and the main motor voltage is disconnected in accordance with IEC 60204-1. Auxiliary voltages (e.g., for separately-driven fans or anti-condensation heating) may still be present. Certain sections of the converter (e.g., the closed-loop controller or any auxiliary equipment) also remain live. If all the voltages have to be completely disconnected, the EMERGENCY OFF pushbutton must be integrated in a protection concept, which must be implemented on the line side. A normally closed contact is available at terminal -X120 for this purpose.

## Connecting

Table 4-34 Terminal block X120 - connection for EMERGENCY OFF category 0, 115 V AC and 24 V DC

| Terminal | 115 V AC and 24 V DC button circuit |
| :---: | :---: |
| 4 | Jumper wired at the factory |
| 5 |  |
| 7 | Loop in EMERGENCY OFF button from line side: Remove jumpers 7-8 and connect button: |
| 8 |  |
| 9 | Jumper wired at the factory |
| 10 |  |
| 11 | Jumper wired at the factory |
| 14 |  |
| 12 | Jumper wired at the factory |
| 13 |  |
| 15 | "On" for monitored start: <br> Remove jumpers 15-16 and connect button |
| 16 |  |
| 17 | NO 1): "trip safety combination" checkback |
| 18 |  |
| Max. connectable cross-section: \#12 AWG (4 mm²) |  |

1) NO: NO contact

## Reconnection to the 24 V DC button circuit

When using the 24 V DC button circuit, you must remove the following jumpers at terminal block -X120:

- 4-5, 9-10, and 11-14

You must also insert the following jumpers at terminal block -X120:

- 4-11, 5-10, and 9-14


## Diagnostics

For a description of messages output during operation and in the event of faults (meaning of LEDs on -K120), refer to the Operating Instructions on the customer DVD supplied with the unit.

### 4.9.10 EMERGENCY STOP category 1; 115 V AC (option N59)

## Description

EMERGENCY OFF category 1 for controlled stop according to IEC 60204-1. The function includes the stopping of the drive via an emergency stop according to an assigned rampdown. This is followed by the interruption of the energy supply of the enclosed drive via the line contactor by bypassing the electronics by means of a safety relay according to IEC 60204-1.
The operational status and function are indicated by a total of eight LEDs (-K120, -K121).

## Connecting

Table 4-35 Terminal block X120 - connection for EMERGENCY STOP category 1 (115 V AC)

| Terminal | Technical specifications |
| :---: | :---: |
| 4 | Jumper wired at the factory |
| 5 |  |
| 7 | Loop in EMERGENCY OFF button from line side: Remove jumpers 7-8 and connect button. |
| 8 |  |
| 9 | Jumper wired at the factory |
| 10 |  |
| 11 | Jumper wired at the factory |
| 14 |  |
| 12 | Jumper wired at the factory |
| 13 |  |
| 15 | "On" for monitored start: <br> Remove jumpers 15-16 and connect button. |
| 16 |  |
| 17 | NO 1): "trip safety combination" checkback |
| 18 |  |
| Max. connectable cross-section: \#12 AWG (4 mm²) |  |

1) $\mathrm{NO}: \mathrm{NO}$ contact

## Setting

The time ( 0.5 to 30 s ) set for the contactor safety combination (-K121) should be greater than (or at least equal to) the time that the drive requires to reach a standstill via the quick stop (OFF3 ramp-down time, p1135), because the converter is disconnected from the energy supply when the time runs out (at -K121).

## Diagnostics

Messages output during operation and in the event of faults (meaning of LEDs on -K120, -K121) are described in the operating instructions included on the customer DVD supplied with the device.

### 4.9.11 EMERGENCY STOP category 1; 24 V DC (option L60)

## Description

EMERGENCY OFF category 1 for controlled stop according to IEC 60204-1. The function includes the stopping of the drive via an emergency stop according to an assigned rampdown. This is followed by the interruption of the energy supply of the enclosed drive via the line contactor by bypassing the electronics by means of a safety relay according to IEC 60204-1.
The operational status and function are indicated by five LEDs (-K120).

## Connecting

Table 4-36 Terminal block X120 - connection for EMERGENCY STOP category 1 (24 V DC)

| Terminal | Technical specifications |
| :---: | :---: |
| 4 | Jumper wired at the factory |
| 11 |  |
| 5 | Jumper wired at the factory |
| 10 |  |
| 7 | Loop in EMERGENCY OFF button from line side: Remove jumpers 7-8 and connect button. |
| 8 |  |
| 9 | Jumper wired at the factory |
| 14 |  |
| 12 | Jumper wired at the factory |
| 13 |  |
| 15 | "On" for monitored start: <br> Remove jumpers 15-16 and connect button. |
| 16 |  |
| 17 | NO 1): "trip safety combination" checkback |
| 18 |  |
| Max. conne | \#12 AWG (4 mm²) |

[^0]
## Setting

The time ( 0.5 to 30 s ) set for the contactor safety combination (-K120) should be greater than (or at least equal to) the time that the drive requires to reach a standstill via the quick stop (OFF3 ramp-down time, p1135), because the converter is disconnected from the energy supply when the time runs out (at -K120).

## Diagnostics

For a description of messages output during operation and in the event of faults (meaning of LEDs on -K120), refer to the Operating Instructions on the customer DVD supplied with the unit.

### 4.9.12 $25-\mathrm{kW}$ braking unit (option L61); 50-kW braking unit (option L62)

## Description

Braking units are used when regenerative energy occurs occasionally and briefly, for example when the brake is applied to the drive (EMERGENCY STOP). The braking units comprise a braking chopper and a load resistor, which must be mounted externally of the drive. To monitor the braking resistance, a thermostat contact integrated in the trip circuit of the drive is provided in the braking resistor.

Table 4-37 Load data for the braking units

| Line voltage | Continuous <br> chopper power <br> $\mathbf{P D B}$ | Peak chopper <br> output <br> $\mathbf{P}_{15}$ | Chopper <br> $\mathbf{P}_{20}$ output <br> $\mathbf{P}_{20}$ | Chopper <br> $\mathbf{P}_{40}$ output <br> $\mathbf{P}_{40}$ | Braking resistor <br> $\mathbf{R}_{\mathbf{B}}$ | Max. current |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 380 V to 480 V | 25 kW | 125 kW | 100 kW | 50 kW | $4.4 \Omega \pm 7.5 \%$ | 189 A |
| 380 V to 480 V | 50 kW | 250 kW | 200 kW | 100 kW | $2.2 \Omega \pm 7.5 \%$ | 378 A |
| 500 V to 600 V | 50 kW | 250 kW | 200 kW | 100 kW | $3.4 \Omega \pm 7.5 \%$ | 306 A |

## Installing the braking resistor

The braking resistor should not be installed in the vicinity of the drive. The installation location must fulfill the following conditions:

- The braking resistors are suitable for floor mounting only.
- The maximum cable length between the cabinet unit and braking resistor is 330 ft ( 100 m ).
- Sufficient space must be available for dissipating the energy converted by the braking resistor.
- A sufficient distance from flammable objects must be maintained.
- The braking resistor must be installed as a free-standing unit.
- Objects must not be placed on or anywhere above the braking resistor.
- The braking resistor should not be installed underneath fire detection systems, since these could be triggered by the resulting heat.
- A roof is required for compliance with NEMA 1. For outdoor installation, braking resistors must be installed in an enclosure (NEMA 3R) for protection against falling rain or sleet.


## ! warning

Fire as a result of inadequate installation
When installation is inadequate (failure to observe the cooling clearances or insufficient distances from combustible objects), there is a risk of fire leading to death or serious injury.

- Maintain a cooling clearance of 7.9 inches $(200 \mathrm{~mm})$ on all sides of the braking resistor with ventilation grills.
- Maintain a sufficient distance from combustible objects.


## A caution

Burns caused by hot braking resistor surfaces
During operation, the braking resistor can reach high temperatures and can cause burns if touched.

- Allow the braking resistor to cool down before starting any work.
- Use the appropriate personnel protection equipment, e.g. gloves.

Table 4-38 Dimensions of the braking resistors

|  | Unit | 25-kW resistor (option L61) | 50-kW resistor (option L62) |
| :--- | :---: | :---: | :---: |
| Width | inch $(\mathrm{mm})$ | $29.1(740)$ | $31.9(810)$ |
| Height | inch $(\mathrm{mm})$ | $23.8(605)$ | $52.1(1325)$ |
| Depth | inch $(\mathrm{mm})$ | $19.1(485)$ | $19.1(485)$ |



Figure 4-23 Dimension drawing of braking resistor rated 25 kW - Specifications in inches (mm)


Figure 4-24 Dimension drawing of braking resistor rated 50 kW - Specifications in inches (mm)

## Connecting the braking resistor

## A. warning

Fire caused by ground fault / short-circuit for non-protected connections to the braking resistor

Non-fused connections to the braking resistor can cause fire with smoke generation in the event of a short-circuit or ground fault and cause serious injuries or death.

- Install the connections to the braking resistor in such a way that a ground fault or shortcircuit can be excluded.
- Comply with local installation regulations, which allow this fault to be ruled out.
- Protect the cables from mechanical damage.
- Take one of the following measures:
- Use cables with double insulation.
- Observe adequate clearances, e.g. through the use of spacers.
- Route the cables in separate cable ducts or pipes.


## NOTICE

Material damage when exceeding the maximum permitted cable length
Exceeding the maximum permitted cable length to the braking resistor can cause property damage due to component failure.

- Comply with the maximum cable length between the cabinet unit and the braking resistor of $330 \mathrm{ft}(100 \mathrm{~m})$.

Table 4-39 Terminal block -X5 - Connection for external braking resistor

| Terminal | Description of function |
| :---: | :--- |
| 1 | Braking resistor connection |
| 2 | Braking resistor connection |
| Max. connectable cross-section: $2 / 0\left(70 \mathrm{~mm}^{2}\right)$ |  |

Recommended conductor cross-sections:

- For L61 (25 kW): \#1 AWG (35 mm²)
- For L62 (50 kW): $1 / 0\left(50 \mathrm{~mm}^{2}\right)$


## Connecting the thermostatic switch

Table 4-40 Connecting the thermostatic switch for the external braking resistor in the trip circuit of the cabinet unit

| Terminal | Description of function |
| :---: | :--- |
| T1 | Thermostatic switch connection: connection to terminal X541:1 (P24 V) |
| T2 | Thermostatic switch connection: connection to terminal X541:5 (DI11) |
| Max. connectable cross-section: <br> - - Version A: \#12 AWG $\left(2.5 \mathrm{~mm}^{2}\right)$ <br> - Version C: (because of TM31): \#14 AWG $\left(1.5 \mathrm{~mm}^{2}\right)$ |  |

## WARNING

## Fire when the thermostatic switch is not evaluated

If the thermostatic switch is not evaluated, then there is the danger of fire damage with death or severe injury.

- Evaluate the thermostatic switch using the Control Unit or a higher-level control system; a shutdown must be carried out if necessary.


### 4.9.12.1 Commissioning

## Commissioning

When commissioning via STARTER, parameters are assigned to "external fault 3" and acknowledged automatically when option L61 or L62 is selected.

When commissioning via AOP30, the necessary parameter settings must be made subsequently.


If, during operation, an "Acknowledge fault" signal is initiated without there being a fault in the Braking Module, then this initiates an external fault 3.
You can prevent this response with the following measures:

- Link the "Acknowledge fault" signal with status bit 3 "Fault active" of status word ZSW1 (r2139.3).
- If a fault is not active, then do not initiate an "Acknowledge fault" signal.


## Drive settings

If the thermostat for the braking resistor is connected to digital input 11, appropriate settings must be made so that the drive is stopped if a fault occurs.

Once the device has been successfully commissioned, you have to make the following changes:


Set the "Expert" access level on the operator panel
<Key pushbutton> - <Access level> - Set "Expert" and confirm.


Switch external fault 2 to DI 11 on the TM31.

Disabling the Vdc-max controller
When the brake chopper is used, the Vdc-max controller must be switched off.

### 4.9.12.2 Diagnostics and duty cycles

## Diagnostics

If the thermostat contact opens due to a thermal overload on the braking resistor, fault F7861 ("External Fault 2") is triggered and the drive is switched off with OFF2.

If the brake chopper triggers a fault, fault F7862 "External fault 3" is triggered in the drive.
You can acknowledge malfunctions in the braking unit by pressing the "Acknowledge" button on the operator panel (when DC link voltage is present).

## Duty cycles



Figure 4-25 Duty cycles for the braking resistors

### 4.9.12.3 Threshold switch

The response threshold at which the braking unit is activated and the DC link voltage generated during braking is specified in the following table.

## WARNING

Electric shock when operating the threshold switch
Operating the threshold switch when a voltage is present can cause death or serious injury.

- Only operate the threshold switch when the cabinet unit is switched off and the DC link capacitors are discharged.

Table 4-41 Response thresholds of the braking units

| Rated voltage | Response <br> threshold | Switch <br> position | Comments |
| :---: | :---: | :---: | :--- |
| $380 \ldots 480 \mathrm{~V}$ | 673 V | 1 | 774 V is the factory setting. For line voltages of $380 \ldots$ <br> AC 3-ph. <br>  |
| 700 V AC 3-ph., the response threshold can be set to |  |  |  |
| 673 V to reduce the voltage stress on the motor and |  |  |  |
| drive. However, this reduces the possible braking power |  |  |  |
| to the square of the voltages $(673 / 774)^{2}=0.75$. |  |  |  |
| The maximum available braking power is therefore $75 \%$. |  |  |  |

## Position of the threshold switch

The braking module is located in the exhaust air duct of the Power Module at the top of the cabinet unit. The position of the threshold switch is indicated in the figures below.


Figure 4-26 Braking modules for frame size FX


Figure 4-27 Braking modules for frame size GX


Figure 4-28
Braking modules for frame sizes HX and JX

## Position of the threshold switch

## Note

## Switch positions

The threshold switches for the braking modules are positioned on the panel as follows:

- Braking modules for frame sizes FX and GX: Position "1" is up; position "2" is down
- Braking modules for frame sizes HX and JX: Position "1" is at the back; position "2" is at the front


### 4.9.13 Line-side surge arrester (option L96)

## Description

### 4.9.14 RTD monitor (option L97)

## Description

## Note

## Additional operating instructions

The PT100 monitor and the parameters for the measurement channels are described in the "Additional operating instructions" section of this documentation package.

The PT100 monitors can monitor up to 9 sensors. The sensors can be connected in a twoor three-wire system. With the two-wire system, inputs $\mathrm{xT1}$ and xT 3 must be assigned. With the three-wire system, input xT2 must also be connected to -B141, -B142, and -B143 (x = 1, 2,3 ). The limit values can be freely programmed for each channel. Shielded signal cables are recommended. If this is not possible, the sensor cables should at least be twisted-pair.

In the factory state, the measurement channels are divided into three groups of 3 channels each. With motors, for example, this means that 2 sets of three PT100s in the stator windings and two PT100s in the motor bearings can be monitored. Unused channels can be suppressed via parameters.

The output relays are integrated in the internal fault and alarm circuit of the drive. The power supply for the PT100 monitor comes from within the drive, and the evaluation takes place within the drive.

When the temperature setting for "alarm" is exceeded, "external alarm 1" (A7850) is returned. When the temperature setting for "fault" is exceeded, "external fault 1 " (F7860) is returned.

## Connecting

Table 4-42 Terminals -A1-B141, -A1-B142, -A1-B143 - connection for PT100 monitor

| Terminal | Technical specifications |
| :---: | :---: |
| -B141: 1T1-1T3 | 24-240 V AC/DC; PT100; sensor 1; group 1 |
| -B141: 2T1-2T3 | 24-240 V AC/DC; PT100; sensor 2; group 1 |
| -B141: 3T1-3T3 | 24-240 V AC/DC; PT100; sensor 3; group 1 |
| -B142: 1T1-1T3 | 24-240 V AC/DC; PT100; sensor 1; group 2 |
| -B142: 2T1-2T3 | 24-240 V AC/DC; PT100; sensor 2; group 2 |
| -B142: 3T1-3T3 | 24-240 V AC/DC; PT100; sensor 3; group 2 |
| -B143: 1T1-1T3 | 24-240 V AC/DC; PT100; sensor 1; group 3 |
| -B143: 2T1-2T3 | 24-240 V AC/DC; PT100; sensor 2; group 3 |
| -B143: 2T1-3T3 | 24-240 V AC/DC; PT100; sensor 3; group 3 |
| Max. connectable cross-section: \#14 AWG (2.5 mm²) |  |

## Diagnostics

For a description of messages output during operation and in the event of faults (meaning of LEDs on -B141, -B142, -B143), refer to the Operating Instructions on the customer DVD supplied with the unit.

### 4.9.15 Insulation monitor (option L87)

## Description

On ungrounded / IT power networks, the insulation monitor checks the entire electricallyconnected circuit for insulation faults. The insulation resistance as well as all insulation faults from the line supply to the motor in the cabinet unit are detected. Two response values (between $1 \mathrm{k} \Omega$ and $10 \mathrm{M} \Omega$ ) can be set. If a response value is undershot, an alarm is output to the terminal. A system fault is output via the signaling relay system.

In the delivery condition of the cabinet unit, the plant configuration (one or more loads on an electrically-connected network) and protection concept (immediate shutdown in the event of an insulation fault or restricted continued operation) are not known. The signaling relays of the insulation monitor must be integrated into the fault and alarm circuit by the customer.

### 4.9 Other connections

## Safety instructions

## Note

## Number of insulation monitors

Only one insulation monitor can be used within one electrically-connected network.

## Note

The connection clip to the basic interference suppression module is removed in the factory
When using the insulation monitoring option, the connecting clip to the basic interference suppression module is removed in the factory and placed in the cabinet unit (see Chapter "Electrical installation/removing the connecting clip to the basic interference suppression module when connected to ungrounded line supplies (IT line system)").

## Controls and displays on the insulation monitor



Figure 4-29 Controls and displays on the insulation monitor

Table 4-43 Meaning of the controls and displays on the insulation monitor

| Position | Meaning |
| :--- | :--- |
| 1 | INFO key: Requests standard information/ <br> ESC key: Back menu function |
| 2 | TEST key: Brings up self-test <br> Arrow key up: Parameter change, scroll function |
| 3 | RESET button: Deletes insulation messages and fault codes <br> Arrow key down: Parameter change, scroll function |
| 4 | Menu key: Brings up menu system <br> Enter key: Confirms parameter change |
| 5 | Alarm LED 1 is lit: Insulation fault, first alarm threshold reached |
| 6 | Alarm LED 2 is lit: Insulation fault, second alarm threshold reached |
| 7 | LED is lit: System error present |

## Connecting

Table 4-44 Connections on the insulation monitor

| Terminal | Technical specifications |
| :---: | :---: |
| A1 | Supply voltage via 6 A melting fuse: |
| A2 | 88 to 264 V AC, 77 to 286 V DC |
| L1 | Connection of the 3 ph . AC system to be monitored |
| L2 |  |
| AK | Connection to coupling device |
| KE | Connection to protective ground |
| T1 | External test button |
| T2 | External test button |
| R1 | External reset key (NC contact or wire jumper, otherwise the fault code is not stored) |
| R2 | External reset key (NC contact or wire jumper) |
| F1 | STANDBY with aid of F1, F2 function input: |
| F2 |  |
| M + | External $\mathrm{k} \Omega$ display, analog output ( 0 to $400 \mu \mathrm{~A}$ ) |
| M- | External k $\Omega$ display, analog output ( 0 to $400 \mu \mathrm{~A}$ ) |
| A | Serial interface RS 485 |
| B | (termination by means of 120 -ohm resistor) |
| 11 | Signaling relay ALARM 1 (mid-position contact) |
| 12 | Signaling relay ALARM 1 (NC contact) |
| 14 | Signaling relay ALARM 1 (NO contact) |
| 21 | Signaling relay ALARM 2 (mid-position contact) |
| 22 | Signaling relay ALARM 2 (NC contact) |
| 24 | Signaling relay ALARM 2 (NO contact) |
| Max. connectable cross-section: \#14 AWG (2.5 mm²) |  |

## Diagnostics

For a description of messages output during operation and in the event of faults (meaning of LEDs on -B101), refer to the Operating Instructions on the customer DVD supplied with the unit.

### 4.9.16 Control power supply, 120 V AC, 5 A (option N70)

## Description

The control power supply provides the auxiliary voltages required for external line-side control circuits of the enclosed drive.

## Adapting the auxiliary power supply (-T10)

A transformer is installed in the Line Connection Module (-T10) to produce the auxiliary voltages of the enclosed drive. The location of the transformer is indicated in the layout diagrams supplied.

When delivered, the taps are always set to the highest level. The line-side terminals of the transformer may need to be reconnected according to the existing line voltage.

The tables below show the appropriate transformer setting for the control power supply based on the existing line voltage.

Table 4-45 Line voltage assignment for the internal power supply ( 380 to 480 V 3 ph . AC )

| Line voltage range | Tap | Adaptation transformer taps (-T10) <br> LH1 - LH2 |
| :---: | :---: | :---: |
| $342 \ldots 390 \mathrm{~V}$ | 380 V | $1-2$ |
| $391 \ldots 410 \mathrm{~V}$ | 400 V | $1-3$ |
| $411 \ldots 430 \mathrm{~V}$ | 415 V | $1-4$ |
| $431 \ldots 450 \mathrm{~V}$ | 440 V | $1-5$ |
| $451 \ldots 470 \mathrm{~V}$ | 460 V | $1-6$ |
| $471 \ldots 528 \mathrm{~V}$ | 480 V | $1-7$ |

Table 4-46 Line voltage assignment for the internal power supply ( 500 to 600 V 3 ph . AC )

| Line voltage range | Tap | Adaptation transformer taps (-T10) <br> LH1 -LH 2 |
| :---: | :---: | :---: |
| $450 \ldots 515 \mathrm{~V}$ | 500 V | $1-8$ |
| $516 \ldots 540 \mathrm{~V}$ | 525 V | $1-9$ |
| $541 \ldots 560 \mathrm{~V}$ | 550 V | $1-10$ |
| $561 \ldots 590 \mathrm{~V}$ | 575 V | $1-11$ |
| $591 \ldots 670 \mathrm{~V}$ | 600 V | $1-12$ |

Once the jumpers have been set, the secondary voltage should be 230 V AC.

## NOTICE

Property damage due to voltage set too high
If the terminals are not reconnected to the actual line voltage, this can result in damage to the device when the voltage is set too high.

- Set the terminals in accordance with the actual line voltage.


### 4.9.17 CAN Communication Board CBC10 (option G20)

## Description



Figure 4-30 CAN CBC10 Communication Board
The CBC10 CANopen communication board (CAN Communication Board) is used to connect drives in the SINAMICS drive system to higher-level automation systems with a CAN bus.

The CANopen Option Board uses two 9-pin sub D connectors for the connection to the CAN bus system.

The connectors can be used as inputs or outputs. Unused pins are plated through.
Among others, the following transmission rates are supported: 10, 20, 50, 125, 250, 500, 800 kBaud, and 1 Mbaud.

## NOTICE

Damage to or malfunction of Option Boards by pulling and plugging them during operation
Pulling and plugging Option Boards during operation can cause them to be damaged or to malfunction.

- Only pull and plug Option Boards when the Control Unit is de-energized.

The module is installed in the option slot of the Control Unit at the factory.

## Interface overview



Figure 4-31 CAN CBC10 Communication Board

## CAN bus interface -X451

Table 4-47 CAN bus interface -X451

|  | Pin | Designation | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | Reserved, do not use |  |
|  | 2 | CAN_L | CAN signal (dominant low) |
|  | 3 | CAN_GND | CAN ground |
|  | 4 | Reserved, do not use |  |
|  | 5 | CAN_SHLD | Optional shield |
|  | 6 | GND | CAN ground |
|  | 7 | CAN_H | CAN signal |
|  | 8 | Reserved, do not use |  |
|  | 9 | Reserved, do not use |  |
| Connector ty | : 9-p | ocket |  |

## NOTICE

Destruction of the CAN interface due to the wrong connector
If PROFIBUS connectors are connected to CAN bus interfaces during operation, this may lead to the CAN interfaces being destroyed.

- Do not connect PROFIBUS connectors to CAN bus interfaces.


## CAN bus interface -X452

Table 4-48 CAN bus interface -X452

|  | Pin | Designation | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | Reserved, do not use |  |
|  | 2 | CAN_L | CAN signal (dominant low) |
|  | 3 | CAN_GND | CAN ground |
|  | 4 | Reserved, do not use |  |
|  | 5 | CAN_SHLD | Optional shield |
|  | 6 | GND | CAN ground |
|  | 7 | CAN_H | CAN signal |
|  | 8 | Reserved, do not use |  |
|  | 9 | Reserved, do not use |  |
| Connector ty | : 9-p | onnector (pins) |  |

## Additional information about communication via CAN bus

## Note

## Additional information

Detailed, comprehensive instructions and information about the CANopen interface can be found in the accompanying function manual. This manual is included under additional documentation on the accompanying customer DVD.

### 4.9.18 PROFINET Communication Board CBE20 (option G33)

## Description



Figure 4-32 CBE20 Ethernet Communication Board
The CBE20 interface module is used for communication via PROFINET / SINAMICS Link / Ethernet/IP.

The module is installed in the option slot of the Control Unit at the factory.
There are 4 Ethernet interfaces available on the module. Diagnosis of the function mode and communication are possible via LEDs.

## Interface overview



Figure 4-33 CBE20 Ethernet Communication Board

## MAC address

The MAC address of the Ethernet interfaces is indicated on the top side of the CBE20. The plate is not visible when the module is installed.

## Note

## Note the MAC address

Remove the module from the option slot on the Control Unit and jot down the MAC address so you will have it available later for commissioning.

## Installation

## NOTICE

Damage to or malfunction of Option Boards by pulling and plugging them during operation
Pulling and plugging Option Boards during operation can cause them to be damaged or to malfunction.

- Only pull and plug Option Boards when the Control Unit is de-energized.


Figure 4-34 Removing the CBE20 from the option slot on the Control Unit

## X1400 Ethernet interface

Table 4-49 Connector X1400, port 1-4

|  | Pin | Signal name | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | RX+ | Receive data + |
|  | 2 | RX- | Receive data - |
|  | 3 | TX+ | Send data + |
|  | 4 | Reserved, do not use |  |
|  | 5 | Reserved, do not use |  |
|  | 6 | TX- | Send data - |
|  | 7 | Reserved, do not use |  |
|  | 8 | Reserved, do not use |  |
|  | Screened backshell | M_EXT | Shield, permanently connected |
| Connector typ | : RJ45 soc |  |  |

### 4.9.19 Temperature sensor module TM150 (option G51)

### 4.9.19.1 Description

The Terminal Module TM150 is used to record and evaluate several temperature sensors. The temperature is measured in a temperature range from $-99^{\circ} \mathrm{C}$ to $+250^{\circ} \mathrm{C}$ for the following temperature sensors:

- PT100 (with monitoring for wire breakage and short-circuit)
- PT1000 (with monitoring for wire breakage and short-circuit)
- KTY84 (with monitoring for wire breakage and short-circuit)
- PTC (with short-circuit monitoring)
- Bimetallic NC contact (without monitoring)

For the temperature sensor inputs, the evaluation can be assigned for $1 \times 2$-wire, $2 \times 2$-wire, 3-wire, or 4-wire for each terminal block. There is no galvanic isolation in the TM150.
A maximum of 12 temperature sensors can be connected to terminal module TM150.


Figure 4-35 Terminal Module TM150

### 4.9.19.2 Connecting

## Temperature sensor connections

Table 4-50 X531-X536 temperature sensor inputs

|  | Terminal | Function 1x2- / 2x2-wire | Function 3- and 4-wire | Technical specifications |
| :---: | :---: | :---: | :---: | :---: |
|  | 1 | +Temp (channel x) | (Channel x) | Temperature sensor connection for sensors with 1x2 wires <br> Connection of the 2nd measurement cable for sensors with 4 wires |
|  | 2 | -Temp (channel x) | (Channel x) | Temperature sensor connection for sensors with $1 \times 2$ wires <br> Connection of the 1st measurement cable for sensors with 3 and 4 wires |
|  | 3 | +Temp (channel y) | $+I_{c}$ <br> (constant current, positive channel $x$ ) | Temperature sensor connection for sensors with $2 \times 2,3$, and 4 wires |
|  | 4 | -Temp (channel y) | - Ic (constant current, negative channel $x$ ) |  |
| Max. connectable cross-section: 1.5 mm² |  |  |  |  |

Measuring current via temperature sensor connection: approx. 0.83 mA
When connecting temperature sensors with 3 wires, a jumper must be inserted between X53x. 2 and X53x. 4 .

Table 4-51 Channel assignment

| Terminal | Channel number [x] <br> for 1x2-, 3-, and 4-wires | Channel number [y] <br> for 2x2-wires |
| :--- | :--- | :--- |
| X531 | 0 | 6 |
| X532 | 1 | 7 |
| X533 | 2 | 8 |
| X534 | 3 | 9 |
| X535 | 4 | 10 |
| X536 | 5 | 11 |

## WARNING

Electric shock in the event of voltage flashovers at the temperature sensor
Voltage flashovers in the signal electronics can occur in motors without safe electrical separation of the temperature sensors.

- Use temperature sensors that fully comply with the specifications of the safety isolation.


## NOTICE

Damage to motor when KTY temperature sensor is connected incorrectly
If a KTY temperature sensor is connected with incorrect polarity, it is not possible to detect when the motor overheats. Overheating can cause damage to the motor.

- Connect a KTY temperature sensor with the correct polarity.


## NOTICE

Overheating of the motor due to jumpering of the temperature sensor connections
Jumpering temperature sensor connections "+Temp" and "-Temp" results in incorrect measurement results. Damage to the motor can result if the overheating is not detected.

- When using several temperature sensors, separately connect the individual sensors to "+Temp" and "-Temp".


## NOTICE

Device failure due to unshielded or incorrectly routed cables to temperature sensors
Unshielded or incorrectly routed cables to temperature sensors can result in interference being coupled into the signal processing electronics from the power side. This can result in significant disturbance of all signals (fault messages) up to failure of individual components (destruction of the devices).

- Only use shielded cables as temperature sensor cables.
- If temperature sensor cables are routed together with the motor cable, use twisted-pair, separately-shielded cables.
- Connect the cable shield at both ends to ground potential over a large surface area.


## Note

Incorrect temperature measured values as a result of cables with an excessively high resistance
An excessively long cable length or an excessively small cable cross-section can falsify the temperature measurement (for a PT100, $10 \Omega$ cable resistance can falsify the measurement result by $10 \%$ ). As a consequence, excessively high measured values are output, which could lead to the motor being unnecessarily tripped prematurely.

- Use only cable lengths $\leq 300 \mathrm{~m}$.
- For cable lengths $>100 \mathrm{~m}$, use cables with a cross-section of $\geq 1 \mathrm{~mm}^{2}$.


## Protective earth connection and shield support

The following diagram shows a typical Weidmüller shield connection clamp for the shield supports.

(1) Protective earth connection $\mathrm{M} 4 / 1.8 \mathrm{Nm}$
(2) Shield connection terminal, Weidmüller company, type: KLBÜ CO1, order number: 1753311001

Figure 4-36 Shield support and protective earth connection of the TM150

### 4.9.19.3 Connection examples



Figure 4-37 Connecting a PT100/PT1000 with $2 \times 2,3$ and 4 wires to the temperature sensor inputs X53x of Terminal Module TM150


Figure 4-38 Connection example for a Terminal Module TM150

### 4.9.20 Sensor Module Cabinet-Mounted SMC30 (option K50)

### 4.9.20.1 Description

The SMC30 Sensor Module is used for determining the actual motor speed. The signals coming from the rotary pulse encoder are converted here and made available to the closedloop controller via the DRIVE-CLiQ interface for evaluation purposes.
For SINAMICS G150 NEMA, the following encoders can be connected to the SMC30 Sensor Module:

- TTL encoder
- HTL encoder
- KTY, PT1000 or PTC temperature sensor

Table 4-52 Connectable encoders with supply voltage

| Encoder type | X520 (SUB-D) | X521 (terminal) | X531 (terminal) | Open-circuit <br> monitoring | Remote sense |
| :---: | :---: | :---: | :---: | :---: | :---: |
| HTL bipolar 24 V | Yes | Yes | Yes | Yes | No |
| HTL unipolar 24 V | Yes | Yes | Yes | No | No |
| TTL bipolar 24 V | Yes | Yes | Yes | Yes | No |
| TTL bipolar 5 V | Yes | Yes | Yes | Yes | To X520 |
| TTL unipolar | No | No | No | No | No |

Table 4-53 Maximum signal cable lengths

| Encoder type | Maximum signal cable length |
| :---: | :---: |
| TTL | $330 \mathrm{ft}(100 \mathrm{~m})$ |
| HTL unipolar | $330 \mathrm{ft}(100 \mathrm{~m})$ |
| HTL bipolar | $990 \mathrm{ft}(300 \mathrm{~m})$ |

## Note

## Prefer a bipolar connection

Because the physical transmission media is more robust, the bipolar connection should always be used for HTL encoders. The unipolar connection should only be used if the encoder type does not output push-pull signals.

## Note

## Only connect one encoder system

Only one encoder system may be connected to the encoder module, either at X520 or at X521/X531. The corresponding unused interface must not be used.

### 4.9 Other connections

Table 4-54 Specification of measuring systems that can be connected

| Parameter | Designation | Threshold 4) | Min. | Max. | Unit |
| :---: | :---: | :---: | :---: | :---: | :---: |
| High signal level <br> (TTL bipolar at X520 or X521/X531) ${ }^{1)}$ | UHdiff |  | 2 | 5 | V |
| Low signal level (TTL bipolar at X520 or X521/X531) ${ }^{1)}$ | ULdiff |  | -5 | -2 | V |
| High signal level (HTL unipolar) | $\mathrm{UH}^{4}{ }^{\text {a }}$ | High | 17 | Vcc | V |
|  |  | Low | 10 | Vcc | V |
| Low signal level (HTL unipolar) | $\mathrm{UL}^{4}$ | High | 0 | 7 | V |
|  |  | Low | 0 | 2 | V |
| High signal level (HTL bipolar) ${ }^{2)}$ | $U_{\text {Hdiff }}$ |  | 3 | Vcc | V |
| Low signal level (HTL bipolar) ${ }^{2)}$ | ULdiff |  | -Vcc | -3 | V |
| Signal frequency | fs |  | - | 300 | kHz |
| Edge clearance | $t_{\text {min }}$ |  | 100 | - | ns |
| Zero pulse inactive time (before and after $\mathrm{A}=\mathrm{B}=\mathrm{high}$ ) | tıo |  | 640 | $\left(\mathrm{t}_{\text {ALo-BHi }}-\mathrm{thi} / 2{ }^{\text {3) }}\right.$ | ns |
| Zero pulse active time (while $\mathrm{A}=\mathrm{B}=$ high and beyond) | $\mathrm{t}_{\mathrm{Hi}}$ |  | 640 | $\mathrm{taLo-BHi}^{-2} \mathbf{~ x ~ t L o ~}{ }^{3)}$ | ns |

1) Other signal levels according to the RS 422 standard.
2) The absolute level of the individual signals varies between 0 V and $\mathrm{V}_{\mathrm{cc}}$ of the measuring system.
${ }^{3)} t_{\text {ALo-BHi }}$ is not a specified value, but is the time between the falling edge of track $A$ and the rising edge after next of track B.
3) The threshold can be set via p0405.04 (switching threshold); the factory state setting is "Low".


Figure 4-39 Signal characteristic of the $A$ and $B$ track between two edges: Time between two edges with pulse encoders


Figure 4-40 Position of the zero pulse to the track signals
For encoders with a 5 V supply at X521/X531, the cable length is dependent on the encoder current (applies to cable cross-sections of $0.5 \mathrm{~mm}^{2}$ ):


Figure 4-41 Signal cable length as a function of the encoder current consumption

For encoders without Remote Sense, the permissible cable length is restricted to 330 ft $(100 \mathrm{~m})$ (reason: The voltage drop depends on the cable length and the encoder current).


Figure 4-42 Sensor Module SMC30

### 4.9.20.2 Connection

## X520: Encoder connection 1 for HTL/TTL encoder with open-circuit monitoring

Table 4-55 Encoder connection X520

|  | Pin | Signal name | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | +Temp ${ }^{1)}$ | Temperature sensor connection KTY841C130 / PT1000 / PTC |
|  | 2 | Reserved, do not use |  |
|  | 3 | Reserved, do not use |  |
|  | 4 | P encoder $5 \mathrm{~V} / 24 \mathrm{~V}$ | Encoder supply |
|  | 5 | P encoder $5 \mathrm{~V} / 24 \mathrm{~V}$ | Encoder supply |
|  | 6 | P sense | Sense input, encoder supply |
|  | 7 | M encoder (M) | Ground, encoder supply |
|  | 8 | -Temp ${ }^{1)}$ | Temperature sensor connection KTY841C130 / PT1000 / PTC |
|  | 9 | M sense | Ground, sense input |
|  | 10 | R | Reference signal R |
|  | 11 | $\mathrm{R}^{*}$ | Inverted reference signal R |
|  | 12 | B* | Inverted incremental signal B |
|  | 13 | B | Incremental signal B |
|  | 14 | A* | Inverted incremental signal A |
|  | 15 | A | Incremental signal A |
| Connector type: 15-pin sub D socket |  |  |  |
| Measuring current via temperature sensor connection: 2 mA |  |  |  |

1) Accuracy of the temperature measurement:

- KTY: $\pm 7^{\circ} \mathrm{C}$ (including evaluation)
- PT1000: $\pm 5^{\circ} \mathrm{C}$ (PT1000 tolerance class B according to EN 60751 including evaluation)
- PTC: $\pm 5^{\circ} \mathrm{C}$ (including evaluation)


| ! WARNING |
| :--- |
| Electric shock in the event of voltage flashovers at the temperature sensor |
| Voltage flashovers in the signal electronics can occur in motors without safe electrical |
| separation of the temperature sensors. |
| - Only use temperature sensors that fully comply with the specifications of the safety |
| isolation. |

## NOTICE

Device failure due to unshielded or incorrectly routed cables to temperature sensors
Unshielded or incorrectly routed cables to temperature sensors can result in interference being coupled into the signal processing electronics from the power side. This can result in significant disturbance of all signals (fault messages) up to failure of individual components (destruction of the devices).

- Only use shielded cables as temperature sensor cables.
- If temperature sensor cables are routed together with the motor cable, use twisted-pair, separately-shielded cables.
- Connect the cable shield at both ends to ground potential over a large surface area.


## NOTICE

Damage to motor when KTY temperature sensor is connected incorrectly
If a KTY temperature sensor is connected with incorrect polarity, it is not possible to detect when the motor overheats. Overheating can cause damage to the motor.

- Connect a KTY temperature sensor with the correct polarity.


## NOTICE

Damage to the encoder due to incorrect supply voltage
The encoder power supply can be set to 5 V or 24 V . The encoder may be damaged due to an incorrect parameter assignment.

- Select the appropriate supply voltage.


## X521 / X531: Encoder connection 2 for HTL/TTL encoder with open-circuit monitoring

Table 4-56 Encoder connection X521

|  | Terminal | Signal name | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | A | Incremental signal A |
|  | 2 | A* | Inverted incremental signal A |
|  | 3 | B | Incremental signal B |
|  | 4 | B* | Inverted incremental signal B |
|  | 5 | R | Reference signal R |
|  | 6 | R* | Inverted reference signal R |
|  | 7 | CTRL | Control signal |
|  | 8 | M | Ground via inductivity |
| Max. connectable cross-section: \#16 AWG (1.5 mm²) |  |  |  |

## Note

## Operation of unipolar HTL encoders

When unipolar HTL encoders are used, $\mathrm{A}^{*}, \mathrm{~B}^{*}$, and $\mathrm{R}^{*}$ on the terminal block must be jumpered with M_Encoder (X531).

Table 4-57 Encoder connection X531

|  | Terminal | Signal name | Technical specifications |
| :--- | :---: | :--- | :--- |

1) Accuracy of the temperature measurement:

- KTY: $\pm 7^{\circ} \mathrm{C}$ (including evaluation)
- PT1000: $\pm 5^{\circ} \mathrm{C}$ (PT1000 tolerance class B according to EN 60751 including evaluation) - PTC: $\pm 5^{\circ} \mathrm{C}$ (including evaluation)


## ! WARNING

Electric shock in the event of voltage flashovers at the temperature sensor
Voltage flashovers in the signal electronics can occur in motors without safe electrical separation of the temperature sensors.

- Only use temperature sensors that fully comply with the specifications of the safety isolation.


## NOTICE

Device failure due to unshielded or incorrectly routed cables to temperature sensors
Unshielded or incorrectly routed cables to temperature sensors can result in interference being coupled into the signal processing electronics from the power side. This can result in significant disturbance of all signals (fault messages) up to failure of individual components (destruction of the devices).

- Only use shielded cables as temperature sensor cables.
- If temperature sensor cables are routed together with the motor cable, use twisted-pair, separately-shielded cables.
- Connect the cable shield at both ends to ground potential over a large surface area.


## NOTICE

Damage to motor when KTY temperature sensor is connected incorrectly
If a KTY temperature sensor is connected with incorrect polarity, it is not possible to detect when the motor overheats. Overheating can cause damage to the motor.

- Connect a KTY temperature sensor with the correct polarity.


## NOTICE

## Damage to the encoder due to incorrect supply voltage

The encoder power supply can be set to 5 V or 24 V . The encoder may be damaged due to an incorrect parameter assignment.

- Select the appropriate supply voltage.


## Note

Cable shield for the encoder connection via terminals
Note that when the encoder is connected via terminals, the cable shield must be applied to the module.

### 4.9.20.3 Connection examples

Connection example 1: HTL encoder, bipolar, without zero mark -> p0405 = 9 (hex)


Figure 4-43 Connection example 1: HTL encoder, bipolar, without zero mark

## Connection example 2: TTL encoder, unipolar, without zero track -> p0405 = A (hex)



Figure 4-44 Connection example 2: TTL encoder, unipolar, without zero track

### 4.9.21 Voltage Sensing Module for determining the actual motor speed and the phase angle (option K51)

## Description

The VSM10 Voltage Sensing Module is used for acquiring the voltage characteristic on the motor side, so that the following functions can be implemented:

- Operation of a permanent-magnet synchronous motor without encoder with the requirement to be able to connect to a motor that is already rotating ("flying restart" function).
- Fast flying restart of large induction motors: the time for the demagnetization of the motor is eliminated as a result of the voltage sensing.
The terminals on the Voltage Sensing Module (-B51) are pre-assigned in the factory and must not be changed by the customer.
When operating a permanent-magnet synchronous motor without encoder, the "Flying restart" function must be activated with p1200.


## Removing the connector jumper in the VSM10 Voltage Sensing Module

If a device is operated on an ungrounded network (IT network), the connector jumper in terminal X530 on the button of the component must be removed from the Voltage Sensing Module (VSM10).

Use two screwdrivers or a suitable tool in order to relieve the holding springs in the terminal and then withdraw the connector jumper.


## Note

False tripping caused by not removing the connection clip with a non-grounded line supply
Failure to remove the connector jumper on a non-grounded line supply (IT system) can cause false tripping in case of sensitive IT network monitoring.

- On an ungrounded power network (IT power network), remove the jumper.


### 4.9.22 Additional SMC30 Sensor Module Cabinet-Mounted (option K52)

## Description

With option K50, an SMC30 Sensor Module is included in the cabinet unit. The additional SMC30 Sensor Module enables reliable actual-value acquisition when using Safety Integrated Extended Functions (requires a license: option K01).

## Note

## Safety Integrated Function Manual

A detailed description of the full functionality and handling of the Safety Integrated functions can be found in the accompanying Function Manual. This manual is available as additional documentation on the customer DVD supplied with the device.

### 4.9.23 Additional customer terminal block TM31 (option G61)

## Description

An interface module TM31 (customer terminal module -A60 or -X65) is already installed as standard. A second module (-A61) provides the following additional digital and analog inputs/outputs in the drive system:

- 8 digital inputs
- 4 bidirectional digital inputs/outputs
- 2 relay outputs with changeover contact
- 2 analog inputs
- 2 analog outputs
- 1 temperature sensor input (KTY84-130/PTC)

Inputs and outputs of the second TM31 must be assigned by the customer; default settings of the terminals are not provided.

### 4.9.24 TM31 wired to customer terminal block (option G65)

## Description

The standard version contains a TM31 interface module (-A60) as a customer terminal block.

With option G65, the connections of the TM31 (-A60) are routed to an intermediate terminal block (-X65), which can be used for customer connections with a larger conductor cross section.

The pin assignment of the interfaces is described in "Electrical installation", "Signal interfaces".

### 4.9.25 Safety license for 1 axis (option K01)

## Description

The Safety Integrated Basic functions do not require a license. A license is, however, required for each axis with safety functions in the case of Safety Integrated Extended functions. It is irrelevant which safety functions are used and how many.

With option K01, the Safety license for 1 axis is included on the CompactFlash Card and activated.

## Licenses

The required license can optionally be ordered with the CompactFlash card.
Subsequent licensing is realized in the Internet using the "WEB License Manager" by generating a license key:
http://www.siemens.com/automation/license

## Activation

The associated license key is entered into parameter p9920 in the ASCII code. The license key is activated using parameter p9921 $=1$.

## Diagnostics

An insufficient license is indicated via the following alarm and LED:

- Alarm A13000 $\rightarrow$ License not sufficient
- LED READY $\rightarrow$ Flashes green/red at 0.5 Hz


## Note

## Safety Integrated Function Manual

Detailed and comprehensive instructions and information for the Safety Integrated functions can be found in the accompanying Function Manual. This manual is available as additional documentation on the customer DVD supplied with the device.

### 4.9.26 Terminal module for activation of "Safe Torque Off" and "Safe Stop 1" (option K82)

## Description

Option K82 (terminal module for activating "Safe Torque Off" and "Safe Stop 1") is used for isolated activation via a variable control-voltage range of the safety functions already present in the standard version, which can also be used without option K82.

Use option K82 to activate the following Safety Integrated functions (terminology according to EN 61800-5-2):

- Safe torque off (STO)
- Safe Stop 1 (SS1, time-controlled)


## Note

## Standard requirements

The integrated safety functions, starting from the Safety Integrated (SI) input terminals of the SINAMICS components (Control Unit, Motor Module), satisfy the requirements according to EN 61800-5-2, EN 60204-1, EN ISO 13849-1 Category 3 (formerly EN 954-1) for Performance Level (PL) d and EN 61508 SIL 2.

In combination with option K82, the requirements specified in EN 61800-5-2, EN 60204-1 as well as in EN ISO 13849-1 Category 3 (formerly EN 954-1) are satisfied for Performance Level (PL) d and EN 61508 SIL 2.

## Note

## Safety Integrated Function Manual

Detailed and comprehensive instructions and information for the Safety Integrated functions can be found in the accompanying Function Manual. This manual is available as additional documentation on the customer DVD supplied with the device.

### 4.9.27 TM54F Terminal Module (option K87)



Figure 4-45 TM54F Terminal Module (option K87)

## Description

The TM54F Terminal Module is a terminal expansion module with safe digital inputs and outputs for controlling the Safety Integrated Extended functions of SINAMICS.
The TM54F is directly connected to a Control Unit via DRIVE-CLiQ.

TM54F features the following interfaces:

Table 4-58 Overview of the TM54F interfaces

| Type | Quantity |
| :--- | :--- |
| Fail-safe digital outputs (F-DO) | 4 |
| Fail-safe digital inputs (F-DI) | 10 |
| Sensor $^{1)}$ power supplies, dynamic response supported ${ }^{2}$ ) | 2 |
| Sensor ${ }^{1)}$ power supply, no dynamic response | 1 |
| Digital inputs to check F_DO for a test stop | 4 |

1) Sensors: Fail-safe devices to issue commands and sense, for example, emergency stop pushbuttons and safety locks, position switches and light arrays/light curtains.
2) Dynamic response: The sensor power supply is switched on and off by the TM54F when the forced dormant error detection is active for the sensors, cable routing, and the evaluation electronics.

The TM54F provides 4 fail-safe digital outputs and 10 fail-safe digital inputs. A fail-safe digital output consists of a 24 V DC switching output, a ground switching output, and a digital input for checking the switching state. A fail-safe digital input comprises two digital inputs.

## Note

## Rated values of the F-DO

The rated values of the F-DO meet the requirements of EN 61131-2 for digital DC outputs with 0.5 A rated current.

The operating ranges of the F-DI meet the requirements of EN 61131-2 for Type 1 digital inputs.

## Note

## Shielding cables

Please note that the F-DIs must take the form of shielded cables if they are $>30 \mathrm{~m}$ in length.

## Note

## Safety Integrated Function Manual

A detailed description of the full functionality and handling of the Safety Integrated functions can be found in the accompanying Function Manual. This manual is available as additional documentation on the customer DVD supplied with the device.

### 4.9.28 Safe Brake Adapter SBA 230 V AC (option K88)

## Description

Safe Brake Control (SBC) is a safety function that is used in safety-related applications. In the no-current state, the brake acts on the motor of the drive using spring force. The brake is released (opened) when current flows through it (=low active).

The Safe Brake Adapter 230 V AC is installed in the cabinet unit in the factory. An infeed is connected to terminal -X12 on the Safe Brake Adapter for the power supply. For control, a connection is established between the Safe Brake Adapter and the Control Interface Module using a cable harness installed in the factory.

For controlling the brake, a connection must be established on site between terminal -X14 on the Safe Brake Adapter and the rectifier of the brake. Direct connection of AC brakes is not permissible.

## NOTICE

Device failure due to connection of a 24 V DC brake
Connection of a 24 V DC brake to option K88 (Safe Brake Adapter 230 V AC) can cause damage to the Safe Brake Adapter and even failure (closing of the brake is not indicated via an LED, the fuse can be tripped, the contact service life of the relay is reduced).

- Do not connect a 24 V DC brake to the Safe Brake Adapter 230 V AC.


## Note

Maximum cable length of the brake control
The maximum permissible cable length of 300 m between the Safe Brake Adapter 230 V AC and the brake must be observed. To accurately calculate the maximum cable length, see the SINAMICS Low Voltage Engineering Manual on the customer DVD supplied with the device.

## Fast de-energization

Some brake rectifier types are equipped with two additional connections for switching the brake load on the DC side. This allows the brake coil to be quickly de-energized, i.e. braking starts earlier.

The Safe Brake Adapter supports such fast de-energizing using the two additional connections -X15:1 and -X15:2. This function does not belong to safe brake control.

## Notes

## Note

## Replacement fuses

The article numbers for spare fuses can be taken from the spare parts list supplied.

## Note

## Standard requirements

The integrated safety functions, starting from the Safety Integrated (SI) input terminals of the SINAMICS components (Control Unit, Motor Module), satisfy the requirements according to EN 61800-5-2, EN 60204-1, DIN EN ISO 13849-1 Category 3 (formerly EN 954-1) for Performance Level (PL) d and IEC 61508 SIL2.

With the Safe Brake Adapter (option K88), the requirements specified in EN 61800-5-2, EN 60204-1, DIN EN ISO 13849-1 Category 3 (formerly EN954-1) as well as for Performance Level (PL) d and IEC 61508 SIL 2 are fulfilled.

## Note

## Safety Integrated Function Manual

A detailed description of the full functionality and handling of the Safety Integrated functions can be found in the accompanying Function Manual. This manual is available as additional documentation on the customer DVD supplied with the device.

### 4.9.29 Control Unit CU320-2 PN (option K95)

With Option K95, the enclosed drive contains a CU320-2 PN control unit, which takes over the communication and open-loop/closed-loop control functions.
A PROFINET interface is available for higher-level communication.

## Connection overview



Figure 4-46 Connection overview of CU320-2 PN Control Unit (without cover)


Figure 4-47 Interface X140 and measuring sockets T0 to T2 - CU320-2 PN (view from below)

## NOTICE

Malfunctions or damage to the Option Board by pulling and plugging it during operation
Pulling and plugging the Option Board during operation can damage it or cause it to malfunction.

- Only pull and plug the Option Board when the Control Unit is de-energized.


Figure 4-48 Connection example of a CU320-2 PN Control Unit

## X100 to X103: DRIVE-CLiQ interface

Table 4-59 DRIVE-CLiQ interface X100 - X103

|  | Pin | Signal name | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | TXP | Send data + |
|  | 2 | TXN | Send data - |
|  | 3 | RXP | Receive data + |
|  | 4 | Reserved, do not use |  |
|  | 5 | Reserved, do not use |  |
|  | 6 | RXN | Receive data - |
|  | 7 | Reserved, do not use |  |
|  | 8 | Reserved, do not use |  |
|  | A | + (24 V) | Power supply |
|  | B | $\mathrm{M}(0 \mathrm{~V})$ | Electronics ground |
| Connector typ Blanking plat | : RJ45 for DRIV | iQ interfaces (50 pcs.) A | 6SL3066-4CA00-0AA0 |

### 4.9 Other connections

## X122: Digital inputs/outputs

Table 4-60 Terminal block X122

|  | Pin | Designation ${ }^{1)}$ | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | DI 0 | Voltage (max.): -3 ... +30 V DC <br> Typical power consumption: 9 mA at 24 V <br> Electrical isolation: reference potential is terminal M1 <br> Signal level (with ripple) <br> High level: $15 \ldots 30 \mathrm{~V}$ <br> Low level: -3 ... +5 V <br> Input delay (typ.): <br> For "0" $\rightarrow$ "1": $50 \mu \mathrm{~s}$ <br> For "1" $\rightarrow$ "0": $150 \mu \mathrm{~s}$ |
|  | 2 | DI 1 |  |
|  | 3 | DI 2 |  |
|  | 4 | DI 3 |  |
|  | 5 | DI 16 |  |
|  | 6 | DI 17 |  |
|  | 7 | M1 | Reference potential for terminal 1... 6 |
|  | 8 | M | Electronics ground |
|  | 9 | DI/DO 8 | As input: <br> Voltage: -3 ... +30 V DC <br> Current consumption, typical: 9 mA at 24 V <br> Level (with ripple) <br> High level: $15 \ldots 30 \mathrm{~V}$ <br> Low level: $-3 \ldots+5 \mathrm{~V}$ <br> DI/DO 8, 9, 10, and 11 are "high-speed inputs" 2) <br> Input delay (typ.): <br> For "0" $\rightarrow$ "1": $5 \mu \mathrm{~s}$ <br> For "1" $\rightarrow$ "0": $50 \mu \mathrm{~s}$ <br> As output: <br> Voltage: 24 V DC <br> Max. load current per output: 500 mA <br> Continuous short-circuit proof <br> Output delay (typ./max.): ${ }^{3)}$ <br> For "0" $\rightarrow$ "1": $150 \mu \mathrm{~s} / 400 \mu \mathrm{~s}$ <br> For "1" $\rightarrow$ "0": $75 \mu \mathrm{~s} / 100 \mu \mathrm{~s}$ <br> Switching frequency: <br> For resistive load: max. 100 Hz <br> For inductive load: max. 0.5 Hz <br> For lamp load: max. 10 Hz <br> Maximum lamp load: 5 W |
|  | 10 | DI/DO 9 |  |
|  | 11 | M |  |
|  | 12 | DI/DO 10 |  |
|  | 13 | DI/DO 11 |  |
|  | 14 | M |  |
|  |  |  |  |
|  |  |  |  |
| Max. connectable cross-section: $1.5 \mathrm{~mm}^{2}$ |  |  |  |

${ }^{1)} \mathrm{DI}:$ Digital input; DI/DO: Bidirectional digital input/output; M: Electronics ground; M1: Reference potential
${ }^{2)}$ The fast inputs can be used as probe inputs or as inputs for the equivalent zero mark.
3) Data for: $\mathrm{V}_{\mathrm{cc}}=24 \mathrm{~V}$; load $48 \Omega$; high ("1") $=90 \% \mathrm{~V}_{\text {out; }}$ low ("0") $=10 \% \mathrm{~V}_{\text {out }}$

The maximum cable length that can be connected is 30 m .

## Note

## Ensuring the function of digital inputs

An open input is interpreted as "low".
Terminal M1 must be connected so that the digital inputs ( DI ) can function.
This is achieved through one of the following measures:

1. Provision of the ground reference of the digital inputs.
2. A jumper to terminal M. (Note: This removes the electrical isolation for these digital inputs.)

## Note

If the 24 V supply is briefly interrupted, then the digital outputs are deactivated during this time.

### 4.9 Other connections

## X132: Digital inputs/outputs

Table 4-61 Terminal block X132

${ }^{1)} \mathrm{DI}:$ Digital input; DI/DO: Bidirectional digital input/output; M: Electronics ground; M2: Reference potential
2) The fast inputs can be used as probe inputs or as inputs for the equivalent zero mark
3) Data for: $\mathrm{V}_{\mathrm{cc}}=24 \mathrm{~V}$; load $48 \Omega$; high ("1") $=90 \% \mathrm{~V}_{\text {out; }}$ low ("0") $=10 \% \mathrm{~V}_{\text {out }}$

The maximum cable length that can be connected is 30 m .

## Note

## Ensuring the function of digital inputs

An open input is interpreted as "low".
To enable the digital inputs (DI) to function, terminal M2 must be connected.
This is achieved through one of the following measures:

1. Provision of the ground reference of the digital inputs.
2. A jumper to terminal $M$. (Note: This removes the electrical isolation for these digital inputs.)

## Note

If the 24 V supply is briefly interrupted, then the digital outputs are deactivated during this time.

## X127: LAN (Ethernet)

Table 4-62 X127 LAN (Ethernet)

|  | Pin | Designation | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | TXP | Ethernet transmit data + |
|  | 2 | TXN | Ethernet transmit data - |
|  | 3 | RXP | Ethernet receive data + |
|  | 4 | Reserved, do not use |  |
|  | 5 | Reserved, do not use |  |
|  | 6 | RXN | Ethernet receive data - |
|  | 7 | Reserved, do not use |  |
|  | 8 | Reserved, do not use |  |
| Connector | pe: |  |  |

## Note

The LAN (Ethernet) interface does not support Auto MDI (X). If the LAN interface of the communication partner also cannot handle auto-MDI(X), then a crossover cable must be used to establish the connection.

For diagnostic purposes, the X127 LAN interface features a green and a yellow LED. These LEDs indicate the following status information:

Table 4-63 LED states for the X127 LAN interface

| LED | Color | Status | Description |
| :--- | :--- | :--- | :--- |
| Link port | - | Off | Missing or faulty link |
|  | Green | Continuous light | 10 or 100 Mbit link available |
| Activity port | - | Off | No activity |
|  | Yellow | Flashing light | Sending or receiving |

## X140: Serial interface (RS232)

The AOP30 operator panel for operating/configuring the device can be connected via the serial interface. The interface is located on the underside of the Control Unit.

Table 4-64 Serial interface (RS232) X140

|  | Pin | Designation | Technical specifications |
| :--- | :--- | :--- | :--- |
| 0 | 2 | RxD | Receive data |
|  | 3 | TxD | Send data |
|  | 5 | Ground | Ground reference |
| $\vdots$ |  |  |  |
|  |  |  |  |
|  |  |  |  |

## Note

## Connecting cable to the AOP30

The connection cable to AOP30 may only contain the three contacts which are shown in the drawing; a completely allocated cable may not be used.

## X150 P1/P2 PROFINET interface

Table 4-65 X150 P1 and X150 P2 PROFINET

|  | Pin | Signal name | Technical specifications |
| :---: | :---: | :---: | :---: |
|  | 1 | RXP | Receive data + |
|  | 2 | RXN | Receive data - |
|  | 3 | TXP | Send data + |
|  | 4 | Reserved, do not use |  |
|  | 5 | Reserved, do not use |  |
|  | 6 | TXN | Send data - |
|  | 7 | Reserved, do not use |  |
|  | 8 | Reserved, do not use |  |
| Connector Cable type | pe: RJ45 PROFINE |  |  |

## Note

## Connection cables

The PROFINET interfaces support Auto MDI(X). It is therefore possible to use both crossed and uncrossed cables to connect the devices.

For diagnostic purposes, the two PROFINET interfaces are each equipped with a green and a yellow LED. These LEDs indicate the following status information:

Table 4-66 LED states of the X150 P1/P2 PROFINET interface

| LED | Color | Status | Description |
| :--- | :--- | :--- | :--- |
| Link port | - | Off | Missing or faulty link |
|  | Green | Continuous light | 10 or 100 Mbit link available |
| Activity port | - | Off | No activity |
|  | Yellow | Flashing light | Data is being received or sent at port x |

## T0, T1, T2: Measuring socket contacts

Table 4-67 Measuring socket contacts T0, T1, T2

|  | Socket | Function | Technical specifications |
| :---: | :---: | :---: | :---: |
| M T0 T1 T2 | M | Ground | Voltage: $0 . .5 \mathrm{~V}$ <br> Resolution: 8 bits <br> Load current: max. 3 mA <br> Sustained short-circuit-proof <br> The reference potential is terminal M |
|  | T0 | Measuring socket contact 0 |  |
|  | T1 | Measuring socket contact 1 |  |
|  | T2 | Measuring socket contact 2 |  |
|  |  |  |  |
| B plug conne | from Ph | Contact, type: ZEC 1.0/ 4 | 3.5 C1 R1.4, order number: 1893708 |

## Note

Cable cross-section
The measuring socket contacts are only suitable for cable cross-sections of $0.2 \mathrm{~mm}^{2}$ to $1 \mathrm{~mm}^{2}$.

## Note

## Use of the measuring socket contacts

The measuring socket contacts are used to support commissioning and diagnostics.
Connection during operation is not permitted.

## DIAG button

The DIAG pushbutton is reserved for service functions.

## Slot for the memory card



Figure 4-49 Slot for the memory card

## Note

Plant standstill by withdrawing or inserting the memory card during operation
If the memory card is withdrawn or inserted during operation, then data can be lost, possibly resulting in a plant standstill.

- Pull and plug the memory card only when the Control Unit is de-energized.


## Note

Insertion direction of the memory card
Only insert the memory card as shown in the photo above (arrow at top right).


## NOTICE

Damage to memory card due to electric fields or electrostatic discharge
Electrical fields or electrostatic discharge may result in damage to the memory card and therefore malfunctions.

- When removing and inserting the memory card, always observe the ESD regulations.


## Note

## Data loss when the Control Unit with memory card is returned

When a defective Control Unit is returned, the data on the memory card (parameters, firmware, licenses, etc.) may be lost during repair and testing.

- Do not return the memory card with the Control Unit. Instead, keep it in a safe place so that it can be inserted in the replacement unit.


## Note

Please note that only SIEMENS memory cards can be used to operate the Control Unit.

## Commissioning

## $5.1 \quad$ Chapter content

This section provides information on the following:

- An overview of the operator panel functions
- Initial commissioning of the cabinet unit (initialization) with STARTER and AOP30
- Entering the motor data (drive commissioning)
- Entering the most important parameters (basic commissioning), concluding with motor identification
- Data backup
- Parameter reset to factory settings



## Important information prior to commissioning

The cabinet unit offers a varying number of internal signal interconnections depending on the factory state and the options installed. For the closed-sloop converter control to process signals correctly, several software settings must be made.

During initial power-up of the Control Unit and during initial commissioning, parameter macros are executed that make the necessary settings. These settings are documented in the Appendix.

After initial power-up or initial commissioning, and also following a "Parameter reset to factory settings", certain parameter values differ from the factory settings stated in the List Manual.

```
! WARNING
Malfunctions of the machine as a result of incorrect or changed parameter settings
Machines can malfunction as a result of incorrect or changed parameter assignment, which
in turn can lead to injuries or death.
- Protect parameter assignments against unauthorized access.
- Respond to possible malfunctions by applying suitable measures (e.g. EMERGENCY
STOP or EMERGENCY OFF).
```


### 5.2 The STARTER commissioning tool

## Description

You can use the STARTER commissioning tool to configure and commission SINAMICS drives and drive systems. The drive can be configured using the STARTER drive configuration wizard.

## Note

## STARTER online help

This section shows you how to carry out commissioning using STARTER. STARTER features a comprehensive online help function, which provides detailed explanations of all the processes and available system settings.
This section therefore provides only a description of the commissioning steps.

## STARTER version prerequisite

The following STARTER version is required to commission the SINAMICS with firmware V5.1:

- STARTER V5.1


## Requirements for installing STARTER

## Hardware

The following minimum requirements must be met:

- PG or PC with Pentium III min. 1 GHz (recommended $>1 \mathrm{GHz}$ )
- 2 GB work memory (4 GB recommended)
- Screen resolution $1024 \times 768$ pixels, 16 -bit color depth
- Free hard disk space $>5 \mathrm{~GB}$


## Software

The following minimum requirements must be met when using STARTER without an existing STEP 7 installation:

64-bit operating systems:

- Microsoft Windows 7 Professional SP1
- Microsoft Windows 7 Ultimate SP1
- Microsoft Windows 7 Enterprise SP1 (Standard Installation)
- Microsoft Windows 10 Professional, from version 1607
- Microsoft Windows 10 Enterprise, from version 1607
- Microsoft Windows 10 Enterprise 2016 LTSB (OS build 14393)
- Microsoft Windows Server 2008 R2 SP1

STARTER setup is possible with native Windows versions with Asian languages only if the Windows 7 software is an MUI version.
Acrobat Reader V9.4 or higher is required to open the function diagrams in the online help.

## Note <br> Requirements in conjunction with STEP 7

If STARTER is used in combination with other STEP 7 components, the requirements for these S7 components apply.

### 5.2.1 Installing the STARTER commissioning tool

STARTER is installed using the "setup" file on the accompanying customer DVD. When you double-click the "Setup" file, the installation Wizard guides you through the process of installing STARTER.

## Note

Time required for installation
The time required for installation depends on the computer capacity and from where it is installed (e.g., DVD, hard disk, network). We recommend installing it from a local data storage medium.

### 5.2.2 Layout of the STARTER user interface

STARTER features four operating areas:


Figure 5-1 STARTER operating areas

| Operating area | Description |
| :--- | :--- |
| 1: Toolbars | In this area, you can access frequently used functions via toolbar buttons. |
| 2: Project navigator | The elements and projects available in the project are displayed here. |
| 3: Workspace | In this area, you can change the settings for the drive units. |
| 4: Detail view | Detailed information about faults and alarms, for example, is displayed this area. |

### 5.3 Procedure for commissioning via STARTER

## Basic procedure using STARTER

STARTER uses a sequence of dialog screens for entering the required drive unit data.

## Note

Default settings in dialog screens
These dialog screens contain default settings, which you may have to change according to your application and configuration.

This is intentional:
Objective: By taking time to consider what configuration data you enter, you can prevent inconsistencies between the project data and drive unit data (identifiable in online mode).

### 5.3.1 Creating the project

Click the STARTER icon on the desktop or select the Start > All programs > STARTER > STARTER menu command in the Windows start menu (e.g., in Windows 7) to start the STARTER commissioning tool.

The first time you run the software, the main screen (shown below) appears with the following windows:

- STARTER Getting Started
- STARTER project wizard

The commissioning steps are listed below as a numbered step sequence.

## Accessing the STARTER project wizard



Figure 5-2 Main screen of the STARTER configuration and commissioning tool
$\Rightarrow$ Hide STARTER Getting Started Drive Commissioning using HTML Help > Close The online help can be permanently hidden by deselecting Options $>$ Settings $>$ Workbench > Show "Getting Started" at start

## Note <br> Project wizard

If you clear the Display wizard during start check box, the project wizard will not be displayed the next time you start STARTER.

You can bring up the project Wizard by choosing Project > New with Wizard.
The online help can be opened again at any time using Options > Settings > Show "Getting Started" at start.

STARTER features a detailed online Help system.

## The STARTER project wizard



Figure 5-3 STARTER project wizard
$\Rightarrow$ Click Arrange drive units offline... in the STARTER project wizard.


Figure 5-4 Creating a new project
$\Rightarrow$ Enter a Project name and, if necessary, the Author, Storage location, and a Comment.
$\Rightarrow$ Click Next > to set the PG/PC interface.


Figure 5-5 Setting the interface
$\Rightarrow$ In Access point:, select the interface according to your device configuration:

- Choose S7ONLINE (STEP 7) access, if the connection to the drive unit is made via PROFINET or PROFIBUS.
- Choose DEVICE access, if the connection to the drive unit is made via the Ethernet interface.
$\Rightarrow$ Click PG/PC..., and set the interface in accordance with your device configuration.
The Properties..., Copy..., and Select... buttons are now active.


Figure 5-6 Setting the interface

## Note <br> Requirement

To configure the interface, you must install the appropriate interface card (e.g., PC Adapter (PROFIBUS))


Figure 5-7 Setting the interface - Properties

## Note

Activate PG/PC is the only master on the bus
You must activate PG/PC is the only master on the bus if no other master (PC, S7, etc.) is available on the bus.

## Note

## Configuring without an interface

Projects can be created and PROFIBUS addresses for the drive objects assigned even if a PROFIBUS interface has not been installed on the PC.

To prevent bus addresses from being assigned more than once, only the bus addresses available in the project are proposed.
If necessary, a previously assigned address can be entered again via manual address entry.
$\Rightarrow$ After completion, click OK to confirm the settings and to return to the project wizard.


Figure 5-8 Setting the interface - Finished
$\Rightarrow$ Click Next $>$ to set a drive unit in the project wizard.


Figure 5-9 Inserting a drive unit
$\Rightarrow$ Choose the following data from the list boxes:
Device: Sinamics
Type: G150 CU320-2 DP or G150 CU320-2 PN with option K95
Version: 5.1
Address of the target device: the corresponding bus address for the cabinet unit The entry in Name: field is user-defined.
$\Rightarrow$ Click Insert
The selected drive unit is displayed in a preview window in the project wizard.


Figure 5-10 Drive unit inserted
$\Rightarrow$ Click Next >.
A summary of the project is displayed.


Figure 5-11 Summary
$\Rightarrow$ Click Complete to finish creating a new drive unit project.

### 5.3.2 Configuring the drive unit

In the project navigator, open the component that contains your drive unit.


Figure 5-12 Project navigator - Configuring the drive unit
$\Rightarrow$ In the project navigator, click the plus sign next to the drive unit you want to configure. The plus sign becomes a minus sign and the drive unit configuration options are displayed as a tree below the drive unit.
$\Rightarrow$ Double-click Configure drive unit.

## Configuring the drive unit



Figure 5-13 Configuring the drive unit
$\Rightarrow$ Under Connection voltage:, choose the correct voltage. Under Cooling method:, choose the correct cooling method for your drive unit.
$\Rightarrow$ Under Standard:, select "NEMA" to restrict the selection of drive units offered.

## Note

Make a pre-selection
This is a preliminary selection of the enclosed drives. You do not define the line voltage yet.
$\Rightarrow \mathrm{A}$ list is now displayed under Drive unit selection:. Choose the corresponding drive unit according to type (article no.) (see rating plate).
$\Rightarrow$ Click Next > .

## Selecting options



Figure 5-14 Selecting options
$\Rightarrow$ Under Options selection: , choose the options for your drive unit by selecting the appropriate check boxes (see nameplate).

## NOTICE

Damage to the dv/dt filter if it is not activated during commissioning
The dv/dt filter may be damaged if it is not activated during commissioning.

- Activate the dv/dt filter during commissioning by selecting the corresponding check box (option L10).


## Note

## Motor reactor

An existing motor reactor (option LO8) must be activated during option selection. Otherwise, the motor control cannot operate optimally.

## Note

## Check option selection

Check your options carefully against the options specified on the nameplate.
Since the wizard establishes internal interconnections on the basis of the options selected, you cannot change the selected options by clicking < Back.
If you make an incorrect entry, delete the entire drive unit from the project navigator and create a new one
$\Rightarrow$ Check your options carefully and then click Next > .

## Selecting the control structure



Figure 5-15 Selecting the control structure
$\Rightarrow$ Select the corresponding settings for the control structure:

- Function modules:
- Technology controller
- Extended signals/monitoring
- Control:
- n/M control + V/f control, I/f control
- V/f Control
- Control type:

Depending on the selected control, you can select from the following open-loop/closedloop control types:

- 0: V/f control with linear characteristic
- 1: V/f control with linear characteristic and FCC
- 2: V/f control with parabolic characteristic
- 3: V/f control with assignable characteristic
- 4: V/f control with linear characteristic and ECO
- 5: V/f control for drive requiring a precise frequency (e.g., textiles)
- 6: V/f control for drive requiring a precise frequency and FCC
- 7: V/f control with parabolic characteristic and ECO
- 15: Operation with braking resistor
- 18: I/f control with fixed current
- 19: V/f control with independent voltage setpoint
- 20: Speed control (without encoder)
- 21: Speed control (with encoder)
- 22: Torque control (without encoder)
- 23: Torque control (with encoder)
$\Rightarrow$ Click Next > .


## Configuring the drive properties



Figure 5-16 Configuring the drive properties
$\Rightarrow$ Under Standard:, choose the appropriate standard for your motor, whereby the following is defined:

- IEC motor ( 50 Hz , SI unit): line frequency 50 Hz , motor data in kW
- NEMA motor ( 60 Hz , US unit): line frequency 60 Hz , motor data in HP
$\Rightarrow$ Under Connection voltage:, enter the appropriate input voltage for the enclosed drive.
$\Rightarrow$ Click Next > .
The connected motor can be selected or entered in different ways:
- By selecting a standard motor from a list
- By entering the motor data


## Selecting the motor type by selecting a standard motor from a list



Figure 5-17 Configuring a motor - Selecting the motor type, selecting standard motor from list
$\Rightarrow$ Under Motor name:, enter a name for the motor.
$\Rightarrow$ Select Select standard motor from list.
$\Rightarrow$ From the selection box next to Motor type:, select the appropriate motor type.
$\Rightarrow$ From the Motor selection: list, select the appropriate motor.
$\Rightarrow$ Under Parallel motor connection, enter the number of motors connected in parallel when required.
The motors connected in parallel must be of the same type and size.
$\Rightarrow$ Click Next >

## Configuring the motor - Selecting the type of connection



Figure 5-18 Configuring the motor - Selecting the type of connection
$\Rightarrow$ Under Connection type:, select whether the motor is connected in a star or delta connection.
The values for the rated motor voltage (p0304) and rated motor current (p0305) are automatically converted according on the selected connection type.
$\Rightarrow$ Click Next $>$ in order to configure the motor holding brake

### 5.3 Procedure for commissioning via STARTER

## Selecting the motor type by entering motor data



Figure 5-19 Configuring a motor - Selecting the motor type, entering motor data
$\Rightarrow$ Under Motor name:, enter a name for the motor.
$\Rightarrow$ Select Enter motor data.
$\Rightarrow$ From the selection box next to Motor type:, select the appropriate motor for your application.
$\Rightarrow$ Under Parallel motor connection, enter the number of motors connected in parallel, if necessary.
Motors connected in parallel must be of the same type and size.

## Note

## Selecting motor type

The selection of the motor type is used to pre-assign specific motor parameters and to optimize the operating characteristics. Details are described in the List Manual in the p0300 parameter.

## Note

## Commissioning an induction motor

The steps described below also apply to commissioning an induction motor.
When commissioning a permanent-magnet synchronous motor, a few special conditions apply. These are detailed in a separate section (see "Setpoint channel and closed-loop control / Permanent-magnet synchronous motors").
$\Rightarrow$ Click Next $>$.
Configuring the motor - Entering motor data


Figure 5-20 Configuring the motor - Entering motor data
$\Rightarrow$ Enter the motor data (see motor nameplate).
$\Rightarrow$ Select Enter optional motor data, if necessary.
$\Rightarrow$ Select Enter optional equivalent circuit diagram data, if necessary

## Note

## Entering the equivalent circuit diagram data

You should only select the Enter optional equivalent circuit diagram data option if the data sheet with equivalent circuit diagram data is available. If any data is missing, an error message will be output when the system attempts to load the drive project to the target system.

## $\Rightarrow$ Click Next > .

Configuring the motor - Entering optional data


Figure 5-21 Entering optional motor data
$\Rightarrow$ Enter the optional motor data.
$\Rightarrow$ Click Next $>$.

## Configuring the motor - Entering the equivalent circuit diagram data



Figure 5-22 Entering the equivalent circuit diagram data
$\Rightarrow$ Select one of the equivalent circuit diagram data representations:

- System of units, physical

The equivalent circuit diagram data are represented in the physical system of units.

- System of units, relative

The equivalent circuit diagram data are represented as a percentage (\%) of the motor rating data.
$\Rightarrow$ Enter the equivalent circuit diagram data completely.
$\Rightarrow$ Click Next > .

## Calculating the motor/controller data



Figure 5-23 Calculating the motor/controller data
$\Rightarrow$ Under Calculation of the motor/controller data, select the appropriate default settings for your device configuration.

## Note

Manual input of the equivalent circuit diagram data
If the equivalent circuit diagram data was entered manually (see "Entering the equivalent circuit diagram data"), the motor/controller data should be calculated without calculating the equivalent circuit diagram data.

```
= Click Next >.
```


## Configuring the motor holding brake



Figure 5-24 Configuring the motor holding brake
$\Rightarrow$ Under Holding brake configuration: choose the appropriate setting for your device configuration:

- 0 : No motor holding brake being used
- 1: Motor holding brake like sequence control
- 2: Motor holding brake always open
- 3: Motor holding brake like sequence control, connection via BICO
$\Rightarrow$ When a motor holding brake is selected, you can also select the "Extended brake control" function module.
$\Rightarrow$ Click Next > .


## Entering the encoder data (option K50)

## Note

## Entering encoder data

If you have specified option K50 (SMC30 Sensor Module Cabinet-Mounted), the following input screen is displayed for you to enter the encoder data.


Figure 5-25 Entering the encoder data
$\Rightarrow$ Under Encoder name:, enter a name of your choice.

## Note

## Factory state

The factory state is a bipolar HTL encoder with 1024 pulses per revolution at terminal X521/X531.
$\Rightarrow$ To select a different predefined encoder configuration, click the Select standard encoder from list radio button and select one of the encoders from the list.
$\Rightarrow$ To enter special encoder configurations, click the Enter data radio button and then the Encoder data button. The following input screen is displayed for you to enter the required data.


Figure 5-26
Entering encoder data - User-defined encoder data
$\Rightarrow$ Select the Measuring system.
For SINAMICS G150 NA, the following encoders can be selected:

- HTL
- TTL
$\Rightarrow$ Enter the required encoder data.
$\Rightarrow$ In the Details tab, special encoder properties can be set, for example, gear ratio, fine resolution, inversion, measuring gear position tracking.
$\Rightarrow$ Click OK.


## NOTICE

Property damage due to selection of incorrect supply voltage for the encoder
Once the encoder has been commissioned, the supply voltage ( $5 / 24 \mathrm{~V}$ ) set for the encoder is activated on the SMC30 module. If a 5 V encoder is connected and the supply voltage has not been set correctly, the encoder may be damaged.

- Set the correct supply voltage for the connected encoder.


## Default settings for setpoints/command sources



Figure 5-27 Default settings for setpoints/command sources
$\Rightarrow$ Under Command sources: and Setpoint sources:, choose the appropriate predefined settings for your device configuration.

The following command and setpoint source options are available:
Command sources: Profidrive (default setting)
TM31 terminals
NAMUR - Do not select!
PROFIdrive NAMUR - Do not select!
Setpoint sources: Profidrive (default setting)
TM31 terminals
Motorized potentiometer
Fixed setpoint

## Note

## Use of CDSO

With SINAMICS G150, only CDS0 is normally used as a default setting for the command and setpoint sources.
Make sure that the selected default setting is compatible with the actual system configuration.

## Note

## Do not use a selection

The choice "No selection" is also available as default setting for the command and setpoint sources; if selected, no default settings are applied for the command and setpoint sources.
$\Rightarrow$ Check your default settings carefully and then click Next >.

### 5.3 Procedure for commissioning via STARTER

## Selecting the drive functions



Figure 5-28 Selecting the drive functions
$\Rightarrow$ Select the required data:

- Technological application:
- "(0) Standard drive (VECTOR)"

Edge modulation is not enabled.
The dynamic voltage reserve is increased ( 10 V ), which reduces the maximum output voltage.

- "(1) Pumps and fans"(default setting)

Edge modulation is enabled.
The dynamic voltage reserve is reduced $(2 \mathrm{~V})$, which increases the maximum output voltage.

- "(2) Sensorless control down to $\mathrm{f}=0$ (passive loads)"

Closed-loop controlled operation down to zero speed is possible for passive loads. These include applications in which the load cannot produce a regenerative torque on startup and the motor comes to a standstill when pulses are inhibited (no overhauling load).

- "(4) Dynamic response in the field-weakening range"

Space vector modulation with overmodulation is enabled.
The dynamic voltage reserve is increased ( 30 V ), which reduces the maximum output voltage.

- "(5) Start-up with high break loose torque"

This selection is suitable for speed-controlled start-up with encoderless vector control. Start-up current permanent and is increased upon accelerating.

- "(6) High load inertia"

Suitable for high load inertia with/without gearbox coupling.
The acceleration model is activated, the acceleration control is $100 \%$.

- Motor identification:
- (0): Disabled
- (1): Identify the motor data and optimize the speed control
- (2): Identify the motor data (at standstill)
- (3): Optimize the speed control (during rotating operation)


## Note

Motor data identification at standstill
In many cases, "Identify motor data (at standstill)" is the correct selection for SINAMICS G150.
For speed control with encoder, the "Identify motor data and optimize speed control" selection is recommended. This measurement is normally performed when a machine is not connected.

## WARNING

Unexpected motor movement during motor identification in the rotating mode
Motor movement caused by the motor data identification routine can result in death, severe injury or material damage.

- Ensure that nobody is in the hazardous zone - and that the mechanical system can freely move.
- Ensure that the EMERGENCY OFF functions are functional during commissioning.

```
\(\Rightarrow\) Click Next >.
```


## Selecting the process data exchange



Figure 5-29 Selecting the process data exchange
$\Rightarrow$ Select the PROFIdrive message frame type.

## Message frame types

- 1: Standard message frame 1, PZD-2/2
- 2: Standard message frame 2, PZD-4/4
- 3: Standard message frame 3, PZD-5/9
- 4: Standard message frame 4, PZD-6/14
- 20: SIEMENS message frame 20, PZD-2/6
- 220: SIEMENS message frame 220, PZD-10/10
- 352: SIEMENS message frame 352, PZD-6/6
- 999: Free frame configuration with BICO (default)
$\Rightarrow$ Click Next >


## Entering important parameters



Figure 5-30 Important parameters
$\Rightarrow$ Enter the required parameter values.

## Note

## Tooltips

STARTER provides ToolTips if you position your cursor on the required field without clicking in the field.
$\Rightarrow$ Click Next $>$.

### 5.3 Procedure for commissioning via STARTER

## Configuring a web server



Figure 5-31 Configuring a web server
$\Rightarrow$ Configure the web server.
The Web server is activated in the factory setting.
Activate and deactivate the web server under Activate web server.
Select Only permit access via secure connection (https) if necessary.

## Note

Industrial Security
Observe the notes on industrial security.

```
= Click Next >.
```


## Summary of the drive unit data



Figure 5-32 Summary of the drive unit data
$\Rightarrow$ Click the Copy text to clipboard button to copy the summary of the drive unit data displayed on the screen to a word processing program for further use.

## $\Rightarrow$ Click Finish.

$\Rightarrow$ Save your project to the hard disk by choosing Project > Save..

### 5.3.3 Transferring the drive project

You have created a project and saved it to your hard disk. You now have to transfer your project configuration data to the drive unit.

## Specifying the online access point

To connect to the target system, the chosen access point must be specified.
In the menu bar, select Target system > Select target devices ...; the following dialog screen appears.


Figure 5-33 Target device selection and access points
The dialog screen lists all existing devices in the project.

Specify access point:

- Select S7ONLINE access for a device, if the connection to the programming device or PC is made via PROFINET or PROFIBUS.
- Select DEVICE access for a device if the connection to the programming device or PC is made via the Ethernet interface.


## Transferring the STARTER project to the drive unit

To transfer the STARTER project you created offline to the drive unit, carry out the following steps:

| Step | Toolbar selection |  |
| :---: | :--- | :--- |
| 1 | Choose <br> Project > Connect to selected target systems |  |
| 2 | Choose <br> Target system $>$ Load > Load project to target system |  |

## Note

## Save project data so it is protected from power failure

The project has now been loaded to the drive unit. This data is currently available only in the drive unit's volatile memory and is not stored on the memory card!
To store the project data on the memory card so that it is protected in the event of a power failure, carry out the following step.

| Step | Toolbar selection |  |
| :---: | :--- | :--- |
| 3 | Choose <br> Target system > Copy RAM to ROM |  |

## Note

## Copy RAM to ROM

The Copy from RAM to ROM button is only active when the drive unit is selected in the project navigator.

## Results of the preceding steps

- You have created a project for your drive unit offline using STARTER.
- You have saved the project data to the hard disk on your PC.
- You have transferred the project data to the drive unit.
- You have saved your project data to your drive unit's memory card so that it is protected in the event of a power failure.


## Note

Tip for working with STARTER
The STARTER commissioning tool assists you in performing complex interventions on the drive system.
If you are confronted in online mode with any system conditions that are beyond your control, you are advised to delete the drive project from the project navigator and carefully create a new project in STARTER using the appropriate configuration data for your application.

### 5.3.4 Commissioning with STARTER via Ethernet

## Description

The Control Unit can be commissioned using a programming device (PG/PC) via the integrated Ethernet interface. This interface is provided for commissioning purposes only and cannot be used to control the drive in operation.

Routing from the integrated Ethernet interface using an (optionally) inserted expansion card CBE20 is not possible.

## Requirements

- STARTER, version 4.1.5 or higher
- Control Unit CU320-2 DP device version "C" or higher, Control Unit CU320-2 PN


## STARTER via Ethernet (example)



Figure 5-34 STARTER via Ethernet (example)

## Procedure for establishing online operation via Ethernet

1. Install the Ethernet interface in the PG/PC according to the manufacturer's specifications.
2. Set the IP address of the Ethernet interface in Windows.

- Assign the PG/PC a free IP address (e.g., 169.254.11.1).
- The factory setting of the internal Ethernet interface -X127 of the Control Unit is 169.254.11.22.

3. Set the access point of the STARTER commissioning tool.
4. Use the STARTER commissioning tool to specify a name for the Control Unit interface.

The Ethernet interface must be initialized so that STARTER can establish communication. Select online operation in STARTER.

## Setting the IP address in Windows 7

## Note

The following procedure refers to the Windows 7 operating system. The procedure can differ slightly for other operating systems (e.g., Windows XP).

1. In the programming device (PG/PC), open the Control Panel using the "Start > Control Panel" menu command.
2. In the Control Panel of your PG/PC, under "Network and Internet", select the "Network and Sharing Center" function.
3. Click the connection link for your indicated network adapter.
4. Click "Properties" in the status dialog of the connection and acknowledge the subsequent confirmation prompt with "Yes".
5. In the properties dialog of the connection, select the "Internet Protocol Version 4 (TCP/IPv4)" element and then click "Properties".
6. In the properties dialog, select the "Use the following IP address" option.
7. Set the IP address of the access interface of the PG/PC to the Control Unit to 169.254.11.1 and the subnet mask to 255.255.0.0.


Figure 5-35 Properties of the Internet Protocol (TCP/IP)
8. Click "OK" and close the Windows-specific window of the network connections.

## Assigning the IP address and the name via STARTER, "Accessible nodes" function

Use STARTER to assign an IP address and a name to the Ethernet interface.

1. Connect the PG/PC and the Control Unit using an Ethernet cable.
2. Switch on the Control Unit.
3. Open STARTER.
4. Create a new project or open an existing project.
5. Use Project -> Accessible nodes or the "Accessible nodes" button to search for nodes available on the Ethernet.
6. The SINAMICS drive object is detected and displayed as a bus node with IP address 169.254.11.22, without a name.


Figure 5-36 Accessible nodes
7. Mark the bus node entry and select the displayed menu command "Edit Ethernet node" with the right mouse button.
8. In the "Edit Ethernet Node" screen, enter the device name for the Ethernet interface (e.g., "drive1") and click the "Assign name" button. Enter the IP address (e.g., 169.254.11.10) and subnet mask (e.g., 255.255 .255 .0 ) in the IP configuration. Then click the "Assign IP configuration" button and close the mask.

## Note

## Naming devices

ST (Structured Text) conventions must be satisfied for the name assignment of IO devices in Ethernet (SINAMICS components). The names must be unique within Ethernet.

Rules for assigning names:

- Other than "-" and ".", no special characters (such as accented characters, spaces, brackets) are permitted in the name of an IO device.
- The device name must not begin or end with the "-" character.
- The device name must not begin with a number.
- Maximum total length of 240 characters (lowercase characters, numbers, hyphen, or period).
- A name component within the device name, i.e., a string between two periods, must not exceed 63 characters.
- The device name must not take the form n.n.n.n ( $\mathrm{n}=0, \ldots 999$ ).
- The device name must not begin with the character sequence "port-xyz" or "port-xyzabcde" (a, b, c, d, e, x, y, z = 0, ... 9).


Figure 5-37 Editing the Ethernet node
9. When you press the "Refresh (F5)" button, the IP address and name will be displayed in the entry for the bus node. If not, close the "Accessible nodes" screen and perform another search for accessible nodes.
10.If the Ethernet interface is displayed as a bus node, select the entry and click the "Accept" button.
11.The SINAMICS drive will be displayed as a drive object in the project navigator.
12. You can now configure the drive unit; see "Configuring the drive unit".

## Note

## Storage location of the IP address

The IP address and device name are stored retentively on the memory card of the Control Unit.

## Parameters

The Ethernet interface properties can also be modified and displayed using parameters.

- p8900 IE Name of Station
- p8901 IE IP Address of Station
- p8902 IE Default Gateway of Station
- p8903 IE Subnet Mask of Station
- p8904 IE DHCP Mode
- p8905 IE Interface Configuration
- r8910 IE Name of Station active
- r8911 IE IP Address of Station active
- r8912 IE Default Gateway of Station active
- r8913 IE Subnet Mask of Station active
- r8914 IE DHCP Mode of Station active
- r8915 IE MAC Address of Station


### 5.4 Operator panel AOP30

## Description

An operator panel with the following features is located in the enclosure door of the drive for operating, monitoring, and commissioning tasks:

- Graphical, back-lit LCD for plain-text display and a "bar graph display" of process variables
- LEDs for indicating the operating modes
- Help function describing causes of and remedies for faults and alarms
- Keypad for operational control of the drive
- LOCAL/REMOTE changeover for selecting the point of operator control (right of control assigned to operator panel or customer terminal block/PROFIBUS)
- Numeric keypad for entering setpoint or parameter values
- Function keys for guided navigation through the menus
- Two-stage safety concept to protect against accidental or unauthorized changes to settings
- IP54 degree of protection (when installed)
- Selectable languages: German, English, French, Italian, Spanish, Chinese, Russian, Portuguese


Figure 5-38 Components of the drive operator panel (AOP30)

### 5.5 First commissioning with the AOP30

### 5.5.1 Initial startup

## Start screen

When the system is switched on for the first time, the Control Unit is initialized automatically. The following screen is displayed:


Figure 5-39 Splash screen
When the system starts up, the parameter descriptions are loaded into the operating field from the CompactFlash card.


Figure 5-40 Loading parameter descriptions during system startup

## Selecting the language

When the system starts up for the first time, a language selection screen appears.

```
Sprachauswahl/Language selection
    English
    Deutsch
    Français
    Español
    Italiano
    Chinese
```



Select a language in the dialog screen.

To change the language, choose <F2> or <F3>.
To select a language, choose < $\mathrm{F} 5>$.

## Navigation within the interactive screens

Within an interactive screen, the selection boxes can usually be selected using the <F2> and/or <F3> keys. Selection fields are generally texts surrounded by a frame. When they are selected, they are highlighted with a white text on a black background.
The present value of a highlighted selection box can usually be changed by pressing <F5> "OK" or "Change". Another entry box then appears and the value you want is entered directly using the numerical keypad or can be selected from a list.

You can change from one interactive screen to the next or previous screen by selecting the "Continue" or "Back" selection boxes and then confirming by pressing <F5> "OK".
If a screen contains particularly important parameters, the selection field "Continue" only appears at the bottom of the screen. This is because every single parameter in this interactive screen has to be checked and/or corrected thoroughly before the next interactive screen can be accessed.

For some commissioning steps, the entire commissioning can be interrupted by selecting "Interrupt commissioning".

### 5.5.2 Basic commissioning

## Entering the motor data

During basic commissioning, you must enter motor data using the operator panel. Use the data shown on the motor nameplate.


Figure 5-41 Example of a motor nameplate

Table 5-1 Motor data

|  | Parameter no. | Values | Unit |
| :---: | :---: | :---: | :---: |
| System of units for entering line frequency and motor data | p0100 | $\begin{aligned} & 0 \\ & 1 \end{aligned}$ | IEC [50 Hz/kW] NEMA [60 Hz/HP] |
| Motor: <br> Rated voltage <br> Rated current <br> Rated power <br> Rated power factor $\cos \phi($ only for $\mathrm{p} 0100=0)$ <br> Rated efficiency $\eta$ (only for p0100 = 1) <br> Rated frequency <br> Rated speed | $\begin{aligned} & \text { p0304 } \\ & \text { p0305 } \\ & \text { p0307 } \\ & \text { p0308 } \\ & \text { p0309 } \\ & \text { p0310 } \\ & \text { p0311 } \\ & \hline \end{aligned}$ |  | [V] <br> [A] <br> [kW]/[HP] <br> [\%] <br> [Hz] <br> [min-1]/[rpm] |

## Basic commissioning: Selecting motor type and entering motor data



## Note

## Selecting motor type

The selection of the motor type is used to pre-assign specific motor parameters and to optimize the operating characteristics. Details are described in the List Manual in the p0300 parameter.

## Note

## Selecting a list motor (p0300 $\geq 100$ )

When a motor type $\geq 100$ is selected, the article number of the associated motor can be selected via drop-down list.

## Note

## Commissioning an induction motor

The steps described below also apply to commissioning an induction motor.
When commissioning a permanent-magnet synchronous motor (p0300 $=2$ ), there are a few special conditions that apply, which are detailed in a separate chapter (see "Setpoint channel and closed-loop control/Permanent-magnet synchronous motors").

## Basic commissioning: Entering encoder data (if available)



When the SMC30 is connected for encoder evaluation (with option K50), it is recognized by the AOP30 and a screen is displayed for you to enter the encoder data.
To navigate through the selection fields, choose <F2> or <F3>.
To activate a selection, choose $<$ F5 $>$.

Predefined encoders can be easily set by selecting parameter p0400 (encoder type selection):

3001: $\quad 1024$ HTL A/B R at X521/X531
3002: $\quad 1024$ TTL A/B R at X521/X531
3003: $\quad 2048$ HTL A/B R at X521/X531
3005: $\quad 1024$ HTL A/B at X521/X531
3006: $\quad 1024$ TTL A/B at X521/X531
3007: $\quad 2048$ HTL A/B at X521/X531
3008: $\quad 2048$ TTL A/B at X521/X531
3009: $\quad 1024$ HTL A/B unipolar at X521/X531
3011: $\quad 2048$ HTL A/B unipolar at X521/X531
3020: $\quad 2048$ TTL A/B R with sense to X520

## Note

## Factory state

The factory state is a bipolar HTL encoder with 1024 pulses per revolution and a 24 V supply voltage

The section "Electrical Installation" contains two connection examples for HTL and TTL encoders.

## Note

## Pre-defined encoder type

If a predefined encoder type is selected via p0400, then the settings of parameters p0404, p0405, and p0408 cannot be changed.

If the connected encoder does not match any of the encoders predefined in p0400, follow the simple procedure below to enter encoder data:

- Via p0400, select an encoder type with data similar to that of the connected encoder.
- Select "User-defined" (p0400 = 9999). Previously set values are stored here.
- Adjust the bit fields of p0404, p0405, and p0408 to the data for the connected encoder.

Table 5-2 Meaning of the bit setting for p0404

| Bit | Meaning | Value 0 | Value 1 |
| :---: | :---: | :---: | :---: |
| 20 | Voltage 5 V | No | Yes |
| 21 | Voltage 24 V | No | Yes |

Table 5-3 Meaning of the bit settings for p0405

| Bit | Meaning | Value 0 | Value 1 |
| :---: | :---: | :---: | :---: |
| 0 | Signal | Unipolar | Bipolar |
| 1 | Level | HTL | TTL |
| 2 | Track monitoring | None | A/B>< -A/B |
| 3 | Zero pulse | 24 V unipolar | Same as A/B track |
| 4 | Switching threshold | Low | High |
| 5 | Pulse/direction | No | Yes |

## NOTICE

Property damage due to selection of incorrect supply voltage for the encoder
Once the encoder has been commissioned, the supply voltage ( $5 / 24 \mathrm{~V}$ ) set for the encoder is activated on the SMC30 module. If a $5-\mathrm{V}$ encoder is connected and the supply voltage has not been set correctly (bit 20 = "Yes", bit 21 = "No"), the encoder may be damaged.

- Set the correct supply voltage for the connected encoder.


## Basic commissioning: Entering basic parameters



Final confirmation

## Back

Permanent parameter acceptance execute with 'continue' and OK

|  | Interr COMM | Cont. |
| :--- | :--- | :--- |
|  |  |  |
|  | $\boldsymbol{V}$ | OK |

Enter the basic commissioning parameters: p0700: Preset command source 5: PROFIdrive 6: TM31 terminals 7: NAMUR - Do not select! 10: PROFIdrive NAMUR - Do not select! p1000: Preset setpoint source
1: PROFIdrive
2: TM31 terminals
3: Motorized potentiometer
4: Fixed setpoint
Once a setpoint source has been selected (p1000), the main setpoint p1070 is defaulted accordingly.
To navigate through the selection fields, choose <F2> or <F3>.
To activate a selection, choose <F5>.
To change a parameter value, navigate to the required selection field and activate with <F5>.
Another window appears, where you can - enter the required value directly, or - select the value from a list.

## Final confirmation

Confirm the basic parameters to save them.
Once you have selected "Continue" and activated your entries with <F5>, the basic parameters you entered are permanently saved and the calculations required for closed-loop control are carried out.

## Note

## Enter the motor-side filter

A filter on the motor side must be entered in p0230:

- Option L07-dv/dt filter compact plus voltage peak limiter: p0230 = 2
- Option L08 - motor reactor: p0230 = 1
- Option L10 - dv/dt filter plus voltage peak limiter: p0230 $=2$.

When p0230 = 4 "External sinusoidal filter", a separate sinusoidal filter can be entered. An input mask for specific filter data then appears.

## NOTICE

Damage to the dv/dt filter if it is not activated during commissioning
The dv/dt filter may be damaged if it is not activated during commissioning.

- Activate the dv/dt filter during commissioning.


## Note

Motor reactor
An existing motor reactor (option L08) must be activated during option selection. Otherwise, the motor control cannot operate optimally.

## Note

## Do not use a selection

The choice "No selection" is also available as default setting for the command and setpoint sources; if selected, no default settings are applied for the command and setpoint sources.

## Basic commissioning: Motor identification



## Selecting the motor identification

To navigate through the selection fields, choose <F2> or <F3>.
To activate a selection, choose <F5>.
Stationary measurement increases the control performance, as this minimizes deviations in the electrical characteristic values due to variations in material properties and manufacturing tolerances.
Rotary measurement determines the data required (e.g., moment of inertia) for setting the speed controller. It also measures the magnetization characteristic and rated magnetization current of the motor.
Change the number of phases to be identified:

- For identification with one phase, the time of the measurement significantly reduced.
- For identification with several phases, the measurement results are averaged.
To activate this function, press the LOCAL key (wait until the LED in the LOCAL key lights up) and then ON.
If motor identification is not carried out, the motor control uses the motor characteristic values calculated from the nameplate data rather than the measured values.


## Note

Complete motor identification
When motor identification is complete, press the OFF key to cancel the power-on inhibit.

## ! WARNING <br> Unexpected motor movement during motor identification in the rotating mode <br> When motor identification with optimization during rotating operation is selected, after the drive is commissioned it initiates movements of the motor that can reach the maximum motor speed. <br> - Observe the general safety instructions. <br> - Ensure that the EMERGENCY OFF functions are functional during commissioning.

## Note

## Activate enable signals

Make sure that the necessary enables have been assigned; otherwise motor identification cannot be carried out.

## Note

## Fault with stationary or rotating measurements

The motor identification cannot be performed if, when selecting the stationary or rotating measurement, a fault is active
Before rectifying the fault, you have to choose "No identification" and close the screen. Motor identification can then be selected again via <MENU> - <Commissioning/service> <Drive commissioning> - <Motor identification>.

### 5.6 Status after commissioning

## LOCAL mode (control via operator panel)

- Switch to LOCAL mode by pressing the "LOCAL/REMOTE" key.
- Control (ON/OFF) is carried out via the "ON" and "OFF" keys.
- You can specify the setpoint using the "increase" and "decrease" keys or by entering the appropriate numbers using the numeric keypad.


## Analog outputs

- The actual speed (r0063) is output as a current output in the range 0 to 20 mA at analog output 0 (X522:2 and 3).
A current of 20 mA is equal to the maximum speed in p1082.
- The actual current value (r0068) is output as a current output in the range 0 to 20 mA at analog output 1 (X522:5 and 6).
A current of 20 mA corresponds to the current limit (p0640), which is set to 1.5 times the rated motor current ( p 0305 ).
5.7 Commissioning an encoder with gear factor


## Digital outputs

- The "enable pulses" signal is output at digital output 0 (X542:2 and 3).
- The "no fault active" signal is output at digital output 1 (X542:5 and 6) (protection against wire breakage).
- The "ready for power up" signal is output at digital output 8 (X541:2).


### 5.7 Commissioning an encoder with gear factor

## Description

When encoders are commissioned ( $\mathrm{p} 0010=4$ ), a gearbox must be configured using parameters p0432 (counter), p0433 (denominator), and p0410 (sign).

To ensure that the commutation position can be accurately determined from the encoder angle, the following applies:

- For resolvers: $z_{p}$ Motor $1 \quad z_{p}=$ number of poles

$$
\frac{z_{p_{-} \text {Motor }}}{z_{p_{-}} \text {Resolver }} \times \frac{1}{n} \geq 1 \text {, Integer }
$$

- For all other absolute encoders:

$$
\frac{z_{p \_ \text {Motor }}}{n} \geq 1 \text {, Integer }
$$

- Where n is the gear factor:

$$
\mathrm{n}=\frac{\text { Encoder speed }}{\text { Motor speed }}=\frac{\mathrm{p} 0432}{\mathrm{p} 0433}
$$

The encoder commissioning program ensures that this uniqueness condition is observed and, if necessary, prevents the system from exiting the commissioning program or outputs an error message.
Sign bit p0410 inverts the calculated encoder angle and the speed, thereby yielding a negative gear factor.

### 5.8 Parameter reset to factory settings

The factory settings represent the defined original status of the basic device per catalog.
Resetting the parameters to the factory settings means that all the parameter settings made for specific configurations or options, as well as those made since the system was delivered are reset.

## Resetting parameters via AOP30



Set parameter filter to "Parameter reset":
<MENU> <Commissioning/Service> <Device commissioning> <OK> <30: Parameter Reset> <OK>

Reset all parameters to the factory settings:
Factory settings for all the device parameters are restored.

## Resetting parameters via STARTER

With STARTER, parameters are reset in online mode. The required steps are described below:

| Step | Toolbar selection |
| :---: | :---: |
| Choose <br> Project > Connect to target system |  |
| Click the drive unit whose parameters you want to reset to the factory settings and click the Restore factory settings button on the toolbar. | 伎 |
| To confirm, click OK. |  |
| Restore Factory Settings |  |
| Do you really want to restore the factory settings? <br> Bus address and baud rate will not be reset. <br> Restore factory settings <br> Save factory settings to ROM |  |
| Choose <br> Target system > Copy RAM to ROM |  |

## Note

## Copy RAM to ROM

The Copy RAM to ROM button is only active when the drive unit is selected in the project navigator.

After a reset of parameters to factory settings, an initial commissioning must be performed.

## Operation

### 6.1 Chapter content

This section provides information on the following:

- Basic information about the drive system
- Command source selection via
- PROFIdrive
- Terminal block
- Setpoint input via
- PROFIdrive
- Analog inputs
- Motorized potentiometer
- Fixed setpoints
- Control via the AOP30 operator panel
- Communication according to PROFIdrive
- Communication via
- PROFIBUS DP
- PROFINET IO
- SINAMICS Link
- Ethernet/IP
- Modbus TCP



### 6.2 General information about command and setpoint sources

## Description

Two default settings are available for selecting the command sources and four for selecting the setpoint sources for the SINAMICS G150 NEMA enclosed drive. The choice "No selection" is also available; if selected, no default settings are applied for the command and setpoint sources.

## Command sources

- PROFIdrive
- TM31 terminals


## Setpoint sources

- PROFIdrive
- Analog inputs
- Motorized potentiometer
- Fixed setpoints

The various assignments are explained in the following sections.

## Note

## Defaults

Make sure that the default settings you choose during commissioning are compatible with the drive configuration (see "Commissioning").

The EMERGENCY OFF signals (N57, N59, N60) are always active (regardless of the command source).

## Function diagrams

At certain points in this section, reference is made to function diagrams. These can be found on the customer DVD in the "SINAMICS G130/G150 List Manual", which provides experienced users with detailed descriptions of all the functions.

### 6.3 Basic information about the drive system

### 6.3.1 Parameters

## Overview

The drive is adapted to the relevant drive task by means of parameters. Each parameter is identified by a unique parameter number and by specific attributes (e.g. read, write, BICO attribute, group attribute, and so on).
The parameters can be accessed via the following operator control units:

- PC with the "STARTER" commissioning tool via PROFIBUS or PROFINET or via Ethernet
- The user-friendly AOP30 Operator Panel


## Parameter types

The following adjustable parameters and display parameters are available:

- Adjustable parameters (write/read)

These parameters have a direct impact on the behavior of a function.
Example: Ramp-up and ramp-down time of a ramp-function generator

- Display parameters (read-only)

These parameters are used to display internal variables.
Example: Current motor current


Figure 6-1 Parameter types
All these drive parameters can be read and changed via PROFIBUS or PROFINET using the mechanisms defined in the PROFIdrive profile.

## Parameter categories

The parameters for individual drive objects (see "Drive objects") are categorized according to data sets as follows (see "Operation/data sets"):

- Data-set-independent parameters These parameters exist only once per drive object.
- Data-set-dependent parameters

These parameters can exist several times for each drive object and can be addressed via the parameter index for reading and writing. A distinction is made between different data set types:

- CDS: Command Data Set

By parameterizing several command data sets and switching between them, the drive can be operated with different pre-configured signal sources

- DDS: Drive Data Set

The drive data set contains parameters for switching between different drive control configurations.

CDS and DDS can be switched over during normal operation. Additional data record types also exist, however these can only be activated indirectly by means of a DDS changeover.

- EDS: encoder Data Set
- MDS: Motor Data Set


Figure 6-2 Parameter categories

### 6.3.2 Drive objects

A drive object is a self-contained software function with its own parameters and, if necessary, its own faults and alarms. Drive objects can be provided as standard (e.g., I/O evaluation), or you can add single (e.g., option board) or multiple objects (e.g., drive control).


Figure 6-3 Drive objects

## Standard drive objects

- Drive control

Drive control handles closed-loop control of the motor. One Power Module and at least one motor and up to three encoders are assigned to the drive control.

- Control Unit, inputs/outputs

The inputs/outputs on the Control Unit are evaluated within a drive object.

## Optional drive objects

- Option Board evaluation

A further drive object handles evaluation of an installed Option Board. The specific method of operation depends on the type of Option Board installed.

- Terminal Module evaluation A separate drive object handles the evaluation of each optional Terminal Module.


## Properties of a drive object

- Separate parameter space
- Separate window in STARTER
- Separate fault/alarm system
- Separate PROFIdrive message frame for process data


## Configuring drive objects

When you commission the system for the first time using the STARTER tool, you will use configuration parameters to set up the software-based "drive objects" that are processed on the Control Unit. Various drive objects can be created within a Control Unit.

The drive objects are configurable function blocks and are used to execute specific drive functions.

If you need to configure additional drive objects or delete existing ones after initial commissioning, the drive system must be switched to configuration mode.

The parameters of a drive object cannot be accessed until the drive object has been configured and you have switched from configuration mode to configuration mode.

## Note

Assignment during the initial commissioning
During initial commissioning, each installed drive object is allocated a number between 0 and 63 for unique identification.

## Parameters

- p0101 Drive object numbers
- r0102 Drive object count
- p0107 Drive object type
- p0108 Drive object configuration


### 6.3.3 Data sets

## Description

For many applications, it is beneficial if more than one parameter can be changed simultaneously by means of one external signal during operation/when the system is ready for operation.

This can be carried out using indexed parameters, whereby the parameters are grouped together in a data set according to their functionality and indexed. Indexing allows several different settings, which can be activated by switching the data set, to be defined in each parameter.

## Note

## Copying data sets

The command and drive data sets can be copied in STARTER (Drive -> Configuration -> "Command data sets" or "Drive data sets" tab).
The displayed command and drive data sets can be selected in the associated STARTER screen forms..

## CDS: Command data set

The BICO parameters (binector and connector inputs) are grouped together in a command data set. These parameters are used to interconnect the signal sources of a drive (see "Operation/BICO technology: Interconnecting signals").
By configuring several command data sets and switching between them, the drive can be operated with different pre-configured signal sources.

A command data set contains the following (examples):

- Binector inputs for control commands (digital signals)
- ON/OFF, enable signals (p0844, etc.)
- Jog (p1055, etc.)
- Connector inputs for setpoints (analog signals)
- Voltage setpoint for V/f control (p1330)
- Torque limits and scaling factors (p1522, p1523, p1528, p1529)

In the factory state, two command data sets are available; this number can be increased to a maximum of four using p0170 (number of command data sets (CDS)).
The following parameters are available for selecting command data sets and for displaying the currently selected command data set:

Table 6-1 Command data set: selection and display

|  | Select bit 1 | Select bit 0 | Display |  |
| :---: | :---: | :---: | :---: | :---: |
| CDS | p0811 | p0810 | selected (r0836) | active (r0050) |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 | 1 |
| 2 | 1 | 0 | 2 | 2 |
| 3 | 1 | 1 | 3 | 3 |

If a command data set, which does not exist, is selected, the current data set remains active.


Figure 6-4 Example: Switching between command data set 0 and 1

## DDS: Drive data set

A drive data set contains various adjustable parameters that are relevant with respect to open and closed-loop drive control:

- Numbers of the assigned motor and encoder data sets:
- p0186: Assigned motor data set (MDS)
- p0187 to p0189: up to 3 assigned encoder data sets (EDS)
- Various control parameters, e.g.:
- Fixed speed setpoints (p1001 to p1015)
- Speed limits min./max. (p1080, p1082)
- Characteristic data of ramp-function generator (p1120 ff)
- Characteristic data of controller (p1240 ff)
- ...

The parameters that are grouped together in the drive data set are identified in the SINAMICS parameter list by "Data set DDS" and are assigned an index [0..n].
It is possible to configure several drive data sets. You can switch easily between different drive configurations (control type, motor, encoder) by selecting the corresponding drive data set.

One drive object can manage up to 32 drive data sets. The number of drive data sets is configured with p0180.

Binector inputs p0820 to p0824 are used to select a drive data set. They represent the number of the drive data set ( 0 to 31 ) in binary format (where p0824 is the most significant bit).

- p0820 BI: Drive data set selection DDS, bit 0
- p0821 BI: Drive data set selection DDS, bit 1
- p0822 BI: Drive data set selection DDS, bit 2
- p0823 BI: Drive data set selection DDS, bit 3
- p0824 BI: Drive data set selection DDS, bit 4


## Supplementary conditions and recommendations

- Recommendation for the number of DDS in a drive The number of DDS in a drive should correspond with the number of changeover options; in other words p0180 (DDS) $\geq$ p0130 (MDS).
- Max. number of DDS for one drive object = 32 DDS


## EDS: Encoder data set

An encoder data set contains various adjustable parameters describing the connected encoder for the purpose of configuring the drive.

- Adjustable parameters, e.g.:
- Encoder interface component number (p0141)
- Encoder component number (p0142)
- Encoder type selection (p0400)

The parameters that are grouped together in the encoder data set are identified in the SINAMICS parameter list by "Data set EDS" and are assigned an index [0..n].

A separate encoder data set is required for each encoder controlled by the Control Unit. Up to 3 encoder data sets are assigned to a drive data set via parameters p0187, p0188, and p0189.

An encoder data set can only be changed using a DDS changeover.
Each encoder may only be assigned to one drive and within a drive must - in each drive data set - either always be encoder 1, always encoder 2 or always encoder 3.

One application for the EDS changeover would be a power component with which several motors are operated in turn. A contactor circuit is used to changeover between these motors. Each of the motors can be equipped with an encoder or be operated without an encoder. Each encoder must be connected to its own SMx.

If encoder 1 ( p 0187 ) is changed over via DDS, then an MDS must also be changed over.
One drive object can manage up to 16 encoder data sets. The number of encoder data sets configured is specified in p0140.

When a drive data set is selected, the assigned encoder data sets are selected automatically.

## MDS: Motor data set

A motor data set contains various adjustable parameters describing the connected motor for the purpose of configuring the drive. It also contains certain display parameters with calculated data.

- Adjustable parameters, e.g.:
- Motor component number (p0131)
- Motor type selection (p0300)
- Rated motor data (p0304 ff)
- ...
- Display parameters, e.g.:
- Calculated rated data (p0330 ff)
- ...

The parameters that are grouped together in the motor data set are identified in the SINAMICS parameter list by "Data set MDS" and are assigned an index [0..n].
A separate motor data set is required for each motor that is controlled by the Control Unit via a Motor Module. The motor data set is assigned to a drive data set via parameter p0186.
A motor data set can only be changed using a DDS changeover.
The motor data set changeover is used, for example, for:

- Changing over between different motors
- Changing over between different windings in a motor (e.g. star-delta changeover)
- Motor data adaptation

If several motors are operated alternately on one Motor Module, a corresponding number of drive data sets must be created. See "Functions / Drive functions" for additional information and instructions on changing over motors.

One drive object can manage up to 16 motor data sets. The number of motor data sets in p0130 may not exceed the number of drive data sets in p0180.

## Example of data set assignment

Table 6-2 Example, data set assignment

| DDS | Motor (p0186) | Encoder 1 (p0187) | Encoder 2 (p0188) | Encoder 3 (p0189) |
| :--- | :--- | :--- | :--- | :--- |
| DDS 0 | MDS 0 | EDS 0 | EDS 1 | EDS 2 |
| DDS 1 | MDS 0 | EDS 0 | EDS 3 | -- |
| DDS 2 | MDS 0 | EDS 0 | EDS 4 | EDS 5 |
| DDS 3 | MDS 1 | EDS 0 | -- | -- |

## Copying the command data set (CDS)

Set parameter p0809 as follows:

1. p0809[0] $=$ Number of the command data set to be copied (source)
2. p0809[1] = Number of the command data to which the data is to be copied (target)
3. $p 0809[2]=1$

Start copying.
Copying is finished when p0809[2] $=0$.

## Copying the drive data set (DDS)

Set parameter p0819 as follows:

1. p0819[0] $=$ Number of the drive data set to be copied (source)
2. $\mathrm{p} 0819[1]=$ Number of the drive data set to which the data is to be copied (target)
3. $\mathrm{p} 0819[2]=1$

Start copying.
Copying is finished when p0819[2] $=0$.

## Copy motor data set (MDS)

Set parameter p0139 as follows:

1. $\mathrm{p} 0139[0]=$ Number of the motor data set that is to be copied (source)
2. p0139[1] = Number of the motor data set which should be copied into (target)
3. $p 0139[2]=1$

Start copying.
Copying has been completed, if p0139[2] $=0$.

## Function diagrams

| FP 8560 | Command data sets (CDS) |
| :--- | :--- |
| FP 8565 | Drive data set (DDS) |
| FP 8570 | Encoder data set (EDS) |
| FP 8575 | Motor data sets (MDS) |

## Parameters

- p0120 Power module data sets (PDS) number
- p0130 Motor data sets (MDS) number
- p0139[0...2] Copy motor data set (MDS)
- p0140 Encoder data sets (EDS) number
- p0170 Command data set (CDS) number
- p0180 Drive data set (DDS) number
- p0186 [0...n] Assigned motor data set (MDS)
- p0187[0...n] Encoder 1 encoder data set number
- p0188[0...n] Encoder 2 encoder data set number
- p0189[0...n] Encoder 3 encoder data set number
- p0809[0...2] Copy command data set CDS
- p0810

BI: Command data set selection CDS bit 0

- p0811 BI: Command data set selection CDS bit 1
- p0819[0...2] Copy drive data set DDS
- p0820[0...n] BI: Drive data set selection, bit 0
- p0821[0...n] BI: Drive data set selection, bit 1
- p0822[0...n] BI: Drive data set selection, bit 2
- p0823[0...n] BI: Drive data set selection, bit 3
- p0824[0...n] BI: Drive data set selection, bit 4


### 6.3.4 BICO technology: Interconnecting signals

## Description

Each drive unit contains a large number of interconnectable input and output variables and internal control variables.

The drive unit can be adapted to a wide range of requirements using BICO technology (Binector Connector Technology).

Digital signals, which can be connected freely by means of BICO parameters, are identified by the prefix $\mathrm{BI}, \mathrm{BO}, \mathrm{CI}$ or CO in their parameter name. These parameters are identified accordingly in the parameter list or in the function diagrams.

## Note

## Using STARTER

The STARTER configuration and commissioning tool is recommended when using BICO technology.

## Binectors, BI: Binector Input, BO: Binector output

A binector is a unitless digital (binary) signal that can assume a value of 0 or 1 .
Binectors are subdivided into binector inputs (signal sink) and binector outputs (signal source).

Table 6-3 Binectors

| Abbreviation and <br> symbol | Name | Description |
| :---: | :--- | :--- |
| BI | Binector input <br> Binector input <br> (signal sink) | Can be interconnected with a binector output as <br> source. <br> The number of the binector output must be <br> entered as a parameter value. |
| BO $\square$ | Binector output <br> Binector output <br> (signal source) | Can be used as a source for a binector input. |

## Connectors, CI: Connector Input, CO: Connector output

A connector is a digital signal, for example, in 32-bit format. It can be used to emulate words ( 16 bits), double words ( 32 bits), or analog signals. Connectors are subdivided into connector inputs (signal sink) and connector outputs (signal source).

The options for interconnecting connectors are restricted to ensure that performance is not adversely affected.

Table 6-4 Connectors

| Abbreviation and <br> symbol | Name | Description |
| :---: | :--- | :--- |
| $\mathrm{Cl} \sum$ | Connector input <br> Connector input <br> (signal sink) | Can be interconnected with a connector output as <br> source. <br> The number of the connector output must be <br> entered as a parameter value. |
| $\mathrm{CO} \square$ | Connector output <br> Connector output <br> (signal source) | Can be used as a source for a connector input. |

## Interconnecting signals using BICO technology

To interconnect two signals, a BICO input parameter (signal sink) must be assigned to the desired BICO output parameter (signal source).
The following information is required to connect a binector/connector input to a binector/connector output:

- Binectors: Parameter number, bit number, and drive object ID
- Connectors without an index: Parameter number and drive object ID
- Connectors with an index: Parameter number, index, and drive object ID
- Data type (signal source for connector output parameter)


Figure 6-5 Interconnecting signals using BICO technology

## Note

A Connector Input (CI) cannot be interconnected with just any Connector Output (CO, signal source). The same applies for a Binector Input (BI) and Binector Output (BO).
"Data type" in the parameter list provides information about the data type of the parameter and the data type of the BICO parameter for each Cl and BI parameter.
For CO and BO parameters, only the data type of the BICO parameter is given.

## Notation:

- BICO input data type: Parameter data type / BICO parameter data type Example: Unsigned32/Integer16
- BICO output data type: BICO parameter data type

Example: FloatingPoint32
The possible interconnections between a BICO input (signal sink) and a BICO output (signal source) are described in the "Possible combinations for BICO interconnections" table found in the List Manual section "Explanations of the parameter list".

The BICO parameter interconnection can be implemented in different data sets (CDS, DDS, MDS, etc.). The different interconnections in the data sets are activated by switching the data sets. Interconnections across drive objects are also possible.

## Internal coding of the binector/connector output parameters

Internal codes are needed, for example, to write BICO input parameters via PROFIdrive.


00010000 hex --> fixed "1"

00000000 hex --> fixed "0"
Figure 6-6 Internal coding of the binector/connector output parameters

## Example 1: Interconnecting digital signals

In this example, we want to operate a drive via terminals DI 0 and DI 1 on the Control Unit using jog 1 and jog 2.


Figure 6-7 Interconnecting digital signals (example)

## Example 2: Interconnecting OC/OFF3 with several drives

In this example, we want to interconnect the OFF3 signal with two drives via terminal DI 2 on the Control Unit.

Each drive has a binector input 1. OFF3 and 2. OFF3. Both signals are processed via an AND gate to STW1.2 (OFF3).


Figure 6-8 Interconnecting OFF3 with several drives (example)

## Analysis of BICO interconnections

The following parameters exist for the analysis of existing BICO interconnections:

- r9481 Number of BICO interconnections
- r9482[0...n] BICO interconnections $\mathrm{BI} / \mathrm{Cl}$ parameters
- r9483[0...n] BICO interconnections BO/CO parameters
- p9494 BICO interconnections, search signal source
- p9495 BICO interconnections, search signal source number
- p9496 BICO interconnections, search signal source first index


## BICO interconnections with other drives

The following parameters are available for BICO interconnections with other drives:

- r9490 Number of BICO interconnections with other drives
- r9491[0...9] BI/CI of BICO interconnections with other drives
- r9492[0...9] BO/CO of BICO interconnections with other drives
- p9493[0...9] Reset of BICO interconnections with other drives


## Binector-connector converters and connector-binector converters

## Binector-connector converter

- Several digital signals are converted to a 32-bit integer double word or to a 16 -bit integer word.
- p2080[0...15] BI: PROFIdrive PZD send bit-serial


## Connector-binector converter

- A 32-bit integer double word or a 16-bit integer word is converted to individual digital signals.
- p2099[0...1] CI PROFIdrive PZD selection receive bit-serial


## Fixed values for interconnection using BICO technology

The following connector outputs are available for interconnecting any fixed value settings:

- p2900[0...n] CO: Fixed value_\%_1
- p2901[0...n] CO: Fixed value_\%_2
- p2930[0...n] CO: Fixed Value_M_1

Example:
These parameters can be used to interconnect the scaling factor for the main setpoint or to interconnect an additional torque.

### 6.3.5 Propagation of faults

## Forwarding faults to the Control Unit

In the case of faults that are, for example, triggered by the Control Unit or a Terminal Module, central functions of the drive are also often affected. As a result of propagation, faults that are triggered by one drive object are therefore forwarded to other drive objects. This response also applies to the faults that are set in a DCC chart on the Control Unit with the aid of the DCC block.

## Propagation types

There are the following types of propagation:

- BICO

The fault is propagated to all active drive objects with closed-loop control functions (infeed, drive) to which there is a BICO interconnection.

- DRIVE

The fault is propagated to all active drive objects with closed-loop control functions.

- GLOBAL

The fault is propagated to all active drive objects.

- LOCAL

The behavior of this propagation type is dependent on parameter p3116.

- With binector input p3116 $=0$ (factory setting) the following applies: The fault is propagated to the first active drive object with closed-loop control functions.
- With binector input p3116 = 1 signal, the following applies: The fault is not forwarded.


### 6.4 Command sources

### 6.4.1 "PROFIdrive" default setting

## Requirements

The "PROFIdrive" default setting was chosen during commissioning:

- STARTER (p0700): "PROFIdrive"
- AOP30 (p0700): "5: PROFIdrive"


## Command sources



Figure 6-9 Command sources - AOP30 <--> PROFIdrive

## Priority

The command source priorities are shown in the diagram "Command sources - AOP30 <-> PROFIdrive".

## Note <br> Emergency OFF signals

The emergency OFF and motor protection signals are always active (regardless of the command source).

All supplementary setpoints are deactivated for LOCAL master control.

## Terminal assignment with the "PROFIdrive" default setting

The "PROFIdrive" default setting uses the following terminal assignment:


Figure 6-10 Terminal assignment with the "PROFIdrive" default setting

## Control word 1

The bit assignment for control word 1 is described in "Description of the control words and setpoints".

## Status word 1

The bit assignment for status word 1 is described in "Description of the status words and actual values".

## Switching the command source

The command source can be switched using the LOCAL/REMOTE key on the AOP30.

### 6.4.2 "TM31 terminals" default setting

## Requirements

The "TM31 terminals" default setting was chosen during commissioning:

- STARTER (p0700): "TM31 terminals"
- AOP30 (p0700): "6: TM31 terminals


## Command sources



Figure 6-11 Command sources - AOP30 <-> TM31 terminals

## Priority

The priority of the command sources is shown in the diagram "Command sources - AOP30 <-> TM31 terminals".

## Note

## Emergency OFF signals

The emergency OFF and motor protection signals are always active (regardless of the command source).

All supplementary setpoints are deactivated for LOCAL master control.

## Terminal assignment with "TM31 terminals" default setting

The "TM31 terminals" default setting uses the following terminal assignment:


Figure 6-12 Terminal assignment with "TM31 terminals" default setting

## Switching the command source

The command source can be switched using the LOCAL/REMOTE key on the AOP30.

### 6.5 Setpoint sources

### 6.5.1 Analog inputs

## Description

The customer terminal module features two analog inputs for specifying setpoints via current or voltage signals.

With the factory setting, analog input 0 (terminal $\mathrm{X} 521: 1 / 2$ ) is used as a current input in the 0 to 20 mA range.

## Requirement

The default setting for analog inputs was chosen during commissioning:

- STARTER (p1000): "TM31 terminals"
- AOP30 (p1000): "2: TM31 terminals


## Signal flow diagram



Figure 6-13 Signal flow diagram: analog input 0

## Function diagrams

| FP 9566 | TM31 - analog input 0 (AI 0) |
| :--- | :--- |
| FP 9568 | TM31 - analog input 1 (AI 1) |

## Parameters

- r4052 Current input voltage/current
- p4053 Analog inputs, smoothing time constant
- r4055 Current referenced input value
- p4056 Analog input type
- p4057 Value $\times 1$ of analog input characteristic
- p4058 Value y1 of analog input characteristic
- p4059 Value x2 of analog input characteristic
- p4060 Value y2 of analog input characteristic
- p4063 Analog input offset


## Note

## Factory state

In the factory state and after basic commissioning, an input current of 20 mA is equal to the main setpoint 100 \% reference speed ( p 2000 ), which has been set to the maximum speed (p1082).

## Example for changing the analog input 0 from current input to voltage input -10 to +10 V



## Note

## Saving changes to protect against power failure

The new analog input must then be stored on the CompactFlash card so that it is protected in the event of a power failure.

## F3505 - Fault: "Analog input wire break"

This fault occurs when analog input type (p4056) is set to 3 ( 4 ... 20 mA with wire break monitoring), and the input current of 2 mA has been undershot.

The fault value can be used to determine the analog input in question.


Component number
3: Module -A60 / -X65
4: Module -A61 (optional)
0: Analog input 0: -X521:1/2
1: Analog input 1: -X521:3/4

### 6.5.2 Motorized potentiometer

## Description

The digital motorized potentiometer enables you to set speeds remotely using switching signals (+/- keys). It is activated via terminals or fieldbus. As long as a logical 1 is present at signal input "MOP up" (setpoint higher), the internal numerator integrates the setpoint. You can set the integration time (time taken for the setpoint to increase) using parameter p1047. In the same way, you can decrease the setpoint using signal input "MOP down". The deceleration ramp can be set using parameter p1048.
Configuration parameter p1030.0 $=1$ (default setting $=0$ ) is used to enable non-volatile storage of the current motorized potentiometer value when powering down the drive unit. When the drive unit is powered up, the start value of the motorized potentiometer is set to the last current value when the drive unit was powered down.

## Requirement

The default setting for the motorized potentiometer was chosen during commissioning:

- STARTER (p1000): "Motorized potentiometer"
- AOP30 (p1000): "3: Motorized potentiometer"


## Signal flow diagram



Figure 6-14 Signal flow diagram: Motorized potentiometer

## Function diagram

FP 3020 Motorized potentiometer

## Parameters

- p1030 Motorized potentiometer, configuration
- p1037 Motorized potentiometer, maximum speed
- p1038 Motorized potentiometer, minimum speed
- p1047 Motorized potentiometer, ramp-up time
- p1048 Motorized potentiometer, ramp-down time
- r1050 Motorized potentiometer, setpoint after the ramp-function generator


### 6.5.3 Fixed speed setpoints

## Description

A total of 15 variable fixed speed setpoints are available.
The default setting specified for the setpoint sources during commissioning via STARTER or the operating panel makes 3 fixed speed setpoints available. They can be selected via terminals or fieldbus.

## Requirement

The default setting for the fixed speed setpoints was chosen during commissioning:

- STARTER (p1000): "Fixed setpoint"
- AOP30 (p1000): "4: Fixed setpoint"


## Signal flow diagram



Figure 6-15 Signal flow diagram: Fixed speed setpoints

## Function diagram

FP 3010 Fixed speed setpoints

## Parameters

- p1001 Fixed speed setpoint 01
- p1002 Fixed speed setpoint 02
- p1003 Fixed speed setpoint 03
- r1024 Fixed speed setpoint effective


## Note

Other fixed speed setpoints are available using p1004 to p1015. These can be selected using p1020 to p1023.

### 6.6 Control via the operator panel

### 6.6.1 Operator panel (AOP30) overview and menu structure

## Description

The operator panel can be used for the following activities:

- Parameterization (commissioning)
- Monitoring status variables
- Controlling the drive
- Diagnosing faults and alarms

All functions can be accessed via a menu.
Your starting point is the main menu, which you can always access using the yellow MENU key:


Dialog screen for the main menu:
It can be accessed at any time with the "MENU" key.
Press "F2" or "F3" to navigate through the menu options in the main menu.

## Note

## AOP reset

To stop the AOP from responding, press the key pushbutton and the OFF key at the same time (and hold for longer than two seconds); the AOP reset will initiate as soon as you release the OFF key.

## Menu structure of the operator panel



Figure 6-16 Menu structure of the operator panel

### 6.6.2 Operation screen menu

## Description

The operation screen displays the most important status variables for the drive unit:
In the factory state, it displays the operating state of the drive, the direction of rotation, the time, as well as four drive variables (parameters) numerically and two in the form of a bar display for continuous monitoring.

There are two ways to reach the operation screen:

1. After the power supply has been switched on and the system has powered up.
2. By pressing the MENU key and F5 "OK"


Figure 6-17 Operation screen
If a fault occurs, the system automatically displays the fault screen (see "Faults and alarms").
In LOCAL control mode, you can choose to enter the setpoint numerically (F2: setpoint).
With F3 "Extras", Screen2 and CDS data set (see section CDS setting via AOP (Page 290)) can be selected.

The individual parameters of the operation screen can be selected using F4 "Sel. par". The corresponding parameter number of the short identifier is displayed using F1 "Help+" and a description of the parameter can be called up.

## Settings

When you choose Commissioning / Service -> AOP settings -> Define operation screen, you can adjust the display type and the values displayed as required (see "AOP settings").

### 6.6.3 Parameterization menu

You can adjust the device settings in the Parameterization menu.
The drive software is modular. The individual modules are called DOs ("drive objects").
The following DOs are available in SINAMICS G150:

- CU: General parameters for the Control Unit
- VECTOR: Drive control
- TM31: Terminal Module TM31
- TM150: Temperature Sensor Module TM150 (option G51)

Parameters with identical functions may exist with the same parameter number in more than one DO (e.g. p0002).
The AOP30 handles devices comprising more than one drive in such a way that attention is focused on one drive (i.e., the "current" drive). The switchover is made in the main menu. The corresponding function key is labeled "Drive".

This drive determines the following:

- Operation screen
- Fault and alarm displays
- Control (ON, OFF, ...) of a drive

You can choose between two AOP display types to suit your requirements:

1. All parameters

All the parameters present in the device are listed here. The DO to which the currently selected parameter belongs is displayed in curly brackets in the top left of the screen.
2. DO selection

In this display, you can pre-select a DO. Only the parameters for this DO are then listed. (The expert list display in STARTER only uses this DO view)
In both cases, the set access level governs which parameters are displayed. You can set the access level in the "Safety inhibits" menu, which is called up using the key button.

The parameters for access levels 1 and 2 are sufficient for simple applications.
At access level 3 ("Expert"), you can change the structure of the function by interconnecting BICO parameters.

In the Data set selection menu, you can choose which of the data sets chosen is currently DISPLAYED on the operator panel.
Data set parameters are indicated by a "c", "d", "m", "e", or "p" between the parameter number and parameter designator.

When a data set parameter is changed, the data set selection dialog appears.


Figure 6-18 Data set selection
Explanation of the operation screen:

- "Max" shows the maximum number of data sets configured (and thereby available for selection) in the drive.
- "Drive" indicates which data set is currently active in the drive.
- "AOP" indicates which particular data set is currently being displayed on the operator panel.


### 6.6.4 Fault/alarm memory menu

When you select this menu, a screen appears containing an overview of faults and alarms that are present.

For each drive object, the system indicates whether any faults or alarms are present. ("Fault" or "Alarm" appears next to the relevant drive object).

In the screenshot below, you can see that at least one active fault/alarm is present for the "VECTOR" drive object. No faults/alarms are indicated for the other drive objects.


## Fault memory/Alarm memory

When you navigate to the line with active alarms/faults and then press the F5 <Diag> key, the system displays a screen in which you have to select the current or old alarms/faults.

## Diagnostics display

When you navigate to the required line and then press the F5 <OK> key, the corresponding faults/alarms are displayed. The list of current faults is selected here as an example.

## Current faults display

A maximum of eight current faults are displayed along with their fault number and a description of the fault.
To display additional help regarding the cause of the problem and how to solve it, choose F1 <Help>.
To acknowledge the faults, choose F5 <Ack.>. If a fault cannot be acknowledged, the fault remains.

### 6.6.5 Commissioning/service menu

### 6.6.5.1 Drive commissioning

This option enables you to recommission the drive from the main menu.

## Basic commissioning

Only the basic commissioning parameters are scanned and stored permanently.

## Complete commissioning

Complete commissioning with motor and encoder data entry is carried out. Following this, key motor parameters are recalculated from the motor data. The parameter values calculated during previous commissioning are lost.

In a subsequent motor identification procedure, the calculated values are overwritten.

## Motor identification

The selection screen for motor identification appears.

## Reset fan operating time

The current operating hours of the fan in the power unit is displayed.
After a fan replacement, the operating hours counter for monitoring the fan running time must be reset.

### 6.6.5.2 Device commissioning

## Device commissioning

In this menu, you can enter the device commissioning status directly. This is the only way to reset parameters to the factory setting, for example.

### 6.6.5.3 Drive diagnostics

## Curve recorder

The curve recorder provides a slow trace function, which monitors a signal trend
A signal selected via a parameter is shown in the form of a curve.


Figure 6-19 Curve recorder

You change settings relevant for the the curve recorder with the F5 key or the menu Commissioning / Service - AOP Settings - Curve recorder settings.

In addition to the curve, the value of the parameter selected in the curve recorder settings is output on the display and updated every 0.5 to 24.5 s (adjustable). With a slowly running time basis (as of 20 minutes/figure), the time basis value flashes in the header in the 1 s-cycle alternately with the text "slow X".

The assignment of the function keys F1 to F5 is normally not visible on the display to maximized the space available to display the curve. Press a function key to show the function of the keys. The labels disappear again if no other key is pressed within 5 seconds.

The curve can be scaled automatically or manually. This is selected with key F3 "scale+" F2 "Auto/Manual" followed by confirmation with F5 "OK."

## - Auto

The scaling of the curve varies dynamically and is based on the maximum value (e.g., 12.49 ) and minimum value (e.g., 0.00) visible on the display up until this moment. Scaling can be changed step-by-step using the F2 and F3 keys. If measured value noise is shown with an excessively high resolution as a result of the automatic scaling, then the resolution can be reduced in four steps by pressing the F2 key. This deactivates the automatic scaling. However, if the measured value leaves the display area, this is expanded. The F3 key can be used to change back to automatic scaling

## - Manually

After selection of manual scaling and confirmation with "OK", a window opens where the maximum and minimum limits for the scaling can be set.


Figure 6-20 Curve recorder - manual scaling
After setting and applying the limits, the curve recorder is displayed and the manual scaling is used.

If the current measured values are outside the display area, the area is expanded automatically.

## Note

## Change of parameter for the curve recorder with manual scaling

The following procedure is used for manual scaling when the parameter for the curve recorder is changed:

- If the current parameter has lower values than the currently set scaling, the scaling is retained.
- If the current parameter has higher values than the currently set scaling, the scaling is adapted automatically.

The curve recorder help is opened using the F1 key.
The curve recorder is exited by pressing the MENU button.

## Note

No recording of data
The values displayed in the curve recorder are not logged and saved, but serve only for display purposes until you exit the screen.

### 6.6.5.4 AOP settings

## Control settings

This defines the settings for the control keys in LOCAL mode (see "Operation / Control via the operator panel / Operation via the operator panel").

## Display settings

In this menu, you set the lighting, brightness, and contrast for the display

## Define operation screen

In this menu, you can switch between five operation screens. You can set the parameters to be displayed.


Figure 6-21 Define operation screen
The following screenshot shows how entries are assigned to the screen positions:

| 10 values: |  |  |
| :--- | :--- | :--- |
| OPERATION | Entry 02 |  |
| Entry 01 | Entry 04 |  |
| Entry 03 | Entry 06 |  |
| Entry 05 | Entry 08 |  |
| Entry 07 | Entry 10 |  |
| Entry 09 |  |  |

4 values / 2 bars:

8 values / 1 bar:

| OPERATION | Entry 02 | $12: 25: 30 \mathrm{~S}$ |
| :--- | :--- | :--- |
| Entry 01 | Entry 04 |  |
| Entry 03 | Entry 06 |  |
| Entry 05 |  | Entry 08 |
| Entry 07 |  | $50 \%$ |
| Entry 09 | $0 \%$ | $100 \%$ |

3 bars:

2 values:


Figure 6-22 Layout of entries on the operation screen

## Lists of signals for the operation screen

The following tables list some of the main signals for the operation screen along with the associated reference variables and default settings for fast commissioning.

## VECTOR object

Table 6-5 List of signals for the operation screen - VECTOR object

| Signal |  | Parameter | Short name | Unit | Scaling (100 \% =...) See table below |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Factory setting (entry no.) |  |  |  |  |  |
| Speed setpoint upstream of ramp-function generator | (1) | r1114 | NSET | rpm | p2000 |
| Output frequency | (2) | r0024 | F_OUT | Hz | Reference frequency |
| Power, smoothed | (3) | r0032 | PACTV | kW | r2004 |
| DC link voltage, smoothed | (4) | r0026 | V_DC | V | p2001 |
| Actual speed value, smoothed | (5) | r0021 | N_ACT | rpm | p2000 |
| Absolute actual value of current, smoothed | (6) | r0027 | I_ACT | A | p2002 |
| Motor temperature | (7) | r0035 ${ }^{\text {1) }}$ | T_MOT | ${ }^{\circ} \mathrm{C}$ | p2006 |
| Drive temperature | (8) | r0037 | T_LT | ${ }^{\circ} \mathrm{C}$ | p2006 |
| Actual torque, smoothed | (9) | r0031 | M_ACT | Nm | p2003 |
| Drive output voltage, smoothed | (10) | r0025 | V_OUT | V | p2001 |
| For diagnostic purposes |  |  |  |  |  |
| Speed setpoint, smoothed |  | r0020 | NSET | rpm | p2000 |
| Modulation depth, smoothed |  | r0028 | MODD | \% | Reference modulation depth |
| Field-generating current component |  | r0029 | IDACT | A | p2002 |
| Torque-generating current component |  | r0030 | IQACT | A | p2002 |
| Drive overload Degree of thermal overload |  | r0036 | LTI2T | \% | 100 \% = Shutdown |
| Speed actual value, motor encoder |  | r0061 | N_ACT | rpm | p2000 |
| Speed setpoint after filter |  | r0062 | NSET | rpm | p2000 |
| Actual speed value after smoothing |  | r0063 | N_ACT | rpm | p2000 |
| Speed controller system deviation |  | r0064 | NDIFF | rpm | p2000 |
| Slip frequency |  | r0065 | FSLIP | Hz | Reference frequency |
| Output frequency |  | r0066 | F_OUT | Hz | Reference frequency |
| Output voltage |  | r0072 | VACT | V | p2001 |
| Modulation depth |  | r0074 | MODD | \% | Reference modulation depth |
| Torque-generating actual current |  | r0078 | IQACT | A | p2002 |
| Actual torque value |  | r0080 | M_ACT | Nm | p2003 |
| For further diagnostics |  |  |  |  |  |
| Fixed speed setpoint effective |  | r1024 |  | rpm | p2000 |
| Active motorized potentiometer setpoint |  | r1050 |  | rpm | p2000 |
| Resulting speed setpoint |  | r1119 | NSET | rpm | p2000 |
| Speed controller output |  | r1508 | NREGY | Nm | p2003 |
| I component of speed controller |  | r1482 | NREGI | Nm | p2003 |
| PROFIBUS setpoint |  | r2050 | PBSET | rpm | p2000 |

[^1]
## VECTOR object scalings

Table 6-6 VECTOR object scalings

| Size | Scaling parameter | Default for quick commissioning |
| :--- | :--- | :--- |
| Reference speed | $100 \%=\mathrm{p} 2000$ | p2000 $=$ Maximum speed $(\mathrm{p} 1082)$ |
| Reference voltage | $100 \%=\mathrm{p} 2001$ | $\mathrm{p} 2001=1000 \mathrm{~V}$ |
| Reference current | $100 \%=\mathrm{p} 2002$ | $\mathrm{p} 2002=$ Current limit $(\mathrm{p} 0640)$ |
| Reference torque | $100 \%=\mathrm{p} 2003$ | $\mathrm{p} 2003=2 \times$ rated motor torque |
| Reference power | $100 \%=\mathrm{r} 2004$ | $\mathrm{r} 2004=(\mathrm{p} 2003 \times \mathrm{p} 2000 \times \pi) / 30$ |
| Reference frequency | $100 \%=\mathrm{p} 2000 / 60$ |  |
| Reference modulation depth | $100 \%=$ Maximum output voltage without overload |  |
| Reference flux | $100 \%=$ Rated motor flux |  |
| Reference temperature | $100 \%=\mathrm{p} 2006$ | $\mathrm{p} 2006=100{ }^{\circ} \mathrm{C}$ |

## TM31 object

Table 6-7 List of signals for the operation screen - TM31 object

| Signal | Parameter | Short name | Unit | Scaling <br> $(100 \%=\ldots)$ |
| :--- | :---: | :---: | :---: | :---: |
| Analog input 0 [V, mA] | $\mathrm{r} 4052[0]$ | AI_IV | $\mathrm{V}, \mathrm{mA}$ | $\mathrm{V}: 100 \mathrm{~V} / \mathrm{mA}: 100 \mathrm{~mA}$ |
| Analog input 1 [V, mA] | $\mathrm{r} 4052[1]$ | AI_IV | $\mathrm{V}, \mathrm{mA}$ | $\mathrm{V}: 100 \mathrm{~V} / \mathrm{mA}: 100 \mathrm{~mA}$ |
| Analog input 0, scaled | $\mathrm{r} 4055[0]$ | $\mathrm{Al}_{-} \%$ | $\%$ | as set in p200x |
| Analog input 1, scaled | $\mathrm{r} 4055[1]$ | $\mathrm{Al}_{-} \%$ | $\%$ | as set in p 200 x |

## Curve recorder settings

In this menu, you can make the following settings:

## Parameter selection

Here you select the parameter whose signal is to be displayed in the form of a trend curve in the curve recorder.

Interpolation (Factory setting: No), used for improved display of values which change suddenly.

- No: Only the measured values are displayed as points, without a connecting line between the points.
- 1: The measured values are connected with a vertical line.
- 2: The measured values are connected with a line, offset at the center.


## Time basis(Factory setting: $2 \mathrm{~min} /$ picture)

The rate of signal recording is set in minutes per picture. The value can be changed in integer multiples of 2 . The value is rounded of when you enter odd numbers. After changing the time basis, the recording is started again.
Background recording(Factory setting: NO)

- YES: Values are still recorded, even if the display screen is exited. When the screen is opened again, the recorded prehistory is displayed.
- NO: The recording is stopped when the curve recorder is exited.

Y scale mode (Factory setting: Auto), defines the display of the curve

- Auto: Scaling is done automatically (making the best possible use of the display height).
- Manual: Scaling is done manually by entering the range limits MIN/MAX. If, in this mode, values that are outside the defined window occur, the limit is automatically adapted for the display so that actual measured values can always be recorded.


## Set date/time (for date stamping of fault codes)

In this menu, you set the date and time.
You can also set whether and/or how the AOP and drive unit are to be synchronized.
Synchronization of the AOP with the drive enables fault codes to be date- and time-stamped.

## Note

Display format for the time
The drive unit displays the time in parameter r3102 in UTC format (days/milliseconds since 01.01.1970).

The setting for the synchronization can be made using "Additional settings":

## Synchronization(Factory setting: None)

- None

The times for the AOP and drive unit are not synchronized.

- AOP -> Drive
- If you activate this option, the AOP and drive unit are synchronized immediately, and the current AOP time is transferred to the drive unit.
- The current AOP time is transferred to the drive unit every time the AOP is started.
- The current AOP time is transferred to the drive unit according to the set synchronization interval.


## Note

Flashing "S"
If the AOP detects a difference between RAM and ROM during synchronization to the drive unit, this is indicated by a flashing " S " at the top right in the display or, if operator input and/or parameter assignment has been disabled, by a flashing key symbol.

- Drive -> AOP
- If you activate this option, the AOP and drive unit are synchronized immediately, and the current drive unit time is transferred to the AOP.
- The current drive unit time is transferred to the AOP every time the AOP is started.
- The current drive unit time is transferred to the AOP according to the set synchronization interval.


## Note

## Time-of-day master

The time in the drive must be set by a time-of-day master (e.g. SIMATIC).

## Synchronization interval

The interval for the time synchronization is set from 1 hour (factory setting) to 99 hours.
The time in the AOP from the time of the last change of the interval is decisive for the interval.

Daylight saving time(Factory setting: no)

- No

The time does not automatically change to daylight saving time.

- Yes

Selection is only possible if synchronization is set to "None" or "AOP -> Drive".
The time is then automatically set to summer or winter time.
After the changeover - for synchronization "AOP -> Drive" - synchronization is immediately carried out, irrespective of the synchronization interval set.

Changes to the synchronization must be saved with "Save".

## Date format

In this menu, the date format can be set:

- DD.MM.YYYY: European date format
- MM/DD/YYYY: North American date format


## DO name display mode

In this menu, you can toggle the display of the DO-name between the standard abbreviation (e.g., VECTOR) and a DO-name of your choice (e.g. motor_1).

User-defined DO name (factory setting: NO)

- Yes: The "User-defined DO-name" stored in parameter p0199 is displayed instead of the standard DO abbreviation.
- No: The standard DO abbreviation is displayed.


## Normalization to motor current

This menu allows a changeover of the reference value for the bar display of parameter r0027 (smoothed absolute value of actual current value) in the operation screens.
Normalization to motor current(factory setting: NO)

- Yes: The bar display of parameter r0027 in the operating screen form is displayed with reference to parameter p0305 (rated motor current).
- No: The bar display of parameter r0027 in the operating screen form is displayed with reference to parameter p2002 (reference current).


## Reset AOP settings

When you choose this menu option, the AOP factory settings for the following are restored:

- Language
- Display (brightness, contrast)
- Operation screen
- Control settings


## Note

## Restoring the factory setting

When you reset parameters, all settings that are different to the factory settings are reset immediately. This may cause the cabinet unit to switch to an unwanted operating state.
For this reason, you should always take great care when resetting parameters.

## Battery symbol

In this menu, the battery symbol can be activated so that it is displayed in the operating screen form. When the display is activated, then the battery symbol is shown instead of the time of day seconds display. It displays the battery voltage in $20 \%$ steps. If the display was received in the last $20 \%$, then the battery symbol flashes in order to indicate that the battery must be replaced.

Battery symbol (factory setting: NO)

- Yes: The battery symbol is shown at the top right of the operating screen form - at the time of day seconds display.
- No: The battery symbol is not displayed in the operating screen form.


### 6.6.5.5 AOP diagnostics

## Software/database version

This menu shows the versions of the firmware and database.
The database version must be compatible with the drive software status (refer to parameter r0018).

## Database contents

For service purposes, the contents of the database are displayed in the screen form.

## Battery status

This menu displays the battery voltage (in volts and as a bar chart). The battery ensures that the data in the database and the current time are retained.

When the battery voltage is represented as a percentage, a battery voltage of $\leq 2.30 \mathrm{~V}$ is equal to $0 \%$, and a voltage of $\geq 3 \mathrm{~V}$ to $100 \%$.

The data is secure up to a battery voltage of 2.30 V .

- If the battery voltage is $\leq 2.45 \mathrm{~V}$, the message "Battery weak - replace soon" is displayed in the status bar.
- If the battery voltage is $\leq 2.30 \mathrm{~V}$, the system displays the following message: "Battery defect - replace immed."
- If the time and/or database are unavailable due to lack of voltage after a prolonged system downtime, the loss is determined using a CRC check when the system is switched on again. This triggers a message instructing the user to replace the battery and then load the database and/or set the time.

For instructions on how to change the battery, see "Maintenance and servicing".

## Keyboard test

In this screen, you can check that the keys are functioning properly. Keys that you press are represented on a symbolic keyboard on the display. You can press keys in any order you wish. You cannot exit the screen (F4 - "Back") until you have pressed each key at least once.

## Note

## Exit keyboard test

Alternatively, you can exit the keyboard test screen by pressing any key and holding it down.

## Screenshots

A screenshot is created by simultaneously pressing keys "1" and "+/-" - and then the display flashes 2 times, one after the other. A maximum of 8 screenshots can be managed.

The list of the saved screenshots is displayed in the "Screenshots" menu item.
The screenshot is selected from the list and is displayed by pressing F5.
While the screenshot is being displayed, the identifier and the time stamp are displayed flashing in the title line every 5 seconds.

By pressing any function key F1 ... F5, the function key assignment is displayed for 5 seconds.

- The display is exited by pressing F4 and the list of screenshots is redisplayed.
- By pressing the F5 key once and then pressing F5 "Clear" again to confirm, the displayed screenshot will be deleted and the list of screenshots will be displayed again.

To clear all of the screenshots, in the list of screenshots, press F5 for longer than 1 second and confirm the following prompt with "Yes".

If there are gaps in the list of screenshots, then they are populated with new screenshots from the top to the bottom. When the list is full, then the oldest chronological entry in the list is overwritten.

## Note

## Battery buffering

The screenshots are saved to the memory, buffered by a battery - and are also available after the power supply has been switched-off and switched-on again.

When the AOP30 is switched off and the battery is too weak - or when changing the batteries - a buffer time of approximately 30 minutes applies.

## LED test

In this screen, you can check that the four LEDs are functioning properly.

## Database statistics

The statistics of the database are indicated in the mask for service purposes.

### 6.6.6 Language selection

The operator panel downloads the texts for the different languages from the drive.
You can change the language of the operator panel via the "Sprachauswahl/Language selection" menu.

## Note

Additional languages for the display
Languages in addition to those currently available for the display are available on request.

### 6.6.7 Operation via the operator panel (LOCAL mode)

You activate the control keys by switching to LOCAL mode. If the green LED in the LOCAL/REMOTE key does not light up, the key is not active.

## Note

OFF in REMOTE
If the "OFF in REMOTE" function is activated, the LED in the LOCAL-REMOTE key flashes.

All supplementary setpoints are deactivated for LOCAL master control.
After the master control has been transferred to the operator panel, the BICO interconnections at bit 0 to bit 10 of the control word of the sequence control are not effective (refer to function diagram 2501).

## Note

Message "Other device has master control"
If STARTER is exercising master control, the message "Other device has master control" appears when the LOCAL-REMOTE key is pressed and the assumption of master control is denied.

### 6.6.7.1 LOCAL/REMOTE key

Activation of LOCAL mode: Press the LOCAL key.
LOCAL mode: LED lights up
REMOTE mode: LED does not light up: The ON, OFF, JOG, direction reversal, faster, and slower keys are not active.

Settings: Menu - Commissioning / Service - AOP Settings - Control Settings
Save LOCAL mode (factory setting: yes)

- Yes: The "LOCAL" or "REMOTE" operating state is saved when the power supply is switched off and restored when the power supply is switched back on.
- No: The "LOCAL" or "REMOTE" operating state is not saved. "REMOTE" is activated when the power supply is switched on.
OFF in REMOTE (factory setting: No)
- Yes: The OFF key functions in REMOTE mode even if the drive is being controlled by external sources (fieldbus, customer terminal block, NAMUR terminal block). WARNING: This function is not an EMERGENCY OFF function!
- No: The OFF key only functions in LOCAL mode.

LOCAL/REMOTE also during operation (factory setting: No)

- Yes: You can switch between LOCAL and REMOTE when the drive is switched on (motor is running).
- No: Before switching to LOCAL, a check is carried out to determine whether the drive is in the operational status. If so, the system does not switch to LOCAL and outputs the error message "Local mode during operation not possible". Before switching to REMOTE, the drive is switched off and the setpoint is set to 0 .


### 6.6.7.2 ON key / OFF key



ON key: Always active in LOCAL when the operator input inhibit is deactivated.
OFF key: In the factory setting, acts as OFF1 = ramp-down at the deceleration ramp ( p 1121 ); when $\mathrm{n}=0$ : voltage disconnection (only if an input contactor is installed) The OFF key is effective in the LOCAL mode and when the "OFF in REMOTE" function is active.

Settings: Menu - Commissioning / Service - AOP Settings - Control Settings
Red OFF key acts as: (factory setting: OFF1)

- OFF1: Ramp-down on the deceleration ramp (p1121)
- OFF2: Immediate pulse inhibit, motor coasts to a standstill
- OFF3: Ramp-down on the emergency stop ramp (p1135)


### 6.6.7.3 CCW/CW selection



## Settings: Menu - Commissioning/Service - AOP Settings - Control Settings

CCW/CW selection (factory setting: No)

- Yes: Switching between CW/CCW rotation by means of the CW/CCW key possible in LOCAL mode
- No: The CW/CCW key has no effect in LOCAL mode

For safety reasons, the CW/CCW key is disabled in the factory setting (pumps and fans must normally only be operated in one direction).

In the "Operation" status in LOCAL mode, the current direction of rotation is indicated by an arrow next to the operating state.

## Note

You have to make additional settings when switching between CW/CCW rotation.

### 6.6.7.4 Jog

JOG
Settings: Menu - Commissioning/Service - AOP Settings - Control Settings JOG key active (factory setting: No)

- Yes: The JOG key functions in LOCAL mode in the "Ready for power up" status (not in "Operation enabled" status). The speed that is set in parameter p1058 is approached.
- No: The JOG key has no effect in LOCAL mode


### 6.6.7.5 Increase setpoint / decrease setpoint

You can use the Increase and Decrease keys to enter the setpoint with a resolution of $1 \%$ of the maximum speed.

Alternatively, the setpoint can also be entered via the numeric keys. To do so, press F2 in the operation screen. The system displays an editing field for entering the required speed. Enter the required value using the numeric keypad. Press F5 "OK" to confirm the setpoint.

Using the number keys, any speed ranging between the maximum speed (p1080) and minimum speed (p1082) can be entered.

Setpoint entry in LOCAL mode is unipolar. You can change the direction of rotation by pressing the key that allows you to switch between CW/CCW rotation.

- CW rotation and "Increase key" mean:

The displayed setpoint is positive and the output frequency is increased.

- CCW rotation and "Increase key" mean:

The displayed setpoint is negative and the output frequency is increased.

### 6.6.7.6 AOP setpoint

## Settings: Menu - Commissioning / Service - AOP Settings - Control Settings

## Save AOP setpoint (factory setting: No)

- Yes: In LOCAL mode, the last setpoint (once you have released the INCREASE or DECREASE key or confirmed a numeric entry) is saved.
The next time you switch the system on in LOCAL mode, the saved value is selected. This is also the case if you switched to REMOTE in the meantime or the power supply was switched off.
When the system is switched from REMOTE to LOCAL mode while the drive is switched on (motor is running), the actual value that was last present is set as the output value for the motorized potentiometer setpoint and saved.
If the system is switched from REMOTE to LOCAL mode while the drive is switched off, the motorized potentiometer setpoint that was last saved is used.
- No: On power-up in LOCAL mode, the speed is always set to the value entered under "AOP starting setpoint". When the system is switched from REMOTE to LOCAL mode while the drive is switched on (motor is running), the actual value that was last present is set as the output value for the AOP setpoint.

AOP setpoint ramp-up time (factory setting: 10 s )
AOP setpoint ramp-down time (factory setting: 10 s )

- Recommendation: Set as ramp-up/ramp-down time (p1120 / p1121). Changing the ramp-up/ramp-down times does not affect the settings for parameters p1120 and p1121 because this is an AOP-specific setting.

AOP starting setpoint (factory setting: 0.000 rpm )
The AOP starting setpoint is the speed setpoint which is active when the drive is switched on (with AOP30-"ON" key). This setpoint is valid on condition that the system setting "Save setpoint" is set to "NO".

## Note <br> Internal ramp-function generator

The internal drive ramp-function generator is always active.

### 6.6.7.7 Inhibit AOP LOCAL mode

Settings: Menu - Commissioning / Service - AOP Settings - Control Settings
Inhibit AOP LOCAL mode (factory setting: No)

- Yes: Deactivates the "Control via operator panel" function, thereby disabling the LOCAL/REMOTE key.
- No: Activates the LOCAL/REMOTE key.

Note
Lock LOCAL
LOCAL functionality can also be inhibited on the drive by means of the p0806 parameter (BI: Inhibit master control).

### 6.6.7.8 Acknowledge fault from the AOP

Settings: Menu - Commissioning/Service - AOP settings - Control settings
Acknowledge fault from the AOP (factory setting: yes)

- Yes: Faults can be acknowledged via the AOP.
- No: Faults cannot be acknowledged via the AOP.


### 6.6.7.9 CDS setting via AOP

Settings: Menu - Commissioning/Service - AOP Settings - Control Settings
CDS changeover via AOP (factory setting: No)

- Yes: The active CDS can be changed by one in LOCAL mode in the operation screen. This is useful if operation via AOP would not be possible due to an activated standard frame.
If CDS0 or CDS2 is active, "CDS+1" triggers a change to CDS1 or CDS3.
If CDS1 or CDS3 is active, "CDS-1" triggers a change to CDS0 or CDS2.
- No: The active CDS cannot be changed in LOCAL mode in the operation screen.


### 6.6.7.10 Operator input inhibit / Parameterization inhibit

To prevent users from accidentally actuating the control keys and changing parameters, you can activate an operator input / configuration inhibit using a key-operated pushbutton. Two key icons appear in the top right of the display when these safety inhibits are enabled.

Table 6-8 Display of operator input / configuration inhibit

| Inhibit type | Online mode | Offline mode |
| :--- | :---: | :---: |
| No safety inhibit | $\square$ |  |
| Operating lock | $\square$ |  |
| Parameterization lock | $\square$ |  |
| Operating lock + configuration inhibit | rerer |  |

Settings


Figure 6-23 Set safety inhibits
The "Operating lock" setting can be changed directly via <F5> "Change" once you have selected the selection field.

When "Parameterization lock" is activated, you have to enter a numeric password (repeat this entry). You must also enter this password when deactivating "Parameterization lock".

Operating lock (factory setting: Not active)

- Active: The parameters can still be viewed, but a parameter value cannot be saved (message: "Note: operating lock active"). The OFF key (red) is enabled. The LOCAL, REMOTE, ON (green), JOG, CW/CCW, INCREASE, and DECREASE keys are disabled.


## Parameterization lock (factory setting: Not active)

- Active: Parameters cannot be changed unless a password is entered. The configuration is the same as with the operating lock mode. If you try to change parameters, the message "Note: Parameterization lock active" is displayed. All the control keys, however, can still be actuated.

Access level (factory setting: Expert):
The different parameters required for this complex application are filtered so that they can be displayed as clearly as possible. You select them according to the access level.

An expert level, which must only be used by expert personnel, is required for certain actions.

## Note

## Copy RAM to ROM

When the operating lock or configuration inhibit is activated, a "Copy RAM to ROM" is automatically executed to back the parameter settings up in non-volatile memory on the memory card.

### 6.6.8 Faults and alarms

## Fault and alarm displays

If a fault occurs, the drive displays the fault and/or alarm on the operator panel. Faults are indicated by the red "FAULT" LED and a fault screen is automatically displayed. You can use the F1 Help function to call up information about the cause of the fault and how to remedy it. You can use F5 Ack. to acknowledge a stored fault.

Alarms are indicated by means of the yellow "ALARM" LED. The system also displays a note in the status bar providing information on the cause.

## What is a fault?

A fault is a message from the drive indicating an error or other exceptional (unwanted) status that results in the drive being switched off. This could be caused by a fault within the drive or an external fault triggered, for example, by the winding temperature monitor for the motor. The faults are displayed and can be reported to a higher-level control system via PROFIBUS. In the factory default setting, the message "Drive fault" is also sent to a relay output. Once you have eliminated the cause of the fault, you must acknowledge the fault code.

## What is an alarm?

An alarm is the response to a fault condition identified by the drive. It does not result in the drive being switched off and does not have to be acknowledged. Alarms are "selfacknowledging", that is, they are reset automatically when the cause of the alarm has been eliminated.

## Fault and alarm displays

Every fault and alarm is entered in the fault/alarm buffer along with time the fault occurred. The time stamp refers to the system time (r2114).

You can call up an overview screen that displays the current status of faults and/or alarms for every drive object in the system by choosing MENU - Fault memory / alarm memory.

A context menu featuring the "Back" and "Ack" options appears when you press F4 "Others".
The function required can be selected using F2 and F3 and executed by pressing F5 "OK".
The "Acknowledge" function sends an acknowledgement signal to each drive object.
The red FAULT LED extinguishes once all the faults have been acknowledged.


Figure 6-24 Fault screen
You can use F5 Ack. to acknowledge a stored fault.


Figure 6-25 Alarm screen
Alarms that are no longer active are removed from the alarm memory with F5 Clear.

### 6.6.9 Saving the parameters permanently

## Description

If parameters are changed using the operator panel (confirm with OK in the Parameter editor), the new values are initially stored in the volatile memory (RAM) of the drive. An "S" flashes in the top right of the AOP display until they are saved to a permanent memory. This indicates that at least 1 parameter has been changed and not yet stored permanently.

Two methods are available for permanently saving parameters that have been changed:

- To store the parameters permanently, choose <MENU> <Parameterization> <OK> <Permanent parameter transfer>.
- When confirming a parameter setting with OK, press the OK key for more than 1 s . The system displays a message asking you whether the setting is to be saved in the EEPROM.
If you press "Yes", the system saves the setting in the EEPROM. If you press "No", the setting is not saved permanently and the " S " starts flashing to indicate this fact.

In both cases, all changes that have not yet been saved permanently are stored in the EEPROM.

### 6.6.10 Parameterization errors

If an error occurs when reading or writing parameters, a popup window containing the cause of the problem is displayed.

The system displays:
Parameter write error (d)pxxxx.yy:0xnn
and a plain-text explanation of the type of parameterization error.

### 6.7 Communication according to PROFIdrive

### 6.7.1 General information

PROFIdrive V4.1 is the PROFIBUS and PROFINET profile for drive technology with a wide range of applications in production and process automation.

PROFIdrive is independent of the bus system used (PROFIBUS, PROFINET).

## Note

## References

PROFIdrive for drive technology is described in the following document:

- PROFIDRIVE system description

PROFIBUS User Organization e.V.
Haid-und-Neu-Straße 7, D-76131 Karlsruhe, Germany, http://www.profibus.com

- IEC 61800-7


## PROFIdrive device classes

Table 6-9 PROFIdrive device classes

| PROFIdrive | PROFIBUS DP | PROFINET |
| :--- | :--- | :--- |
| Peripheral device (P device) | DP slave | IO device |
| Motion controller (higher-level controller or host <br> of the automation system) | Class 1 DP master | IO controller |
| Supervisor (engineering station) | Class 2 DP master | IO supervisor |

- Drive unit (PROFIBUS: Slave, PROFINET IO: IO device)

Example: CU320-2 Control Unit

- Controller (PROFIBUS: Master Class 1, PROFINET IO: IO controller)

A controller is typically a higher-level controller in which the automation program runs.
Example: SIMATIC S7 and SIMOTION

- Supervisor (PROFIBUS: Master Class 2, PROFINET IO: IO Supervisor)

Devices for configuring, commissioning and operator control and monitoring while the bus is in operation and devices that exchange data with drive units and controllers only acyclically.

Examples: Programming devices, operator control and monitoring devices

## Properties of controllers, supervisors, and drive units

Table 6-10 Properties of the Controller, Supervisor, and Drive Unit

| Properties | Controller | Supervisor |
| :--- | :--- | :--- |
| As bus node | Active | Drive unit |
| Sending of messages | Permitted without external request | Only possible at request of controller |
| Receiving of messages | Possible without any restrictions | Only receiving and acknowledging <br> permitted |

## Communication services

Four communication services are defined in the PROFIdrive profile:

- Cyclic data exchange via a cyclic data channel Motion control systems require cyclically updated data during operation for open-loop and closed-loop control tasks. This data must be sent to the drive units in the form of setpoints or transmitted from the drive units in the form of actual values, via the communications system. Transmission of this data is usually time-critical.
- Acyclic data exchange via an acyclic data channel An acyclic parameter channel for exchanging parameters between the controller/ supervisor and drive units is additionally available. Access to this data is not time-critical.
- Alarm channel

Alarms are output on an event-driven basis, and indicate the the incoming and outgoing status of error conditions.

- Isochronous mode


## Interface IF1 and IF2

The Control Unit can communicate via two different interfaces (IF1 and IF2).

Table 6-11 Properties of IF1 and IF2

|  | IF1 | IF2 |
| :--- | :--- | :--- |
| PROFIdrive and SIEMENS <br> frame | Yes | No |
| Free telegram | Yes | Yes |
| Isochronous mode | Yes | Yes |
| Drive object types | All | All |
| Can be used for | PROFINET IO, PROFIBUS DP, <br> SINAMICS Link, PN Gate, <br> Ethernet/IP | PROFINET IO, PROFIBUS DP, <br> CANopen, SINAMICS Link, <br> PN Gate, Ethernet/IP |
| Cyclic operation | Yes | Yes |
| PROFIsafe | Yes | Yes |

## Note

For additional information on the IF1 and IF2 interfaces, see section "Parallel operation of communication interfaces".

### 6.7.2 Application classes

## Description

There are different application classes for PROFIdrive according to the scope and type of the application processes. PROFIdrive features a total of six application classes, the three most important are considered here.

## Selection of message frames as a function of the application class

The message frames listed in the table below can be used in the following application classes:

Table 6-12 Selection of message frames as a function of the application class

| Message frame (p0922 = x) | Description | Class 1 | Class 3 | Class 4 |
| :---: | :---: | :---: | :---: | :---: |
| 1 | Speed setpoint, 16 bit | x |  |  |
| 2 | Speed setpoint, 32 bit | X |  |  |
| 3 | Speed setpoint, 32 bit with 1 position encoder |  |  | x |
| 4 | Speed setpoint, 32 bit with 2 position encoders |  |  | x |
| 5 | Speed setpoint, 32 bit with 1 position encoder and DSC |  |  | x |
| 6 | Speed setpoint, 32 bit with 2 position encoders and DSC |  |  | x |
| 7 | Positioning, message frame 7 (basic positioner) |  | x |  |
| 9 | Positioning, message frame 9 (basic positioner with direct input) |  | x |  |
| 20 | Speed setpoint, 16 bit VIK-NAMUR | x |  |  |
| 81 | Encoder message frame, 1 encoder channel |  |  | x |
| 82 | Extended encoder message frame, 1 encoder channel + speed actual value 16 bits |  |  | x |
| 83 | Extended encoder message frame, 1 encoder channel + speed actual value 32 bits |  |  | x |
| 102 | Speed setpoint, 32 bit with 1 position encoder and torque reduction |  |  | x |
| 103 | Speed setpoint, 32 bit with 2 position encoders and torque reduction |  |  | x |
| 105 | Speed setpoint, 32 bit with 1 position encoder, torque reduction and DSC |  |  | x |
| 106 | Speed setpoint, 32 bit with 2 position encoders, torque reduction and DSC |  |  | x |
| 110 | Basic positioner with MDI, override and XIST_A |  | x |  |
| 111 | Basic positioner in MDI mode |  | x |  |


| Message frame (p0922 = x) | Description | Class 1 | Class 3 | Class 4 |
| :---: | :---: | :---: | :---: | :---: |
| 116 | Speed setpoint, 32 bits with 2 position encoders, torque reduction, and DSC, plus actual load, torque, power, and current values |  |  | x |
| 118 | Speed setpoint, 32 bits with 2 external position encoders, torque reduction, and DSC, plus actual load, torque, power, and current values |  |  | x |
| 125 | DSC with torque feedforward control, 1 position encoder (encoder 1) |  |  | x |
| 126 | DSC with torque feedforward control, 2 position encoders (encoder 1 and encoder 2) |  |  | x |
| 136 | 136 DSC with torque feedforward control, 2 position encoders (encoder 1 and encoder 2), 4 trace signals |  |  | X |
| 138 | DSC with torque precontrol, 2 external position encoders (encoder 2 and encoder 3), 4 trace signals |  |  | x |
| 139 | Closed-loop speed/position control with DSC and torque feedforward control, 1 position encoder, clamping status, supplementary actual values |  |  | x |
| 166 | Manufacturer-specific telegram for hydraulic axis (HLA) with 2 encoder channels and HLA additional signals | x | x | x |
| 220 | Speed setpoint, 32 bit, metal industry | x |  |  |
| 352 | Speed setpoint, 16 bit, PCS7 | x |  |  |
| 370 | Infeed | X | x | x |
| 371 | Infeed, metal industry | x |  |  |
| 390 | Control unit with digital inputs/outputs | x | x | x |
| 391 | Control unit with digital inputs/outputs and 2 measuring probes | x | x | x |
| 392 | Control unit with with digital inputs/outputs and 6 measuring probes | x | x | x |
| 393 | Control unit with digital inputs/outputs and 8 measuring probes | x | X | x |
| 394 | Control unit with digital inputs/outputs | x | X | X |
| 395 | Control Unit with digital inputs/outputs and 16 measuring probes | x | x | X |
| 396 | Telegram for the transfer of DU-global status data (DO CU), for the control of the digital I/O on SOC-CUs, as well as for 8 CU probe channels and 8 CU cam controllers | x | X | X |
| 999 | Free message frames | x | X | x |

### 6.7.3 Cyclic communication

Cyclic communication is used to exchange time-critical process data (e.g., setpoints and actual values).

### 6.7.3.1 Message frames and process data

## General information

Through selection of a message frame via CU parameter p0922, the process data to be transferred is defined.

From the perspective of the drive unit, the received process data represents the receive words and the process data to be sent represents the send words.

The receive and send words comprise the following elements:

- Receive words: Control words and setpoints
- Send words: Status words and actual values


## "Profidrive" default setting

When the "Profidrive" default setting is chosen for command and setpoint selection (see "Command sources / "Profidrive" default settings"), "Free frame" (p0922 = 999) is selected.

The receive frame is parameterized as follows as a result of the default setting:

| STW1 | NSET_A |
| :---: | :---: |

The send frame is as follows (factory setting):

| ZSW1 | NACT_- | IAACT_- | MACT_- | PACT_ | FAULT_CODE |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | SMOOTH | SMOOTH | SMOOTH | SMOOTH |  |

No additional settings are necessary to use these message frames.

## User-defined message frame selection

## a. Standard message frames

Standard message frames are structured in accordance with PROFIdrive profile or internal company specifications. Internal interconnection of process data is performed automatically in accordance with the message frame number setting in parameter p0922.

The following standard message frames can be set via parameter p0922

- p0922 = 1 -> Speed setpoint, 16-bit
- p0922 = $2->$ Speed setpoint, 32-bit
- p0922 $=3 \quad->$ Speed setpoint 32-bit with 1 position controllers
- p0922 = $4 \quad->$ Speed setpoint 32-bit with 2 position controllers
- p0922 $=20 \quad$-> Speed setpoint, 16-bit VIK-NAMUR
- p0922 = 352 -> Speed setpoint, 16 bit PCS7

The interface mode of the control and status word is automatically set based on the setting in p0922.

- p0922 = 1, 352, 999:

STW 1/ZSW 1: Interface Mode SINAMICS/MICROMASTER, p2038 = 0

- p0922 = 20:

STW 1/ZSW 1: Interface Mode PROFIdrive VIK-NAMUR, p2038 = 2

## b. Manufacturer-specific message frames

The manufacturer-specific message frames are structured in accordance with internal company specifications. The internal process data links are set up automatically in accordance with the frame number setting.

The following manufacturer-specific message frames can be set via p0922:

- p0922 = 220 Speed setpoint, 32 bit, metal industry
c. Free message frames $(\mathrm{p} 0922=999)$

Send and receive message frames can be configured as required by using BICO technology to interconnect the send and receive words. The default process data assigned under a) is retained during the changeover to p0922 $=999$, although it can be changed or supplemented at any time.

To maintain compliance with the PROFIdrive profile, however, the following assignments should be retained:

- Interconnect PZD receive word 1 as control word 1 (STW 1)
- Interconnect PZD send word 1 as status word 1 (ZSW 1)

Refer to function diagrams FP2460 and FP2470 for details on interconnection options.

## Message frame interconnections

When p0922 = 999 (factory setting) is changed to p0922 $=999$, the message frames are interconnected and blocked automatically.

## Note

## Exceptions

Exceptions here are message frames 20, 220, and 352. In addition to the fixed interconnections, selected process data (PZD) can be interconnected as required in the send/receive frame.

When you change p0922 $=999$ to p0922 = 999, the previous message frame interconnection is retained and can be changed.

## Note

## Easy method for creating extended message frame interconnections

If p0922 = 999, a message frame can be selected in p2079. A message frame interconnection is automatically made and blocked. However, the message frame can also be extended.

This is an easy method for creating extended message frame interconnections on the basis of existing message frames.

### 6.7.3.2 Structure of the message frames

Table 6-13 Structure of the message frames


### 6.7.3.3 Overview of control words and setpoints

Table 6-14 Overview of control words and setpoints

| Abbreviation | Description | Parameter | Function diagram |
| :---: | :---: | :---: | :---: |
| STW1 | Control word 1 (interface mode <br> SINAMICS, p2038 = 0) | See table "Control word 1 (interface mode <br> SINAMICS, p2038 = 0)" | FP2442 |
| STW1 | Control word 1 (interface mode <br> VIK-NAMUR, p2038 = 2) | See table "Control word 1 (interface mode <br> VIK-NAMUR, p2038 = 2)" | FP2441 |
| STW1_BM | Control word 1, metal industry (interface <br> mode SINAMICS, p2038 = 0) | See table "Control word 1, metal industry <br> (interface mode SINAMICS, p2038 =0)" | FP2425 |
| STW2 | Control word 2 (interface mode <br> SINAMICS, p2038 = 0) | See table "Control word 2 (interface mode <br> SINAMICS, p2038 = 0)" | FP2444 |
| STW2_BM | Control word 2, metal industry (interface <br> mode SINAMICS, p2038 = 0) | See table "Control word 2, metal industry <br> (interface mode SINAMICS, p2038 = 0)" | FP2426 |
| NSET_A | Speed setpoint A (16-bit) | p11570 | FP3030 |
| NSET_B | Speed setpoint B (32-bit) | FP3080 |  |
| PCS7_x | PCS7-specific setpoints |  |  |

### 6.7.3.4 Overview of status words and actual values

Table 6-15 Overview of status words and actual values

| Abbreviation | Description | Parameter | Function diagram |
| :---: | :---: | :---: | :---: |
| ZSW1 | Status word 1 (interface mode SINAMICS, p2038 = 0) | See table "Status word 1 (interface mode SINAMICS, p2038 = 0)" | FP2452 |
| ZSW1 | Status word 1 (interface mode VIK-NAMUR, p2038 = 2) | See table "Status word 1 (interface mode VIK-NAMUR, p2038 = 2)" | FP2451 |
| ZSW1_BM | Status word 1, metal industry (interface mode SINAMICS, p2038 = 0) | See table "Status word 1, metal industry (interface mode SINAMICS, p2038 = 0)" | FD2428 |
| ZSW2 | Status word 2 (interface mode SINAMICS, p2038 = 0) | See table "Status word 2 (interface mode SINAMICS, p2038 = 0)" | FD2454 |
| ZSW2_BM | Status word 2, metal industry (interface mode SINAMICS, p2038 = 0) | See table "Status word 2, metal industry (interface mode SINAMICS, p2038 = 0)" | FP2429 |
| NACT_A | Speed setpoint A (16-bit) | r0063[0] | FP4715 |
| NACT_B | Speed setpoint B (32-bit) | r0063 | FP4710 |
| IAACT | Actual value of current | r0068[0] | FP6714 |
| MACT | Actual torque value | r0080[0] | FP6714 |
| PACT | Actual power value | r0082[0] | FP6714 |
| NACT_SMOOTH | Actual speed value, smoothed | r0063[1] | FP4715 |
| IAACT_SMOOTH | Actual value of current, smoothed | r0068[1] | FP6714 |
| MACT_SMOOTH | Actual torque value, smoothed | r0080[1] | FP6714 |
| PACT_SMOOTH | Actual power value, smoothed | r0082[1] | FP6714 |
| MELD_NAMUR | VIK-NAMUR message bit bar | r3113, see table "NAMUR message bit bar" | -- |
| WARN_CODE | Alarm code | r2132 | FD8065 |
| FAULT_CODE | Fault code | r2131 | FP8060 |

### 6.7.4 Acyclic communication

Acyclic communication, as opposed to cyclic communication, means data is transferred only when an explicit request is made (e.g., in order to read and write parameters).

The "Read data record" and "Write data record" services are available for acyclic communication.

The following options are available for reading and writing parameters:

- S7 protocol

This protocol uses the STARTER commissioning tool, for example, in online mode via PROFIBUS.

- PROFIdrive parameter channel with the following data records:
- PROFIBUS: Data block 47 (0x002F)

The DPV1 services are available for master class 1 and master class 2.

- PROFINET: Data block 47 and 0xB02F as global access, data block 0xB02E as local access


## Note

## References

Refer to the following documentation for a detailed description of acyclic communication: Reference: PROFIdrive Profile V4.1, May 2006, Order No: 3.172

## Addressing:

- PROFIBUS DP, addressing is carried out via the logical address or the diagnostics address.
- PROFINET IO, addressing is carried out exclusively via a diagnostics address that is assigned to a module starting from slot 1. Parameters cannot be accessed using slot 0 .


Figure 6-26 Reading and writing data

## Characteristics of the parameter channel

- One 16 -bit address exists for each parameter number and subindex.
- Concurrent access by several additional PROFIBUS masters (master class 2 ) or PROFINET IO Supervisor (e.g., commissioning tool).
- Transfer of different parameters in one access (multiple parameter request).
- Transfer of complete arrays or part of an array possible.
- Only one parameter request is processed at a time (no pipelining).
- A parameter request/parameter response must fit into a data set (e.g. PROFIBUS: max. 240 bytes).
- The request or the response header is user data.


### 6.7.4.1 Structure of requests and responses

## Structure of parameter request and parameter response

Table 6-16 Structure of the parameter request

|  | Parameter request |  |  | Offset |
| :---: | :---: | :---: | :---: | :---: |
| Values for write access only | Request header | Request reference | Request ID | 0 |
|  |  | Axis | Number of parameters | 2 |
|  | 1st parameter address | Attribute | Number of elements | 4 |
|  |  | Parameter number |  | 6 |
|  |  | Subindex |  | 8 |
|  | ... |  |  |  |
|  | nth parameter address | Attribute | Number of elements |  |
|  |  | Parameter number |  |  |
|  |  | Subindex |  |  |
|  | 1st parameter value(s) | Format | Number of values |  |
|  |  | Values |  |  |
|  |  | ... |  |  |
|  | ... |  |  |  |
|  | nth parameter value(s) | Format | Number of values |  |
|  |  | Values |  |  |
|  |  | ... |  |  |

Table 6-17 Structure of the parameter response

|  | Parameter response |  |  | Offset |
| :---: | :---: | :---: | :---: | :---: |
| Values for read access only Error values for negative response only | Response header | Request reference mirrored | Response ID | 0 |
|  |  | Axis mirrored | Number of parameters | 2 |
|  | 1st parameter value(s) | Format | Number of values | 4 |
|  |  | Values or error values |  | 6 |
|  |  | ... |  |  |
|  | ... |  |  |  |
|  | nth parameter value(s) | Format | Number of values |  |
|  |  | Values or error values |  |  |
|  |  | ... |  |  |

## Description of fields in the parameter request and response

Table 6-18 Fields in parameter request and response

| Field | Data type | Values | Comments |
| :---: | :---: | :---: | :---: |
| Request reference | Unsigned8 | 0x01 ... 0xFF |  |
|  | Unique identification of the request/response pair for the master. The master changes the request reference with each new request. The slave mirrors the request reference in its response. |  |  |
| Request ID | Unsigned8 | $\begin{array}{l\|} \hline 0 \times 01 \\ 0 \times 02 \end{array}$ | Read request Write request |
|  | Specifies the type of request. <br> In the case of a write request, the changes are made in a volatile memory (RAM). A save operation is needed in order to transfer the modified data to the non-volatile memory (p0971, p0977). |  |  |
| Response ID | Unsigned8 | $\begin{aligned} & 0 \times 01 \\ & 0 \times 02 \\ & 0 \times 81 \\ & 0 \times 82 \end{aligned}$ | Read request (+) <br> Write request (+) <br> Read request (-) <br> Write request (-) |
|  | Mirrors the request ID and specifies whether request execution was positive or negative. <br> Negative means: <br> Cannot execute part or all of request. <br> The error values are transferred instead of the values for each subresponse. |  |  |
| Drive object number | Unsigned8 | 0x00 ... 0xFF | Number |
|  | Setting for the drive object number of a drive unit with more than one drive object. Different drive objects with separate parameter number ranges can be accessed via the same DPV1 connection. |  |  |
| Number of parameters | Unsigned8 | 0x01 ... 0x27 | Number 1 ... 39 <br> Limited by DPV1 frame length |
|  | Defines the number of adjoining areas for the parameter address and/or parameter value for multi-parameter requests. <br> The number of parameters $=1$ for single requests. |  |  |
| Attribute | Unsigned8 | $\begin{aligned} & 0 \times 10 \\ & 0 \times 20 \\ & 0 \times 30 \end{aligned}$ | Value <br> Description <br> Text (not implemented) |


| Field | Data type | Values | Comments |
| :---: | :---: | :---: | :---: |
|  | Type of parameter element accessed. |  |  |
| Number of elements | Unsigned8 | $\begin{array}{\|l\|} \hline 0 \times 00 \\ 0 \times 01 \ldots 0 \times 75 \end{array}$ | Special function <br> Number 1 ... 117 <br> Limited by DPV1 frame length |
|  | Number of array elements accessed. |  |  |
| Parameter number | Unsigned16 | 0x0001 ... 0xFFFF | No. $1 . . .65535$ |
|  | Addresses the parameter accessed. |  |  |
| Subindex | Unsigned16 | 0x0000 ... 0xFFFF | No. $0 . . .65535$ |
|  | Addresses the first array element of the parameter to be accessed. |  |  |
| Format | Unsigned8 | $0 \times 02$ $0 \times 03$ $0 \times 04$ $0 \times 05$ $0 \times 06$ $0 \times 07$ $0 \times 08$ Other values | Data type Integer8 <br> Data type Integer16 <br> Data type Integer32 <br> Data type Unsigned8 <br> Data type Unsigned16 <br> Data type Unsigned32 <br> Data type FloatingPoint <br> See PROFIdrive profile V3.1 |
|  |  | $\begin{array}{\|l} \hline 0 \times 40 \\ 0 \times 41 \\ 0 \times 42 \\ 0 \times 43 \\ 0 \times 44 \end{array}$ | Zero (without values as a positive subresponse a write request) <br> Byte <br> Word <br> Double word <br> Error |
|  | The format and number specify the adjoining space containing values in the message frame. <br> It is preferable to specify data types according to the PROFIdrive Profile for write access. Bytes, words and double words are also possible as a substitute. |  |  |
| Number of values | Unsigned8 | 0x00 ... 0xEA | Number 0 ... 234 <br> Limited by DPV1 frame length |
|  | Specifies the number of subsequent values. |  |  |
| Error values | Unsigned16 | 0x0000 ... 0x00FF | Meaning of error values --> see following table |
|  | The error values in the event of a negative response. <br> If the values make up an odd number of bytes, a zero byte is appended. This ensures the integrity of the word structure of the message frame. |  |  |
| Values | Unsigned16 | 0x0000 ... 0x00FF |  |
|  | The values of the parameter for read or write access. <br> If the values make up an odd number of bytes, a zero byte is appended. This ensures the integrity of the word structure of the message frame. |  |  |

## Error values in parameter responses

Table 6-19 Error values in parameter responses

| Error value | Meaning | Comments | Additional info |
| :---: | :---: | :---: | :---: |
| 0x00 | Illegal parameter number. | Access to a parameter that does not exist. | - |
| 0x01 | Parameter value cannot be changed. | Modification access to a parameter value that cannot be changed. | Subindex |
| 0x02 | Lower or upper value limit exceeded. | Modification access with value outside value limits. | Subindex |
| 0x03 | Invalid subindex. | Access to a subindex that does not exist. | Subindex |
| 0x04 | No array. | Access with subindex to an unindexed parameter. | - |
| $0 \times 05$ | Wrong data type. | Modification access with a value that does not match the data type of the parameter. | - |
| 0x06 | Illegal set operation (only reset allowed) | Modification access with a value not equal to 0 in a case where this is not allowed. | Subindex |
| $0 \times 07$ | Description element cannot be changed | Modification access to a description element that cannot be changed. | Subindex |
| 0x09 | No description data | Access to a description that does not exist (the parameter value exists). | - |
| 0x10 | Read job will not be executed. | The read request is refused because know-how protection is active. | - |
| 0x0B | No parameter change rights. | Modification access with no parameter change rights. | - |
| $0 \times 0 \mathrm{~F}$ | No text array exists | Access to a text array that does not exist (the parameter value exists). | - |
| $0 \times 11$ | Request cannot be executed due to operating status. | Access is not possible temporarily for unspecified reasons. | - |
| 0x14 | Illegal value. | Modification access with a value that is within the limits but is illegal for other permanent reasons (parameter with defined individual values). | Subindex |
| 0x15 | Response too long. | The length of the present response exceeds the maximum transfer length. | - |
| 0x16 | Illegal parameter address. | Impermissible or unsupported value for attribute, number of elements, parameter number, subindex or a combination of these. | - |
| $0 \times 17$ | Illegal format. | Write request: illegal or unsupported parameter data format. | - |
| $0 \times 18$ | Number of values inconsistent. | Write request: a mismatch exists between the number of values in the parameter data and the number of elements in the parameter address. | - |
| $0 \times 19$ | Drive object does not exist. | You have attempted to access a drive object that does not exist. | - |
| 0x20 | Parameter text cannot be changed. | - | - |
| 0x21 | 0x21 Service not supported. | Illegal or unknown request ID. | - |
| 0x65 | Parameter presently deactivated. | You have tried to access a parameter that, although available, does not currently perform a function (e.g., n control set and access to a V/f control parameter). | - |


| Error value | Meaning | Comments | Additional info |
| :---: | :---: | :---: | :---: |
| 0x6B | Write access for the enabled controller. | Write access is possible while the device is in the "Controller enable" state. <br> Pay attention to the parameter attribute "changeable" in the description of parameters in the List Manual (C1, C2, $\mathrm{U}, \mathrm{T})$. | - |
| 0x6C | Parameter \%s [\%s]: unit unknown. | - | - |
| 0x6D | Parameter \%s [\%s]: write access only in the commissioning state, encoder (p0010 = 4). | - | - |
| 0x6E | Parameter \%s [\%s]: write access only in the commissioning state, motor (p0010 = 3). | - | - |
| 0x6F | Parameter \%s [\%s]: write access only in the commissioning state, power module (p0010 = 2). | - | - |
| 0x70 | Parameter \%s [\%s]: write access only in quick commissioning (p0010 = 1). | - | - |
| 0x71 | Parameter \%s [\%s]: write access only in the ready state $(\mathrm{p} 0010=0)$. | - | - |
| 0x72 | Parameter \%s [\%s]: write access only in the commissioning state, parameter reset $(\mathrm{p} 0010=30)$. | - | - |
| 0x73 | Parameter \%s [\%s]: write access only in the commissioning state, safety ( $\mathrm{p} 0010=95$ ). | - | - |
| 0x74 | Parameter \%s [\%s]: write access only in the commissioning state, tech. application/units ( $\mathrm{p} 0010=5$ ). | - | - |
| 0x75 | Parameter \%s [\%s]: write access only in the commissioning state (p0010 not equal to 0 ). | - | - |
| 0x76 | Parameter \%s [\%s]: write access only in the commissioning state, download (p0010 = 29). | - | - |
| 0x77 | Parameter \%s [\%s] must not be written during download. | - | - |
| 0x78 | Parameter \%s [\%s]: write access only in the commissioning state, drive configuration (device: p0009 = 3). | - | - |
| 0x79 | Parameter \%s [\%s]: write access only in the commissioning state, define drive type (device: p0009 = 2). | - | - |
| 0x7A | Parameter \%s [\%s]: write access only in the commissioning state, data record base configuration (device: p0009 = 4). | - | - |
| 0x7B | Parameter \%s [\%s]: write access only in the commissioning state, device configuration (device: p0009 = 1). | - | - |


| Error value | Meaning | Comments | Additional info |
| :---: | :---: | :---: | :---: |
| 0x7C | Parameter \%s [\%s]: write access only in the commissioning state, device download (device: p0009 = 29). | - | - |
| 0x7D | Parameter \%s [\%s]: write access only in the commissioning state, device parameter reset (device: p0009 = 30). | - | - |
| 0x7E | Parameter \%s [\%s]: write access only in the commissioning state, device ready (device: p0009 = 0). | - | - |
| 0x7F | Parameter \%s [\%s]: write access only in the commissioning state, device (device: p0009 not equal to 0). | - | - |
| $0 \times 81$ | Parameter \%s [\%s] must not be written during download. | - | - |
| 0x82 | Transfer of master control is blocked by BI: p0806. | - | - |
| $0 \times 83$ | Parameter \%s [\%s]: requested BICO interconnection not possible. | BICO output does not supply float values. The BICO input, however, requires a float value. | - |
| 0x84 | Parameter \%s [\%s]: parameter change inhibited (refer to p0300, p0400, p0922) | - | - |
| 0x85 | Parameter \%s [\%s]: access method not defined. | - | - |
| $0 \times 87$ | Write job will not be executed. | The write job is rejected because know-how protection is active. | - |
| $0 \times C 8$ | Below currently valid limit. | Modification request for a value that, although within "absolute" limits, is below the currently valid lower limit. | - |
| 0xC9 | Above currently valid limit. | Modification request for a value that, although within "absolute" limits, is above the currently valid upper limit (e.g., governed by the current converter rating). | - |
| 0xCC | Write access not permitted. | Write access is not permitted because an access key is not available. | - |

### 6.7.4.2 Determining the drive object numbers

Additional information about the drive system (e.g., drive object numbers) can be determined as follows from parameters p0101, r0102, and p0107/r0107:

1. The value of parameter r0102 ("Number of drive objects") is read via a read request to drive object 1.

The drive object with drive object number 1 is the Control Unit (CU), which is always present in every drive system, at a minimum.
2. Depending on the result of the initial read request, further read requests to drive object 1 are used to read the indices of parameter p0101 ("Drive object numbers"), as specified by parameter r0102.

Example:
If the number of drive objects is " 5 ", the values of indices 0 to 4 of parameter p0101 are read. The relevant indexes can also be read at once. The relevant indexes can also be read at once.
3. Following this, parameter r0107/p0107 ("Drive object type") is read for each drive object (indicated by the drive object number).

Depending on the drive object, parameter 107 can be either an adjustable parameter or a display parameter.

The value in parameter r0107/p0107 indicates the drive object type. The coding for the drive object type can be found in the parameter list.

### 6.7.4.3 Example 1: Reading parameters

## Requirements

- The PROFIdrive controller has been commissioned and is fully operational.
- PROFIdrive communication between the controller and the device is operational.
- The controller can read and write data records in conformance with PROFINET/PROFIBUS.


## Task description

Following the occurrence of at least one fault (ZSW1.3 = "1") on drive 2 (also drive object number 2), the active fault codes are to be read from the fault buffer r0945[0] ... r0945[7].

The request is to be handled using a request and response data block.

## Basic procedure

1. Create a request to read the parameters.
2. Initiate the request.
3. Evaluate the response.

## Creating the request

Table 6-20 Parameter request

| Parameter request | Request reference $=25$ hex | Request ID $=01$ hex | Offset |
| :--- | :--- | :--- | :---: |
|  | Number of parameters $=01$ hex | $0+1$ |  |
|  | Axis $=02$ hex | Number of elements $=08$ hex | $4+5$ |
| Parameter address | Attribute $=10$ hex | 6 |  |
|  | Parameter no. $=945$ dec | 8 |  |
|  | Subindex $=0$ dec |  |  |

## Information about the parameter request:

- Request reference:

The value is selected at random from the valid value range. The request reference establishes the relationship between request and response.

- Request identifier:

01 hex $\rightarrow$ This identifier is required for a read request.

- Axis

02 hex $\rightarrow$ Drive 2, fault buffer with drive- and device-specific faults

- Number of parameters:

01 hex $\rightarrow$ One parameter is read.

- Attribute

10 hex $\rightarrow$ The parameter values are read.

- Number of elements:

08 hex $\rightarrow$ The current incident with eight faults is to be read.

- Parameter number:

945 dec $\rightarrow$ p0945 (fault code) is read.

- Subindex:

0 dec $\rightarrow$ Reading starts from index 0 .

## Initiating the request

If ZSW1.3 = "1" $\rightarrow$ Initiate parameter request

## Evaluating the response

Table 6-21 Parameter response

| Parameter response | Offset |  |  |
| :--- | :--- | :--- | :---: |
|  | Request reference mirrored = 25 hex | Response ID $=01$ hex | $0+1$ |
|  | Axis mirrored $=02$ hex | Number of parameters $=01$ hex | $2+3$ |
| Parameter <br> value | Format $=06$ hex | Number of values $=08$ hex | $4+5$ |
|  | 1st value $=1355$ dec | 6 |  |
|  | 2nd value $=0$ dec | 8 |  |
|  | $\ldots$ | $\ldots$ |  |
|  | 8th value $=0$ dec | 20 |  |

Information about the parameter response:

- Request reference mirrored:

This response belongs to the request with request reference 25 .

- Response identifier:

01 hex $\rightarrow$ Read request positive, values available starting from 1st value

- Axis mirrored, number of parameters:

The values correspond to the values from the request.

- Format:

06 hex $\rightarrow$ Parameter values are in the Unsigned16 format.

- Number of values:

08 hex $\rightarrow 8$ parameter values are available.

- 1st value ... 8th value:

In the fault buffer of drive 2, a fault is only entered in the 1st value.

### 6.7.4.4 Example 2: Writing parameters (multi-parameter request)

## Requirements

- The PROFIdrive controller has been commissioned and is fully operational.
- PROFIdrive communication between the controller and the device is operational.
- The controller can read and write data records in conformance with PROFINET/PROFIBUS.
- Special requirements for this example:

Control mode: Vector control (with extended setpoint channel)

## Task description

Jog 1 and 2 are to be set up for drive 2 (also drive object number 2) via the input terminals of the Control Unit. A parameter request is to be used to write the corresponding parameters as follows:

- BI: p1055 = r0722.4 Jog bit 0
- BI: p1056 = r0722.5 Jog bit 1
- p1058 = 300 rpm Jog 1 speed setpoint
- p1059 = 600 rpm Jog 2 speed setpoint

The request is to be handled using a request and response data block.


Input in BI: p1055 and BI: p1056
Object
0: Device
1: CU320
63: Wiring to itself
Parameter number

| r0722 | 1 | 4 |
| :---: | :---: | :---: |
| r0722 | 1 | 5 |
| $31 \ldots 16$ | $=02 D 20404 \mathrm{Hex}$ |  | $\begin{aligned} & \text { 02D2 } 20405 \mathrm{Hex}\end{aligned}$



Figure 6-27 Task description for multi-parameter request (example)

## Basic procedure

1. Create a request to write the parameters.
2. Initiate the request.
3. Evaluate the response.

## Creating the request

Table 6-22 Parameter request

| Parameter request |  |  | Offset |
| :---: | :---: | :---: | :---: |
| Request header | Request reference $=40$ hex | Request ID = 02 hex | $0+1$ |
|  | Axis = 02 hex | Number of parameters $=04$ hex | $2+3$ |
| 1st parameter address | Attribute $=10$ hex | Number of elements = 01 hex | $4+5$ |
|  | Parameter no. $=1055 \mathrm{dec}$ |  | 6 |
|  | Subindex $=0 \mathrm{dec}$ |  | 8 |
| 2nd parameter address | Attribute $=10$ hex | Number of elements = 01 hex | $10+11$ |
|  | Parameter no. $=1056$ dec |  | 12 |
|  | Subindex $=0 \mathrm{dec}$ |  | 14 |
| 3rd parameter address | Attribute $=10$ hex | Number of elements = 01 hex | $16+17$ |
|  | Parameter no. $=1058 \mathrm{dec}$ |  | 18 |
|  | Subindex $=0 \mathrm{dec}$ |  | 20 |
| 4th parameter address | Attribute $=10$ hex | Number of elements = 01 hex | $22+23$ |
|  | Parameter no. $=1059 \mathrm{dec}$ |  | 24 |
|  | Subindex $=0 \mathrm{dec}$ |  | 26 |
| 1st parameter value(s) | Format = 07 hex | Number of values = 01 hex | $28+29$ |
|  | Value $=02 \mathrm{D} 2$ hex |  | 30 |
|  | Value $=0404$ hex |  | 32 |
| 2nd parameter value(s) | Format = 07 hex | Number of values = 01 hex | $34+35$ |
|  | Value = 02D2 hex |  | 36 |
|  | Value $=0405$ hex |  | 38 |
| 3rd parameter value(s) | Format $=08$ hex | Number of values $=01$ hex | $40+41$ |
|  | Value = 4396 hex |  | 42 |
|  | Value $=0000$ hex |  | 44 |
| 4th parameter value(s) | Format $=08$ hex | Number of values = 01 hex | $46+47$ |
|  | Value $=4416$ hex |  | 48 |
|  | Value $=0000$ hex |  | 50 |

## Information about the parameter request:

- Request reference:

The value is selected at random from the valid value range. The request reference establishes the relationship between request and response.

- Request identifier:

02 hex $\rightarrow$ This identifier is required for a write request.

- Axis:

02 hex $\rightarrow$ The parameters are written to drive 2.

- Number of parameters:

04 hex $\rightarrow$ The multi-parameter request comprises four individual parameter requests.

## 1st parameter address ... 4th parameter address

- Attribute:

10 hex $\rightarrow$ The parameter values are to be written.

- Number of elements: 01 hex $\rightarrow 1$ array element is written.
- Parameter number:

Specifies the number of the parameter to be written (p1055, p1056, p1058, p1059).

- Subindex:
$0 \mathrm{dec} \rightarrow$ Identifier of the first array element.


## 1st parameter value ... 4th parameter value

- Format

07 hex $\rightarrow$ Data type Unsigned32 08 hex $\rightarrow$ Data type FloatingPoint

- Number of values: 01 hex $\rightarrow$ A value in the specified format is written to each parameter
- Value:

BICO input parameter: Enter signal source
Adjustable parameter: enter value

Initiating the request

## Evaluating the response

Table 6-23 Parameter response

| Parameter response |  | Offset |  |
| :--- | :--- | :--- | :---: |
| Response <br> header | Request reference mirrored = 40 hex | Response ID $=02$ hex | 0 |
|  | Axis mirrored $=02$ hex | Number of parameters $=04$ hex | 2 |

Notes on the parameter response:

- Request reference mirrored:

This response belongs to the request with request reference 40.

- Response identifier:

02 hex $\rightarrow$ Write request positive

- Axis mirrored:

02 hex $\rightarrow$ The value matches the value from the request.

- Number of parameters:

04 hex $\rightarrow$ The value matches the value from the request.

### 6.7.5 Diagnostic channels

The drive provides the standard diagnostics for PROFIBUS and PROFINET. This allows the PROFldrive classes of the drive to be integrated into the system diagnostics of a higher-level control system and automatically displayed on an HMI.

The information transferred is saved for the drive objects in the following parameters:

- r0947[0...63] fault number
- r2122[0...63] alarm code
- r9747[0...63] SI message code (with safety messages)
- r3120[0..63] component fault
- r3121[0..63] component alarm
- r9745[0..63] SI component (with safety message)

The messages entered in these parameters are combined to create PROFIdrive message classes for diagnostics. Determining the source of a message is realized by transferring the component number as channel number.

The diagnostics are activated via the appropriate parameterization in the configuration tool being used (e.g. via HW Config).

The functional scope of the diagnostic channels depends on the bus system

|  |  | PROFIdrive message classes |  |  |
| :--- | :--- | :---: | :---: | :---: |
|  |  | Faults | Alarms | Component assignment |
| PROFINET | GSDML | X | X | X |
|  | TIA | X | X | X |
| PROFIBUS | GSD | X | - | - |
|  | TIA | X | - | - |

- The drive transfers the messages in the sequence in which they occurred.
- The time stamps are generated from the higher-level controller when the messages are received
- The existing mechanisms of TIA and S7 Classic can be used.
- Alarms or faults are acknowledged using the already known acknowledgment routes.
- Transfer is possible via interface IF1 and/or IF2.


## Note

## Constraint

If Shared device is activated, only one of the controllers can receive diagnoses.

## Note

## Additional information

PROFIdrive message classes of the individual SINAMICS faults and alarms are provided in the List Manual

### 6.7.5.1 Diagnostics via PROFINET

For PROFINET, to transfer PROFIdrive message classes, channel diagnostics (Channel Diagnosis) are used (see PROFINET IO specification (http://www.profibus.com)).

A message always comprises the following components in this specific sequence:

- Block Header (6 Byte)
- Blocktype
- Blocklength
- BlockversionHigh
- BlockversionLow
- API (4 Byte)
- Slot Number (2 Byte)
- Sub Slot Number (2 Byte)
- Channel Number (2 Byte)
- Channel Properties (0x8000) (2 Byte)
- User Structure Identifier (2 Byte)
- Channel Diagnosis Data (6 Byte)
- Channel Number (2 Byte)
- Channel Properties (2 Byte)
- Channel Error Type (2 Byte)


## Overview



Figure 6-28 Components of a message

Individual components of the Channel Diagnosis Data block can be included n times in a message. A precise explanation of these message components is subsequently provided:

Table 6-24 Components of a message


[^2]
## System response - Reading out diagnostics data

The converter requests diagnostics data via "Read data set" (detailed information is provided in the PROFINET-IO specification (http://www.profibus.com)).

## Example:

For example, a read record with index 0x800C can be used to read out diagnostics data from specific sub slots
The following rules apply exemplarily:

- 1 message block, if at this drive object (one or several) faults of the same message class are identified.
- n messages
if, at this drive object, n faults of different message classes are identified.


## Note

If a fault is active on the CU drive object, then this fault is propagated to all of the drive objects associated with the CU. This fault can therefore be read out at each drive object.

### 6.7.5.2 Diagnostics via PROFIBUS

For communication via PROFIBUS, in the case of fault the following diagnostics data is output:

- Standard diagnostics
- Identifier-related diagnostics
- Status messages/module status
- Channel-related diagnostics
- Data sets DS0/DS1 and diagnostics alarm


## Message structure

The following applies if a message contains all of the specified diagnostics data:

- Standard diagnostics Is always located at the beginning of the message.
- Data sets DS0/DS1 and diagnostics alarm Is always located at the end of the message. This message part is always slot-specific. The actual state of the slot responsible for the message is always transferred in the message.

The other diagnostics data (types) can be in any sequence. This is the reason that the following diagnostics data include a header:

- Identifier-related diagnostics
- Status messages/module status
- Channel-related diagnostics

The diagnostic data type can be uniquely identified based on the header.

## Note

The master must operate in the DPV1 mode.

## Standard diagnostics

For communication via PROFIBUS, standard diagnostics is structured as follows.

|  | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Octet | Name |  |  |  |  |  |  |  |  |
| 1 | Station status 1 | $\begin{gathered} \text { Master_ } \\ \text { Lock } \\ =0 \end{gathered}$ | Prm_Fault | 0 | Not Supported | Ext_Diag | Cfg_Fault | Station_ <br> Not Ready | Station_ <br> Non Exist $=0$ |
| 2 | Station status 2 | 0 | 0 | Sync Mode | Freeze_ Mode | WD_On | 1 | Stat_Diag $=0$ | Prm_Req |
| 3 | Station status 3 | Ext_ <br> Diag_ Overflow | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 |  | Master_Add |  |  |  |  |  |  |  |
| 5 |  | Ident_Number (HighByte) of the slave |  |  |  |  |  |  |  |
| 6 |  | Ident_Number (LowByte) of the slave |  |  |  |  |  |  |  |

In this context, the following values are decisive for diagnostics:

- Ext_Diag
- Group signal for diagnostics in the slave
- = 1 , if at least 1 alarm is active
- Ext_Diag_Overflow

Display, diagnostics overflow in the slave (for more than 240 bytes)

## Identifier-related diagnostics

The identifier-related diagnostics provides a bit (KB_n) for each slot 1 allocated when configuring the device. If a diagnostics message is active at a slot, then it's KB_n = true.

| Bit |  | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Octet | Name |  |  |  |  |  |  |  |  |
| 1 | HeaderByte Station status 1 | 0 | 1 | Block length (2 ... 32) incl. this byte |  |  |  |  |  |
| 2 | $\begin{gathered} \text { Bit } \\ \text { structure } \end{gathered}$ | KB_7 | KB_6 | KB_5 | KB_4 | KB_3 | KB_2 | KB_1 | KB_0 |
| 3 | $\begin{gathered} \text { Bit } \\ \text { structure } \end{gathered}$ | ... | ... | ... | ... | KB_11 | KB_10 | KB_9 | KB_8 |
| ... |  |  |  |  |  |  |  |  |  |
| x | $\begin{gathered} \text { Bit } \\ \text { structure } \end{gathered}$ | ... | ... | KB_n+1 | KB_n | ... | ... | ... | ... |

## Status messages/module status

Status messages and module status briefly represent an overview of the state of the devices:


## Note

## Status value

Diagnostics for SINAMICS are only available in cyclic PROFIBUS operation, so that the state $00=$ "Valid user data" is always output for all slots.

## Channel-related diagnostics

Channel-related diagnostics encompasses the following data:

|  | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Octet | Name |  |  |  |  |  |  |  |  |
| X | HeaderByte | 1 ${ }^{1)}$ | $0{ }^{1)}$ |  | $0 \ldots 63$ (module number) including these bytes |  |  |  |  |
| $x+1$ |  | $1^{2)}$ | $1^{2)}$ |  | 0 (no component assignment) |  |  |  |  |
| $x+2$ |  | $0^{3)}$ | 03) |  | Message classes: <br> 2 Undervoltage <br> 3 Overvoltage <br> 9 Error <br> 16 Hardware/software error <br> 17 Line supply/filter faulted <br> 18 DC-link overvoltage <br> 19 Power electronics faulted 20 Electronic component overtemp. <br> 21 Ground/phase fault detected 22 Motor overload <br> 23 Commun. with controller faulted <br> 24 Safety monit. Detected an error <br> 25 Act. Position/speed value error <br> 26 Internal communication faulted <br> 27 Infeed faulted <br> 28 Braking controller faulted <br> 29 External signal state error <br> 30 Application/function faulted <br> 31 Parameterization/commiss. error |  |  |  |  |

1) $\cong$ Channel-related diagnostics
2) $\xlongequal{ }$ Input/output
3) "Channel type "non specific"

## System response

Only one signal is generated if channel-related diagnostics identifies several faults belonging to the same message class at the same drive object.

## Data sets DS0/DS1 and diagnostics alarm

The PROFIdrive message classes are transferred using diagnostic alarm DS0/DS1. All faults are assigned channel 0 . The drive objects are assigned using the slot number.

The structure is as follows:

|  | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Octet | Name |  |  |  |  |  |  |  |  |
| 1 | Header-Byte | 0 | 0 | $=15$ (block length) |  |  |  |  |  |
| 2 |  | 0 | $=1$ (diagnostics alarm) |  |  |  |  |  |  |
| 3 |  | 0 ... 244 (slot number $\triangleq$ drive object) |  |  |  |  |  |  |  |
| 4 |  | 0 ... 31 (sequence number) |  |  |  |  | Add_Ack | Alarm_Specifier ${ }^{1)}$ |  |
| 5 | DS0 (byte 0) | 0 | 0 | 0 | 0 | 12) | 0 | $1^{3)}$ | 14) |
| 6 | DS0 (byte 1) | 0 | 0 | 0 | $1{ }^{5)}$ | $\left.0^{6}\right)$ | $\left.0^{6}\right)$ | $1{ }^{6)}$ | $1{ }^{6)}$ |
| 7 | DS0 (Byte 2) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | DS0 (byte 3) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | Info (byte 1) | Mixed | = 0x45 (ChanneITypeID $=$ SINAMICS) |  |  |  |  |  |  |
| 10 | Info (byte 2) | $=24$ (number of diagnostic bits/channel) |  |  |  |  |  |  |  |
| 11 | Info (byte 3) | $=1$ (1 channel signals) |  |  |  |  |  |  |  |
| 12 | Channel Error Vector | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Channel 0 1 |
| 13 | Channelrelated diagnostics (channel 0) | Err 7 | Err 6 | Err 5 | Err 4 | Err 3 | Err 2 | Err 1 | Err 0 |
| 14 |  | Err 15 | Err 14 | Err 13 | Err 12 | Err 11 | Err 10 | Err 9 | Err 8 |
| 15 |  | 0 | 0 | 0 | 0 | Err 19 | Err 18 | Err 17 | Err 16 |

1) Alarm_Specifier
$1 \triangleq$ error has occurred and the slot is not OK
$2 \triangleq$ error is resolved and the slot is OK
$3 \triangleq$ error is resolved and the slot is not okay
2) Channel fault present
$=1$; as long as the drive object has an error condition
3) Internal fault
$=1$; as long as the drive object has an error condition
4) Module fault
= 1; as long as the drive object has an error condition
5) Channel information present
= 1 ; 气 DS1 exists
6) Type class of module
= 0011; 气 Distributed

### 6.7.6 Further information about PROFIdrive communication

## Further information about PROFIdrive communication

For more information about PROFIdrive communication, refer to "PROFIdrive communication" in the accompanying "SINAMICS S120 Function Manual".

### 6.8 Communication via PROFIBUS DP

### 6.8.1 PROFIBUS port

## Position of the PROFIBUS connection, address switch, and diagnostics LED

The PROFIBUS connection, address switch, and diagnostics LED are located on the Control Unit CU320-2 DP.


Figure 6-29 View of the control unit with PROFIBUS interface

## PROFIBUS connection

PROFIBUS is connected by means of a 9-pin sub D socket (X126); the terminals are isolated.

Table 6-25 X126-PROFIBUS connection

|  | Pin | Signal name | Meaning | Range |
| :---: | :---: | :---: | :---: | :---: |
|  | 1 | SHIELD | Ground connection |  |
|  | 2 | M24_SERV | Teleservice supply, ground | 0 V |
|  | 3 | RxD/TxD-P | Receive/transmit data P (B/B') | RS485 |
|  | 4 | CNTR-P | Control signal | TTL |
|  | 5 | DGND | PROFIBUS data reference potential (C/C') |  |
|  | 6 | VP | Supply voltage plus | $5 \mathrm{~V} \pm 10$ \% |
|  | 7 | P24_SERV | Teleservice supply, P, +(24 V) | 24 V (20.4 V to 28.8 V) |
|  | 8 | RxD/TxD-N | Receive/transmit data N (A/A') | RS485 |
|  | 9 | - | Not assigned |  |

## Connectors

Cables must be connected via PROFIBUS connectors because they have the necessary bus terminating resistors.

The figure below shows the correct PROFIBUS connector with and without a PG/PC connector.


PROFIBUS connector without PG/PC connection 6ES7972-0BA42-0XA0


PROFIBUS connector with PG/PC connection 6ES7972-0BB42-0XA0

## Bus terminating resistor

The bus terminating resistor must be switched on or off depending on its position in the bus, otherwise the data will not be transmitted properly.
The terminating resistors for the first and last nodes in a line must be switched on; the resistors must be switched off at all other connectors.

The cable shield must contact at both ends with the greatest possible surface area.

## Note

## Connector type

The proper connector assignment (IN/OUT) in conjunction with the terminating resistor must be observed according to the connector type.

First bus node Last bus node


Figure 6-30 Position of the bus terminating resistors

## Cable routing



Figure 6-31 Cable routing for Type A cabinets


Figure 6-32 Cable routing for Type C cabinets

### 6.8.2 Control via PROFIBUS

## "COM (PROFIdrive)" diagnostics LED

The PROFIBUS diagnostics LED is located on the front of the Control Unit. Its meaning is described in the following table.

Table 6-26 Description of the "COM" LED

| Color | Status | Description |
| :---: | :---: | :--- |
| ---- | Off | Cyclic communication is not (yet) running. <br> Note: <br> The PROFIdrive is ready for communication when the Control Unit is ready for opera- <br> tion (see LED RDY). |
| Green | Continuous light | Cyclic communication is taking place. |
| Green | Flashing 0.5 Hz | Cyclic communication has not yet fully occured. <br> Possible causes: <br> - The controller is not transmitting any setpoints. <br> - In isochronous mode, the controller did not transmit a Global Control (GC) or it trans- <br> mitted an incorrect Global Control. |
| Red | Flashing 0.5 Hz | PROFIBUS master is sending incorrect parameter assignment/configuration data |
| Red | Flashing 2 Hz | Cyclic bus communication has been interrupted or could not be established. |

## Setting the PROFIBUS address

There are two ways to set the PROFIBUS address:

1. Via p0918

- To set the bus address for a PROFIBUS node using STARTER, first set the rotary code switches to $0_{\text {dec }}\left(00_{\text {hex }}\right)$ and $127_{\text {dec }}\left(7 F_{\text {hex }}\right)$.
- Then use parameter p0918 to set the address to a value between 1 and 126.

2. Via the PROFIBUS address switches on the Control Unit

- The address is set manually to values between 1 and 126 using the rotary coding switches. In this case, p0918 is only used to read the address.


## Note

The rotary coding switches used to set the PROFIBUS address are located beneath the cover.

## Note

Address 126 is used for commissioning. Permitted PROFIBUS addresses are $1 \ldots 126$.
When several Control Units are connected to a PROFIBUS line, you set the addresses differently compared to the the factory setting. Each PROFIBUS address in a PROFIBUS line can only be assigned once. Either set the PROFIBUS address in absolute terms using the rotary coding switches or selectively in parameter p0918. Any change to the bus address takes effect only after a POWER ON.

The currently set address of the rotary coding switch is displayed in parameter r2057.

## PROFIBUS address switches

The PROFIBUS address is set as a hexadecimal value via two rotary coding switches. Values between $0_{\text {dec }}\left(00_{\text {hex }}\right)$ and $127_{\text {dec }}\left(7 \mathrm{~F}_{\text {hex }}\right)$ can be set as the address. The upper rotary coding switch $(\mathrm{H})$ is used to set the hexadecimal value for $16{ }^{1}$, and the lower rotary coding switch (L) is used to set the hexadecimal value for $16^{\circ}$.

Table 6-27 PROFIBUS address switches

| Rotary coding switches | Significance | Examples |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | 21 dec | $35_{\text {dec }}$ | 126dec |
|  |  | 15 hex | 23 hex | 7Enex |
|  | $16^{1}=16$ | 1 | 2 | 7 |
|  | $16^{0}=1$ | 5 | 3 | E |

The factory setting for the rotary coding switches is $0_{\text {dec }}\left(00_{\text {hex }}\right)$.

## Setting the PROFIBUS ID number

The PROFIBUS ID number (PNO-ID) can be set using p2042.
SINAMICS can be operated on PROFIBUS with various identities. This allows a PROFIBUS GSD that is independent of the device to be used (e.g., PROFldrive VIK-NAMUR with ID number 3AA0 hex).

- 0: SINAMICS S/G
- 1: VIK-NAMUR

New settings do not take effect until after POWER ON, reset, or download.

## Note

## Totally Integrated Automation

The benefits of Totally Integrated Automation (TIA) are only available when " 0 " is selected.

### 6.8.3 Monitoring: Message frame failure

## Description

There are two cases for monitoring message frame failure:

- Message frame failure with a bus fault

After a message frame failure and the additional monitoring time has elapsed (p2047), bit r2043.0 is set to "1" and alarm A01920 is output. Binector output r2043.0 can be used for an emergency stop, for example.

Once the delay time (p2044) has elapsed, fault F01910 is output.
Fault F01910 triggers fault response OFF2 (pulse inhibit) for the infeed and OFF3 (quick stop) in the drive.
If an OFF response is not required, the fault response can be reconfigured accordingly.
Fault F01910 can be acknowledged immediately. The drive can then be operated even without PROFIBUS.


Figure 6-33 Monitoring message frame failure with a bus fault

- Message frame failure with a CPU stop

After message frame failure, bit r2043.0 is set to "1". Binector output r2043.0 can be used for an emergency stop, for example.
Once the delay time (p2044) has elapsed, fault F01910 is output.
Fault F01910 triggers fault response OFF2 (pulse inhibit) for the infeed and OFF3 (quick stop) in the drive.
If an OFF response is not required, the fault response can be reconfigured accordingly.
Fault F01910 can be acknowledged immediately. The drive can then be operated even without PROFIBUS.


Figure 6-34 Monitoring message frame failure for a CPU stop

### 6.8.4 Further information about communication via PROFIBUS DP

Further information about communication via PROFIBUS DP
For more information about communication via PROFIBUS DP, refer to "Communication via PROFIBUS DP" in the accompanying "SINAMICS S120 Function Manual".

### 6.9 Communication via PROFINET IO

### 6.9.1 Activating online operation: STARTER via PROFINET IO

Description
Online operation with PROFINET IO takes place via TCP/IP.

## Requirements

- STARTER Version 4.2 or higher
- Control Unit CU320-2 PN or CBE20


## STARTER via PROFINET IO (example)



Figure 6-35 STARTER via PROFINET (example)

Procedure, Establishing online operation with PROFINET

1. Setting the IP address in Windows XP

An available fixed IP address is assigned to the PC/PG.
2. Settings in STARTER
3. Assigning the IP address and the name

The PROFINET interface must be given a name so that the STARTER can establish communication.
4. Select online operation in STARTER.

## Setting the IP address in Windows XP

On the desktop, right-click on "Network environment" -> Properties -> double-click on Network card and choose -> Properties -> Internet Protocol (TCP/IP) -> Properties -> Enter the freely-assignable addresses.


Figure 6-36 Properties of the Internet Protocol (TCP/IP)

## Settings in STARTER

The following settings are required in STARTER for communication via PROFINET:

- Tools -> Set PG/PC Interface...


Figure 6-37 Set PG/PC Interface

- Right-click Drive unit -> Target device -> Online access -> Module address


Figure 6-38 Establishing online access

## Assigning the IP address and the name

## Note

## Naming devices

ST (Structured Text) conventions must be satisfied for the name assignment of IO Devices in PROFINET (SINAMICS components). The names must be unique within PROFINET. The characters "-" and "." are not permitted in the name of an IO device.

## Assignment with STARTER, "Accessible nodes" function

Use the STARTER to assign an IP address and a name to the PROFINET interface.

- Connect the direct Ethernet cable from the PG/PC to the PROFINET interface.
- Switch on the Control Unit.
- Open STARTER.
- A search is performed for available nodes in PROFINET via Project -> Accessible nodes or the "Accessible nodes" button.
- The SINAMICS drive object is detected and displayed as a bus node with IP address 0.0.0.0 and without a name.
- Mark the bus node entry and select the displayed menu item "Edit Ethernet node" with the right mouse button.
- In the following "Edit Ethernet node" screen, enter the device name for the PROFINET interface and click the "Assign name" button. Enter the IP address (e.g., 169.254.11.22) in the IP configuration and specify the subnet mask (e.g., 255.255.0.0). Then click the "Assign IP configuration" button. Close the screen.
- The "Update (F5)" button displays the IP address and name in the entry for the bus node. If not, close the "Accessible nodes" screen and perform another search for accessible nodes.
- If the PROFINET interface is displayed as a bus node, select the entry and click the "Accept" button.
- The SINAMICS drive is displayed as a drive object in the project tree.
- Further configurations can be performed for the drive object.
- Click "Connect to target system" and load the project to the Control Unit's memory card with Target system -> Load -> To target device.


## Note

## Storage location of the IP address

The IP address and device name for the Control Unit are stored on the memory card (non-volatile).

### 6.9.2 General information about PROFINET IO

### 6.9.2.1 General information about PROFINET IO for SINAMICS

## General information

PROFINET IO is an open Industrial Ethernet standard for a wide range of production and process automation applications. PROFINET IO is based on Industrial Ethernet and observes TCP/IP and IT standards.

Deterministic signal processing in real time is important in industrial networks. PROFINET IO satisfies these requirements.

The international standard IEC 61158 ensures vendor neutrality and openness.
PROFINET IO is optimized for high-speed, time-critical data transmissions at field level.

## PROFINET IO

Within the context of Totally Integrated Automation (TIA), PROFINET IO is the systematic development of the following systems:

- PROFIBUS DP, the established fieldbus
- Industrial Ethernet, the communication bus for the cell level

Experience gained from both systems was integrated into PROFINET IO. An Ethernet-based automation standard defined by PROFIBUS International (PROFIBUS Nutzerorganisation e. V.), PROFINET IO is a manufacturer-independent communication and engineering model.

PROFINET IO defines every aspect of the data exchange between IO controllers (devices with so-called "master functionality" and the IO devices (those with so-called "slave functionality") as well as parameter assignment and diagnostic processes. A PROFINET IO system is configured by virtually the same method used for PROFIBUS.

A PROFINET IO system is assembled from the following devices:

- The IO controller controls automation tasks.
- An IO device is controlled and monitored by an IO controller. An IO device can consist of several modules and submodules.
- An IO supervisor is an engineering tool, typically based on a PC, to configure e and diagnose the individual IO devices (drive units).


## IO devices: Drive units with PROFINET interface

- SINAMICS G150 with CU320-2 DP and inserted CBE20
- SINAMICS G150 with CU320-2 PN

With SINAMICS G150 and CBE20 or with CU320-2 PN, communication via PROFINET IO with RT is possible.

## Note

CU320-2 DP and inserted CBE20
The cyclic process data channel for PROFIBUS DP is initially deactivated for CU320-2 DP and inserted CBE20. However, it can be activated again with parameter p8839 = 1 (see "Parallel operation of communication interfaces").

## References

## Note

References
PROFINET for drive technology is standardized and described in the following document:
PROFIBUS-Profile PROFIdrive - Profile Drive Technology
Version V4.1, May 2006,
PROFIBUS User Organization e. V.
Haid-und-Neu-Straße 7,
76131 Karlsruhe, Germany
http://www.profibus.com,
Order no. 3.172, spec. Section 6

- IEC 61800-7


### 6.9.2.2 Real-time (RT) and isochronous real-time (IRT) communication

## Real-time communication

When communication is via TCP/IP, runtimes may occur that are too long and are not defined for the requirements of production automation. When communicating time-critical IO user data, PROFINET IO therefore uses its own real-time channel, rather than TCP/IP.

Real time means that a system processes external events over a defined period.

## Determinism

Determinism means that a system will react in a predictable ("deterministic") manner. With PROFINET IO with IRT, it is possible to precisely determine (predict) the transmission instant.

## PROFINET IO with RT (Real Time)

Real-time data is treated with a higher priority than TCP(UDP)/IP data. Transmission of timecritical data takes place at guaranteed time intervals. RT communication is the basis for data exchange with PROFINET IO.

## PROFINET IO with IRT (Isochronous Real Time)

Isochronous Real Time: Real time property of PROFINET IO in which IRT frames are transmitted deterministically and via planned communication paths in a defined sequence to achieve the best possible synchronism and performance between the IO controller and IO device (drive unit). IRT is also known as scheduled communication in which knowledge about the network structure (topology) is utilized. IRT requires special network components that support scheduled data transmission.

SINAMICS cycle times of minimum $250 \mu$ (on-board) / $500 \mu$ (CBE20) and a jitter accuracy of less than $1 \mu \mathrm{~s}$ can be achieved when this transmission method is implemented.


Figure 6-39 Bandwidth distribution/reservation, PROFINET IO

### 6.9.2.3 Addresses

## MAC address

Every Ethernet and PROFINET interface is assigned a worldwide unique device identifier in the factory. This 6-byte long device identifier is the MAC address. The MAC address consists of:

- 3-byte manufacturer identification
- 3-byte device identification (consecutive number)

The MAC address is printed on a label (CBE20) or specified on the type plate (CU320-2 PN), e.g.: 08-00-06-6B-80-C0.

The Control Unit CU320-2 PN has two onboard interfaces:

- One Ethernet interface
- A PROFINET interface with two ports

The two MAC addresses of the Ethernet and PROFINET interfaces are stamped on the type plate.

## IP address

The TCP/IP protocol is a prerequisite for establishing a connection and for parameter assignment. For a PROFINET device to be addressed as a node on Industrial Ethernet, this device also requires an IP address that is unique within the network. The IP address is made up of 4 decimal numbers with a range of values from 0 through 255. The decimal numbers are separated by a decimal point.
The IP address comprises:

- Address of the station (also called host or network node)
- Address of the (sub)network


## IP address assignment

The IP addresses of IO devices can be assigned by the IO controller and always have the same subnet mask as the IO controller. In this case, the IP address is not stored permanently. The IP address entry is lost after POWER ON/OFF. The IP address can be assigned retentively via the STARTER function "Accessible nodes".

This function can also be performed in STEP 7 HW Config. Here, the function is called "Edit Ethernet node".

## Note

IP addresses of the onboard interfaces
It is not permissible that the IP address band of the Ethernet interface and the PROFINET interface are the same. The factory setting of the IP address of the Ethernet interface X127 is 169.254.11.22; the subnet mask is 255.255.0.0.

Ethernet interface X 127 is intended for commissioning and diagnostics.
Do not use this interface for other purposes and ensure that X127 is always accessible (e.g. for service).

## Note

## Part of a company network

If the network is part of an existing Ethernet company network, obtain the information (IP address) from your network administrator.

## Device name (NameOfStation)

An IO device does not have a device name upon delivery. An IO device can only be addressed by an IO controller, for example, for the transfer of project engineering data (including the IP address) during startup or for user data exchange in cyclic operation, after it has been assigned a device name with the IO supervisor.

## Note

## Non-volatile saving of the device name

The device name must be stored retentively either with STARTER or with HW Config of STEP 7.

## Note

Address data for ports
You can enter the address data for the internal PROFINET ports X150 P1 and P2 in STARTER in the expert list using parameters p8920, p8921, p8922, and p8923.

You can enter the address data for the ports of the CBE20 module in STARTER in the expert list using parameters p8940, p8941, p8942, and p8943.

## Replacement of Control Unit (IO device)

If the IP address and device name are stored in non-volatile memory, this data is also forwarded with the memory card of the Control Unit. The memory card allows the module to be replaced without an IO supervisor when a fault occurs in a PROFINET device.

If an entire Control Unit needs to be replaced due to a device or module defect, the new Control Unit automatically carries out parameter assignment and configuration based on the data on the memory card. Following this, cyclic exchange of user data is restarted.

### 6.9.2.4 Data transmission

## Properties

The Communication Board CBE20 supports:

- IRT - isochronous real-time Ethernet
- RT - real-time Ethernet
- Standard Ethernet services (TCP/IP, LLDP, UDP and DCP)


## PROFIdrive frame for cyclic data transmission, acyclic services

Message frames for sending and receiving process data are available for each drive object of a drive unit with cyclic process data exchange.
In addition to cyclic data transfer, acyclic services can also be used for parameter assignment and configuration of the drive. These acyclic services can be utilized by the IO supervisor or IO controller.

## Sequence of drive objects in the message frame

On the drive side, the sequence of drive objects in the message frame is displayed via a list in p0978[0...24] where it can also be changed.

You can use the STARTER commissioning tool to display the sequence of drive objects for a commissioned drive system in online mode under "Drive unit" > "Communication" > "Message frame configuration".

When you create the configuration on the controller side (e.g. HW Config), the process-datacapable drive objects for the application are added to the message frame in this sequence.

## Note

Order of the drive objects
The sequence of drive objects in HW Config must be the same as that in the drive (p0978).
Drive objects after the first zero in p0978 must not be configured in HW Config.

The frame structure depends on the drive objects taken into account during configuration. Configurations that do not take into account all of the drive objects present in the drive system are permitted.

### 6.9.2.5 Communication channels

## PROFINET connection channels

- A Control Unit has an integrated Ethernet interface (X127).
- The Control Unit CU320-2 PN has a PROFINET interface (X150) with two ports onboard: P1 and P2
- A Control Unit CU320-2 PN can establish a total of 8 communication connections simultaneously via the integrated PROFINET interfaces.


## Control Unit with CBE20

The CBE20 communication board can be optionally inserted into Control Unit CU320-2 PN or CU320-2 DP:

- The Communication Board CBE20 is a PROFINET switch with 4 additional PROFINET ports.


## Note

## PROFINET routing

Routing is not possible between the onboard interfaces X127 and X150 of the CU320-2 PN or between the onboard interfaces of the CU320-2 PN and an inserted CBE20.

### 6.9.3 Communication with CBE20

### 6.9.3.1 Selecting the CBE20 firmware

The CBE20 is a Communication Board that can be flexibly used and which can be operated with different communication profiles. Only one firmware of a communication profile can be loaded at any one time. The available firmware files are saved with the communication profiles in UFW files on the Control Unit memory card.

The required file is selected using parameter p8835. A POWER ON must be carried out after selecting the desired UFW file. During the subsequent system boot, the corresponding UFW file is loaded. The new selection then becomes active.

Table 6-28 Functionality and selection in the pointer file

| Functionality (p8835) | Pointer file content |
| :--- | :---: |
| PROFINET device | 1 |
| PN Gate | 2 |
| SINAMICS Link | 3 |
| EtherNet/IP | 4 |
| Customer-specific ${ }^{1}$ ) | 99 |

1) Path for the UFW file and folders on the memory card: /OEM/SINAMICS/CODE/CB/CBE20.UFW

## Identification of the firmware version

Using parameter r8858, the loaded firmware version of the PROFINET interface can be identified uniquely.

## Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p8835

CBE20 firmware selection

- r8858[0...39] COMM BOARD read diagnostics channel


### 6.9.3.2 EtherNet/IP

SINAMICS S120 supports the communication with the fieldbus EtherNet Industrial Protocol (EtherNet/IP or also EIP). EtherNet/IP is an open standard based on Ethernet, which is predominantly used in the automation industry. EtherNet/IP is supported by the Open DeviceNet Vendor Association (ODVA).

For communication with EtherNet/IP, an Ethernet CBE20 option board is required. By setting p8835 = 4, you can choose the communication profile EtherNet/IP. After POWER ON, the profile becomes active.

### 6.9.4 PROFINET media redundancy

To increase the availability of PROFINET, you can create a ring topology. If the ring is interrupted at one point, the data paths between the devices are automatically reconfigured. After reconfiguration, the devices can be re-accessed in the new topology that is created.

To create a ring topology with media redundancy, route the two ends of a line-type PROFINET topology to a switch which serves as redundancy manager (e.g. a suitable SCALANCE switch). Closing the linear bus topology is realized using 2 ports (ring ports) of the SCALANCE redundancy manager, which monitors the data telegrams in the PROFINET ring. All other connected PROFINET nodes are redundancy clients.
The Media Redundancy Protocol (MRP) is the standard procedure for media redundancy. Using this procedure, a maximum of 50 devices can participate in each ring. In the case of an interrupted cable, data transfer is only briefly interrupted as the system switches over to the redundant data path.

If a short-term interruption is not permitted, data transfer must be set to IRT High Performance. The uninterruptible MRRT is then automatically set. A SIMOTION controller (or another suitable controller) is required in this case.

The two integrated PROFINET IO interfaces of the Control Units CU320-2 PN can be configured as redundancy clients.

For a CBE20, only the first two ports are capable of establishing a ring topology. Routing between the integrated PROFINET IO interfaces and a CBE20 is not possible.

### 6.9.5 PROFINET system redundancy

### 6.9.5.1 Overview

Redundant systems can be created when using the SINAMICS PROFINET Control Unit CU320-2 PN.

Precondition for system-redundant systems is a so-called H -system. The H -system consists of 2 fault-tolerant controls (master and reserve CPU), which are constantly synchronized via fiber-optic cables. If one controller fails, the other automatically takes on the job. This reduces system downtimes.

## Preconditions

- SIMATIC controller S7-400H with two PROFINET H-CPUs type 41xH
- SINAMICS drive with a PROFINET Control Unit (CU320-2 PN)
- Redundant communication links


## Benefits

- No system downtime in the case of a controller failure
- Component replacement possible during ongoing operation
- Configuration changes possible during ongoing operation
- Automatic synchronization after replacing components


## Restrictions

- IRT is not supported.
- No simultaneous operation of Shared Device and system redundancy.
- Maximum 2 cyclic PROFINET connections.
- System redundancy is only possible via the onboard interface of SINAMICS PROFINET Control Unit (CU320-2 PN)
- For the duration of switching from one controller to the other, the setpoints of the last connection remain frozen and valid.


### 6.9.5.2 Design, configuring and diagnostics

## Configuration

The figure below shows a sample structure of a system-redundant controller with 3 converters.


Figure 6-40 System redundancy with converters

## Configuring

Configuring the redundancy takes place in STEP 7. In the converter, you only have to configure the communication via PROFINET.

System redundancy does not depend on the topology of the system.

## Diagnostics LEDs

Diagnostics states are shown as follows using LEDs with PROFINET system redundancy:

| Color | State | Significance |
| :--- | :--- | :--- |
| Green | Continuous light | 2 redundancy connections available and setpoints are OK. |
| Green | Flashing light | Only one redundancy connection is available or setpoints are missing. |
| Red | Flashing light 2 Hz | No connection or setpoint failure (F01910). |

## Additional information

You can find further descriptions of the PROFINET system redundancy online in the following manuals:

- System manual "Fault-tolerant SIMATIC S7-400H systems"

SIMATICS S7-400H Manual
(https://support.industry.siemens.com/cs/ww/en/view/82478488)

- Application description Configuration examples for S7-400H PROFINET SIMATICS S7-400H configuration examples (https://support.industry.siemens.com/cs/ww/en/view/90885106)


### 6.9.5.3 Faults, alarms and parameters

## Faults and alarms

- F01910 (N, A) Fieldbus: Setpoint timeout
- A01980 PN: Cyclic connection interrupt
- A01982 PROFINET: Second controller missing
- A01983 PROFINET: System redundancy switchover


## Parameters

- r2043.0... 2 BO: IF1 PROFIdrive PZD status
- r8843.0... 2 BO: IF2 PZD status
- r8936[0...1] PN state of the cyclic connection
- r8937[0...5] PN diagnostics
- r8960[0...2] PN subslot controller assignment
- r8961[0...3] PN IP Address Remote Controller 1
- r8962[0...3] PN IP Address Remote Controller 2


### 6.9.6 PROFIenergy

### 6.9.6.1 Description

PROFlenergy is an energy management system for production plants, based on the PROFINET communication protocol. The functionality is certified in the PROFlenergy profile of the PNO. Drive units which have PROFlenergy functionality, can be certified in an approved laboratory. Certified devices support the PROFlenergy commands and respond accordingly to the requirements and operating states.
SINAMICS supports PROFlenergy profile V1.1. PROFlenergy commands are transferred from the controller to the drive with PROFINET data sets in acyclic operation. The PROFlenergy commands are transferred using the PROFINET data set 0x80A0.

The following table provides an overview of the PROFlenergy functionality and the support of the various SINAMICS devices.

| Functions |  | SINAMICS support |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\begin{aligned} & \stackrel{y}{O} \\ & \stackrel{y}{0} \\ & \stackrel{y}{2} \\ & \text { O} \\ & \frac{\mathrm{N}}{2} \end{aligned}$ | $\frac{\circ}{i n}$ | $\begin{aligned} & \sum_{0}^{5} \\ & \hline 0 \end{aligned}$ | $\begin{aligned} & \text { O-N } \\ & \text { N0 } \end{aligned}$ |  | $\stackrel{\text { O}}{\stackrel{0}{0}}$ | $\frac{80}{0}$ | $\begin{aligned} & \text { 을 } \\ & \text { 은 } \\ & \text { 븐 } \\ & \hline \end{aligned}$ |
| Control commands |  | x | x | x | x | x | x | x | x | x |
| Query commands |  | X | x | X | x | X | x | x | X | x |
| Measured values | ID 34 | X | X | X | X | X | x | X | X | x |
|  | ID 166 | - | x | x | x | x | x | x | x | x |
|  | ID 200 | x | x | x | x | x | x | x | x | x |
| Measuring value access |  | x | x | x | x | x | x | x | x | x |
| PROFlenergy energy-saving mode 1 | Shutdown Digital outputs | - | - | - | - | X | - | - | - | - |
|  | Shutdown <br> Encoder | - | - | - | - | X | - | - | - | - |
| PROFlenergy energy-saving mode 2 | Switch on interlocking | X | X | X | X | - | X | X | X | X |
| Inhibit PROFlenergy |  | x | x | x | X | X | x | X | X | x |
| PROFlenergy energy-saving mode in PROFIdrive state S3/S4 |  | - | - | - | x | X | x | x | X | x |

Figure 6-41 PROFlenergy functions

### 6.9.6.2 Tasks of PROFlenergy

PROFlenergy is a data interface based on PROFINET. It allows loads to be shut down during non-operational periods in a controlled fashion, and irrespective of the manufacturer and device. Consequently, the process should be given only the energy it actually requires. The majority of the energy is saved by the process, the PROFINET device itself contributes only a few watts to the saving potential.


Figure 6-42 Energy saving during pauses with PROFlenergy
The following objectives are reached in detail by temporarily shutting down or stopping unused drives and equipment:

- Lower energy costs.
- Reduction of thermal emissions.
- Longer service life by reducing the effective operating times
- The drive units provide standardized consumption data for analysis.
- The PROFlenergy state of the participating devices is displayed.
- The PROFlenergy state is available with BICO interconnections for further processing, e.g. to shutdown secondary systems that are not required.


## Basics

The PROFINET devices and the power modules are shut down using special commands in the user program of the PROFINET IO controller. No additional hardware is required; the PROFlenergy commands are interpreted directly by the PROFINET devices.

### 6.9.6.3 PROFIenergy - Properties of the drive system

SINAMICS drive system devices meet the following requirements:

- The devices are certified for PROFlenergy.
- The devices support the PROFlenergy Class 3 functional unit.
- The devices support the PROFlenergy energy-saving mode 2.


### 6.9.6.4 PROFlenergy - Commands

## Principle of operation

At the start and end of pauses, the plant operator activates or deactivates the pause function of the plant after which the IO controller sends the PROFlenergy "START_Pause" /
"END_Pause" command to the PROFINET devices. The device then interprets the content of the PROFlenergy command and switches off or on again.

Further PROFlenergy functions can be used to fetch device information during the pauses. The user can use them to transfer the "START_Pause" / "END_Pause" command in time.

## PROFlenergy control commands

| Control commands | Description |
| :--- | :--- |
| START_Pause | Switches from the operating state to the energy-saving mode <br> depending on the pause duration. <br> Switches from the energy-saving mode to the operating state <br> depending on the pause duration. |
| START_Pause_with_time_response | Switches from the operating state to the energy-saving mode <br> and also specifies the transition times in the command <br> response. |
| END_Pause | Switches from the energy-saving mode to the operating state. <br> Cancels a switch from the operating state to the energy-saving <br> mode. |

## PROFlenergy query commands

| Query commands | Description |
| :--- | :--- |
| List_Energy_Saving_Modes | Determines all supported energy-saving modes. |
| Get_Mode | Determines the energy-saving mode. |
| PEM_Status | Determines the current PROFlenergy status. |
| PEM_Status_with_CTTO | Determines the current PROFlenergy status, such as the PEM <br> status and together with the regular transition time to the <br> operating state. |
| PE_Identify | Determines the supported PROFlenergy commands. |
| Query_Version | Shows the implemented PROFlenergy profile. |
| Get_Measurement_List | This command returns the measured value IDs that can be <br> accessed using the "Get_Measurement_Values" command. |
| Get_Measurement_List_with_object <br> _number | This command returns the measured value IDs and the <br> associated object number that can be accessed using the <br> "Get_Measurement_Values_with_object_number" command. |


| Query commands | Description |
| :--- | :--- |
| Get_Measurement_Values | The command returns the requested measured value using the <br> measured value ID: <br> - For power measured values: The command addresses the <br> sum of the measured value over all control drive objects. <br> - For energy measured values: The command returns the <br> sum of the measured value over all control drive objects. <br> - For power factors: This measured value is supported only <br> for a SINAMICS with a control drive object. |
| Get_Measurement_Values_with_ <br> object_number | This command returns the measurement values requested <br> using the measurement value ID and the object number. The <br> object number corresponds to the drive object ID. <br> The drive object ID of the Control Unit is used to address the <br> measured values as with "Get_Measurement_Value". |

### 6.9.6.5 PROFlenergy - Measurement values

Table 6-29 Overview of the PROFlenergy measured values

| PROFlenergy measured value |  | PROFlenergy accuracy |  | Unit | SINAMICS source parameters | Value range |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | ID | Name | Domain |  |  | Parameters | Name |

### 6.9.6.6 PROFlenergy - Energy-saving mode

The drive units support PROFlenergy energy-saving mode 2. The following two parameters indicate the effective PROFlenergy mode:

- Parameter r5600 indicates the currently active PROFlenergy mode.
- Using interconnectable bits, the r5613 parameter indicates whether the PROFlenergy energy saving is active.


## Activating the energy saving mode

The energy-saving mode can activated or deactivated for the drive devices using the PROFlenergy control commands (see also PROFlenergy commands).

## General converter behavior when in the PROFlenergy energy-saving mode

- When the PROFlenergy energy-saving mode is active, the inverter issues alarm A08800.
- When the PROFlenergy energy-saving mode is active, the inverter does not send any diagnostic alarms.
- When the PROFlenergy energy-saving mode is active, then the READY-LED flashes green in the on / off ratio: 500 ms on, 3000 ms off.
- If the bus connection to the control system is interrupted while the inverter is in the energy-saving mode, the inverter exits the energy-saving mode and resumes normal operation ("ready_to_operate").
- The inverter changes into normal operation if the control system goes into the stop condition while the inverter is in the energy-saving mode.


### 6.9.6.7 Transition to energy-saving mode from PROFIdrive Operation state (S4)

If you set p5611.2 = 1, you enable the transition to energy-saving mode from PROFIdrive Operation state (S4)

To do so, you must make one of the following settings:

- p5611.1 = 1: with the transition to energy-saving mode, the drive issues an OFF1 command and enters the Switching On Inhibited state (S1).
- p5611.1 = 0: You use p5614 to interconnect a signal source that you use to switch off the drive and place it in Switching On Inhibited state (S1).

If the control sends the command "End_Pause" or "Start_Pause" with a pause time of 0, the converter continues to run automatically - if the enables are still set.

### 6.9.6.8 Disabling PROFlenergy and pause time

## Disabling PROFlenergy

If you set p5611.0 $=1$, you disable the response of the converter to PROFlenergy control commands. In this case, the converter ignores the PROFlenergy control commands.

## Pause time

- Minimum pause time: p5602
- When the pause time, which is sent using command "Start_Pause", is equal to or greater than the value in p5602[1], then the inverter goes into the energy-saving mode.
- If the pause time is less than p5602[1], the inverter ignores the command.
- Maximum duration: p5606


### 6.9.6.9 PROFlenergy applications

Applications for PROFlenergy and for programming with SIMATIC S7 are available at the following link: PROFIenergy applications (http://support.automation.siemens.com/WW/view/en/20229805/136000\&csplffrm=12\&cssw= 0\&csbinh=0).

### 6.9.6.10 Function diagrams and parameters

## Function diagrams

FP 2381 PROFlenergy - Control commands / query commands
FP 2382 PROFlenergy - States
FP 2610 Sequence control - Sequencer

## Parameters

- r5600 Pe hibernation ID
- p5602[0...1] Pe hibernation pause time, minimum
- p5606[0...1] Pe hibernation duration, maximum
- p5611 Pe energy-saving properties, general
- p5612[0...1] Pe energy-saving properties, mode-dependent
- r5613.0... 1 CO/BO: Pe energy-saving active/inactive
- p5614 BI: Set Pe switching on inhibited signal source


### 6.9.7 Support of I\&M data sets $1 . . .4$

## Identification \& Maintenance (I\&M)

I\&M data records contain information for a standardized and simplified identification and maintenance of PROFINET devices. I\&M data sets $1 . . .4$ contain plant-specific information, such as the installation location and date. PROFINET supports I\&M data sets $0 . . .4$.

I\&M data sets $1 . . .3$ can be set with the SIMATIC Manager (STEP 7) and also with HW Config (STEP 7).

## I\&M parameters

Table 6-30 Parameter designation, assignment and meaning

| I\&M parameter <br> designation | Format | Size/ <br> octets | Initialization | SINAMICS <br> parameters | Meaning |
| :--- | :--- | :---: | :--- | :--- | :--- |
| I\&M 0: <br> IM_SUPPORTED | - | - | - | r8820[62,63] | The parameter indicates which I\&M data sets <br> are supported. <br> The value 0x1E indicates that I\&M data sets <br> $1 \ldots .4$ are available. |
| I\&M 1: <br> TAG_FUNCTION | Visible <br> string | 32 | Space <br> 0x20...0x20 | p8806[0...31] | Text that identifies the function or task of the <br> device. |
| I\&M 1: <br> TAG_LOCATION | Visible <br> string | 22 | Space <br> 0x20...0x20 | p8806[32...53 |  |
| I\&M 2: <br> INSTALLATION_ <br> DATE | Visible <br> string | 16 | Space that identifies the device location. <br> $0 \times 20 \ldots 0 \times 7 E$ | p8807[0...15] | Text with the date of the installation or the <br> initial commissioning of the device. The <br> following date formats are supported: <br> YYYY-MM-DD |


| I\&M parameter designation | Format | Size/ octets | Initialization | SINAMICS parameters | Meaning |
| :---: | :---: | :---: | :---: | :---: | :---: |
| I\&M 4: SIGNATURE | Octet string | 54 | $\begin{aligned} & \text { Space } \\ & 0 \times 00 \ldots 0 \times 00 \end{aligned}$ | p8809[0...53] | The parameter can be filled automatically by the system, in which case it contains a standard value, namely, a functional check signature for the change tracking by Safety Integrated. The check signature has the following format: <br> - The first four octets (0...3) contain the content of parameter r9781 index 0: "SI change monitoring checksum (Control Unit)". <br> - The second four octets (4...7) contain the content of parameter r9782 index 0: "SI change monitoring time stamp (Control Unit)". <br> - The remainder (octets $8 . . .53$ ) contains zeroes. <br> Alternatively, a user can enter a user value from an application and so overwrite the standard value. Parameter p8805 specifies which value is entered in p8809: <br> - p8805 $=0$ standard value entered <br> - p8805 = 1 user value entered <br> When p8805 = 0 is set, the standard setting for p8809 is restored again. |

The I\&M data sets $1 \ldots 4$ are stored permanently in parameters p8806...p8809. Significant properties of these four parameters:

- They can be displayed in the STARTER expert list.
- The SINAMICS "Reset parameter" (p0976 = 1, p0970 = 1) function does not have any effect on the content of parameters.
- I\&M data sets are not changed when the alternative parameter sets are stored or loaded. The transfer of parameter sets between a memory card and non-volatile device memory does not have any effect on the I\&M data sets.


## Parameters

- p8805[0...1] Identification and Maintenance configuration
- p8806[0...53] Identification and Maintenance 1
- p8807[0...15] Identification and Maintenance 2
- p8808[0...53] Identification and Maintenance 3
- r8809[0...53] Identification and Maintenance 4


### 6.9.8 Further information about communication via PROFINET IO

Further information about communication via PROFINET IO
For more information about communication via PROFINET IO, refer to "Communication via PROFINET IO" in the accompanying "SINAMICS S120 Function Manual".

### 6.10 Communication via SINAMICS Link

### 6.10.1 Basic principles of SINAMICS Link

SINAMICS Link allows data to be directly exchanged between a maximum of 64 Control Units (CU320-2 PN and CU320-2 DP). The participating Control Units must be equipped with the CBE20 supplementary module. Other nodes cannot be integrated into this communication.

Possible applications include:

- Torque distribution for n drives
- Setpoint cascading for n drives
- Load distribution of drives coupled through a material web
- Master/slave function for infeed units


## Requirements

The following requirements must be met to operate SINAMICS Link:

- r0108.31: Function module "PROFINET CBE20" must be activated.
- r2064[1]: The bus cycle time ( $T_{d p}$ ) must be an integer multiple of $\mathrm{p} 0115[0$ ] (current controller cycle).
- r2064[2]: The master cycle time ( $T_{\text {mapc }}$ ) must be an integer multiple of p0115[1] (speed controller cycle).
- p0115[0]: The current controller cycle must be set to $250 \mu \mathrm{~s}$ or $500 \mu \mathrm{~s}$. A cycle with $400 \mu \mathrm{~s}$ is not permitted. At $400 \mu \mathrm{~s}$, alarm A01902 is output with alarm value "4". To remedy this, set the current controller cycle p0115[0] to $500 \mu \mathrm{~s}$.


## Send and receive data

The SINAMICS Link telegram contains 32 indices (0...31) for the process data (PZD1...32). Each PZD is exactly 1 word long (= 16 bits). Slots that are not required are automatically filled with zeros. There is always a fixed assignment between the index and PZD: The index i always corresponds to PZD i+1.

| Slot | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| PZD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |

SINAMICS Link telegram content, Part 1

| Slot | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :--- | :--- |
| PZD | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |

SINAMICS Link telegram content, Part 2
Each transfer cycle, every SINAMICS Link node can send 1 telegram with 32 PZD. Each node receives all of the message frames that are sent. For each transfer cycle clock, a node can select and process up to 32 PZD from all telegrams that have been received. Single words and double words can be sent and received. You must write double words in two consecutive PZD.

Limitations:

- In a message frame, a PZD may only be sent and received once. If a PZD occurs more than once in a message frame, then alarm A50002 or A50003 is output.
- Reading in own transmit data is not possible; otherwise a corresponding alarm A50006 is output.
- A50006: It is configured that own data sent can be received. This is not permitted.
- A50007: The send telegram word is larger than possible in the project.
- A50008: The receive telegram word is larger than possible in the project.
- The maximum number of PZD that can be received and sent also depends on the drive object. The number of PZDs that can be evaluated corresponds to communication according to PROFldrive; however, for SINAMICS Link, it is limited to a maximum of 32 PZDs.
- If, as a result of a project download, parameters of the CBE20 are change, then alarm A08531 is output. In this case, a POWER ON is required to activate the values.


## Transmission time

With SINAMICS Link, a transmission time of up to $500 \mu$ s is possible (with a max. controller cycle of $500 \mu \mathrm{~s}$; synchronous bus cycle of $500 \mu \mathrm{~s}$ ).

## Bus cycle and number of nodes

The bus cycle of the SINAMICS Link may be operated either synchronized with the current controller cycle or not synchronized.

- Synchronized operation is set with $\mathrm{p} 8812[0]=1$.

Up to 16 nodes can communicate with each other via SINAMICS Link with a $500 \mu \mathrm{~s}$ bus cycle. To do this, the maximum number of nodes must be set with p8811 = 16 .

Up to 64 nodes can communicate with each other via SINAMICS Link with a $1000 \mu \mathrm{~s}$ or $2000 \mu \mathrm{~s}$ bus cycle. To do this, the maximum number of nodes must be set with p8811 = 64 .

- In non-synchronized operation ( $\mathrm{p} 8812[0]=0$ ), the PZD sampling time ( $\mathrm{p} 2048 / \mathrm{p} 8848$ ) is active instead of the bus cycle (p8812[1]).
After changing over parameter p8811 and p8812, a POWER ON must be carried out to accept the settings.


### 6.10.2 Topology

Only a line topology with the following structure is permitted for SINAMICS Link.


Figure 6-43 Maximum topology

## Features

- The CBE20 can be assigned to IF1 or IF2 when SINAMICS Link is used.

The interface, assigned to the CBE20, must be switched into synchronous operation.
You must also make the following parameter settings in order to assign, e.g. IF1 to SINAMICS Link:

- For IF1: p8839[0] = 2 (COMM BOARD)
- For IF2: p8839[1] = 1 (Control Unit on-board)

The following data is applicable for the case (IF1 $\xlongequal[=]{ }$ SINAMICS Link):

- The number of the respective node must be entered manually in parameter p8836.

Each node must be assigned a different number.
Enter the numbers in ascending order starting with "1".

- If p8836 is set to 0 , the nodes and the complete following line is shut down for SINAMICS Link.
- Gaps in the numbering are not permitted, as then SINAMICS Link would not function.
- The associated IP addresses are assigned automatically, but are however not visible.
- The node with the number 1 is automatically the sync master of the communication link.
- For non-synchronized operation (p8812[0] = 0), a maximum of 64 nodes is possible (p8811 = 64).
- With synchronized operation ( $\mathrm{p} 8812[0]=1$ ), up to 16 nodes ( $\mathrm{p} 8811=16$ ) are possible with a $500 \mu \mathrm{~s}$ bus cycle and up to 64 nodes (p8811 $=64$ ) with a $1000 \mu \mathrm{~s}$ or $2000 \mu \mathrm{~s}$ bus cycle.
- The ports of the CBE20 must be interconnected strictly in accordance with the above diagram. You must always connect port 2 (P2) of node $n$ with port 1 (P1) of node $n+1$.
- In the "SINAMICS Link" mode, ports 3 and 4 of the CBE20 can only be used in conjunction with the STARTER commissioning tool.


## Corresponding parameters for IF1 or IF2

Use different parameters for configuring, depending on which interface SINAMICS Link is assigned:

Table 6-31 Corresponding parameters for IF1 or IF2

| Parameters | IF1 | IF2 |
| :--- | :---: | :---: |
| Setting of the processing mode for PROFIdrive STW1.10 "Control by PLC". | p2037 | p8837 |
| Connector output to interconnect the PZD (setpoints) received from the fieldbus controller in <br> the word format. | r2050 | r8850 |
| Selects the PZD (actual values) to be sent to the fieldbus controller in the word format. | p2051 | p8851 |
| Displays the PZD (actual values) sent to the fieldbus controller in the word format. | r2053 | r8853 |
| Connector output to interconnect the PZD (setpoints) received from the fieldbus controller in <br> the double word format. | r 2060 | r8860 |
| Selects the PZD (actual values) to be sent to the fieldbus controller in the double word format. | p2061 | p8861 |
| Displays the PZD (actual values) sent to the fieldbus controller in the double word format. | r2063 | r8863 |

### 6.10.3 Configuring and commissioning

## Commissioning

When commissioning, proceed as follows:

1. Set the Control Unit parameter $\mathrm{p} 0009=1$ (device configuration).
2. Set the Control Unit parameter p8835 $=3$ (SINAMICS Link).
3. Using p8839, define which interface should be used (for example for IF1: p8839[0] = 2 ).
4. If SINAMICS Link is assigned to IF1, set parameter p2037 of the drive objects to 2 (do not freeze setpoints).
If SINAMICS Link was assigned IF2, then p8837 must be used for the setting.
5. Assign the nodes in parameter p8836 to the SINAMICS Link node number.

The first Control Unit is always assigned the number 1. Node number 0 means that for this Control Unit SINAMICS Link has been shut down. Observe the specifications under "Topology".
6. Set the Control Unit parameter p0009 $=0$ (ready).
7. Then execute a "Copy RAM to ROM".
8. Perform a POWER ON (switch-off/switch-on).

## Sending data

## Note

The parameters listed in the following description refer to the assignment of SINAMICS Link to IF1. If you assigned SINAMICS Link to IF2, then you find the corresponding parameters in the previous chapter.

In this example, the first node "Control Unit 1" has two drive objects: "Drive 1" and "Drive 2". Proceed as follows to send data:

1. If SINAMICS Link is assigned to IF1, then for each drive object, in its associated parameter p2051[0...31], you define which data (PZDs) should be sent.
If SINAMICS Link was assigned IF2, then p8851 must be used for the setting. The data must be simultaneously assigned to a send slot of the p8871[0...31].
2. Enter the double words in $\mathrm{p} 2061[\mathrm{x}]$.

If SINAMICS Link was assigned to IF2, then the double word data must be written to p8861[0...31].
3. For each drive object, allocate the send parameters in p8871[0...31] to a send slot of its own node.

Table 6-32 Compiling send data of drive 1 (DO2)

| $\begin{aligned} & \text { p2051[x] } \\ & \text { Index } \end{aligned}$ | $\mathrm{p} 2061[\mathrm{x}]$ <br> Index | Contents | From parameter | Slots in the send buffer$\qquad$$\mathrm{p} 8871[\mathrm{x}]$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | X | Telegram word |
| 0 | - | ZSW1 | r0899 | 0 | 1 |
| - | 1 | Actual speed value part 1 | r0061[0] | 1 | 2 |
| - |  | Actual speed value part 2 |  | 2 | 3 |
| - | 3 | Actual torque value part 1 | r0080 | 3 | 4 |
| - |  | Actual torque value part 2 |  | 4 | 5 |
| 5 | - | Current fault code | r2131 | 5 | 6 |
| 6 | - | 0 | 0 | 6 | 0 |
| .. |  | ... |  | ... | ... |
| 15 | - | 0 | 0 | 15 | 0 |
| ... |  | ... |  | ... | ... |
| 31 | - | 0 | 0 | 31 | 0 |

Table 6-33 Compiling send data of drive 2 (DO3)

| p2051[x] <br> Index | $\mathrm{p} 2061[\mathrm{x}]$ <br> Index | Contents | From parameter | Slots in the send buffer p8871[x] |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | X | Telegram word |
| - | - | - | - | 0... $5^{1)}$ | 0 |
| 0 | - | ZSW1 | r0899 | 6 | 7 |
| - | 1 | Actual speed value part 1 | r0061[0] | 7 | 8 |
| - |  | Actual speed value part 2 |  | 8 | 9 |
| - | 3 | Actual torque value part 1 | r0080 | 9 | 10 |
| - |  | Actual torque value part 2 |  | 10 | 11 |
| 5 | - | Current fault code | r2131 | 11 | 12 |
| 6 | - | 0 | 0 | 12 | 0 |
| ... |  | ... |  | $\ldots$ | ... |
| 15 | - | 0 | 0 | 15 | 0 |
| $\ldots$ |  | ... |  | $\ldots$ | $\ldots$ |
| 31 | - | 0 | 0 | 31 | 0 |

1) $0 . . .5$ here remain free, as they are already assigned by DO 2 .

Table 6-34 Compiling send data of Control Unit 1 (DO1)

| $\mathrm{p} 2051[\mathrm{x}]$ <br> Index | $\mathrm{p} 2061[\mathrm{x}]$ <br> Index | Contents | From parameter | Slots in the send buffer p8871[x] |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | x | Telegram word |
| - | - | - | - | 0...11 ${ }^{1)}$ | 0 |
| 0 | - | Control word, faults/alarms | r2138 | 12 | 13 |
| - | 1 | Missing enables part 1 | r0046 | 13 | 14 |
| - |  | Missing enables part 2 |  | 14 | 15 |
| 15 | - | 0 | 0 | 15 | 0 |
| $\ldots$ |  | ... |  | ... | $\ldots$ |
| 31 | - | 0 | 0 | 31 | 0 |

1) $0 . . .11$ here remain free, as they are already assigned by DO2 and DO3.

Send slots PZD 16 to 31 are not required for this telegram and are therefore filled with a zero.

1. For double words (e.g. $1+2$ ), assign two consecutive send slots, e.g. p2061[1] => p8871[1] = PZD 2 and p8871[2] = PZD 3.
2. Enter the following PZD into the next parameter slots of $\mathrm{p} 2051[\mathrm{x}]$ or $\mathrm{p} 2061[2 \mathrm{x}]$.
3. You must fill the unused slots of $\mathrm{p} 8871[0 . . .31]$ with zeros.
4. The sequence of the PZDs in the send telegram of this node are defined in parameter p8871[0...31] by the entries in the required slots.

## Receiving data

The sent frames of all nodes are simultaneously available on the SINAMICS Link. Each telegram has a length of 32 PZD. Each frame bears a marking of the sender. For each node, you select from all frames the PZDs that you want to receive. You can process a maximum of 32 PZD.

## Note

## The first word of the receive data

If you have not deactivated the evaluation of bit 10 with p2037 $=2$, the first word of the receive data (PZD 1) must be a control word, where bit $10=1$ is set.

In this example, Control Unit 2 receives selected data from the telegram of Control Unit 1. Proceed as follows to receive data:

1. In parameter p8872[0...31] enter the address of the node for which you want to read one or more PZDs (e.g. p8872[3] = $1 \rightarrow$ from node 1, read in PZD 4, p8872[15] = $0 \rightarrow$ do not read in PZD 16).
2. After setting the parameters, using parameter r2050[0...31] or r2060[0...31] you can read out the values.

Table 6-35 Receive data for Control Unit 2

| From the sender |  | Receiver |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sent from | $\begin{aligned} & \text { Tel. Word }{ }^{1)} \\ & \text { p8871[x] } \end{aligned}$ | Address p8872[x] | Receive buffer p8870[x] | Data sent to |  | Parameter | Contents |
|  |  |  |  | r2050[x] | r2060[x] |  |  |
| p2051[0] | 0 | 1 | PZD 1 | 0 | - | r0899 | ZSW1 |
| p2061[1] | 1 | 1 | PZD 2 | - | 1 | r0061[0] | Actual speed value part 1 |
|  | 2 | 1 | PZD 3 | - |  | r0061[0] | Actual speed value part 2 |
| p2061[3] | 3 | 1 | PZD 4 | - | 3 | r0080 | Actual torque value part 1 |
|  | 4 | 1 | PZD 5 | - |  |  | Actual torque value part 2 |
| p2051[5] | 5 | 1 | PZD 6 | 5 | - | r2131 | Current fault code |
| p2051[4] | 6 | 1 | PZD 7 | 6 | - | r0899 | ZSW1 |
| p2061[5] | 7 | 1 | PZD 8 | - | 7 | r0061[0] | Actual speed value part 1 |
|  | 8 | 1 | PZD 9 | - |  |  | Actual speed value part 2 |
| p2061[6] | 9 | 1 | PZD 10 | - | 9 | r0080 | Actual torque value part 1 |
|  | 10 | 1 | PZD 11 | - |  |  | Actual torque value part 2 |
| p2051[7] | 11 | 1 | PZD 12 | 11 | - | r2131 | Current fault code |
| p2051[8] | 12 | 1 | PZD 13 | 12 | - | 2138 | Control word, faults/alarms |
| p2061[9] | 13 | 1 | PZD 14 | - | 13 | r0046 | Missing enables part 1 |
|  | 14 | 1 | PZD 15 | - |  |  | Missing enables part 2 |
| - | 15 | 0 | PZD 16 | 15 | - | 0 | Empty |
| ... | ... | $\ldots$ | ... | ... | ... | ... | $\ldots$ |
| - | 31 | 0 | PZD 32 | 31 | 0 | 0 | - |

[^3]
## Note

For double words, two PZDs must be read in succession. To do this, read in a 32 bit setpoint, which is on PZD $2+$ PZD 3 of the telegram of node 2. Emulate this setpoint on PZD 2 + PZD 3 of node 1: $\mathrm{p} 8872[1]=2, \mathrm{p} 8870[1]=2, \mathrm{p} 8872[2]=2, \mathrm{p} 8870[2]=3$

## Activation

To activate SINAMICS Link connections, perform a POWER ON for all nodes. The assignments of p2051[x]/2061[2x] and the links of the read parameters $\mathrm{r} 2050[\mathrm{x}] / 2060[2 \mathrm{x}]$ can be changed without a POWER ON.

## Settings for enclosed drives with 1.25 kHz rated pulse frequency

For the following enclosed drives with 1.25 kHz rated pulse frequency must also the set parameter p0115[0] from $400 \mu$ s to $250 \mu$ s or $500 \mu \mathrm{~s}$ can be set:

- 380-480 V AC, 3 phase: All enclosed drives with rated output current $\mathrm{I}_{\mathrm{N}} \geq 605 \mathrm{~A}$
- 500-600 V AC, 3 phase: All enclosed drives

The following conditions must be generally met:

1. r2064[1] Bus cycle time (Tdp) must be an integer multiple of p0115[0] (current controller clock cycle).
2. r2064[2] Master cycle time (Tmapc) must be an integer multiple of p0115[1] (speed control cycle).

### 6.10.4 Example

## Task

Configure SINAMICS Link for two nodes and transfer the following values:

- Send data from node 1 to node 2
- r0898 CO/BO: Control word sequence control drive 1 (1 PZD), in the example PZD 1
- r0079 CO: Total torque setpoint (2 PZD), in the example PZD 2
- r0021 CO: Smoothed actual speed (2 PZDs), in the example PZD 3
- Send data from node 2 to node 1
- r0899 CO/BO: Status word sequence control drive 2 (1 PZD), in the example PZD 1
- IF1 is used for SINAMICS Link.


## Procedure

1. For all nodes, set $\mathrm{p} 0009=1$, in order to change the device configuration.
2. For all CBE20 nodes, set the "SINAMICS Link" mode using p8835 = 3 .
3. Limit the maximum number of nodes for all nodes with p8811 $=8$. By setting p8811, parameter p8812[1] is preassigned, and parameter p8836, if necessary, is corrected.
4. Assign the node numbers for the devices involved:

- Node 1 (气 device 1): p8836 = 1- Node 2 (气 device 2): p8836 = 2

5. You can set all CBE20 to isochronous mode with $\mathrm{p} 8812[0]=1$.
6. Make the following interface setting for all nodes:

- For IF1: p8839[0] = 2 (COMM BOARD)
- For IF2: p8839[1] = 1 (Control Unit onboard)

7. For both nodes, set $\mathrm{p} 0009=0$, perform "Copy RAM to ROM" followed by a POWER ON to activate the modified firmware variant and the new settings in the CBE20.
8. Define the send data for node 1 :

- Define the PZD that node 1 is to send: p2051[0] = drive 1:r0898 (PZD 1) p2061[1] = drive1:r0079 (PZD 2 + PZD 3) p2061[3] = drive1:r0021 (PZD 4 + PZD 5)
- Place these PZD in the send buffer (p8871) of node 1: p8871[0] = 1 (r0898) p8871[1] = 2 (r0079 1st part) p8871[2] = 3 (r0079 2nd part) p8871[3] = 4 (r0021 1st part) p8871[4] = 5 (r0021 2nd part)

9. Define the receive data for node 2 :

- Specify that the data placed in the receive buffer p8872 of node 2 in locations 0 to 4 is received from node 1:
$\mathrm{p} 8872[0]=1$
p8872[1] = 1
p8872[2] = 1
p8872[3] = 1
p8872[4] = 1
- Specify that PZD1, PZD2 and PZD3 of node 1 are to be placed in the receive buffer p8870 of node 2 in locations 0 to 4:
p8870[0] = 1 (PZD1)
p8870[1] = 2 (PZD2 1st part)
p8870[2] = 3 (PZD2 2nd part)
p8870[3] $=4$ (PZD3 1st part)
p8870[4] = 5 (PZD3 2nd part)
- r2050[0], r2060[1] and r2060[3] subsequently contain (after step 13) the values of PZD 1, PZD 2 and PZD 3 of node 1.
10.Define the send data for node 2 :
- Specify the PZDs that node 2 is to send: p2051[0] = drive1:r0899 (PZD length is 1 word)
- Place this PZD in the send buffer (p8871) of node 2: p8871[0] = 1
11.Define the receive data for node 1 :
- Specify the data that will be placed in the receive buffer p8872 of node 1 in location 0 , received from node 2:
p8872[0] = 2
- Specify that PZD1 of node 2 is stored in the receive buffer p8870 of node 1 in location 0 :
p8870[0] = 1
- r2050[0] subsequently contains (after step 13) the value of PZD 1 of node 2.
12.Perform a "Copy RAM to ROM" for both nodes to back up the parameterization and the data.

13. Set p8842 =1, to activate parameters p8870, p8871 and p8872.

r0021: Actual speed smoothed
r0079: Total torque setpoint
r0898: Control word sequence control drive 1
r0899: Status word sequence control drive 2

Figure 6-44 SINAMICS Link: Configuration example

### 6.10.5 Communication failure when booting or in cyclic operation

If at least one SINAMICS Link node does not correctly boot after commissioning or fails during cyclic operation, then alarm A50005 "Sender was not found on the SINAMICS Link" is output to the other nodes.
The alarm value contains the number of the sender that could not be found. Once the problem is eliminated on the node involved, the warning is automatically canceled.
If several nodes are involved, the message occurs a multiple number of times consecutively with different node numbers. The alarm is automatically canceled after the fault has been eliminated in the node involved.

When a node fails in cyclic operation, in addition to alarm A50005, fault F08501 "COMM BOARD: Setpoint timeout" is output.

### 6.10.6 Transmission times for SINAMICS Link

Transmission times at a communication cycle of 1 ms
p2048/p8848 = 1 ms

| Bus cycle [ms] | Transmission times [ms] |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Sync both | Sync send | Sync receive | Async both |
| 0.5 | 1.0 | 1.5 | 1.3 | 1.6 |
| 1.0 | 1.5 | 2.1 | 2.1 | 2.2 |
| 2.0 | 3.0 | 3.6 | 3.1 | 2.8 |

Transmission times at a communication cycle of 4 ms
p2048/p8848 = 4 ms

| Bus cycle [ms] | Transmission times [ms] |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Sync both | Sync send | Sync receive | Async both |
| 0.5 | 1.0 | 3.0 | 2.8 | 4.6 |
| 1.0 | 1.5 | 3.6 | 3.6 | 5.2 |
| 2.0 | 3.0 | 5.1 | 4.6 | 5.8 |

### 6.10.7 Function diagrams and parameters

## Key statement

FP 2197 Control Unit communication - SINAMICS Link overview (r0108.31 = 1, p8835 = 3)
FP 2198 Control Unit communication - SINAMICS Link configuration (r0108.31 = 1, p8835 = 3)
FP 2199 Control Unit communication - SINAMICS Link receive data (r0108.31 = 1, p8835 = 3)
FP 2200 Control Unit communication - SINAMICS Link send data (r0108.31 = 1, p8835 = 3)

## Parameters

- r0108.31: Drive objects function module PROFINET CBE20
- p0115 Sampling time for additional functions
- p2037 IF1 PROFIdrive STW1.10 = 0 mode
- r2050[0...31] CO: IF1 PROFIdrive PZD receive word
- p2051[0...31] CI: IF1 PROFIdrive PZD send word
- r2060[0...30] CO: IF1 PROFIdrive PZD receive double word
- p2061[0...30] CI: IF1 PROFIdrive PZD send double word
- p8811 SINAMICS Link project selection
- p8812[0...1] SINAMICS Link cycle settings
- p8835 CBE20 firmware selection
- p8836 SINAMICS Link node address
- p8839[0...1] PZD interface hardware assignment
- p8870[0...31] SINAMICS Link PZD receive word
- p8871[0...31] SINAMICS Link PZD send word
- p8872[0...31] SINAMICS Link PZD receive address


### 6.11 Communication via EtherNet/IP

### 6.11.1 Overview

EtherNet/IP (short: EIP) is real-time Ethernet, and is mainly used in automation technology.
For communication via EtherNet/IP, you require an Ethernet CBE20 option board (option G33).
Via the onboard interface of the CU320-2 PN, no communication is possible via EtherNet/IP.

### 6.11.2 Connect drive device to Ethernet/IP

In order that your drive can be connected to a control system via Ethernet, your control system requires a generic I/O module for cyclic communication via Ethernet/IP. You manually create this generic I/O module in the control system.

## Create generic I/O module and connect the drive to the control system

To connect the drive to a control system via Ethernet, proceed as follows:

1. Connect the drive to the control system via an Ethernet cable.
2. In your control, create a generic I/O module with Ethernet/IP functionality:

- Insert a new module in your control system.
- Select a generic Ethernet module from the selection.
- Enter the network parameters for the newly inserted module (IP address, subnet mask, standard gateway, station name).

3. For the generic I/O module, enter the lengths of the process data for cyclic communication, which you have selected in STARTER, r2067[0] (input), r2067[1] (output), for example: Standard telegram 2/2.

In the STARTER telegram configuration, read out the length of the process data for all drive objects (for input and output) - and add them (see PROFIdrive "Message frames and process data (Page 299)").

- Input 101:

Here, enter the sum of all input process data of your drive objects from STARTER.

- Output 102:

Here, enter the sum of all output process data of your drive objects from STARTER.

- Configuration 103

Here, you generally enter the value 0 or 1 .
4. In STARTER, set the same values for IP address, subnet mask, standard gateway and the name station as in the control system (see section "Configuring communication (Page 371)").

Furthermore, you can find a detailed description of how to create a generic I/O module on the following Internet page:
(Creating a generic I/O module
(https://support.industry.siemens.com/cs/gr/en/view/92045369)).

## Routing and shielding Ethernet cables

You can find information on how to do this on the following Internet page:
Ethernet IP (https://www.odva.org/Publication-Download).

## Commissioning the drive in an EtherNet/IP network

To commission the drive, connect the drive via an interface (depending on the Control Unit type: PROFIBUS, PROFINET, Ethernet, etc) with your computer, on which the STARTER with version $\geq 4.5$ is installed.

### 6.11.3 Configuring communication

## Make the communication settings

Make the following settings for the CBE20 in order to communicate with a higher-level control via EtherNet/IP:

1. With p8835 $=4$, set the firmware version "Ethernet//P".
2. Set the IP address using p8941.

You can find the currently valid address in r8951.
3. Set the subnet mask using p8943.

You can find the currently valid subnet mask in r8953.
4. Set the standard gateway using p8942.

You can find the currently valid standard gateway in r8952.
5. Set the station name using p8940.

You can find the currently valid station name in r8950.
6. Set "Save and activate configuration" as interface configuration with p8945 $=2$.
7. Save the data using command "Copy RAM to ROM".
8. Perform a POWER ON.

Your settings become active after switching on.

### 6.11.4 Supported objects

## Overview

| Object class |  | Object name | Objects required | SINAMICS objects |
| :---: | :---: | :---: | :---: | :---: |
| hex | dec |  |  |  |
| 1 hex | 1 | Identity object | x | - |
| 4 hex | 4 | Assembly Object | x | - |
| 6 hex | 6 | Connection Management Object | x | - |
| 32C hex | 812 | Siemens Drive Object | - | x |
| 32D hex | 813 | Siemens Motor Data Object | - | x |
| F5 hex | 245 | TCP/IP Interface Object ${ }^{1)}$ | x | - |
| F6 hex | 246 | Ethernet Link Object ${ }^{1)}$ | x | - |
| 300 hex | 768 | Stack Diagnostic Object | - | x |
| 302 hex | 770 | Adapter Diagnostic Object | - | x |
| 303 hex | 771 | Explicit Messages Diagnostic Object | - | x |
| 304 hex | 772 | Explicit Message Diagnostic List Object | - | x |
| 401 hex | 1025 | Parameter object | - | x |
| $\begin{aligned} & 402 \text { hex ... } \\ & \text { 43E hex } \end{aligned}$ | 1026 ... 1086 | Parameter object | - | X |

1) These objects are part of the Ethernet/IP system management.

For Assembly Object " 4 hex" you define the data length. Assembly Object is assigned a cycle in the control system.

Identity Object, Instance Number: 1 hex

## Supported services

Class - Get Attribute all

- Get Attribute single

Instance - Get Attribute all

- Get Attribute single
- Reset

Table 6-36 Class Attribute

| No. | Service | Type | Name |
| :---: | :---: | :---: | :--- |
| 1 | get | UINT16 | Revision |
| 2 | get | UINT16 | Max Instance |
| 3 | get | UINT16 | Num of Instances |

Table 6-37 Instance Attribute

| No. | Service | Type | Name | Value/explanation |
| :---: | :---: | :---: | :--- | :--- |
| 1 | get | UINT16 | Vendor ID | 1251 |
| 2 | get | UINT16 | Device Type <br> - Siemens Drive | 0C hex |
| 3 | get | UINT16 | Product code | r0964[1] |
| 4 | get | UINT16 | Revision |  |
| 5 | get | UINT16 | Status | See the following table |
| 6 | get | UINT32 | Serial number | Bits 0 $\ldots$ 19: Consecutive number; <br> Bits 20 ... 23: Production identifier <br> Bits 24 ... 27: Month of manufacture (0 = Jan, <br> B = Dec) <br> Bits 28 ... 31: Year of manufacture $(0=2002)$ |
| 7 | get | Short <br> String | Product name | Max. length 32 bytes |

Table 6-38 Explanation for No. 5 of the previous table

| Byte | Bit | Name | Description |
| :---: | :---: | :---: | :---: |
| 1 | 0 | Owned | 0 : Inverter is not assigned to any master <br> 1: Inverter is assigned to a master |
|  | 1 |  | Reserved |
|  | 2 | Configured | 0: EtherNet/IP basic settings <br> 1: Modified EtherNet/IP settings |
|  | 3 |  | Reserved |
|  | 4... 7 | Extended <br> Device Status | 0: Self-test or status not known <br> 1: Firmware update active <br> 2: At least one I/O connection with error <br> 3: No I/O connections <br> 4: Incorrect configuration in the ROM <br> 5: Fatal fault <br> 6: At least one I/O connection is active <br> 7: All I/O connections in the quiescent state <br> 8 ... 15: Reserved |
| 2 | 8... 11 |  | Not used |
|  | 12... 15 |  | Reserved |

## Assembly Object, Instance Number: 4 hex

## Supported services

Class - Get Attribute single
Instance

- Get Attribute single
- Set Attribute single

Table 6-39 Class Attribute

| No. | Service | Type | Name |
| :---: | :---: | :---: | :--- |
| 1 | get | UINT16 | Revision |
| 2 | get | UINT16 | Max Instance |
| 3 | get | UINT16 | Num of Instances |

Table 6-40 Instance Attribute

| No. | Service | Type | Name | Value/explanation |
| :---: | :---: | :---: | :--- | :--- |
| 3 | get | Array of <br> UINT8 | Assembly | 1 byte array |

## Connection Management Object, Instance Number: 6 hex

## Supported services

Class - Get Attribute all

- Get Attribute single

Instance • Forward open

- Forward close
- Get Attribute single
- Set Attribute single

Table 6-41 Class Attribute

| No. | Service | Type | Name |
| :---: | :---: | :---: | :--- |
| 1 | get | UINT16 | Revision |
| 2 | get | UINT16 | Max Instance |
| 3 | get | UINT16 | Num of Instances |

Table 6-42 Instance Attribute

| No. | Service | Type | Name | Value/explanation |
| :---: | :---: | :---: | :--- | :--- |
| 1 | get | UINT16 | OpenReqs | Counters |
| 2 | get | UINT16 | OpenFormat Rejects | Counters |
| 3 | get | UINT16 | OpenResource Rejects | Counters |
| 4 | get | UINT16 | OpenOther Rejects | Counters |
| 5 | get | UINT16 | CloseReqs | Counters |
| 6 | get | UINT16 | CloseFormat Rejects | Counters |
| 7 | get | UINT16 | CloseOther Rejects | Counters |
| 8 | get | UINT16 | ConnTimeouts | Counters <br> Number of bus errors |

## Siemens Drive Object, Instance Number: 32C hex

Supported services
Class • Get Attribute single
Instance - Get Attribute single

- Set Attribute single

Table 6-43 Class Attribute

| No. | Service | Type | Name |
| :---: | :---: | :---: | :--- |
| 1 | get | UINT16 | Revision |
| 2 | get | UINT16 | Max Instance |
| 3 | get | UINT16 | Num of Instances |

Table 6-44 Instance Attribute

| No. | Service | Name | Value/explanation |
| :---: | :---: | :---: | :---: |
| 2 | get, set | Commisioning state | p0010: commissioning parameter filter |
| 3... 18 | get | STW1 | STW1 bit-by-bit access: <br> Attr. 3 = STW1.0 <br> Attr. $18=$ STW1. 15 |
| 19 | get | Main setpoint | Main setpoint |
| 20... 35 | get | ZSW1 | ZSW1 bit-by-bit access: <br> Attr. $20=$ ZSW1.0 <br> Attr. 35 = ZSW1. 15 |
| 36 | get | Actual Frequency | Main actual value (actual frequency) |
| 37 | get, set | Ramp Up Time | p1120[0]: ramp-function generator ramp-up time |
| 38 | get, set | Ramp Down Time | p1121[0]: ramp-function generator ramp-down time |
| 39 | get, set | Current Limit | p0640[0]: current limit |
| 40 | get, set | Frequency MAX Limit | p1082[0]: maximum speed |
| 41 | get, set | Frequency MIN Limit | p1080[0]: minimum speed |
| 42 | get, set | OFF3 Ramp Down Time | p1135[0]: OFF3 ramp-down time |
| 43 | get, set | PID Enable | p2200[0]: technology controller enable |
| 44 | get, set | PID Filter Time Constant | p2265: technology controller actual value filter time constant |
| 45 | get, set | PID D Gain | p2274: technology controller differentiation time constant |
| 46 | get, set | PID P Gain | p2280: technology controller proportional gain |
| 47 | get, set | PID I Gain | p2285: technology controller integral time |
| 48 | get, set | PID Up Limit | p2291: technology controller maximum limiting |
| 49 | get, set | PID Down Limit | p2292: technology controller minimum limiting |
| 50 | get | Speed setpoint | r0020: speed setpoint |
| 51 | get | Output Frequency | r0024: output frequency |
| 52 | get | Output Voltage | r0025: output voltage |
| 53 | get | DC Link Voltage | r0026[0]: DC link voltage |


| No. | Service | Name | Value/explanation |
| :---: | :---: | :---: | :---: |
| 54 | get | Actual Current | r0027: current actual value |
| 55 | get | Actual Torque | r0031: actual torque value |
| 56 | get | Output power | r0032: active power actual value |
| 57 | get | Motor Temperature | r0035[0]: motor temperature |
| 58 | get | Power Unit Temperature | r0037[0]: power unit temperature |
| 59 | get | Energy kWh | r0039: energy display |
| 60 | get | CDS Eff (Local Mode) | r0050: active command data set |
| 61 | get | Status Word 2 | r0053: status word 2 |
| 62 | get | Control Word 1 | r0054: control word 1 |
| 63 | get | Motor Speed (Encoder) | r0061: actual speed value |
| 64 | get | Digital Inputs | r0722: digital inputs status |
| 65 | get | Digital Outputs | r0747: digital outputs status |
| 66 | get | Analog Input 1 | r0752[0]: Analog input 1 |
| 67 | get | Analog Input 2 | r0752[1]: Analog input 2 |
| 68 | get | Analog Output 1 | r0774[0]: Analog output 1 |
| 69 | get | Analog Output 2 | r0774[1]: Analog output 2 |
| 70 | get | Fault Code 1 | r0947[0]: fault number 1 |
| 71 | get | Fault Code 2 | r0947[1]: fault number 2 |
| 72 | get | Fault Code 3 | r0947[2]: fault number 3 |
| 73 | get | Fault Code 4 | r0947[3]: fault number 4 |
| 74 | get | Fault Code 5 | r0947[4]: fault number 5 |
| 75 | get | Fault Code 6 | r0947[5]: fault number 6 |
| 76 | get | Fault Code 7 | r0947[6]: fault number 7 |
| 77 | get | Fault Code 8 | r0947[7]: fault number 8 |
| 78 | get | Pulse Frequency | r1801: pulse frequency |
| 79 | get | Alarm Code 1 | r2110[0]: alarm number 1 |
| 80 | get | Alarm Code 2 | r2110[1]: alarm number 2 |
| 81 | get | Alarm Code 3 | r2110[2]: alarm number 3 |
| 82 | get | Alarm Code 4 | r2110[3]: alarm number 4 |
| 83 | get | PID setpoint Output | r2260: technology controller setpoint after rampfunction generator |
| 84 | get | PID Feedback | r2266: technology controller actual value after filter |
| 85 | get | PID Output | r2294: technology controller output signal |

Siemens Motor Data Object, Instance Number: 32D hex
Supported services
Class - Get Attribute single Instance - Get Attribute single

Table 6-45 Class Attribute

| No. | Service | Type | Name |
| :---: | :---: | :---: | :--- |
| 1 | get | UINT16 | Revision |
| 2 | get | UINT16 | Max Instance |
| 3 | get | UINT16 | Num of Instances |

Table 6-46 Instance Attribute

| No. | Service | Type | Name | Value/explanation |
| :---: | :---: | :---: | :--- | :--- |
| 2 | get, set | UINT16 | Commisioning <br> state | p0010: commissioning parameter filter |
| 3 | get | INT16 | Motor Type | p0300: motor type |
| 6 | get, set | REAL | Rated Current | p0305: rated motor current |
| 7 | get, set | REAL | Rated Voltage | p0304: rated motor voltage |
| 8 | get, set | REAL | Rated Power | p0307: rated motor power |
| 9 | get, set | REAL | Rated Frequency | p0310: rated motor frequency |
| 10 | get, set | REAL | Rated <br> Temperature | p0605: Mot_temp_mod $1 / 2$ / sensor threshold and <br> temperature value |
| 11 | get, set | REAL | Max Speed | p0322: maximum motor speed |
| 12 | get, set | UINT16 | Pole pair number | p0314: motor pole pair number |
| 13 | get, set | REAL | Torque Constant | p0316: motor torque constant |
| 14 | get, set | REAL | Inertia | p0341: motor moment of inertia |
| 15 | get, set | REAL | Base Speed | p0311: rated motor speed |
| 19 | get, set | REAL | Cos Phi | p0308: rated motor power factor |

## TCP/IP Interface Object, Instance Number: F5 hex

## Supported services

Class - Get Attribute all

- Get Attribute single

Instance - Get Attribute all

- Get Attribute single
- Set Attribute single

Table 6-47 Class Attribute

| No. | Service | Type | Name |
| :---: | :---: | :---: | :--- |
| 1 | get | UINT16 | Revision |
| 2 | get | UINT16 | Max Instance |
| 3 | get | UINT16 | Num of Instances |

Table 6-48 Instance Attribute

| No. | Service | Type | Name | Value/explanation |
| :---: | :---: | :---: | :---: | :---: |
| 1 | get | UNIT32 | Status | Fixed value: 1 hex <br> 1: Configuration acknowledged, by DHCP or saved values |
| 2 | get | UNIT32 | Configuration Capability | Fixed value: 94 hex <br> 4 hex: DHCP supported, <br> 10 hex: Configuration can be adjusted, <br> 80 hex: ACD-capable |
| 3 | get, set | UNIT32 | Configuration Control | 1 hex: Saved values <br> 3 hex: DHCP |
| 4 | get, set | UNIT16 | Path Size (in WORDs) | Fixed value: 2 hex |
|  |  | UNIT8 | Path | 20 hex, <br> F6 hex, <br> 24 hex, <br> 05 hex, where 5 hex is the number of instances of F6 hex (four physical ports plus one internal port). |
| 5 | get, set | STRING | Interface Configuration | r61000: name of station |
|  |  | UNIT32 |  | r61001: IP address |
| 6 | get, set | UNIT16 | Host Name | Host Name Length |
|  |  | STRING |  | - |
| 10 | get, set | UNIT8 | Select ACD | local OM flash: <br> 0: Disabled, <br> 1: Enabled |
| 11 | get, set | UNIT8 | Last Conflict Detected | local OM flash ACD Activity |
|  |  | UNIT8 |  | local OM flash Remote MAC |
|  |  | UNIT8 |  | local OM flash ARP PDU |

Link Object, Instance Number: F6 hex
Supported services

Class - Get Attribute all

- Get Attribute single

Instance

- Get Attribute all
- Get Attribute single
- Set Attribute single

Table 6-49 Class Attribute

| No. | Service | Type | Name |
| :---: | :---: | :---: | :--- |
| 1 | get | UINT16 | Revision |
| 2 | get | UINT16 | Max Instance |
| 3 | get | UINT16 | Num of Instances |

Table 6-50 Instance Attribute

| No. | Service | Type | Name | Value/explanation |
| :---: | :---: | :---: | :---: | :---: |
| 1 | get | UINT32 | Interface Speed | 0 : link down, 10: 10 Mbps , 100: 100 Mbps |
| 2 | get |  | Interface Flags | Bit 1: Link-Status <br> Bit 2: Duplex Mode (0: half duplex, 1 duplex) bit 3 ... 5: Automatic state identification <br> Bit 6: Reset required <br> Bit 7: Local hardware fault ( $0=\mathrm{ok}$ ) |
| 3 | get | ARRAY | Physical Address | r8935: Ethernet MAC address |
| 4 | get, get_and _clear | Struct of | Interface Counters | Optional, required if the "Media Counters Attribute" is implemented. |
|  |  | UINT32 | In Octets | Received octets |
|  |  | UINT32 | In Ucast Packets | Received Unicast packets |
|  |  | UINT32 | In NUcast Packets | Received non-Unicast packets |
|  |  | UINT32 | In Discards | Incoming packets, not processed |
|  |  | UINT32 | In Errors | Incoming packets with errors |
|  |  | UINT32 | In Unknown Protos | Incoming packets with unknown protocol |
|  |  | UINT32 | Out Octets | Sent octets |
|  |  | UINT32 | Out Ucast Packets | Sent Unicast packets |
|  |  | UINT32 | Out NUcast packets | Sent non-Unicast packets |
|  |  | UINT32 | Out Discards | Outgoing packets, not processed |
|  |  | UINT32 | Out Errors | Outgoing packets, with errors |
| 5 | get, get_and _clear | Struct of | Media Counters | Media-specific counters |
|  |  | UINT32 | Alignment Errors | Structure received, which does not match the number of octets |
|  |  | UINT32 | FCS Errors | Structure received, which does not pass the FCS check |
|  |  | UINT32 | Single Collisions | Structure successfully transmitted, precisely one collision |
|  |  | UINT32 | Multiple Collisions | Structure successfully transmitted, several collisions |
|  |  | UINT32 | SQE Test Errors | Number of SQE errors |
|  |  | UINT32 | Deferred Transmissions | First transmission attempt delayed |
|  |  | UINT32 | Late Collisions | Number of collisions that occurred delayed by 512 bit timers to the request |
|  |  | UINT32 | Excessive Collisions | Transmission unsuccessful as a result of intensive collisions |
|  |  | UINT32 | MAC Transmit Errors | Transmission unsuccessful as a result of an internal MAC sublayer transmission error. |
|  |  | UINT32 | Carrier Sense Errors | Times that the carrier sense condition was lost or never asserted when attempting to transmit a frame |


| No. | Service | Type | Name | Value/explanation |
| :---: | :---: | :---: | :--- | :--- |
|  |  | UINT32 | Frame Too Long | Structure too large |
|  |  | UINT32 | MAC Receive <br> Errors | Transmission unsuccessful as a result of an <br> internal MAC sublayer receive error. |
|  | get, set | Struct of | Interface Control |  |
|  |  | UINT16 | Control Bits |  |
|  | UINT16 | Forced Interface <br> Speed |  |  |
| 10 | get | String | Interface_Label | Interface-Label |

## Parameter Object, Instance Number: 401 hex

## Supported services

Class

- Get Attribute all
Instance • Get Attribute all
- Set Attribute single

Table 6-51 Class Attribute

| No. | Service | Type | Name |
| :---: | :---: | :---: | :--- |
| 1 | get | UINT16 | Revision |
| 2 | get | UINT16 | Max Instance |
| 3 | get | UINT16 | Num of Instances |

Parameter access to drive object $0(\mathrm{DO} 0)$ is realized via this class.

## Example: Read parameter 2050[10] (connector output to interconnect the PZD received from the fieldbus controller)

Get Attribute single function with the following values:

- Class = 401 hex
- Instance $=2050=802$ hex $\xlongequal{\wedge}$ parameter number
- Attribute $=10=\mathrm{A}$ hex $\xlongequal{\wedge}$ Index 10


## Example: Parameter 1520[0] writing (upper torque limit)

Set Attribute single function with the following values:

- Class $=401$ hex
- Instance $=1520=5$ F0 hex $\xlongequal{\wedge}$ parameter number
- Attribute $=0=0$ hex $\triangleq$ index 0
- Data $=500.0$ (value)


## Parameter Object, Instance Number: 401 hex ... 43E hex

Supported services
Class • Get Attribute all
Instance

- Get Attribute all
- Get Attribute single
- Set Attribute single

Table 6-52 Class Attribute

| No. | Service | Type | Name |
| :---: | :---: | :---: | :--- |
| 1 | get | UINT16 | - |
| 2 | get | UINT16 | Max slot num |
| 3 | get | UINT16 | Max slot ID |

Parameter access to drive object 0 ( DO 0 ) is realized via this class.
The class structure is analog to 401 hex. Drive object (DO) is selected via the class number.
Example:
0x401-> DO 1
0x402 -> DO 2

0x43E -> DO 62

### 6.11.5 Integrate the drive device into the Ethernet network via DHCP

## Integrating the drive into an Ethernet network

Proceed as follows to integrate the drive into Ethernet:

1. Set p8944 (CBE $2 x$ DHCP mode $)=2$ or 3 .

- p8944 = 2: The DHCP server assigns the IP address based on the MAC address.
- p8944 = 3: The DHCP server assigns the IP address based on the station name.

2. Save the settings with p8945 $=2$.

When it is switched on the next time, the drive retrieves the IP address made available by a DHCP. You can address the drive as Ethernet node.

## Displays

- r8950: Station name of the CBE20
- r8954: DHCP mode of the CBE20
- r8955: MAC address of the CBE20


### 6.11.6 Parameters, faults and alarms

## Parameters

- p0978 List of drive objects
- p0922 IF1 PROFIdrive PZD telegram selection
- p0999[0...99] List of modified parameters 10
- p8835 CBE20 firmware selection
- p8842 COMM BOARD activate send configuration
- p8940[0...239] CBE2x Name of Station
- p8941[0...3] CBE2x IP address
- p8942[0...3] CBE2x Default Gateway
- p8943[0...3] CBE2x Subnet Mask
- p8944 CBE2x DHCP mode
- p8945 CBE2x interfaces configuration
- r8950[0...239] CBE2x Name of Station actual
- r8951[0...3] CBE2x IP address actual
- r8952[0...3] CBE2x Default Gateway actual
- r8954 CBE2x DHCP Mode actual
- r8955[0...5] CBE2x MAC address


## Faults and alarms

- F08501 PN/COMM BOARD: Setpoint timeout
- A08526 PN/COMM BOARD: No cyclic connection
- A50011 EtherNetIP/COMM BOARD: Configuration error


### 6.12 Communication via MODBUS TCP

### 6.12.1 Overview

The Modbus protocol is a communication protocol based on a master/slave architecture.
Modbus offers three transmission modes:

- Modbus ASCII - via a serial interface data in the ASCII code. The data throughput is lower compared to RTU.
- Modbus RTU - via a serial interface data in the binary format. The data throughput is greater than in ASCII code.
- Modbus TCP - via Ethernet data as TCP/IP packages. TCP port 502 is reserved for Modbus TCP.

With the Control Unit CU320-2, only transfer type "Modbus TCP" is available.

## Modbus functionality

Process data and parameters are accessed via the Modbus register.

- Process data: 40100-40119
- Drive data: 40300-40522
- All parameters via DS47: 40601-40722

Modbus TCP always provides a basic Ethernet functionality, which corresponds to the functionality of Ethernet interface X127:

- Commissioning access for STARTER with S7 protocol
- DCP to set the IP address etc.
- SNMP for identification


## General information about communication

Communication with Modbus TCP runs via the Ethernet interfaces:

- X150:

For Modbus TCP with a CU320-2 PN.

- X1400:

For Modbus TCP with a CU320-2 PN or a CU320-2 DP via a CBE20
Precisely one Modbus connection can be established. A simultaneous connection via interfaces X150 and X1400 is rejected, and is acknowledged using Alarm A08555.

However, you can use one interface for Modbus TCP, and the other as PROFINET interface.

## Drive object that can be addressed via Modbus

With Modbus TCP, you always address drive object DO1 from the list of drive objects (p0978[0]). A vector drive object must be in this parameter.

However, Modbus TCP is only activated if, under p0978[0], there is a drive object that is supported by Modbus TCP. If p0978[0] does not contain a valid drive object, then establishing communication is acknowledged with Alarm A08555.

## Diagnostics LEDs in Modbus TCP

Diagnostics states are shown as follows using LEDs with Modbus TCP:

| Color | State | Significance |
| :--- | :--- | :--- |
| Green | Continuous light | Connections and setpoints are OK. |
| Green | Flashing light | Connection is OK, but no setpoints (dependent on timeout). |
| Red | Flashing light 2 Hz | No connection or setpoint timeout. |

### 6.12.2 Configuring Modbus TCP via interface X150

## Activate Modbus TCP via X150 (CU320-2 PN)

1. For drive object DO1, set p2030 $=13$ (Modbus TCP).
2. Using p8921, set the IP address for the onboard PROFINET interface on the Control Unit.
3. Set the standard gateway using p8922.
4. Set the subnet mask using p8923.
5. Set the DHCP mode using p8924.
6. Select the setting "Activate and save configuration" as interface configuration using p8945 $=2$.
7. In the STARTER commissioning tool, check the list of drive object p0978.

When required, change the sequence of the drive objects using the telegram configuration ("Drive device" > "Communication" > "Telegram configuration").
8. Save the settings in the STARTER commissioning tool and carry out a POWER ON.

## Modbus settings with interface X150

Using the following parameters, set the communication for Modbus TCP with a X150 interface:

| Parameters | Explanation |
| :--- | :--- |
| p2040 | Setting the monitoring time to monitor the received process data via fieldbus <br> interface. <br> If process data is not transferred within one cycle of the fieldbus monitoring time, <br> then the drive shuts down with fault F01910. |
| r2050[0...19] | Connector output to interconnect the PZD received from the fieldbus controller <br> via IF1. |
| p2051[0...24] | Selects the PZD (actual values) to be sent to the fieldbus controller in the word <br> format via IF1. |
| r2053[0...24] | Displays the PZD (actual values) sent to the fieldbus controller in the word <br> format via IF1. |
| r2054 | Status display for the internal communication interface. |
| p8839[0...1] | Assigning the PN onboard interface (X150) for acyclic communication via PZD <br> interface 1 (IF1) and interface 2 (IF2). |
| r8850[0...19] | Connector output to interconnect the PZD (setpoints) received in the word format <br> via IF2. |
| p8851[0...24] | Selects the PZD (actual values) to be sent in the word format via IF2. |
| $r 8853[0 . .24]$ | Displays the PZD (actual values) sent in the word format via IF2. |
| r8854 | Status display for COMM BOARD. |

### 6.12.3 Configuring Modbus TCP via interface X1400

## Activating Modbus TCP via X1400 (CBE20)

1. For drive object DO1, set p8835 $=5$ (Modbus TCP).
2. Set the IP address for the CBE20 using p8941.
3. Set the standard gateway for the CBE20 using p8942.
4. Set the subnet mask for the CBE20 using p8943.
5. Set the DHCP mode for the CBE20 using p8944.
6. With p8945 $=2$, set "Activate and save configuration" to save and activate the settings made in the previous steps.
7. In the STARTER commissioning tool, check the list of drive object p0978.

When required, change the sequence of the drive objects using the telegram configuration ("Drive device" > "Communication" > "Telegram configuration").
8. Save the settings in the STARTER commissioning tool and carry out a POWER ON.

## Modbus settings with interface X1400

Using the following parameters, set the communication for Modbus TCP with a X1400 interface:

| Parameters | Explanation |
| :--- | :--- |
| r2050[0...19] | Connector output to interconnect the PZD received from the fieldbus controller <br> via IF1. |
| p2051[0...24] | Selects the PZD (actual values) to be sent to the fieldbus controller in the word <br> format via IF1. |
| r2053[0...24] | Displays the PZD (actual values) sent to the fieldbus controller in the word <br> format via IF1. |
| r2054 | Status display for the internal communication interface. |
| p8840 | Setting the monitoring time to monitor the received process data via the COMM <br> BOARD. <br> If, within this time, the Control Unit does not receive any process data from the <br> COMM BOARD, then the drive shuts down with fault F08501. |
| p8839[0...1] | Assigning the CBE20 interface (x1400) for cyclic communication via PZD <br> interface 1 (IF1) and interface 2 (IF2). |
| r8850[0...19] | Connector output to interconnect the PZD (setpoints) received in the word format <br> via IF2. |
| p8851[0...24] | Selects the PZD (actual values) to be sent in the word format via IF2. |
| r8853[0...24] | Displays the PZD (actual values) sent in the word format via IF2. |
| r8854 | Status display for COMM BOARD. |

### 6.12.4 Mapping tables

## Modbus register and Control Unit parameters

The Modbus protocol contains register or bit numbers for addressing memory. You must assign the appropriate control words, status words and parameters to these registers in the slave.

The valid holding register address range extends from 40001 up to 40722 . When trying to access other holding registers, the "Exception code" error is output

The process data are transferred into the register range from 40100 up to 40119.

## Note

"R"; "W"; "R/W" in the Access column stands for read (with FC03); write (with FC06); read/write.

Table 6-53 Assigning the Modbus register to the parameters - Process data

| Register | Description | Access | Unit | Scaling | ON/OFF text or Value range | Data / parameter |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Control data |  |  |  |  |  |  |
| 40100 | Control word (see List Manual, function diagram 2442) | R/W | - | 1 | - | Process data 1 |
| 40101 | Main setpoint | R/W | - | 1 | - | Process data 2 |
| 40102 | STW 3 | R/W | - | 1 | - | Process data 3 |
| 40103 | STW 4 | R/W | - | 1 | - | Process data 4 |
| 40104 | PZD 5 | R/W | - | 1 | - | Process data 5 |
| 40105 | PZD 6 | R/W | - | 1 | - | Process data 6 |
| 40106 | PZD 7 | R/W | - | 1 | - | Process data 7 |
| 40107 | PZD 8 | R/W | - | 1 | - | Process data 8 |
| 40108 | PZD 9 | R/W | - | 1 | - | Process data 9 |
| 40109 | PZD 10 | R/W | - | 1 | - | Process data 10 |
| Status data |  |  |  |  |  |  |
| 40110 | Status word (see List Manual, function diagram 2452) | R | - | 1 | - | Process data 1 |
| 40111 | Main actual value | R | - | 1 | - | Process data 2 |
| 40112 | ZSW 3 | R | - | 1 | - | Process data 3 |
| 40113 | ZSW 4 | R | - | 1 | - | Process data 4 |
| 40114 | PZD 5 | R | - | 1 | - | Process data 5 |
| 40115 | PZD 6 | R | - | 1 | - | Process data 6 |
| 40116 | PZD 7 | R | - | 1 | - | Process data 7 |
| 40117 | PZD 8 | R | - | 1 | - | Process data 8 |
| 40118 | PZD 9 | R | - | 1 | - | Process data 9 |
| 40119 | PZD 10 | R | - | 1 | - | Process data 10 |

Table 6-54 Assigning the Modbus register to the parameters - Parameter data

| Register | Description | Access | Unit | Scaling | ON/OFF text or Value range | Data / parameter |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Drive identification |  |  |  |  |  |  |
| 40300 | Actual power unit code number | R | - | 1 | 0... 65535 | r0200 |
| 40301 | Control Unit firmware | R | - | 1 | 0... 65535 | r0018 / 10000 |
| Drive data |  |  |  |  |  |  |
| 40320 | Rated power of the power unit | R | kW | 100 | $0 \ldots 655.35$ | r0206 |
| 40321 | Current limit | R/W | \% | 10 | $0.0 \ldots 6553.5$ | p0640 |
| 40322 | Ramp-up time | R/W | s | 100 | $10.00 \ldots 655.35$ | p1120 |
| 40323 | Ramp-down time | R/W | s | 100 | 10,00 ... 655.35 | p1121 |
| 40324 | Reference speed | R/W | RPM | 1 | $6 \ldots 65535$ | p2000 |
| Drive diagnostics |  |  |  |  |  |  |
| 40340 | Speed setpoint | R | RPM | 1 | -32768 ... 32767 | r0020 |
| 40341 | Actual speed value | R | RPM | 1 | -32768 ... 32767 | r0021 |


| Register | Description | Access | Unit | Scaling | ON/OFF text or Value range | Data / parameter |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 40342 | Output frequency | R | Hz | 100 | - 327.68 .. 327.67 | r0024 |
| 40343 | Output voltage | R | V | 1 | 0... 65535 | r0025 |
| 40344 | DC-link voltage | R | V | 1 | 0... 65535 | r0026 |
| 40345 | Actual current value | R | A | 100 | $0 \ldots 655.35$ | r0027 |
| 40347 | Actual active power | R | kW | 100 | $0 \ldots 655.35$ | r0032 |
| 40349 | Control priority | R | - | 1 | MAN AUTO | r0807 |
| Fault diagnostics |  |  |  |  |  |  |
| 40400 | Failure number, index 0 | R | - | 1 | $0 \ldots 65535$ | r0947[0] |
| 40401 | Failure number, index 1 | R | - | 1 | 0... 65535 | r0947[1] |
| 40402 | Failure number, index 2 | R | - | 1 | 0... 65535 | r0947[2] |
| 40403 | Fault number, index 3 | R | - | 1 | 0... 65535 | r0947[3] |
| 40404 | Fault number, index 4 | R | - | 1 | 0... 65535 | r0947[4] |
| 40405 | Fault number, index 5 | R | - | 1 | 0... 65535 | r0947[5] |
| 40406 | Fault number, index 6 | R | - | 1 | $0 \ldots 65535$ | r0947[6] |
| 40407 | Fault number, index 7 | R | - | 1 | $0 \ldots 65535$ | r0947[7] |
| 40408 | Alarm number | R | - | 1 | 0... 65535 | r2110[0] |
| 40409 | Actual alarm code | R | - | 1 | 0... 65535 | r2132 |
| 40499 | PRM ERROR code | R | - | 1 | 0... 255 | - |
| Technology controller ${ }^{3}$ ) |  |  |  |  |  |  |
| 40500 | Technology controller enable | R/W | - | 1 | $0 \ldots 1$ | p2200, r2349.0 |
| 40501 | Technology controller MOP | R/W | \% | 100 | -200.0 ... 200.0 | p2240 |
| Adapt technology controller ${ }^{1)}$ |  |  |  |  |  |  |
| 40510 | Time constant for actual-value filters of the technology controller | R/W | - | 100 | $0.00 \ldots 60.0$ | p2265 |
| 40511 | Scaling factor for actual value of the technology controller | R/W | \% | 100 | $0.00 \ldots 500.00$ | p2269 |
| 40512 | Proportional amplification of the technology controller | R/W | - | 1000 | $0.000 \ldots 65.535$ | p2280 |
| 40513 | Integral time of the technology controller | R/W | s | 1 | $0 \ldots 60$ | p2285 |
| 40514 | Time constant D-component of the technology controller | R/W | - | 1 | $0 \ldots 60$ | p2274 |
| 40515 | Max. limit of technology controller | R/W | \% | 100 | -200.0 ... 200.0 | p2291 |
| 40516 | Min. limit technology controller | R/W | \% | 100 | -200.0 ... 200.0 | p2292 |
| PID diagnostics |  |  |  |  |  |  |
| 40520 | Effective setpoint acc. to internal technology controller MOP ramp-function generator | R | \% | 100 | -100.0 ... 100.0 | r2250 |
| 40521 | Actual value of technology controller after filter | R | \% | 100 | -100.0 ... 100.0 | r2266 |
| 40522 | Output signal technology controller | R | \% | 100 | -100.0 ... 100.0 | r2294 |

[^4]Table 6-55 Assignment of the Modbus register for general parameter access using DS47

| Register | Description | Access | Unit | Scaling | ON/OFF text <br> or Value range | Data / parameter |
| :--- | :--- | :--- | :--- | :--- | :---: | :--- |
| 40601 | DS47 Control | R/W | - | - | - | - |
| 40602 | DS47 header | R/W | - | - | - | - |
| 40603 | DS47 data 1 | R/W | - | - | - | - |
| $\ldots$ | $\ldots$ |  |  |  |  |  |
| 40722 | DS47 data 120 | R/W | - | - | - | - |

## Note

## Limited value range

Modbus TCP registers have a maximum 16 bit width. The values of display parameters ( $r$ parameters) cannot always be represented with 16 bits. In these particular cases, the maximum value that can be represented is displayed.

- Unsigned: 65535
- Signed min: -32768
- Signed max: 32767


### 6.12.5 Write and read access using function codes

## Function codes used

For data exchange between the master and slave, predefined function codes are used for communication via Modbus.

The Control Unit uses the following Modbus function codes:

- FC 03: Holding register to read data from the inverter
- FC 06: Write single register to write to individual register
- FC 16: Write to multiple registers to write to several registers


## Structure of a Modbus TCP message

Table 6-56 Individual components, including Modbus Application Header (MBAP) and function code

| Application Data Unit (ADU) |  |  |  |  | Protocol Data Unit (PDU |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Modbus Application Header |  |  |  |  | Unit ID |  |
| FCode | Data |  |  |  |  |  |
| Transaction ID | Protocol ID | Length | 2 bytes | 1 byte | 1 byte |  |
| 2 bytes | 2 bytes | $\ldots 252$ bytes |  |  |  |  |

## Structure of a read request via Modbus function code 03 (FC 03)

Any valid register address is permitted as the start address.
Via FC 03, the control can address more than one register with one request. The number of addressed registers is contained in bytes 10 and 11 of the read request.

Table 6-57 Structure of a read request via slave number 17, example

| Value | Byte | Description |
| :--- | :--- | :--- |
| MBAP header |  |  |
| 03 h | 7 |  |
| 00 h | 8 | Register start address "High" (register 40110) |
| 6 h | 9 | Register start address "Low" |
| 00 h | 10 | Number of registers "High" (2 registers: 40110; 40111) |
| 02 h | 11 | number of registers "Low" |

The response returns the corresponding data set:

Table 6-58 Slave response to the read request, example

| Value | Byte | Description |
| :--- | :--- | :--- |
| MBAP header |  |  |
| 03 h | 7 |  |
| 04 h | 8 | Number of bytes (4 bytes are returned) |
| 11 h | 9 | Data first register "High" |
| 22 h | 10 | Data first register "Low" |
| 33 h | 11 | Data second register "High" |
| 44 h | 12 | Data second register "Low" |

Table 6-59 Invalid read request

| Read request | Inverter response |
| :--- | :--- |
| Invalid register address | Exception code 02 (invalid data address) |
| Read a write-only register | Telegram in which all values are set to 0. |
| Read a reserved register | Exception code 03 (invalid data value) |
| Controller addresses more than 125 registers | Exception code 02 (invalid data address) |
| The start address and the number of registers of an <br> address are located outside of a defined register block |  |

## Structure of a write request via Modbus function code 06 (FC 06)

Start address is the holding register address.
Via FC 06, with one request, only precisely one register can be addressed. The value, which is written to the addressed register, is contained in bytes 10 and 11 of the write request.

Table 6-60 Structure of a write request for slave number 17, example

| Value | Byte | Description |  |  |
| :--- | :--- | :--- | :--- | :---: |
| MBAP header |  |  |  |  |
| 06 h | 7 | Function code |  |  |
| 00 h | 8 | Register start address "High" (write register 40100) |  |  |
| 63 h | 9 | Register start address "Low" |  |  |
| 55 h | 10 | Register data "High" |  |  |
| 66 h | 11 | Register data "Low" |  |  |

The response returns register address (bytes 8 and 9) and the value (bytes 10 and 11), which the higher-level control had written to the register.

Table 6-61 Slave response to the write request, example

| Value | Byte | Description |
| :--- | :--- | :--- |
| MBAP header |  |  |
| 06 h | 7 | Function code |
| 00 | h | 8 |
| 63 h | 9 | Register start address "High" |
| 55 h | 10 | Register start address "Low" |
| 66 h | 11 | Register data "High" |

Table 6-62 Invalid write request

| Write request | Inverter response |
| :--- | :--- |
| Incorrect address (a holding register address does not exist) | Exception Code 02-invalid data <br> address |
| Write to a "read-only" register | Exception Code 04 - device failure |
| Write to a reserved register |  |

For Exception Code 4, via the holding register 40499, you can read out the internal drive error code, which has occurred for the last parameter access via the holding register.

### 6.12.6 Communication via data set 47

Via FC 16, with one request, up to 122 registers can be written to directly one after the other, while for Write Single Register (FC 06) you must individually write the header data for each register.

## Header

In addition to the transfer type, the start address and the number of the following registers in the header.

## User data

You control the access in the user data via register 40601.
In register 40602, you define the access as well as the length of the request data.
Register 40603 contains the request reference - it is defined by the user - and the access type -reading or writing.
From register 40603 and higher, the request aligns communication via data set 47 according to PROFIdrive.

Register 40604 contains the number of the drive object and the number of parameters that are read out or written to.

Register 40605 contains the atribute that you use to control whether you read out the parameter value or the parameter attribute. In the number of elements you specify how many indices are read.

### 6.12.6.1 Communication details

General parameter access is realized using the Modbus register 40601 ... 40722.
Communication via DS47 is controlled via register 40601. Register 40602 contains the function code (always = $47=2 \mathrm{Fhex}$ ) and the number of the following user data. User data are contained in registers 40603 ... 40722.

Communication overview

| Value in the register |  |  |  | Explanation |
| :---: | :---: | :---: | :---: | :---: |
| 40601 |  | 40602 | $40603 \ldots 40722$ |  |
| 0 | 47 | ... | ... | Write values for acyclic access |
| 1 | 47 | Request length [bytes] | Request data | Activate acyclic access |
| 2 | 47 | Response length [bytes] | Response data | Response for a successful request |
| 2 | 47 | 0 | Error code | Response for an erronous request |

## Error codes

1 hex: Invalid Length (invalid length)
2 hex: Invalid State (in the actual inverter state, this action is not permitted)
3 hex: Invalid function code ( $\mathrm{FC} \neq 2 \mathrm{~F}$ hex)
4 hex: Response not ready (the response has still not been issued)
5 hex: Internal Error (general system error)
Incorrect access operations to parameters via data set 47 are logged in registers 40603 ... 40722. The error codes are described in the PROFIdrive profile.

### 6.12.6.2 Examples: Read parameters

Table 6-63 Write parameter request: Reading the parameter value of r0002 from slave number 17

| Value | Byte | Description |
| :---: | :---: | :---: |
| MBAP header |  |  |
| 10 h | 7 | Function code (write multiple) |
| 0258 h | 8,9 | Register start address |
| 0007 h | 10,11 | Number of registers to be read (40601 ... 40607) |
| OE h | 12 | Number of data bytes (7 registers, each 2 bytes $=14$ bytes) |
| 0001 h | 13,14 | 40601: DS47 Control $=1$ (activate request) |
| 2 FOA h | 15,16 | 40602: Function 2 F h (47), request length 10 bytes (0A h) |
| 8001 h | 17,18 | 40603: Request reference $=80 \mathrm{~h}$, request identifier $=1 \mathrm{~h}$ |
| 0101 h | 19,20 | 40604: DO-Id = 1, number of parameters = 1 |
| 1001 h | 21,22 | 40605: Attribute, number of elements $=1$ |
| 0002 h | 23,24 | 40606: Parameter number $=2$ |
| 0000 h | 25,26 | 40607: Subindex $=0$ |

Table 6-64 Start parameter request: Reading the parameter value of r0002 from slave number 17

| Value | Byte | Description |  |
| :--- | :--- | :--- | :--- | :--- |
| MBAP header |  |  |  |
| 03 h | 7 | Function code (read) |  |
| 0258 h | 8,9 | Register start address |  |
| 0007 h | 10,11 | Number of registers to be read (40601 ... 40607) |  |
| 0010 h | 12,13 | Number of registers |  |

Table 6-65 Response for successful read operation

| Value | Byte | Description |
| :---: | :---: | :---: |
| MBAP header |  |  |
| $\begin{aligned} & 03 \mathrm{~h} \\ & 20 \mathrm{~h} \end{aligned}$ | 7 8 | Function code (read) <br> Number of following data bytes ( 20 h : 32 bytes $\hat{=} 16$ registers) |
| 0002 h | 9,10 | 40601: DS47 Control $=2$ (the request was executed) |
| $2 \mathrm{F0} 8 \mathrm{~h}$ | 11,12 | 40602: Function code 2 F h (47), response lengths 8 bytes |
| 8001 h | 13,14 | 40603: Request reference mirrored $=80 \mathrm{~h}$, response identifier = 1 (request parameter) |
| 0101 h | 15,16 | 40604: DO-ID $=1$, number of parameters $=1$ |
| 0301 h | 17,18 | 40605: Format, number of elements $=1$ |
| 001 Fh | 19,20 | 40606: Parameter value $=1 \mathrm{~F}$ h (31) |

### 6.12 Communication via MODBUS TCP

Table 6-66 Response for unsuccessful read operation - read request still not completed

| Value | Byte | Description |
| :---: | :---: | :---: |
| MBAP header |  |  |
| $\begin{aligned} & 03 \mathrm{~h} \\ & 20 \mathrm{~h} \end{aligned}$ | 7 8 | Function code (read) <br> Number of following data bytes ( 20 h : 32 bytes $\hat{=} 16$ registers) |
| $\begin{aligned} & 0001 \mathrm{~h} \\ & 2 \mathrm{~F} 00 \mathrm{~h} \\ & 0004 \mathrm{~h} \end{aligned}$ | $\begin{aligned} & 9,10 \\ & 11,12 \\ & 13,14 \end{aligned}$ | 40601: Check value 1 = request is processed <br> 40602: Function 2 F h(47), response length 0 (fault) <br> 40603: Error code: 0004 Response Not Ready (response has still not been issued) |

### 6.12.6.3 Examples: Write parameter

Table 6-67 Write parameter request: Writing the parameter value of p1121 from slave number 17


Table 6-68 Start parameter request: Writing the parameter value of p1121 from slave number 17

| Value | Byte | Description |
| :---: | :---: | :---: |
| MBAP header |  |  |
| 03 h | 7 | Function code (read) |
| 0258 h | 8,9 | Register start address |
| 0007 h | 10,11 | Number of registers to be written to (40601 ... 40610) |
| 0010 h | 12,13 | Number of registers |

Table 6-69 Response for successful write operation

| Value | Byte | Description |
| :---: | :---: | :---: |
| MBAP header |  |  |
| $\begin{aligned} & 03 \mathrm{~h} \\ & 20 \mathrm{~h} \end{aligned}$ | 7 8 | Function code (read) <br> Number of following data bytes ( 20 h : 32 bytes $\hat{=} 16$ registers) |
| 0002 h | 9,10 | 40601: DS47 Control $=2$ (request was executed) |
| 2 FO 4 h | 11,12 | 40602: Function code 2 F h (47), response length 4 bytes |
| 8002 h | 13,14 | 40603: Request reference mirrored $=80 \mathrm{~h}$, response identifier $=2$ (change parameter) |
| 0101 h | 15,16 | 40604: DO-ID $=1$, number of parameters $=1$ |

Table 6-70 Response for unsuccessful write operation - write request still not completed

| Value | Byte | Description |
| :---: | :---: | :---: |
| MBAP header |  |  |
| $\begin{aligned} & 03 \mathrm{~h} \\ & 20 \mathrm{~h} \end{aligned}$ | 7 8 | Function code (read) <br> Number of following data bytes (20 h: 32 bytes $\hat{=} 16$ registers) |
| $\begin{aligned} & 0001 \mathrm{~h} \\ & 2 \mathrm{~F} 00 \mathrm{~h} \\ & 0004 \mathrm{~h} \end{aligned}$ | $\begin{aligned} & 9,10 \\ & 11,12 \\ & 13,14 \end{aligned}$ | 40601: DS47 Control $=1$ (request is processed) <br> 40602: Function 2 F h(47), response length 0 (fault) <br> 40603: Error code: 0004 Response Not Ready (response has still not been issued) |

### 6.12.7 Communication procedure

## Logical error

If the slave detects a logical error within a request, it responds to the master with an "exception response". In the response, the slave sets the highest bit in the function code to 1. If the slave receives, for example, an unsupported function code from the master, the slave responds with an "exception response" with code 01 (Illegal function code).

Table 6-71 Overview of exception codes

| Exception <br> code | Modbus name | Remark |
| :--- | :--- | :--- |
| 01 | Illegal function code | An unknown (unsupported) function code was sent to the slave. |
| 02 | Illegal Data Address | An invalid address was requested. |
| 03 | Illegal data value | An invalid data value was detected. |
| 04 | Server failure | Slave has terminated during processing. |

## Process data monitoring time (setpoint timeout)

The "Setpoint timeout" only applies for access to process data (40100 ... 40109, 40110 ... 40119). The "Setpoint timeout" is not generated for parameter data (40300 ... 40522).

Fieldbus interface:
In parameter p2040 you define the time for cyclic data exchange for process data.
Setting range: $0 \ldots 20 \mathrm{~ms}$.
The time depends on the amount of data to be transferred and the control.
"Setpoint timeout" (F01910) is issued by the Modbus if p2040 is set to a value $>0 \mathrm{~ms}$ and no process data is requested within this time period.

COMM BOARD (CBE20):
In parameter p8840 you define the time for cyclic process data exchange.
Setting range: $0 \ldots 20 \mathrm{~ms}$.
The time depends on the amount of data to be transferred and the control.
"Setpoint timeout" (F08501) is issued by the Modbus if p8840 is set to a value > 0 ms and no process data is requested within this time period.

### 6.12.8 Parameters, faults and alarms

## Parameters

- p0978 List of drive objects
- p2030 Fieldbus interface protocol selection
- p2040 Fieldbus interface monitoring time:
- r2050[0...19] CO: IF1 PROFIdrive PZD receive word
- p2051[0...24] CI: IF1 PROFIdrive PZD send word
- r2053[0...24] IF1 PROFIdrive diagnostics PZD send word
- r2054 PROFIBUS status
- p8835 CBE20 firmware selection
- p8839 PZD interface hardware assignment
- p8840 COMM BOARD monitoring time
- r8850[0...19] CO: IF2 PZD receive word
- p8851[0...24] CI: IF2 PZD send word
- r8853[0...24] IF2 diagnostics PZD send
- r8854 COMM BOARD state
- p8920[0...239] PN Name of Station
- p8921[0...3] PN IP address
- p8922[0...3] PN default gateway
- p8923[0... 3 PN Subnet Mask
- p8924 PN DHCP mode
- p8925 PN interfaces configuration
- p8940[0...239] CBE2x Name of Station
- p8941[0...3] CBE2x IP address
- p8942[0...3] CBE2x Default Gateway
- p8943[0...3] CBE2x Subnet Mask
- p8944 CBE2x DHCP mode
- p8945 CBE2x interfaces configuration


## Faults and alarms

- F01910 Fieldbus: Setpoint timeout
- A01925 Modbus TCP connection interrupted
- F08501 PN/COMM BOARD: Setpoint timeout
- A08526 PN/COMM BOARD: No cyclic connection
- A08555 Modbus TCP commissioning fault


### 6.13 Communication services and used port numbers

The drive unit supports the protocols listed in the following table. The address parameters, the relevant communication layer as well as the communication role and the communication direction are specified for each protocol.

This information allows you to match the security measures for the protection of the automation system to the used protocols (e.g. firewall). As the security measures are limited to Ethernet and PROFINET networks, no PROFIBUS protocols are listed in the table.

The following table shows the various layers and protocols that are used.

## Layers and protocols

| Report | Port number | (2) Link layer <br> (4) Transport layer | Function | Description |
| :---: | :---: | :---: | :---: | :---: |
| PROFINET protocols |  |  |  |  |
| DCP <br> Discovery and configuration protocol | Not relevant | (2) Ethernet II and IEEE 802.1Q and Ethertype 0x8892 (PROFINET) | Accessible nodes, <br> PROFINET Discovery and configuration | DCP is used by PROFINET to determine PROFINET devices and to make basic settings. <br> DCP uses the special multicast MAC address: xx-xx-xx-01-0E-CF, <br> $x x-x x-x x=$ Organizationally Unique Identifier |
| LLDP <br> Link Layer Discovery protocol | Not relevant | (2) Ethernet II and IEEE 802.1Q and Ethertype 0x88CC (PROFINET) | PROFINET <br> Link Layer Discovery protocol | LLDP is used by PROFINET to determine and manage neighborhood relationships between PROFINET devices. <br> LLDP uses the special multicast MAC address: 01-80-C2-00-00-0E |
| MRP <br> Media <br> Redundancy <br> Protocol | Not relevant | (2) Ethernet II and IEEE 802.1Q and Ethertype 0x88E3 (PROFINET) | PROFINET medium redundancy | MRP enables the control of redundant routes through a ring topology. <br> MRP uses the special multicast MAC address: $x x-x x-x x-01-15-4 E,$ <br> $x x-x x-x x=$ Organizationally Unique Identifier |
| РTCP <br> Precision Transparent Clock Protocol | Not relevant | (2) Ethernet II and IEEE 802.1Q and Ethertype 0x8892 (PROFINET) | PROFINET <br> send clock and time synchronization , based on IEEE 1588 | PTC enables a time-delay measurement between RJ45 ports and thus enables the send cycle synchronization and time synchronization. <br> PTCP uses the special multicast MAC address: xx-xx-xx-01-0E-CF, <br> $x x-x x-x x=$ Organizationally Unique Identifier |
| PROFINET IO data | Not relevant | (2) Ethernet II and IEEE 802.1Q and Ethertype 0x8892 (PROFINET) | PROFINET Cyclic IO data transfer | The PROFINET IO frames are used to cyclically transfer I/O data between the PROFINET IO controller and IO devices via Ethernet. |
| PROFINET <br> Context <br> Manager | 34964 | (4) UDP | PROFINET connection less RPC | The PROFINET context manager provides an endpoint mapper in order to establish an application relationship (PROFINET $A R)$. |


| Report | Port number | (2) Link layer <br> (4) Transport layer | Function | Description |
| :---: | :---: | :---: | :---: | :---: |
| Connection-oriented communication protocols |  |  |  |  |
| HTTP <br> Hypertext transfer protocol | 80 | (4) TCP | Hypertext transfer protocol | HTTP is used for the communication with the CU internal Web server. <br> Is open in the delivery state and can be deactivated. |
| ISO on TCP (according to RFC 1006) | 102 | (4) TCP | ISO-on-TCP protocol | ISO on TCP (according to RFC 1006) is used for the message-oriented data exchange to a remote CPU, WinAC or devices of other suppliers. <br> Communication with ES, HMI, etc. <br> Is open in the delivery state and is always required. |
| SNMP <br> Simple network management protocol | 161 | (4) UDP | Simple network management protocol | SNMP enables the reading out and setting of network management data (SNMP managed Objects) by the SNMP manager. Is open in the delivery state and is always required. |
| HTTPS <br> Secure Hypertext transfer protocol | 443 | (4) TCP | Secure Hypertext transfer protocol | HTTPS is used to communicate with the web server integrated in the CPU via Transport Layer Security (TLS). Is open in the delivery state and can be deactivated. |
| Reserved | 49152... 65535 | (4) TCP <br> (4) UDP | - | Dynamic port area that is used for the active connection endpoint if the application does not specify the local port. |

### 6.14 Parallel operation of communication interfaces

## General information

The two cyclic interfaces for the setpoints and actual values differ by the parameter ranges used (BICO technology, etc.) and the functions that can be used. The interfaces are designated as cyclic interface 1 (IF1) and cyclic interface 2 (IF2).
Cyclic process data (setpoints/actual values) are processed using interfaces IF1 and IF2. The following interfaces are used:

- Onboard interfaces of the Control Unit for PROFIBUS DP or PROFINET.
- An optional interface (COMM Board) for PROFINET (CBE20) or CANopen (CBC10) for insertion in the Control Unit.

Parameter p8839 is used to set the parallel use of the Control Unit onboard interfaces and COMM-Board. The functionality is assigned to interfaces IF1 and IF2 using indices.

For example, the following applications are possible:

- PROFIBUS DP for drive control and PROFINET for acquisition of actual values/measured values of the drive
- PROFIBUS DP for control and PROFINET for engineering only
- Mixed mode with two masters (the first for logic and coordination and the second for technology)
- SINAMICS Link via IF2 (CBE20); standard frames and PROFIsafe via IF1
- Operation of redundant communication interfaces


## Assignment of communication interfaces to cyclic interfaces

With the factory setting p8839 $=99$, the communication interfaces are permanently assigned to one of the cyclic interfaces (IF1, IF2), depending on the communication system, e.g., PROFIBUS DP, PROFINET, or CANopen.

The user is essentially free to define the assignment to the cyclic interfaces (via parameter assignment) for parallel operation of the communication interfaces.

Table 6-72 Properties of the cyclic interfaces IF1 and IF2

| Feature | IF1 | IF2 |
| :--- | :--- | :--- |
| Setpoint (BICO signal source) | r2050, r2060 | r8850, r8860 |
| Actual value (BICO signal sink) | p2051, p2061 | p8851, p8861 |

Table 6-73 Implicit assignment of hardware to cyclic interfaces for p8839[0] = p8839[1] $=99$

| Plugged hardware interface | IF1 | IF2 |
| :--- | :--- | :--- |
| No option, only Control Unit onboard interface <br> (PROFIBUS, PROFINET, or USS) | Control Unit onboard | -- |
| CU320-2 DP with CBE20 (optional PROFINET <br> interface) | COMM BOARD | Control Unit onboard <br> PROFIBUS or Control <br> Unit onboard USS |
| CU320-2 PN with CBE20 (optional PROFINET <br> interface) | Control Unit onboard | COMM BOARD <br> PROFINET |
| CAN option CBC10 | Control Unit onboard | COMM BOARD CAN |

Parameter p8839[0,1] is used to set the parallel operation of the hardware interfaces and the assignment to the cyclic interfaces IF1 and IF2 for the Control Unit drive object.
The object sequence for process data exchange via IF2 depends on the object sequence of IF1; see "List of drive objects" (p0978).
The factory setting of $\mathrm{p} 8839[0,1]=99$ enables the implicit assignment (see table above).
An alarm is output in case of invalid or inconsistent definition of the assignment via parameter assignment.

## Note

## Parallel operation of PROFIBUS and PROFINET

The data of isochronous applications can only be processed via one of the two interfaces IF1 or IF2 (p8815). 2 configuration options are available if additionally the PROFINET module CBE20 is inserted in the CU320-2 DP:

- p8839[0] = 1 and p8839[1] = 2: PROFIBUS isochronous, PROFINET cyclic
- p8839[0] = 2 and p8839[1] = 1: PROFINET isochronous, PROFIBUS cyclic


## Parameters for IF2

The following parameters are available in order to optimize the IF2 for a PROFIBUS or PROFINET interface:

- Receive and send process data: r8850, p8851, r8853, r8860, p8861, r88631)
- Diagnostic parameters: r8874, r8875, r88761)
- Binector-connector converters: p8880, p8881, p8882, p8883, p8884, r88891)
- Connector-binector converters: r8894, r8895, p8898, p88991)
${ }^{1)}$ Meaning of 88 xx is identical to 20 xx


## Note

A PROFIBUS slave/PROFINET device with two interfaces cannot be shown with the HW Config configuration tool. In the case of parallel operation, a SINAMICS drive therefore appears twice in the project or in two projects, although physically it is just one device.

## Parameters

| p8839 | PZD interface hardware assignment |
| :--- | :--- |
| Description: | Assignment of the hardware for cyclic communication via PZD interface 1 and <br> interface 2. |
| Value: | 0: Inactive |
|  | 1: Control Unit onboard |
|  | 2: COMM BOARD |
|  | 99: Automatic |

For p8839, the following rules apply:

- The setting of p8839 applies to all drive objects of a Control Unit (device parameter).
- When setting p8839[0] = 99 and p8839[1] = 99 (automatic assignment, factory setting), the hardware used is automatically assigned to interfaces IF1 and IF2. Both indices must be selected so that the automatic assignment is activated. If both indices are not selected, then an alarm is output and the setting p8839[x] = 99 is treated just like 'inactive'.
- An alarm is output if the same hardware (Control Unit onboard or COMM BOARD) is selected in p8839[0] and p8839[1]. The following then applies: the setting of p8839[0] and the setting of p8839[1] is treated like 'inactive'.
- If the CAN board (CBC10) is used, the entry of $\mathrm{p} 8839[0]=2$ is not permissible (no assignment of the CAN board to IF1). An alarm is then output.
- If $\mathrm{p} 8839[\mathrm{x}]=2$ is set and the COMM BOARD is missing or defective, then the corresponding interface is not supplied by the Control Unit onboard interface. Message A08550 is output instead.


## Parameters

- p0922 IF1 PROFIdrive frame selection
- p0978[0...24] List of drive objects
- p8815[0...1] IF1/IF2 PZD functionality selection
- p8839[0...1] PZD interface hardware assignment


### 6.15 Engineering Software Drive Control Chart (DCC)

## Graphical configuring and expansion of the device functionality by means of available closed-loop control, arithmetic, and logic function blocks

Drive Control Chart (DCC) expands the facility for the simplest possible configuring of technological functions for both the SIMOTION motion control system and the SINAMICS drive system. This provides the user with a new dimension of system adaptability for specific machine functions.
DCC does not restrict the number of functions that can be used; the only restriction is the performance of the target platform.
The user-friendly DCC Editor enables easy graphical configuration and a clear representation of control loop structures as well as a high degree of reusability of existing diagrams.

The open-loop and closed-loop control functionality is defined by using multi-instanceenabled blocks (Drive Control Blocks (DCBs)) from a pre-defined library (DCB library) that are selected and graphically linked by dragging and dropping.
Test and diagnostic functions allow verification of the program behavior, and troubleshooting in the event of a fault.

The block library encompasses a large selection of closed-loop, arithmetic and logic function blocks, as well as comprehensive open-loop and closed-loop control functions.

For combining, analyzing and acquiring binary signals, all commonly used logic functions are available for selection (AND, XOR, on/off delay, RS flipflop, counter, etc.). Numerous computation functions are available for monitoring and evaluating numerical variables; for example absolute value generation, division, min/max evaluation.
Besides drive control functions, it is also a simple matter to configure axis winding functions, PI controllers, ramp-function generators, and wobble generators.

Almost unlimited programming of control structures is possible in conjunction with the SIMOTION motion control system. These can then be combined with other program sections to form an overall program.

Drive Control Chart for SINAMICS also provides a convenient basis for resolving drive-level open-loop and closed-loop control tasks directly in the drive. This results in further adaptability of SINAMICS for the task set. On-site processing in the drive supports modular machine concepts and results in increased overall machine performance.

## Note <br> Detailed documentation

A detailed description of the DCC Editor and the available Drive Control Blocks is given in the relevant documentation. This documentation is available on the accompanying customer DVD.

## Setpoint channel and closed-loop control

### 7.1 Chapter content

This chapter provides information on the setpoint channel and closed-loop control functions.

- Setpoint channel
- Direction reversal
- Skip speed
- Minimum speed
- Speed limiting
- Ramp-function generator
- V/f control
- Vector speed control with/without encoder



## Function diagrams

At certain points in this section, reference is made to function diagrams. These can be found on the customer DVD in the "SINAMICS G130/G150 List Manual", which provides experienced users with detailed descriptions of all the functions.

### 7.2 Setpoint channel

### 7.2.1 Setpoint addition

## Description

The supplementary setpoint can be used to enter correction values from higher-level closedloop controls. This can be easily carried out using the addition point for the main/ supplementary setpoint in the setpoint channel. Both variables are imported simultaneously via two separate or one setpoint source and added in the setpoint channel.

## Function diagram

FP 3030 Main/supplementary setpoint, setpoint scaling, jogging

## Parameters

- p1070 Main setpoint
- p1071 Main setpoint scaling
- r1073 Main setpoint effective
- p1075 Supplementary setpoint
- p1076 Supplementary setpoint scaling
- r1077 Supplementary setpoint effective
- r1078 Total setpoint effective


### 7.2.2 Direction reversal

## Description

Due to the direction reversal in the setpoint channel, the drive can be operated in both directions of rotation with the same setpoint polarity.
Use the p1110 or p1111 parameter to block negative or positive direction of rotation.

## Note

## Incorrect rotating field during cable installation

If an incorrect rotating field was connected when the cables were installed and the cabling cannot be changed, the rotating field can be changed during drive commissioning via p1821 (rotating field direction reversal), thus enabling a direction reversal. Modifying parameter p1821 produces a direction reversal of the motor and the actual encoder value without changing the setpoint.

## Requirements

Direction reversal is initiated:

- via PROFIBUS by means of control word 1 , bit 11
- via the enclosed drive operator panel (LOCAL mode) with the "Direction reversal" key.


## Note

## Factory state

Note that only one direction of rotation is enabled in the factory state when control is carried out via the AOP30.

## Function diagram

$$
\text { FP } 3040 \text { Direction limiting and direction reversal }
$$

## Parameters

- p1110 BI: Inhibit negative direction
- p1111 BI: Inhibit positive direction
- p1113 BI: Setpoint inversion
- r1114 Setpoint after direction limiting


### 7.2.3 $\quad$ Skip frequency bands and minimum speed

## Description

In the case of variable-speed drives, it is possible for the control range of the overall drive train to contain bending-critical speeds that the drive must not be be run at or near in steadystate condition. In other words, although the drive can pass through this range, it must not remain within it because resonant oscillations may be excited. The skip frequency bands allow this range to be blocked for steady-state operation. Because the points at which critical speed resonances occur in a drive train can vary depending on age or thermal factors, a broader control range must be blocked. To prevent constant speed step changes in the vicinity of these skip frequency bands (speeds), they are provided with a hysteresis. The skip speed values apply in the positive and negative directions of rotation.

Specifying a minimum speed allows a specific range to be disabled around speed 0 rpm for steady-state operation.

## Signal flow diagram



Figure 7-1 Signal flow diagram: Skip frequency bands and minimum speed

## Function diagram

FP $3050 \quad$ Skip frequency bands and speed limiting

## Parameters

- p1080 Minimum speed
- p1091 Skip speed 1
- p1092 Skip speed 2
- p1093 Skip speed 3
- p1094 Skip speed 4
- p1098 Skip speed scaling
- r1099.0 Skip speed band status word
- p1101 Skip speed bandwidth
- p1106 Minimum speed signal source
- r1112 Speed setpoint after minimum limiting


### 7.2.4 Speed limiting

## Description

The purpose of speed limiting is to limit the maximum permissible speed of the entire drive train to protect the drive and load machine/process against damage caused by excessive speeds.

## Signal flow diagram



Figure 7-2 Signal flow diagram: Speed limiting

## Function diagram

FP $3050 \quad$ Skip frequency bands and speed limiting

## Parameters

- p1082 Maximum speed
- p1083 CO: Speed limit in positive direction of rotation
- r1084 CO: Speed limit positive effective
- p1085 Cl : Speed limit in positive direction of rotation
- p1086 CO: Speed limit in negative direction of rotation
- r1087 CO: Speed limit negative effective
- p1088 CI: Speed limit in negative direction of rotation
- r1119 CO: Ramp-function generator, setpoint at the input


### 7.2.5 Ramp-function generator

## Description

The ramp-function generator limits the rate at which the setpoint changes when the drive is accelerating or decelerating. This prevents imposing unwanted setpoint step changes on the drive train. Additional rounding times can also be set in the lower and upper speed ranges to improve control quality and prevent load surges, thereby protecting mechanical components such as shafts and couplings.

The ramp-up and ramp-down times each refer to the maximum speed (p1082). The rounding times that can be set can prevent the speed actual value from being overshot when the setpoint is approached, thereby improving control quality.

When final rounding is set, a sudden reduction of the setpoint during ramp-up may cause a setpoint overshoot if continuous smoothing is selected via p1134 = 0. The longer the specified final rounding-off time, the greater the overshoot.

Rounding is also effective in the zero crossover; in other words, when the direction is reversed, the ramp-function generator output is reduced to zero via initial rounding, the ramp-down time, and final rounding before the new, inverted setpoint is approached via initial rounding, the ramp-up time, and final rounding. Rounding times that can be set separately are active in the event of a quick stop (OFF3). The actual ramp-up/ramp-down times increase with active rounding.

The rounding type can be set using p1134 and separately activated/deactivated using p1151.0 in the zero point.

The ramp-up time ( p 1120 ) can be scaled via the connector input p 1138 , and the ramp-down time ( p 1121 ) via connector input p 1139 . Scaling is deactivated in the factory setting.

## Note

## Effective ramp-up time

The effective ramp-up time increases when you enter initial and final rounding times.
Effective ramp-up time $=$ p1120 $+(0.5 \times \mathrm{p} 1130)+(0.5 \times \mathrm{p} 1131)$

## Signal flow diagram



Figure 7-3 Signal flow diagram: Ramp-function generator

## Ramp-function generator tracking

If the drive is in the range of the torque limits, the speed actual value is removed from the speed setpoint. The ramp-function generator tracking updates the speed setpoint in line with the speed actual value and so levels the ramp.

Parameter p1145 is used to deactivate ramp-function generator tracking (p1145 = 0) or set the permissible deviation ( $p 1145>1$ ). Once the permissible deviation is reached, the speed setpoint at the ramp-function generator output will only be further increased in proportion to the speed setpoint.

Parameters p1151.1 and p1151.2 can be used to set whether the ramp-function generator tracking is carried out with or without a change of polarity.
Parameter r1199.5 indicates whether the ramp-function generator tracking feature is active.
without tracking

with tracking


Figure 7-4 Ramp-function generator tracking

## Without ramp-function generator tracking

- $\mathrm{p} 1145=0$
- The drive accelerates to t 2 , even though the setpoint after t 1 is smaller than the actual value.


## With ramp-function generator tracking

- At p1145>1 (values between 0 and 1 are not applicable), ramp-function generator tracking is activated when the torque limit is approached. The ramp-function generator output thereby only exceeds the speed actual value by the deviation value defined in p1145.
- t1 and t2 almost identical.


## Function diagrams

| FP 3060 | Basic ramp-function generator |
| :--- | :--- |
| FP 3070 | Extended ramp-function generator |
| FP 3080 | Ramp-function generator selection, status word, tracking |

## Parameters

- r1119 CO: Ramp-function generator, setpoint at the input
- p1120 Ramp-function generator, ramp-up time
- p1121 Ramp-function generator, ramp-down time
- p1130 Ramp-function generator, initial rounding time
- p1131 Ramp-function generator, final rounding time
- p1134 Ramp-function generator, rounding type
- p1135 OFF3 ramp-down time
- p1136 OFF3 initial rounding time
- p1137 OFF3 final rounding time
- p1138 CI: Ramp-function generator ramp-up time scaling
- p1139 CI: Ramp-function generator ramp-down time scaling
- p1140 BI: Enable ramp-function generator/disable ramp-function generator
- p1141 BI: Continue ramp-function generator/Freeze ramp-function generator
- p1142 BI: Enable setpoint/disable setpoint
- p1143 BI: Accept ramp-function generator setting value
- p1144 CI: Ramp-function generator setting value
- p1145 Ramp-function generator tracking intensity
- p1148 Ramp function generator tolerance for ramp-up and ramp-down active
- r1149 CO: Ramp-function generator acceleration
- r1150 Ramp-function generator, speed setpoint at the output
- p1151 CO: Ramp-function generator configuration
- r1199.0... 8 Ramp-function generator status word


### 7.3 V/f (V/Hz) control

## Description

The simplest solution for a control procedure is the $\mathrm{V} / \mathrm{f}$ characteristic, whereby the stator voltage for the induction motor or synchronous motor is controlled proportionately to the stator frequency. This method has proven successful in a wide range of applications with low dynamic requirements, such as:

- Pumps and fans
- Belt drives
- Multi-motor drives

V/f control aims to maintain a constant flux $(\Phi)$ in the motor, whereby the flux is proportional to the magnetization current $(\mathrm{l} \mu)$ or the ratio of voltage $(\mathrm{V})$ to frequency $(\mathrm{f})$.
$\Phi \sim I \mu \sim V / f$
The torque (M) generated by the induction motors is, in turn, proportional to the product (or, more precisely, the vector product ( $\Phi \times \mathrm{l})$ ) of the flux and current.
$M \sim \Phi \times I$
To generate as much torque as possible with a given current, the motor must function using the greatest possible constant flux. To maintain a constant flux ( $\Phi$ ), therefore, the voltage ( V ) must change in proportion to the frequency (f) to ensure a constant magnetization current ( $\mathrm{l} \mu$ ). V/f characteristic control is derived from these basic premises.
The field-weakening range is above the rated motor frequency, where the maximum voltage is reached. The flux and maximum torque decrease as the frequency increases; this is illustrated in the following diagram.


Figure 7-5 Operating ranges and characteristic curves for the induction motor with converter supply

Several variations of the V/f characteristic exist; these are listed in the following table.

Table 7-1 p1300 V/f characteristics

| Parameter value | Meaning | Application/property |  |
| :---: | :---: | :---: | :---: |
| 0 | Linear characteristic | Standard with variable voltage boost |  |
| 1 | Linear characteristic with flux current control (FCC) | Characteristic that compensates for voltage losses in the stator resistance for static/ dynamic loads (flux current control FCC). This is particularly useful for small motors, since they have a relatively high stator resistance. |  |
| 2 | Parabolic characteristic | Characteristic that takes into account the motor torque curve (e.g., fan/pump) <br> - Quadratic characteristic (f² characteristic) <br> - Energy saving because the low voltage also results in small currents and losses |  |
| 3 | Programmable characteristic | Characteristic that takes into account the motor/machine torque characteristic |  |
| 4 | Linear characteristic and ECO | Characteristic (see parameter value 0 ) and Eco mode at a constant operating point. <br> - At a constant operating point, the efficiency is optimized by varying the voltage. <br> - This requires active slip compensation; the scaling must be set such that the slip is fully compensated (p1335 = $100 \%$ ). |  |

### 7.3 V/f (V/Hz) control

| $\begin{array}{c}\text { Parameter } \\ \text { value }\end{array}$ | Meaning | $\quad$ Application/property |
| :---: | :--- | :--- |
| 5 | $\begin{array}{l}\text { Precise frequency } \\ \text { drives (textiles) }\end{array}$ | $\begin{array}{l}\text { Characteristic (see parameter value 0) that takes into account the technological } \\ \text { specifics of an application (e.g., textile applications). } \\ \text { - The current limitation (Imax controller) affects only the output voltage and not the } \\ \text { output frequency. }\end{array}$ |
| 6 | $\begin{array}{l}\text { Precise frequency } \\ \text { Slip compensation and resonance damping are disabled. }\end{array}$ |  |
| drives with flux |  |  |
| current control (FCC) |  |  | \(\left.\left.\begin{array}{l}Characteristic (see parameter value 1) that takes into account the technological <br>

specifics of an application (e.g., textile applications). <br>
- The current limitation (Imax controller) affects only the output voltage and not the <br>
output frequency.\end{array}\right\} $$
\begin{array}{l}\text { - Slip compensation and resonance damping are disabled. } \\
\text { Voltage losses in the stator resistor are also compensated for static / dynamic loads } \\
\text { (flux current control FCC). This is particularly useful for small motors, since they have } \\
\text { a relatively high stator resistance. }\end{array}
$$\right\}\)

## Function diagram

FP $6301 \quad$ V/f characteristic and voltage boost

## Parameters

- p1300 Open-loop/closed-loop control operating mode
- p1320 V/f control programmable characteristic frequency 1
- p1327 V/f control programmable characteristic voltage 4
- p1330 CI: V/f control independent of voltage setpoint
- p1331 Voltage limiting
- p1333 V/f control FCC starting frequency
- r1348 V/f control Eco-factor actual value
- p1350 V/f control soft startup


### 7.3.1 Voltage boost

## Description

With low output frequencies, the V/f characteristics yield only a small output voltage.
With low frequencies, too, the ohmic resistance of the stator windings has an effect and can no longer be ignored vis-à-vis the machine reactance. With low frequencies, therefore, the magnetic flux is no longer proportional to the magnetization current or the V/f ratio.

Therefore. the output voltage may be too low to:

- Magnetize the induction motor
- Maintain the load
- Compensate for the voltage losses (ohmic losses in the winding resistors) in the system
- Induce a breakaway / accelerating / braking torque

You can choose whether the voltage boost is to be active permanently (p1310) or only during acceleration (p1311). Via p1312, you can also set a one-time voltage boost in the first ramp-up after the pulse enable.


Figure 7-6 Voltage boost total

## Note

Voltage boost effect
The voltage boost affects all V/f characteristics (p1300) from 0 to 7.

## Note

## Avoid thermal overload

If the voltage boost value is too high, this can result in a thermal overload of the motor winding.

## Permanent voltage boost (p1310)

The voltage boost is active across the entire frequency range up to the rated frequency $f_{n}$; at higher frequencies, the value decreases continuously.


Figure 7-7 Permanent voltage boost (example: p1300 $=0, \mathrm{p} 1310>0, \mathrm{p} 1311=\mathrm{p} 1312=0$ )

## Voltage boost on acceleration (p1311)

The voltage boost is effective only during an acceleration process and only until the setpoint is reached.

The voltage boost is effective only when the "ramp-up active" signal (r1199.0 = 1) is present. Via parameter r0056.6, it is possible to observe whether the voltage boost at acceleration is active.


Figure 7-8 Voltage boost during acceleration (example: p1300 $=0, \mathrm{p} 1310=0, \mathrm{p} 1311>0$ )

## Voltage boost at startup (p1312)

The voltage boost is effective only during the first acceleration after the pulse enable and only until the setpoint is reached.
The voltage boost is effective only when the "ramp-up active" signal (r1199.0 = 1) is present. Via parameter r0056.5, it is possible to observe whether the voltage boost at startup is active.

## Function diagram

FP $6300 \quad$ V/f characteristic and voltage boost

## Parameters

- r0056.5 Voltage boost at start up active/inactive
- r0056.6 Acceleration voltage active/inactive
- p0304 Rated motor voltage
- p0305 Rated motor current
- r0395 Current stator resistance
- p1310 Startup current (voltage boost), continual
- p1311 Startup current (voltage boost) on acceleration
- p1312 Startup current (voltage boost) at startup
- r1315 Voltage boost total


### 7.3.2 Resonance damping

## Description

The resonance damping function dampens active current oscillations that frequently occur under no-load conditions.

The resonance damping is active in a range from approximately $6 \%$ of the rated motor frequency ( p 0310 ). The switch-off frequency is determined by p 1349.

For p1300 $=5$ and 6 (textiles) the resonance damping is internally disabled in order to be able to precisely set the output frequency.


Figure 7-9 Resonance damping

## Note

## Automatic setting

When p1349 = 0, the changeover limit is automatically set to $95 \%$ of the rated motor frequency, but only up to 45 Hz .

## Function diagram

FP 6310 Resonance damping and slip compensation

## Parameters

- r0066 Output frequency
- r0078 Current actual value torque-generating
- p1338 V/f control resonance damping gain
- p1339 V/f control resonance damping filter time constant
- p1349 V/f control resonance damping maximum frequency


### 7.3.3 Slip compensation

## Description

Slip compensation essentially keeps the speed of induction motors constant, irrespective of the load ( $\mathrm{M}_{1}$ or $\mathrm{M}_{2}$ ).
When the load is increased from $M_{1}$ to $M_{2}$, the setpoint frequency is increased automatically so that the resulting frequency and thus also the motor speed remain constant. When the load is reduced from $M_{2}$ to $M_{1}$, the setpoint frequency is automatically decreased accordingly.
For p1300 $=4$ and 7 (V/f controllers with ECO), the slip compensation must be activated to ensure correct operation.
For p1300 = 5 and 6 (textiles), the slip compensation is internally disabled in order to be able to precisely set the output frequency.
If a motor holding brake is used, a setting value can be specified at the slip compensation output via p1351. A parameter setting of p1351>0 turns on the slip compensation automatically (p1335 = $100 \%$ ).


Figure 7-10 Slip compensation

## Function diagram

FP 6310 Resonance damping and slip compensation

## Parameters

- r0330 Rated motor slip
- p1334 Slip compensation starting frequency
- p1335 Slip compensation scaling p1335 $=0.0$ \%: Slip compensation is disabled. p1335 $=100.0$ \%: Slip is fully compensated.
- p1336 Slip compensation limit value
- r1337 CO: Actual slip compensation
- p1351 CO: Motor holding brake start frequency


### 7.4 Vector speed/torque control with/without an encoder

## Description

Compared with V/f control, vector control offers the following benefits:

- Stability vis-à-vis load and setpoint changes
- Short rise times with setpoint changes ( $->$ better command behavior)
- Short settling times with load changes ( $->$ better disturbance characteristic)
- Acceleration and braking are possible with maximum adjustable torque
- Motor protection due to variable torque limitation in motor and regenerative mode
- Drive and braking torque controlled independently of the speed
- Maximum breakaway torque possible at speed 0

These benefits are available without speed feedback.
Vector control can be used with or without an encoder.
The following criteria indicate when an encoder is required:

- Maximum speed accuracy requirements
- Maximum dynamic response requirements
- Better command behavior
- Shortest settling times when disturbances occur
- Torque control is required in a control range greater than 1:10
- Allows a defined and/or variable torque for speeds below approx. $10 \%$ of the rated motor frequency (p0310) to be maintained.
- A speed controller is normally always required for applications in which an unknown speed can represent a safety risk (where a load can be dropped, e.g., lifting gear, elevators, etc).

With regard to setpoint input, vector control is divided into:

- Closed-loop speed Control
- Torque/current control (in short: torque control)


### 7.4.1 Vector control without an encoder

## Description

For encoderless vector control (SLVC: Sensorless Vector Control), the position of the flux and actual speed must be determined via the electric motor model. The model makes use of the available current and voltage actual value signals. At low frequencies (approx. 1 Hz ), the model cannot determine the speed.

For this reason and due to uncertainties in the model parameters or inaccurate measurements, the system is switched from closed-loop to open-loop operation in this range.

The changeover between closed-loop/open-loop operation is controlled on the basis of time and frequency conditions (p1755, p1756, p1758 - only for induction motors). The system does not wait for the time condition to elapse if the setpoint frequency at the ramp-function generator input and the actual frequency are below p1755 x (1-(p1756 / $100 \%$ ) simultaneously.
Transition from open-loop to closed-loop operation always takes place when the changeover speed in p1755 (characteristic "1" in the figure below). If the speed increase is set very slow and a changeover delay time $>0$ is set in p1759, transition takes place after the changeover delay time (characteristic " 2 " in the figure below).


Figure 7-11 Changeover conditions

## Setting the torque setpoint

In open-loop operation, the calculated actual speed value is the same as the setpoint value. For vertical loads and acceleration processes, parameters p1610 (static torque setpoint) and p1611 (additional acceleration torque) must be adapted to the necessary maximum torque in order to generate the static or dynamic load torque of the drive. If, on induction motors, p 1610 is set to $0 \%$, only the magnetizing current r0331 is injected; at a value of $100 \%$, the rated motor current p0305 is injected.
For permanent-magnet synchronous motors, at p1610 $=0 \%$, a precontrol absolute value derived from the supplementary torque r1515 remains instead of the magnetizing current for induction motors. To ensure that the drive does not stall during acceleration, p1611 can be
increased or acceleration feedfoward control for the speed controller can be used. This is also advisable to ensure that the motor is not subject to thermal overload at low speeds.

If the moment of inertia of the drive is almost constant, acceleration feedforward control via p1496 offers more advantages than the additional acceleration torque via p1611. The moment of inertia of the drive is determined with the rotating measurement via p1900 $=3$ and $\mathrm{p} 1960=1$.

Encoderless vector control has the following characteristics at low frequencies:

- Closed-loop controlled operation for passive loads down to approx. 0 Hz output frequency $(\mathrm{p} 0500=2)$, for p1750.2 $=1$ and p1750.3 $=1$.
- Starting of an induction motor in closed-loop controlled mode (after the motor has been completely excited), if the speed setpoint before the ramp-function generator is greater than p 1755.
- Reversing without the need to change to open-loop controlled mode is possible, if the range of the changeover speed ( p 1755 ) is passed through in a shorter time than the changeover waiting time set ( p 1758 ), and the speed setpoint before the ramp-function generator lies outside the open-loop controlled speed range ( p 1755 ).
- In closed-loop torque controlled mode, at low speeds, the system always switches over to open-loop controlled mode.


## Note

## Requirement

In this case, the speed setpoint upstream of the ramp-function generator must be greater than the changeover speed in p1755.

Closed-loop controlled operation down to approx. 0 Hz (settable via parameter p1755) and the ability to start or reverse at 0 Hz directly in closed-loop operation (settable via parameter p 1750 ) results in the following benefits:

- No switchover operation required within closed-loop control (bumpless behavior, no frequency dips, no discontinuities in the torque).
- Closed-loop speed control without encoder down to and including 0 Hz
- Passive loads down to a frequency of 0 Hz
- Steady-state closed-loop speed control down to approx. 0 Hz possible
- Higher dynamic performance when compared to open-loop controlled operation


## Note

## Automatic changeover

If, in the closed-loop controlled mode, start from 0 Hz or reversing takes longer than 2 s , or the time set in p1758 - then the system automatically changes over from closed-loop controlled into open-loop controlled operation.

## Note

## Operation in encoderless torque control

Operation in encoderless closed-loop torque control only makes sense if, in the speed range below the changeover speed of the motor model (p1755), the setpoint torque is greater than the load torque. The drive must be able to follow the setpoint and the associated setpoint speed (p1499).

## Closed-loop operation down to standstill for non-overhauling (passive) loads

With only non-overhauling load at the starting point, it is possible to maintain steady-state closed-loop operation down to zero frequency (standstill) without having to change over to open-loop operation.
Parameter p1750.2 = 1 must be set.
Closed-loop control without changeover is restricted to applications with non-overhauling load:
These include applications in which the load cannot produce a regenerative torque at startup and the motor comes to a standstill when pulses are inhibited; for example, moments of inertia, brakes, pumps, fans, centrifuges, extruders, etc.

Standstill of any duration is possible without holding current, only the motor magnetization current is injected.

Steady-state regenerative operation at a frequency close to 0 Hz is not possible.
It is also possible to select sensorless control for passive loads during commissioning by setting p0500 $=2$ (technology application $=$ passive loads (for sensorless control down to $f=0)$ ).
This function is activated automatically if quick commissioning is exited with p3900 $>0$, or if automatic calculation is called ( $\mathrm{p} 0340=1,3,5$ or $\mathrm{p} 0578=1$ ).

## Blocking drives

If the load torque is higher than the torque limiting of the encoderless closed-loop vector control, the drive is braked to zero speed (standstill). To ensure that open-loop controlled mode is not switched to after time p1758, p1750.6 can be set to 1 . It may be necessary to increase p2177 (Motor blocked delay time).

## Note

Exception for reversing drives
It is not permissible to use this setting if the load can force the drive to reverse.

## Active loads

Active loads that can be used to reverse the drive, e.g., hoisting gear, must be started in the open-loop speed control mode. In this case, bit p1750.6 must be set to 0 (open-loop controlled operation when the motor is blocked). The static (steady state) torque setpoint (p1610) must be greater than the maximum occurring load torque.

## Note

## Loads that can drive the motor

For applications with high regenerative load torques at low speeds, p1750.7 can also be set to 1 . As a result, the speed changeover limits of the motor model are increased and a faster changeover to open-loop controlled operation is possible.

## Permanent-magnet synchronous motors

## Standard procedure: open-loop controlled operation at low speeds

Permanent-magnet synchronous motors are normally started and reversed in open-loop operation. The changeover speeds are set to $10 \%$ as well as $5 \%$ of the rated motor speed. Changeover is not subject to any time condition (p1758 is not evaluated). Prevailing load torques (motor or regenerative) are adapted in open-loop operation, facilitating constanttorque crossover to closed-loop operation even under high static loads. Whenever the pulses are enabled, the rotor position is identified.


Figure 7-12 Zero point in open-loop operation at low speeds

## Extended method: closed-loop controlled operation to zero speed

By superimposing high-frequency pulses onto the driving fundamental voltage and evaluating the superimposed pulses occurring as a result in the machine current, it is possible to determine the continuous rotor position down to zero frequency (standstill).

With Siemens series 1FW4 and 1PH8 torque motors, it is possible to approach the rated torque from a standstill at any load, or even to stop the load at a standstill.

This method is suitable for motors with internal magnets.

## Note

## Use of a sine-wave filter

When using a sine-wave filter, apply the open-loop method.

The following advantages are obtained by maintaining closed-loop controlled operation:

- No switchover required within closed-loop control (smooth switchover, no discontinuities in the torque).
- Sensorless closed-loop speed and torque control down to and including 0 Hz
- Higher dynamic performance compared to open-loop controlled operation.
- Encoderless operation of drive line-ups (e.g. in the paper industry, master-slave operation).
- Active (including hanging/suspended) loads down to a frequency equal to zero.

Basic conditions for the use of third-party motors:

- Experience shows that this method is extremely well suited for interior permanent magnet synchronous motors (IPMSM).
- The ratio of stator quadrature-axis reactance (Lsq): Stator direct-axis reactance (Lsd) must be > 1 (recommendation: minimum > 1.5).
- The asymmetrical reactance ratio (Lsq:Lsd) is maintained in the motor up to a certain current; this determines the possible operating limits of the method. If it you want to be able to operate the method up to the rated motor torque, the reactance ratio must be maintained up to the rated motor current.

The following parameter input is prerequisite for optimal performance:

- Input of the saturation characteristic: p0362 - p0369
- Input of the load characteristic: p0398, p0399

Commissioning sequence for closed-loop controlled operation down to zero speed:

- Perform commissioning with motor identification at standstill.
- Enter the parameters for saturation characteristic and load characteristic.
- Activate closed-loop operation down to zero speed via parameter p1750 bit 5 .


Figure 7-13 Zero point in closed-loop operation down to zero speed

## Function diagrams

FP 6730 Interface to the Motor Module (ASM), p0300 = 1)
FP 6731 Interface to the Motor Module (PEM), p0300 = 2)

## Parameters

- p0305 Rated motor current
- r0331 Motor magnetizing current/short-circuit current
- p0362 Saturation characteristic flux 1
p0365 Saturation characteristic flux 4
- p0366 Saturation characteristic I_mag 1
... ...
p0369 Saturation characteristic I_mag 4
- p0398 Magnet angle. Decoupling (cross saturation) coefficient 1
- p0398 Magnet angle. Decoupling (cross saturation) coefficient 3
- p0500 Technology application
- p0578 Calculate technology/unit-dependent parameters
- p1605 Sample pulsing regime configuration
- r1606 CO: Sample pulsing regime current
- p1607 Pulsing regime stimulus
- r1608 CO: Pulsing regime response
- p1610 Torque setpoint static (SLVC)
- p1611 Supplementary accelerating torque (SLVC)
- p1750 Motor model configuration
- p1755 Motor model changeover speed encoderless operation
- p1756 Motor model changeover speed hysteresis
- p1758 Motor model changeover delay time, closed/open-loop control
- p1759 Motor model changeover delay time open/closed loop control
- r1762.1 Motor model deviation component 1 - deviation Model2
- p1798 Motor model pulsing regime speed adaptation Kp
- p1810.3 Modulator configuration - current measurement oversampling activated (for PEM pulsing regime)


### 7.4.2 Vector control with encoder

## Description

Benefits of vector control with an encoder:

- The speed can be controlled right down to 0 Hz (standstill).
- Stable control response throughout the entire speed range
- Allows a defined and/or variable torque for speeds below approx. $10 \%$ of the rated motor speed to be maintained
- Compared with speed control without an encoder, the dynamic response of drives with an encoder is significantly better because the speed is measured directly and integrated in the model created for the current components.


## Motor model change

A model change takes place between the voltage model and the observer model within the speed range p1752 x ( $100 \%-\mathrm{p} 1753$ ) and p1752. In the voltage model range (i.e., at lower speeds), torque accuracy depends on whether thermal tracking of the rotor resistance is carried out correctly. In the observer-model range and at speeds of less than approx. $20 \%$ of the rated speed, torque accuracy depends primarily on whether thermal tracking of the stator resistance is carried out correctly. If the resistance of the supply cable is greater than 20 to $30 \%$ of the total resistance, this should be entered in p0352 before motor data identification is carried out (p1900/p1910).

To deactivate thermal adaptation, set p0620 $=0$. This may be necessary if adaptation cannot function accurately enough due to the following general conditions. This may be the case, for example, if a sensor is not used for temperature measurement and the ambient temperatures fluctuate significantly or the overtemperatures of the motor (p0626 to p0628) deviate significantly from the default settings due to the design of the motor.

## Function diagrams

FP 4715 Actual speed value and rotor position measurement, motor encoder
FP 6030 Speed setpoint, droop
FP 6040 Speed controller with/without encoder
FP 6050 Speed controller adaptation (Kp_n/Tn_n adaptation)
FP 6060 Torque setpoint
FP 6490 Speed control configuration

### 7.4.3 Actual speed value filter

## Description

The actual speed value filter is used to suppress cyclic disturbance variables during speed acquisition.
The actual speed value filter can be set as follows:

- 2nd order lowpass (PT2: -40 dB/decade)
- General filter 2nd order

STARTER converts band-stop and low-pass with reduction in the parameters of the general 2nd order filter.

The actual speed value filter is activated with p1656.4 $=1$. The properties of the actual speed value filter are set with p1677 to p1681.
As long as changes to the data of the actual speed value filter are being made, the conversion of the new filter data can be prevented using p1699 $=1$. When p1699 $=0$ is set, the calculation will be performed and the new values applied.

## Note

For the vector control, there are two current setpoint filters and one actual speed value filter. The actual speed value filter has been allocated the number " 5 ".

## Function diagram

FP 4715 Encoder evaluation - Actual speed value and pole position sensing, motor encoder (encoder 1), n_actual_filter 5

## Parameters

- p1655[4] CI: Speed actual value filter 5 natural frequency tuning
- p1656.4 Actual speed value filter 5 activation
- p1677 Actual speed value filter 5 type
- p1678 Actual speed value filter 5 denominator natural frequency
- p1679 Actual speed value filter 5 denominator damping
- p1680 Actual speed value filter 5 numerator natural frequency
- p1681 Actual speed value filter 5 numerator damping
- p1699 Filter data acceptance


### 7.4.4 Speed controller

Both closed-loop control techniques with and without encoder (SLVC, VC) have the same speed controller structure that contains the following components as the kernel:

- PI controller
- Speed controller feedfoward control
- Droop

The total of the output variables forms the torque setpoint, which is reduced to the permissible size by means of the torque setpoint limitation.

## Function of the speed controller

The speed controller receives its setpoint (r0062) from the setpoint channel and its actual value (r0063) either directly from the actual speed value encoder (vector control with an encoder) or indirectly via the motor model (encoderless vector control). The system difference is increased by the PI controller and, in conjunction with the feedfoward control, results in the torque setpoint.

When the load torque increases, the speed setpoint is reduced proportionately when droop is active, which means that the single drive within a group (two or more mechanically connected motors) is relieved when the torque becomes too great.


Figure 7-14 Speed controller
The optimum speed controller setting can be determined via the automatic speed controller optimization function (p1900 $=1$, rotating measurement).
If the moment of inertia has been specified, the speed controller ( $\mathrm{Kp}, \mathrm{Tn}$ ) can be calculated by means of automatic configuration ( $\mathrm{p} 0340=4$ ). The controller parameters are defined in accordance with the symmetrical optimum as follows:
$\mathrm{Tn}=4 \mathrm{x}$ Ts
$\mathrm{Kp}=0.5 \times \mathrm{r} 0345 / \mathrm{Ts}=2 \times \mathrm{r0345} / \mathrm{Tn}$
Ts = Sum of the short delay times (includes p1442 and p1452).

If vibrations occur with these settings, the speed controller gain ( Kp ) will need to be reduced manually. Actual-speed-value smoothing can also be increased (standard procedure for gearless or high-frequency torsion vibrations) and the controller calculation performed again because this value is also used to calculate Kp and Tn.

The following relationships apply for optimization:

- If Kp is increased, the controller becomes faster, although overshoot is increased. However, signal ripples and vibrations in the speed control loop will increase.
- If Tn is reduced, the controller will speed up, However, this increases the overshoot.

When setting the speed control manually, you are advised to define the dynamic response via Kp (and actual-speed-value smoothing) first, so that the integral time can subsequently be reduced as much as possible. Please note that the closed-loop control must also remain stable in the field-weakening range.

To suppress any vibrations that occur in the speed controller, it is usually only necessary to increase the smoothing time in p1452 for operation without an encoder or p1442 for operation with an encoder, or reduce the controller gain.

The integral output of the speed controller can be monitored via r1482 and the limited controller output via r1508 (torque setpoint).

## Note

Reduced dynamic response for encoderless operation
Compared with speed control with an encoder, the dynamic response of encoderless drives is significantly reduced. The actual speed is derived by means of a model calculation based on the drive output variables for current and voltage that have a corresponding interference level. To this end, the actual speed must be adjusted by means of filter algorithms in the software.

## Speed controller response when a brake is opened

After a motor has been a magnetized, "Open brake" is controlled. The value that the BICO input delivers defines the speed controller response:

- BICO input p1475 (torque setting value for the motor holding brake) supplies a value of 0 :
- The speed controller I component is immediately enabled; this means that the system can respond to a slipping load and establish a holding torque.
- Depending on the parameter assignment, the speed setpoint remains inhibited until the brake opening time has elapsed ( $\mathrm{p} 1275.6=0$ ) - or until the brake feedback signal is received $(\mathrm{p} 1275.6=1)$.
- BICO input p1475 (torque setting value for the motor holding brake) supplies a value $\neq 0$ :
- The speed controller I component is held at the specified setting value until the "Brake open" feedback signal is received.
- Only then are the speed controller I component and the speed setpoint enabled.


## Function diagram

FP 6040 Speed controller with/without encoder

## Parameters

- r0062 CO: Speed setpoint after filter
- r0063 CO: Actual speed value, smoothed
- p0340 Automatic calculation of motor/control parameters
- r0345 Rated motor startup time
- p1442 Speed controller actual speed value smoothing time
- p1452 Speed controller actual speed value smoothing time (without encoder)
- p1460 Speed controller P gain adaptation speed lower
- p1462 Speed controller integral time adaptation speed lower
- p1470 Speed controller encoderless operation $P$ gain
- p1472 Speed controller encoderless operation integral time
- p1475 CI: Speed controller torque setting value for motor holding brake
- p1478 CI: Speed controller integrator setting value
- r1482 CO: Speed controller I-torque output
- r1508 CO: Torque setpoint before supplementary torque
- p1960 Rotating measurement selection


## Examples of speed controller settings

A number of examples of speed controller settings with vector control without encoders $(p 1300=20)$ are provided below. These should not be considered generally valid and must be checked in terms of the control response required.

- Fans (large centrifugal masses) and pumps
$\mathrm{Kp}(\mathrm{p} 1470)=2$ to 10
$\mathrm{Tn}(\mathrm{p} 1472)=250 \mathrm{~ms}$ to 500 ms
The Kp = 2 and $\mathrm{Tn}=500 \mathrm{~ms}$ settings result in asymptotic approximation of the actual speed to the setpoint speed after a setpoint step change. During many simple control procedures, this is satisfactory for pumps and fans.
- Grinding mills, separators (large centrifugal masses)
$\mathrm{Kp}(\mathrm{p} 1470)=12$ to 20
$\mathrm{Tn}(\mathrm{p} 1472)=500 \mathrm{~ms}$ to 1000 ms
- Kneader drives
$\mathrm{Kp}(\mathrm{p} 1470)=10$
$\mathrm{Tn}(\mathrm{p} 1472)=200 \mathrm{~ms}$ to 400 ms


## Note

## Check speed control gain

We recommend checking the effective speed control gain (r1468) during operation. If this value changes during operation, Kp adaptation is being used ( $\mathrm{p} 1400.5=1$ ). $\underline{K p}$ adaptation can, if necessary, be deactivated or its behavior changed.

- Operation with an encoder (p1300 = 21)

A smoothing value for the actual speed value ( p 1442 ) $=5 \mathrm{~ms}$ to 20 ms ensures quieter operation of motors with gear units.

### 7.4.4.1 Speed controller feedfoward control (integrated feedfoward control with balancing)

## Description

The command behavior of the speed control loop can be improved by calculating the accelerating torque from the speed setpoint and connecting it on the input side of the speed controller. This torque setpoint mv is applied directly as an additive reference variable on the input side/supply side of the current controller by means of adaptation elements (enabled via p1496).
The torque setpoint ( mv ) is calculated from:
$m v=p 1496 \times J \times(d n / d t)=p 1496 \times p 0341 \times p 0342 \times(d n / d t)$
The motor moment of inertia p0341 is calculated when the drive system is commissioned. The factor p0342 between the total moment of inertia J and the motor moment of inertia must be determined manually or by optimizing the speed controller. The acceleration is calculated from the speed difference as a function of time $\mathrm{dn} / \mathrm{dt}$.

## Note

Using speed controller optimization
When speed controller optimization is carried out, the ratio between the total moment of inertia and that of the motor ( p 0342 ) is determined and acceleration feedfoward control scaling ( p 1496 ) is set to $100 \%$.
If $\mathrm{p} 1400.2=\mathrm{p} 1400.3=0$, then the feedfoward control balancing is automatically set.

2) Only when p14002 $=0$

Figure 7-15 Speed controller with feedfoward control
When correctly adapted, when accelerating, the speed controller only has to compensate disturbance variables in its control loop. This is achieved with a relatively minor controlled variable change at the controller output.
The effect of the feedfoward control variable can be adapted according to the application using the weighting factor p1496. For p1496 = $100 \%$, the feedfoward control is calculated according to the motor and load moment of inertia (p0341, p0342). A balancing filter is used automatically to prevent the speed controller from acting against the injected torque setpoint. The time constant of the balancing filter corresponds to the equivalent delay time of the speed control loop. The speed controller feedfoward control is correctly set ( $\mathrm{p} 1496=100 \%$, calibration using p0342) if the I component of the speed controller (r1482) does not change while ramping-up or ramping-down in the range $\mathrm{n}>20 \% \times \mathrm{p} 0310$. Thus, the precontrol allows a new speed setpoint to be approached without overshoot (prerequisite: the torque limitation does not act and the moment of inertia remains constant).

If the speed controller is feedfoward controlled by means of injection, the speed setpoint (r0062) is delayed with the same smoothing time ( p 1442 or p 1452 ) as the actual value (r1445). This ensures that no target/actual difference (r0064) occurs at the controller input during acceleration, which would be attributable solely to the signal propagation time.
When speed feedfoward control is activated, the speed setpoint must be specified continuously or without a higher interference level (prevents sudden torque changes). An appropriate signal can be generated by smoothing the speed setpoint or activating the rampfunction generator rounding p1130-p1131.
The startup time r0345 ( $\mathrm{T}_{\text {startup }}$ ) is a measure for the total moment of inertia J of the machine and describes the time during which the non-loaded drive can be accelerated with the rated motor torque r0333 ( $\mathrm{M}_{\text {mot,rated }}$ ) from standstill to the rated motor speed p 0311 ( $\mathrm{n}_{\text {mot,rated }}$ ).
$\mathrm{r} 0345=\mathrm{T}_{\text {startup }}=\mathrm{J} \times\left(2 \times \pi \times \mathrm{n}_{\text {mot,rated }}\right) /\left(60 \times \mathrm{M}_{\text {mot,rated }}\right)=\mathrm{p} 0341 \times \mathrm{p} 0342 \times(2 \times \pi \times \mathrm{p} 0311) /$ (60 x r0333)

The ramp-up and ramp-down times should always be set to values larger than the startup time.

## Note

## Setting the ramp-function generator

The ramp-up and ramp-down times ( p 1120 ; p1121) of the ramp-function generator in the setpoint channel should be set accordingly so that the motor speed can track the setpoint during acceleration and braking. This will optimize the function of speed controller feedfoward control.

Acceleration feedfoward control using a connector input (p1495) is activated by the parameter settings p1400.2 $=1$ and p1400.3 $=0$. For balancing, p1428 (dead time) and p1429 (time constant) can be set.

## Function diagram

FP 6031 Pre-control balancing reference/acceleration model

## Parameters

- p0311 Rated motor speed
- r0333 Rated motor torque
- p0341 Motor moment of inertia
- p0342 Ratio between the total and motor moment of inertia
- r0345 Rated motor startup time
- p1400.2 Acceleration feedfoward control source
- p1428 Speed feedfoward control balancing dead time
- p1429 Speed feedfoward control balancing time constant
- p1496 Acceleration feedfoward control scaling
- r1518 Acceleration torque


### 7.4.4.2 Reference model

## Description

The reference model is activated with p1400.3 = 1 .
The reference model is used to emulate the speed control loop with a P speed controller.
The loop emulation can be set in p1433 to p1435. It takes effect if p1437 is connected to the output of the model r1436.

The reference model delays the setpoint-actual value deviation for the integral component of the speed controller so that settling (stabilizing) operations can be suppressed.

The reference model can also be externally emulated and the external signal entered via p1437.


Figure 7-16 Reference model

## Function diagram

FP 6031 Pre-control balancing reference/acceleration model

## Parameters

- p1400.3 Reference model speed setpoint I component
- p1433 Speed controller reference model natural frequency
- p1434 Speed controller reference model damping
- p1435 Speed controller reference model deadtime
- r1436 Speed controller reference model speed setpoint output
- p1437 Speed controller reference model I component input


### 7.4.4.3 Speed controller adaptation

## Description

With the speed controller adaptation, any speed controller oscillation can be suppressed.
Two adaptation methods are available, namely free Kp_n adaptation and speed-dependent Kp_n/Tn_n adaptation.

Free Kp_n adaptation is also active in "operation without encoder" mode and is used in "operation with encoder" mode as an additional factor for speed-dependent Kp_n adaptation.

Speed-dependent Kp_n/Tn_n adaptation is only active in "operation with encoder" mode and also affects the Tn_n value.


Figure 7-17 Free Kp adaptation

## Example of speed-dependent adaptation



Figure 7-18 Example of speed-dependent adaptation
For operation without encoder, a higher value is in p 1464 than in p 1465 . As a consequence, the behavior is inverted: Kp increases with increasing speed and Tn decreases.

## Special case, encoderless operation in the field-weakening range

In encoderless operation, dynamic reduction for the field-weakening range can be activated with p1400.0 $=1$.
$\mathrm{Kp} / \mathrm{Tn} \sim$ flux setpoint
$\mathrm{Kp} / \mathrm{Tn}$ decreases proportionally with the flux setpoint (minimum: factor 0.25 ).
This dynamic reduction is activated to reduce the controller dynamic response in the fieldweakening range. Up to the field-weakening range, the higher controller dynamic of the speed controller is kept.

## Function diagram

FP 6050 Speed controller adaptation (Kp_n/Tn_n adaptation)

## Parameters

- p1400.5 Speed control configuration: $\mathrm{Kp} / \mathrm{Tn}$ adaptation active
- p1400.6 Speed control configuration: Free Tn adaptation active
- p1470 Speed controller encoderless operation P gain
- p1472 Speed controller encoderless operation integral time

Free Kp_n adaptation

- p1455 Speed controller P gain adaptation signal
- p1456 Speed controller P gain adaptation lower starting point
- p1457 Speed controller P gain adaptation upper starting point
- p1458 Adaptation factor. lower
- p1459 Adaptation factor. upper
- p1466 Cl: Speed controller P gain scaling

Speed-dependent Kp_n/Tn_n adaptation (VC only)

- p1460 Speed controller P gain adaptation speed, lower
- p1461 Speed controller Kp adaptation speed, upper scaling
- p1462 Speed controller integral action time adaptation speed, lower
- p1463 Speed controller Tn adaptation speed, upper scaling
- p1464 Speed controller adaptation speed, lower
- p1465 Speed controller adaptation speed, upper

Dynamic response reduction field weakening (encoderless VC only)

- p1400.0 Speed control configuration: Automatic $\mathrm{Kp} / T \mathrm{n}$ adaptation active


### 7.4.4.4 Droop

## Description

Droop (enabled via p1492) ensures that the speed setpoint is reduced proportionally as the load torque increases.
The droop function has a torque limiting effect on a drive that is coupled to a different speed (e.g. guide roller on a material web). In this way, a very effective load distribution can also be realized in connection with the torque setpoint of a leading speed-controlled drive. In contrast to torque control or load distribution with overriding and limitation, with the appropriate setting, such a load distribution controls even a smooth mechanical connection.
This method is only suitable to a limited extent for drives that are accelerated and braked with significant changes in speed.
The droop feedback is used, for example, in applications in which two or more motors are operated with a common shaft and fulfill the above requirements. It limits the torque differences that can occur as a result of the connection between the motors by modifying the speeds of the individual motors (drive is relieved when the torque becomes too great).


Figure 7-19 Speed controller with droop

## Requirement

- All connected drives must be operated with vector and speed control (with or without speed actual value encoder).
- The setpoints at the ramp function generators of the mechanically connected drives must be identical; the ramp function generators must have identical ramp-up and ramp-down times.


## Function diagram

FP 6030 Speed setpoint, droop

## Parameters

- r0079 Total speed setpoint
- r1482 Speed controller I torque output
- p1488 Droop input source
- p1489 Droop feedback scaling
- r1490 Droop feedback speed reduction
- p1492 Droop feedback enable
- r1508 Torque setpoint before supplementary torque


### 7.4.4.5 Open actual speed value

## Description

Via the parameter p1440 ( Cl : speed controller actual speed value) is the signal source for the actual speed value of the speed controller. With the factory setting, the unsmoothed actual speed value r0063[0] is the default signal source.

Via parameter p1440, for example, a filter can be switched into the actual value channel or an external actual speed value can be fed in, according to the specific system requirements.

Parameter r1443 displays the actual speed value present at p1440.

## Note

## Feeding an external actual speed value

When feeding in an external actual speed value, ensure the monitoring functions continue to be derived from the motor model.

## Behavior in conjunction with speed control with an encoder ( $\mathrm{p} 1300=21$ )

A motor encoder must always be available for the motor model's speed or position signal (for example, evaluation via SMC; see p0400). The actual speed of the motor (r0061) and the position information for synchronous motors continue to come from this motor encoder and are not influenced by the setting in p1440.

Interconnection of p 1440 :
When interconnecting connector input p1440 with an external actual speed value, ensure the speed scaling is the same (p2000).

The external speed signal should correspond on average to the speed of the motor encoder (r0061).

## Behavior in conjunction with speed control without an encoder (p1300 = 20)

Depending on the transmission path of the external speed signal, dead times will accumulate; these dead times must be taken into account in the speed controller's parameter assignment (p1470, p1472) and can lead to commensurate losses in dynamic performance. Signal transmission times must therefore be minimized.

Parameter setting p1750.2 = 1 is required so that the speed controller can operate even during a standstill. Otherwise, the system will switch over to open-loop controlled operation in the lower speed range; this will cause the speed controller to switch off, and the measured actual speed will no longer have any effect.

## Monitoring the speed deviation between the motor model and the external speed

The external actual speed (r1443) is compared with the actual speed of the motor model (r2169). If the deviation is greater than the tolerance threshold set in p3236, after the switchoff delay time set in p3238 expires, fault F07937 (Drive: Speed deviation motor model to external speed) is generated and the drive switched-off corresponding to the set response (factory setting: OFF2).


Figure 7-20 "Model / external speed deviation in tolerance" monitoring

## Function diagrams

| FP 6040 | Vector control - Speed controller with/without encoder |
| :--- | :--- |
| FP 8012 | Signals and monitoring function - Torque messages, motor blocked/stalled |

## Parameters

- r0063[0] Actual speed unsmoothed
- p1440 CI: Speed controller actual speed value
- p1442 Speed controller actual speed value smoothing time
- r1443 CO: Speed controller actual speed value at actual value input
- p1452 Speed controller actual speed value smoothing time (without encoder)
- r2169 CO: Actual speed value smoothed, messages
- r2199.7 Model / external speed deviation in tolerance
- p3236 Speed threshold 7
- p3237 Hysteresis speed 7
- p3238 OFF delay n_act_motor_model = n_act_external


### 7.4.5 Torque control

## Description

For encoderless speed control ( $\mathrm{p} 1300=20$ ) or speed control with an encoder ( $\mathrm{p} 1300=21$ ), it is possible to change over to closed-loop torque control using BICO parameter p1501. It is not possible to change over between speed control and torque control if closed-loop torque control is directly selected with $\mathrm{p} 1300=22$ or 23 . The torque setpoint and/or supplementary setpoint can be entered using BICO parameter p1503 (CI: torque setpoint) or p1511 (CI: supplementary torque setpoint). The supplementary torque is effective for both closed-loop torque control and speed control. As a result of this characteristic, a feedforward control torque can be implemented for the speed control using the supplementary torque setpoint.

## Note

## No assignment to fixed torque setpoints

For safety reasons, assignments to fixed torque setpoints are currently not possible.

## Note

## Regenerative energy without feedback capability

If energy is regenerated and cannot be injected back into the line supply, then a braking module with a connected braking resistor must be used.


Figure 7-21 Closed-loop speed/torque control
The total of the two torque setpoints is limited in the same way as the speed control torque setpoint. Above the maximum speed (p1082), a speed limiting controller reduces the torque limits in order to prevent the drive from accelerating any further.

A "real" closed-loop torque control (with a speed that automatically sets itself) is only possible in the closed-loop control range but not in the open-loop control range of the encoderless closed-loop vector control. In the open-loop controlled range, the torque setpoint changes the setpoint speed via a ramp-up integrator (integrating time $\sim$ p1499 x p0341 x p0342). This is the reason that encoderless closed-loop torque control close to standstill is only suitable for applications that require an accelerating torque there and no load torque (e.g. traversing drives). Closed-loop torque control with encoder does not have this restriction.

## OFF responses

- OFF1 and p1300 $=22,23$
- Response as for OFF2
- OFF1, p1501 $=$ " 1 " signal and p1300 $=22,23$
- No separate braking response; the braking response is provided by a drive that specifies the torque.
- The pulses are inhibited when the brake application time (p1217) expires. Standstill is detected when the actual speed value undershoots the speed threshold (p1226) or when the monitoring time (p1227) started when speed setpoint $\leq$ speed threshold (p1226) expires.
- Power-on inhibit is activated.
- OFF2
- Immediate pulse suppression, the drive coasts to standstill.
- The motor brake (if configured) is closed immediately.
- Power-on inhibit is activated.
- OFF3
- Switch to speed-controlled operation
- n_set $=0$ is input immediately to brake the drive along the OFF3 deceleration ramp ( p 1135 ).
- When standstill is detected, the motor brake (if configured) is closed.
- The pulses are inhibited when the motor brake closing time (p1217) has elapsed. Standstill is detected when the actual speed value undershoots the speed threshold (p1226) or when the monitoring time (p1227) started when speed setpoint $\leq$ speed threshold (p1226) expires.
- Power-on inhibit is activated.


## Function diagram

FP 6060 Torque setpoint

## Parameters

- p0341 Motor moment of inertia
- p0342 Ratio between the total and motor moment of inertia
- p1300 Open-loop/closed-loop control mode
- p1499 Accelerating for torque control, scaling
- p1501 Change over between closed-loop speed/torque control
- p1503 Torque setpoint
- p1511 Supplementary torque 1
- p1512 Supplementary torque 1 scaling
- p1513 Supplementary torque 2
- p1514 Supplementary torque 2 scaling
- r1515 Supplementary torque total


### 7.4.6 $\quad$ Torque limiting

## Description



Figure 7-22 Torque limiting
This value specifies the maximum permissible torque; different limits can be parameterized for motor and regenerative mode.

- p0640 Current limit
- p1520 CO: Torque limit, upper/motoring
- p1521 CO: Torque limit, lower/regenerative
- p1522 CI: Torque limit, upper/motoring
- p1523 CI: Torque limit, lower/regenerative
- p1524 CO: Torque limit, upper/motoring, scaling
- p1525 CO: Torque limit, lower/regenerative scaling
- p1530 Power limit, motoring
- p1531 Power limit, regenerative

The currently active torque limits are displayed in the following parameters:

- r0067 Maximum drive output current
- r1526 Torque limit, upper/motoring without offset
- r1527 Torque limit, lower/regenerative without offset

All of the following limits act on the torque setpoint, which is present either at the speed controller output for speed control or as a torque input for closed-loop torque control. The minimum or the maximum of the various limits is used. This minimum or maximum is cyclically calculated and is displayed in r1538 or r1539.

- r1538 Upper effective torque limit
- r1539 Lower effective torque limit

These cyclical values therefore limit the torque setpoint at the speed controller output/torque input and indicate the maximum possible torque at a given moment If the torque setpoint is limited, then this is displayed using parameter p1407.

- r1407.8 Upper torque limit active
- r1407.9 Lower torque limit active


## Function diagrams

| FP 6060 | Torque setpoint |
| :--- | :--- |
| FP 6630 | Upper/lower torque limit |
| FP 6640 | Current/power/torque limits |

### 7.4.7 Current setpoint filter

## Description

The current setpoint filter is used to suppress cyclic disturbance variables that can be caused by mechanical vibrations in the drive train.
The current setpoint filter can be set as follows:

- Low-pass 2nd order (PT2: -40 dB/decade)
- General 2nd order filter

Band-stop and low-pass with reduction are converted into the parameters of the general 2nd order filter via STARTER.

The current setpoint filters are activated with p1656.0 = 1 and p1656.1 $=1$. The properties of the current setpoint filter are set with p1657 to p1666.
As long as changes to the data of the current setpoint filter are being made, the conversion of the new filter data can be prevented using p1699 $=1$. When p1699 $=0$ is set, the calculation will be performed and the new values applied.

## Function diagram

FP 6710 Current setpoint filter

## Parameters

- p1655[0] CI: Current setpoint filter 1 natural frequency tuning
- p1655[1] CI: Current setpoint filter 2 natural frequency tuning
- p1656.0 Current setpoint filter 1 activation
- p1657 Current setpoint filter 1 type
- p1658 Current setpoint filter 1 denominator natural frequency
- p1659 Current setpoint filter 1 denominator damping
- p1660 Current setpoint filter 1 numerator natural frequency
- p1661 Current setpoint filter 1 numerator damping
- p1656.1 Current setpoint filter 2 activation
- p1662 Current setpoint filter 2 type
- p1663 Current setpoint filter 2 denominator natural frequency
- p1664 Current setpoint filter 2 denominator damping
- p1665 Current setpoint filter 2 numerator natural frequency
- p1666 Current setpoint filter 2 numerator damping
- p1699 Filter data acceptance


### 7.4.8 Current controller adaptation

Current controller adaptation can be used to adapt the $P$ gain of the current controller and the dynamic precontrol of the $\mathrm{I}_{\mathrm{q}}$ current controller depending on the current.
The current controller adaptation is directly activated with setting p1402.2 = 1 or deactivated with $\mathrm{p} 1402.2=0$.
It is automatically activated with p1959.5 (p1959.5 = 1) or deactivated (p1959.5 = 0).


Figure 7-23 Current controller adaptation for p0393 < 1, with p0391 < p0392
When swapping the $I_{q}$ interpolation points (e.g. for induction motors), the current controller adaptation appears as follows:


Figure 7-24 Current controller adaptation with swapped $I_{q}$ interpolation points for $00393>1$, with p0392 < p0391

## Function diagram

FP 6714 Vector control - Iq and Id controller

## Parameters

- p0391 Current controller adaptation, starting point KP
- p0392 Current controller adaptation, starting point KP adapted
- p0393 Current controller adaptation $P$ gain scaling
- p1402 Current control and motor model configuration
- p1703 Isq current controller precontrol scaling
- p1715 Current controller P gain
- p1717 Current controller integral time
- p1959 Rotating measurement configuration


### 7.4.9 Permanent-magnet synchronous motors

## Description



Permanent-magnet synchronous motors without encoders are supported during operations without encoders.

Typical applications include direct drives with torque motors, which are characterized by high torque at low speeds, e.g., Siemens 1FW3 series torque motors. When these drives are used, gear units and mechanical parts subject to wear can be dispensed with if the application allows this.

## ! WARNING

Electric shock when permanent magnet synchronous motors rotate
As soon as the motor turns, a voltage is generated at the connection terminals that when touched can result in death or serious injury.

- Disconnect the motor when working on the drive.
- If the connecting cables to the motor cannot be disconnected, secure the motor to prevent unintended rotating movements, e.g., by a holding brake.


## Features

- Field weakening of up to approx. 1.2 times the rated speed (depending on the supply voltage of the drive and motor data, also see general conditions)
- Flying restart (during operation without encoders, only when a VSM module is used to record the motor speed and phase angle (option K51))
- Speed and torque vector control
- Vector V/f control for diagnostics
- Motor identification
- Speed controller optimization (rotary measurement)


## General conditions

- Maximum speed and maximum torque are dependent on the drive output voltage available and the back EMF of the motor (calculation specifications: EMF must not exceed Urated, drive).
- Calculating the maximum speed:

$$
n_{\max }=n_{n} \cdot \sqrt{\frac{3}{2}} \cdot \frac{U_{V d c} \max \cdot \cdot_{n}}{P_{n}}
$$

- Depending on the terminal voltage and load cycle, the maximum torque can be taken from the motor data sheets/configuration instructions.
- No thermal model is available for the closed-loop control of a permanent-magnet synchronous motor. The motor can only be protected against overheating through the use of temperature sensors (PTC, KTY). To achieve a high level of torque accuracy, we recommend the use of a temperature sensor (KTY) to measure the motor temperature.


## Commissioning

The following sequence is recommended for commissioning:

- Configure the drive

When the drive is commissioned using STARTER or the AOP30 operator panel, the permanent-magnet synchronous motor must be selected. The motor data specified in the table below must then be entered. Finally, the motor identification routine and speed optimization (p1900) are activated. Encoder adjustment is activated automatically together with the motor identification routine.

- Motor identification (standstill measurement, p1910)
- Speed controller optimization (rotary measurement, p1960)


## Motor data for permanent-magnet synchronous motors

Table 7-2 Motor data rating plate

| Parameter | Description | Comments |
| :--- | :--- | :--- |
| p0304 | Rated motor voltage | If this value is not known, the value "0" can also be entered. <br> Entering the correct value, however, means that the stator leak- <br> age inductance (p0356, p0357) can be calculated more accu- <br> rately. |
| p0305 | Rated motor current |  |
| p0307 | Rated motor power |  |
| p0310 | Rated motor frequency |  |
| p0311 | Rated motor speed |  |
| p0314 | Motor pole pair number | If this value is not known, the value "0" can also be entered. |
| p0316 | Motor torque constant | If this value is not known, the value "0" can also be entered. |

If the torque constant $k_{T}$ is not stamped on the rating plate or specified in the data sheet, you can calculate this value from the rated motor data or from the stall current $l_{0}$ and stall torque $\mathrm{M}_{0}$ as follows:

$$
\mathrm{k}_{\mathrm{T}}=\frac{\mathrm{M}_{\mathrm{N}}}{\mathrm{I}_{\mathrm{N}}}=\frac{60 \frac{\mathrm{~s}}{\min } \times \mathrm{P}_{\mathrm{N}}}{2 \pi \times \mathrm{n}_{\mathrm{N}} \times \mathrm{I}_{\mathrm{N}}}
$$

or

$$
\mathrm{k}_{\mathrm{T}}=\frac{\mathrm{M}_{0}}{\mathrm{I}_{0}}
$$

The optional motor data can be entered if it is known. Otherwise, this data is estimated from the rating plate data or determined using motor identification or speed controller optimization.

Table 7-3 Motor data rating plate

| Parameter | Description | Comments |
| :--- | :--- | :--- |
| p0320 | Rated motor short-circuit current | This is used for the field weakening characteristic |
| p0322 | Maximum motor speed | Maximum mechanical speed |
| p0323 | Maximum motor current | De-magnetization protection |
| p0325 | Rotor position identification current 1. Phase | - |
| p0327 | Optional load angle | Optional; otherwise leave at $90^{\circ}$ |
| p0328 | Reluctance torque constant | - |
| p0329 | Rotor position identification current | - |
| p0341 | Motor moment of inertia | For speed controller feedforward control |
| p0344 | Motor weight | - |
| p0350 | Stator resistance, cold | - |
| p0356 | Quadrature axis stator inductance Lq | - |
| p0357 | In-line stator inductance Ld | - |

## Short-circuit protection

For short circuits that can occur in the drive or in the motor cable, the rotating machine would supply the short-circuit until it comes to a standstill. An output contactor can be used for protection. This should be located as close as possible to the motor. This is particularly necessary if the motor can still be driven by the load when a fault develops. The contactor must be provided with a protective circuit against overvoltage on the motor side so that the motor winding is not damaged as a result of the shutdown.

Control signal r0863.1 (VECTOR) is used to control the contactor via a free digital output; the checkback contact of the contactor is connected to parameter p0864 via a free digital input.

This means that if the drive develops a fault with a shutdown response, at the instant in time that the pulses are inhibited, the motor is isolated from the drive so that energy is not fed back to the fault location.

## Function diagrams

FP 6721 Vector control - ID setpoint (PEM, p0300 = 2)
FP 6724 Vector control - field weakening controller (PEM, p0300 = 2)
FP 6731 Vector control - Interface to Motor Module (PEM, p0300 = 2)

## Output terminals

### 8.1 Chapter content

This section provides information on:

- Analog outputs
- Digital outputs



## Function diagrams

At certain points in this section, reference is made to function diagrams. These can be found on the customer DVD in the "SINAMICS G130/G150 List Manual", which provides experienced users with detailed descriptions of all the functions.

### 8.2 Analog outputs

## Description

The Customer Terminal Block features two analog outputs for outputting setpoints via current or voltage signals.
Delivery condition:

- AOO: Actual speed value 0 to 20 mA
- AO1: Actual motor value 0 to 20 mA


## Signal flow diagram



Figure 8-1 Signal flow diagram: analog output 0

## Function diagram

FP 1840, TM31-analog outputs (AO 0 to AO 1)
FP 9572

## Parameters

- p4071 TM31 analog outputs signal source
- p4073 TM31 analog outputs smoothing time constant
- r4074 Analog outputs current output voltage/current
- p4076 TM31 analog outputs type
- p4077 TM31 analog outputs characteristic value $\times 1$
- p4078 TM31 analog outputs characteristic value y1
- p4079 TM31 analog outputs characteristic value $\times 2$
- p4080 TM31 analog outputs characteristic value y2


### 8.2.1 List of signals for the analog signals

## List of signals for the analog outputs

Table 8-1 List of signals for the analog outputs

| Signal | Parameters | Unit | Scaling ( $100 \%=. .$. ) See table below |
| :---: | :---: | :---: | :---: |
| Speed setpoint before the setpoint filter | r0060 | rpm | p2000 |
| Motor speed unsmoothed | r0061 | rpm | p2000 |
| Actual speed value after smoothing | r0063 | rpm | p2000 |
| Output frequency | r0066 | Hz | Reference frequency |
| Output current | r0068 | Aeff | p2002 |
| DC link voltage | r0070 | V | p2001 |
| Torque setpoint | r0079 | Nm | p2003 |
| Output power | r0082 | kW | r2004 |
| For diagnostic purposes |  |  |  |
| Speed controller system deviation | r0064 | rpm | p2000 |
| Modulation depth | r0074 | \% | Reference modulation depth |
| Torque-generating current setpoint | r0077 | A | p2002 |
| Torque-generating actual current | r0078 | A | p2002 |
| Flux setpoint | r0083 | \% | Reference flux |
| Actual flux | r0084 | \% | Reference flux |
| For further diagnostics |  |  |  |
| Speed controller output | r1480 | Nm | p2003 |
| I component of speed controller | r1482 | Nm | p2003 |

## Scaling

Table 8-2 Scaling

| Size | Scaling parameter | Default for quick commissioning |
| :--- | :--- | :--- |
| Reference speed | $100 \%=$ p2000 | p2000 $=$ Maximum speed (p1082) |
| Reference voltage | $100 \%=$ p2001 | p2001 $=1000 \mathrm{~V}$ |
| Reference current | $100 \%=$ p2002 | p2002 $=$ Current limit $(\mathrm{p} 0640)$ |
| Reference torque | $100 \%=\mathrm{p} 2003$ | $\mathrm{p} 2003=2 \times$ rated motor torque |
| Reference power | $100 \%=\mathrm{r} 2004$ | $\mathrm{r} 2004=(\mathrm{p} 2003 \times \mathrm{p} 2000 \times \pi) / 30$ |
| Reference frequency | $100 \%=\mathrm{p} 2000 / 60$ |  |
| Reference modulation depth | $100 \%=$ Maximum output voltage without over- <br> load |  |
| Reference flux | $100 \%=$ Rated motor flux | $\mathrm{p} 2006=100^{\circ} \mathrm{C}$ |
| Reference temperature | $100 \%=\mathrm{p} 2006$ |  |

## Example: Changing analog output 0 from current to voltage output -10 V ... +10 V



Voltage output present at terminal 1 , ground is at terminal 2


Set analog output type 0 to $-10 \ldots+10 \mathrm{~V}$.

Example: Changing analog output 0 from current to voltage output $-10 \mathrm{~V} . . .+10 \mathrm{~V}$ and setting the characteristic


Voltage output present at terminal 1, ground is at terminal 2

Set TM31.AO_type [analog output 0] to $-10 \mathrm{~V} \ldots+10 \mathrm{~V}$.

Set TM31.AO_char. x1 to $0.00 \%$.

Set TM31.AO_char. y1 to 0.000 V .

Set TM31.AO_char. x2 to $100.00 \%$.

Set TM31.AO_char. y2 to 10.000 V .

### 8.3 Digital outputs

## Description

Four bi-directional digital outputs (terminal X541) and two relay outputs (terminal X542) are available. These outputs are, for the most part, freely parameterizable.

## Signal flow diagram



Figure 8-2 Signal flow diagram: Digital outputs

## Delivery condition

Table 8-3 Digital outputs, delivery condition

| Digital output | Terminal | Delivery condition |
| :---: | :---: | :---: |
| DO0 | X542: 2.3 | "Enable pulses" |
| DO1 | X542: 5.6 | "No fault" |
| DI/DO8 | X541:2 | "Ready to start" |
| DI/DO9 | X541:3 |  |
| DI/DO10 | X541:4 |  |
| DI/DO11 | X541:5 |  |

### 8.3 Digital outputs

## Selection of possible connections for the digital outputs

Table 8-4 Selection of possible connections for the digital outputs

| Signal | Bit in status word 1 | Parameter |
| :---: | :---: | :---: |
| 1 = Ready to start | 0 | r0899.0 |
| 1 = Ready for operation | 1 | r0899.1 |
| 1 = Operation enabled | 2 | r0899.2 |
| 1 = Fault present | 3 | r2139.3 |
| 0 = Coast to stop active (OFF2 active) | 4 | r0899.4 |
| $0=$ Fast stop active (OFF3 active) | 5 | r0899.5 |
| 1 = Closing lockout active | 6 | r0899.6 |
| 1 = Alarm present | 7 | r2139.7 |
| 1 = Setpoint/actual speed deviation within tolerance band | 8 | r2197.7 |
| 1 = Master control requested | 9 | r0899.9 |
| $1=\mathrm{f}$ or n comparison value reached or exceeded | 10 | r2199.1 |
| $1=1, M$ or P limit reached | 11 | r1407.7 |
| 1 = Open holding brake | 12 | r0899.12 |
| 0 = Alarm, motor overtemperature | 13 | r2135.14 |
| $\begin{array}{\|l} \hline 1=\text { Motor rotates forward }\left(n \_ \text {act } \geq 0\right) \\ 0=\text { Motor rotates backwards }\left(n \_ \text {act }<0\right) \\ \hline \end{array}$ | 14 | r2197.3 |
| 0 = Alarm thermal overload in power unit (A5000) | 15 | r2135.15 |
| 1 = Pulses enabled |  | r0899.11 |
| 1 = n_act $\leq$ p2155 |  | r2197.1 |
| 1 = n_act > p2155 |  | r2197.2 |
| 1 = Ramp-up/ramp-down completed |  | r2199.5 |
| 1 = \|n_act < p2161 (preferably as n_min or $\mathrm{n}=0$ message) |  | r2199.0 |
| 1 = \|M_set| < p2174 |  | r2198.10 |
| 1 = LOCAL mode active (control via operator panel or control panel) |  | r0807.0 |
| 1 = Motor blocked |  | r2198.6 |

## Functions, monitoring and protective functions

### 9.1 Content of this chapter

This section provides information on:

- Drive functions:

Motor identification, efficiency optimization, quick magnetization for induction motors, Vdc control, automatic restart, flying restart, motor changeover, friction characteristic, armature short-circuit braking, DC braking, increase in the output frequency, pulse frequency wobbling, runtime, simulation operation, direction reversal, unit changeover, derating behavior with increased pulse frequency, simple brake control, energy savings indicator for fluid-flow machines, write protection, know-how protection, emergency operation, web server

- Extension functions:

Technology controller, bypass function, extended brake control, extended monitoring functions, inertia estimator

- Monitoring and protective functions:

Power module protection, thermal monitoring functions and overload responses, blocking protection, stall protection, thermal motor protection


## Function diagrams

At certain points in this section, reference is made to function diagrams. These can be found on the customer DVD in the "SINAMICS G130/G150 List Manual", which provides experienced users with detailed descriptions of all the functions.

### 9.2 Drive functions

### 9.2.1 Motor data identification and automatic speed controller optimization

## Description

Two motor identification options, which are based on each other, are available:

- Motor identification with p1910 (standstill measurement)
- Rotating measurement with p1960 (speed controller optimization)

These can be selected more easily via p1900. p1900 $=2$ selects the motor identification (motor not rotating). Parameter setting p1900 = 1 also activates the rotating measurement; p1910 is set to 1 , and p1960 is set in accordance with the current control type (p1300).
Depending on p1300, parameter p1960 is set as follows:

- p1960 = 1, if p1300 = 20 or 22 (encoderless control)
- p1960 $=2$, if p1300 $=21$ or 23 (control with encoder)

The measurements configured using p1900 are started in the following sequence after the corresponding drive has been enabled:

- Motor identification at standstill, after the measurement has been completed, the pulses are inhibited and parameter p1910 is reset to 0 .
- Encoder adjustment - after the measurement has been completed, the pulses are inhibited and parameter p1990 is reset to 0 .
- Rotating measurement - after the measurement has been completed, the pulses are inhibited and parameter p1960 is reset to 0 .
- After all of the measurements activated using p1900 have been successfully completed, p1900 itself is set to 0 .


## Note

## Non-volatile saving

To make the new controller setting permanent, the data must be saved in non-volatile memory with p0977 or p0971.

## ! warning

## Unexpected motor movement during motor identification in the rotating mode

When motor identification with optimization during rotating operation is selected, after the drive is commissioned it initiates movements of the motor that can reach the maximum motor speed.

- Observe the general safety instructions.
- Ensure that the EMERGENCY OFF functions are functional during commissioning.


### 9.2.1.1 Motor data identification

## Description

Motor identification with p1910 is used for determining the motor parameters at standstill (see also p1960: speed controller optimization):

- Equivalent circuit diagram data p1910 = 1
- Magnetization characteristic p1910=3

For control engineering reasons, you are strongly advised to carry out motor data identification because the equivalent circuit diagram data, motor cable resistance, IGBT onstate voltage, and compensation for the IGBT lockout time can only be estimated if the data on the nameplate is used. For this reason, the stator resistance for the stability of sensorless vector control or for the voltage boost with the V/f characteristic is very important.

Motor data identification is essential if long supply cables or third-party motors are used. When motor data identification is started for the first time, the following data is determined with p1910 = 1 on the basis of the data on the nameplate (rated data):

Table 9-1 Data determined through p1910

|  | Induction motor | Permanent-magnet synchronous motor |
| :---: | :---: | :---: |
| p1910 $=1$ | - Stator resistance (p0350) <br> - Rotor resistance (p0354) <br> - Stator leakage inductance (p0356) <br> - Rotor leakage inductance (p0358) <br> - Magnetizing inductance (p0360) <br> - Drive valve threshold voltage ( p 1825 ) <br> - Drive valve interlock times (p1828 ... p1830) | - Stator resistance (p0350) <br> - Stator leakage inductance q axis (p0356) <br> - Stator inductance d axis (p0357) <br> - Drive valve threshold voltage (p1825) <br> - Drive valve interlock times (p1828 ... p1830) |
| p1910 $=3$ | - Saturation characteristic (p0362 ... p0366) | Not recommended <br> Notice: When encoder adjustment is complete, the motor is automatically rotated approx. one revolution in order to determine the encoder zero mark. |

Since the nameplate data provides the initialization values for identification, you must ensure that it is entered correctly and consistently (taking into account the connection type (wye/delta)) so that the above data can be determined.

It is advisable to enter the motor supply cable resistance (p0352) before the standstill measurement ( p 1910 ) is performed, so that it can be subtracted from the total measured resistance when the stator resistance is calculated ( p 0350 ).

Entering the cable resistance improves the accuracy of thermal resistance adaptation, particularly when long supply cables are used. This governs behavior at low speeds, particularly during encoderless vector control.


Figure 9-1 Equivalent circuit diagram for induction motor and cable
If an output filter (see p0230) or series inductance (p0353) is used, the data for this must also be entered before the standstill measurement is carried out.

The inductance value is then subtracted from the total measured value of the leakage. With sine-wave filters, only the stator resistance, valve threshold voltage, and valve interlocking time are measured.

## Note

Large spread of the rated motor impedance
With diffusion of more than $35 \%$ to $40 \%$ of the motor nominal impedance, the dynamic response of the speed and current control is restricted to the area of the voltage limit and to field weakening mode.

## Note

Perform standstill measurement with the motor in a cold state
The standstill measurement must be carried out when the motor is cold. In p0625, enter the estimated ambient temperature of the motor during the measurement (with KTY sensor: set p0600, p0601 and read r0035). This is the reference point for the thermal motor model and thermal $R_{s} / R_{R}$ adaptation.

In addition to the equivalent circuit diagram data, motor data identification (p1910 $=3$ ) can be used for induction motors to determine the magnetization characteristic of the motor. Due
to the higher accuracy, the magnetization characteristic should, if possible, be determined during the rotating measurement (without encoder: p1960 $=1$, 3 ; with encoder: p1960 = 2, 4). If the drive is operated in the field-weakening range, this characteristic should be determined for vector control in particular. The magnetization characteristic can be used to calculate the field-generating current in the field-weakening range more accurately, thereby increasing torque accuracy.

## Note

## Results of the rotating measurement

In comparison with the standstill measurement (p1910), for induction motors, the rotating measurement ( p 1960 ) allows the rated magnetization current and saturation characteristic to be determined more accurately.


Figure 9-2 Magnetization characteristic

## Carrying out motor identification

- Enter p1910 > 0. Alarm A07991 is displayed.
- Identification starts when the motor is switched on.
- p1910 resets itself to "0" (successful identification) or fault F07990 is output.
- r0047 displays the current status of the measurement.


## Note

## Non-volatile saving

To make the new controller setting permanent, the data must be saved in non-volatile memory with p0977 or p0971.

| ! WARNING |
| :--- |
| Unexpected motor movement when identifying the motor |
| When motor identification is selected, movements of the motor can be initiated after the |
| drive is commissioned. |
| - Observe the general safety instructions. |
| - Ensure that the EMERGENCY OFF functions are functional during commissioning. |

### 9.2.1.2 Rotating measurement and speed controller optimization

## Description

"Rotating measurement" can be activated using p1960 or using p1900=1.
The main difference between rotating measurement and standstill measurement is speed control optimization, with which the drive's moment of inertia is ascertained and the speed controller is set. In addition, the saturation characteristic and rated magnetization current of induction motors are measured.
If the rotating measurement is not to be carried out using the speed set in p1965, this parameter can be changed before the measurement is started. Higher speeds are recommended.

The same applies to the speed in p 1961 , at which the saturation characteristic is determined and the encoder test is carried out.

The speed controller is set to the symmetrical optimum in accordance with dynamic factor p1967. p1967 must be set before the optimization run and only affects the calculation of the controller parameters.

If, during the measurement, it becomes clear that the drive cannot operate in a stable manner with the specified dynamic factor or that the torque ripples are too great, the dynamic response is reduced automatically and the result displayed in r1968. The drive must also be checked to ensure that it is stable across the entire range. The dynamic response might need to be reduced or $\mathrm{Kp} / \mathrm{Tn}$ adaptation for the speed controller configured accordingly.
When commissioning induction machines, you are advised to proceed as follows:

- Before connecting the load, a complete "rotating measurement" (without encoder: p1960 = 1; with encoder: p1960 = 2) should be carried out. Since the induction machine is idling, you can expect highly accurate results for the saturation characteristic and the rated magnetization current.
- When the load is connected, speed controller optimization should be repeated because the total moment of inertia has changed. This is done by selecting parameter p1960 (without encoder: p1960 = 3; with encoder: p1960 = 4).
The saturation characteristic recording is automatically deactivated in parameter p1959 during the speed tuning run.

When permanent-magnet synchronous motors are commissioned, the speed controller should be tuned $(\mathrm{p} 1900=3$ or $\mathrm{p} 1960>0)$ when the load is connected.

## Carrying out the rotating measurement (p1960>0)

The following measurements are carried out when the enable signals are set and a switchon command is issued in accordance with the settings in p1959 and p1960.

- Encoder test

If a speed encoder is used, the direction of rotation and the pulse number are checked.

- Induction motors only:
- Measurement of the magnetization characteristic (p0362 to p0369)
- Measurement of the magnetization current (p0320) and determination of the offset voltage of the drive for offset compensation
- Measurement of the saturation of the leakage inductance and setting of the current controller adaptation (p0391 to p0393)
This is automatically activated with 1 LA1 and 1 LA8 motors ( $p 0300=11,18$ ) (see p1959.5).
- Speed controller optimization
- p1470 and p1472, when p1960 = 1 (operation without encoder)
- p1460 and p1462, when p1960 = 2 (operation with encoder)
- Kp adaptation switch-off
- Acceleration feedforward control setting (p1496)
- Setting for the total-moment-of-inertia-to-motor ratio (p0342)


## Note

## Non-volatile saving

To make the new controller setting permanent, the data must be saved in non-volatile memory with p0977 or p0971.

## A. warning

Unexpected motor movement during motor identification in the rotating mode
When motor identification with optimization during rotating operation is selected, after the drive is commissioned it initiates movements of the motor that can reach the maximum motor speed.

- Observe the general safety instructions.
- Ensure that the EMERGENCY OFF functions are functional during commissioning.


## Note

## Speed controller optimization for operation with encoder

If speed control optimization is used for operation with encoder, then the control operating mode is automatically reset temporarily to speed control without encoder so that the encoder test can be carried out.

### 9.2.1.3 Shortened rotating measurement

A normal rotating measurement cannot always be performed when the load is connected. When switching on the motor for the first time, a moment of inertia measurement and the measurement of the magnetization current and the saturation characteristic can be performed with a simplified measuring procedure. There are two methods for this shortened rotating measurement:

- Measurement shortened (p1959.12 = 1)
- After measurement: Direct transfer to operation (p1959.13 = 1)

During the shortened rotating measurement, the drive is not moved up to the rated speed but up to the value set in p1965 (factory setting $40 \%$ ). Parameter p1961 can be adjusted at the plant, but it must be high enough to ensure that the machine has left open-loop controlled operation. The machine should be operated in no-load operation (torque < $30 \%$ of $\mathrm{Mrated}^{\text {a }}$ ) as far as is possible.
During the shortened rotating measurement the saving of parameters is disabled, because parameter adjustments are automatically made for the measurement, which are to be reassigned after the measurement.

## Shortened measurement (p1959.12 = 1)

If p1959.12 = 1 is set, a shortened rotating measurement is carried out. In this case, the magnetizing current and moment of inertia are determined with a somewhat lower degree of accuracy; the vibration test is no longer required.
After the end of the measurement, the drive is moved to standstill and all the parameters modified for performing the measurement are set to their original values.

## After measurement: Direct transfer to operation (p1959.13 = 1)

If p1959.13 = 1 is set, the drive is not stopped after the end of the shortened measurement, but is instead moved to the desired setpoint speed with the set ramp up.

Since braking to standstill cannot be performed during this measurement and no pulses are locked, no more parameters can be changed that could later be written back during operation.

## Do not change controller parameters during the measurement (p1959.11 = 1)

With the rotating measurement, the drive independently changes its speed controller parameters during start-up. This also occurs if bits 3 and 4 of parameter 1959 are not set. In many cases, however, the decoupling of drives is linked to high cost. The loads have high moments of inertia. The controller parameters set by the drive do not always match the drive application and may therefore potentially cause damage to the mechanical system.
If $\mathrm{p} 1959.11=1$ is set, the recalculation of the speed controller parameters is prevented.

### 9.2.1.4 Parameters

- r0047 Motor data identification and speed controller optimization
- p1300 Open-loop/closed-loop control operating mode
- p1900 Motor data identification and rotating measurement
- p1909 Motor data identification, control word
- p1910 Motor data identification selection
- p1959 Rotating measurement configuration
- p1960 Rotating measurement selection
- p1961 Saturation characteristic speed to determine
- p1965 Speed controller optimization speed
- p1967 Speed controller optimization dynamic factor
- r1968 Speed controller optimization actual dynamic factor
- r1973 Rotating measurement encoder test pulse number determined
- p1980 Pole position identification procedure
- r3925 Identification final display
- r3927 Motor data identification, control word
- r3928 Rotating measurement configuration


### 9.2.2 Efficiency optimization

## Description

The following can be achieved when optimizing efficiency using p1580:

- Lower motor losses in the partial load range
- Minimization of noise in the motor


Figure 9-3 Efficiency optimization
It only makes sense to activate this function if the dynamic response requirements of the speed controller are low (e.g., pump and fan applications).
For p1580 $=100 \%$, the flux in the motor under no-load operating conditions is reduced to half of the setpoint (reference flux) ( $\mathrm{p} 1570 / 2$ ). As soon as load is connected to the drive, the setpoint (reference) flux increases linearly with the load and, reaching the setpoint set in p1570 at approx. r0077 $=$ r0331 $\times \mathrm{p} 1570$.
In the field-weakening range, the final value is reduced by the actual degree of field weakening. The smoothing time (p1582) should be set to approx. 100 ms to 200 ms . Flux differentiation (see also p1401.1) is automatically deactivated internally following magnetization.

## Function diagrams

FP 6722 Field weakening characteristic, Id setpoint (ASM, p0300 = 1)
FP 6723 Field weakening controller, flux controller for induction motor (p0300 = 1)

## Parameters

- r0077 Current setpoints, torque-generating
- r0331 Motor magnetizing current/short-circuit current (actual)
- p1570 Flux setpoint
- p1580 Efficiency optimization
- p1582 Flux setpoint smoothing time


### 9.2.3 Fast magnetization for induction motors

## Description

Fast magnetization for induction motors is used to reduce delay time during magnetization.

## Features

- Rapid flux build-up by injecting a field-generating current at the current limit, which considerably reduces the magnetization time.
- If the "flying restart" function is activated, the excitation build-up time set in p0346 is still used.


## Commissioning

Parameter setting p1401.6 = 1 is necessary to activate fast magnetization.
This setting initiates the following sequence during motor starting:

- The maximum excitation build-up current of the induction motor (in reference to the permitted rated power module current (r0207[0])) is set with parameter p0644 ("Current limit excitation build-up induction motor").
- The field-generating current setpoint jumps to the value set in p0644 or the maximum of Imax $=0.9 \times$ r0067 (high limit field-generating current setpoint).
- The flux increases as fast as physically possible with the specified current.
- The flux setpoint r0083 is made to follow accordingly.
- As soon as the flux threshold value programmed in p1573 is reached (min.: $10 \%$, max. $200 \%$, factory setting: $100 \%$ ), excitation ceases and the speed setpoint is enabled. The flux threshold value must not be set too low for a large load because the torqueproducing current is limited during magnetization.


## Note <br> Influence of the flux threshold value

The flux threshold value set in parameter p1573 is effective only if the actual flux during magnetization reaches the value programmed in p1573 before the timer set in p0346 runs down.

- The flux is increased further until the flux setpoint in p1570 has been reached.
- The field-producing current setpoint is reduced using a flux controller with $P$ gain ( p 1590 ) and the assigned smoothing factor (p1616).


## Notes

When quick magnetization is selected ( $\mathrm{p} 1401.6=1$ ), soft starter is deactivated internally, and alarm A07416 displayed.

When the stator resistance identification function is active (see p0621 "Identification of stator resistance after restart"), quick magnetization is deactivated internally, and alarm A07416 displayed.

The parameter does not work when combined with the "flying restart" function (see p1200), i.e., flying restart is performed without quick magnetization.

## Function diagrams

FP 6491 Flux control configuration
FP 6722 Field weakening characteristic, Id setpoint (ASM, p0300 = 1)
FP 6723 Field weakening controller, flux controller (ASM, p0300 = 1)

## Parameters

- p0320 Motor rated magnetization current/short-circuit current
- p0346 Motor excitation build-up time
- p0621 Stator resistance identification after restart
- p0640 Current limit
- p0644 Current limit excitation build-up induction motor
- p1401 Flux control configuration
- p1570 Flux setpoint
- p1573 Flux threshold value magnetization
- p1590 Flux controller P gain
- p1616 Current setpoint smoothing time


### 9.2.4 Vdc control

## Description

The "Vdc control" function can be activated using the appropriate measures if an overvoltage or undervoltage is present in the DC link.

- Overvoltage in the DC link
- Typical cause:

The drive is operating in regenerative mode and is supplying too much energy to the DC link.

- Remedy:

Reduce the regenerative torque to maintain the DC link voltage within permissible limits.

## Note

Fault F30002 "DC link overvoltage"
If failure often arises and fault F30002 "DC link overvoltage" is reported when switching off or during rapid load changes, you may be able to improve the situation by increasing the gain factor for the Vdc controller p1250 (p1290), e.g., from "1.00" to "2.00".

- Undervoltage in the DC link
- Typical cause:

Failure of the mains voltage or supply for the DC link.

- Remedy:

Specify a regenerative torque for the rotating drive to compensate the existing losses, thereby stabilizing the voltage in the DC link. This process is known as kinetic buffering.
Kinetic buffering is only possible as long as energy is generated by the movement of the drive.

## Properties

- Vdc control
- This comprises Vdc_max control and Vdc_min control (kinetic buffering), which are independent of each other.
- It contains a joint PI controller. The dynamic factor is used to set Vdc_min and Vdc_max control independently of each other.
- Vdc_min control (kinetic buffering)
- With this function, the kinetic energy of the motor is used for buffering the DC link voltage in the event of a momentary power failure, thereby decelerating the drive.
- Vdc_max control
- This function is used to control momentary regenerative load without shutdown using "overvoltage in the DC link".
- Vdc_max control is only recommended for a supply without active closed-loop control for the DC link and without feedback.


## Description of Vdc_min control (kinetic buffering)



Figure 9-4 Switching Vdc_min control on/off (kinetic buffering)

## Note

## Activation of kinetic buffering

Kinetic buffering must only be activated in enclosed drive type A in conjunction with a secure external power supply.

When Vdc_min control is enabled with $\mathrm{p} 1240=2.3$ ( p 1280 ), it is activated if the power fails when the Vdc_min switch-in level (r1246 (r1286)) is undershot. In general, the regenerative power (braking energy) of the drive machine generated when the motor speed is reduced is used to buffer the DC link voltage of the drive; in other words, when Vdc_min control is active, the motor speed no longer follows the main setpoint and can be reduced to zero. The drive continues operating until the shutdown threshold of the DC link voltage is undershot (see "Switching Vdc_min control on/off" <1>).

## Note

## Parameter specifications in brackets

All parameter specifications in parentheses refer to V/f control.

Distinction between V/f control and speed control:

- V/f control

The Vdc_min controller acts on the speed setpoint channel. When Vdc_min control is active, the drive setpoint speed is reduced so that the drive becomes regenerative.

- Speed control

The Vdc_min controller acts on the speed controller output and affects the torquegenerating current setpoint. When Vdc_min control is active, the torque-generating current setpoint is reduced so that the drive becomes regenerative.

If the power fails, the DC link voltage decreases due to the lack of power from the supply system. When the DC link voltage threshold set via parameter p1245 (p1285) is reached, the Vdc_min controller is activated. Due to the PID properties of the controller, the motor speed is reduced to the extent that the regenerative drive energy maintains the DC link voltage at the level set in p1245 (p1285). The kinetic energy of the drive governs the dropout characteristic of the motor speed and, in turn, the buffering duration. In centrifugal mass drives (e.g., fans), buffering can last a few seconds. In drives with a low centrifugal mass (e.g., pumps), however, buffering can last just $100-200 \mathrm{~ms}$. When the power is restored, the Vdc_min controller is deactivated and the drive is ramped up to its setpoint speed at the ramp-function generator ramp. As long as the Vdc_min controller is active, an alarm A7402 (drive: DC link voltage minimum controller active) will be issued.

If the drive can no longer generate any regenerative energy (because, for example, it is almost at a standstill), the DC link voltage continues to drop. If the minimum DC link voltage is undershot (see "Switching Vdc_min control on/off" <1>), the drive will shut down with fault F30003 (power unit: DC link undervoltage).

If a speed threshold set with parameter p1257 (p1297) is undershot when Vdc_min control is active (see diagram "Switching Vdc_min control on/off" <2>), the drive is shut down with F7405 (drive: kinetic buffering minimum speed not reached).

If a shutdown with undervoltage in the DC link (F30003) occurs without the drive first coming to a standstill despite the fact that Vdc_min control is active, the controller may have to be optimized via dynamic factor p1247 (p1287). Increasing the dynamic factor in p1247 (p1287) causes the controller to intervene more quickly. The default setting for this parameter, however, should be sufficient for most applications.

Parameter p1256 = 1 (p1296) can be used to activate time monitoring for kinetic buffering. The monitoring time can be set in parameter p1255 (p1295). If buffering (i.e., the power failure) lasts longer than the time set here, the drive will shut down with fault F7406 (drive: kinetic buffering maximum time exceeded). The standard fault reaction for this fault is OFF3, which means that this function can be used for controlled drive deceleration in the event of a power failure. In this case, excess regenerative energy can only be dissipated via an additional braking resistor.

## Description of Vdc_max control



Figure 9-5 Switching Vdc_max control on/off
The switch-in level of the Vdc_max control (r1242 or r1282) is calculated as follows:

- when automatic switch-in level sensing is disabled (p1254 (p1294) $=0$ )
- AC/AC device: $\mathrm{r} 1242(\mathrm{r} 1282)=1.15 \times \sqrt{ } 2 \times \mathrm{p} 0210$ (device supply voltage)
- DC/AC device: r 1242 (r1282) $=1.15 \times \mathrm{p} 0210$ (device supply voltage)
- when the automatic switch-in level sensing is enabled (p1254=1) r1242 (r1282) = Vdc_max - 50 V (Vdc_max: overvoltage threshold of the drive)


## Function diagram

FP 6220 (FP 6320) Vdc_max controller and Vdc_min controller

## Parameters

- p1240 (p1280) Vdc controller or Vdc monitoring configuration
- r1242 (r1282) Vdc_min controller switch-in level
- p1243 (p1283) Vdc_max controller dynamic factor
- p1245 (p1285) Vdc_min controller switch-on level (kinetic buffering)
- r1246 (r1286) Vdc_min controller switch-on level (kinetic buffering)
- p1247 (p1287) Vdc_min controller dynamic factor (kinetic buffering)
- (p1288) Vdc_max controller feedback coupling factor ramp function generator (V/f)
- p1249 (p1289) Vdc_max controller speed threshold
- p1250 (p1290) Vdc controller proportional gain
- p1251 (p1291) Vdc controller integral time
- p1252 (p1292) Vdc controller rate time
- (p1293) Vdc_min controller output limit (V/f)
- p1254 (p1294) Vdc_max controller automatic ON level detection
- p1255 (p1295) Vdc_min controller time threshold
- p1256 (p1296) Vdc_min controller response (kinetic buffering)
- p1257 (p1297) Vdc_min controller speed threshold
- r1258 (r1298) Vdc controller output


### 9.2.5 $\quad$ Automatic restart function

## Description

The automatic restart function automatically restarts the drive after an undervoltage or a power failure. The alarms present are acknowledged and the drive is restarted automatically.
The drive can be restarted using one of two procedures:

- The standard procedure starting from standstill, or
- Starting the drive with the flying restart function. For drives with low moments of inertia and load torques that allow the drive to come to a standstill within a matter of seconds (e.g., pump drives operating against a pressure head), then starting from standstill is recommended.


## Note

Drives with high moments of inertia
The flying restart function can also be activated for drives with large moments of inertia (such as fan drives). This enables you to switch to the motor that is still rotating.

## A. Warning

Unexpected movement of the motor during automatic restart
If p1210 is set to values greater than ( $>$ ) 1, the motor can be restarted automatically without the need to issue the ON command.
In the event of prolonged power failures and when the automatic restart function is activated (p1210>1), the drive may have been at a standstill for a long time and mistakenly considered to have been switched off.
For this reason, entering the area around the drive when it is in this condition can result in death, serious injury, or property damage.

- Observe the general safety instructions.
- Ensure that the EMERGENCY OFF functions are functional.


## Automatic restart mode

Table 9-2 Automatic restart mode

| p1210 | Mode | Meaning |
| :---: | :--- | :--- |
| 0 | Disables automatic <br> restart | Automatic restart inactive |
| 1 | Acknowledges all faults <br> without restarting | Any faults that are present, are acknowledged automatically <br> once the cause has been rectified. If further faults occur after <br> faults have been acknowledged, these will also be acknowledged <br> automatically. A minimum time of p1212 + 1 s must expire <br> between successful fault acknowledgment and a fault re- <br> occurring if the signal ON/OFF1 (control word 1, bit 0) is at a <br> HIGH signal level. If the ON/OFF1 signal is set to LOW, the time <br> between a fault being acknowledged and another fault occurring <br> must be at least 1 s. <br> With P1210 = 1, no F07320 fault is generated if the <br> acknowledgment attempt faults, for example due to too great a <br> frequency of fault occurrence. |
| 4 | Automatic restart after <br> line supply failure, <br> without additional <br> startup attempts | An automatic restart is only carried out, if fault F30003 has also <br> occurred at the Motor Module, or there is a HIGH signal at <br> binector input p1208[1], or in the case of an infeed drive object <br> (A_Infeed), fault F06200 has occurred. If additional faults are <br> pending, then these faults will also be acknowledged; if this is <br> successful, the startup attempt will be resumed. The failure of the <br> CU's 24 V power supply will be interpreted as a line supply <br> failure. <br> For the case that only the phase voltage fails, time monitoring <br> can be set using p1213. |
| 6 | Restart after fault, with <br> additional startup <br> attempts | An automatic restart is carried out after any fault or for <br> p1208[0] = 1. If the faults occur one after the other, then the <br> number of startup attempts is defined using p1211. Monitoring <br> over time can be set using p1213. |
| 16 | Restart after line supply <br> failure, after manual <br> acknowledgment | Restart after fault, after <br> manual <br> acknowledgment |
| As with p1210 = 4. Pending faults must be manually <br> acknowledged. <br> This is followed by an automatic restart. |  |  |
| As with p1210 = 6. Pending faults must be manually <br> acknowledged. <br> This is followed by an automatic restart. |  |  |
| 10 |  |  |

## Startup attempts (p1211) and waiting time (p1212)

p1211 is used to specify the number of startup attempts. The number is decremented internally after each successful fault acknowledgment (line supply voltage must be restored or the infeed signals that it is ready). Fault F07320 is output when the number of configured startup attempts is reached.
If $\mathrm{p} 1211=\mathrm{x}, \mathrm{x}+1$ startup attempts will be made.

## Note

## Start of a startup attempt

A startup attempt starts immediately when the fault occurs.
The faults are acknowledged automatically at intervals of half the waiting time p1212.
Following successful acknowledgment and restoration of the voltage, the system is automatically powered up again.

The startup attempt has been successfully completed if the flying restart and the motor magnetization (induction motor) have been completed (r0056.4 = 1) and one additional second has expired. The startup counter is not reset to the initial value p1211 until this point.
If additional faults occur between successful acknowledgment and the end of the startup attempt, then the startup counter, when it is acknowledged, is also decremented.

## Automatic restart monitoring time (p1213)

- p1213[0] = monitoring time for automatic restart

The monitoring time starts when the faults are detected. If the automatic acknowledgments are not successful, the monitoring time will continue. If the drive has not successfully restarted by the time the monitoring time expires (flying restart and motor magnetization must have been completed: r0056.4 = 1), fault F07320 is output.

The monitoring is deactivated with p1213 = 0. If p1213 is set to a value lower than the sum of p1212, the magnetization time r0346 and the additional delay time due to flying restart, then fault F07320 will be generated on every restart attempt. If, for p1210 $=1$, the time in p1213 is set to a value lower than p1212, then fault F07320 will also be generated on every restart attempt.
The monitoring time must be extended if the faults that occur cannot be immediately and successfully acknowledged (e.g., when faults are permanently present).
For p1210 $=14,16$ manual acknowledgment of the pending fault must take place within the time in p1213[0]. Otherwise, fault F07320 will be generated when the specified time runs out.

- $\mathrm{p} 1213[1]=$ monitoring time for startup counter resetting

The startup counter (see r1214) is only reset to starting value p1211 once the time in p1213[1] has expired after a successful restart. The delay time is not effective for error acknowledgment without an automatic restart ( $\mathrm{p} 1210=1$ ). If the power supply fails (blackout), the wait time only starts once the power has been restored and the Control Unit is ramped up. The startup counter is set to starting value p1211 when F07320 has occurred, the switch-in command is withdrawn and the fault is acknowledged.
If starting value p1211 or mode p1210 is changed, the startup counter is immediately updated.

## Faults without automatic restart (p1206)

The automatic restart function can be disabled for up to 10 fault numbers via p1206[0...9]. The parameter is only effective if p1210 = 6 and p1210 $=16$.

## Parameters

- p1206[0...9] Faults without automatic restart
- p1210 Automatic restart mode
- p1211 Automatic restart, start attempts
- p1212 Automatic restart, delay time start attempts
- p1213 Automatic restart monitoring time
- r1214 Automatic restart status


## Settings

### 9.2.6 Flying restart

## Description

The "flying restart" function (enabled via p1200) allows the drive to switch to a motor that is still rotating. Switching on the drive without the flying restart function would not allow any flux to build up in the motor while it is rotating. Since the motor cannot generate any torque without flux, this can cause it to switch off due to overcurrent (F07801).
The flying restart function first determines the speed of the drive with which V/f or vector control is initialized so that the drive and motor frequency can be synchronized.
During the standard start-up procedure for the drive, the motor must be at a standstill. The drive then accelerates the motor to the setpoint speed. In many cases, however, the motor is not at a standstill.

Two different situations are possible here:

1. The drive rotates as a result of external influences, such as water (pump drives) or air (fan drives). In this case, the drive can also rotate against the direction of rotation.
2. The drive rotates as a result of a previous shutdown (e.g. OFF 2 or a power failure). The drive slowly coasts to a standstill as a result of the kinetic energy stored in the drive train (example: induced-draft fan with a high moment of inertia and a steeply descending load characteristic in the lower speed range).
In accordance with the setting chosen (p1200), the flying restart function is activated in the following situations:

- Once power has been restored and the automatic restart function is active
- After a shutdown with the OFF2 command (pulse inhibit) when the automatic restart function is active
- When the ON command is issued


## Note

## Applications for flying restart function

The flying restart function must be used in cases where the motor may still be running or may still be driven by the load in order to prevent shutdowns due to overcurrent (F7801).

## Note

## Information on flying restart function

If the value set for parameter p1203 (search speed factor) is higher, the search curve is flatter and, as a result, the search time is longer. A lower value has the opposite effect.
In motors with a small moment of inertia, the flying restart function can cause the drive to accelerate slightly.
In group drives (multiple motors on a drive), the flying restart function should not be activated due to the different coasting properties of the individual motors.

### 9.2.6.1 Flying restart without an encoder

## Description

Depending on parameter p 1200 , the flying restart function is started with the maximum search speed $\mathrm{n}_{\text {search, max }}$ once the de-excitation time ( p 0347 ) has elapsed (see diagram "Flying restart").
$n_{\text {Search, } \text { max }}=1.25 \times \mathrm{n}_{\text {max }}$ (p1082)
The flying restart function behaves differently with V/f control and vector control:

- V/f characteristic (p1300 < 20):

The search speed yielded from parameter p1203 reduces the search frequency in accordance with the motor current. The assignable search current ( p 1202 ) is injected here. If the search frequency is similar to the rotor frequency, a current minimum occurs.

Once the frequency has been found, the motor is magnetized. The output voltage during the magnetization time ( p 0346 ) is increased to the voltage value yielded from the V/f characteristic (see "Flying restart").

- Vector control without a speed encoder:

The motor speed is determined using the speed adaptation control loop for the electric motor model. To begin with, the search current (p1202) is injected and then the controller is activated starting from the maximum search frequency. The dynamic response of the controller can be altered using the search speed factor (p1203). If the deviation of the speed adaptation controller is not too great, the motor continues to be magnetized for the duration assigned in p0346.
Once the excitation build-up time (p0346) has elapsed, the ramp-function generator is set to the speed actual value and the motor is ramped up to the current setpoint frequency.


Figure 9-6 Flying restart

## WARNING

Unexpected movement of the motor when flying restart is activated
When "flying restart" (p1200) is activated, the drive may still be accelerated by the search current despite the fact that it is at standstill and the setpoint is 0 !
For this reason, entering the operating area of the motor when it is in this condition can result in death, serious injury, or property damage.

- Observe the general safety instructions.
- Ensure that the EMERGENCY OFF functions are functional.


## Note

Flying restart without encoder for permanent-magnet synchronous motors
Flying restart without encoder for permanent-magnet synchronous motors is only possible when using a voltage sensing module VSM10 to record the motor speed (option K51).

## Flying restart without encoder for long cables

In the case of long motor cables, the procedure described above lead to problems during a flying restart. In such cases, the following settings can improve the flying restart function:

- Enter the line resistance in parameter p0352 before motor data identification.
- Set the parameter p1203 to at least $300 \%$. With this setting, flying restart takes longer than for values below $300 \%$.


## Note

Optimize the flying restart function
To optimize the flying restart, a trace recording should be used to check the function. If necessary, you can improve the result by making settings for parameters p1202 and p1203.

## Fast flying restart (only for induction motors)

The "Fast flying restart" function can be activated during operation without encoder (vector control, V/f control linear and parabolic). For a fast flying restart, the initial frequency is set to zero.
In this procedure, the flying restart function is performed successfully within a period of approximately 200 ms .

Fast flying restart function only works under the following conditions:

- With a current regulator cycle time of $250 \mu$ s or $400 \mu \mathrm{~s}$ (without motor-side filter and without long cables)
- Up to $4 x$ the rated speed for vector control
- Up to the rated speed for V/f control


## Note

The "fast flying restart" function is only possible for induction motors.

The settings for fast flying restart are configured in the expert list.

1. The "Fast flying restart" procedure is selected by setting p1780.11 = 1 .

For operation with encoder, settings of this bit are ignored because fast flying restart is not possible in this case.
2. Fast flying restart is activated using the p1200 parameter, as with the normal flying restart.
3. For the determination of the line resistance, a motor data identification must be carried out at standstill ( $\mathrm{p} 1900=2$ ).
The critical parameters are the motor stator resistance ( p 0350 ) and the motor stator leakage inductance (p0356).

The following condition code bits are available for the fast flying restart:

- For V/f control: r1204.14 (Fast flying start activated).
- For vector control: r1205.16 (fast flying restart activated) or r1205.17 (fast flying restart finished).


## Note

Detection current must not become too small
If you have any problems with the fast flying restart it can be useful to set the search current ( p 1202 ) to values $>30 \%$. Problems can occur if the drive is operated far into the field weakening, or if it is operated with motor-side filters or long lines.

## Fast flying restart with voltage measurement via VSM10

The time for the connection to a rotating induction motor can be shortened when the terminal voltage of the motor is measured.

Settings for fast flying restart with voltage measurement:

1. Select the voltage measurement for the fast flying restart: $p 0247.5=1$.
2. Activate the flying restart: $\mathrm{p} 1200>0$.

The following status bits indicate the characteristic of the flying restart:

1. For V/f control: r1204.15
2. For vector control: r1205.18, r1205.19, r1205.20

## Note

Voltage amplitude must not be too small
If the measured voltage amplitude undershoots the $1 \%$ limit of the converter rated voltage, the flying restart with voltage measurement is deactivated and the motor speed sought.

### 9.2.6.2 Flying restart with an encoder

## Description

The flying restart function behaves differently with V/f control and vector control:

- V/f characteristic (p1300<20):

Flying restart without an encoder (see Chapter "Flying restart without an encoder")

- Vector control with a speed encoder:

Since the speed is known from the start, the motor can be magnetized immediately at the appropriate frequency. The duration of magnetization is specified in p0346. Once the excitation build-up time has elapsed, the ramp-function generator is set to the actual speed value and the motor ramped up to the current setpoint speed.

## A Warning

## Unexpected movement of the motor when flying restart is activated

When "flying restart" ( p 1200 ) is activated, the drive may still be accelerated by the search current despite the fact that it is at standstill and the setpoint is 0 !

For this reason, entering the operating area of the motor when it is in this condition can result in death, serious injury, or property damage.

- Observe the general safety instructions.
- Ensure that the EMERGENCY OFF functions are functional.


### 9.2.6.3 Parameters

- p0352 Line resistance
- p1200 Flying restart operating mode
- 0 : Flying restart inactive
- 1: Flying restart always active (start in setpoint direction)
- 2: Flying restart active after On, fault, OFF2 (start in setpoint direction)
- 3: Flying restart active after fault, OFF2 (start in setpoint direction)
- 4: Flying restart always active (start only in setpoint direction)
- 5: Flying restart active after On, fault, OFF2 (start only in setpoint direction)
- 6: Flying restart active after fault, OFF2 (start only in setpoint direction)
- p1202 Flying restart, search current
- p1203 Flying restart search rate factor
- r1204 Flying restart, V/f control status
- r1205 Flying restart, vector control status


## Note

## Set search direction for the flying restart

For p1200 $=1,2,3$, the following applies: Search in both directions, start only in the setpoint direction.
For p1200 $=4,5,6$, the following applies: Search only in the setpoint direction.

### 9.2.7 Checking for a short-circuit/ground fault at a motor

When switching on the power unit, test pulses can be generated that check the connection between the power unit and motor - or the motor winding itself - for a short-circuit or ground fault.

Depending on the configuration in p1901, you can define as to whether only the short circuit test is executed - or additionally, also a ground fault test (with higher current pulses).

- $\mathrm{p} 1901.0=1$

Checks for a line-line short-circuit once/always when the pulses are enabled.

- $\mathrm{p} 1901.1=1$

Checks for a a ground fault once/always when the pulses are enabled.

- p1901.2
p1901.2 = 0: The checks selected with bit 00 or bit 01 are performed once when the pulses are enabled.
p1901.2 = 1: The checks selected with bit 00 or bit 01 are performed each time the pulses are enabled.

The ground fault test is only possible when the motor is stationary, and is therefore only realized when flying restart is deactivated (p1200 = 0) .

The result of the checks that have been set is displayed in r1902.
The tests slightly delay motor starting, depending on what checks have been selected.

## Note

The ground fault and short-circuit test are automatically deactivated as soon as a sine-wave filter is connected, as the filter could be excited by the test pulse.

### 9.2.8 Motor changeover

### 9.2.8.1 Description

The motor data set changeover is used, for example, for:

- Changing over between different motors
- Motor data adaptation


## Note

Switch to a rotating motor
To switch to a rotating motor, the "flying restart" function must be activated.

### 9.2.8.2 Example of changing over between two motors

## Requirements

- First commissioning has been completed.
- 2 motor data sets (MDS), p0130 $=2$
- 2 drive data sets (DDS), p0180 = 2
- 2 digital outputs to control the auxiliary contactors
- 2 digital inputs to monitor the auxiliary contactors
- 1 digital input to select the data set
- 2 auxiliary contactors with auxiliary switches (1 NO contact)
- 2 motor contactors with positively-driven auxiliary switches (1 NC contact, 1 NO contact)


Figure 9-7 Example of motor changeover

Table 9-3 Settings for the motor changeover example

| Parameter | Settings | Comments |
| :--- | :--- | :--- |
| p0130 | 2 | Configure 2 MDSs |
| p0180 | 2 | Configure 2 DDSs |
| p0186[0..1] | 0,1 | The MDSs are assigned to the DDSs. |
| p0820 | Digital input, DDS selection | The digital input to change over the motor is selected via the <br> DDS. Binary coding is used (p0820 $=$ bit 0, etc.). |
| p0821 to p0824 | 0 | Different numbers mean different thermal models. |
| p0826[0..1] | 1,2 | The bits of r0830 are assigned to the MDSs. If p0827[0] = 0, <br> for example, bit r0830.0 is set via DDS0 when MDS0 is <br> selected. |
| p0827[0..1] | 0,1 | The digital outputs for the auxiliary contactors are assigned to <br> the bits. |
| r0830.0 and r0830.1 | Digital outputs, auxiliary <br> contactors | Digital inputs, auxiliary contacts |
| p0831[0..1] | The digital inputs for the feedback signal of the motor <br> contactors are assigned. |  |
| p0833.00 and .01 | 0,0 | The drive controls the contactor circuit and pulse inhibition. |

## Motor changeover sequence

1. Pulse inhibition:

The pulses are inhibited following the selection of a new drive data set using p0820 to p0824.
2. Open motor contactor:

Motor contactor 1 is opened (r0830 = 0), and the status bit "Motor changeover active" (r0835.0) is set.
3. Change over drive data set:

The requested data set is activated (r0051 = data set currently effective, r0837 = requested data set).
4. Energize motor contactor:

After the feedback signal (motor contactor opened) from motor contactor 1, the appropriate bit of r0830 is set and motor contactor 2 is energized.
5. Enable pulses:

After the feedback signal (motor contactor closed) from motor contactor 2, the bit "motor data set changeover active" (r0835.0) is reset and the pulses are enabled. The motor has now been changed over.

### 9.2.8.3 Function diagrams

| FP 8565 | Drive Data Sets (DDS) |
| :--- | :--- |
| FP 8575 | Motor Data Sets (MDS) |

### 9.2.8.4 Parameters

- r0051 Drive data set DDS effective
- p0130 Motor Data Sets (MDS), count
- p0180 Drive Data Sets (DDS), count
- p0186 Motor data sets (MDS), number
- p0819[0...2] Copy Drive Data Set DDS
- p0820 BI: Drive Data Set DDS selection, bit 0
- p0821 BI: Drive Data Set DDS selection, bit 1
- p0822 BI: Drive Data Set DDS selection, bit 2
- p0823 BI: Drive Data Set DDS selection, bit 3
- p0824 BI: Drive Data Set DDS selection, bit 4
- p0826 Motor changeover, motor number
- p0827 Motor changeover status word bit number
- p0828 Motor changeover, feedback signal
- r0830 Motor changeover, status
- p0831 Motor changeover, contactor feedback signal
- p0833 Data set changeover configuration


### 9.2.9 Friction Characteristic

## Description

The friction characteristic curve is used to compensate the friction torque for the motor and the driven machine. A friction characteristic allows the speed controller to be feedforward controlled and improves the control response.

Ten (10) interpolation points are used for the friction characteristic. The coordinates of every interpolation point are defined by a speed parameter ( p 382 x ) and a torque parameter (p383x) (point $1=\mathrm{p} 3820$ and p3830, point $10=\mathrm{p} 3829$ and p3839).

## Features

- There are 10 interpolation points to represent the friction characteristic.
- An automatic function supports the friction characteristic plot.
- A connector output (r3841) can be interconnected as friction torque (p1569).
- The friction characteristic can be activated and de-activated (p3842).


## Commissioning

Speeds for making measurements as a function of the maximum speed p1082 are preassigned in p382x when commissioning the drive system for the first time. These can be appropriately changed corresponding to the actual requirements.

The automatic friction characteristic plot can be activated using p3845. The characteristic is then plotted the next time that it is enabled.

The following settings are possible:

- p3845 $=0 \quad$ Friction characteristic plot de-activated
- p3845 = 1 Friction characteristic plot activated, all directions

The friction characteristic is plotted in both directions of rotation. The result of the positive and negative measurement is averaged and entered into p383x.

- p3845 = 2 Friction characteristic plot activated, positive direction
- p3845 $=3 \quad$ Friction characteristic plot activated, negative direction

Parameter p3847 (friction characteristic plot, warm-up time) is used to specify the time the drive will take to warm up to its operating temperature. During this time, the highest speed set for the friction characteristic plot is reached and maintained in order for the drive to warm up to its operating temperature. The measurement then begins at the highest speed.
! WARNING

## Unexpected motor movement during the friction characteristic plot

When the friction characteristic is plotted, the drive can cause the motor to move. As a result, the motor may reach maximum speed.

For this reason, entering the area around the drive when it is in this condition can result in death, serious injury, or property damage.

- Observe the general safety instructions.
- Ensure that the EMERGENCY OFF functions are functional.


## Function diagram

FP $7010 \quad$ Friction characteristic

## Parameters

- p3820 Friction characteristic, value n0
- ...
- p3839 Friction characteristic, value M9
- r3840 Friction characteristic, status word
- r3841 Friction characteristic, output
- p3842 Activate friction characteristic
- p3843 Friction characteristic smoothing time friction moment difference
- p3844 Friction characteristic number changeover point at the top
- p3845 Activate friction characteristic plot
- p3846 Friction characteristic plot ramp-up/ramp-down time
- p3847 Friction characteristic plot warm-up time


### 9.2.10 Armature short-circuit braking, DC braking

### 9.2.10.1 General information

The "External armature short circuit" function for permanent-magnet synchronous motors controls an external contactor, which short-circuits the motor through resistors in the event of pulse suppression. This decreases the motor's kinetic energy.

The "Internal armature short circuit" function for permanent-magnet synchronous motors short-circuits a half bridge in the power module to control the motor power consumption, thus braking the motor.

The "DC braking" function for induction motors injects direct current into the motor, thus braking the motor.

### 9.2.10.2 External armature short-circuit braking

## Description

External armature short circuit braking is only available for synchronous motors. It is used preferably when braking in an emergency, if controlled braking via the drive is no longer possible (for example, in the event of a power failure, an EMERGENCY OFF, etc.) or if no regenerative infeed is used. In this case, the motor stator windings are short-circuited via external braking resistors. This creates additional resistance in the motor circuit, which helps reduce the kinetic energy of the motor.

The external armature short circuit is activated via p1231 = 1 (with contactor feedback signal) or p1231 $=2$ (without contactor feedback signal). It is initiated when the pulses are suppressed.

This function uses output terminals to control an external contactor, which then short-circuits the motor through resistors when the pulses are suppressed.

A prerequisite for the use of the external armature short circuit is the use of a permanentmagnet synchronous motor (p0300 = 2xx).

## ! WARNING

Motor accelerates uncontrollably for pulling loads
For pulling loads, for an armature short circuit, the motor can uncontrollably accelerate if a mechanical brake is not additionally used. If the motor accelerates uncontrollably this can result in severe injury or death.

- For pulling loads, only use armature short circuit braking to support a mechanical brake (a mechanical brake is mandatory).


## NOTICE

Property damage due to use of motors that are not short-circuit proof
When using motors that are not short-circuit proof, activating the external armature shortcircuit braking can damage these motors.

- Only use motors that are short-circuit proof.
- Use suitable resistances for the short-circuiting.


## Note

## Consequences of incorrect configuration

In case of incorrect configuration (e.g., induction motor and external armature short-circuit selected), fault F07906 "Armature short circuit/internal voltage protection: Parameterization error" is generated.

## Function diagram

FP 7014 Technology function - External armature short circuit

## Parameters

- p0300 Motor type selection
- p1230 BI: Armature short-circuit/DC braking activation
- p1231 Armature short-circuit/DC braking configuration
- 1: External armature short circuit with contactor feedback signal
- 2: External armature short-circuit without contactor feedback signal
- p1235 BI: External armature short circuit, contactor feedback signal
- p1236 External armature short circuit, contactor feedback signal monitoring time
- p1237 External armature short circuit, waiting time when opening
- r1238 CO: Armature short circuit, external state
- r1239 CO/BO: Armature short-circuit/DC braking status word


### 9.2.10.3 Internal armature short-circuit braking

## Description

Internal armature short circuit braking is only available for synchronous motors. It is used preferably when braking in an emergency, if controlled braking via the drive is no longer possible (for example, in the event of a power failure, an EMERGENCY OFF, etc.) or if no regenerative infeed is used. In this case, the motor stator windings are short-circuited via a half bridge in the power module. This creates additional resistance in the motor circuit, which helps reduce the kinetic energy of the motor.

The internal armature short circuit is configured via p1231 = 4 and activated via p1230. It is initiated when the pulses are suppressed.

A prerequisite for the use of the internal armature short circuit is the use of a permanentmagnet synchronous motor $(p 0300=2 x x)$.

## DANGER

Electric shock due to armature short-circuit braking
When the armature short-circuit is active, all the motor terminals are at half the DC-link potential after the pulse suppression.

Contact with live parts can result in death or serious injury.

- Observe the general safety instructions.


## WARNING

Motor accelerates uncontrollably for pulling loads
For pulling loads, for an armature short circuit, the motor can uncontrollably accelerate if a mechanical brake is not additionally used. If the motor accelerates uncontrollably this can result in severe injury or death.

- For pulling loads, only use armature short circuit braking to support a mechanical brake (a mechanical brake is mandatory).


## NOTICE <br> Property damage due to use of motors that are not short-circuit proof or use of an incorrectly dimensioned Power Module/Motor Module <br> When motors that are not short-circuit proof are used, the motors or the Power Module/Motor Module can be damaged when the internal armature short-circuit braking is activated. <br> - Only use motors that are short-circuit proof. <br> - Use suitable resistances for the short-circuiting. <br> - The Power Module / Motor Module must be dimensioned for 1.8 times the short-circuit current of the motor.

## Function diagram

FP 7016 Technology function - Internal armature short circuit

## Parameters

- p0300 Motor type selection
- p1230 BI: Armature short-circuit/DC braking activation
- p1231 Armature short-circuit/DC braking configuration
- 4: Internal armature short circuit/DC braking
- r1239 CO/BO: Armature short-circuit/DC braking status word


### 9.2.10.4 DC braking

## Description

DC braking is only available for induction motors. It is used preferably when braking in an emergency, if controlled braking via the drive is no longer possible (for example, in the event of a power failure, an EMERGENCY OFF, etc.) or if no regenerative infeed is used.
DC braking is activated via p1231 $=4$ or p1231 $=14$. It can be initiated via an input signal p1230 (signal = 1) or a fault response.

## A. warning

## Motor accelerates uncontrollably for pulling loads

For pulling loads, when DC braking is used, during the demagnetization time, the motor can accelerate uncontrollably. This can result in severe injury or death. An additional supporting mechanical brake is only closed after the demagnetization time - when the motor is already rotating - and therefore does not prevent the motor from accelerating uncontrollably.

- Do not use DC braking for pulling loads.


## Activating the DC braking via an input signal

## p1231 = 4 (internal armature short-circuit/DC braking)

If DC braking is activated with the digital input signal, the pulses are initially inhibited for the duration of the motor demagnetizing period ( p 0347 ) in order to demagnetize the motor parameter p1234 (speed at the start of DC braking) is ignored.
After this, the braking current (p1232) is injected as long as the input is activated in order to brake the motor or keep it at a standstill.

## p1231 = 14 (DC braking below the starting speed)

DC braking is activated when a 1-signal is present at binector input p1230 during operation, and the current speed is less than the starting speed ( p 1234 ).
Following prior demagnetizing ( p 0347 ) of the motor for the period set in p 1233 , braking current p1232 is injected, then switched off automatically.

Withdrawing the input signal for DC braking
If $D C$ braking is withdrawn, the drive returns to its selected operating mode.
The following applies:

- Vector control (controlled with or without encoder):

If the "flying restart" function is activated, the drive is synchronized with the motor frequency and then returns to closed-loop controlled mode. If the "flying restart" function is not activated, the drive can only be restarted from standstill without overcurrent fault.

- For V/f control:

With the "Flying restart" function activated, the converter frequency is synchronized with the motor frequency, and the drive will then return to V/f mode. If the "flying restart" function is not activated, the drive can only be restarted from standstill without overcurrent fault.

## DC braking as a fault response

## Activation via p0491 $=4$, p2101 $=6$ (internal armature short-circuit/DC braking)

If DC braking is activated as a fault response, the motor is initially braked in field-oriented mode along the braking ramp, down to the threshold set in p1234 (speed at the start of DC braking). The slope of the ramp is identical to that of the OFF1 ramp (configured via p1082, p1121). After this, the pulses are disabled for the period set in p0347 (demagnetizing time) in order to demagnetize the motor. Then DC braking starts for the period set in p1233 (DC braking duration).

- If an encoder is present, the braking operation lasts until the speed falls below the standstill threshold set in p1226.
- In the absence of an encoder, only the period set in p1233 is applied.


## Activation via p1231 = 5 (DC braking for OFF1/OFF3)

DC braking is activated with OFF1 or OFF3.

- If the motor speed $\geq \mathrm{p} 1234$, the motor is braked down to p 1234 . As soon as the motor speed is < p1234, the pulses are disabled and the motor is demagnetized.
- If the motor speed at OFF1/OFF3 is already < p1234, the pulses are immediately inhibited and the motor is demagnetized.

DC braking is then activated for the period set in p1233 (DC braking duration) and then switched off.

When OFF1/OFF3 is prematurely canceled, then normal operation is resumed.
DC braking as emergency braking of a fault response remains active.

## Function diagram

FP 7017 Technology functions - DC braking

## Parameters

- p0300 Motor type selection
- p0491 Motor encoder fault response: ENCODER
- p1226 Threshold for standstill detection
- p1230 BI: Armature short-circuit/DC braking activation
- p1231 Armature short-circuit/DC braking configuration
- 4: Internal armature short circuit/DC braking
- 5: DC braking with OFF1/OFF3
- 14: DC braking below starting speed
- p1232 DC braking, braking current
- p1233 DC braking duration
- p1234 Speed at the start of DC braking
- r1239 CO/BO: Armature short-circuit/DC braking status word
- p2100 Changing the fault reaction, fault number
- p2101 Changing the fault reaction, reaction


### 9.2.11 Increasing the output frequency

### 9.2.11.1 Description

In applications that require higher output frequencies, the pulse frequency of the drive may have to be increased.

It may also be necessary to change the pulse frequency to prevent resonances from occurring.
Since increasing the pulse frequency also increases the switching losses, a derating factor for the output current must be taken into account when the drive is configured.

Once the pulse frequency has been increased, the new output currents are automatically included in the calculation for power unit protection.

### 9.2.11.2 Default pulse frequencies

The specified maximum output frequencies can be achieved with the default pulse frequencies listed below.

Table 9-4 Maximum output frequency with default pulse frequency

| Drive rating <br> $[\mathrm{HP}(\mathrm{kW})]$ | Default pulse frequency <br> $[\mathrm{kHz}]$ | Maximum output frequency <br> $[\mathrm{Hz}]$ |  |
| :---: | :---: | :---: | :---: |
| Line supply voltage 380 to $480 \mathrm{~V} \mathrm{AC}, 3$ phase |  |  |  |
| $150 \ldots 400(110 \ldots 250)$ | 2 | 160 |  |
| $500 \ldots 800(315 \ldots 560)$ | 1.25 | 100 |  |
| Line supply voltage 500 to $600 \mathrm{~V} \mathrm{AC}, 3$ phase |  |  |  |
| $150 \ldots 800(110 \ldots 560)$ | 1.25 | 100 |  |

The pulse frequencies set in the factory are also the minimum frequencies.
The scanning times for the inputs and outputs of the customer terminal module are set in the factory to $4000 \mu \mathrm{~s}$. This is also the minimum limit.

### 9.2.11.3 Increasing the pulse frequency

## Description

The pulse frequency can be increased in a virtually continuously variable manner between the value preassigned in the factory and the maximum pulse frequency that can be set.

## Procedure

1. Parameter p0009 on the Control Unit must be set to 3 "Basic drive configuration".
2. Parameter p0112 "Sampling times default setting p0115" of the DO VECTOR must be set to 0 "Expert".
3. Use p0113 to enter any pulse frequency between 1 kHz and 2 kHz . If a higher pulse frequency is to be set (e.g., 2.2 kHz ), this value must be divided by 2 or by 4 to obtain a result between 1 kHz and 2 kHz (e.g., 2.2 kHz divided by 2 is 1.1 kHz ).
4. Not all pulse frequencies are accepted in parameter p 0113 ; in such cases, the alarm "Impermissible value" is output.
5. If the frequency entered in parameter p0113 is not accepted, parameter r0114[0] recommends a different frequency that can deviate from the entered pulse frequency by several hertz. This frequency should be entered in p0113.
6. After entering the frequency in p0113, parameter p0009 on the Control Unit must be set to 0 "Ready" again.
7. The Control Unit re-initializes. After startup, the pulse frequencies recommended in r0114[i] ( $\mathrm{i}=1,2, \ldots$ ) can be entered in parameter p1800 "Pulse frequency" of the DO VECTOR.

## Note

## Entering the pulse frequency

The pulse frequency entered in p1800 must correspond precisely to the value given in r0114[i]; otherwise, the entry will be rejected.

### 9.2.11.4 Maximum output frequency achieved by increasing the pulse frequency

By multiplying the base pulse frequency (with integers), the following output frequencies can be achieved (taking into account the derating factors):

Table 9-5 Maximum output frequency achieved by increasing the pulse frequency

| Pulse frequency <br> $[\mathrm{kHz}]$ | Maximum output frequency <br> $[\mathrm{Hz}]$ |
| :---: | :---: |
| 1.25 | 100 |
| 2 | 160 |
| 2.5 | 200 |
| $\geq 4$ | $300^{1)}$ |

${ }^{\text {1) }}$ The maximum output frequency is limited to 300 Hz due to the closed-loop control.

### 9.2.11.5 Parameters

- p0009 Device commissioning parameter filter
- p0112 Sampling times pre-setting p0115
- p0113 Minimum pulse frequency, selection
- p0115 Sampling times
- p1800 Pulse frequency


### 9.2.12 Derating behavior with increased pulse frequency

## Description

To reduce motor noise or to increase output frequency, the pulse frequency can be increased relative to the factory setting.
The increase in the pulse frequency normally results in a reduction of the maximum output current (see "Technical data/current derating depending on the pulse frequency").

During commissioning of the drive, the behavior at overload is automatically adjusted in such a way that the pulse frequency is variably reduced so that the required output power can be provided.

## Properties:

- The reaction to overload depends on the setting of parameter p0290:
- p0290 = 0: Reduce output current or output frequency
- p0290 = 1: No reduction, shutdown when overload threshold is reached
- p0290 = 2: Reduce the output current or output and pulse frequency (not using $\mathrm{I}^{\mathrm{I} t}$ ).
- p0290 = 3: Reduce the pulse frequency (not using ${ }^{12}$ t)
- p0290 = 2: On overload, the pulse frequency (and consequently the output frequency) is first reduced until it has dropped to the rated pulse frequency; then the output frequency is reduced if overload continues to persist.
The rated pulse frequency is half the inverse value of the current controller cycle: 0.5 x 1/p0115[0].
- Reduction of the pulse frequency is executed in whole multiples based on the rated pulse frequency ( 5 kHz -> 2.5 kHz -> 1.25 kHz or $4 \mathrm{kHz} \mathrm{->} 2 \mathrm{kHz}$ ).
- After entry of the maximum speed in p1082, the system automatically calculates whether the pulse frequency is sufficient for the entered maximum speed; if necessary the pulse frequency is increased automatically to a value that is necessary for this.
On overload, this new pulse frequency will no longer be fallen below even when p0290 $=2$ or 3; the downstream reaction (reduce output current or switch off) will be triggered.


## Exceptions:

- With an activated sine-wave filter ( $p 0230=3,4$ ), this behavior is not permitted because the factory set pulse frequency ( 2.5 kHz or 4 kHz ) must not be changed through this measure. Consequently in this case the selection possibility for the parameter p0290 is limited to " 0 " and " 1 ".


## Activation of the variable pulse frequency

During commissioning, the parameter p 0290 is automatically set to " 2 ". This activates pulse frequency reduction under overload.

## Deactivation of the variable pulse frequency

By changing the parameter p0290 to " 0 " or " 1 " the variable pulse frequency is deactivated.

## Function diagram

FP 8014 Signals and monitoring functions - thermal monitoring power module

## Parameters

- r0036 Power module overload I t
- r0037 CO: Power module temperatures
- p0115 Sampling times for internal control loops
- p0230 Drive filter type, motor side
- p0290 Power module overload response
- p1082 Maximum speed
- r2135.13 Fault: thermal overload in power module
- r2135.15 Alarm: thermal overload in power module


### 9.2.13 Pulse frequency wobbling

## Description

Pulse frequency wobbling uses a statistical method to vary the pulse frequency slightly. The mean pulse frequency value still corresponds to the set value, but the statistical variation of the momentary value produces a modified noise spectrum.

This method reduces subjectively perceptible motor noise, particularly at the relatively low factory-set default pulse frequencies.

Pulse frequency wobbling is activated with p1810.2 $=1$. The amplitude of the statistical wobble signal can be set in the range of $0 \%$ to $20 \%$ via p1811.

## Restrictions

- Pulse frequency wobbling can only be activated (p1810.2 = 1) if the following prerequisites are met:
- The drive is in pulse inhibiting mode.
- p1800 < $2 \times 1000 / p 0115[0]$
- p1811 (Pulse frequency wobbling amplitude) can only be activated if the following prerequisites are met:
- $\mathrm{p} 1802.2=1$
- p0230 (output filter) < 3 (no sine-wave filter)
- When pulse frequency wobbling is activated and pulse enable applied, the maximum pulse frequency ( p 1800 ) can be set as follows:
- p1811 = 0: p1800 $\leq 2 \times 1000 / p 0115[0]$
- p1811 > 0: p1800 $\leq 1000 / p 0115[0]$
- Parameter p1811 is set to 0 if the pulse frequency (p1800) setting is greater than 1000 / p0115[0] when pulse frequency wobbling is activated and pulse enable applied.
- Parameter p1811 is set to 0 and parameter p 1810.2 to 0 if the pulse frequency ( p 1800 ) setting is greater than $2 \times 1000 / p 0115[0]$ when pulse frequency wobbling is activated and pulse inhibit applied.


## Note

## Disable pulse frequency wobbling

If pulse frequency wobbling is deactivated ( $\mathrm{p} 1810.2=0$ ), all the indices of parameter p1811 are set to 0 .

## Parameters

- p1800 Pulse frequency setpoint
- p1810.2 Wobbling activated
- p1811[D] Pulse frequency wobbling amplitude


### 9.2.14 Runtime (operating hours counter)

## Total system runtime

The entire system runtime is displayed in r 2114 (Control Unit); it is made up of $\mathrm{r} 2114[0]$ (milliseconds) and r2114[1] (days).
Index 0 indicates the system runtime in milliseconds; after reaching $86,400,000 \mathrm{~ms}$ ( 24 hours), the value is reset. Index 1 indicates the system runtime in days.

The value is saved when the drive unit is switched off.
After the drive unit has been switched on, the counter continues to run with the value that was saved the last time the drive unit was switched off.

## Relative system runtime

The relative system runtime since the last POWER ON is displayed in p0969 (Control Unit). The value is indicated in milliseconds and the counter overflows after 49 days.

## Current motor operating hours

The motor operating hours counter p0650 (drive) resumes when the pulses are enabled. When the pulse enable is withdrawn, the counter is stopped and the value saved.

The counter is deactivated with p0651 $=0$.
If the maintenance interval set in p0651 is reached, alarm A01590 is triggered. Once the motor has been serviced, the maintenance interval must be reset.

## Note

If the motor data set (MDS) is changed over, e.g., in the case of a star-delta (wye-delta) changeover, without a change of motor, the two values in p0650 must be added to determine the correct number of operating hours of the motor.

## Operating hours counter for the fan

The operating hours of the fan in the power module are displayed in p0251 (drive).
The number of hours operated can only be reset to 0 in this parameter (for example, after a fan has been replaced).
The service life of the fan is entered in p0252 (drive).
Alarm A30042 (service life of the fan reached or exceeded) is output when this figure is reached, and also 500 hours beforehand. Evaluation of the fault value in the alarm provides details of the cause of the alarm.
Monitoring is deactivated with p0252 $=0$.

## Time stamp mode

The mode for the time stamp can be set via parameter p3100.

| Setting | Explanation |
| :--- | :--- |
| $p 3100=0$ | Time stamp operating hours |
| $p 3100=1$ | Time stamp UTC format |
| $p 3100=2$ | Time stamp operating hours +01.01 .2000 <br> Additional setting for firmware V4.7 and above. <br> With this setting, the value in p3102 is used as the time stamp of the error <br> messages. For firmware versions prior to V4.7, the time base of p2114 was <br> used with setting p3100 $=0$. |

## Note

## Time stamp settings depending on the firmware version

If a project is upgraded from firmware V 4.6 to V 4.7 , the time stamp settings of the old project are retained. The indicated times of the error messages do not differ from those of the old firmware version.

If a new project is created in firmware version V4.7 and above, the factory setting is p3100 = 2 and therefore a different time base for error messages. If the behavior of versions earlier than V4.7 is desired, p3100 $=0$ should be set.

### 9.2.15 Simulation mode

## Description

Simulation mode is predominantly used to simulate the drive without a motor being connected and without a DC link voltage. In this case, it should be noted that the simulation mode can only be activated under an actual DC link voltage of 40 V . If the voltage lies above this threshold, simulation mode is reset, and a fault code F07826 is issued.

Communication with a higher-level automation system can be tested using simulation mode. If the drive is also to return actual values, note that it must be switched over to encoderless operation during simulation mode. This means that large parts of the SINAMICS software (e.g., software channel, sequence control, communications, technology function, etc.) can be tested in advance without requiring a motor.

Simulation mode also allows you test the correct functioning of the power module. Particularly with devices greater than $150 \mathrm{HP}(110 \mathrm{~kW})(400 \mathrm{~V})$, you must check that the power semi-conductor can be activated properly after repairs. This is done by injecting a low DC voltage as DC link voltage (e.g., 12 V ) and then switching on the device and enabling the pulses.

## Note

## Deactivated functions in simulation mode

The following functions are de-activated in simulation mode:

- Motor data identification
- Motor data identification, rotating without an encoder
- Pole position identification

No flying restart is carried-out for V/f control and encoderless closed-loop vector control.

## Note

Activation of the binector output r0863.1 in simulation mode
Binector output r0863.1 = 1 is set in simulation mode. For this reason, a check must be made to determine whether additional devices are switched on by this signal before activating simulation mode. If necessary, the corresponding BICO interconnection must be disconnected temporarily.

## Commissioning

Simulation is activated using p1272 = 1; the following pre-requisites must be fulfilled:

- First commissioning has been completed (default: standard induction motors).
- The DC link voltage is less than 40 V (observe the tolerance of the DC link voltage sensing).

Alarm A07825 (simulation mode activated) is output during simulation mode.

## Parameter

- p1272 Simulation mode


### 9.2.16 Direction reversal

## Description

The direction of rotation of the motor can be reversed using direction reversal via p1821 without having to change the motor rotating field by interchanging two phases on the motor and inverting the encoder signals using p0410.

Reversal via p1821 can be detected from the motor direction of rotation. The speed setpoint and actual value and torque setpoint and actual value remain unchanged, as does the relative position change.
A pulse inhibit must be set prior to attempting reversal.
The direction reversal can be set differently for each drive data set.

## Note

## Drive data set changeover with differently set direction reversal

Fault F7434 will be returned in the event of a drive data set changeover with different direction reversal settings and pulse enable.

A reversal can be observed by checking parameters r0069 (phase currents) and r0089 (phase voltage). The absolute position reference is lost on reversal.

The output direction of rotation of the drive can be reversed via p1820. This means that the rotating field can be changed without having to interchange the power connections. If an encoder is being used, the direction of rotation must be adapted using p0410, if necessary.

## NOTICE

## Unintended acceleration of the drive due to external speed actual value

When external actual speed values are used for the speed controller via p1440, positive feedback can occur in the speed control loop, which can cause the drive to accelerate up to the speed limit and become damaged.

- When using external speed actual values for the speed controller, additionally change its polarity when reversing the direction of rotation (p1821 = 1).


## WARNING

Excessively high torque due to an inappropriate phase sequence of the motor after direction reversal

If a drive is synchronized to the line supply, when the direction is reversed, high torques can be generated when connecting to the line supply if the phase sequence of the line voltage does not match the phase sequence of the rotating motor. This high torque can destroy the coupling between the motor and load and therefore result in death or severe injury.

- As a consequence, for this constellation, check the phase sequence of the VSM wiring and correct if necessary.


## Function diagrams

FP 4704, 4715 Encoder evaluation
FP 6730, 6731 Interface to Motor Module

## Parameters

- r0069 Phase currents, actual value
- r0089 Phase voltage, actual value
- p0410 Encoder inversion actual value
- p1820 Reverse the output phase sequence
- p1821 Direction of rotation


### 9.2.17 Switching unit systems (SI/US/\%)

## Description

Parameters and process variables for input and output can be switched to a suitable unit system (SI units, US units or referenced variables (\%)) with the help of the unit changeover function.
The following constraints apply to the unit changeover:

- Unit changeover is only possible for the "VECTOR" drive object.
- Parameters of the nameplate of the drive and motor can be toggled between SI and US units; however, a relative representation is not possible.
- Once the changeover parameter has been changed, all parameters that are assigned to a unit group depending on this parameter are jointly changed over to the new unit.
- A separate parameter is available for selecting technological units (p0595) for the representation of technological variables in the technology controller.
- If a changeover is made to relative values and the reference value is subsequently changed, the \% value entered in a parameter will not change.


## Example:

- With a reference speed of 1500 rpm , a fixed speed of $80 \%$ corresponds to a value of 1200 rpm .
- If the reference speed is changed to 3000 rpm , the value of $80 \%$ is retained and is now 2400 rpm .


## Restrictions

- When a unit changeover occurs, rounding to the decimal places is carried out. This can mean that the original value might change by up to one decimal place.
- If a referenced form is selected and the reference parameters (e.g., p2000) are changed retrospectively, the physical significance of some of the control parameters is also adjusted, which can affect the control behavior.
- If the reference variables (p2000 to p2007) are changed in offline mode in STARTER, there is a risk that the parameter value ranges will be violated. In this case, appropriate fault messages will be displayed when the parameters are loaded to the drive unit.


## Switching units

The units can be switched via the AOP30 and via STARTER.

- Unit changeover via AOP30 is always carried out immediately. Once the corresponding parameters have been changed, the values affected are displayed in the new selected unit.
- If STARTER is used, unit changeover can only take place in offline mode in the configuration screen of the corresponding drive object. The new units are not displayed until after the download ("Load project to target system") and subsequent upload ("Load project to $\mathrm{PG}^{\prime \prime}$ ) have been completed.


## Unit groups

Each parameter that can be switched is assigned to a unit group, which can be switched within certain limits depending on the group.
This assignment and the units groups for each parameter appear in the parameter list in the SINAMICS List Manual.

The unit groups can be individually switched using 4 parameters (p0100, p0349, p0505 and p0595).

## Parameters

- p0010 Commissioning parameter filter
- p0100 IEC/NEMA mot stds
- p0349 Unit system, motor equivalent circuit diagram data
- p0505 Unit system selection
- p0595 Technological unit selection
- p0596 Technological unit reference value
- p2000 Reference speed reference frequency
- p2001 Reference voltage
- p2002 Reference current
- p2003 Reference torque
- r2004 Reference power
- p2005 Reference angle
- p2006 Reference temperature
- p2007 Reference acceleration


### 9.2.18 Simple brake control

## Description

The "Simple brake control" is used exclusively for the control of holding brakes. The holding brake is used to secure drives against unwanted motion when deactivated.
The control command for releasing and applying the holding brake is transmitted directly to the drive via DRIVE-CLiQ from the Control Unit, which logically combines the signals with the system-internal processes and monitors these signals.
The drive then performs the action and controls the output for the holding brake appropriately.
The mode of operation of the holding brake can be configured using p1215.


Figure 9-8 Sequence diagram, simple brake control
The start of the closing time for the brake depends on the expiration of the shorter of the two times p1227 (standstill detection monitoring time) and p1228 (pulse suppression delay time).

## A warning

## Improper use of simple brake control

Accidents causing serious injury or death can occur if the basic brake control is incorrectly used.

- Do no use the simple brake control for operational braking.
- Observe the special technological and machine-specific requirements and standards for maintaining personnel and machine protection.
- Also take into consideration the risks that can result from suspended axes.


## Features

- Automatic activation using sequence control
- Standstill monitoring
- Forced brake release (p0855, p1215)
- Application of brake for a 1 signal "unconditionally close holding brake" (p0858)
- Application of brake after "Enable speed controller" signal has been canceled (p0856)


## Signal connections

The holding brake is controlled using free digital outputs on the Control Unit or the TM31. If necessary, control must be realized using a relay for connection of a holding brake with higher voltage or with higher power requirement.

For this, parameter p 1215 must be set to " 3 " (motor holding brake like sequence control, connection via BICO ) and the appropriate BICO parameters of the selected digital outputs must be interconnected.

## Commissioning

If p1215 is set to "0" (no brake available) during initial commissioning and a connected brake is recognized, simple brake control is activated automatically (p1215 = 1). In this case, fault F07935 "Motor holding brake detected" appears and must be acknowledged.

## NOTICE

Property damage resulting from destruction of the brake due to incorrect configuration settings

When a motor holding brake is present, parameter setting p1215 = "0" (no motor holding brake present) causes the motor holding brake to remain applied. If the motor is in motion, this leads to destruction of the brake.

- When a motor holding brake is present, set parameter p1215 to a value $>1$.

Notes on setting up the release time ( p 1216 ):

- The release time (p1216) should be set greater than the actual release time of the holding brake. As a result, the drive will not accelerate when the brake is closed.

Notes for setting up the closing time (p1217):

- The closing time (p1217) should be set greater than the actual closing time of the holding brake. As a result, the pulses are suppressed only after the holding brake is closed.
- If the closing time ( p 1217 ) is set too low compared to the actual closing time of the holding brake, the load may drop suddenly.
- If the closing time (p1217) is set too high compared to the actual closing time of the holding brake, the controller acts against the holding brake and thus reduces its service life.


## Function diagram

FP $2701 \quad$ Simple brake control $(\mathrm{r} 0108.14=0)$

## Parameters

- r0056.4 Magnetizing complete
- r0060 CO: Speed setpoint before the setpoint filter
- r0063[0...2] CO: Actual speed value
- r0108.14 Extended brake control
- p0855[C] BI: Unconditionally release holding brake
- p0856 BI: Speed controller enabled
- p0858 BI: Unconditionally apply holding brake
- r0899.12 BO: Holding brake released
- r0899.13 BO: Command, close holding brake
- p1215 Motor holding brake configuration
- p1216 Motor holding brake release time
- p1217 Motor holding brake closing time
- p1226 Threshold for standstill detection
- p1227 Standstill detection monitoring time
- p1228 Pulse suppression delay time
- p1278 Brake control diagnostic evaluation


### 9.2.19 Synchronization

## Description

You can synchronize a motor with the supply using the "Synchronization" function and an existing voltage sensing module VSM10 (to measure the mains voltage). The connection to the mains or the required contactor control can take place using the existing bypass function or a higher-level controller.

Use of the bypass function supports temporary (for example, for maintenance work without plant standstill) or permanent operation of the motor on the mains.

Synchronization is activated with the p3800 parameter. Voltage measurement takes place via VSM10 which is assigned to a drive (using DRIVE-CLiQ) and measures the mains voltage.

## Features

- Connector inputs for the actual voltage sensing of the motor via VSM10 (p3661, r3662)
- Setting a phase difference (p3809)
- Can be activated by parameter (p3800)
- Can be enabled by parameter (p3802)


## Function diagram

FP $7020 \quad$ Technology functions - Synchronizing

## Parameters

- p3800[0...n] Sync network drive activation
- p3801[0...n] Sync-line-drive drive object number
- p3802[0...n] BI: Sync network drive enable
- r3803 CO/BO: Sync network drive control word
- r3804 CO: Sync network drive target frequency
- r3805 CO: Sync network drive frequency difference
- p3806[0...n] Sync network drive frequency difference threshold value
- r3808 CO: Sync network drive phase difference
- p3809[0...n] Sync network drive phase setpoint value
- p3811[0...n] Sync network drive frequency limitation
- r3812 CO: Sync network drive correction frequency
- p3813[0...n] Sync network drive phase synchronism threshold value
- r3814 CO: Sync network drive voltage difference
- p3815[0...n] Sync network drive voltage difference threshold value
- r3819.0... 7 CO/BO: Sync network drive status word


### 9.2.20 Energy savings indicator for pumps, fans, and compressors

## Function of the energy savings indicator

This function determines the amount of energy used by pumps, fans, and compressors and compares it with the extracted energy requirement for similar equipment equipped with a conventional throttle control.
The amount of energy saved is calculated over the last 100 operating hours and is displayed in kWh . For an operating time of less than 100 hours, the potential energy savings is extrapolated to 100 operating hours.
The pump, fan, or compressor characteristic with the conventional throttle control is specified using 5 adjustable interpolation points.

## Background

In a conventionally controlled pump, fan or compressor, the flow rate of the medium is controlled using valves or throttles. In so doing, the driving machine runs constantly at the rated speed. The system efficiency decreases significantly if the flow rate is reduced by means of valves or throttles. The pressure in the system increases. The motor even consumes energy when the valves or throttles are completely closed, i.e., with flow rate $Q=0$. In addition, undesirable process-related situations can occur; for example, cavitation in the pumps, fans, and compressors or increased heating of the pumps, fans, and compressors and the medium.

As a result of variable speed operation, a drive under partial load consumes considerably less energy than with conventional process control via valves or throttles. This applies in particular for pumps, fans, and compressors with parabolic load characteristics. With SINAMICS, a closed-loop control of the flow rate or pressure is achieved via a speed control of the pump, fan or compressor. As a consequence, the equipment is controlled close to its maximum efficiency over the complete operating range.

In comparison to pumps, fans, and compressors, machines with linear or constant load characteristic (e.g. conveyor drives or positive displacement pumps) have lower potential savings.

## Energy savings through use of a variable speed drive

When a variable speed drive is used, the flow rate of the pump, fan, or compressor is controlled as a function of speed. The flow rate changes proportionally with the speed of the pump, fan, or compressor. Any existing valve or throttle remains open. Therefore, the equipment works close to optimum efficiency and consumes considerably less energy, particularly in the partial load range, than equipment controlled by means of valves or throttles.


Figure 9-9 Potential for energy savings
Legend for top characteristic:
H[\%] = Head, P[\%] = Flow pressure, Q[\%] = Flow rate, V[\%] = Volumetric flow
Legend for bottom characteristic:
$\mathrm{P}[\%]=$ Rated input of conveyor, $\mathrm{n}[\%]=$ Speed of conveyor
Interpolation points p3320 to p3329 for equipment curve with $\mathrm{n}=100 \%$ :
P1...P5 = Rated input, n1...n5 = Speed in accordance with variable speed machine

## Adapting the pump, fan, or compressor characteristic

The 5 interpolation points of the pump, fan, or compressor characteristic are entered using parameters p3320 to p3329. This characteristic can be configured individually for each drive data record.

Table 9-6 Interpolation points of the pump, fan, or compressor characteristic

| Interpolation point | Parameter | Factory setting: <br> P: Power in \% <br> $\mathrm{n}:$ Speed in \% |  |
| :---: | :---: | :---: | :--- |
|  | p 3320 | $\mathrm{P} 1=25.00$ |  |
| 2 | p 3321 | $\mathrm{n} 1=0.00$ |  |
|  | p 3322 | $\mathrm{P} 2=50.00$ |  |
| 3 | p 3323 | $\mathrm{n} 2=25.00$ |  |
|  | p 3324 | $\mathrm{P} 3=77.00$ |  |
| 4 | p 3325 | $\mathrm{n} 3=50.00$ |  |
|  | p 3326 | $\mathrm{P} 4=92.00$ |  |
| 5 | p 3327 | $\mathrm{n} 4=75.00$ |  |
|  | p 3328 | $\mathrm{P} 5=100.00$ |  |

## Note

Consequences of not adjusting the pump, fan, or compressor curve
If the interpolation points of the pump, fan, or compressor curve are not adapted, the factory setting will be used to calculate the energy savings indicator. The values of the factory setting could then deviate from the equipment characteristic and cause incorrect calculation of the actual energy savings.

## Energy savings indication

The energy savings are displayed in parameter r0041.
By setting p0040 $=1$, the value of the r0041 parameter is reset to 0 . Parameter p0040 is then automatically set to 0 .

### 9.2.21 Write protection

## Description

The write protection is used to prevent unintended changes to adjustable parameters. No password is required for write protection.

## Activating write protection

The write protection can be activated as follows:

- With the STARTER in online mode and after selecting the drive unit viaProject > Write protection for drive unit > Activate.
- With the AOP30 operator panel via p7761 $=1$.

All adjustable parameters affected by write protection can no longer be changed now.
In the STARTER, all write-protected adjustable parameters in the expert list and in operation screens are disabled (grayed out).
In AOP30, an attempt to change a write-protected adjustable parameter is denied and an error message is displayed.
Write requests of write-protected adjustable parameters via communication are handled differently:

- Parameter changes of controllers of class 1 (e.g. SIMATIC PLCs) are executed.
- Parameter changes of controllers of class 2 (engineering or commissioning tools, e.g. STARTER) are not executed.


## Deactivating write protection

Write protection can be deactivated as follows:

- With the STARTER in online mode and after selecting the drive unit viaProject > Write protection for drive unit > Deactivate.
- With the AOP30 operator panel via p7761 $=0$.


## Write protection status

The write protection status can be displayed using parameter r7760.0:

- $\mathrm{r} 7760.0=0$ : Write protection is not active
- $r 7760.0=1$ : Write protection is active


## Exceptions for activated write protection

The following functions or adjustable parameters are excluded from write protection:

- Changing the access level ( p 0003 )
- Commissioning of parameter filter (p0009)
- Module detection via LED (p0124, p0144, p0154)
- Resetting parameters (p0972, p0976)
- Saving parameters (p0977)
- Acknowledging a fault (p2102, p3981)
- RTC time stamp, time setting, synchronization (p3100, p3101, p3103)
- Master control mode selection (p3985)
- Trace (p4700ff.)
- Function generator (p4800ff.)
- Activating/deactivating write protection (p7761)
- Flashing of component (p9210, p9211)


## Note

List of exceptions for activated write protection
A list of the adjustable parameters that can be changed in spite of activated write protection can be found in the List Manual.
The list has the designation "WRITE_NO_LOCK".

## Write protection for multi-master fieldbus systems

For fieldbus systems (e.g., CAN bus) that can be operated as multi-master bus systems, access to all the adjustable parameters is also possible when write protection is activated.
For these bus systems, the behavior when write protection is activated can be set via parameter p7762:

- $\mathrm{p} 7762=0$ : Write access is independent of p 7761
- $p 7762=1$ : Write access is dependent on p7761


## Parameters

- r7760 Write protection/know-how protection status
- p7761 Write protection
- p7762 Write protection multi-master fieldbus system access behavior


### 9.2.22 Know-how protection

### 9.2.22.1 Description

Know-how protection is used, for example, so that a machine manufacturer can encrypt its configuration know-how and protect it against modification and duplication.
A password is required for know-how protection, and the saved data are encrypted.
When know-how protection is activated, most of the adjustable parameters cannot be changed or read. The monitoring parameters are displayed unchanged. The contents of screen forms in the STARTER are not displayed.

Know-how protection can be combined with copy protection.

## Characteristics when know-how protection is activated

- Except for a small number of system parameters and the parameters specified in an exception list, all other parameters are locked.
- The values of these parameters are not visible in the expert list and so cannot be changed. The text "know-how protected" appears instead of the parameter values.
- Know-how protected parameters can be hidden in the expert list. This requires that the "not know-how protected" filter is set in the "Online value" column.
- The values of display parameters remain visible.
- The contents of screen forms are not displayed when know-how protection is active.
- Know-how protection can be combined with copy protection.
- The same know-how protection is used for scripts.
- The drive unit as well as the drive objects and DCC charts therein can be displayed as inconsistent.


## Functions that can be executed when know-how protection is active

The following functions can be executed although know-how protection is active:

- Restoring the factory settings
- Saving parameters
- Acknowledging faults
- Displaying faults and alarms
- Displaying history of faults and alarms
- Reading out the diagnostic buffer
- Switching over to the control panel (complete control panel functionality: fetching master control, all buttons and adjustable parameters)
- Displaying created acceptance documentation


## Note

## List of exceptions with activated know-how protection

A list of the adjustable parameters which, in spite of activated know-how protection, can be changed, is provided in the List Manual.
The list has the designation "KHP_WRITE_NO_LOCK".

## Functions that cannot be executed when know-how protection is active

The following functions cannot be executed when know-how protection is active:

- Download
- Automatic controller adjustment
- Stationary/rotating measurement
- Clearing fault buffer
- Creating acceptance documentation


## Functions which can be executed as an option when know-how protection is active

The functions listed below can be executed with activated know-how protection provided diagnostic functions were permitted when it was activated:

- Trace function
- Function generator
- Measuring functions

Adjustable parameters that are read-only when know-how protection is active
The following adjustable parameters can be read but not changed when know-how protection is active:

- Motor parameters (p0100, p0300, p0304, p0305, p0349)
- Data sets (p0120, p0130, p0140, p0150, p0170, p0180)
- Encoder type (p0400)
- Reference values (p2000, p2001, p2002, p2003, p2005, p2006, and p2007)

These parameters are grayed out in the STARTER in the expert list.

## Note

List of adjustable parameters that are read-only when know-how protection is active
A list of the setting parameters, which can only be read when know-how protection is activated, are provided in the List Manual.
The list has the designation "KHP_ACTIVE_READ".

## AOP30 with activated know-how protection

The AOP30 operator panel does not display the parameters that are protected when knowhow protection is active.

The adjustable parameters that are read-only when know-how protection is active are displayed. An attempt to change these adjustable parameters will be denied and an error message displayed.

### 9.2.22.2 Activating know-how protection

Know-how protection can be activated using STARTER in online mode.

## Activating know-how protection

Know-how protection is activated via STARTER in online mode in the following way:

- Select the drive unit via Project > Know-how protection for drive unit > Activate.
- A dialog appears in which the following settings are made:
- It can be selected as to whether know-how protection should be realized with or without copy protection.
- Clicking on Specify opens a further dialog in which the password is entered and confirmed. The password may consist of a maximum of 30 characters, and all characters are permissible.
- If Copy from RAM to ROM is selected, the settings are permanently saved after exiting the screen form.
If Copy RAM to ROM is not selected, then the settings for know-how protection are only saved non-retentively and are no longer available after the system has been switched on the next time.
- After the dialog is closed with OK, know-how protection is activated and the data (parameters, DCC) are saved as encrypted data on the memory card.
All protected setting parameters in the expert list display the text "know-how protected" instead of the parameter value.


## Note

## Password check for know-how protection and Windows language settings

If the Windows language settings are changed after activating know-how protection, this can cause errors during a subsequent password verification. This is why you should use only ASCII characters for the password.

## Note regarding know-how protection

## Note

Secure deletion of existing unencrypted data
If unencrypted data are already saved on the memory card before the encrypted data are saved, reliable deletion of these unencrypted data is not ensured. No specific deletion method is used in order to remove the unencrypted data from the memory card for good.
In this case, the user must ensure that the unencrypted data are reliably deleted, e.g., through the use of special PC tools.

### 9.2.22.3 Deactivating know-how protection

Know-how protection can be deactivated using STARTER in online mode.

## Deactivating know-how protection

Know-how protection is deactivated via STARTER in online mode in the following way:

- Select the drive unit via Project > Know-how protection for drive unit > Deactivate.
- A dialog appears in which know-how protection can be temporarily or permanently deactivated:
- Temporary deactivation:

Select temporary, and enter the password and confirm with OK.

- Permanent deactivation:

Select permanent, and enter the password, selectCopy RAM to ROM, and confirm with OK.

## Note regarding deactivation of know-how protection

## Note

Permanently or temporarily deactivating know-how protection
Temporary deactivation means that know-how protection will be reactivated after a POWER ON. Data will continue to be saved on the memory card as encrypted data. The reactivation of know-how protection is carried out with the existing password.
Permanent deactivation means that know-how protection is no longer active even after a POWER ON. Data will be saved on the memory card as unencrypted data.
If know-how protection finally is deactivated permanently, it can be re-activated again if necessary.

### 9.2.22.4 Changing the know-how protection password

The password for know-how protection can be changed using STARTER in online mode.

## Changing password

The password for know-how protection is changed via STARTER in online mode in the following way:

- Select the drive unit via Project > Know-how protection for drive unit > Change password.
- A dialog appears in which the following inputs are made:
- Input of the old password
- Input of the new password

The password may consist of 1 to 30 characters, and all characters are permissible.

- Confirmation of the new password
- After you close the dialog box with OK, the changed password is activated.


### 9.2.22.5 OEM exception list

Adjustable parameters can be designated as exempt from know-how protection using the OEM exception list. The parameters included in the exception list can be read and modified even when know-how protection is active.
The exception list can be created only via the expert list in STARTER in online mode. Parameter p7763 defines the number of parameters that are to be contained in the exception list. In parameter p7764, the parameter number that is to belong to the exception list is entered in each index. The exception list can be created separately for each drive object.

## Note

## Changing parameter p7763

After a change in parameter p7763, a "Load to PG" operation is required so that the index field of parameter p7764 is adapted.

With the factory setting, the exception list of the Control Unit consists of one parameter (p7763 = 1). p7766 (password input) is entered in parameter p7764[0] of the Control Unit so that the password for the deactivation can be entered when know-how protection is activated.

## Note

Absolute know-how protection
If parameter p7766 is removed from the exception list and know-how protection is activated, then a password can no longer be entered. Consequently, the know-how protection can no longer be deactivated!
In this case, the drive can only be accessed after restoring the factory setting.

### 9.2.22.6 Memory card copy protection

Memory card copy protection allows you to ensure that the data encrypted and stored on the memory card (parameter and DCC data) cannot be copied to another memory card and used there.
Memory card copy protection can be activated during activation of know-how protection via STARTER.

When know-how protection and memory card copy protection are activated, the encryption of data (parameter and DCC data) includes the serial numbers of the memory card (r7843) and the control unit (r7758).

Saved during the ramp-up of the drive unit, the serial numbers of the memory card and the control unit compared to the actual serial numbers. If these serial numbers do not match, fault F13100 is output and the device cannot continue to be operated. The fault value can be evaluated to determined the individual cause.

### 9.2.22.7 Spare part replacement when know-how protection with copy protection is activated

For the transfer of configuration data with know-how protection and memory card copy protection between machine manufacturer (OEMs) and end customer, a possible scenario is the replacement of a damaged memory card or a defective control unit:
A process by which data are transferred between machine manufacturer (OEM) and end customer applies in this situation.

## Replacement of a damaged memory card or a defective control unit at the end customer

## Assumptions:

- The drive is protected with know-how protection and memory card copy protection
- The end customer has a replacement memory card or a replacement control unit on site.
- The required STARTER project is not saved at the end customer.
- The machine manufacturer has a control unit of the same type as the end customer.


## Sequence:

- The end customer communicates the serial numbers of the memory card and control unit to the machine manufacturer.
- The machine manufacturer links the STARTER project with the serial numbers of the memory card (p7769) and control unit (p7759).
- The machine manufacturer loads the STARTER project into the drive unit.
- Following the download, the machine manufacturer activates the copy protection and know-how protection (p7765, p7767, p7768).
- The machine manufacturer saves the project via p0971 or p0977 to the memory card.
- The machine manufacturer takes the PS-ACX files and any generated DCC-YDB files from the ".. IUSERISINAMICSIDATA" area of the memory card and sends them to the end customer (e.g., via e-mail).
- The end customer copies the files to the "..IUSERISINAMICSIDATA" area of its memory card, inserts this memory card into the control unit and switches on the drive unit.
- After power-up, the end customer saves the project (via p0971 or p0977). Parameters from the OEM exception list must be re-entered if necessary.


### 9.2.22.8 Overview of important parameters

- r7758[0...19] KHP control unit serial number
- p7759[0...19] KHP control unit reference serial number
- r7760 Write protection/know-how protection status
- p7761 Write protection
- p7762 Write protection multi-master fieldbus system access behavior
- p7763 KHP OEM exception list number of indices for p7764
- p7764[0...n] KHP OEM exception list
- p7765 KHP memory card copy protection
- p7766[0...29] KHP password input
- p7767[0...29] KHP password new
- p7768[0...29] KHP password confirmation
- p7769[0...20] KHP memory card reference serial number
- r7843[0...20] Memory card serial number

KHP: Know-how protection (know-how protection)

### 9.2.23 Emergency operation

## Description

The emergency operation, Essential Service Mode (ESM), provides the option of operating the drive if needed, for as long as possible, even when errors occur.

This function can be used, for example, in applications in which an unintended stoppage can cause major secondary damage.
For example, fan drives in large buildings are intended to enable the evacuation of persons via escape routes when a fire occurs by exhausting the smoke that is generated.

## Features

- In emergency operation, the automatic restart function is activated irrespective of the setting of parameter p1210. The result of this is that the drive is automatically switched back on if an OFF2 occurs due to an internal fault.
- In emergency operation, the switching off of the drive due to faults is suppressed. Exceptions to this rule are faults that would lead to the destruction of the device.
- The emergency operation is triggered by a continuous signal via the digital input, which is set as a signal source using p3880.
- If the drive is in bypass mode when emergency operation is activated, the motor is automatically switched over to drive operation. In this case, there is no back synchronization to the converter, i.e. the "Flying restart" function must be activated (p1200 = 1).
- When emergency operation ends, the drive returns to normal operation and acts in accordance with the currently pending commands and setpoints.


## Note

Loss of warranty for a drive in emergency operation
In the event of emergency operation, all warranty claims on the part of the customer are voided.

Emergency operation is an exceptional state, and is not suitable for continuous operation.
The essential service mode can have the following effects:

- Exceptionally high temperatures inside and outside the converter
- Open fire inside and outside the converter
- Emissions of light, noise, particles, gases.

The converter logs the essential service mode, and the faults that occur while in essential service mode in a password-protected memory. This data is only accessible for the service and repair organization.

## WARNING

Active essential service mode and selection of "Safe Torque Off"
Using the essential service mode and simultaneously using a Safety Integrated function can lead to the essential service mode being exited, and can therefore result in death or severe injury, e.g. when a smoke extraction system fails. The background is that the motor must continue to run during essential service mode as long as possible and also must not be shut down by a Safety Integrated function.

- Do not use a Safety Integrated function simultaneously with the essential service mode.


## Activation of emergency operation

Emergency operation is activated via a continuous signal on the digital input, which is set as a signal source using p3880.

Only the digital inputs on the Control Unit are permitted as signal sources:

- r0722.x (high active)
- r0723.x (low active)
$x=0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,20,21$


## Note

Special features when the essential service mode is either activated or deactivated
Signal p3880 = 1 activates the essential service mode:

- If the motor was switched off by activating essential service mode, the converter switches the motor on.
- If the motor was switched on by activating essential service mode, the converter switches the speed setpoint to "ESM setpoint source".

Signal p3880 $=0$ deactivates the essential service mode:

- If one of the OFF1, OFF2 or OFF3 commands is active, the converter switches off the motor.
- If neither OFF1, OFF2 nor OFF3 is active, the converter switches the speed setpoint from the "ESM setpoint source" to the normal setpoint source.


## Note

Emergency operation is not fully functional until one of the following requirements is met:

- p3880 is wired offline; a POWER ON of the CU must then be performed after the download to the device.
- p3880 is wired online.


## Setpoint source for emergency operation

When emergency operation is activated, the setpoint set using p3881 is switched to:

- p3881 = 0: Last known setpoint (r1078 smoothed) - factory setting
- p3881 = 1: Fixed speed setpoint 15 (p1015)
- p3881 = 3: Fieldbus
- p3881 = 5: TB30/TM31 analog input
- p3881 = 6: Enable of reaction OFF1
- p3881 = 7: Enable of reaction OFF2

When using the analog setpoint value from TB30/TM31 (p3881 = 5) the setpoint is used that is set via p3886.
If, when setting p3881 $=3$ or 5 , the setpoint is lost (e.g. cable break or fieldbus failure), then the alternative setpoint that is set via p3882 is automatically switched to:

- p3882 = 0: Last known setpoint (r1078 smoothed) - factory setting
- p3882 = 1: Fixed speed setpoint 15 (p1015)
- p3882 = 2: Maximum speed (p1082)


## Direction of rotation in emergency operation

Depending on your system, you may have to invert the setpoint locally for emergency operation. To do this, parameter p3883 can be linked with a free digital input:

- Signal in p3883 = 0 : The direction of rotation of the setpoint configured for emergency operation is maintained
- Signal in p3883 = 1: Reversal of the direction of rotation of the setpoint configured for emergency operation


## Automatic restart

In emergency operation, if the automatic restart function is activated, the parameter settings of p1206, 1210, and p1212 subsequently have no effect. The settings in p1211 (automatic restart, start attempts) and p1213 (automatic restart monitoring time) are still effective. The setting of p1213 [0] = p1213 [1] = 0.0 s allows an unlimited number of startup attempts.

## Bypass as a fallback strategy

If the drive fails due to an internal, non-acknowledgeable error, emergency operation is no longer possible. In this case, the motor can be operated via the controller in bypass mode if the drive fails. For this purpose, bit 7 of the status word for the automatic restart (r1214.7) must be interconnected with p1266.
The bypass function must also be activated without synchronization (p1260 $=3$ ), and the changeover source for the bypass must be set to "Bypass via signal (BI: p1266)" (p1267 = 1).
You must ensure that r1214.7 is also set, otherwise there will be no changeover to the line supply. To end the bypass mode, the essential service mode must be deactivated. There is no switchover to converter operation (drive coasts down).

## Behavior in the event of an encoder error

When operating in vector control with encoder in emergency operation, there is an automatic switchover to encoderless operation and movement of the drive continues in the event of an encoder error.

## Display of activations/faults of essential service mode

The number of activations and the errors that occurred during essential service mode are displayed in parameter r3887:

- r3887[0]: Number of activations of essential service mode
- r3887[1]: Number of faults during essential service mode

The counter statuses in r 3887 can be reset with $\mathrm{p} 3888=1$.

## Function diagrams

FP 3040 Setpoint channel - Direction limitation and direction reversal

FP 7033 Technology functions - Emergency operation (ESM, Essential Service Mode

## Parameters

- p3880 BI: ESM activation signal source
- p3881 ESM setpoint source
- p3882 ESM setpoint source alternative
- p3883 BI: ESM direction of rotation signal source
- p3886 CI: ESM setpoint TB30/TM31 analog input
- r3887[0...1] ESM number of activations/faults
- p3888 ESM reset number of activations/faults
- r3889.0... 10 CO/BO: ESM status word


### 9.2.24 Web server

### 9.2.24.1 Description

## General information

The integrated Web server provides information about the drive unit via its Web pages. Access is via an Internet browser. The information on the Web pages is shown in English. For information about message texts, drive object statuses, and parameter names, there is a language selection that enables the display to be switched to the languages that are stored on the memory card.

The most important functions of the Web server are described below. However, the "Files" and "User's Area" display areas of the Web server are described in detail in a separate document (see "User-defined Web pages"). For this reason, these display areas are not included in this description.

## Activation/configuration

The Web server is activated in the factory setting.
The Web server is configured using parameter p8986 (Web server configuration).

## Data transmission

Access is via unsecure transmission (http) or secure transmission (https).
The type of transmission is specified by the input of the corresponding address.
For safety reasons, secure transmission can be forced by deactivation of the http port.

## Access

The Web server is accessed via the following interfaces:

- LAN interface of the Control Unit CU320-2 DP or CU320-2 PN
- PROFINET interface of the CU320-2 PN

The drive is addressed using the IP address.
The IP address can be taken from the following parameters:

- Integrated Ethernet interface (LAN interface): r8911[0...3]
- PROFINET interface: r8931[0...3]


## Access rights

There are two users, each having different authorizations:

- "SINAMICS" user (activated in the factory setting):
- Open diagnostics pages
- Reset the fault memory
- Create/expand/remove parameter lists
- Read/write/back up parameters
- "Administrator" user, additionally:
- Update configuration
- Update firmware
- Load user-defined pages to the drive

The settings for write-protection and know-how protection also apply for access via the Web server to drive parameters and the configuration.

## Supported browsers

Access to the Web server is possible with the following Internet browsers:

- Microsoft Internet Explorer 8
- Only on Windows XP Professional SP3 32 bit
- Only functions already available in SINAMICS runtime V4.7 (exclusive file and folder handling)
- No longer any support in future SINAMICS Firmware versions
- Microsoft Internet Explorer 11
- Microsoft Edge
- Mozilla Firefox 45
- Google Chrome 49


## User-defined Web pages

You can add your own self-created Web pages to the standard Web pages of the Web server. The SIEMENS Industry Online Support contains detailed information on:

1. Go to the following SIEMENS website in your browser:

SINAMICS Application Examples (https://www.automation.siemens.com/mc-app/sinamics-application-examples/Home/Index?language=en)
2. In the search screen, select "S120" as the DriveType and "Web Server" as the Speciality.
3. Click the desired brief information in the list of results.

The corresponding brief information is then displayed in the SIEMENS Industry Online Support. From there, you can then download a detailed description as a PDF file.

### 9.2.24.2 Starting the Web server

## Requirements

- The Web server is active in the factory setting.
- A functional, commissioned drive project.
- PG/PC is connected to the Control Unit (target device).


## Starting the Web server

1. Enter the IP address of the SINAMICS drive in the address line of the Internet browsers (e.g. http://169.254.11.22). Confirm with <Return>. The start page of the Web server opens. The most important data of your drive is displayed.


Figure 9-10 Start page of the Web server
2. At the top left, enter the Login name (e.g., SINAMICS) and, if necessary, the password. In the factory setting, only the "SINAMICS" user is activated. A password is not assigned.
3. Click "Login" to confirm the input.

## SIEMENS SINAMICS S120



Figure 9-11 Start page after logging in
After logging in, you can open the various display areas of the Web server using the navigation on the left side.

## Logout

If you no longer require the Web server or want to block the detailed display areas, you can log out.

To do so, click "Logout" at the top left in the navigation.

### 9.2.24.3 Web server configuration

## Configuration using STARTER

The configuration dialog is called by selecting the drive in the project navigator and selecting "Web server" in the context menu.


Figure 9-12 Configuring the Web server using STARTER

## Activating the web server

The Web server is activated in the factory setting.
If required, access can be limited to a secure connection (https).

## Note

## Access via secure connection (https)

You require security certificates for both SINAMICS and the Internet Browser to access the Web server via an https connection. These security certificates must be installed on each computer from which the Web server is to be called.
Contact your System Administrator regarding this.

## Enabling users

The "SINAMICS" user is activated in the factory setting. If required, a password can be assigned for this.
The "Administrator" user is not activated in the factory setting. If it is activated, a password can additionally be assigned.

## Note

## Secure passwords

SINAMICS does not specify any password rules for the assignment of passwords. You can therefore assign any passwords without restriction. No check is made for illegal characters or existing passwords. Therefore, as the user, you are responsible for the required password security.

Use a sufficiently long password (e.g., 10 characters). Use special characters and avoid passwords that you have already used elsewhere.
Please note that if the Windows language settings are changed, errors can occur when subsequently checking the password. If you use language-specific special characters, you must ensure that the same language setting is active for subsequent entry of the password.

## Configuration using AOP30 or the expert list

The configuration is made using parameter p8986 (Web server configuration):
Bit 00: Activate the web server (factory setting: activated)
Bit 01: Permit access only with https (factory setting: not activated)
Bit 02: Activate "SINAMICS" user (factory setting: activated)
Bit 03: Activate "Administrator" user (factory setting: not activated)

## Note

## Password assignment after activation of the "Administrator" user

After the user "Administrator" has been activated via parameter p8986 (via AOP30 or via the expert list), it is necessary to assign a password via STARTER. Otherwise the "Administrator" user cannot access the Web server.

### 9.2.24.4 Display areas

The Web server has various displays areas that are opened using the menu commands of the navigation.

Home
This menu command is used to open the start page of the Web server.

## Device Info

This menu command is used to display the most important device information.

## Diagnostics

This menu command is used to display the operating state for each drive object on the "Service overview" tab.
Color coding is also used to show whether a fault or alarm is pending for the respective drive object.

The "Trace files" tab displays the trace files that are located in the "USER/SINAMICS/DATA/TRACE" directory on the memory card.

## Messages and Logs

This menu command is used to show the diagnostic buffer on the "Diag buffer" tab.
The fault and alarm messages of the drive are shown on the "Alarms drive" tab. The "Reset alarms" button can be used to reset the acknowledgeable faults.

## Parameter

This menu command can be used to create and manage self-defined parameter lists. A maximum of 20 parameter lists with up to 40 parameters each can be managed.
For each parameter list, the access rights (read, write, change) of the two users ("SINAMICS" and "Administrator") can be specified separately.

The settings for write-protection and know-how protection also apply for access via the web server to the parameters.
The created parameter lists are saved on the memory card of the drive. Therefore, a parameter selection performed once is retained for further access even after the drive is switched off.

## Manage config

This menu command can be used by the "Administrator" user to upload and update firmware and project files.

## Files

This menu command can be used by the "Administrator" user to load user-defined pages in the drive.

## User's Area

This menu command can be used by the "Administrator" user to open user-defined pages.

### 9.2.24.5 Overview of important parameters

- r8911 IE IP Address of Station active
- r8931 PN IP Address of Station active
- p8986 Web server configuration
- p8987[0...1] Web server port assignment


### 9.3 Extended functions

### 9.3.1 Technology controller

## Description

The "technology controller" function module allows simple control functions to be implemented, e.g.:

- Level control
- Temperature control
- Dancer roll position control
- Pressure control
- Flow control
- Simple control without higher-level control
- Tension control

The technology controller features:

- Two scalable setpoints
- Scalable output signal
- Separate fixed values
- Separate motorized potentiometer
- The output limits can be activated and deactivated via the ramp-function generator.
- The D component can be switched to the system deviation or actual value channel.
- The motorized potentiometer of the technology controller is only active when the drive pulses are enabled.
The technology controller is designed as a PID controller, whereby the derivative element can be switched to the control deviation channel or the actual value channel (factory setting). The P, I, and D components can be set separately.
A value of 0 deactivates the corresponding component. Setpoints can be specified via two connector inputs. The setpoints can be scaled via parameters p2255 and p2256.

A ramp-function generator in the setpoint channel can be used to set the setpoint ramp-up/ramp-down time via parameters p2257 and p2258. The setpoint and actual value channel each have a smoothing element. The smoothing time can be set via parameters p2261 and p2265.

The setpoints can be specified via separate fixed setpoints (p2201 to p2215), the motorized potentiometer, or via the fieldbus (e.g. PROFIBUS, PROFINET).

Feedforward control can be integrated via a connector input.
The output can be scaled via parameter p2295 and the control direction reversed. It can be limited via parameters p2291 and p2292 and interconnected as required via a connector output (r2294).
The actual value can be integrated, for example, via an analog input on the TM31.
If a PID controller has to be used for control reasons, the D component is switched to the setpoint / actual value difference ( $\mathrm{p} 2263=1$ ) unlike in the factory setting. This is always necessary when the $D$ component is to be effective, even if the reference variable changes. The $D$ component is only activated if p2274>0.

## Note

## Ramp-up/down time freeze

If you enter " 0 s " for the power up time or ramp-down time for the ramp function generator of the technology controller, the current values of the respective ramp function generator will be frozen.

## Commissioning

The "technology controller" function module can be activated by running the commissioning wizard. Parameter r0108.16 indicates whether the function module has been activated.

## Example: Liquid level control

The objective here is to maintain a constant level in the container.
This is carried out by means of a variable-speed pump in conjunction with a sensor for measuring the level.

The level is determined via an analog input (e.g. AIO TM31) and sent to the technology controller. The level setpoint is defined in a fixed setpoint. The resulting controlled variable is used as the setpoint for the speed controller.

In this example, a TM31 Terminal Module is used.


Figure 9-13 Level control: Application


Figure 9-14 Level control: Controller structure

## Function diagrams

FP 7950 Technology controller - Fixed values, binary selection
FP 7951 Technology controller - Fixed values, direct selection
FP 7954 Technology controller - motorized potentiometer
FP 7958 Technology controller - closed-loop controller

## Key control parameters

- p1155 = r2294 CI: Speed controller speed setpoint 1 [FP 3080]
- p2253 = r2224 Technology controller setpoint effective via fixed setpoint [FD 7950]
- $\mathrm{p} 2263=1 \quad \mathrm{D}$ component in fault signal [FD 7958]
- p2264 = r4055 Actual value signal $X_{\text {actual }}$ via AIO of TM31 [FP 9566]
- p2280 $=\mathrm{Kp} \quad$ Calculate $P$ gain by means of optimization
- p2285 $=$ Tn Calculate integral time by means of optimization
- $\mathrm{p} 2200=1 \quad$ Technology controller enabled


### 9.3.2 Bypass function

The bypass function uses digital drive outputs to activate two contactors and uses digital inputs to evaluate the contactor's feedback (e.g., via TM31). This circuit allows the motor to be switched to the drive or directly onto the supply line. The contactors are activated by the drive. The feedback signals for the contactor positions must be returned to the drive.

The bypass circuit can be implemented in two ways:

- without synchronizing the motor to the line supply
- with synchronizing the motor to the supply.

The following applies to all bypass versions:

- The bypass switch is also always shut down if one of the "OFF2" or "OFF3" control word signals is canceled (motor coasts down). The motor remains connected if OFF1 is canceled.
- Exception:

If necessary, the bypass switch can be interlocked by a higher-level controller such that the drive can be shut down completely (i.e. including the controller electronics) while the motor is operated on the supply.
The protective interlocking must be implemented on the system side.

- When the drive is started up again after POWER OFF, the status of the bypass contactors is evaluated. After powering up, the drive can thereby change straight into "Ready to start and bypass" status. This is only possible if the bypass is activated via a control signal, the control signal ( p 1266 ) is still present once the system has been ramped up, and the "automatic restart" function is active (p1210 = 4).
The bypass function is automatically restarted by the restart process. To accelerate the motor to the setpoint speed and/or to synchronize to the line supply, the pulses are enabled, possibly with the motor already rotating. In this case, it is recommend to activate the "Flying restart" function (p1200 = 1) in order to avoid high current peaks.
- Changing the drive o "Ready to start and bypass" status after powering up is of a higher priority than the automatic restart function.
- Monitoring of the motor temperatures using temperature sensors is active while the drive is in either the "Ready to start and bypass" state or the "Ready for operation and bypass" state.
- The two motor contactors must be designed for switching under load.


## Note

## Information on the examples

The examples contained in the following descriptions are only basic circuits designed to explain the basic function. The dimensions of specific circuit configurations (contactors, protective equipment) must be calculated for specific systems.

## NOTICE

## Device damage as a result of incorrect phase sequence

The target frequency r3804 is specified as an absolute value. It does not contain information about the direction of the rotating field (phase sequence)!

If the phase sequence of the line voltage, which the system must synchronize with, does not match the motor voltage phase sequence then this results in incorrect synchronization. In the worst-case scenario, this can mechanically damage the plant or system.

- Ensure that the line voltage phase sequence matches that of the motor voltage. You can correct the phase sequence as follows:
- Interchange the two feeder cables at the converter output or at the line contactor.
- Correct the phase sequence of the motor or converter output voltage using p1820 or p1821.


## Requirement

The bypass function is only possible for encoderless closed-loop speed control (p1300 = 20) or V/f control (p1300 $=0 \ldots 19$ ) and when an induction motor is used.

## Establishing the bypass function

The bypass function is part of the "technology controller" function module that can be activated by running the commissioning wizard. Parameter r0108.16 indicates whether the function module has been activated.

### 9.3.2.1 $\quad$ Synchronized bypass with overlap ( $\mathrm{p} 1260=1$ )

## Description

The "Bypass synchronized with overlap" is used for drives with low inertia. These are drives in which the speed would drop very quickly when contactor K1 is opened.

When "bypass with synchronization with overlap ( $\mathrm{p} 1260=1$ )" is activated, the motor is transferred, synchronized to the line supply and is also retrieved again. During the changeover, both contactors K1 and K2 are closed at the same time for a period (phase lock synchronization).

A voltage sensing module VSM10 is required for this type of bypass which measures the mains voltage required for the drive to be synchronized.
An output reactor is used to decouple the drive from the line supply - the impedance value for the reactor is $10( \pm 2) \%$.


Figure 9-15 Typical circuit diagram for synchronized bypass overlap

## Note

As a result of the overlap, when synchronizing back to the converter, the DC link voltage can increase; in the worst case scenario this can result in a fault trip. It is possible to activate an overvoltage protection function, which, when a Vdc max threshold (r1242) is reached, the pulses are inhibited; as a consequence, the DC link voltage stops increasing. When the pulses are inhibited, the motor coasts down, which is why it must be restarted on the fly. As a consequence, overvoltage protection is only active if the "Flying restart" function was activated (p1200 = 1).

## Activation

The synchronized bypass with overlap (p1260 = 1) function can only be activated using a control signal. It cannot be activated using a speed threshold.

## Parameter assignment

Once the synchronized bypass with overlap (p1260 = 1) function has been activated, the following parameters must be set.

Table 9-7 Parameter settings for synchronized bypass with overlap

| Parameter |  |
| :--- | :--- |
| $r 1261.0$ | Signal "Command switch motor - power unit" |
| $r 1261.1$ | Signal "Command switch motor - line supply" |
| $p 1266=$ | Setting the control signal |
| $p 1269[0]=$ | Signal source for contactor K1 feedback |
| $p 1269[1]=$ | Signal source for contactor K2 feedback |
| $p 3800=1$ | Synchronization is activated. |
| $p 3802=r 1261.2$ | Synchronization activation is triggered by the bypass function. |

## Transfer process



Figure 9-16 Signal diagram: Synchronized bypass with overlap
Transfer of motor to the line supply (contactors K1 and K2 are controlled by the converter):

- The initial state is as follows: Contactor K1 is closed, contactor K2 is open, and the motor is operated by the drive.
- The control bit "bypass command" (p1266) is set (e.g., by the higher-level automation).
- The bypass function sets the control word bit "synchronizing" (r1261.2).
- Since the bit is set while the drive is running, the "Transfer motor to line supply" synchronization process is started.
- Once motor synchronization to line frequency, line voltage and line phasing is complete, the synchronization algorithm reports this state (r3819.2).
- The bypass mechanism evaluates this signal and closes contactor K2 (r1261.1 = 1). The signal is evaluated internally - BICO wiring is not required.
- After contactor K2 has fed back the "closed" state (r1269[1] = 1), contactor K1 is opened and the drive inhibits the pulses. The drive is in "Ready to operate and bypass" state.
- If the On command is cancelled in this phase, the drive will change to "Ready to start and bypass" status. If the appropriate contactors are being used, the drive will be isolated from the line supply and the DC link discharged.
To transfer the motor back from the line supply, the sequence is simply reversed: At the start of the process, contactor K2 is closed and contactor K1 is open.
- The "Bypass command" control bit is canceled (e.g., by the higher-level automation).
- The bypass function sets the control word bit "synchronizing".
- The pulses are enabled. Since "synchronizing" is set before "pulse enable", the drive interprets this as a command to retrieve the motor from the line supply.
- Once drive synchronization to line frequency, line voltage and line phasing is complete, the synchronization algorithm reports this state.
- The bypass mechanism evaluates this signal and closes contactor K1. The signal is evaluated internally - BICO wiring is not required.
- Once contactor K1 has reported "closed" status, contactor K2 is opened and the motor is again operated by the drive.


### 9.3.2.2 Synchronized bypass without overlap (p1260 = 2)

## Description

When "Synchronized bypass without overlap (p1260 = 2)" is activated, contactor K2 (to be closed) is only closed when contactor K1 is opened (anticipatory type synchronization). During this time, the motor is not connected to the mains, and its speed is determined by the load and the friction. This type for bypass is therefore suitable for drives with high inertia (see Note below).

Synchronization setpoint p3809 is used to correct a phase rotation in the signal sensing of the voltage actual values ( $\mathrm{p} 3809=-180^{\circ} \ldots 179.90^{\circ}$ ). Furthermore, using this parameter, the setpoint angle of the motor voltage can be set (in a range up to a maximum of $20^{\circ} \mathrm{el}$, see p3813) to compensate for friction or load-dependent speed decrease during the bypass switchover.
The phase position of the motor voltage before synchronization can be set using p3809 to enable an "advance start" before the line supply to which synchronization should be performed As a result of the motor braking in the short time in which both contactors are open, when closing contactor K2, a phase and frequency difference of approximately zero must now be obtained.
If the angular difference is $>20^{\circ} \mathrm{el}$ during switch-over, the current surges that cannot be regarded as negligible would have to be anticipated. For this reason, synchronism is only reached if the angular difference is $\leq \mathrm{p} 3813$ (maximum of $20^{\circ} \mathrm{el}$ ). Compensating a speed decrease using p3809 is only practical if the motor is evenly loaded during the switchover period.
For instance, for conveyor belts, the load can also change during the bypass sequence, depending on the process environment. If, during the switchover process, the angular
difference is more than $20^{\circ} \mathrm{el}$ or if the load for each bypass operation differs, then the "Bypass with synchronization with overlap (p1260 = 1)" mode must be used.

A voltage sensing module VSM10 is required for this type of bypass which measures the mains voltage required for the drive to be synchronized.
For the function to run correctly, the moment of inertia of the drive and the load must be sufficient.

## Note

## Sufficiently high moment of inertia

A sufficiently high moment of inertia is characterized by a change in the motor speed during opening of the contactors K1 and K2 that is approximately equal to the rated slip. Further, it must be ensured that at the switchover instant, the motor is not significantly braked as a result of external effects (e.g. friction).

By exerting the effort described above to determine the synchronization setpoint (p3809), the use of a decoupling reactor is no longer necessary.


Figure 9-17 Example: Circuit for synchronized bypass without overlap

## Activation

The synchronized bypass without overlap $(\mathrm{p} 1260=2)$ function can only be activated using a control signal. It cannot be activated using a speed threshold.

### 9.3 Extended functions

## Parameter assignment

Once the synchronized bypass without overlap (p1260 = 2) function has been activated, the following parameters must be set.

Table 9-8 Parameter setting for bypass function with synchronization without overlapping

| Parameter | Description |
| :---: | :---: |
| r1261.0 | Signal "Command switch motor - power unit" |
| r1261.1 | Signal "Command switch motor - line supply" |
| p1266 = | Setting the control signal |
| p1269[0] = | Signal source for contactor K1 feedback |
| p1269[1] = | Signal source for contactor K2 feedback |
| p3800 $=1$ | Synchronization is activated. |
| p3802 $=$ r1261.2 | Synchronization activation is triggered by the bypass function. |
| p3809 = | Setting of the phase setpoint for synchronizing the power network and drive |

### 9.3.2.3 Bypass without synchronization (p1260 = 3)

## Description

When the motor is transferred to the supply, contactor K1 is opened (following drive pulse inhibit). The system then waits for the motor excitation time to elapse, after which contactor K2 is closed, connecting the motor directly across the line.
If the motor is connected to the supply in a non-synchronized manner, an equalizing current flows when the motor is switched in, and this must be taken into account when designing the protective equipment (see figure "Circuit for bypass without synchronization"). This is why this type of bypass is only suitable for drives with low power.
When the motor is transferred from the supply by the drive, contactor K2 opens first, then K1 closes after the de-excitation time. The drive then captures the rotating motor and the motor is operated on the drive.
A voltage sensing module VSM10 is required for this type of bypass.
Contactor K2 must be designed for switching under load.
Contactors K1 and K2 must be interlocked against closing at the same time.
The "flying restart" function must be activated (p1200 = 1).


Figure 9-18 Example: Circuit for bypass without synchronization

## Activation

The bypass without synchronization ( $\mathrm{p} 1260=3$ ) can be triggered using the following signals (p1267):

- Bypass using control signal (p1267.0 = 1):

The bypass is triggered using a digital signal (p1266), e.g. from a higher-level automation system. If the digital signal is canceled, a changeover to drive operation is triggered once the debypass delay time ( p 1263 ) has expired.

- Bypass at a specific speed threshold (p1267.1 = 1):

Once a certain speed is reached, the system switches to bypass, i.e. the drive is used as a starting drive. The bypass cannot be connected until the speed setpoint is greater than the bypass speed threshold ( p 1265 ).
The system reverts to drive operation when the setpoint (on the input of the ramp-function generator, r 1119 ) falls below the bypass speed threshold ( p 1265 ). The setpoint > comparison value condition prevents the bypass from being reactivated right away if the actual speed is still above the bypass speed threshold (p1265) after switching back to drive operation.
The bypass time (switch to bypass), debypass time (revert to drive), bypass speed variables and the command source for changing over are set using parameters.

### 9.3 Extended functions

## Parameter assignment

Once the bypass without synchronization $(\mathrm{p} 1260=3)$ function has been activated, the following parameters must be set.

Table 9-9 Parameter setting for bypass function with synchronization without overlapping

| Parameter | Description |
| :--- | :--- |
| $r 1261.0$ | Signal "Command switch motor - power unit" |
| $r 1261.1$ | Signal "Command switch motor - line supply" |
| $p 1262=$ | Bypass dead time setting |
| $p 1263=$ | Bypass delay time setting |
| $p 1264=$ | Bypass delay time setting |
| $p 1265=$ | Speed threshold setting when p1267.1 = 1 |
| $p 1266=$ | Control signal setting when p1267.0 = 1 |
| p1267.0 $=$ <br> $p 1267.1 ~$ | Trigger signal setting for bypass function |
| $p 1269[0]=$ | Signal source to provide the feedback signal of contactor K1 |
| $p 1269[1]=$ | Signal source for contactor K2 feedback |
| $p 3800=0$ | Synchronization is deactivated. |
| $p 1200=1$ | The "flying restart" function is always active. |

### 9.3.2.4 Function diagram

$$
\text { FP } 7020 \text { Synchronization }
$$

### 9.3.2.5 Parameters

Bypass function

- p1200 Flying restart operating mode
- p1260 Bypass configuration
- r1261 CO/BO: Bypass control/status word
- p1262 Bypass dead time
- p1263 Debypass (revert to drive) delay time
- p1264 Bypass delay time
- p1265 Bypass speed threshold
- p1266 BI: Bypass control command
- p1267 Bypass changeover source configuration
- p1268 BI: Bypass feedback signal synchronization completed
- p1269 BI: Bypass switch feedback signal
- p1274 BI: Bypass switch monitoring time

Synchronization

- p3800 Sync-supply-drive activation
- p3801 Sync-supply-drive drive object number
- p3802 BI: Sync-supply-drive enable
- r3803 CO/BO: Sync-supply-drive control word
- r3804 CO: Sync-supply-drive target frequency
- r3805 CO: Sync-supply-drive frequency difference
- p3806 Sync-supply-drive frequency difference threshold
- r3808 CO: Sync-supply-drive phase difference
- p3809 Sync-supply-drive phase setpoint
- p3811 Sync-supply-drive frequency limitation
- r3812 CO: Sync-supply-drive correction frequency
- p3813 Sync-supply-drive phase synchronism threshold
- r3814 CO: Sync-supply-drive voltage difference
- p3815 Sync-supply-drive voltage difference threshold
- r3819 CO/BO: Sync-supply-drive status word


### 9.3.3 Extended brake control

## Description

The "Extended brake control" function module allows complex braking control for motor holding brakes and holding brakes.
The brake is controlled as follows (the sequence reflects the priority):

- Via parameter p1215
- Via binector parameters p1219[0..3] and p0855
- Via standstill detection
- Via a connector interconnection threshold value


## Commissioning

The "Extended brake control" function module can be activated by running the commissioning wizard. Parameter r0108.14 indicates whether the function module has been activated.

Parameter p1215 must be set to " 3 " and the brake controlled via a digital output on customer Terminal Module TM31.

## Extended brake control for braking with checkback

For braking with feedback ( $\mathrm{p} 1275.5=1$ ), the brake control reacts to the checkback contacts of the brake. If the timer p1216 is greater than the time until the checkback signal, then the approach is delayed by the corresponding time difference.

In order to be able to approach with as little delay as possible, the opening time set in p1216 must be shorter than the time until the checkback signal. However, if the timer in p1216 is set shorter, then alarm A07931 "Brake does not open" appears.
Remedy:

1. Activate "Enable with checkback" (p1275.6 = 1).

The pulse enable (BO: r1229.3) and setpoint enable (BO: r0899.15) are now independent of the set timer ( $\mathrm{p} 1217, \mathrm{p} 1216$ ). The associated enable is determined only by the feedback signal (BI: p1222, BI: p1223). The timers (p1216, p1217) only influence the alarms A07931 "Brake does not open" and A07932 "Brake does not close".
2. Optional: In order that the two alarms no longer appear, set both timers ( $\mathrm{p} 1217, \mathrm{p} 1216$ ) to 0 ms .

Result: The monitoring of the brake and the display of the alarms are switched off.

## Example 1: Starting against applied brake

When the device is switched on, the setpoint is enabled immediately (if other enable signals are issued), even if the brake has not yet been released (p1152 = 1). The factory setting p1152 = r0899.15 must be separated here. The drive first builds up torque against the applied brake. The brake is not released until the motor torque or current ( p 1220 ) has exceeded braking threshold 1 ( p 1221 ).

Depending on the type and design of the brake, the time required to completely release the brake differs. It must be taken into consideration that, once the braking threshold torque has been exceeded, the operation enabling signal (p0899.2) is interrupted for the time interval that the brake is being released ( p 1216 ) to ensure that the motor current does not exceed the permissible limits during this period and the motor torque generated does not damage the brake. Time interval p1216 must be set on the basis of the time the brake actually requires to release.

This configuration is used, for example, when the drive is connected to a belt that is under tension (loop accumulator in the steel industry).

## Example 2: Emergency brake

If emergency braking is required, electrical and mechanical braking must take place simultaneously. This can be achieved if OFF3 is used as a tripping signal for emergency braking:
p1219[0] $=$ r0898.2 and p1275.00 $=1$ (OFF3 to "apply brake immediately" and invert signal).
To prevent the drive from working in opposition to the brake, the OFF3 ramp (p1135) should be set to 0 seconds. Any regenerative energy produced must be converted into heat via a braking resistor.

This type of braking is often used, for example, for calendars, cutting tools, running gears, and presses.

## Example 3: Service brake on crane drives

For cranes with manual control, it is important that the drive respond immediately when the control lever is moved (master switch). To ensure this, the drive is switched on using the On command ( p 0840 ) (pulses are enabled). The speed setpoint ( p 1142 ) and speed controller ( p 0856 ) are inhibited. The motor is magnetized. The magnetization time generally applicable for three-phase motors ( 1 to 2 seconds) is therefore eliminated.

Now, the only delay between the deflection of the master switch and the start of motor movement is the brake release time. Deflection of the master switch generates a "setpoint enable from the control" (bit interconnected with p1142, p1229.2, p1224.0). The speed controller is enabled immediately, and the speed setpoint is enabled once the brake release time (p1216) has elapsed. When the master switch is in the zero position, the speed setpoint is inhibited and the drive ramps down along the down ramp of the ramp-function generator. The brake closes once the standstill limit (p1226) is undershot. Once the brake closing time ( p 1217 ) has elapsed, the speed controller is inhibited (the motor is no longer generating any force). Extended braking control is used with the modifications described below.


Figure 9-19 Example: Holding brake on a crane drive

### 9.3 Extended functions

## Control and status messages for extended brake control

Table 9-10 Control of extended brake control

| Signal name | Binector input | Control word sequence control/ <br> interconnection parameters |
| :--- | :--- | :--- |
| Enable speed setpoint | p1142 BI: Enable speed setpoint | STWA.6 |
| Enable setpoint 2 | p1152 BI: Setpoint 2 enable | p1152 = r899.15 |
| Unconditionally release holding brake | p0855 BI: Unconditionally release <br> holding brake | STWA.7 |
| Enable speed controller | p0856 BI: Enable speed controller | STWA.12 |
| Unconditionally apply holding brake | p0858 BI: Unconditionally apply holding <br> brake | STWA.14 |

Table 9-11 Status message of extended brake control

| Signal name | Parameter | Brake status word |
| :--- | :--- | :--- |
| Command, release brake (continuous signal) | r 1229.1 | B_ZSW. 1 |
| Pulse enable, extended brake control | r 1229.3 | B_ZSW.3 |
| Brake does not release | r 1229.4 | B_ZSW.4 |
| Brake does not close | r 1229.5 | B_ZSW. 5 |
| Brake threshold exceeded | r 1229.6 | B_ZSW.6 |
| Brake threshold fallen below | r 1229.7 | B_ZSW. 7 |
| Brake monitoring time expired | r 1229.8 | B_ZSW. 8 |
| Request, pulse enable missing/n_ctrl inhibited | r 1229.9 | B_ZSW.9 |
| Brake OR logic operation result | r 1229.10 | B_ZSW. 10 |
| Brake AND logic operation result | r 1229.11 | B_ZSW. 11 |

## Function diagrams

| FP 2704 | Extended brake control - standstill detection $(\mathrm{r0108.14}=1)$ |
| :--- | :--- |
| FP 2707 | Extended brake control - release/close brake $(\mathrm{r} 0108.14=1)$ |
| FP 2711 | Extended brake control - signal outputs (r0108.14 = 1) |

## Parameters

- r0108.14 Extended brake control
- r0899 CO/BO: Status word sequence control


## Standstill monitoring

- r0060 CO: Speed setpoint before the setpoint filter
- r0063[0...2] CO: Actual speed value
- p1224[0...3] BI: Apply motor holding brake at standstill
- p1225 CI: Standstill detection threshold value
- p1226 Standstill monitoring speed threshold
- p1227 Standstill detection monitoring time
- p1228 Standstill detection delay time
- p1276 Motor holding brake standstill detection bypass

Release and apply brake

- p0855 BI: Unconditionally release holding brake
- p0858 BI: Unconditionally apply holding brake
- p1216 Motor holding brake release time
- p1217 Motor holding brake closing time
- p1218[0...1] BI: Release motor holding brake
- p1219[0...3] BI: Immediately apply motor holding brake
- p1220 CI: Release motor holding brake, signal source, threshold
- p1221 Release motor holding brake, threshold
- p1277 Motor holding brake, delay, braking threshold exceeded
- p1279 BI: Motor holding brake OR/AND logic operation


## Brake monitoring functions

- p1222 BI: Motor holding brake, feedback signal, brake closed
- p1223 BI: Motor holding brake, feedback signal, brake released

Configuration, control/status words

- p1215 Motor holding brake configuration
- r1229 CO/BO: Motor holding brake status word
- p1275 Motor holding brake control word
- p1278 Motor holding brake type


### 9.3.4 Extended monitoring functions

## Description

The "extended monitoring functions" function module enables additional monitoring functions:

- Speed setpoint monitoring: $\mid n \_$set $\mid \leq p 2161$
- Speed setpoint monitoring: $n \_$set $>0$
- Load monitoring


## Description of load monitoring

This function monitors power transmission between the motor and the working machine. Typical applications include V-belts, flat belts, or chains that loop around the belt pulleys or cog wheels of drive and outgoing shafts and transfer the peripheral speeds and forces. Load monitoring can be used here to identify blocking of the driven machine and interruptions to the power transmission.
During load monitoring, the current speed/torque curve is compared with the programmed speed/torque curve (p2182 to p2190). If the current value is outside the programmed tolerance bandwidth, a fault or alarm is triggered depending on parameter p2181. The fault or alarm code can be delayed by means of parameter p2192 to prevent false alarms caused by brief transitional states.


Figure 9-20 Load monitoring (p2181=1)

## Commissioning

The "extended monitoring functions" function module can be activated by running the commissioning wizard. Parameter r0108.17 indicates whether the function module has been activated.

## Function diagrams

| FP 8010 | Speed messages 1 |
| :--- | :--- |
| FP 8011 | Speed messages 2 |
| FP 8013 | Load monitoring |

## Parameters

- p2150 Hysteresis speed 3
- p2151 Cl : Speed setpoint for messages
- p2161 Speed threshold 3
- p2181 Load monitoring, response
- p2182 Load monitoring, speed threshold 1
- p2183 Load monitoring, speed threshold 2
- p2184 Load monitoring, speed threshold 3
- p2185 Load monitoring, speed threshold 1 upper
- ...
- p2190 Load monitoring, speed threshold 3 lower
- p2192 Load monitoring, delay time
- r2198.4 $\mid$ n_set $\mid \leq p 2161$
- r2198.5 n_set > 0
- r2198.11 Load monitoring signals alarm
- r2198.12 Load monitoring signals fault


### 9.3 Extended functions

### 9.3.5 Moment of inertia estimator

## Background

From the load moment of inertia and the speed setpoint change, the inverter calculates the accelerating torque required for the motor. Via the speed controller precontrol, the accelerating torque specifies the main percentage of the torque setpoint. The speed controller corrects inaccuracies in the precontrol (feed-forward control).


Figure 9-21 Influence of the moment of inertia estimator on the speed control
The more precise the value of the moment of inertia in the inverter, the lower the overshoot after speed changes.

Imprecise value of the moment of inertia
in the converter


The value of the moment of inertia in the
converter corresponds to reality


Figure 9-22 Influence of the moment of inertia estimator on the speed

## Function

From the actual speed, the actual motor torque and the frictional torque of the load, the inverter calculates the total moment of inertia of the load and motor.


Figure 9-23 Overview of the function of the moment of inertia estimator

## Calculating the load torque

The load torque must first be determined to determine the moment of inertia.


Figure 9-24 Calculating the load torque
Phases with constant speed not equal to zero are required to determine the load torque (e.g. friction force).

For small speed changes, the converter calculates the load torque $M_{L}$ from the actual motor torque.

The following conditions must be satisfied to do this:

- $\quad$ Speed $\geq$ p1226
- Acceleration setpoint $<81 / \mathrm{s}^{2}$
- Acceleration x moment of inertia $(\mathrm{r} 1493)<0.9 \times \mathrm{p} 1560$

Once the load torque is specified, the moment of inertia in the acceleration or deceleration phase can be determined. If the source of p1502 has a 1 signal, the moment of inertia is not estimated.
The accuracy of the moment of inertia estimation increases as the acceleration rate increases. The start value of the moment of inertia estimator is the configured moment of inertia (p0341 x p0342 + p1498).

## Calculating the moment of inertia

For larger changes, the converter initially calculates the accelerating torque $\mathrm{M}_{B}$ as difference between the motor torque $M_{M}$, load torque $M_{L}$ and frictional torque $M_{R}$ :

$$
M_{B}=M_{M}-M_{L}-M_{R}
$$



Figure 9-25 Calculating the moment of inertia
The moment of inertia J of the motor and load is then obtained from the accelerating torque $M_{B}$ and the angular acceleration $\alpha$
$J=M_{B} / \alpha$
The following conditions must be fulfilled for this calculation:
(1) The rated acceleration torque $M_{B}$ must satisfy the following two conditions:

- $\mathrm{M}_{\mathrm{B}}$ must be greater than p1560 $\times$ r0333 (rated motor torque).
- $M_{B}$ must be greater than $80 \%$ of the friction torque ( $0.4 \times(\mathrm{p} 1563-\mathrm{p} 1564)$ ).
(2) For operation without encoder, the speed must be >p1755 (in closed-loop controlled operation).
(3) The converter calculates the load torque again after acceleration.

If the load estimation has taken place and the moment of inertia does not settle (stabilize) ( $\mathrm{r} 1407.24 / 26=0$ ), then increasing the acceleration ( $\mathrm{p} 2572 / \mathrm{p} 2573$ ) is recommended.
If the load moment of inertia is significantly greater than the motor moment of inertia, then the transient event can also be improved via parameterization of the load moment of inertia (p1498).

## Moment of inertia precontrol

In applications where the motor predominantly operates with a constant speed, the inverter can only infrequently calculate the moment of inertia using the function described above. Moment of inertia precontrol is available for situations such as these. The moment of inertia precontrol assumes that there is an approximately linear relationship between the moment of inertia and the load torque.

You can configure the moment of inertia precontrol via p5310.

- Using bit 0, you can activate the calculation of the characteristic (p5312 ... p5315).
- Using bit 1, you can activate the moment of inertia precontrol.

The following bit combinations are possible:

```
p5310.0 = 0, Moment of inertia precontrol not active
p5310.1 = 0
p5310.0 = 0, Cyclic calculation of the coefficients without moment of inertia pre-
p5310.1 = 1 control (commissioning)
p5310.0 = 1, Moment of inertia precontrol activated (without cyclic calculation of
p5310.1 = 0 the coefficients)
p5310.0 = 1, Moment of inertia precontrol activated (with cyclic calculation of the
p5310.1 = 1 coefficients)
```

The status word of the moment of inertia precontrol is indicated in r5311.

## Example

For a horizontal conveyor, in a first approximation, the moment of inertia depends on the load.


Figure 9-26 Relationship between moment of inertia $J$ and load torque ML
The relationship between load torque and torque is saved in the inverter as linear characteristic.

- In positive direction of rotation:

Moment of inertia $\mathrm{J}=\mathrm{p} 5312 \times$ load torque $\mathrm{ML}_{\mathrm{L}}+\mathrm{p} 5313$

- In negative direction of rotation:

Moment of inertia $\mathrm{J}=\mathrm{p} 5314 \times$ load torque $\mathrm{ML}_{\mathrm{L}}+\mathrm{p} 5315$
You have the following options to determine the characteristic:

- You already know the characteristic from other measurements. In this case, you must set the parameters to known values when commissioning the system.
- The inverter iteratively determines the characteristic by performing measurements while the motor is operational.

Additional supplementary functions:

- Accelerated moment of inertia estimation (p1400.24 = 1)

Using this setting, when the drive accelerates steadily, the moment of inertia can be more quickly estimated.

- Speed controller adaptation (p5271.2 = 1)

The estimated load moment of inertia is taken into account for the speed controller gain.

## Commissioning

The "inertia estimator" function module can be activated by running the commissioning wizard. Parameter r0108.10 indicates whether the function module has been activated.

## Activating the moment of inertia estimator

The moment of inertia estimator is deactivated in the factory setting. p1400.18 $=0$, $\mathrm{p} 1400.20=0, \mathrm{p} 1400.22=0$.

If you performed the rotating measurement for the motor identification during commissioning, we recommend leaving the moment of inertia estimator deactivated.

## Preconditions

- You have selected encoderless vector control.
- The load torque must be constant whilst the motor accelerates or brakes.

Typical of a constant load torque are conveyor applications and centrifuges, for example.
Fan applications, for example, are not permitted.

- The speed setpoint is free from superimposed unwanted signals.
- The motor and load are connected to each other with an interference fit.

Drives with slip between the motor shaft and load are not permitted, e.g. as a result of loose or worn belts.

If the conditions are not met, you must not activate the moment of inertia estimator.

## Procedure

To activate the moment of inertia estimator, proceed as follows:

1. Set $\mathrm{p} 1400.18=1$
2. Check: p1496 $=0$
3. Activate the acceleration model of the speed controller pre-control: p1400.20 $=1$.

With p1400.22 = 1 , the valued determined by the moment of inertia estimator is retained at a pulse inhibit.

With p1400.24 = 1 , the moment of inertia can be determined in an accelerated manner for steady acceleration processes.

## Function diagram

FP 6035 Moment of inertia estimator (r0108.10 = 1)

## Parameters

- r0108 Drive objects function module
- r0333 Rated motor torque
- p0341 Motor moment of inertia
- p0342 Ratio between the total and motor moment of inertia
- p1226 Speed threshold for standstill detection
- p1400 Speed control configuration
- p1402 Current control and motor model configuration
- r1407 CO/BO: Status word, speed controller
- r1493 CO: Moment of inertia total
- p1496 Acceleration precontrol scaling
- p1497 Cl: Moment of inertia scaling
- p1498 Load moment of inertia
- p1502 BI: Freezing the moment of inertia estimator
- r1518 CO: Acceleration torque
- r1538 CO: Upper effective torque limit
- r1539 CO: Lower effective torque limit
- p1560 Moment of inertia estimator acceleration threshold value
- p1561 Moment of inertia estimator change time moment of inertia
- p1562 Moment of inertia estimator change time load
- p1563 CO: Moment of inertia estimator load torque positive direction of rotation
- p1564 CO: Moment of inertia estimator load torque negative direction of rotation
- p1755 Motor model changeover speed encoderless operation
- p5310 Moment of inertia precontrol configuration
- r5311 Moment of inertia precontrol status word
- p5312 Moment of inertia precontrol linear positive
- p5313 Moment of inertia precontrol constant positive
- p5314 Moment of inertia precontrol linear negative
- p5315 Moment of inertia precontrol constant negative
- p5316 Moment of inertia precontrol change time moment of inertia


### 9.4 Monitoring functions and protective functions

### 9.4.1 Power unit protection, general

## Description

SINAMICS power modules offer comprehensive protection of power components.

Table 9-12 General power module protection

| Protection against: | Protective measure | Response |
| :---: | :---: | :---: |
| Overcurrent ${ }^{1}$ | Monitoring with two thresholds: <br> - First threshold exceeded | A30031, A30032, A30033 <br> Current limiting in phase $U$ has responded. Pulsing in this phase is inhibited for one pulse period. <br> F30017 -> OFF2 is triggered if the threshold is exceeded too often. |
|  | - Second threshold exceeded | F30001 "Overcurrent" -> OFF2 |
| DC link overvoltage ${ }^{1)}$ | Comparison of DC link voltage with hardware shutdown threshold | F30002 "Overvoltage" -> OFF2 |
| DC link undervoltage ${ }^{1)}$ | Comparison of DC link voltage with hardware shutdown threshold | F30003 "Undervoltage" -> OFF2 |
| Short circuit ${ }^{1}$ ) | Second monitoring threshold checked for overcurrent <br> Uce monitoring of IGBT module | F30001 "Overcurrent" -> OFF2 <br> F30022 "Monitoring Uce" -> OFF2 |
| Ground fault | Monitoring of sum of all phase currents | After threshold in p0287 is exceeded: <br> F30021 "Power module: ground fault" -> OFF2 <br> Note: <br> The sum of all phase currents is displayed in r0069[6]. For operation, the value in p0287[1] must be greater than the sum of the phase currents when the insulation is intact. |
| Line phase-failure detection ${ }^{1)}$ |  | F30011 "Line phase-failure in main circuit" -> OFF2 |

1) Monitoring thresholds are permanently set in the converter and cannot be changed by the user.

### 9.4.2 Thermal monitoring and overload responses

## Description

The thermal power module monitor is responsible for identifying critical situations. Possible reactions can be assigned and used when alarm thresholds are exceeded to enable continued operation (e.g., with reduced power) and prevent immediate shutdown. However, the parameter assignment options represent only interventions below the shutdown thresholds that cannot be changed by the user.

The following thermal monitoring options are available:

- $i^{2}$ t monitoring - A07805 - F30005
$i^{2} \mathrm{t}$ monitoring is used to protect components that have a high thermal time constant compared with semi-conductors. Overload with regard to $i^{2 t}$ is present when the drive load (r0036) is greater than 100 \% (load as a \% of rated operation).
- Heat-sink temperature - A05000 - F30004 Used to monitor the temperature r0037[0] of the heat sinks on the power semiconductors (IGBT).
- Chip temperature - A05001 - F30025

Significant temperature differences can occur between the barrier junction of the IGBT and the heat sink. The calculated barrier junction temperature is displayed in r0037[13...18]; the monitoring ensures that the specified maximum barrier junction temperature is not exceeded.

If an overload occurs with respect to any of these three monitoring functions, an alarm is first output. The alarm threshold p0294 ( $\mathrm{i}^{2 t}$ monitoring) can be assigned relative to the shutdown (trip) values.

## Example

The temperature difference between two sensors must not exceed 15 Kelvin (K); a temperature difference of 5 K is set for the temperature monitoring of the heat sink and the air intake. This means that 15 K or 5 K below the shutdown threshold an alarm is issued regarding the pending overtemperature. Parameter p0294 merely allows a change in the alarm threshold so that an alarm is received earlier and, if necessary, steps can be taken to intervene in the drive process (e.g., reduce the load, reduce the ambient temperature).

## Overload responses

The power module responds with alarm A07805. The Control Unit initiates the responses assigned via p0290 at the same time that the alarm is issued. Possible responses include:

- Reduction in pulse frequency (p0290 = 2, 3)

This is a highly effective method of reducing losses in the power module, since switching losses account for a very high proportion of overall losses. In many applications, a temporary pulse frequency reduction in favor of maintaining the process can be tolerated.

## Disadvantage:

The pulse frequency reduction increases the current ripple, which can cause increased torque ripple on the motor shaft (when moment of inertia is low) and increased noise level. Reducing the pulse frequency does not affect the dynamic response of the current control circuit, since the sampling time for the current control circuit remains constant.

- Reduction in output frequency ( $\mathrm{p} 0290=0,2$ )

This response is recommended if pulse frequency reduction is not desired or if the pulse frequency has already been set to the lowest level. Further, the load should also have a characteristic similar to a fan, that is, a quadratic torque characteristic with falling speed. Reducing the output frequency has the effect of significantly reducing the drive output current which, in turn, reduces losses in the power module.

- No reduction (p0290 = 1)

You should choose this option if it is not possible to reduce the pulse frequency or the output current. With this response, the drive does not change its operating point once an alarm threshold has been overshot, which means that the drive can be operated until it reaches its shutdown values. Once the shutdown threshold is reached, the drive switches off with an "overtemperature" or "overload" fault. The time until shutdown, however, is not defined and depends on the degree of overload. Only the alarm threshold can be changed so that an alarm is received earlier and, if necessary, steps can be taken to intervene in the drive process (e.g., reduce the load, reduce the ambient temperature).

## Function diagram

FP 8014 Thermal monitoring, power module

## Parameters

- r0036 CO: Power module overload $\mathrm{I}^{2 \mathrm{t}}$
- r0037 CO: Power module temperatures
- p0290 Power module overload response
- r0293 CO: Power module alarm threshold model temperature
- p0294 Power module warning $\mathrm{I}^{2 t}$ overload
- r2135.13 Fault: thermal overload in power module
- r2135.15 Alarm: thermal overload in power module


### 9.4.3 Blocking protection

## Description

The "Motor blocked" fault is only triggered when the speed of the drive is below the adjustable speed threshold in p2175. With vector control, it must also be ensured that the speed controller is at the limit. With V/f control, the current limit must already have been reached.
Once the ON delay (p2177) has elapsed, the message "Motor blocked" and fault F07900 are generated.

The enable for the blocking monitoring can be deactivated via p2144.


Figure 9-27 Blocking protection

## Function diagram

FP 8012 Signals and monitoring functions - Torque messages, motor blocked/stalled

## Parameters

- p2144 BI: Motor blocking monitoring enable (negated)
- p2175 Motor blocked speed threshold
- p2177 Motor blocked delay time


### 9.4.4 Stall protection (vector control only)

## Description

During speed control with an encoder, if the speed threshold set in p1744 for stall detection is exceeded, then r1408.11 (speed adaptation, speed deviation) is set.
If the error threshold value set in p1745 is exceeded when in the low speed range (less than p1755 x (100 \% - p1756)), r1408.12 (motor stalled) is set.

If one of these two signals is set, then fault F07902 (motor stalled) is returned after the delay time in p2178.
 $0.00 \ldots 210000.001 / \mathrm{min}$ p1744(100.00)


Error threshold value for stall detection
Figure 9-28 Stall protection

## Function diagrams

FP 6730 Vector control - Interface to Motor Module (ASM, p0300 = 1)
FP 8012 Messages and monitoring - Torque messages, motor blocked/stalled

## Parameters

- r1408 CO/BO: Control status word 3
- p1744 Motor model speed threshold stall detection
- p1745 Motor model error threshold stall detection
- p1755 Motor model changeover speed encoderless operation
- p1756 Motor model changeover speed hysteresis encoderless operation
- p2178 Motor stalled delay time


### 9.4.5 Thermal motor protection

### 9.4.5.1 Description

## Description

The priority of thermal motor protection is to identify critical situations. Possible reactions can be assigned (p0610) and used when alarm thresholds are exceeded to enable continued operation (e.g., with reduced power) and prevent immediate shutdown.

- Effective protection is also possible without a temperature sensor (p0600 = 0 or p4100 = 0). The temperatures of different motor components (stators, core, rotors) can be determined indirectly using a temperature model.
- Connecting temperature sensors allows the motor temperature to be determined directly. In this way, accurate start temperatures are available immediately when the motor is switched on again or after a power failure.


### 9.4.5.2 Temperature sensor connection to customer terminal module TM31 (option G60)

## Temperature measurement via KTY

The sensor is connected to terminals X522:7 (temp+) and X522:8 (temp-) on the customer terminal module (-A60/-A65) in the forward direction of the diode. The measured temperature is limited to between $-220{ }^{\circ} \mathrm{F}\left(-140^{\circ} \mathrm{C}\right)$ and $+371.5^{\circ} \mathrm{F}\left(+188.6^{\circ} \mathrm{C}\right)$ and is made available for further evaluation.

- Activate the motor temperature measurement via external sensor: p0600 = 10 After completion of commissioning, the source for the external sensor is set to the customer terminal module (-A60/-A65) (p0603 = \{TM31\} r4105).
- $\quad$ Set the KTY temperature sensor type: p4100 = 2


## Temperature measurement via PTC

The connection is made to the user terminal block (-A60 / -A65) at terminal X522:7/8. The threshold for changing over to an alarm or fault is $1650 \Omega$. If the threshold is exceeded, the system switches internally from an artificially-generated temperature value of $-58{ }^{\circ} \mathrm{F}\left(-50{ }^{\circ} \mathrm{C}\right)$ to $+482^{\circ} \mathrm{F}\left(+250^{\circ} \mathrm{C}\right)$ and makes this value available for further evaluation.

- Activate the motor temperature measurement via external sensor: p0600 = 10 After completion of commissioning, the source for the external sensor is set to the customer terminal module (-A60/-A65) (p0603 = \{TM31\} r4105).
- $\quad$ Set the PTC temperature sensor type: p4100 = 1


## Temperature measurement via PT1000

The connection is made to user terminal block (TM31) at terminal X522:7/8. The measured temperature is limited to between $-99^{\circ} \mathrm{C}$ up to $+188.6^{\circ} \mathrm{C}$ and is available for further evaluation.

- Activating the motor temperature measurement via the external sensor: $\mathrm{p} 0600=10$ After completion of commissioning, the source for the external sensor is set to the customer terminal block (-A60 / -A65) (p0603 = \{TM31\} r4105).
- Set the PT1000 temperature sensor type: $\mathrm{p} 4100=6$.


### 9.4.5.3 Temperature sensor connection to a sensor module (option K50)

## Temperature measurement via KTY

The sensor is connected to the respective Temp- and Temp+ terminals on the Sensor Module in the forward direction of the diode (see the corresponding section in the chapter titled "Electrical installation").

- Activate motor temperature measurement via encoder 1: $\mathrm{p} 0600=1$.
- Set the KTY temperature sensor type: p0601 = 2 .


## Temperature measurement via PTC

The sensor is connected to the respective Temp- and Temp+ terminals on the Sensor Module (see the corresponding section in the chapter titled "Electrical installation"). The threshold for switching to an alarm or fault is $1650 \Omega$.

- Activate motor temperature measurement via encoder 1: $\mathrm{p} 0600=1$.
- Set the PTC temperature sensor type: p0601 = 1 .


## Temperature measurement via PT1000

The device is connected to the appropriate terminals Temp- and Temp+ on the Sensor Module (see corresponding section in chapter "Electrical installation").

- Activate motor temperature measurement via encoder 1: $00600=1$.
- Set the PTC temperature sensor type: $00601=6$.


### 9.4.5.4 Temperature sensor connection directly to the control interface module

## Temperature measurement via KTY

The sensor is connected to terminals X41:3 (temp-) and X41:4 (temp+) on the Control Interface Module in the forward direction of the diode.

- Activate motor temperature measurement via Motor Module: p0600=11.
- $\quad$ Set the KTY temperature sensor type: p0601 $=2$.


## Temperature measurement via PTC

The sensor is connected to terminals $\mathrm{X} 41: 3$ (temp-) and $\mathrm{X} 41: 4$ (temp+) on the Control Interface Module. The threshold for switching to an alarm or fault is $1650 \Omega$.

- Activate motor temperature measurement via Motor Module: p0600 = 11 .
- Set the PTC temperature sensor type: p0601 = 1 .


## Temperature measurement using the bimetal normally closed contact

The sensor is connected to terminals $\times 41: 3$ (temp-) and $\times 41: 4$ (temp+) on the Control Interface Module. The threshold for switching to an alarm or fault is $100 \Omega$.

- Activate motor temperature measurement via Motor Module: p0600 = 11 .
- Set the temperature sensor type bimetal normally closed contact: p0601 $=4$.


## Temperature measurement via PT100

The sensor is connected to terminals $\mathrm{X} 41: 3$ (temp-) and $\mathrm{X} 41: 4$ (temp+) on the Control Interface Module. The temperature offset for the PT100 reading can be set via p0624.

- Activate motor temperature measurement via Motor Module: p0600 = 11 .
- $\quad$ Set the PT100 temperature sensor type: p0601 $=5$.


## Temperature measurement via PT1000

The connection is made at the terminals X41:3 (Temp-) and X41:4 (Temp+) at the Control Interface Module.

- Activate motor temperature measurement via Motor Module: p0600 = 11:
- Set the PT1000 temperature sensor type: p0601 $=6$.


### 9.4.5.5 Temperature sensor evaluation

## Temperature measurement via KTY, PT100 or PT1000

- When the alarm threshold is reached (set via p0604; factory state after commissioning $248{ }^{\circ} \mathrm{F}\left(120^{\circ} \mathrm{C}\right)$ ), alarm A07910 is triggered.

Parameter p0610 can be used to set how the drive responds to the alarm triggered:

- 0: No response, only alarm, no reduction of I_max
- 1: Alarm and reduction of I_max and fault (F07011)
- 2: Alarm and fault (F07011), no reduction of I_max
- 12: Alarm and fault (F07011), no reduction of I_max, temperature storage
- When the fault threshold is reached (set via p0605, factory state after commissioning $311^{\circ} \mathrm{F}\left(155^{\circ} \mathrm{C}\right)$ ), fault F 07011 is triggered in conjunction with the setting in p0610.


## Temperature measurement via PTC or bimetallic NC contact

- Once the PTC or the bimetallic normally closed contact responds, alarm A07910 is initiated.
- Fault F07011 is returned once the waiting time defined in p0606 has elapsed.


## Sensor monitoring for wire breakage/short-circuit

A sensor monitoring for short-circuit in the sensor cable is possible for a PTC and a KTY84 sensor. Wire break monitoring is possible for a KTY84 sensor:
If the temperature of the motor temperature monitoring is outside the designated range of $220{ }^{\circ} \mathrm{F}\left(-140^{\circ} \mathrm{C}\right)$ to $+482^{\circ} \mathrm{F}\left(+250^{\circ} \mathrm{C}\right)$, this means there is a wire break or short-circuit of the sensor cable. Alarm A07015 ("Motor temperature sensor alarm") is output. Fault F07016 ("Drive: Motor temperature sensor fault") is triggered once the waiting time defined in p0607 has elapsed.

Fault F07016 can be suppressed using p0607 = 0. If an induction motor is connected, the drive continues operating with the data calculated in the thermal motor model.

If the system detects that the motor temperature sensor set in p0600 is not connected, alarm A07820 "Temperature sensor not connected" is triggered.

### 9.4.5.6 Thermal motor models

Thermal motor models are used so that thermal motor protection is ensured even without a temperature sensor or with a deactivated temperature sensor (p0600 = 0) .

The simultaneous use of temperature sensors and a thermal motor model also makes sense. For example, a very fast temperature increase that is not detected by the sensors in sufficient time can potentially damage a motor. This situation can occur for motors with a low thermal capacity.

Depending on the particular temperature model, the temperature rise is either assigned to various motor parts (stator, rotor) or is calculated from the motor current and the thermal time constant. A combination of motor temperature model with additional temperature sensors can also be used.

## NOTICE

Damage due to overheating when motor is operated without sensor
A thermal motor model cannot fully replace a sensor. The thermal model cannot protect the motor in the event of incorrect installation, elevated ambient temperature, or incorrect parameter assignment. Without temperature sensors, thermal motor models are not in a position to identify or take into account the ambient temperatures or the initial motor temperature. This can result in overheating of the motor and cause damages.

- Do not use the thermal motor models when an increased ambient temperature or an increased initial motor temperature can occur.


## Thermal motor model 1 (for permanent-magnet synchronous machines)

By using the thermal $\mathrm{I}^{2 t}$ motor model, the temperature rise of the motor windings as a result of dynamic motor loads is also determined in addition to data acquired using a temperature sensor.

The model motor temperature is indicated in r0632. It is calculated from the following values:

- Absolute value of the actual current, unsmoothed (r0068[0])
- Motor stall current (p0318)
- I2t motor model thermal time constant (p0611)
- Measured motor temperature (r0035) or motor ambient temperature (p0625) for operation without temperature sensor
- Motor temperature at rated load (p0605, for expansion p0627)


## Commissioning the motor model

The thermal ${ }^{22 t}$ motor model is activated via $00612.0=1$, the expansions of the motor model can additionally be activated via p0612.8 $=1$.

## Note

When commissioning the motor, thermal motor model 1 (p0612.0 = 1) including expansion ( $\mathrm{p} 0612.8=1$ ) is automatically activated.
Preconditions for automatic activation:

- Use of a permanent magnet synchronous motor
- There is no motor sensor
- No (other) thermal motor model is activated


## Important settings

The most important parameters for thermal motor model 1 and/or for the expansion of this model are subsequently explained.
When the expansion is subsequently activated, the corresponding parameters of the expansion are preassigned with the parameter values before activating the expansion.

| Parameters for the following <br> settings |  | Explanation |  |
| :---: | :---: | :--- | :---: |
| $\mathrm{p} 0612.8=0$ | $\mathrm{p} 0612.8=1$ |  |  |
| p 0605 | p 5390 | Alarm threshold <br> If the model motor temperature (r0632) exceeds the alarm threshold, alarm A07012 <br> "Drive: Motor temperature model $1 / 3$ overtemperature" is output |  |
| p 0615 | p 5391 | Fault threshold <br> If the model motor temperature (r0632) exceeds the fault threshold, fault F07011 <br> "Drive: Motor overtemperature" is output. |  |
| p 0605 | $\mathrm{p} 0627+40^{\circ} \mathrm{C}$ | Rated temperature (winding) <br> Defines the rated overtemperature of the stator winding referred to the ambient <br> temperature. |  |
| 1.333 (fixed | p 5350 | Boost factor <br> value) |  |
| $\mathrm{p} 0612=0 \times 1$ | $\mathrm{p} 0612=0 \times 101$ | Activation <br> Activates the motor module and/or additionally the expansion. |  |
| r0632 | $\mathrm{r0632}$ | Actual temperature <br> Indicates the stator winding temperature of the motor temperature model. |  |
| r0034 | r0034 | Motor utilization <br> Indicates the actual motor utilization level. |  |

## Taking into account the ambient temperature

If, for thermal motor model 1, a temperature sensor has not been the configured, then motor module 1 automatically uses an ambient temperature of $20^{\circ} \mathrm{C}$ for the calculation. You can enter one of these ambient temperatures deviating from the standard temperature as follows:

1. Activate the setting p0612.12 = 1 .

This enables parameter p0613.
2. The factory setting is $20^{\circ} \mathrm{C}$. If you wish to take into account an ambient temperature, which deviates from the factory setting, in the motor model, then enter the expected ambient temperature in p0613.

## Note

When commissioning the motor, the setting p0612.12 = 1 is automatically activated. p0613 can be configured as required.

## Thermal motor model 2 (for induction motors)

The thermal motor model 2 is used for induction motors. It is a thermal 3-mass model.
This makes a thermal motor protection possible even for operation without temperature encoder or with temperature sensor deactivated (p0600 = 0).

The thermal 3-mass model is activated with p0612.1 $=1$. The total motor mass is entered using p0344.

The 3-mass model splits up the total motor mass as follows:

- p0617 = thermally active iron mass (stator): laminated cores and frame) as a percentage of p0344
- p0618 = thermally active copper mass (stator: windings) as a percentage of p0344
- p0619 = thermally active rotor mass (rotor) as a percentage of p0344
- p0625 = ambient temperature
- p0626 = overtemperature, stator iron
- p0627 = overtemperature, stator winding
- p0628 = rotor winding temperature rise

Motor temperature rises are calculated on the basis of motor measured values. The calculated temperature rises are indicated in the parameters:

- r0630 Motor temperature model ambient temperature
- r0631 Motor temperature model stator iron temperature
- r0632 Motor temperature model stator winding temperature
- r0633 Motor temperature model rotor temperature

For operation with a KTY encoder, the calculated temperature value of the 3-mass model permanently tracks the measured temperature value. After the temperature sensor is switched off ( $\mathrm{p} 0600=0$ ), the last temperature value continues to be used for calculation.

### 9.4.5.7 Function diagrams

| FP 8016 | Thermal monitoring motor |
| :--- | :--- |
| FP 8017 | Thermal motor models |
| FP 9576 | TM31 - temperature evaluation (KTY/PTC) |

### 9.4.5.8 Parameters

Temperature sensor evaluation

- r0035 CO: Motor temperature
- p0600 Motor temperature sensor for monitoring
- p0601 Motor temperature sensor type
- p0603 Motor temperature signal source
- p0604 Motor overtemperature fault threshold
- p0605 Motor overtemperature alarm threshold
- p0606 Motor overtemperature timer
- p0607 Temperature sensor fault timer
- p0610 Motor overtemperature response
- p0614 Thermal resistor adaptation reduction factor
- p0624 Motor temperature offset PT100
- p4100 TM31 temperature evaluation, sensor type
- r4105 CO: TM31 temperature evaluation, actual value

Thermal motor model 1 (for permanent-magnet synchronous machines)

- r0034 CO: Motor load
- r0068[0] CO: Absolute value of actual current value, unsmoothed
- p0318 Motor stall current
- p0605 Motor overtemperature alarm threshold
- p0610 Motor overtemperature response
- p0611 12t motor model thermal time constant
- p0612 Thermal motor model configuration
- p0613 Mot_temp_mod 1/3 ambient temperature
- p0615 I2t motor model fault threshold
- p0625 Motor ambient temperature
- p0627 Motor overtemperature, stator winding
- p0632 Mot_temp_mod stator winding temperature
- p5350 Mot_temp_mod 1/3 zero speed boost factor
- p5390 Mot_temp_mod 1/3 alarm threshold
- p5391 Mot_temp_mod 1/3 fault threshold


## Thermal motor model 2 (for induction motors)

- p0344 Motor weight
- p0612 Thermal motor model configuration
- p0617 Stator thermally relevant iron component
- p0618 Stator thermally relevant copper component
- p0619 Rotor thermally relevant mass
- p0625 Motor ambient temperature
- p0626 Motor overtemperature, stator iron
- p0627 Motor overtemperature, stator winding
- p0628 Motor overtemperature, rotor winding
- r0630 Mot_temp_mod ambient temperature
- r0631 Mot_temp_mod stator iron temperature
- r0632 Mot_temp_mod stator winding temperature
- r0633 Mot_temp_mod rotor temperature


### 9.4.6 Temperature measurement via TM150 (option G51)

### 9.4.6.1 Description

The Terminal Module 150 (TM150) has 64 -pole terminals for temperature sensors. Temperature sensors can be connected in a $1 \times 2$-, $1 \times 3$-, or $1 \times 4$-wire system. In a $2 \times 2$-wire system, up to 12 input channels can be evaluated. Twelve (12) input channels can be evaluated in the factory setting. The temperature channels can be combined into as many as 3 groups and evaluated together.
Temperature sensors of type PTC, KTY84, bimetallic NC contact, PT100, and PT1000 can be connected and evaluated. The fault and alarm thresholds of the temperature values can be set from $-99^{\circ} \mathrm{C}$ to $251^{\circ} \mathrm{C}$.

The temperature sensors are connected to terminal strips X531 to X536 according to the following table.
The temperature inputs of the TM150 are not electrically isolated.

## Selection of sensor types

- p4100[0...11] sets the sensor type for the respective temperature channel.
- r4105[0...11] indicates the actual value of the temperature channel.

For switching temperature sensors, such as PTC and bimetallic NC contact, two limits are displayed symbolically:

- r4105[0...11] $=-50^{\circ} \mathrm{C}$ : The actual temperature value is below the rated response temperature.
- $\mathrm{r} 4105[0 \ldots 11]=+250^{\circ} \mathrm{C}$ : The actual temperature value is above the rated response temperature.


## Note

## PTC and bimetallic NC contact

The value indicated in r4105[0...11] does not correspond to the actual temperature value.

Table 9-13 Selection of sensor types

| Value of p4100[0...11] | Temperature sensor | Temperature display range r4105[0..11] |
| :---: | :--- | :--- |
| 0 | Evaluation disabled | - |
| 1 | PTC thermistor | $-50^{\circ} \mathrm{C}$ or $+250^{\circ} \mathrm{C}$ |
| 2 | KTY84 | $-99^{\circ} \mathrm{C}$ to $+250^{\circ} \mathrm{C}$ |
| 4 | Bimetallic NC contact | $-50^{\circ} \mathrm{C}$ or $+250^{\circ} \mathrm{C}$ |
| 5 | PT100 | $-99^{\circ} \mathrm{C}$ to $+250^{\circ} \mathrm{C}$ |
| 6 | PT1000 | $-99^{\circ} \mathrm{C}$ to $+250^{\circ} \mathrm{C}$ |

## Measurement of cable resistances

When using 2-wire sensors (1x2-, 2x2-wire system), the cable resistance can be measured and saved to increase the measuring accuracy.
Procedure for determining the cable resistance:

1. Select the measuring method $(1 \times 2 / 2 x 2)$ for the corresponding terminal block ( $p 4108[0 \ldots 5$ ] $=0,1)$.
2. Set the required sensor type for the relevant channel $(p 4100[x]=1 \ldots 6, x=0 \ldots 5$ or 0...11).
3. Jumper the sensor to be connected (short-circuit the sensor cable in the vicinity of the sensor).
4. Connect the sensor cables to the relevant terminals $1(+), 2(-)$ or $3(+), 4(-)$.
5. Start measurement of the cable resistance $(p 4109[x]=1)$ for the relevant channel.
6. After $\mathrm{p} 4109[\mathrm{x}]=0$, check the measured resistance value in $\mathrm{p} 4110[\mathrm{x}]$.
7. Remove jumper across the temperature sensor again.

The measured cable resistance is then taken into account when evaluating the temperature. The cable resistance value is saved in $\mathrm{p} 4110[0 . .11]$.

## Note

## Line resistance

The value for the cable resistance in p4110[0...11] can also be entered directly.

## Line filter

A mains filter is available to suppress radiated noise. Using p4121, the filter can be set to a 50 Hz or 60 Hz rated line frequency.

### 9.4.6.2 Measurement with up to 6 channels

## Temperature measurement with a sensor in 2-wire technology

With $\mathrm{p} 4108[0 \ldots 5]=0$, you measure using a sensor in 2-wire technology on a 4-wire connection to terminals 1( +) and 2( - ).
Terminals 3 and 4 remain open.

## Temperature measurement with a sensor in 3-wire technology

With p4108[0...5] $=2$, you measure using a sensor in 3-wire technology on a 4-wire connection to terminals 3(+) and 4(-).
The measuring wire is connected to terminal 1(+).
You must short circuit terminals 2(-) and 4(-).

## Temperature measurement with a sensor in 4-wire technology

With p4108[0...5] = 3, you measure using a sensor in 4-wire technology on a 4-wire connection to terminals $3(+)$ and 4(-).
The measuring wire is connected to terminals $1(+)$ and 2(-).

### 9.4.6.3 Measurement with up to 12 channels

## Temperature measurement with two sensors in 2-wire system

With p4108[0...5] = 1 you measure using two sensors in 2-wire system.
The first sensor is connected to terminals 1(+) and 2(-).
The second sensor (number $=$ first sensor +6 ) is connected to terminals 3(+) and 4(-).
For connection of two sensors in 2-wire system to terminal X531, the first sensor is assigned to temperature channel 1 and the second sensor is assigned to channel $7(1+6)$.

## Note

## Connection diagram for 12 temperature channels

The temperature sensors connected to a TM150 are not numbered consecutively. The first 6 temperature channels retain their numbering of 0 to 5 . The other 6 temperature channels are consecutively numbered from 6 to 11, starting at terminal X531.

Example for 8 temperature channels:

- $2 \times 2$-wire at terminal X 531 : $\mathrm{p} 4108[0]=1 \triangleq$ sensor 1 is at channel 0 and sensor 2 is at channel 6
- $2 \times 2$-wire at terminal X 532 : $\mathrm{p} 4108[1]=1 \triangleq$ sensor 1 is at channel 1 and sensor 2 is at channel 7
- $1 \times 3$-wire at terminal X 533 : $\mathrm{p} 4108[2]=2 \xlongequal{=}$ sensor 1 is at channel 2
- $1 \times 3$-wire at terminal X 534 : $\mathrm{p} 4108[3]=2 \triangleq$ sensor 1 is at channel 3
- $1 \times 4$-wire at terminal X 535 : $\mathrm{p} 4108[4]=3 \triangleq$ sensor 1 is at channel 4
- $1 \times 2$-wire at terminal X 536 : $\mathrm{p} 4108[5]=0 \triangleq$ sensor 1 is at channel 5


### 9.4.6.4 Forming groups of temperature sensors

With p 4111 [ $0 . . .2$ ], temperature channels can be formed into groups. For each group, the following calculated values are provided from the actual temperature values (r4105[0...11]):

- Maximum: r4112[0...2], (index 0,1,2 = group 0,1,2)
- Minimum: r4113[0...2]
- Average value: r4114[0...2]

Example:
The actual temperature values from channels $0,3,7$, and 9 are to be combined in group 1:

- $p 4111[1] .0=1$
- $\mathrm{p} 4111[1] .3=1$
- $\mathrm{p} 4111[1] .7=1$
- $\mathrm{p} 4111[1] .9=1$

The calculated values from group 1 are available in the following parameters for interconnection:

- r4112[1] = maximum
- r4113[1] = minimum
- r4114[1] = average value


## Note <br> Forming groups of temperature channels <br> Only form groups of continuously measuring temperature sensors. Only the two temperatures $-50^{\circ} \mathrm{C}$ and $+250^{\circ} \mathrm{C}$ are assigned to switching temperature sensors PTC and bimetallic NC contact, depending on the switch status. <br> Within a group including continuously measuring temperature sensors, the calculated maximum/minimum/mean values is significantly falsified by inclusion of switching temperature sensors.

### 9.4.6.5 Evaluation of temperature channels

One alarm threshold and one fault threshold can be set for each of the 12 temperature channels via p4102[0...23] (even parameter indices: warning thresholds, odd parameter indices: fault thresholds). The temperature thresholds can be set for each channel from $-99^{\circ} \mathrm{C}$ to $+251^{\circ} \mathrm{C}$. For $\mathrm{p} 4102[0 \ldots 23]=251$, the evaluation of the corresponding threshold is deactivated.
Using p4118[0...11], a hysteresis for the fault/alarm thresholds can be set in p4102[0...23] for each channel.

The following applies to the warning thresholds:

- If the actual temperature value associated with a channel exceeds the specified warning threshold ( $\mathrm{r} 4105[\mathrm{x}]>\mathrm{p} 4102[2 \mathrm{x}]$ ), the corresponding alarm is output. Timer p4103[0...11] is started at the same time.
- The alarm remains until the actual temperature value (r4105[x]) has reached or fallen below the alarm threshold ( $\mathrm{p} 4102[2 \mathrm{x}]$ ) - hysteresis ( $\mathrm{p} 4118[\mathrm{x}]$ ).
- If, after the timer has expired, the actual temperature value is still above the alarm threshold, then the corresponding fault is output.

The following applies to the fault thresholds:

- If the actual temperature value associated with a channel exceeds the specified fault threshold ( $\mathrm{r} 4105[\mathrm{x}]>\mathrm{p} 4102[2 \mathrm{x}+1]$ ), the corresponding fault is output.
- The fault remains until the actual temperature value ( $\mathrm{r} 4105[\mathrm{x}]$ ) has reached or fallen below the fault threshold ( $\mathrm{p} 4102[2 \mathrm{x}+1]$ ) - hysteresis ( $\mathrm{p} 4118[\mathrm{x}]$ ) and the fault has been acknowledged.

Using p4119[0...11], a filter for smoothing the temperature signal can be activated for each channel.
The time constant of the filter depends on the number of active temperature channels and can be read off in r4120.

## Failure of a sensor within a group

The response to the failure of a temperature sensor within a group can be set with parameter p4117[0...2]:

- $p 4117[x]=0$ : The failed sensor is not taken into account in the group.
- $\mathrm{p} 4117[\mathrm{x}]=1$ : In the event of a failed sensor, the value $300^{\circ} \mathrm{C}$ is output for the maximum value, minimum value, and the mean value of the group.


### 9.4.6.6 Function diagrams

FP 9625 TM150 - Temperature evaluation structure (channel 0...11)
FP 9626 TM150 - Temperature evaluation 1x2-, 3-, 4-wire (channel 0...5)
FP 9627 TM150 - Temperature evaluation 2x2-wire (channel 0...11)

### 9.4.6.7 Parameters

- p4100[0...11] TM150 sensor type
- r4101[0...11] TM150 sensor resistance
- p4102[0...23] TM150 fault threshold/alarm threshold
- p4103[0...11] TM150 delay time
- r4104.0... 23 BO: TM150 temperature evaluation status
- r4105[0...11] CO: TM150 actual temperature value
- p4108[0...5] TM150 terminal block measurement method
- p4109[0...11] TM150 cable resistance measurement
- p4110[0...11] TM150 cable resistance value
- p4111[0...2] TM150 group channel assignment
- r4112[0...2] CO: TM150 group actual temperature value maximum value
- $\mathrm{r} 4113[0 \ldots 2]$ CO: TM150 group actual temperature value minimum value
- r4114[0...2] CO: TM150 group actual temperature value average
- p4117[0...2] TM150 group sensor fault effect
- p4118[0...11] TM150 fault threshold/alarm threshold hysteresis
- p4119[0...11] TM150 activate/deactivate smoothing
- r4120 TM150 Temperature filter time constant
- p4121 TM150 filter rated line frequency


## Diagnostics / faults and alarms

### 10.1 Chapter content

This section provides information on the following:

- Information on available diagnostics and on eliminating the causes of errors



### 10.2 Diagnostics

## Description

This section describes procedures for identifying the causes of problems and the measures you need to take to rectify them.

## Note

## Errors or malfunctions

If faults or malfunctions occur in the device, you must carefully check the possible causes and take the necessary steps to rectify them. If you cannot identify the cause of the problem or you discover that components are defective, your regional office or sales office should contact Siemens Service and describe the problem in more detail. Addresses of contact persons are listed in the preface.

### 10.2.1 Diagnostics via LEDs

## Control unit (-A10)

Table 10-1 Description of the LEDs on the CU320-2 DP Control Unit

| LED | Color | Status | Description |
| :---: | :---: | :---: | :---: |
| RDY (READY) | --- | OFF | The electronics power supply is missing or lies outside the permissible tolerance range. |
|  | Green | Continuous light | The component is ready for operation and cyclic DRIVE-CLiQ communication is taking place. |
|  |  | Flashing 0.5 Hz | Commissioning/reset |
|  |  | Flashing 2 Hz | Writing to memory card. |
|  |  | Flashing light 0.5 s on 3 s off | PROFlenergy energy saving mode is active (in conjunction with option G33 - CBE20) |
|  | Red | Flashing 2 Hz | General errors |
|  | Red/green | Flashing 0.5 Hz | Control Unit is ready for operation. However, there are no software licenses. |
|  | Orange | Flashing 0.5 Hz | Firmware update in progress for the connected DRIVE-CLiQ components. |
|  |  | Flashing 2 Hz | Firmware update of components is complete. Waiting for POWER ON of the respective component. |
|  | Green/orange or red/orange | Flashing 2 Hz | Component detection via LED is activated (p0124[0]). <br> Note: <br> Both options depend on the LED status when component recognition is activated using p0124[0] $=1$. |


| LED | Color | Status | Description |
| :---: | :---: | :---: | :---: |
| COM PROFIdrive cyclic operation | --- | OFF | Cyclic communication is not (yet) running. <br> Note: <br> The PROFIdrive is ready for communication when the Control Unit is ready for operation (see LED RDY). |
|  | Green | Continuous light | Cyclic communication is taking place. |
|  |  | Flashing 0.5 Hz | Cyclic communication has not yet fully occured. <br> Possible causes: <br> - The controller is not transmitting any setpoints. <br> - In isochronous mode, the controller did not transmit a Global Control (GC) or it transmitted an incorrect Global Control. |
|  | Red | Flashing 0.5 Hz | PROFIBUS master is sending incorrect parameter assignment/configuration data |
|  |  | Flashing 2 Hz | Cyclic bus communication has been interrupted or could not be established. |
| OPT (OPTION) | --- | OFF | Electronics power supply is missing or is outside the permissible tolerance range. <br> The component is not ready for operation. <br> The Option Board is missing or an associated drive object has not been created. |
|  | Green | Continuous light | Option Board is ready for operation. |
|  |  | Flashing 0.5 Hz | Depends on the option board used ${ }^{11}$. |
|  | Red | Continuous light | Depends on the option board used ${ }^{11}$. |
|  |  | 0.5 Hz flashing light | Depends on the option board used ${ }^{11}$. |
|  |  | Flashing 2 Hz | At least one fault is pending on this component. The Option Board is not ready (e.g., after switching on). |
| RDY and COM | Red | Flashing 2 Hz | Bus error - communication has been interrupted. |
| RDY and OPT | Orange | Flashing 0.5 Hz | The firmware of the connected option board is being updated. |

${ }^{1)}$ Any individual behaviors of the LED OPT are described at the respective Option Board.

Table 10-2 Description of the LEDs on the CU320-2 PN Control Unit

| LED | Color | Status | Description |
| :---: | :---: | :---: | :---: |
| RDY (READY) | --- | OFF | The electronics power supply is missing or lies outside the permissible tolerance range. |
|  | Green | Continuous light | The component is ready for operation and cyclic DRIVE-CLiQ communication is taking place. |
|  |  | Flashing 0.5 Hz | Commissioning/reset |
|  |  | Flashing 2 Hz | Writing to memory card. |
|  |  | Flashing light 0.5 s on 3 s off | PROFlenergy energy saving mode is active |
|  | Red | Flashing 2 Hz | General errors |
|  | Red/green | Flashing 0.5 Hz | Control Unit is ready for operation. However, there are no software licenses. |
|  | Orange | Flashing 0.5 Hz | Firmware update in progress for the connected DRIVE-CLiQ components. |
|  |  | Flashing 2 Hz | Firmware update of components is complete. Waiting for POWER ON of the respective component. |
|  | Green/orange or red/orange | Flashing 2 Hz | Component detection via LED is activated (p0124[0]). <br> Note: <br> Both options depend on the LED status when component recognition is activated using $\mathrm{p} 0124[0]=1$. |
| COM PROFIdrive cyclic operation | --- | OFF | Cyclic communication is not (yet) running. <br> Note: <br> The PROFIdrive is ready for communication when the Control Unit is ready for operation (see LED RDY). |
|  | Green | Continuous light | Cyclic communication is taking place. |
|  |  | Flashing 0.5 Hz | Cyclic communication is still not completely running. <br> Possible causes: <br> - The controller is not transferring any setpoints. <br> - For isochronous operation, either none or a faulty Global Control (GC) has been transferred from the controller. <br> - "Shared Device" has been selected and only one controller connected. |
|  | Red | Flashing 0.5 Hz | Bus error, incorrect parameter assignment/configuration |
|  |  | Flashing 2 Hz | Cyclic bus communication has been interrupted or could not be established. |
| OPT (OPTION) | --- | OFF | Electronics power supply is missing or is outside the permissible tolerance range. <br> The component is not ready for operation. <br> The Option Board is missing or an associated drive object has not been created. |
|  | Green | Continuous light | Option Board is ready for operation. |
|  |  | Flashing 0.5 Hz | Depends on the option board used ${ }^{11}$. |
|  | Red | Continuous light | Depends on the option board used ${ }^{11}$. |
|  |  | 0.5 Hz flashing light | Depends on the option board used ${ }^{11}$. |
|  |  | Flashing 2 Hz | At least one fault is pending on this component. The Option Board is not ready (e.g., after switching on). |
| RDY and COM | Red | Flashing 2 Hz | Bus error - communication has been interrupted. |
| RDY and OPT | Orange | Flashing 0.5 Hz | The firmware of the connected option board is being updated. |

[^5]
## Customer terminal module TM31 (-A60)

Table 10-3 Description of the LEDs on the TM31

| LED | Color | Status | Description |
| :--- | :--- | :--- | :--- |
| READY | --- | OFF | The electronics power supply is missing or lies outside the permissible <br> tolerance range. |
|  | Green | Continuous light | The component is ready for operation and cyclic DRIVE-CLiQ communi- <br> Cation is taking place. |
|  | Orange | Continuous light | DRIVE-CLiQ communication is being established. |
|  | Red | Continuous light | This component has at least one fault. <br> Remark: <br> The LED is activated irrespective of whether the corresponding messag- <br> es have been reconfigured. |
|  | Green/red | Flashing 0.5 Hz | Firmware is being downloaded. |
|  | Flashing 2 Hz | Firmware download is complete. Waiting for POWER ON. |  |
|  | Green/orange <br> or <br> red/orange | Flashing light | Detection of the components via LED is activated (p0154). <br> Remark: <br> Both options depend on the LED status when module recognition is acti- <br> vated via p0154 = 1. |

## Control Interface Module - Interface module in the Power Module (-T1)

Table 10-4 Description of the "READY" and "DC LINK" LEDs on the Control Interface Module

| LED, status |  | Description |
| :--- | :--- | :--- |
| READY | DC LINK |  |
| Off | Off | The electronics power supply is missing or lies outside the permissible tolerance <br> range. |
| Green | O-- 1) | The component is ready for operation and cyclic DRIVE-CLiQ communication is <br> taking place. |
|  | Orange | The component is ready for operation and cyclic DRIVE-CLiQ communication is <br> taking place. <br> The DC link voltage is present. |
|  | Red | The component is ready for operation and cyclic DRIVE-CLiQ communication is <br> taking place. <br> The DC-link voltage lies outside the permitted tolerance range. |
| Orange | Orange | DRIVE-CLiQ communication is being established. |
| Red | $---1)$ | This component has at least one fault. <br> Remark: <br> The LED is activated irrespective of whether the corresponding messages have been <br> reconfigured. |
| Flashing light $0.5 \mathrm{~Hz}:$ <br> green/red | $---1)$ | Firmware is being downloaded. |
| Flashing light $2 \mathrm{~Hz}:$ <br> green/red | $---1)$ | Firmware download is complete. Waiting for POWER ON. |
| Flashing light $2 \mathrm{~Hz}:$ <br> green/orange <br> or <br> red/orange | $---1)$ | Detection of the components via LED is activated (p0124). <br> Note: <br> Both options depend on the LED status when module recognition is activated via <br> p0124 = 1. |

1) Irrespective of the status of the LED "DC LINK"

Table 10-5 Meaning of the "POWER OK" LED on the Control Interface Module

| LED | Color | Status | Description |
| :--- | :--- | :--- | :--- |
| POWER OK | Green | Off | DC link voltage < 100 V and voltage at $-\mathrm{X9:1/2}$ less than 12 V. |
|  |  | On | The component is ready for operation. |
|  | Flashing light | There is a fault. If the LED continues to flash after you have performed <br> a POWER ON, please contact your Siemens service center. |  |



## A. warning

## Touching live parts of the DC link

Hazardous DC link voltages may be present at any time regardless of the status of the "DC LINK" LED. This means the touching of live parts can result in death or serious injury.

- Observe the warning information on the component.


## SMC30 - Encoder evaluation (-B83)

Table 10-6 Description of the LEDs on the SMC30

| LED | Color | Status | Description |
| :---: | :---: | :---: | :---: |
| READY | --- | OFF | The electronics power supply is missing or lies outside the permissible tolerance range. |
|  | Green | Continuous light | The component is ready for operation and cyclic DRIVE-CLiQ communication is taking place. |
|  | Orange | Continuous light | DRIVE-CLiQ communication is being established. |
|  | Red | Continuous light | This component has at least one fault. <br> Remark: <br> The LED is activated irrespective of whether the corresponding messages have been reconfigured. |
|  | Green/red | Flashing 0.5 Hz | Firmware is being downloaded. |
|  |  | Flashing 2 Hz | Firmware download is complete. Waiting for POWER ON. |
|  | Green/orange or red/orange | Flashing light | Detection of the components via LED is activated (p0144). <br> Remark: <br> Both options depend on the LED status when module recognition is activated via p0144 $=1$. |
| OUT>5 V | --- | OFF | The electronics power supply is missing or lies outside the permissible tolerance range. <br> Voltage supply $\leq 5 \mathrm{~V}$. |
|  | Orange | Continuous light | Electronics power supply for measuring system is present. <br> Voltage supply > 5 V . <br> Notice: <br> It must be ensured that the connected encoder is permitted to be operated with a 24 V voltage supply. <br> Operating an encoder designed for a 5 V supply with a 24 V supply can damage the encoder electronics beyond repair. |

## CBE20 - Communication Board Ethernet

Table 10-7 Description of the LEDs on ports 1-4 of the X1400 interface on the CBE20

| LED | Color | Status | Description |
| :--- | :--- | :--- | :--- |
| Link port | --- | OFF | Electronics power supply is missing or outside permissible tolerance <br> range (link missing or defective). |
|  | Green | Continuous light | A different device is connected to port x and a physical connection exists. |
| Activity port | --- | OFF | Electronics power supply is missing or outside permissible tolerance <br> range (no activity). |
|  | Yellow | Continuous light | Data is being received or sent at port x. |

Table 10-8 Description of the Sync and Fault LEDs on the CBE20

| LED | Color | Status | Description |
| :---: | :---: | :---: | :---: |
| Fault | --- | OFF | If the link port LED is green: <br> The CBE20 is operating error-free, and data is being exchanged with the configured IO controller. |
|  | Red | Flashing light | - The watchdog timer has elapsed. <br> - Communication has been interrupted. <br> - The IP address is incorrect. <br> - Incorrect or missing configuration. <br> - Incorrect parameter assignment. <br> - Incorrect or missing device name. <br> - IO controller not present/switched off but Ethernet connection present. <br> - Other CBE20 errors. |
|  |  | Continuous light | CBE20 bus error <br> - No physical connection to a subnet/switch. <br> - Incorrect transmission rate. <br> - Full-duplex transmission is not activated. |
| Sync | --- | OFF | If the link port LED is green: <br> Control Unit task system is not synchronized with the IRT clock. An internal substitute clock is generated. |
|  | Green | Flashing light | Control unit task system has synchronized with the IRT clock and data is being exchanged. |
|  |  | Continuous light | Task system and MC-PLL have synchronized with the IRT clock. |

Table 10-9 Description of the OPT LED on the Control Unit

| LED | Color | Status | Description |
| :---: | :---: | :---: | :---: |
| OPT | --- | OFF | Electronics power supply is missing or outside permissible tolerance range. <br> The CBE20 is defective or not inserted. |
|  | Green | Continuous light | CBE20 is ready and cyclic communication is taking place. |
|  |  | Flashing 0.5 Hz | CBE20 is ready but cyclic communication is not running. Possible causes: <br> - Communication is being established. <br> -At least one fault is present. |
|  | Red | Continuous light | Cyclic communication via PROFINET has not yet been established. However, acyclic communication is possible. SINAMICS is waiting for a parameterization/configuration frame. |
|  |  | Flashing 0.5 Hz | The firmware download to the CBE20 has failed. Possible causes: <br> - The memory card of the Control Unit is faulty. <br> - The CBE20 is out of order. <br> The CBE20 cannot be used in this state. |
|  |  | Flashing 2 Hz | Communication between the Control Unit and the CBE20 is faulty. Possible causes: <br> - The CBE20 was removed following power-up. <br> - The CBE20 is defective. |
|  | Orange | Flashing 0.5 Hz | Firmware is being updated. |

## TM150 - Terminal Module (-A151)

Table 10-10 Description of the LEDs on the TM150

| LED | Color | Status | Description |
| :---: | :---: | :---: | :---: |
| READY | - | Off | The electronics power supply is missing or lies outside the permissible tolerance range. |
|  | Green | Continuous light | The component is ready for operation and cyclic DRIVE-CLiQ communication is taking place. |
|  | Orange | Continuous light | DRIVE-CLiQ communication is being established. |
|  | Red | Continuous light | This component has at least one fault. <br> Remark: <br> The LED is activated irrespective of whether the corresponding messages have been reconfigured. |
|  | Green/red | Flashing 0.5 Hz | Firmware is being downloaded. |
|  |  | Flashing 2 Hz | Firmware download is complete. Waiting for POWER ON. |
|  | Green/orange or red/orange | Flashing 2 Hz | Detection of the components via LED is activated ( p 0154 ). <br> Remark: <br> Both options depend on the LED status when module recognition is activated via p0154 $=1$. |

### 10.2.2 Diagnostics via parameters

## All Objects: Key diagnostic parameters (details in List Manual)

| Parameter | Name |
| :--- | :--- |
|  | Description |
| r0945 | Fault code |
|  | Displays the fault number. Index 0 is the most recent fault (last fault to have occurred). |
|  | Fault time received in milliseconds |
|  | Displays the system runtime in ms at which the fault occurred. |
| r2109 | Fault value |
|  | Displays additional information about the fault. This information is required for detailed fault diagnosis. |
| r2122 | Fault time removed in milliseconds |
|  | Displays the system runtime in ms at which the fault was rectified. |
|  | Alarm code |
| r2123 | Displays the numbers of the alarms that have occurred. |
|  | Alarm time received in milliseconds |
| r2124 | Alarm value |
|  | Displays additional information about the alarm. This information is required for detailed alarm diagnosis. |
| r2125 | Alarm time removed in milliseconds |
|  | Displays the system runtime in ms at which the alarm was rectified. |

## Control unit: Key diagnostic parameters (details in List Manual)

| Parameter | Name |
| :---: | :---: |
|  | Description |
| r0002 | Control unit status display |
|  | Status display for the Control Unit |
| r0018 | Control unit firmware version |
|  | Displays the firmware version of the Control Unit. The display parameters of the firmware version of other connected components can be found in the parameter description in the List Manual. |
| r0037 | Control unit temperature |
|  | Display of the measured temperature on the Control Unit. |
| r0721 | CU digital inputs, actual terminal value |
|  | Displays the actual value at the digital input terminals on the CU. This parameter shows the actual value, uninfluenced by simulation mode of the digital inputs. |
| r0722 | CO/BO: CU digital inputs status |
|  | Displays the status of the digital inputs on the CU. This parameter shows the status of the digital inputs under the influence of simulation mode of the digital inputs. |
| r0747 | CU digital outputs status |
|  | Display of the CU digital output status. This parameter shows the status of the digital inputs under the influence of simulation mode of the digital inputs. |
| r2054 | PROFIBUS status |
|  | Displays the status of the PROFIBUS interface. |
| r8937 | PN diagnostics |
|  | Diagnostics display of the cyclic PROFINET connections. |
| r9976[0..7] | System utilization |
|  | Displays the system load. <br> The individual values (computation load and cyclic load) are measured over short time slices; from these values, the maximum, the minimum and the average value are generated and displayed in the appropriate indices. The degree of memory utilization of the data and program memory is also displayed. |

## VECTOR: Key diagnostic parameters (details in List Manual)

| Parameter | Name |
| :--- | :--- |
|  | Description |
| r0002 | Drive operating display |
|  | The value provides information about the current operating state and the conditions necessary to reach the <br> next status. |
|  | Speed setpoint, smoothed |
|  | Displays the current smoothed speed/velocity setpoint at the input of the speed/velocity controller or V/f <br> characteristic (after the interpolator). |
| r0024 | CO: Actual speed value, smoothed |
|  | Displays the smoothed actual value of the motor speed/velocity. |
|  | CO: Output frequency smoothed |
|  | Displays the smoothed converter frequency. |


| Parameter | Name |
| :---: | :---: |
|  | Description |
| r0026 | CO: DC link voltage, smoothed |
|  | Displays the smoothed actual value of the DC link. |
| r0027 | CO: Absolute actual value of current, smoothed |
|  | Displays the smoothed actual value of the current. |
| r0031 | Actual torque, smoothed |
|  | Displays the smoothed actual torque. |
| r0034 | CO: Motor load |
|  | Displays the motor load from the thermal $\mathrm{I}^{2} \mathrm{t}$ motor model. |
| r0035 | CO: Motor temperature |
|  | If r0035 does not equal $-200.0^{\circ} \mathrm{C}$, the following applies: <br> - This temperature indicator is valid. <br> - An KTY sensor is connected. <br> - If using an asynchronous motor, the thermal motor model is activated ( $p 0600=0$ or p0601 = 0). If r0035 equals $-200.0^{\circ} \mathrm{C}$, the following applies: <br> - This temperature indicator is invalid (temperature sensor fault). <br> - A PTC sensor is connected. <br> If using a synchronous motor, the thermal motor model is activated ( $p 0600=0$ or p0601 $=0$ ). |
| r0037 | CO: Power module temperatures |
|  | Displays the measured temperatures in the Power Module. |
| r0046 | CO/BO: Missing enables |
|  | Displays missing enable signals that are preventing the closed-loop drive control from being commissioned. |
| r0049 | Motor data set/encoder data set effective (MDS, EDS) |
|  | Displays the effective motor data set (MDS) and the effective encoder data sets (EDS). |
| r0050 | CO/BO: Command data set CDS effective |
|  | Displays the effective command data set (CDS) |
| r0051 | CO/BO: Drive data set DDS effective |
|  | Effective drive data set (DDS) display. |
| r0056 | CO/BO: Status word closed-loop control |
|  | Displays the status word of the closed-loop control. |
| r0063 | CO: Actual speed value |
|  | Displays the current actual speed value for speed control and V/f control. |
| r0066 | CO: Output frequency |
|  | Displays the output frequency of the Motor Module. |
| r0070 | CO: Actual DC-link voltage value |
|  | Displays the measured actual value of the DC link voltage. |
| r0072 | CO: Output voltage |
|  | Displays the current output voltage of the power unit (Motor Module). |
| r0082 | CO: Active power actual value |
|  | Displays the current active power. |
| r0206 | Rated power unit power |
|  | Displays the rated power unit power for various load duty cycles. |


| Parameter | Name |
| :--- | :--- |
|  | Description |
| r0207 | Rated power unit current |
|  | Displays the rated power unit power for various load duty cycles. |
| 0208 | Rated power unit line supply voltage |
|  | Displays the rated line supply voltage of the power unit. |
| 0209 | Power unit maximum current |
|  | Display of the maximum output current of the power unit. |

## TM31: Key diagnostic parameters (details in List Manual)

| Parameter | Name |
| :--- | :--- |
|  | Description |
| r0002 | TM31 status display |
|  | Status display for the TM31 Terminal Module. |
|  | TM31 digital inputs actual terminal value |
|  | Displays the actual value at the digital input terminals on the TM31. This parameter shows the actual value, <br> uninfluenced by simulation mode of the digital inputs. |
| r4047 | CO/BO: TM31 digital inputs status |
|  | Displays the status of the digital inputs on the TM31. This parameter shows the status of the digital inputs <br> under the influence of simulation mode of the digital inputs. |
|  | TM31 digital outputs status |

### 10.2.3 Indicating and rectifying faults

The device features a wide range of functions that protect the drive against damage if a fault occurs (faults and alarms).

## Indicating faults and alarms

If a fault occurs, the drive displays the fault and/or alarm on the AOP30 operator panel. Faults are indicated by the red "FAULT" LED and a fault screen is automatically displayed. You can use the F1 Help function to call up information about the cause of the fault and how to remedy it. You can use F5 Ack. to acknowledge a stored fault.

Any alarms are displayed by the yellow flashing "ALARM" LED. The system also displays a note in the status bar providing information on the cause.

Every fault and alarm is entered in the fault/alarm buffer along with time the error occurred. The time stamp refers to the relative system time in milliseconds (r0969).

Activate the "Set date/time - AOP synchronization -> Drive" setting to date- and time-stamp errors on the AOP30.

## What is a fault?

A fault is a message from the drive indicating an error or other exceptional (unwanted) status. This could be caused by a fault within the converter or an external fault triggered, for example, from the winding temperature monitor for the induction motor. The faults are displayed and can be reported to a higher-level control system via PROFIdrive. In the delivery condition, the message "Drive fault" is also sent to a relay output. Once you have rectified the cause of the fault, you have to acknowledge the fault message.

## What is an alarm?

An alarm is the response to a fault condition identified by the drive. It does not result in the drive being switched off and does not have to be acknowledged. Alarms are "self acknowledging", that is, they are reset automatically when the cause of the alarm has been eliminated.

### 10.3 Overview of alarms and faults

If a fault occurs, the drive indicates the fault and/or alarm. Faults and alarms are listed in a fault/alarm list, together with the following information:

- Fault/alarm number
- Standard drive response
- Description of the possible cause of the fault/alarm
- Description of the procedure for rectifying the problem
- Standard fault acknowledgment after it has been rectified


## Note

## List of faults and alarms

The list of faults and alarms is included on the customer DVD.
The CD also includes descriptions of possible fault responses (OFF1, OFF2, etc.).

## Note

## Faults and alarms wired and preset at the factory

The faults and alarms described below have been wired specifically for the enclosed drives listed in this document and preset via macro. This ensures that the appropriate response is initiated when faults and alarms are generated due to additional components installed in the drive enclosure.

It is possible to reprogram the faults and alarms described, provided the stated options are not included in the scope of the equipment.

### 10.3.1 "External alarm 1"

## Causes

Alarm A7850 ("External alarm 1") is triggered by the following optional protection device in the drive:

- Temperature Sensor for tripping the alarm threshold in the Line Harmonics Filter compact (option L01)
- PT100 tripping unit (option L97)


## Remedy

When a fault is indicated, the following procedure is recommended:

1. Identify the cause by examining the specified devices (display or LEDs).
2. Check the fault display on the relevant protection device and establish the fault.
3. Rectify the displayed fault with the help of the relevant operating instructions provided in the "Additional Operating Instructions" section of this documentation package.

### 10.3.2 "External fault 1"

## Causes

Fault code F7860 ("External Fault 1") is triggered by the following optional protection device in the drive:

- Temperature Sensor for tripping the fault threshold in the Line Harmonics Filter compact (option L01)
- PT100 tripping unit (option L97)


## Remedy

When a fault is indicated, the following procedure is recommended:

1. Identify the cause by examining the specified devices (display or LEDs).
2. Check the fault display on the relevant protection device and establish the fault.
3. Rectify the displayed fault with the help of the relevant operating instructions provided in the "Additional Operating Instructions" section of this documentation package.

### 10.3.3 "External fault 2"

## Causes

Fault code F7861 ("External Fault 2") is triggered when the braking resistor connected in options L61 and L62 experiences thermal overload, thereby activating the thermostat. The drive is switched off with OFF2.

Remedy
The cause of the braking resistor overload must be eliminated and the fault code acknowledged.

### 10.3.4 "External fault 3"

## Causes

Fault code F7862 "External fault 3" is triggered when the braking unit fitted in options L61 and L62 triggers a fault. The drive is switched off with OFF2.

## Remedy

The cause of the braking unit overload must be eliminated and the fault code acknowledged.

## Maintenance and servicing

### 11.1 Chapter content

This section provides information on the following:

- Maintenance and servicing procedures that have to be carried out on a regular basis to ensure the availability of the cabinet units
- Replacing device components when the unit is serviced
- Forming the DC link capacitors
- Upgrading the cabinet unit firmware
- Loading new operator panel firmware from the PC


Not observing fundamental safety instructions and residual risks
Failure to observe the basic safety instructions and residual risks in Chapter 1 can lead to accidents resulting in serious injury or death.

- Comply with the basic safety instructions.
- Take into account residual risks when assessing risks.


## ! DANGER

Electric shock due to the residual charge of the DC link capacitors
Because of the DC link capacitors, a hazardous voltage is present for up to 5 minutes after the power supply has been switched off.
Contact with live parts can result in death or serious injury.

- Only open the device after 5 minutes have elapsed.
- Measure the voltage before starting work on the DCP and DCN DC link terminals.


## ! DANGER

## Electric shock from external supply voltages

When an external supply voltage for individual options (L50 / L55) is connected or an external 115 V AC auxiliary supply is used, dangerous voltages are still present on the components even when the mains switch is open.

Contact with live parts can result in death or serious injury.

- Switch off external supply voltages and external 115 V AC auxiliary supply before opening the device.


### 11.2 Maintenance

The drive mainly comprises electronic components. Apart from the fan(s), the unit contains very few components that are subject to wear or require maintenance or servicing. The purpose of maintenance is to maintain the drive condition as per specification. Dirt and contamination must be removed regularly and parts subject to wear replaced.
The following points must generally be observed.

### 11.2.1 Cleaning

## Dust deposits

Dust deposits inside the drive must be removed at regular intervals (or at least once a year) by qualified personnel in line with the relevant safety regulations. The unit must be cleaned with a brush and vacuum cleaner and for inaccessible areas with dry compressed air (max. 14.5 Psi (1 bar)).

## Ventilation

The ventilation openings in the enclosure must never be obstructed. The fan must be checked to make sure that it is functioning correctly.

## Cable and screw terminals

Cable and screw terminals must be checked regularly to ensure that they are securely in position and retightened if necessary. Cabling must be checked for defects. Defective parts must be replaced immediately.

## Note

## Maintenance intervals

The actual intervals at which maintenance procedures are to be performed depend on the installation conditions (cabinet environment) and the operating conditions.

Siemens offers its customers support in the form of a service contract. For further details, contact your regional office or sales office.

### 11.3 Servicing

Servicing involves activities and procedures for maintaining and restoring the specified condition of the device.

## Required tools

The following tools are required for replacing components:

- Standard set of tools with screwdrivers, screw wrenches, socket wrenches, etc.
- Torque wrenches 1.5 Nm up to 100 Nm
- 600 mm extension for socket wrenches


## Tightening torques for screw connections

The following tightening torques apply when tightening current-conducting connections (DC link connections, motor connections, busbars, cable lugs) and other connections (ground connections, protective ground connections, steel threaded connections).

Table 11-1 Tightening torques for screw connections

| Thread | Ground connections, protective ground <br> connections, steel threaded connections | Aluminum threaded connections, <br> plastic, busbars, cable lugs |
| :---: | :---: | :---: |
| M3 | 1.3 Nm | 0.8 Nm |
| M4 | 3 Nm | 1.8 Nm |
| M5 | 6 Nm | 3 Nm |
| M6 | 10 Nm | 6 Nm |
| M8 | 25 Nm | 13 Nm |
| M10 | 50 Nm | 25 Nm |
| M12 | 88 Nm | 50 Nm |
| M16 | 215 Nm | 115 Nm |

## Note

## Screw connections for protective covers

The threaded connections for the protective covers made of Makrolon may only be tightened with 2.5 Nm .

### 11.3.1 Installation device

## Description

The installation device is used for installing and removing the power blocks.
It is used as an installation aid, which is placed in front of and secured to the module. The telescopic guide support allows the withdrawable device to be adjusted according to the height at which the power blocks are installed. Once the mechanical and electrical connections have been removed, the power block can be removed from the module, whereby the power block is guided and supported by the guide rails on the withdrawable devices.


Figure 11-1 Installation device

## Article no.

The article number for the installation device is 6SL3766-1FA00-0AA0.

### 11.3.2 Using lifting lugs to transport power blocks

## Lifting lugs

The power blocks are fitted with lifting lugs for attaching a lifting harness to transport the power block in the event of replacement.

The locations of the lifting lugs are illustrated by arrows in the figures below.

## NOTICE

Device damage due to improper transport
Improper transport can cause mechanical stresses on the power block housing or the busbars that damage the device.

- When transporting the power blocks, use a lifting harness in which the ropes or chains run vertically.
- Do not use the power block busbars as lifting handles or for attaching a lifting harness.


Figure 11-2 Lifting lugs on power block frame size FX, GX


Figure 11-3 Lifting lugs on power block frame size HX, JX

## Note

Crane lifting lugs on power blocks HX, JX
On size HX and JX power blocks, the front lifting lug is located behind the busbar.

### 11.4 Replacing components

## WARNING

Improper transport and installation of devices and components
Improper transport or installation of the devices can result in serious or fatal injury and substantial property damage.

- Transport, install, and remove the devices and components only if you are qualified to do so.
- Note that devices and components are in some cases heavy and top-heavy, and take the necessary precautionary measures. The weights of the individual power blocks are listed in the corresponding section.


### 11.4.1 Replacing the filter mats

The filter mats must be checked at regular intervals. If the mats are too dirty to allow the air supply to flow normally, they must be replaced.

## Note

Replacing the filter mats
Filter mat replacement is only relevant for options M23, M43 and M54.
Failure to replace dirty filter mats can cause premature thermal shutdown of the drive.

### 11.4.2 Replacing the Control Interface Module, frame size FX

## Replacement of Control Interface Module



Figure 11-4 Replacement of Control Interface Module, frame size FX

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Disconnect the plug connections for the fiber optic cables and signal cables ( 5 plugs).
2. Remove DRIVE-CLiQ cables and connections on -X41, -X42, -X46 (6 connectors). The DRIVE-CLiQ cables should be marked in order to ensure subsequent correct assembly.
3. Take out the retaining screws for the IPD card (2 screws) and remove the IPD card from connector -X45 on the Control Interface Module.
4. Remove the retaining screws for the Control Interface Module ( 2 screws).

When removing the Control Interface Module, you must remove 5 additional connectors one after the other ( 2 at the top, 3 below).

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the Control Interface Module is removed. This can cause the device to fail.

- When removing the Control Interface Module, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.
Tightening torque for the retaining screws of the Control Interface Module (M6 x 16, item (4): 6 Nm .

## Note

Specifications for the installation
The tightening torques specified in the "Tightening torques for screw connections" table must be observed.
Carefully insert the plug-in connections and ensure that they are secure.
The fiber-optic cable connectors must be reinstalled at their original slot. The fiber-optic cables and sockets are labeled accordingly (U11, U21, U31) for correct assignment.

### 11.4.3 Replacing the Control Interface Module, frame size GX

## Replacement of Control Interface Module



Figure 11-5 Replacement of Control Interface Module, frame size GX

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Disconnect the plug connections for the fiber optic cables and signal cables ( 5 plugs).
2. Remove DRIVE-CLiQ cables and connections on -X41, -X42, -X46 (6 connectors). The DRIVE-CLiQ cables should be marked in order to ensure subsequent correct assembly.
3. Take out the retaining screws for the IPD card (2 screws) and remove the IPD card from connector -X45 on the Control Interface Module.
4. Remove the retaining screws for the Control Interface Module ( 2 screws).

When removing the Control Interface Module, you must remove 5 additional connectors one after the other ( 2 at the top, 3 below).

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the Control Interface Module is removed. This can cause the device to fail.

- When removing the Control Interface Module, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.
Tightening torque for the retaining screws of the Control Interface Module (M6 x 16, item (4): 6 Nm .

## Note

Specifications for the installation
The tightening torques specified in the "Tightening torques for screw connections" table must be observed.
Carefully insert the plug-in connections and ensure that they are secure.
The fiber-optic cable connectors must be reinstalled at their original slot. The fiber-optic cables and sockets are labeled accordingly (U11, U21, U31) for correct assignment.

### 11.4.4 Replacing the Control Interface Module, frame size HX

## Replacement of Control Interface Module



Figure 11-6 Replacement of Control Interface Module, frame size HX

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Disconnect the plug connections for the fiber optic cables and signal cables ( 5 plugs).
2. Remove DRIVE-CLiQ cables and connections on -X41, -X42, -X46 (6 connectors). The DRIVE-CLiQ cables should be marked in order to ensure subsequent correct assembly.
3. Take out the retaining screws for the IPD card (2 screws) and remove the IPD card from connector -X45 on the Control Interface Module.
4. Remove the retaining screws for the Control Interface Module ( 2 screws).

When removing the Control Interface Module, you must remove 5 additional connectors one after the other ( 2 at the top, 3 below).

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the Control Interface Module is removed. This can cause the device to fail.

- When removing the Control Interface Module, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.
Tightening torque for the retaining screws of the Control Interface Module (M6 x 16, item (4): 6 Nm .

## Note

Specifications for the installation
The tightening torques specified in the "Tightening torques for screw connections" table must be observed.
Carefully insert the plug-in connections and ensure that they are secure.
The fiber-optic cable connectors must be reinstalled at their original slot. The fiber-optic cables and sockets are labeled accordingly (U11, U21, U31) for correct assignment.

### 11.4.5 Replacing the Control Interface Module, frame size JX

## Replacement of Control Interface Module



Figure 11-7 Replacement of Control Interface Module, frame size JX

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Disconnect the plug connections for the fiber optic cables and signal cables ( 5 plugs).
2. Remove DRIVE-CLiQ cables and connections on -X41, -X42, -X46 (6 connectors). The DRIVE-CLiQ cables should be marked in order to ensure subsequent correct assembly.
3. Take out the retaining screws for the IPD card (2 screws) and remove the IPD card from connector -X45 on the Control Interface Module.
4. Remove the retaining screws for the Control Interface Module ( 2 screws).

When removing the Control Interface Module, you must remove 5 additional connectors one after the other ( 2 at the top, 3 below).

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the Control Interface Module is removed. This can cause the device to fail.

- When removing the Control Interface Module, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.
Tightening torque for the retaining screws of the Control Interface Module (M6 x 16, item (4): 6 Nm .

## Note

Specifications for the installation
The tightening torques specified in the "Tightening torques for screw connections" table must be observed.
Carefully insert the plug-in connections and ensure that they are secure.
The fiber-optic cable connectors must be reinstalled at their original slot. The fiber-optic cables and sockets are labeled accordingly (U11, U21, U31) for correct assignment.

### 11.4.6 Replacing the power block, frame size FX

## Replacement of power block



Figure 11-8 Replacement of power block, frame size FX

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access to the power block.
- Remove the protective cover.
- Remove the Control Interface Module (see corresponding section).


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Unscrew the connection to the outgoing motor section ( 3 screws).
2. Unscrew the connection to the line supply ( 3 screws).
3. Remove the retaining screws at the top ( 2 screws).
4. Remove the retaining screws at the bottom ( 2 screws).
5. Disconnect the plug for the thermocouple.
6. Unscrew the 2 retaining screws for the fan and attach the fitting device for the power block at this position.
You can now remove the power block.

## Note

The power block weighs approx. 70 kg !

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the power block is removed. This can cause the device to fail.

- When removing the power block, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.

## Note

## Specifications for the installation

The tightening torques specified in the "Tightening torques for screw connections" table must be observed.
Carefully insert the plug-in connections and ensure that they are secure.

## Note

## Connection clip for the basic interference suppression module

The connection clip for the basic interference suppression module is mounted on the spare power block together with a yellow warning label.

Please note the information in Chapter "Removing the connection clip to the basic interference suppression module for operation on an ungrounded line supply (IT system)".

### 11.4.7 Replacing the power block, frame size GX

## Replacement of power block



Figure 11-9 Replacement of power block, frame size GX

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access to the power block.
- Remove the protective cover.
- Remove the Control Interface Module (see corresponding section).


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Unscrew the connection to the outgoing motor section (3 screws).
2. Unscrew the connection to the line supply ( 3 screws).
3. Remove the retaining screws at the top ( 2 screws).
4. Remove the retaining screws at the bottom ( 2 screws).
5. Disconnect the plug for the thermocouple.
6. Unscrew the 2 retaining screws for the fan and attach the fitting device for the power block at this position.

You can now remove the power block.

## Note

The power block weighs approx. 102 kg !

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the power block is removed. This can cause the device to fail.

- When removing the power block, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.

## Note

## Specifications for the installation

The tightening torques specified in the "Tightening torques for screw connections" table must be observed.

Carefully insert the plug-in connections and ensure that they are secure.

## Note

## Connection clip for the basic interference suppression module

The connection clip for the basic interference suppression module is mounted on the spare power block together with a yellow warning label.

Please note the information in Chapter "Removing the connection clip to the basic interference suppression module for operation on an ungrounded line supply (IT system)".

### 11.4.8 Replacing the power block, frame size HX

## Replacement of left power block



Figure 11-10 Replacement of power block, frame size HX: left power block

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access to the power block.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Remove the busbar ( 6 screws).
2. Unscrew the connection to the DC link (8 nuts).
3. Remove the retaining screw at the top ( 1 screw).
4. Remove the retaining screws at the bottom ( 2 screws).
5. Disconnect the plug connections for the fiber optic cables and signal cables (3 plugs).
6. Remove the connection for the current transformer and associated ground (PE) connection (1 plug).
7. Remove the connection for the DC link sensor (1 nut).
8. Remove the power connections ( 6 screws).
9. Unscrew the 2 retaining screws for the fan and attach the fitting device for the power block at this position.
You can now remove the power block.

## Note

The power block weighs approx. 94 kg !

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the power block is removed. This can cause the device to fail.

- When removing the power block, ensure that you do not damage any signal cables.
11.4 Replacing components


## Installation steps

Installation is carried out the same as removal, but in the reverse order.

## Note

Specifications for the installation
The tightening torques specified in the "Tightening torques for screw connections" table must be observed.

Carefully insert the plug-in connections and ensure that they are secure.

## Note

Connection clip for the basic interference suppression module
The connection clip for the basic interference suppression module is mounted on the spare power block together with a yellow warning label.
Please note the information in Chapter "Removing the connection clip to the basic interference suppression module for operation on an ungrounded line supply (IT system)".

## Replacement of right power block



Figure 11-11 Replacement of power block, frame size HX: right power block

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access to the power block.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Remove the busbars ( 12 screws).
2. Unscrew the connection to the DC link (8 nuts).
3. Remove the retaining screw at the top ( 1 screw).
4. Remove the retaining screws at the bottom ( 2 screws).
5. Disconnect the plug connections for the fiber optic cables and signal cables (3 plugs).
6. Remove the connection for the current transformer and associated ground (PE) connection (2 plugs).
7. Unscrew the 2 retaining screws for the fan and attach the fitting device for the power block at this position.

You can now remove the power block.

## Note

The power block weighs approx. 88 kg !

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the power block is removed. This can cause the device to fail.

- When removing the power block, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.

## Note

## Specifications for the installation

The tightening torques specified in the "Tightening torques for screw connections" table must be observed.

Carefully insert the plug-in connections and ensure that they are secure.

### 11.4.9 Replacing the power block, frame size JX

## Replacement of left power block



Figure 11-12 Replacement of power block, frame size JX: left power block

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access to the power block.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Unscrew the connection to the DC link (8 nuts).
2. Remove the retaining screw at the top ( 1 screw).
3. Remove the retaining screws at the bottom ( 2 screws).
4. Disconnect the plug connections for the fiber optic cables and signal cables (2 plugs).
5. Remove the connections to the mains supply ( 6 screws).
6. Unscrew the 2 retaining screws for the fan and attach the fitting device for the power block at this position.

You can now remove the power block.

## Note

The power block weighs approx. 102 kg !

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the power block is removed. This can cause the device to fail.

- When removing the power block, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.

## Note

## Specifications for the installation

The tightening torques specified in the "Tightening torques for screw connections" table must be observed.

Carefully insert the plug-in connections and ensure that they are secure.

## Note

## Connection clip for the basic interference suppression module

The connection clip for the basic interference suppression module is mounted on the spare power block together with a yellow warning label.

Please note the information in Chapter "Removing the connection clip to the basic interference suppression module for operation on an ungrounded line supply (IT system)".

## Replacement of right power block



Figure 11-13 Replacement of power block, frame size JX: right power block

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access to the power block.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Remove the busbar ( 8 screws).
2. Unscrew the connection to the DC link (8 nuts).
3. Remove the retaining screw at the top ( 1 screw).
4. Remove the retaining screws at the bottom ( 2 screws).
5. Disconnect the plug connections for the fiber optic cables and signal cables (2 plugs).
6. Remove the connection for the current transformer and associated ground (PE) connection (1 plug).
7. Unscrew the 2 retaining screws for the fan and attach the fitting device for the power block at this position.
You can now remove the power block.

## Note

The power block weighs approx. 90 kg !

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the power block is removed. This can cause the device to fail.

- When removing the power block, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.

## Note

## Specifications for the installation

The tightening torques specified in the "Tightening torques for screw connections" table must be observed.
Carefully insert the plug-in connections and ensure that they are secure.

### 11.4.10 Replacing the fan, frame size FX

## Replacement of fan



Figure 11-14 Replacement of fan, frame size FX

## Description

The typical service life of the device fans is 50,000 hours. In practice, however, the service life depends on other variables (e.g., ambient temperature, cabinet enclosure, etc.) and, therefore, may deviate from this value.

The fans must be replaced in good time to maintain the availability of the enclosed drive.

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Remove the retaining screws for the fan ( 2 screws).
2. Disconnect the supply cables ( $1 \times$ "L", $1 \times$ "N").

You can now carefully remove the fan.

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the fan is removed. This can cause the device to fail.

- When removing the fan, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.

## Note

## Pay attention to the tightening torques

The tightening torques specified in the "Tightening torques for screw connections" table must be observed.

## Note

Reset the operating hours counter
Following fan replacement, the operating hours counter of the fan should be reset via p0251 $=0$.

### 11.4.11 Replacing the fan, frame size GX

## Replacement of fan



Figure 11-15 Replacement of fan, frame size GX

## Description

The typical service life of the device fans is 50,000 hours. In practice, however, the service life depends on other variables (e.g., ambient temperature, cabinet enclosure, etc.) and, therefore, may deviate from this value.

The fans must be replaced in good time to maintain the availability of the enclosed drive.

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Remove the retaining screws for the fan (3 screws).
2. Disconnect the supply cables ( $1 \times$ "L", $1 \times$ "N").

You can now carefully remove the fan.

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the fan is removed. This can cause the device to fail.

- When removing the fan, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.

## Note

## Pay attention to the tightening torques

The tightening torques specified in the "Tightening torques for screw connections" table must be observed.

## Note

Reset the operating hours counter
Following fan replacement, the operating hours counter of the fan should be reset via p0251 $=0$.

### 11.4.12 Replacing the fan, frame size HX

## Replacement of fan, left power block



Figure 11-16 Replacement of fan, frame size HX: left power block

## Description

The typical service life of the device fans is 50,000 hours. In practice, however, the service life depends on other variables (e.g., ambient temperature, cabinet enclosure, etc.) and, therefore, may deviate from this value.

The fans must be replaced in good time to maintain the availability of the enclosed drive.

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Remove the busbar ( 6 screws).
2. Remove the retaining screws for the fan (3 screws).
3. Disconnect the supply cables ( $1 \times$ "L", $1 \times$ "N").

You can now carefully remove the fan.

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the fan is removed. This can cause the device to fail.

- When removing the fan, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.

## Note

## Pay attention to the tightening torques

The tightening torques specified in the "Tightening torques for screw connections" table must be observed.

## Note

Reset the operating hours counter
Following fan replacement, the operating hours counter of the fan should be reset via p0251 $=0$.

## Replacement of fan, right power block



Figure 11-17 Replacement of fan, frame size HX: right power block

## Description

The typical service life of the device fans is 50,000 hours. In practice, however, the service life depends on other variables (e.g., ambient temperature, cabinet enclosure, etc.) and, therefore, may deviate from this value.

The fans must be replaced in good time to maintain the availability of the enclosed drive.

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Remove the busbar ( 12 screws).
2. Remove the retaining screws for the fan (3 screws).
3. Disconnect the supply cables ( $1 \times$ "L", $1 \times$ "N").

You can now carefully remove the fan.

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the fan is removed. This can cause the device to fail.

- When removing the fan, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.

## Note

## Pay attention to the tightening torques

The tightening torques specified in the "Tightening torques for screw connections" table must be observed.

## Note

## Reset the operating hours counter

Following fan replacement, the operating hours counter of the fan should be reset via p0251 $=0$.

### 11.4.13 Replacing the fan, frame size JX

## Replacement of fan, left power block



Figure 11-18 Replacement of fan, frame size JX: left power block

## Description

The typical service life of the device fans is 50,000 hours. In practice, however, the service life depends on other variables (e.g., ambient temperature, cabinet enclosure, etc.) and, therefore, may deviate from this value.

The fans must be replaced in good time to maintain the availability of the enclosed drive.

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Remove the retaining screws for the fan (3 screws).
2. Disconnect the supply cables ( $1 \times$ "L", $1 \times$ "N").

You can now carefully remove the fan.

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the fan is removed. This can cause the device to fail.

- When removing the fan, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.

## Note

## Pay attention to the tightening torques

The tightening torques specified in the "Tightening torques for screw connections" table must be observed.

## Note

Reset the operating hours counter
Following fan replacement, the operating hours counter of the fan should be reset via p0251 $=0$.

## Replacement of fan, right power block



Figure 11-19 Replacement of fan, frame size JX: right power block

## Description

The typical service life of the device fans is 50,000 hours. In practice, however, the service life depends on other variables (e.g., ambient temperature, cabinet enclosure, etc.) and, therefore, may deviate from this value.

The fans must be replaced in good time to maintain the availability of the enclosed drive.

## Preparatory steps

- Disconnect the enclosed drive from the power supply.
- Allow unimpeded access.
- Remove the protective cover.


## Removal steps

The steps of the removal procedure correspond to the numbers shown in the figure.

1. Remove the busbar (8 screws).
2. Remove the retaining screws for the fan (3 screws).
3. Disconnect the supply cables ( $1 \times$ "L", $1 \times$ "N").

You can now carefully remove the fan.

## NOTICE

Device damage due to signal cable damage during removal
Signal cables can become damaged when the fan is removed. This can cause the device to fail.

- When removing the fan, ensure that you do not damage any signal cables.


## Installation steps

Installation is carried out the same as removal, but in the reverse order.

## Note

## Pay attention to the tightening torques

The tightening torques specified in the "Tightening torques for screw connections" table must be observed.

## Note

## Reset the operating hours counter

Following fan replacement, the operating hours counter of the fan should be reset via p0251 $=0$.

### 11.4.14 Replacing cylindrical fuses

The following fuses are executed as cylindrical fuses:

- Fan fuses (-T1 -F10, -T1 -F11)
- Fuses for auxiliary power supply (-F11, -F12)
- Fuse for the internal 230 V AC supply (-F21)


Figure 11-20 Fuse holder
Article numbers for replacing fuses that have blown can be found in the spare parts list.

## Note

Eliminate the source of the error
Make sure that the source of the error is eliminated before your replace the fuse.

### 11.4.15 Replacing the LV HRC fuses

## Description

LV HRC fuses (low-voltage high-rupturing capacity fuses), also called blade fuses, are used in the mains switches of the line supply, for example.


Figure 11-21 LV HRC fuse

## Preparatory steps

- Keep the safety equipment close at hand: LV HRC fuse grip with sleeve for LV HRC fuse links
- Observe the national safety regulations.


Figure 11-22 LV HRC fuse grip with sleeve for LV HRC fuses

## Note

If required, the LV HRC fuse grip can be ordered from Siemens using article number 3NX1.

## Removal steps

The following steps are used to remove the LV HRC fuse:

1. Open the main switch.
2. Remove the front shock hazard protection cover of the cabinet in front of the fuses.

! WARNING
Electric shock as the cover above the line supply connections has been removed
When the lower cover (over the line connections) is removed, line voltage is present even when the main switch is switched off. Contact with the connections can result in death or serious injury.

- Do not remove the cover (shock protection) over the line connections.

3. Locate the LV HRC fuse puller with forearm protection for LV HRC fuse-links over the fuse.
4. Withdraw the defective fuse.

## NOTICE

## Device failure after a LV HRC fuse trips

When a low-voltage high-rupturing-capacity fuse trips, the neighboring low-voltage high-rupturing-capacity fuses may also become damaged. Failure to replace all fuses at the same time can cause the device to fail.

- After a low-voltage high-rupturing-capacity fuse trips, always replace all low-voltage high-rupturing-capacity fuses at the same time. Always use fuses of the same type.


## Installation steps

The following steps are used to install the LV HRC fuse:

1. Insert the new fuse into the LV HRC fuse puller.
2. Insert the fuse into the fuse holder.
3. Press the release button on the LV HRC fuse puller to release the grip from the new fuse.
4. Attach the front shock hazard protection cover.

The main switch can then be switched on.

## ! WARNING

## Electric shock when using unsuitable fuses

If unsuitable fuses are used, an electric shock can cause severe injury or death.

- Use only fuses specified in the spare parts list.


### 11.4.16 Replacing the door-mounted operator panel

1. De-energize the device.
2. Open the enclosure.
3. On the operator panel, disconnect the power supply and communication line.
4. Release the fastenings on the operator panel.
5. Remove the operator panel.
6. Install the new operator panel.
7. Carry out the remaining steps by reversing the sequence.

### 11.4.17 Replacing the backup battery for the door-mounted operator panel

Table 11-2 Technical specifications for the backup battery

| Type | CR2032 3 V lithium battery |
| :--- | :--- |
| Manufacturer | Maxell, Sony, Panasonic |
| Nominal capacity | 220 mAh |
| Self-discharge at $20^{\circ} \mathrm{C}$ | $1 \% /$ year |
| Service life (in backup mode) | $>1$ year at $70^{\circ} \mathrm{C} ;>1.5$ years at $20^{\circ} \mathrm{C}$ |
| Service life (in operation) | $>2$ years |

## Replacement

1. De-energize the device.
2. Open the cabinet.
3. On the operator panel, disconnect the 24 V DC power supply and communication line.
4. Open the cover of the battery compartment.
5. Remove the old battery.
6. Insert the new battery.
7. Close the cover of the battery compartment.
8. Reconnect the 24 V DC power supply and communication line.
9. Close the cabinet.

### 11.4 Replacing components

## Note <br> Time for replacing the battery

The battery replacement procedure must not take longer than one minute to ensure that that AOP settings are retained.


Figure 11-23 Replacing the backup battery for the door-mounted operator panel

## Note <br> Battery disposal

The battery must be disposed of in accordance with the applicable country-specific guidelines and regulations.

### 11.5 Forming the DC link capacitors

## Description

If the device is kept in storage for more than two years, the DC link capacitors must be reformed.

If commissioning takes place within two years of the date of manufacture, the DC link capacitors do not need to be re-formed. The date of manufacture is indicated in the serial number on the rating plate (see "Device overview").

## NOTICE

Damages due to neglected reforming
If the device is not re-formed after having been in storage for more than two years, operation with load can result in damages to the device.

- Form the device after it has been in storage for more than two years.


## Note

## Storage period

It is important that the storage period be calculated from the date of manufacture and not from the date that the equipment was shipped.

## Procedure

The DC link capacitors are re-formed by applying the rated voltage without load for at least 30 minutes at room temperature.

- Operation via PROFIBUS:
- Set bit 3 of control word 1 (operation enable) permanently to "0".
- Switch on the drive using an ON signal (bit 0 of the control word); all other bits must be set in such a way that the drive can be operated.
- Once the wait time has elapsed, switch off the drive and restore the original PROFIBUS setting.
- Operation via terminal block:
- Set p0852 to "0" (factory setting is "1").
- Switch on the drive (via digital input 0 on the customer terminal module).
- Once the wait time has elapsed, switch off the drive and restore the original setting for p0852.


## Note

Reforming via AOP30
Reforming cannot be carried out in LOCAL mode via the AOP30.

### 11.6 Messages after replacement of DRIVE-CLiQ components

When DRIVE-CLiQ components (Control Interface Module, TM31, SMCxx) are replaced, a message is not usually displayed on start-up, since the replacement part is identified as an identical component and accepted.

However, in the unlikely event that a fault code from the "Topology fault" category is displayed, one of the following faults might have occurred during the replacement procedure:

- A Control Interface Module with different firmware data was installed.
- When connecting DRIVE-CLiQ cables, the connections were reversed.


## Automatic firmware update

A firmware update for the replaced DRIVE-CLiQ component may run automatically after switching on the electronics.

- The following LEDs will flash slowly to indicate that an automatic firmware update is in progress: the "RDY" LED on the Control Unit (orange, 0.5 Hz ) and an LED on the relevant DRIVE-CLiQ component (green/red, 0.5 Hz ).


## Note

## Do not shut down the drive

During this operation, the converter should not be shut down, as otherwise the firmware update must be started again.

- Once the automatic firmware update is complete, this is signaled be rapid flashing of the "RDY" LED on the Control Unit (orange, 2 Hz ) and rapid flashing of an LED on the relevant DRIVE-CLiQ component (green/red, 2 Hz ).
- To complete the automatic firmware update, a POWER ON must be performed (switch off the device and switch it on again).


### 11.7 Upgrading the drive firmware

Upgrading the device firmware, e.g. by installing a new memory card with a new firmware version, may also necessitate an upgrade of the firmware of the DRIVE-CLiQ components contained in the enclosed drive.

If the system detects that the firmware in the DRIVE-CLiQ components needs to be upgraded, it will do this independently as part of the automatic firmware update.

## Automatic firmware update sequence

1. During an automatic firmware update, the "RDY" LED on the Control Unit flashes slowly (orange, 0.5 Hz ).
2. The firmware update is performed sequentially in the DRIVE-CLiQ components as needed; during the update process, an LED of the respective component flashes slowly (green/red, 0.5 Hz ).
3. Once the firmware update of an individual DRIVE-CLiQ component is complete, the LED of the relevant component flashes rapidly (green/red, 2 Hz ).
4. Once the firmware update for all components is complete, the LED of the Control Unit flashes rapidly (orange, 2 Hz ).
5. To complete the automatic firmware update, a POWER ON must be performed (switch off the device and switch it on again).

## Note

Do not interrupt the power supply of the components during the upgrade because the firmware update must otherwise be started once again.

### 11.8 Downloading new operator panel firmware from the PC

## Description

A necessary update of AOP functionality might require new firmware to be loaded on the AOP.

After the drive is switched on, if a newer version of the firmware is found on the memory card, a prompt will appear on the AOP30 asking whether to load the new firmware. This prompt should be answered "YES".
The firmware will then be loaded automatically to the operator panel and the following dialog screen will appear.


Figure 11-24 Dialog screen: Loading firmware
If the firmware cannot be loaded successfully, it can be loaded using the following manual method.

The load program LOAD_AOP30 and the firmware file can be found on the customer DVD.

## Firmware loading procedure

1. Make the RS232 connection from the PC to the AOP30.
2. Provide the supply voltage ( 24 V DC).
3. Start the LOAD_AOP30 program on the PC.
4. Choose the PC interface (COM1, COM2).
5. Choose and open the firmware (AOP30.H86).
6. Following the instructions in the status window of the program, turn on the power supply for the AOP30 while pressing the red key (O).
7. The load procedure starts automatically.
8. Perform a POWER ON (cycle the power supply off and then back on).

## Technical specifications

### 12.1 Chapter content

This chapter provides information on the following:

- General and specific technical specifications for the devices.
- Information on restrictions that apply when the devices are used in unfavorable climatic environmental conditions (derating)


### 12.2 General specifications

### 12.2 General specifications

Table 12-1 General technical specifications

| Electrical data |  |  |  |
| :---: | :---: | :---: | :---: |
| Power network configurations | Grounded TN/TT systems and non-grounded IT systems |  |  |
| Line frequency | $47 \ldots 63 \mathrm{~Hz}$ |  |  |
| Output frequency | $0 \ldots 300 \mathrm{~Hz}$ |  |  |
| Power factor <br> - Fundamental mode <br> - Total | $\begin{aligned} & \geq 0.96 \\ & 0.75 \ldots 0.93 \end{aligned}$ |  |  |
| Converter efficiency | > 98 \% |  |  |
| Switching at input | Once every 3 minutes |  |  |
| Overvoltage category | III according to IEC 61800-5-1 |  |  |
| Mechanical specifications |  |  |  |
| Type of enclosure | NEMA 1, optionally NEMA 1 filtered or NEMA 12 (ventilated) |  |  |
| Protection class | I according to IEC 61800-5-1 |  |  |
| Cooling method | Forced air cooling AF according to IEC 60146 |  |  |
| Sound pressure level | $\leq 75 \mathrm{~dB}(\mathrm{~A})$ at power supply frequency of 60 Hz |  |  |
| Touch protection | EN 50274 with intended use |  |  |
| Cabinet system | Rittal TS 8, doors with double-barb lock, three-section base plates for cable entry |  |  |
| Paint finish | RAL 7035 (indoor requirements) |  |  |
| Compliance with standards |  |  |  |
| Standards | IEC 60146-1, IEC 61800-2, IEC 61800-3, IEC 61800-5-1, IEC 60204-1, IEC 60529 |  |  |
| UL listing | Optional listing per UL508A |  |  |
| RI suppression | According to EMC product standard for adjustable-speed electrical power drive systems IEC 61800-3, category C3 |  |  |
| Environmental conditions |  |  |  |
|  | Storage | Transport | Operation |
| Ambient temperature | $\begin{aligned} & -13^{\circ} \mathrm{F}\left(-25^{\circ} \mathrm{C}\right) \ldots+131^{\circ} \mathrm{F} \\ & \left(+55^{\circ} \mathrm{C}\right) \end{aligned}$ | $\begin{aligned} & -13^{\circ} \mathrm{F}\left(-25^{\circ} \mathrm{C}\right) \ldots+158^{\circ} \mathrm{F} \\ & \left(+70^{\circ} \mathrm{C}\right) \\ & \text { from }-40^{\circ} \mathrm{F}\left(-40^{\circ} \mathrm{C}\right) \text { for } \\ & 24 \text { hours } \end{aligned}$ | $\begin{array}{\|l\|} \hline 32^{\circ} \mathrm{F} \ldots 104^{\circ} \mathrm{F} \\ \left(0^{\circ} \mathrm{C} \ldots+40^{\circ} \mathrm{C}\right) \\ \text { to }+122^{\circ} \mathrm{F}\left(+50^{\circ} \mathrm{C}\right) \text { with } \\ \text { derating } \end{array}$ |
| Relative humidity (no condensation) Corresponds to class | 5 to $95 \%$ <br> 1K4 acc. to IEC 60 721-3-1 | $\begin{aligned} & 5 \ldots 95 \% \text { at } 104^{\circ} \mathrm{F}\left(40^{\circ} \mathrm{C}\right) \\ & 2 \mathrm{~K} 3 \text { acc. to IEC } 60721-3-2 \end{aligned}$ | $5 \ldots 95 \%$ <br> 3K3 acc. to IEC 60 721-3-3 |
| Environmental class / harmful chemical substances | 1C2 acc. to IEC 60721-3-1 | 2C2 acc. to IEC 60721-3-2 | 3C2 acc. to IEC 60721-3-3 |
| Organic/biological influences | 1B1 acc. to IEC 60721-3-1 | 2B1 acc. to IEC 60721-3-2 | 3B1 acc. to IEC 60721-3-3 |
| Mechanically active substances ${ }^{2)}$ | 1S1 acc. to IEC 60721-3-1 | 2S1 acc. to IEC 60721-3-2 | 3S1 acc. to IEC 60721-3-3 |
| Pollution degree | 2 according to IEC 61800-5-1 |  |  |
| Installation altitude | Up to $6600 \mathrm{ft}(2000 \mathrm{~m})$ above sea level without derating, $>6600 \mathrm{ft}(2000 \mathrm{~m})$ above sea level with derating (see "Derating data") |  |  |


| Mechanical stability | Storage | Transport | Operation |  |
| :--- | :--- | :--- | :--- | :---: |
| Vibrational load |  |  |  |  |
| - Displacement | 1.5 mm at 5 to 9 Hz | 3.1 mm at 5 to 9 Hz | 0.075 mm at 10 to 58 Hz |  |
| - Acceleration | $5 \mathrm{~m} / \mathrm{s}^{2}$ at $>9 \ldots 200 \mathrm{~Hz}$ | $10 \mathrm{~m} / \mathrm{s}^{2}$ at $>9 \ldots 200 \mathrm{~Hz}$ | $10 \mathrm{~m} / \mathrm{s}^{2}$ at $>58$ to 200 Hz |  |
| Shock load <br> - Acceleration | $40 \mathrm{~m} / \mathrm{s}^{2}$ at 22 ms | $100 \mathrm{~m} / \mathrm{s}^{2}$ at 11 ms | $100 \mathrm{~m} / \mathrm{s}^{2}$ at 11 ms |  |
| Functional safety | Safety Integrity Level (SIL) | SIL 2 according to IEC 61508 and IEC $61800-5-2$ |  |  |
| Performance Level and <br> Category | PL d and Category 3 according to EN ISO $13849-1$ |  |  |  |

Deviations from the defined classes are shown in italics.

### 12.2.1 Derating data

### 12.2.1.1 Current derating as a function of the ambient temperature

## Permissible output current as a function of the ambient temperature

The enclosed drives and related system components are suited for an ambient temperature of $113^{\circ} \mathrm{F}\left(40^{\circ} \mathrm{C}\right)$ and altitudes up to $6600 \mathrm{ft}(2000 \mathrm{~m})$ above mean sea level (MSL). If the enclosed drives are operated at ambient temperatures above $113^{\circ} \mathrm{F}\left(40^{\circ} \mathrm{C}\right)$, the output current must be decreased. Ambient temperatures above $122{ }^{\circ} \mathrm{F}\left(50^{\circ} \mathrm{C}\right)$ are not permissible. The following tables indicate the permissible output current as a function of the ambient temperature for the different degrees of protection.

Table 12-2 Current derating factors as a function of the ambient temperature (inlet air temperature at the air inlet of the drive) for enclosed drives in a NEMA 1 enclosure

| Installation altitude above sea level | Current derating factor <br> at an ambient temperature (air intake temperature) of |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} 68^{\circ} \mathrm{F} \\ \left(20^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{gathered} 77^{\circ} \mathrm{F} \\ \left(25^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{gathered} 86^{\circ} \mathrm{F} \\ \left(30^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{gathered} 95^{\circ} \mathrm{F} \\ \left(35^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{aligned} & 104{ }^{\circ} \mathrm{F} \\ & \left(40^{\circ} \mathrm{C}\right) \end{aligned}$ | $\begin{aligned} & 113^{\circ} \mathrm{F} \\ & \left(45^{\circ} \mathrm{C}\right) \end{aligned}$ | $\begin{aligned} & 122{ }^{\circ} \mathrm{F} \\ & \left(50^{\circ} \mathrm{C}\right) \end{aligned}$ |
| $0 \ldots 6600 \mathrm{ft}(0 \ldots 2000 \mathrm{~m})$ | 100 \% | 100 \% | 100 \% | 100 \% | 100 \% | 93.3 \% | 86.7 \% |

Table 12-3 Current derating factors as a function of the ambient temperature (inlet air temperature at the air inlet of the drive) for enclosed drives in a NEMA 12 enclosure

| Installation altitude above sea level | Current derating factor at an ambient temperature (air intake temperature) of |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} 68^{\circ} \mathrm{F} \\ \left(20^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{gathered} 77^{\circ} \mathrm{F} \\ \left(25^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{gathered} 86^{\circ} \mathrm{F} \\ \left(30^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{gathered} 95^{\circ} \mathrm{F} \\ \left(35^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{aligned} & 104^{\circ} \mathrm{F} \\ & \left(40^{\circ} \mathrm{C}\right) \end{aligned}$ | $\begin{aligned} & 113{ }^{\circ} \mathrm{F} \\ & \left(45^{\circ} \mathrm{C}\right) \end{aligned}$ | $\begin{aligned} & 122{ }^{\circ} \mathrm{F} \\ & \left(50^{\circ} \mathrm{C}\right) \end{aligned}$ |
| 0 ... $6600 \mathrm{ft}(0 \ldots 2000 \mathrm{~m})$ | 100 \% | 100 \% | 100 \% | 100 \% | 93.3 \% | 86.7 \% | 80.0 \% |

### 12.2.1.2 Installation altitudes over 6.600 ft and up to 16.500 ft above MSL

When operating SINAMICS G150 NEMA enclosed drives at altitudes over 6,600 ft ( $2,000 \mathrm{~m}$ ) above MSL, keep in mind that as the altitude increases, the air pressure and therefore also the density of the air decrease. As a result of the drop in air density the cooling effect and the insulation strength of the air are reduced.

The drive units can be installed at altitudes over 6,600 ft and up to $16,500 \mathrm{ft}(2000 \mathrm{~m}$ to 5000 m ) if the following measures are applied.

## Decreasing the ambient temperature and the output current

Due to the reduced cooling efficiency, it is necessary, on the one hand, to reduce the ambient temperature and, on the other hand, to lower heat loss in the enclosed drive by reducing the output current, whereby ambient temperatures lower than $104^{\circ} \mathrm{F}\left(40^{\circ} \mathrm{C}\right)$ may be offset for compensation purposes and are taken into account in the tables. The following tables indicate the permissible output currents as a function of the installation height and ambient temperature for the different degrees of protection. The specified values already include the permissible compensation between installation altitude and ambient temperatures lower than $104^{\circ} \mathrm{F}\left(40^{\circ} \mathrm{C}\right)$ (incoming air temperature at the inlet to the enclosed drive). Theses values are only applicable if the cabinet installation provides a flow of cooling air through the drive units as indicated in the technical specifications.

Table 12-4 Current derating as a function of the ambient temperature (inlet air temperature at the air inlet of the enclosed drive) and installation altitude for enclosed drives in a NEMA 1 enclosure

| Installation altitude above mean sea level | Current derating factor <br> at an ambient temperature (air intake temperature) of |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} 68^{\circ} \mathrm{F} \\ \left(20^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{gathered} 77^{\circ} \mathrm{F} \\ \left(25^{\circ} \mathrm{C}\right) \\ \hline \end{gathered}$ | $\begin{gathered} 86^{\circ} \mathrm{F} \\ \left(30^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{gathered} 95^{\circ} \mathrm{F} \\ \left(35^{\circ} \mathrm{C}\right) \\ \hline \end{gathered}$ | $\begin{aligned} & 104{ }^{\circ} \mathrm{F} \\ & \left(40^{\circ} \mathrm{C}\right) \\ & \hline \end{aligned}$ | $\begin{aligned} & 113^{\circ} \mathrm{F} \\ & \left(45^{\circ} \mathrm{C}\right) \\ & \hline \end{aligned}$ | $\begin{aligned} & 122{ }^{\circ} \mathrm{F} \\ & \left(50^{\circ} \mathrm{C}\right) \end{aligned}$ |
| 0 ... 6600 ft (0 ... 2000 m ) | 100 \% | 100 \% | 100 \% | 100 \% | 100 \% | 93.3 \% | 86.7 \% |
| ... $8250 \mathrm{ft}(\ldots 2500 \mathrm{~m})$ | 100 \% | 100 \% | 100 \% | 100 \% | 96.3 \% |  |  |
| ... $9900 \mathrm{ft}(\ldots 3000 \mathrm{~m})$ | 100 \% | 100 \% | 100 \% | 98.7 \% |  |  |  |
| ... $11550 \mathrm{ft}(\ldots 3500 \mathrm{~m})$ | 100 \% | 100 \% | 100 \% |  |  |  |  |
| ... $13200 \mathrm{ft}(\ldots 4000 \mathrm{~m})$ | 100 \% | 100 \% | 96.3 \% |  |  |  |  |
| ... $14850 \mathrm{ft}(\ldots 4500 \mathrm{~m})$ | 100 \% | 97.5 \% |  |  |  |  |  |
| ... 16500 ft (... 5000 m ) | 98.2 \% |  |  |  |  |  |  |

Table 12-5 Current derating as a function of the ambient temperature (inlet air temperature at the air inlet of the enclosed drive) and installation altitude for enclosed drives in a NEMA 12 enclosure

| Installation altitude above mean sea level in $m$ | Current derating factor at an ambient temperature (air intake temperature) of |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} 68^{\circ} \mathrm{F} \\ \left(20^{\circ} \mathrm{C}\right) \\ \hline \end{gathered}$ | $\begin{gathered} 77^{\circ} \mathrm{F} \\ \left(25^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{gathered} 86^{\circ} \mathrm{F} \\ \left(30^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{gathered} 95^{\circ} \mathrm{F} \\ \left(35^{\circ} \mathrm{C}\right) \end{gathered}$ | $\begin{aligned} & 104^{\circ} \mathrm{F} \\ & \left(40^{\circ} \mathrm{C}\right) \end{aligned}$ | $\begin{aligned} & 113^{\circ} \mathrm{F} \\ & \left(45^{\circ} \mathrm{C}\right) \end{aligned}$ | $\begin{aligned} & 122^{\circ} \mathrm{F} \\ & \left(50^{\circ} \mathrm{C}\right) \end{aligned}$ |
| 0 ... $6600 \mathrm{ft}(0 \ldots 2000 \mathrm{~m})$ | 100 \% | 100 \% | 100 \% | 100 \% | 93.3 \% | 86.7 \% | 80.0 \% |
| ... $8250 \mathrm{ft}(\ldots 2500 \mathrm{~m})$ | 100 \% | 100 \% | 100 \% | 96.3 \% | 89.8 \% |  |  |
| ... $9900 \mathrm{ft}(\ldots 3000 \mathrm{~m})$ | 100 \% | 100 \% | 98.7 \% | 92.5 \% |  |  |  |
| ... $11550 \mathrm{ft}(\ldots 3500 \mathrm{~m})$ | 100 \% | 100 \% | 94.7 \% |  |  |  |  |
| ... $13200 \mathrm{ft} \mathrm{(..}$.4000 m ) | 100 \% | 96.3 \% | 90.7 \% |  |  |  |  |
| ... $14850 \mathrm{ft} \mathrm{(..}$.4500 m ) | 97.5 \% | 92.1 \% |  |  |  |  |  |
| ... $16500 \mathrm{ft}(\ldots 5000 \mathrm{~m})$ | 93.0 \% |  |  |  |  |  |  |

## Use of an isolation transformer to reduce transient overvoltages to IEC 61800-5-1

This reduces overvoltage category III to overvoltage category II, which lowers the air insulation capacity requirements. An additional (input) voltage derating is not necessary if the following basic conditions are met:

- The isolation transformer must be fed from a low-voltage or medium-voltage network; it must not be supplied directly from a high-voltage network.
- It is permissible to use the isolation transformer to supply one or more enclosed drives.
- The lines between the isolation transformer and the enclosed drive(s) must be installed in such as way that the possibility of a direct lightning strike is ruled out; in other words, overhead lines must not be used.
- The following power network configurations are permissible:
- TN power networks with grounded star point (no grounded phase conductor)
- IT power networks (operation with a ground fault must be limited to the shortest time possible)


### 12.2.1.3 Current derating as a function of the pulse frequency

When the pulse frequency is increased, the derating factor of the output current must be taken into account. This derating factor must be applied to the currents specified in the technical data for the enclosed drives.

Table 12-6 Derating factor of the output current as a function of the pulse frequency for devices with a rated pulse frequency of 2 kHz

| Article no. | Type rating | Output current | Derating factor for pulse frequency |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 6SL3710-... | [hp / kW] | [A] | 2.5 kHz | 4 kHz | 5 kHz | 7.5 kHz | 8 kHz |
| Supply voltage 380 to 480 V AC, 3 phase |  |  |  |  |  |  |  |
| 1GE32-1_U3 | 150 / 110 | 210 | 95 \% | 82 \% | 74 \% | 54 \% | 50 \% |
| 1GE32-6_U3 | 200 / 132 | 260 | 95 \% | 83 \% | 74 \% | 54 \% | 50 \% |
| 1GE33-1_U3 | 250 / 160 | 310 | 97 \% | 88 \% | 78 \% | 54 \% | 50 \% |
| 1GE33-8_U3 | 300 / 200 | 380 | 96 \% | 87 \% | 77 \% | 54 \% | 50 \% |
| 1GE35-0_U3 | 400 / 250 | 490 | 94 \% | 78 \% | 71 \% | 53 \% | 50 \% |

Table 12-7 Derating factor of the output current as a function of the pulse frequency for devices with a rated pulse frequency of 1.25 kHz

| Article no. | Type rating | Output current | Derating factor for pulse frequency |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 6SL3710-... | [hp / kW] | [A] | 2 kHz | 2.5 kHz | 4 kHz | 5 kHz | 7.5 kHz |
| Supply voltage 380 to 480 V AC, 3 phase |  |  |  |  |  |  |  |
| 1GE36-1_U3 | $500 / 315$ | 605 | 83 \% | 72 \% | 64 \% | 60 \% | 40 \% |
| 1GE37-5_U3 | 600 / 400 | 745 | 83 \% | 72 \% | 64 \% | 60 \% | 40 \% |
| 1GE38-4_U3 | $700 / 450$ | 840 | 87 \% | 79 \% | 64 \% | 55 \% | 40 \% |
| 1GE41-0_U3 | 800 / 560 | 985 | 92 \% | 87 \% | 70 \% | 60 \% | 50 \% |
| Supply voltage 500 to 600 V AC, 3 phase |  |  |  |  |  |  |  |
| 1GF31-8_U3 | 150 / 110 | 175 | 92 \% | 87 \% | 70 \% | 60 \% | 40 \% |
| 1GF32-2_U3 | 200 / 132 | 215 | 92 \% | 87 \% | 70 \% | 60 \% | 40 \% |
| 1GF32-6_U3 | 250 / 160 | 260 | 92 \% | 88 \% | 71 \% | 60 \% | 40 \% |
| 1GF33-3_U3 | 300 / 200 | 330 | 89 \% | 82 \% | 65 \% | 55 \% | 40 \% |
| 1GF34-1_U3 | 400 / 250 | 410 | 89 \% | 82 \% | 65 \% | 55 \% | 35 \% |
| 1GF34-7_U3 | 450 / 315 | 465 | 92 \% | 87 \% | 67 \% | 55 \% | 35 \% |
| 1GF35-8_U3 | 600 / 400 | 575 | 91 \% | 85 \% | 64 \% | 50 \% | 35 \% |
| 1GF37-4_U3 | 700 / 500 | 735 | 87 \% | 79 \% | 64 \% | 55 \% | 35 \% |
| 1GF38-1_U3 | 800 / 560 | 810 | 83 \% | 72 \% | 61 \% | 55 \% | 35 \% |

## Note

Derating factors for pulse frequencies in the range between fixed values
The relevant derating factors can be determined by linear interpolation for pulse frequencies in the range between the specified fixed values.

### 12.2.2 Overload capability

The drive is equipped with an overload reserve to deal with breakaway torques, for example.
In drives with overload requirements, the appropriate base-load current must therefore be used as a basis for the required load.
The overloads apply under the precondition that the converter is operated at its base-load current before and after the overload (a duty cycle duration of 300 s is used as a basis here).

Another precondition is that the frequency converter is operated at its factory-set pulse frequency at output frequencies $>10 \mathrm{~Hz}$.
For additional information on overload capability, see the Low Voltage configuration manual.

## Low overload

The base-load current for low overload (L) is based on a load duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s .


Figure 12-1 Low overload

## High overload

The base-load current for a high overload $\mathrm{I}_{\mathrm{H}}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s .

Drive current


Figure 12-2 High overload

### 12.3 Technical specifications

## Note

## Notes on the technical specifications

Current, voltage and power figures in these tables are rated values.
The cables to the device are protected by fuses of operating class gG .
The cable cross-sections have been determined for three-core copper cables routed horizontally in air at $104^{\circ} \mathrm{F}\left(40^{\circ} \mathrm{C}\right)$ ambient temperature (according to DIN VDE 0276-1000 and IEC 60364-5-52) with a permissible operating temperature of $158{ }^{\circ} \mathrm{F}\left(70^{\circ} \mathrm{C}\right)$ (e.g. Protodur NYY or NYCWY) and the recommended cable protection according to DIN VDE 0100 section 430 and IEC 60364-4-43.

## NOTICE

## Material damage caused by impermissible cable temperatures

The improper laying of cables can produce short-circuits caused by damage of the insulation that result from excessive temperatures.

When the conditions differ from the above stated (cable routing, cable grouping, ambient temperature), the following instructions for routing the cables must be taken into account:

- The cable cross-section required depends on the current being conducted in the cable.
- The permissible current load capability of cables is defined in IEC 60364-5-52, for example. It depends partly on ambient conditions such as temperature and partly on the type of routing. If the cables are routed individually, they will be cooled relatively well. If several cables are routed together, they may heat each other up. The corresponding derating factors for these boundary conditions is provided in IEC 60364-5-52.


### 12.3 Technical specifications

### 12.3.1 Enclosed drive type A, 380 V-480 V 3 AC

Table 12-8 Type A, 380 to 480 V AC, 3 phase, part 1

| Article number | 6SL3710- | 1GE32-1AU3 | 1GE32-6AU3 | 1GE33-1AU3 |
| :---: | :---: | :---: | :---: | :---: |
| Rated motor output at $400 \mathrm{~V}, 50 \mathrm{~Hz}$ at $460 \mathrm{~V}, 60 \mathrm{~Hz}$ | $\begin{aligned} & \text { kW } \\ & \text { HP } \end{aligned}$ | $\begin{aligned} & 110 \\ & 150 \end{aligned}$ | $\begin{aligned} & 132 \\ & 200 \end{aligned}$ | $\begin{aligned} & 160 \\ & 250 \end{aligned}$ |
| Rated input voltage | V | 380 to 480 V AC , 3 phase $\pm 10 \%(-15 \%<1 \mathrm{~min})$ |  |  |
| Rated input current ${ }^{1)}$ | A | 239 | 294 | 348 |
| Rated output current | A | 210 | 260 | 310 |
| Base-load current $\mathrm{lL}^{2}{ }^{\text {) }}$ | A | 205 | 250 | 302 |
| Base-load current $\mathrm{lH}^{3}$ ) | A | 178 | 233 | 277 |
| Max. output frequency ${ }^{4}$ | Hz | 160 | 160 | 160 |
| Power loss | kW | 2.9 | 3.8 | 4.4 |
| Cooling air requirement | $\begin{aligned} & \text { CFM } \\ & \mathrm{m}^{3} / \mathrm{s} \end{aligned}$ | $\begin{array}{\|l\|} \hline 360 \\ 0.17 \end{array}$ | $\begin{array}{\|l\|} \hline 487 \\ 0.23 \end{array}$ | $\begin{aligned} & 763 \\ & 0.36 \end{aligned}$ |
| Sound pressure level at $50 / 60 \mathrm{~Hz}$ | $\mathrm{dB}(\mathrm{A})$ | 67/68 | 69/73 | 69/73 |
| Line connection |  | $2 \times 3 / 0$ AWG to $250 \mathrm{kcmil}{ }^{6}$ | $\begin{aligned} & 2 \times 3 / 0 \mathrm{AWG} \\ & \text { to } 250 \mathrm{kcmil}^{6} \end{aligned}$ | $2 \times 2$ AWG to 600 kcmil 7$)$ |
| Motor connection |  | $2 \times 3 / 0$ AWG to 500 kcmil | $\begin{aligned} & 2 \times 3 / 0 \mathrm{AWG} \\ & \text { to } 500 \mathrm{kcmil} \end{aligned}$ | $2 \times 3 / 0$ AWG to 500 kcmil |
| Approx. weight (standard version) | $\begin{array}{\|l\|l\|} \hline \mathrm{lb} \\ \mathrm{~kg} \\ \hline \end{array}$ | $\begin{aligned} & 950 \\ & 430 \end{aligned}$ | $\begin{aligned} & 950 \\ & 430 \end{aligned}$ | $\begin{aligned} & 1250 \\ & 570 \\ & \hline \end{aligned}$ |
| Power block frame size |  | FX | FX | GX |
| Dimensions (standard version) width x height x depth | inch <br> mm | $\begin{aligned} & 39.4 \times 94.5 \times 23.6 \\ & 1000 \times 2400 \times 600 \end{aligned}$ | $\begin{array}{\|l} 39.4 \times 94.5 \times 23.6 \\ 1000 \times 2400 \times 600 \end{array}$ | $\begin{aligned} & 39.4 \times 94.5 \times 23.6 \\ & 1000 \times 2400 \times 600 \end{aligned}$ |
| Fuse type per phase ${ }^{5)}$ <br> Rated current <br> Frame size acc. to IEC 60269 <br> UL file no. E167357 | A | $\begin{aligned} & \text { 3NE1230-2 } \\ & 315 \\ & 1 \end{aligned}$ | $\begin{aligned} & \text { 3NE1331-2 } \\ & 350 \\ & 2 \end{aligned}$ | $\begin{aligned} & \text { 3NE1334-2 } \\ & 500 \\ & 2 \end{aligned}$ |
| SCCR (short circuit current rating) for G150 type A acc. to UL508A file no. E83449 | kA IC | 65 | 65 | 65 |
| Minimum short-circuit current ${ }^{8)}$ | A | 3000 | 3600 | 4400 |

1) The input current is based on the rated output current and includes 10 A for optional external auxiliaries.
2) The base-load current $I_{L}$ is based on a duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
3) The base-load current $I_{H}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
4) Maximum output frequency at factory-set default pulse frequency (for information on increasing the output frequency, see "Functions, monitoring and protective functions/Increasing the output frequency"; for information on derating data, see "Derating data").
5) The SCCR value of the enclosed drive is based on the fuses listed. Substitutes are not permitted.
6) Stripped lengths of the power cables: front 0.71 " ( 18 mm ), rear 1.46 " ( 37 mm ).

Tightening torque: $275 \mathrm{lb} . \mathrm{in}$. ( 31 Nm ).
7) Stripped lengths of the power cables: front 1" ( 25.4 mm ), rear 2" ( 50.8 mm ).

Tightening torque: $375 \mathrm{lb} . \mathrm{in}$. ( 42.4 Nm ).
8) Minimum current required for reliable triggering of the protective devices.

Table 12-9 Type A, 380 to 480 V AC, 3 phase, part 2

| Article number | 6SL3710- | 1GE33-8AU3 | 1GE35-0AU3 | 1GE36-1AU3 |
| :---: | :---: | :---: | :---: | :---: |
| Rated motor output at $400 \mathrm{~V}, 50 \mathrm{~Hz}$ at $460 \mathrm{~V}, 60 \mathrm{~Hz}$ | $\begin{aligned} & \text { kW } \\ & \text { HP } \end{aligned}$ | $\begin{aligned} & 200 \\ & 300 \end{aligned}$ | $\begin{aligned} & 250 \\ & 400 \end{aligned}$ | $\begin{aligned} & 315 \\ & 500 \end{aligned}$ |
| Rated input voltage | V | 380 to 480 V AC , 3 phase $\pm 10 \%(-15 \%<1 \mathrm{~min}$ ) |  |  |
| Rated input current ${ }^{1)}$ | A | 405 | 519 | 639 |
| Rated output current | A | 380 | 490 | 605 |
| Base-load current $\mathrm{lL}^{2}$ ) | A | 370 | 477 | 590 |
| Base-load current $\mathrm{lH}^{3}$ ) | A | 340 | 438 | 460 |
| Max. output frequency ${ }^{4)}$ | Hz | 160 | 160 | 100 |
| Power loss | kW | 5.3 | 6.4 | 8.2 |
| Cooling air requirement | $\begin{aligned} & \mathrm{CFM} \\ & \mathrm{~m}^{3} / \mathrm{s} \end{aligned}$ | $\begin{array}{\|l\|} \hline 763 \\ 0.36 \end{array}$ | $\begin{array}{\|l\|} \hline 763 \\ 0.36 \end{array}$ | $\begin{aligned} & 1653 \\ & 0.78 \end{aligned}$ |
| Sound pressure level at $50 / 60 \mathrm{~Hz}$ | $\mathrm{dB}(\mathrm{A})$ | 69/73 | 69/73 | 70/73 |
| Line connection |  | $\begin{array}{\|l\|} \hline 2 \times 2 \text { AWG } \\ \text { to } 600 \mathrm{kcmil} \\ \hline \end{array}$ | $\begin{array}{\|l\|} \hline 3 \times 1 / 0 \mathrm{AWG} \\ \text { to } 500 \mathrm{kcmil}{ }^{6} \end{array}$ | $\begin{aligned} & 3 \times 1 / 0 \mathrm{AWG} \\ & \text { to } 500 \mathrm{kcmil}^{6} \text { ) } \end{aligned}$ |
| Motor connection |  | $2 \times 3 / 0 \text { AWG }$ $\text { to } 500 \mathrm{kcmil}$ | $3 \times 1 / 0 \text { AWG }$ $\text { to } 500 \text { kcmil }$ | $3 \times 2 / 0 \text { AWG }$ <br> to 500 kcmil |
| Approx. weight (standard version) | $\begin{array}{\|l} \hline \mathrm{lb} \\ \mathrm{~kg} \\ \hline \end{array}$ | $\begin{aligned} & 1250 \\ & 570 \end{aligned}$ | $\begin{aligned} & 1250 \\ & 570 \end{aligned}$ | $\begin{aligned} & 2000 \\ & 900 \end{aligned}$ |
| Power block frame size |  | GX | GX | HX |
| Dimensions (standard version) width x height x depth | inch mm | $\begin{aligned} & 39.4 \times 94.5 \times 23.6 \\ & 1000 \times 2400 \times 600 \end{aligned}$ | $\begin{array}{\|l\|} \hline 39.4 \times 94.5 \times 23.6 \\ 1000 \times 2400 \times 600 \\ \hline \end{array}$ | $\begin{aligned} & 47.2 \times 94.5 \times 23.6 \\ & 1200 \times 2400 \times 600 \end{aligned}$ |
| Fuse type per phase ${ }^{5)}$ <br> Rated current <br> Frame size acc. to IEC 60269 <br> UL file no. E167357 | A | $\begin{aligned} & \text { 3NE1334-2 } \\ & 500 \\ & 2 \end{aligned}$ | $\begin{aligned} & \hline \text { 3NE1436-2 } \\ & 630 \\ & 3 \end{aligned}$ | $\begin{aligned} & \text { 3NE1438-2 } \\ & 800 \\ & 3 \end{aligned}$ |
| SCCR (short circuit current rating) for G150 type A acc. to UL508A file no. E83449 | kA IC | 65 | 65 | 65 |
| Minimum short-circuit current ${ }^{7}$ | A | 4400 | 8000 | 10000 |

1) The input current is based on the rated output current and includes 10 A for optional external auxiliaries.
2) The base-load current $I_{L}$ is based on a duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
3) The base-load current $l_{H}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
4) Maximum output frequency at factory-set default pulse frequency (for information on increasing the output frequency, see "Functions, monitoring and protective functions/Increasing the output frequency"; for information on derating data, see "Derating data").
${ }^{5)}$ The SCCR value of the enclosed drive is based on the fuses listed. Substitutes are not permitted.
5) Stripped lengths of the power cables: front 1" ( 25.4 mm ), rear 2" ( 50.8 mm ).

Tightening torque: $375 \mathrm{lb} . \mathrm{in}$. ( 42.4 Nm ).
7) Minimum current required for reliable triggering of the protective devices.

### 12.3 Technical specifications

Table 12-10 Type A, 380 to 480 V AC, 3 phase, part 3

| Article number | 6SL3710- | 1GE37-5AU3 | 1GE38-4AU3 | 1GE41-0AU3 |
| :---: | :---: | :---: | :---: | :---: |
| Rated motor output at $400 \mathrm{~V}, 50 \mathrm{~Hz}$ at $460 \mathrm{~V}, 60 \mathrm{~Hz}$ | $\begin{aligned} & \text { kW } \\ & \text { HP } \end{aligned}$ | $\begin{aligned} & 400 \\ & 600 \end{aligned}$ | $\begin{aligned} & 450 \\ & 700 \\ & \hline \end{aligned}$ | $\begin{array}{\|l} 560 \\ 800 \\ \hline \end{array}$ |
| Rated input voltage | V | 380 to 480 V AC , 3 phase $\pm 10 \%(-15 \%<1 \mathrm{~min})$ |  |  |
| Rated input current ${ }^{1)}$ | A | 785 | 883 | 1034 |
| Rated output current | A | 745 | 840 | 985 |
| Base-load current lı ${ }^{2}$ | A | 725 | 820 | 960 |
| Base-load current $\mathrm{IH}^{3}$ ) | A | 570 | 700 | 860 |
| Max. output frequency ${ }^{4}$ | Hz | 100 | 100 | 100 |
| Power loss | kW | 9.6 | 10.1 | 14.4 |
| Cooling air requirement | $\begin{aligned} & \text { CFM } \\ & \mathrm{m}^{3} / \mathrm{s} \end{aligned}$ | $\begin{aligned} & 1653 \\ & 0.78 \end{aligned}$ | $\begin{aligned} & 1653 \\ & 0.78 \end{aligned}$ | $\begin{aligned} & 3136 \\ & 1.48 \end{aligned}$ |
| Sound pressure level at $50 / 60 \mathrm{~Hz}$ | $\mathrm{dB}(\mathrm{A})$ | 70/73 | 70/73 | 72/75 |
| Line connection |  | $4 \times 2 / 0$ AWG to $600 \mathrm{kcmil}{ }^{6}$ | $4 \times 2 / 0$ AWG to $600 \mathrm{kcmil}{ }^{6)}$ | $4 \times 2 / 0$ AWG to $600 \mathrm{kcmil}{ }^{6}$ |
| Motor connection |  | $3 \times 2 / 0$ AWG to 500 kcmil | $4 \times 2 / 0$ AWG to 600 kcmil | $4 \times 2 / 0$ AWG to 600 kcmil |
| Approx. weight (standard version) | $\begin{array}{\|l} \hline \mathrm{lb} \\ \mathrm{~kg} \\ \hline \end{array}$ | $\begin{aligned} & 2000 \\ & 900 \end{aligned}$ | $\begin{aligned} & 2000 \\ & 900 \end{aligned}$ | $\begin{aligned} & 3100 \\ & 1400 \end{aligned}$ |
| Power block frame size |  | HX | HX | JX |
| Dimensions (standard version) width x height x depth | inch <br> mm | $\begin{aligned} & 47.2 \times 94.5 \times 23.6 \\ & 1200 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 47.2 \times 94.5 \times 23.6 \\ & 1200 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 63 \times 94.5 \times 23.6 \\ & 1600 \times 2400 \times 600 \end{aligned}$ |
| Fuse type per phase ${ }^{5)}$ <br> Rated current <br> Frame size acc. to IEC 60269 <br> UL file no. E167357 | A | $\begin{aligned} & \text { 3NE1448-2 } \\ & 850 \\ & 3 \end{aligned}$ | $\begin{aligned} & 2 \times 3 \text { NE } 1436-2 \\ & 2 \times 630 \\ & 3 \end{aligned}$ | $\begin{aligned} & 2 \times 3 \text { NE } 1437-2 \\ & 2 \times 710 \\ & 3 \end{aligned}$ |
| SCCR (short circuit current rating) for G150 type A acc. to UL508A file no. E83449 | kA IC | 65 | 65 | 65 |
| Minimum short-circuit current ${ }^{7}$ | A | 10500 | 16,000 | 18400 |

${ }^{1)}$ The input current is based on the rated output current and includes 10 A for optional external auxiliaries.
2) The base-load current $I_{L}$ is based on a duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
3) The base-load current $l_{H}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
4) Maximum output frequency at factory-set default pulse frequency (for information on increasing the output frequency, see "Functions, monitoring and protective functions/Increasing the output frequency"; for information on derating data, see "Derating data").
5) The SCCR value of the enclosed drive is based on the fuses listed. Substitutes are not permitted.
6) Stripped lengths of the power cables: front 1" ( 25.4 mm ), rear 2" ( 50.8 mm ).

Tightening torque: $375 \mathrm{lb} . \mathrm{in}$. (42.4 Nm).
7) Minimum current required for reliable triggering of the protective devices.

### 12.3.2 Enclosed chassis type C, 380 V - 480 V 3 AC

Table 12-11 Type C, 380 to 480 V AC, 3 phase, part 1

| Article number | 6SL3710- | 1GE32-1CU3 | 1GE32-6CU3 | 1GE33-1CU3 |
| :---: | :---: | :---: | :---: | :---: |
| Rated motor output at $400 \mathrm{~V}, 50 \mathrm{~Hz}$ at $460 \mathrm{~V}, 60 \mathrm{~Hz}$ | $\begin{aligned} & \text { kW } \\ & \mathrm{HP} \end{aligned}$ | $\begin{array}{\|l\|} \hline 110 \\ 150 \\ \hline \end{array}$ | $\begin{aligned} & 132 \\ & 200 \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|} \hline 160 \\ 250 \\ \hline \end{array}$ |
| Rated input voltage | V | 380 to 480 V AC , 3 phase $\pm 10 \%(-15 \%<1 \mathrm{~min}$ ) |  |  |
| Rated input current ${ }^{1)}$ | A | 229 | 284 | 338 |
| Rated output current | A | 210 | 260 | 310 |
| Base-load current $\mathrm{IL}^{2}$ ) | A | 205 | 250 | 302 |
| Base-load current $\mathrm{lH}^{3}$ ) | A | 178 | 233 | 277 |
| Max. output frequency ${ }^{4)}$ | Hz | 100 | 100 | 100 |
| Power loss | kW | 2.9 | 3.8 | 4.4 |
| Cooling air requirement | $\begin{aligned} & \text { CFM } \\ & \mathrm{m}^{3} / \mathrm{s} \end{aligned}$ | $\begin{array}{\|l} 360 \\ 0.17 \end{array}$ | $\begin{array}{\|l\|} 487 \\ 0.23 \end{array}$ | $\begin{array}{\|l} 763 \\ 0.36 \end{array}$ |
| Sound pressure level at $50 / 60 \mathrm{~Hz}$ | $\mathrm{dB}(\mathrm{A})$ | 67/68 | 69/73 | 69/73 |
| Line connection |  | $2 \times 3 / 0 \mathrm{AWG}$ <br> to 250 kcmil | $2 \times 3 / 0 \text { AWG }$ $\text { to } 250 \text { kcmil }$ | $\begin{aligned} & 2 \times 2 \mathrm{AWG} \\ & \text { to } 600 \mathrm{kcmil} \end{aligned}$ |
| Motor connection |  | $2 \times 3 / 0 \mathrm{AWG}$ $\text { to } 500 \text { kcmil }$ | $2 \times 3 / 0 \mathrm{AWG}$ $\text { to } 500 \text { kcmil }$ | $\begin{aligned} & 2 \times 3 / 0 \mathrm{AWG} \\ & \text { to } 500 \mathrm{kcmil} \end{aligned}$ |
| Approx. weight (standard version) | $\begin{array}{\|l\|} \hline \mathrm{lb} \\ \mathrm{~kg} \end{array}$ | $\begin{aligned} & 480 \\ & 220 \end{aligned}$ | $\begin{aligned} & 480 \\ & 220 \end{aligned}$ | $\begin{array}{\|l\|l} 640 \\ 290 \end{array}$ |
| Power block frame size |  | FX | FX | GX |
| Dimensions (standard version) width x height x depth | inch <br> mm | $\begin{aligned} & 15.8 \times 94.5 \times 23.6 \\ & 400 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 15.8 \times 94.5 \times 23.6 \\ & 400 \times 2400 \times 600 \\ & \hline \end{aligned}$ | $\begin{aligned} & 15.8 \times 94.5 \times 23.6 \\ & 400 \times 2400 \times 600 \end{aligned}$ |
| Circuit breaker max. current rating | A | 500 | 600 | 700 |
| Recommended fuse type per phase ${ }^{5)}$ Rated current <br> Frame size acc. to IEC 60269 UL file no. E167357 | A | $\begin{aligned} & \text { 3NE1230-2 } \\ & 315 \\ & 1 \end{aligned}$ | $\begin{aligned} & \text { 3NE1331-2 } \\ & 350 \\ & 2 \end{aligned}$ | $\begin{aligned} & \text { 3NE1334-2 } \\ & 500 \\ & 2 \end{aligned}$ |
| Recommended fuse base per phase ${ }^{5)}$, UL file no. E171267 |  | 3NH3320 | 3NH3320 | 3NH3420 |


| Article number | 6SL3710- | 1GE32-1CU3 | 1GE32-6CU3 | 1GE33-1CU3 |
| :--- | :--- | :--- | :--- | :--- |
| SCCR (short circuit current rating) for <br> G150 type C | kA IC | 65 | 65 | 65 |
| acc. to UL508A file no. E83449 when <br> the fuses and fuse bases listed above <br> and a UL-listed circuit breaker are <br> used |  |  |  |  |
| Minimum short-circuit current 6 ) | A | 3000 | 3600 | 4400 |

1) The input current is based on the rated output current.
${ }^{2)}$ The base-load current $I_{L}$ is based on a duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
2) The base-load current $l_{H}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
3) Maximum output frequency at factory-set default pulse frequency (for information on increasing the output frequency, see "Functions, monitoring and protective functions/Increasing the output frequency"; for information on derating data, see "Derating data").
4) To obtain the SCCR value for the enclosed drive, it is necessary to use the fuses with fuse base listed above. Substitutes are not permitted. Also, the UL-listed circuit breaker with minimum SCCR of $65 \mathrm{kA}, 480 \mathrm{~V}$ AC for motor branch circuit protection may not exceed the current rating shown.
5) Minimum current required for reliable triggering of the protective devices.

Table 12-12 Type C, 380 to 480 V AC, 3 phase, part 2

| Article number | 6SL3710- | 1GE33-8CA3 | 1GE35-0CA3 | 1GE36-1CA3 |
| :---: | :---: | :---: | :---: | :---: |
| Rated motor output at $400 \mathrm{~V}, 50 \mathrm{~Hz}$ at $460 \mathrm{~V}, 60 \mathrm{~Hz}$ | $\begin{aligned} & \text { kW } \\ & \text { HP } \end{aligned}$ | $\begin{aligned} & 200 \\ & 300 \\ & \hline \end{aligned}$ | $\begin{aligned} & 250 \\ & 400 \\ & \hline \end{aligned}$ | $\begin{array}{r} 315 \\ 500 \\ \hline \end{array}$ |
| Rated input voltage | V | 380 to 480 V AC , 3 phase $\pm 10 \%(-15 \%<1 \mathrm{~min})$ |  |  |
| Rated input current ${ }^{1)}$ | A | 395 | 509 | 629 |
| Rated output current | A | 380 | 490 | 605 |
| Base-load current lı ${ }^{2}$ | A | 370 | 477 | 590 |
| Base-load current $\mathrm{lH}^{3}$ ) | A | 340 | 438 | 460 |
| Max. output frequency ${ }^{4}$ | Hz | 100 | 100 | 100 |
| Power loss | kW | 5.3 | 6.4 | 8.2 |
| Cooling air requirement | $\begin{aligned} & \mathrm{CFM} \\ & \mathrm{~m}^{3} / \mathrm{s} \end{aligned}$ | $\begin{array}{\|l\|} \hline 763 \\ 0.36 \end{array}$ | $\begin{array}{\|l} \hline 763 \\ 0.36 \end{array}$ | $\begin{aligned} & 1653 \\ & 0.78 \end{aligned}$ |
| Sound pressure level at $50 / 60 \mathrm{~Hz}$ | $\mathrm{dB}(\mathrm{A})$ | 69/73 | 69/73 | 70/73 |
| Line connection |  | $2 \times 2$ AWG <br> to 600 kcmil | $2 \times 1 / 0$ AWG to 500 kcmil | $3 \times 1 / 0$ AWG to 500 kcmil |
| Motor connection |  | $2 \times 3 / 0 \text { AWG }$ $\text { to } 500 \text { kcmil }$ | $2 \times 1 / 0$ AWG to 500 kcmil | $3 \times 2 / 0$ AWG <br> to 500 kcmil |
| Approx. weight (standard version) | $\begin{array}{\|l} \hline \mathrm{lb} \\ \mathrm{~kg} \end{array}$ | $\begin{aligned} & 640 \\ & 290 \end{aligned}$ | $\begin{aligned} & 640 \\ & 290 \end{aligned}$ | $\begin{aligned} & 1400 \\ & 640 \end{aligned}$ |
| Power block frame size |  | GX | GX | HX |
| Dimensions (standard version) width x height x depth | inch <br> mm | $\begin{aligned} & 15.8 \times 94.5 \times 23.6 \\ & 400 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 15.8 \times 94.5 \times 23.6 \\ & 400 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 23.6 \times 94.5 \times 23.6 \\ & 600 \times 2400 \times 600 \\ & \hline \end{aligned}$ |
| Circuit breaker max. current rating | A | 800 | 1200 | 1200 |
| Recommended fuse type per phase ${ }^{5)}$ Rated current <br> Frame size acc. to IEC 60269 UL file no. E167357 | A | $\begin{aligned} & \text { 3NE1334-2 } \\ & 500 \\ & 2 \end{aligned}$ | $\begin{aligned} & \text { 3NE1436-2 } \\ & 630 \\ & 3 \end{aligned}$ | $\begin{aligned} & \text { 3NE1438-2 } \\ & 800 \\ & 3 \end{aligned}$ |
| Recommended fuse base per phase ${ }^{5)}$, UL file no. E171267 |  | 3NH3420 | 3NH3420 | 3NH3420 |


| Article number | 6SL3710- | 1GE33-8CA3 | 1GE35-0CA3 | 1GE36-1CA3 |
| :--- | :--- | :--- | :--- | :--- |
| SCCR (short circuit current rating) for <br> G150 type C <br> acc. to UL508A file no. E83449 when <br> the fuses and fuse bases listed above <br> and a UL-listed circuit breaker are <br> used | kA | 65 | 65 | 65 |
| Minimum short-circuit current ${ }^{6}$ ) | A | 4400 | 8000 |  |

1) The input current is based on the rated output current.
2) The base-load current $I_{L}$ is based on a duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
3) The base-load current $\mathrm{I}_{\mathrm{H}}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
4) Maximum output frequency at factory-set default pulse frequency (for information on increasing the output frequency, see "Functions, monitoring and protective functions/Increasing the output frequency"; for information on derating data, see "Derating data").
5) To obtain the SCCR value for the enclosed drive, it is necessary to use the fuses with fuse base listed above. Substitutes are not permitted. Also, the UL-listed circuit breaker with minimum SCCR of $65 \mathrm{kA}, 480 \mathrm{~V}$ AC for motor branch circuit protection may not exceed the current rating shown.
${ }^{6)}$ Minimum current required for reliable triggering of the protective devices.

Table 12-13 Type C, 380 to 480 V AC, 3 phase, part 3

| Article number | 6SL3710- | 1GE37-5CA3 | 1GE38-4CA3 | 1GE41-0CA3 |
| :---: | :---: | :---: | :---: | :---: |
| Rated motor output at $400 \mathrm{~V}, 50 \mathrm{~Hz}$ at $460 \mathrm{~V}, 60 \mathrm{~Hz}$ | $\begin{aligned} & \text { kW } \\ & \text { HP } \end{aligned}$ | $\begin{aligned} & 400 \\ & 600 \end{aligned}$ | $\begin{array}{r} 450 \\ 700 \\ \hline \end{array}$ | $\begin{aligned} & 560 \\ & 800 \\ & \hline \end{aligned}$ |
| Rated input voltage | V | 380 to 480 V AC , 3 phase $\pm 10 \%(-15 \%<1 \mathrm{~min})$ |  |  |
| Rated input current ${ }^{1)}$ | A | 775 | 873 | 1024 |
| Rated output current | A | 745 | 840 | 985 |
| Base-load current $\mathrm{lL}^{2}$ ) | A | 725 | 820 | 960 |
| Base-load current $\mathrm{lH}^{3}{ }^{\text {) }}$ | A | 570 | 700 | 860 |
| Max. output frequency ${ }^{4}$ | Hz | 100 | 100 | 100 |
| Power loss | kW | 9.6 | 10.1 | 14.4 |
| Cooling air requirement | $\begin{aligned} & \mathrm{CFM} \\ & \mathrm{~m}^{3} / \mathrm{s} \end{aligned}$ | $\begin{aligned} & 1653 \\ & 0.78 \end{aligned}$ | $\begin{aligned} & 1653 \\ & 0.78 \end{aligned}$ | $\begin{aligned} & 3136 \\ & 1.48 \end{aligned}$ |
| Sound pressure level at $50 / 60 \mathrm{~Hz}$ | $\mathrm{dB}(\mathrm{A})$ | 70/73 | 70/73 | 72/75 |
| Line connection |  | $4 \times 2 / 0$ AWG to 600 kcmil | $4 \times 2 / 0$ AWG to 600 kcmil | $4 \times 2 / 0$ AWG to 600 kcmil |
| Motor connection |  | $3 \times 2 / 0$ AWG <br> to 500 kcmil | $4 \times 2 / 0$ AWG to 600 kcmil | $4 \times 2 / 0$ AWG to 600 kcmil |
| Approx. weight (standard version) | $\begin{array}{\|l} \hline \mathrm{lb} \\ \mathrm{~kg} \end{array}$ | $\begin{aligned} & 1400 \\ & 640 \end{aligned}$ | $\begin{aligned} & 1400 \\ & 640 \end{aligned}$ | $\begin{aligned} & 2250 \\ & 1020 \end{aligned}$ |
| Power block frame size |  | HX | HX | JX |
| Dimensions (standard version) width x height x depth | inch <br> mm | $\begin{aligned} & 23.6 \times 94.5 \times 23.6 \\ & 600 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 23.6 \times 94.5 \times 23.6 \\ & 600 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 39.4 \times 94.5 \times 23.6 \\ & 1000 \times 2400 \times 600 \end{aligned}$ |
| Circuit breaker max. current rating | A | 1600 | 2000 | 2000 |
| Recommended fuse type per phase ${ }^{5)}$ Rated current <br> Frame size acc. to IEC 60269 <br> UL file no. E167357 | A | $\begin{aligned} & \text { 3NE1448-2 } \\ & 850 \\ & 3 \end{aligned}$ | $\begin{aligned} & 2 \times 3 \text { NE1436-2 } \\ & 2 \times 630 \\ & 3 \end{aligned}$ | $\begin{aligned} & 2 \times 3 \text { NE } 1437-2 \\ & 2 \times 710 \\ & 3 \end{aligned}$ |
| Recommended fuse base per phase ${ }^{5)}$, UL file no. E171267 |  | 3NH3420 | $2 \times 3 \mathrm{NH} 3420$ | $2 \times 3 \mathrm{NH} 3420$ |


| Article number | 6SL3710- | 1GE37-5CA3 | 1GE38-4CA3 | 1GE41-0CA3 |
| :--- | :--- | :--- | :--- | :--- |
| SCCR (short circuit current rating) for <br> G150 type C <br> acc. to UL508A file no. E83449 when <br> the fuses and fuse bases listed above <br> and a UL-listed circuit breaker are <br> used | kA | 65 | 65 | 65 |
| Minimum short-circuit current ${ }^{6}$ ) | A | 10500 | 16,000 | 18400 |

1) The input current is based on the rated output current.
2) The base-load current $I_{L}$ is based on a duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
3) The base-load current $\mathrm{I}_{\mathrm{H}}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
4) Maximum output frequency at factory-set default pulse frequency (for information on increasing the output frequency, see "Functions, monitoring and protective functions/Increasing the output frequency"; for information on derating data, see "Derating data").
5) To obtain the SCCR value for the enclosed drive, it is necessary to use the fuses with fuse base listed above. Substitutes are not permitted. Also, the UL-listed circuit breaker with minimum SCCR of $65 \mathrm{kA}, 480 \mathrm{~V}$ AC for motor branch circuit protection may not exceed the current rating shown.
${ }^{6)}$ Minimum current required for reliable triggering of the protective devices.

### 12.3.3 Enclosed drive type A, 500 V - 600 V 3 AC

Table 12-14 Type A, 500 to 600 V AC, 3 phase, part 1

| Article number | 6SL3710- | 1GF31-8AU3 | 1GF32-2AU3 | 1GF32-6AU3 |
| :---: | :---: | :---: | :---: | :---: |
| Rated motor output at $500 \mathrm{~V}, 50 \mathrm{~Hz}$ at $575 \mathrm{~V}, 60 \mathrm{~Hz}$ | $\begin{aligned} & \text { kW } \\ & \text { HP } \end{aligned}$ | $\begin{aligned} & 110 \\ & 150 \\ & \hline \end{aligned}$ | $\begin{array}{\|l} 132 \\ 200 \\ \hline \end{array}$ | $\begin{array}{r} 160 \\ 250 \\ \hline \end{array}$ |
| Rated input voltage | V | 500 to 600 V AC , 3 phase $\pm 10 \%(-15 \%<1 \mathrm{~min}$ ) |  |  |
| Rated input current ${ }^{1)}$ | A | 201 | 234 | 280 |
| Rated output current | A | 175 | 215 | 260 |
| Base-load current IL ${ }^{2}$ | A | 171 | 208 | 250 |
| Base-load current lit ${ }^{3}$ | A | 157 | 192 | 233 |
| Max. output frequency ${ }^{4}$ | Hz | 100 | 100 | 100 |
| Power loss | kW | 3.8 | 4.2 | 5.0 |
| Cooling air requirement | $\begin{aligned} & \mathrm{CFM} \\ & \mathrm{~m}^{3} / \mathrm{s} \end{aligned}$ | $\begin{aligned} & 763 \\ & 0.36 \end{aligned}$ | $\begin{array}{\|l} 763 \\ 0.36 \end{array}$ | $\begin{aligned} & 763 \\ & 0.36 \end{aligned}$ |
| Sound pressure level at $50 / 60 \mathrm{~Hz}$ | $\mathrm{dB}(\mathrm{A})$ | 69/73 | 68/73 | 69/73 |
| Line connection |  | $\begin{aligned} & 2 \times 3 / 0 \mathrm{AWG} \\ & \text { to } 250 \mathrm{kcmil} \text { 6) } \\ & \hline \end{aligned}$ | $\begin{aligned} & 2 \times 3 / 0 \mathrm{AWG} \\ & \text { to } 250 \mathrm{kcmil} \text { 6) } \end{aligned}$ | $2 \times 3 / 0$ AWG to $250 \mathrm{kcmil}{ }^{6)}$ |
| Motor connection |  | $2 \times 3 / 0$ AWG <br> to 500 kcmil | $2 \times 3 / 0 \text { AWG }$ $\text { to } 500 \text { kcmil }$ | $\begin{aligned} & 2 \times 3 / 0 \mathrm{AWG} \\ & \text { to } 500 \mathrm{kcmil} \end{aligned}$ |
| Approx. weight (standard version) | $\begin{array}{\|l} \hline \mathrm{lb} \\ \mathrm{~kg} \end{array}$ | $\begin{aligned} & 1200 \\ & 550 \end{aligned}$ | $\begin{aligned} & 1200 \\ & 550 \end{aligned}$ | $\begin{aligned} & 1200 \\ & 550 \end{aligned}$ |
| Power block frame size |  | GX | GX | GX |
| Dimensions (standard version) width x height x depth | inch mm | $\begin{aligned} & 39.4 \times 94.5 \times 23.6 \\ & 1000 \times 2400 \times 600 \end{aligned}$ | $\begin{array}{\|l\|} \hline 39.4 \times 94.5 \times 23.6 \\ 1000 \times 2400 \times 600 \\ \hline \end{array}$ | $\begin{aligned} & 39.4 \times 94.5 \times 23.6 \\ & 1000 \times 2400 \times 600 \end{aligned}$ |
| Fuse type per phase ${ }^{5)}$ <br> Rated current <br> Frame size acc. to IEC 60269 <br> UL file no. E167357 | A | $\begin{aligned} & \text { 3NE1227-2 } \\ & 250 \\ & 1 \end{aligned}$ | $\begin{aligned} & \text { 3NE1230-2 } \\ & 315 \\ & 1 \end{aligned}$ | $\begin{aligned} & \text { 3NE1331-2 } \\ & 350 \\ & 2 \end{aligned}$ |
| SCCR (short circuit current rating) for G150 type A acc. to UL508A file no. E83449 | kA IC | 25 | 25 | 25 |
| Minimum short-circuit current ${ }^{7}$ ) | A | 2400 | 3000 | 3600 |

${ }^{1)}$ The input current is based on the rated output current and includes 10 A for optional external auxiliaries.
2) The base-load current IL is based on a duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
3) The base-load current $\mathrm{I}_{\mathrm{H}}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
4) Maximum output frequency at factory-set default pulse frequency (for information on increasing the output frequency, see "Functions, monitoring and protective functions/Increasing the output frequency"; for information on derating data, see "Derating data").
5) The SCCR value of the enclosed drive is based on the fuses listed. Substitutes are not permitted.
6) Stripped lengths of the power cables: front $0.71^{\prime \prime}(18 \mathrm{~mm})$, rear 1.46 " $(37 \mathrm{~mm})$.

Tightening torque: $275 \mathrm{lb} . \mathrm{in}$. ( 31 Nm ).
7) Minimum current required for reliable triggering of the protective devices.

### 12.3 Technical specifications

Table 12-15 Type A, 500 to 600 V AC, 3 phase, part 2

| Article number | 6SL3710- | 1GF33-3AU3 | 1GF34-1AU3 | 1GF34-7AU3 |
| :---: | :---: | :---: | :---: | :---: |
| Rated motor output at $500 \mathrm{~V}, 50 \mathrm{~Hz}$ at $575 \mathrm{~V}, 60 \mathrm{~Hz}$ | $\begin{aligned} & \text { kW } \\ & \text { HP } \end{aligned}$ | $\begin{aligned} & 200 \\ & 300 \end{aligned}$ | $\begin{array}{r} 250 \\ 400 \\ \hline \end{array}$ | $\begin{array}{\|l} 315 \\ 450 \\ \hline \end{array}$ |
| Rated input voltage | V | 500 to 600 V AC , 3 phase $\pm 10 \%(-15 \%<1 \mathrm{~min})$ |  |  |
| Rated input current ${ }^{1)}$ | A | 353 | 436 | 493 |
| Rated output current | A | 330 | 410 | 465 |
| Base-load current lı ${ }^{2}$ | A | 320 | 400 | 452 |
| Base-load current $\mathrm{IH}^{3}$ ) | A | 280 | 367 | 416 |
| Max. output frequency ${ }^{4}$ | Hz | 100 | 100 | 100 |
| Power loss | kW | 6.1 | 8.1 | 7.8 |
| Cooling air requirement | $\begin{aligned} & \text { CFM } \\ & \mathrm{m}^{3} / \mathrm{s} \end{aligned}$ | $\begin{aligned} & 763 \\ & 0.36 \end{aligned}$ | $\begin{aligned} & 1653 \\ & 0.78 \end{aligned}$ | $\begin{aligned} & 1653 \\ & 0.78 \end{aligned}$ |
| Sound pressure level at $50 / 60 \mathrm{~Hz}$ | $\mathrm{dB}(\mathrm{A})$ | 69/73 | 72/75 | 72/75 |
| Line connection |  | $2 \times 2$ AWG <br> to $600 \mathrm{kcmil}{ }^{7}$ ) | $2 \times 2$ AWG <br> to 600 kcmil 7 ) | $\begin{aligned} & 3 \times 1 / 0 \mathrm{AWG} \\ & \text { to } 500 \mathrm{kcmil} 7 \text { ) } \end{aligned}$ |
| Motor connection |  | $2 \times 3 / 0$ AWG to 500 kcmil | $2 \times 3 / 0$ AWG to 500 kcmil | $3 \times 1 / 0 \text { AWG }$ $\text { to } 500 \text { kcmil }$ |
| Approx. weight (standard version) | $\begin{array}{\|l} \hline \mathrm{lb} \\ \mathrm{~kg} \\ \hline \end{array}$ | $\begin{aligned} & 1200 \\ & 550 \end{aligned}$ | $\begin{aligned} & 1700 \\ & 780 \end{aligned}$ | $\begin{array}{\|l} \hline 1700 \\ 780 \end{array}$ |
| Power block frame size |  | GX | HX | HX |
| Dimensions (standard version) width x height x depth | inch <br> mm | $\begin{aligned} & 39.4 \times 94.5 \times 23.6 \\ & 1000 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 47.2 \times 94.5 \times 23.6 \\ & 1200 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 47.2 \times 94.5 \times 23.6 \\ & 1200 \times 2400 \times 600 \end{aligned}$ |
| Fuse type per phase ${ }^{5)}$ <br> Rated current <br> Frame size acc. to IEC 60269 <br> UL file no. E167357 | A | $\begin{aligned} & \text { 3NE1334-2 } \\ & 500 \\ & 2 \end{aligned}$ | $\begin{aligned} & \text { 3NE1334-2 } \\ & 500 \\ & 2 \end{aligned}$ | $\begin{aligned} & \text { 3NE1435-2 } \\ & 560 \\ & 3 \end{aligned}$ |
| SCCR (short circuit current rating) for G150 type A acc. to UL508A file no. E83449 | kA IC | 25 | 25 | 30/35 ${ }^{6}$ |
| Minimum short-circuit current ${ }^{8)}$ | A | 5200 | 5200 | 6200 |

1) The input current is based on the rated output current and includes 10 A for optional external auxiliaries.
2) The base-load current $I_{L}$ is based on a duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
3) The base-load current $I_{H}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
4) Maximum output frequency at factory-set default pulse frequency (for information on increasing the output frequency, see "Functions, monitoring and protective functions/Increasing the output frequency"; for information on derating data, see "Derating data").
5) The SCCR value of the enclosed drive is based on the fuses listed. Substitutes are not permitted.
6) $\operatorname{SCCR}=30 \mathrm{kA}$ if a contactor is installed (options L13). SCCR $=35 \mathrm{kA}$ without contactor.
7) Stripped lengths of the power cables: front 1" ( 25.4 mm ), rear 2" ( 50.8 mm ).

Tightening torque: $375 \mathrm{lb} . \mathrm{in}$. ( 42.4 Nm ).
8) Minimum current required for reliable triggering of the protective devices.

Table 12-16 Type A, 500 to 600 V AC, 3 phase, part 3

| Article number | 6SL3710- | 1GF35-8AU3 | 1GF37-4AU3 | 1GF38-1AU3 |
| :---: | :---: | :---: | :---: | :---: |
| Rated motor output at $500 \mathrm{~V}, 50 \mathrm{~Hz}$ at $575 \mathrm{~V}, 60 \mathrm{~Hz}$ | $\begin{aligned} & \text { kW } \\ & \text { HP } \end{aligned}$ | $\begin{aligned} & 400 \\ & 600 \end{aligned}$ | $\begin{aligned} & 500 \\ & 700 \end{aligned}$ | $\begin{aligned} & 560 \\ & 800 \\ & \hline \end{aligned}$ |
| Rated input voltage | V | 500 to 600 V AC , 3 phase $\pm 10 \%(-15 \%<1 \mathrm{~min}$ ) |  |  |
| Rated input current ${ }^{1)}$ | A | 608 | 774 | 852 |
| Rated output current | A | 575 | 735 | 810 |
| Base-load current $\mathrm{lL}^{2}$ ) | A | 560 | 710 | 790 |
| Base-load current $\mathrm{lH}^{3}$ ) | A | 514 | 657 | 724 |
| Max. output frequency ${ }^{4)}$ | Hz | 100 | 100 | 100 |
| Power loss | kW | 8.7 | 12.7 | 14.1 |
| Cooling air requirement | $\begin{aligned} & \mathrm{CFM} \\ & \mathrm{~m}^{3} / \mathrm{s} \end{aligned}$ | $\begin{aligned} & 1653 \\ & 0.78 \end{aligned}$ | $\begin{aligned} & 3136 \\ & 1.48 \end{aligned}$ | $\begin{aligned} & 3136 \\ & 1.48 \end{aligned}$ |
| Sound pressure level at $50 / 60 \mathrm{~Hz}$ | $\mathrm{dB}(\mathrm{A})$ | 72/75 | 72/75 | 72/75 |
| Line connection |  | $3 \times 1 / 0$ AWG to $500 \mathrm{kcmil}{ }^{6)}$ | $\begin{aligned} & 4 \times 2 / 0 \mathrm{AWG} \\ & \text { to } \left.600 \mathrm{kcmil}^{6}\right) \end{aligned}$ | $\begin{array}{\|l\|} \hline 4 \times 2 / 0 \mathrm{AWG} \\ \text { to } \left.600 \mathrm{kcmil}^{6}\right) \\ \hline \end{array}$ |
| Motor connection |  | $2 \times 3 / 0 \text { AWG }$ $\text { to } 500 \text { kcmil }$ | $\begin{aligned} & 4 \times 2 / 0 \mathrm{AWG} \\ & \text { to } 600 \mathrm{kcmil} \end{aligned}$ | $4 \times 2 / 0 \mathrm{AWG}$ $\text { to } 600 \text { kcmil }$ |
| Approx. weight (standard version) | $\begin{array}{\|l} \hline \mathrm{lb} \\ \mathrm{~kg} \\ \hline \end{array}$ | $\begin{array}{\|l} \hline 1700 \\ 780 \end{array}$ | $\begin{aligned} & 3100 \\ & 1360 \end{aligned}$ | $\begin{aligned} & 3100 \\ & 1400 \end{aligned}$ |
| Power block frame size |  | HX | JX | JX |
| Dimensions (standard version) width x height x depth | inch <br> mm | $\begin{aligned} & 47.2 \times 94.5 \times 23.6 \\ & 1200 \times 2400 \times 600 \\ & \hline \end{aligned}$ | $\begin{aligned} & 63 \times 94.5 \times 23.6 \\ & 1600 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 63 \times 94.5 \times 23.6 \\ & 1600 \times 2400 \times 600 \\ & \hline \end{aligned}$ |
| Fuse type per phase ${ }^{5)}$ <br> Rated current <br> Frame size acc. to IEC 60269 <br> UL file no. E167357 | A | $\begin{aligned} & \text { 3NE1447-2 } \\ & 670 \\ & 3 \end{aligned}$ | $\begin{aligned} & \hline \text { 3NE1448-2 } \\ & 850 \\ & 3 \end{aligned}$ | $\begin{aligned} & 2 \times 3 \text { NE1334-2 } \\ & 2 \times 500 \\ & 2 \end{aligned}$ |
| SCCR (short circuit current rating) for G150 type A acc. to UL508A file no. E83449 | kA IC | 35 | 35 | 35 |
| Minimum short-circuit current ${ }^{7}$ | A | 8400 | 10500 | 10400 |

1) The input current is based on the rated output current and includes 10 A for optional external auxiliaries.
2) The base-load current $I_{L}$ is based on a duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
3) The base-load current $l_{H}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
4) Maximum output frequency at factory-set default pulse frequency (for information on increasing the output frequency, see "Functions, monitoring and protective functions/Increasing the output frequency"; for information on derating data, see "Derating data").
5) The SCCR value of the enclosed drive is based on the fuses listed. Substitutes are not permitted.
6) Stripped lengths of the power cables: front 1" ( 25.4 mm ), rear 2" ( 50.8 mm ).

Tightening torque: $375 \mathrm{lb} . \mathrm{in}$. ( 42.4 Nm ).
7) Minimum current required for reliable triggering of the protective devices.

### 12.3 Technical specifications

### 12.3.4 Enclosed chassis type C, 500 V-600 V 3 AC

Table 12-17 Type C, 500 to 600 V AC, 3 phase, part 1

| Article number | 6SL3710- | 1GF31-8CU3 | 1GF32-2CU3 | 1GF32-6CU3 |
| :---: | :---: | :---: | :---: | :---: |
| Rated motor output at $400 \mathrm{~V}, 50 \mathrm{~Hz}$ at $460 \mathrm{~V}, 60 \mathrm{~Hz}$ | $\begin{aligned} & \text { kW } \\ & \text { HP } \end{aligned}$ | $\begin{aligned} & 110 \\ & 150 \\ & \hline \end{aligned}$ | $\begin{array}{r} 132 \\ 200 \\ \hline \end{array}$ | $\begin{array}{\|l} 160 \\ 250 \\ \hline \end{array}$ |
| Rated input voltage | V | 500 to 600 V AC , 3 phase $\pm 10 \%(-15 \%<1 \mathrm{~min}$ ) |  |  |
| Rated input current ${ }^{1)}$ | A | 191 | 224 | 270 |
| Rated output current | A | 175 | 215 | 260 |
| Base-load current $\mathrm{lL}^{2}$ ) | A | 170 | 208 | 250 |
| Base-load current $1{ }^{3}{ }^{3}$ | A | 157 | 192 | 233 |
| Max. output frequency ${ }^{4)}$ | Hz | 100 | 100 | 100 |
| Power loss | kW | 3.8 | 4.2 | 5.0 |
| Cooling air requirement | $\begin{aligned} & \mathrm{CFM} \\ & \mathrm{~m}^{3} / \mathrm{s} \end{aligned}$ | $\begin{aligned} & 763 \\ & 0.36 \end{aligned}$ | $\begin{aligned} & 763 \\ & 0.36 \end{aligned}$ | $\begin{array}{\|l} 763 \\ 0.36 \end{array}$ |
| Sound pressure level at $50 / 60 \mathrm{~Hz}$ | $\mathrm{dB}(\mathrm{A})$ | 69/73 | 69/73 | 69/73 |
| Line connection |  | $2 \times 3 / 0$ AWG to 250 kcmil | $2 \times 3 / 0$ AWG to 250 kcmil | $2 \times 3 / 0 \mathrm{AWG}$ <br> to 250 kcmil |
| Motor connection |  | $2 \times 3 / 0$ AWG to 500 kcmil | $2 \times 3 / 0$ AWG to 500 kcmil | $\begin{aligned} & 2 \times 3 / 0 \mathrm{AWG} \\ & \text { to } 500 \mathrm{kcmil} \end{aligned}$ |
| Approx. weight (standard version) | $\begin{array}{\|l\|l} \hline \mathrm{lb} \\ \mathrm{~kg} \\ \hline \end{array}$ | $\begin{aligned} & 640 \\ & 290 \end{aligned}$ | $\begin{aligned} & 640 \\ & 290 \end{aligned}$ | $\begin{aligned} & 640 \\ & 290 \end{aligned}$ |
| Power block frame size |  | GX | GX | GX |
| Dimensions (standard version) width x height x depth | inch mm | $\begin{aligned} & 15.8 \times 94.5 \times 23.6 \\ & 400 \times 2400 \times 600 \\ & \hline \end{aligned}$ | $\begin{aligned} & 15.8 \times 94.5 \times 23.6 \\ & 400 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 15.8 \times 94.5 \times 23.6 \\ & 400 \times 2400 \times 600 \\ & \hline \end{aligned}$ |
| Circuit breaker max. current rating | A | 400 | 500 | 600 |
| Recommended fuse type per phase ${ }^{5)}$ Rated current <br> Frame size acc. to IEC 60269 UL file no. E167357 | A | $\begin{aligned} & \text { 3NE1227-2 } \\ & 250 \\ & 1 \end{aligned}$ | $\begin{aligned} & \text { 3NE1230-2 } \\ & 315 \\ & 1 \end{aligned}$ | $\begin{aligned} & \text { 3NE1331-2 } \\ & 350 \\ & 2 \end{aligned}$ |
| Recommended fuse base per phase ${ }^{5)}$, UL file no. E171267 |  | 3NH3320 | 3NH3320 | 3NH3320 |


| Article number | 6SL3710- | 1GF31-8CU3 | 1GF32-2CU3 | 1GF32-6CU3 |
| :--- | :--- | :--- | :--- | :--- |
| SCCR (short circuit current rating) for <br> G150 type C | kA IC | 35 | 35 | 35 |
| acc. to UL508A file no. E83449 when <br> the fuses and fuse bases listed above <br> and a UL-listed circuit breaker are <br> used |  |  |  |  |
| Minimum short-circuit current ${ }^{6}$ ) | A | 2400 | 3000 | 3600 |

1) The input current is based on the rated output current.
2) The base-load current IL is based on a duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
3) The base-load current $\mathrm{I}_{\mathrm{H}}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
4) Maximum output frequency at factory-set default pulse frequency (for information on increasing the output frequency, see "Functions, monitoring and protective functions/Increasing the output frequency"; for information on derating data, see "Derating data").
5) To obtain the SCCR value for the enclosed drive, it is necessary to use the fuses with fuse base listed above. Substitutes are not permitted. Also, the UL-listed circuit breaker with minimum SCCR of $35 \mathrm{kA}, 600 \mathrm{~V}$ AC for motor branch circuit protection may not exceed the current rating shown.
6) Minimum current required for reliable triggering of the protective devices.

### 12.3 Technical specifications

Table 12-18 Type C, 500 to 600 V AC, 3 phase, part 2

| Article number | 6SL3710- | 1GF33-3CU3 | 1GF34-1CU3 | 1GF34-7CU3 |
| :---: | :---: | :---: | :---: | :---: |
| Rated motor output at $400 \mathrm{~V}, 50 \mathrm{~Hz}$ at $460 \mathrm{~V}, 60 \mathrm{~Hz}$ | $\begin{aligned} & \text { kW } \\ & \text { HP } \end{aligned}$ | $\begin{aligned} & 200 \\ & 300 \\ & \hline \end{aligned}$ | $\begin{aligned} & 250 \\ & 400 \end{aligned}$ | $\begin{array}{r} 315 \\ 450 \\ \hline \end{array}$ |
| Rated input voltage | V | 500 to 600 V AC , 3 phase $\pm 10 \%(-15 \%<1 \mathrm{~min})$ |  |  |
| Rated input current ${ }^{1)}$ | A | 343 | 426 | 483 |
| Rated output current | A | 330 | 410 | 465 |
| Base-load current lı ${ }^{2}$ | A | 320 | 400 | 452 |
| Base-load current $\mathrm{lH}^{3}$ ) | A | 280 | 367 | 416 |
| Max. output frequency ${ }^{4}$ | Hz | 100 | 100 | 100 |
| Power loss | kW | 6.1 | 8.1 | 7.8 |
| Cooling air requirement | $\begin{aligned} & \text { CFM } \\ & \mathrm{m}^{3} / \mathrm{s} \end{aligned}$ | $\begin{aligned} & 763 \\ & 0.36 \end{aligned}$ | $\begin{aligned} & 1653 \\ & 0.78 \end{aligned}$ | $\begin{aligned} & 1653 \\ & 0.78 \end{aligned}$ |
| Sound pressure level at $50 / 60 \mathrm{~Hz}$ | $\mathrm{dB}(\mathrm{A})$ | 69/73 | 72/75 | 72/75 |
| Line connection |  | $\begin{aligned} & 2 \times 2 \mathrm{AWG} \\ & \text { to } 600 \mathrm{kcmil} \end{aligned}$ | $2 \times 2$ AWG <br> to 600 kcmil | $3 \times 1 / 0$ AWG to 500 kcmil |
| Motor connection |  | $2 \times 3 / 0$ AWG <br> to 500 kcmil | $2 \times 3 / 0$ AWG <br> to 500 kcmil | $3 \times 1 / 0$ AWG to 500 kcmil |
| Approx. weight (standard version) | $\begin{aligned} & \mathrm{lb} \\ & \mathrm{~kg} \end{aligned}$ | $\begin{aligned} & 640 \\ & 290 \end{aligned}$ | $\begin{aligned} & 1400 \\ & 640 \end{aligned}$ | $\begin{aligned} & 1400 \\ & 640 \end{aligned}$ |
| Power block frame size |  | GX | HX | HX |
| Dimensions (standard version) width x height x depth | inch <br> mm | $\begin{aligned} & 15.8 \times 94.5 \times 23.6 \\ & 400 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 23.6 \times 94.5 \times 23.6 \\ & 600 \times 2400 \times 600 \\ & \hline \end{aligned}$ | $\begin{aligned} & 23.6 \times 94.5 \times 23.6 \\ & 600 \times 2400 \times 600 \\ & \hline \end{aligned}$ |
| Circuit breaker max. current rating | A | 800 | 1000 | 1000 |
| Recommended fuse type per phase ${ }^{5)}$ Rated current <br> Frame size acc. to IEC 60269 UL file no. E167357 | A | $\begin{aligned} & \text { 3NE1334-2 } \\ & 500 \\ & 2 \end{aligned}$ | $\begin{aligned} & \text { 3NE1334-2 } \\ & 500 \\ & 2 \end{aligned}$ | $\begin{aligned} & \text { 3NE1435-2 } \\ & 560 \\ & 3 \end{aligned}$ |
| Recommended fuse base per phase ${ }^{5)}$, UL file no. E171267 |  | 3NH3420 | 3NH3420 | 3NH3420 |


| Article number | 6SL3710- | 1GF33-3CU3 | 1GF34-1CU3 | 1GF34-7CU3 |
| :--- | :--- | :--- | :--- | :--- |
| SCCR (short circuit current rating) for <br> G150 type C <br> acc. to UL508A file no. E83449 when <br> the fuses and fuse bases listed above <br> and a UL-listed circuit breaker are <br> used | kA | 35 | 35 | 35 |
| Minimum short-circuit current ${ }^{6}$ ) | A | 5200 | 5200 |  |

1) The input current is based on the rated output current.
2) The base-load current IL is based on a duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
3) The base-load current $\mathrm{I}_{\mathrm{H}}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
4) Maximum output frequency at factory-set default pulse frequency (for information on increasing the output frequency, see "Functions, monitoring and protective functions/Increasing the output frequency"; for information on derating data, see "Derating data").
5) To obtain the SCCR value for the enclosed drive, it is necessary to use the fuses with fuse base listed above. Substitutes are not permitted. Also, the UL-listed circuit breaker with minimum SCCR of $35 \mathrm{kA}, 600 \mathrm{~V}$ AC for motor branch circuit protection may not exceed the current rating shown.
6) Minimum current required for reliable triggering of the protective devices.

### 12.3 Technical specifications

Table 12-19 Type C, 500 to 600 V AC, 3 phase, part 3

| Article number | 6SL3710- | 1GF35-8CU3 | 1GF37-4CU3 | 1GF38-1CU3 |
| :---: | :---: | :---: | :---: | :---: |
| Rated motor output at $400 \mathrm{~V}, 50 \mathrm{~Hz}$ at $460 \mathrm{~V}, 60 \mathrm{~Hz}$ | $\begin{aligned} & \text { kW } \\ & \mathrm{HP} \end{aligned}$ | $\begin{aligned} & 400 \\ & 600 \\ & \hline \end{aligned}$ | $\begin{aligned} & 500 \\ & 700 \\ & \hline \end{aligned}$ | $\begin{aligned} & 560 \\ & 800 \\ & \hline \end{aligned}$ |
| Rated input voltage | V | 500 to 600 V AC , 3 phase $\pm 10 \%$ (-15 \% < 1 min ) |  |  |
| Rated input current ${ }^{1)}$ | A | 598 | 764 | 842 |
| Rated output current | A | 575 | 735 | 810 |
| Base-load current $\mathrm{lL}^{2}$ ) | A | 560 | 710 | 790 |
| Base-load current $\mathrm{l}^{3}{ }^{3}$ | A | 514 | 657 | 724 |
| Max. output frequency ${ }^{4)}$ | Hz | 100 | 100 | 100 |
| Power loss | kW | 8.7 | 12.7 | 14.1 |
| Cooling air requirement | $\begin{aligned} & \mathrm{CFM} \\ & \mathrm{~m}^{3} / \mathrm{s} \end{aligned}$ | $\begin{aligned} & 1653 \\ & 0.78 \end{aligned}$ | $\begin{aligned} & 3136 \\ & 1.48 \end{aligned}$ | $\begin{aligned} & 3136 \\ & 1.48 \end{aligned}$ |
| Sound pressure level at $50 / 60 \mathrm{~Hz}$ | $\mathrm{dB}(\mathrm{A})$ | 72/75 | 72/75 | 72/75 |
| Line connection |  | $3 \times 1 / 0$ AWG to 500 kcmil | $4 \times 2 / 0$ AWG to 600 kcmil | $4 \times 2 / 0$ AWG to 600 kcmil |
| Motor connection |  | $3 \times 3 / 0$ AWG to 500 kcmil | $4 \times 2 / 0$ AWG to 600 kcmil | $4 \times 2 / 0$ AWG to 600 kcmil |
| Approx. weight (standard version) | $\begin{array}{\|l\|} \hline \mathrm{lb} \\ \mathrm{~kg} \end{array}$ | $\begin{aligned} & 1400 \\ & 640 \end{aligned}$ | $\begin{aligned} & 2150 \\ & 980 \end{aligned}$ | $\begin{aligned} & 2250 \\ & 1020 \end{aligned}$ |
| Power block frame size |  | HX | JX | JX |
| Dimensions (standard version) width x height x depth | inch <br> mm | $\begin{aligned} & 23.6 \times 94.5 \times 23.6 \\ & 600 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 39.4 \times 94.5 \times 23.6 \\ & 1000 \times 2400 \times 600 \end{aligned}$ | $\begin{aligned} & 39.4 \times 94.5 \times 23.6 \\ & 1000 \times 2400 \times 600 \end{aligned}$ |
| Circuit breaker max. current rating | A | 1200 | 1600 | 2000 |
| Recommended fuse type per phase ${ }^{5)}$ Rated current <br> Frame size acc. to IEC 60269 UL file no. E167357 | A | $\begin{aligned} & \text { 3NE1447-2 } \\ & 670 \\ & 3 \end{aligned}$ | $\begin{aligned} & \text { 3NE1448-2 } \\ & 850 \\ & 3 \end{aligned}$ | $\begin{aligned} & 2 \times 3 \text { NE1334-2 } \\ & 2 \times 500 \\ & 2 \end{aligned}$ |
| Recommended fuse base per phase ${ }^{5)}$, UL file no. E171267 |  | 3NH3420 | 3NH3420 | $2 \times 3 \mathrm{NH} 3420$ |


| Article number | 6SL3710- | 1GF35-8CU3 | 1GF37-4CU3 | 1GF38-1CU3 |
| :--- | :--- | :--- | :--- | :--- |
| SCCR (short circuit current rating) for <br> G150 type C | kA IC | 35 | 35 | 35 |
| acc. to UL508A file no. E83449 when <br> the fuses and fuse bases listed above <br> and a UL-listed circuit breaker are <br> used |  |  |  |  |
| Minimum short-circuit current ${ }^{6}$ ) | A | 8400 | 10500 | 10400 |

1) The input current is based on the rated output current.
2) The base-load current IL is based on a duty cycle of $110 \%$ for 60 s or $150 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
3) The base-load current $\mathrm{I}_{\mathrm{H}}$ is based on a duty cycle of $150 \%$ for 60 s or $160 \%$ for 10 s with a duty cycle duration of 300 s (see "Overload capability").
4) Maximum output frequency at factory-set default pulse frequency (for information on increasing the output frequency, see "Functions, monitoring and protective functions/Increasing the output frequency"; for information on derating data, see "Derating data").
5) To obtain the SCCR value for the enclosed drive, it is necessary to use the fuses with fuse base listed above. Substitutes are not permitted. Also, the UL-listed circuit breaker with minimum SCCR of $35 \mathrm{kA}, 600 \mathrm{~V}$ AC for motor branch circuit protection may not exceed the current rating shown.
6) Minimum current required for reliable triggering of the protective devices.

## Appendix

## A. $1 \quad$ Acronyms and abbreviations

## A

| A... | Alarm |
| :--- | :--- |
| AC | Alternating Current |
| AI | Analog Input |
| AO | Analog Output |
| AOP | Advanced Operator Panel (with plain-text display) |

B
BI Binector Input
BICO Blnector/COnnector
BO Binector Output
C
C Capacitance

CAN Serial bus system
CB Communication Board
CDS Command Data Set
CI Connector Input
COM Center contact on a changeover contact
CU Control Unit
D
DC Direct Current
DDS Drive Data Set
DI Digital Input
DI/DO Digital Input/Digital Output bidirectional
DO Digital Output
E
EMC ElectroMagnetic Compatibility
EN European Standard
ESD Electrostatic Sensitive Device
F
F... Fault

FAQ Frequently Asked Questions
FW FirmWare
H
HW HardWare

| I |  |
| :--- | :--- |
| I/O | Input/Output |
| IEC | International Electrotechnical Commission Standard |
| IGBT | Insulated Gate Bipolar Transistor |
| J |  |
| JOG | Jog mode |
| L |  |
| L | Inductance |
| LED | Light-Emitting Diode |
| M |  |
| M | Reference ground |
| MDS | Motor Data Set |
| N |  |
| NC | Normally Closed contact |
| NEMA | Standardization body in the USA (United States of America) |
| NO | Normally Open contact |
| P |  |
| p ... | Adjustable parameter |
| PDS | Power unit Data Set |
| PE | Protective Earth (ground) |
| PROFIBUS | Serial data bus |
| PTC | Positive Temperature Coefficient |
| R |  |
| r... | Display parameter (read-only) |
| RAM | Random Access Memory (read-write) |
| RFG | Ramp-Function Generator |
| RS 232 | Serial interface |
| RS 485 | Standard describing the physical characteristics of a digital serial interface. |
| S |  |
| SI | Safety Integrated |
| STW | PROFIdrive control word |
| SW | SoftWare |
| T |  |
| TIA | Totally Integrated Automation |
| TM | Terminal Module |
| U |  |
| UL | Underwriters Laboratories Inc. |
| V |  |
| Vdc | DC link voltage |
| Z |  |
| ZSW | PROFIdrive status word |
|  |  |

## A. $2 \quad$ Parameter macros

## Parameter macro p0015 = G150 enclosed drive

This macro is used to make default settings for operating the drive.

Table A- 1 Parameter macro p0015 = G150 enclosed drive

| Sink |  |  | Source |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | Description | DO | Parameter | Description | DO |
| p0400[0] | Encoder type selection | Vector | 9999 | User-defined | Vector |
| p0404[0] | Encoder configuration | Vector | 200008h |  | Vector |
| p0405[0] | Square-wave encoder track A/B | Vector | 9h | Bipolar, like A/B track | Vector |
| p0408[0] | Rotary encoder pulse no. | Vector | 1024 | 1024 pulses per revolution | Vector |
| p0420[0] | Encoder connection | Vector | 0x2 | Encoder connection = terminal | Vector |
| p0500 | Technology application | Vector | 1 | Pumps, fans | Vector |
| p0600 | Motor temperature sensor for monitoring | Vector | 0 | No sensor | Vector |
| p0601 | Motor temperature sensor type | Vector | 0 | No sensor | Vector |
| p0603 | CI: Motor temperature | Vector | r4105 | Sensor on TM31 | TM31 |
| p0604 | Motor overtemperature alarm threshold | Vector | 120 | $120{ }^{\circ} \mathrm{C}$ | Vector |
| p0605 | Motor overtemperature fault threshold | Vector | 155 | $155{ }^{\circ} \mathrm{C}$ | Vector |
| p0606 | Motor overtemperature timer | Vector | 0 | 0 s | Vector |
| p0610 | Response to motor overtemperature condition | Vector | 12 | Messages, no reduction of I_max, temperature saved | Vector |
| p0700[0] | Macro binector input (BI) | Vector | 70005 | PROFIdrive | Vector |
| p0864 | Infeed operation | Vector | 1 |  | Vector |
| p1000[0] | Macro Connector Inputs (Cl) for speed setpoints | Vector | 100001 | PROFIdrive | Vector |
| p1001 | CO: Fixed speed setpoint 1 | Vector | 300 | 300 rpm | Vector |
| p1002 | CO: Fixed speed setpoint 2 | Vector | 600 | 600 rpm | Vector |
| p1003 | CO: Fixed speed setpoint 3 | Vector | 1500 | 1500 rpm | Vector |
| p1083 | CO: Speed limit in positive direction of rotation | Vector | 6000 | 6000 rpm | Vector |
| p1086 | CO: Speed limit in negative direction of rotation | Vector | -6000 | -6000 rpm | Vector |
| p1115 | Ramp-function generator selection | Vector | 1 | Extended ramp-function generator | Vector |
| p1120 | Ramp-function generator, ramp-up time | Vector | 20 | 20 s | Vector |
| p1121 | Ramp-function generator, ramp-down time | Vector | 30 | 30 s | Vector |
| p1135 | OFF3 ramp-down time | Vector | 10 | 10 s | Vector |
| p1200 | Flying restart operating mode | Vector | 0 | Flying restart not active | Vector |
| p1240 | Vdc controller configuration | Vector | 1 | Vdc-max controller enabled | Vector |


| Sink |  |  | Source |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | Description | DO | Parameter | Description | DO |
| p1254 | Vdc controller automatic ON level detection | Vector | 1 | Automatic detection enabled | Vector |
| p1280 | Vdc controller configuration (V/f) | Vector | 1 | Vdc-max controller enabled | Vector |
| p1300 | Open-loop/closed-loop control operating mode | Vector | 20 | Encoderless speed control | Vector |
| p1911 | Number of phases to be identified | Vector | 1 | 1 phase | Vector |
| p2051[0] | CI: PROFIBUS PZD send word | Vector | r2089[0] | ZSW1 | Vector |
| p2051[1] | Cl : PROFIBUS PZD send word | Vector | r0063[0] | n -act unsmoothed | Vector |
| p2051[2] | CI: PROFIBUS PZD send word | Vector | r0068[0] | l-act unsmoothed | Vector |
| p2051[3] | CI: PROFIBUS PZD send word | Vector | r0080[0] | M-act unsmoothed | Vector |
| p2051[4] | CI: PROFIBUS PZD send word | Vector | r0082[0] | P-act unsmoothed | Vector |
| p2051[5] | CI : PROFIBUS PZD send word | Vector | r2131 | FAULT | Vector |
| p2080[0] | BI: PROFIBUS send status word 1 | Vector | r0899.0 | Ready to start | Vector |
| p2080[1] | BI: PROFIBUS send status word 1 | Vector | r0899.1 | Ready to operate | Vector |
| p2080[2] | BI: PROFIBUS send status word 1 | Vector | r0899.2 | Operation enabled | Vector |
| p2080[3] | BI: PROFIBUS send status word 1 | Vector | r2139.3 | Fault | Vector |
| p2080[4] | BI: PROFIBUS send status word 1 | Vector | r0899.4 | OFF2 inactive | Vector |
| p2080[5] | BI: PROFIBUS send status word 1 | Vector | r0899.5 | OFF3 inactive | Vector |
| p2080[6] | BI: PROFIBUS send status word 1 | Vector | r0899.6 | Power-on inhibit active | Vector |
| p2080[7] | BI: PROFIBUS send status word 1 | Vector | r2139.7 | Alarm present | Vector |
| p2080[8] | BI: PROFIBUS send status word 1 | Vector | r2197.7 | Speed setpoint - actual value deviation within tolerance | Vector |
| p2080[9] | BI: PROFIBUS send status word 1 | Vector | r0899.9 | Control requested | Vector |
| p2080[10] | BI: PROFIBUS send status word 1 | Vector | r2199.1 | Comparison value reached | Vector |
| p2080[11] | BI: PROFIBUS send status word 1 | Vector | r1407.7 | I. M or P limit not reached | Vector |
| p2080[12] | BI: PROFIBUS send status word 1 | Vector | 0 |  | Vector |
| p2080[13] | BI: PROFIBUS send status word 1 | Vector | r2129.14 | No alarm for motor overtemperature | Vector |
| p2080[14] | BI: PROFIBUS send status word 1 | Vector | r2197.3 | Clockwise | Vector |
| p2080[15] | BI: PROFIBUS send status word 1 | Vector | r2129.15 | No Therm. alarm Power unit overload | Vector |
| p2088 | PROFIBUS Invert status word in bits | Vector | B800h |  | Vector |
| p2128[14] | Select fault/alarm code for trigger | Vector | 7910 | A7910: Alarm, motor overtemperature | Vector |
| p2128[15] | Select fault/alarm code for trigger | Vector | 5000 | A5000: Therm. alarm Power unit overload | Vector |
| p2153 | Speed actual value filter time constant | Vector | 20 | 20 ms | Vector |
| p4053[0] | TM31 analog inputs, smoothing time constant | TM31 | 0 | 0 ms | TM31 |
| p4053[1] | TM31 analog inputs, smoothing time constant | TM31 | 0 | 0 ms | TM31 |
| p4056[0] | Type of analog inputs | TM31 | 2 | Current 0... 20 mA | TM31 |
| p4056[1] | Type of analog inputs | TM31 | 2 | Current 0... 20 mA | TM31 |


| Sink |  |  | Source |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | Description | DO | Parameter | Description | DO |
| p4076[0] | Type of analog outputs | TM31 | 0 | Current 0... 20 mA | TM31 |
| p4076[1] | Type of analog outputs | TM31 | 0 | Current 0... 20 mA | TM31 |
| p4071[0] | Signal analog output 0 | TM31 | r0063 | Actual speed value, smoothed | Vector |
| p4071[1] | Signal analog output 1 | TM31 | r0068 | Absolute current actual value | Vector |
| p4100 | Type of temperature sensor | TM31 | 0 | Evaluation disabled | TM31 |
| p4102[0] | Temperature evaluation, alarm threshold | TM31 | $251{ }^{\circ} \mathrm{C}$ | When this value is exceeded, alarm A35211 is triggered. | TM31 |
| p4102[1] | Temperature evaluation, fault threshold | TM31 | $251{ }^{\circ} \mathrm{C}$ | When this value is exceeded, fault F35207 is triggered. | TM31 |
| p7003 | Winding system | Vector | 1 | Separate winding systems | Vector |

## Parameter macro p0700 = 5: PROFIdrive (70005)

This macro is used to set the PROFIdrive interface as the default command source.

Table A- 2 Parameter macro p0700 $=5$ : PROFIdrive

| Sink |  |  | Source |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Parameter | Description | DO | Parameter | Description | DO |
| p0840[0] | ON/OFF1 | Vector | r2090.0 | PZD 1 bit 0 | Vector |
| p0844[0] | No OFF2_1 | Vector | r2090.1 | PZD 1 bit 1 | Vector |
| p0845[0] | No OFF2_2 | Vector | r0722.3 | CU DI3 | CU |
| p0848[0] | No OFF3_1 | Vector | r2090.2 | PZD 1 bit 2 | Vector |
| p0849[0] | No OFF3_2 | Vector | r0722.2 | CU DI2 | CU |
| p0806 | Inhibit LOCAL mode | Vector | 0 |  | Vector |
| p0810 | Command Data Set selection CDS bit 0 | Vector | 0 | Vector |  |
| p0852 | Operation enable | Vector | r2090.3 | PZD 1 bit 3 | Vector |
| p0854 | Control requested | Vector | r2090.10 | PZD 1 bit 10 | Vector |
| p0922 | PROFIdrive PZD telegram (message <br> frame) selection | Vector | 999 | Free telegram (message frame) |  |
| p1020 | Fixed speed setpoint selection, bit 0 | Vector | 0 | configuration | Vector |
| p1021 | Fixed speed setpoint selection, bit 1 | Vector | 0 |  | Vector |
| p1035 | Motorized potentiometer (MOP) raise <br> setpoint | Vector | r2090.13 | PZD 1 bit 13 | Vector |
| p1036 | Motorized potentiometer (MOP) lower <br> setpoint | Vector | r2090.14 | PZD 1 bit 14 | Vector |
| p1113 | Setpoint inversion | Vector | r2090.11 | PZD 1 bit 11 | Vector |
| p1140 | RFG enable | Vector | r2090.4 | PZD 1 bit 4 | Vector |
| p1141 | Continue RFG | Vector | r2090.5 | PZD 1 bit 5 | Vector |
| p1142 | n_set enable | Vector | r2090.6 | PZD 1 bit 6 | Vector |
| p2103 | Acknowledge fault 1 | Vector | r2090.7 | PZD 1 bit 7 | Vector |
| p2104 | Acknowledge fault 2 | Vector | r4022.3 | TM31 DI3 | TM31 |
| p2106 | Ext. fault_1 | Vector | r0722.1 | CU DI1 | CU |


| Sink |  |  | Source |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | Description | DO | Parameter | Description | DO |
| p2107 | Ext. fault_2 | Vector | 1 |  | Vector |
| p2112 | Ext. alarm_1 | Vector | r0722.0 | CU DIO | CU |
| p2116 | Ext. alarm_2 | Vector | 1 |  | Vector |
| p0738 | DI/DO8 | CU | 1 | +24 V | CU |
| p0748.8 | Invert DI/DO8 | CU | 0 | Not inverted |  |
| p0728.8 | Set DI/DO8 input or output | CU | 1 | Output |  |
| p0739 | DI/DO9 | CU | 1 | +24 V | CU |
| p0748.9 | Invert DI/DO9 | CU | 0 | Not inverted |  |
| p0728.9 | Set DI/DO9 input or output | CU | 1 | Output |  |
| p0740 | DI/DO10 | CU | 1 | +24 V | CU |
| p0748.10 | Invert DI/DO10 | CU | 0 | Not inverted |  |
| p0728.10 | Set DI/DO10 input or output | CU | 1 | Output |  |
| p0741 | DI/DO11 | CU | 1 | +24 V | CU |
| p0748.11 | Invert DI/DO11 | CU | 0 | Not inverted |  |
| p0728.11 | Set DI/DO11 input or output | CU | 1 | Output |  |
| p0742 | DI/DO12 | CU | 1 | +24 V | CU |
| p0748.12 | Invert DI/DO12 | CU | 0 | Not inverted |  |
| p0728.12 | Set DI/DO12 input or output | CU | 1 | Output |  |
| p0743 | DI/DO13 | CU | r0899.6 | Power-on inhibit active | Vector |
| p0748.13 | Invert DI/DO13 | CU | 1 | Inverted |  |
| p0728.13 | Set DI/DO13 input or output | CU | 1 | Output |  |
| p0744 | DI/DO14 | CU | 1 | +24 V | CU |
| p0748.14 | Invert DI/DO14 | CU | 0 | Not inverted |  |
| p0728.14 | Set DI/DO14 input or output | CU | 1 | Output |  |
| p0745 | DI/DO15 | CU | r2138.7 | Ack. fault | Vector |
| p0748.15 | Invert DI/DO15 | CU | 0 | Not inverted |  |
| p0728.15 | Set DI/DO15 input or output | CU | 1 | Output |  |
| p2103 | Acknowledge fault 1 | TM31 | r2090.7 | PZD 1 bit 7 | Vector |
| p2104 | Acknowledge fault 2 | TM31 | r4022.3 | TM31 DI3 | TM31 |
| p4030 | DO0 | TM31 | r0899.11 | Pulses enabled | Vector |
| p4031 | DO1 | TM31 | r2139.3 | Fault | Vector |
| p4048.1 | Invert DO1 | TM31 | 1 | Inverted |  |
| p4038 | DO8 | TM31 | r0899.0 | Ready to start | Vector |
| p4028.8 | Set DI/DO8 input or output | TM31 | 1 | Output |  |
| p4039 | DO9 | TM31 | 0 |  | TM31 |
| p4028.9 | Set DI/DO9 input or output | TM31 | 0 | Input |  |
| p4040 | DO10 | TM31 | 0 |  | TM31 |
| p4028.10 | Set DI/DO10 input or output | TM31 | 0 | Input |  |
| p4041 | DO11 | TM31 | 0 |  | TM31 |
| p4028.11 | Set DI/DO11 input or output | TM31 | 0 | Input |  |

## Parameter macro p0700 = 6: Terminal module TM31 (70006)

This macro is used to set customer terminal module TM31 as the command source.

Table A- 3 Parameter macro p0700 = 6: Terminal module TM31

| Sink |  |  | Source |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | Description | DO | Parameter | Description | DO |
| p0840[0] | ON/OFF1 | Vector | r4022.0 | TM31 DI0 | TM31 |
| p0844[0] | No OFF2_1 | Vector | 1 |  | CU |
| p0845[0] | No OFF2_2 | Vector | r0722.3 | CU DI3 | CU |
| p0848[0] | No OFF3_1 | Vector | 1 |  | Vector |
| p0849[0] | No OFF3_2 | Vector | r0722.2 | CU DI2 | CU |
| p0806 | Inhibit LOCAL mode | Vector | 0 |  | Vector |
| p0810 | Command Data Set selection CDS bit 0 | Vector | 0 |  | Vector |
| p0852 | Operation enable | Vector | r4022.4 | TM31 DI4 | TM31 |
| p0854 | Control requested | Vector | 1 |  | Vector |
| p0922 | PROFIdrive PZD telegram (message frame) selection | Vector | 999 | Free telegram (message frame) configuration |  |
| p1020 | Fixed speed setpoint selection, bit 0 | Vector | r4022.1 | TM31 DI1 | TM31 |
| p1021 | Fixed speed setpoint selection, bit 1 | Vector | r4022.2 | TM31 DI2 | TM31 |
| p1035 | Motorized potentiometer (MOP) raise setpoint | Vector | r4022.1 | TM31 DI1 | TM31 |
| p1036 | Motorized potentiometer (MOP) lower setpoint | Vector | r4022.2 | TM31 DI2 | TM31 |
| p1113 | Direction of rotation reversal | Vector | 0 |  | TM31 |
| p1140 | RFG enable | Vector | 1 |  | Vector |
| p1141 | Start RFG | Vector | 1 |  | Vector |
| p1142 | n_set enable | Vector | 1 |  | Vector |
| p2103 | Acknowledge fault 1 | Vector | 0 |  | Vector |
| p2104 | Acknowledge fault 2 | Vector | r4022.3 | TM31 DI3 | TM31 |
| p2106 | Ext. fault_1 | Vector | r0722.1 | CU DI1 | CU |
| p2107 | Ext. fault_2 | Vector | 1 |  | Vector |
| p2112 | Ext. alarm_1 | Vector | r0722.0 | CU DIO | CU |
| p2116 | Ext. alarm_2 | Vector | 1 |  | Vector |
| p0738 | DI/DO8 | CU | 1 | +24 V | CU |
| p0748.8 | Invert DI/DO8 | CU | 0 | Not inverted |  |
| p0728.8 | Set DI/DO8 input or output | CU | 1 | Output |  |
| p0739 | DI/DO9 | CU | 1 | +24 V | CU |
| p0748.9 | Invert DI/DO9 | CU | 0 | Not inverted |  |
| p0728.9 | Set DI/DO9 input or output | CU | 1 | Output |  |
| p0740 | DI/DO10 | CU | 1 | +24 V | CU |
| p0748.10 | Invert DI/DO10 | CU | 0 | Not inverted |  |
| p0728.10 | Set DI/DO10 input or output | CU | 1 | Output |  |

A. 2 Parameter macros

| Sink |  |  | Source |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | Description | DO | Parameter | Description | DO |
| p0741 | DI/DO11 | CU | 1 | +24 V | CU |
| p0748.11 | Invert DI/DO11 | CU | 0 | Not inverted |  |
| p0728.11 | Set DI/DO11 input or output | CU | 1 | Output |  |
| p0742 | DI/DO12 | CU | 1 | +24 V | CU |
| p0748.12 | Invert DI/DO12 | CU | 0 | Not inverted |  |
| p0728.12 | Set DI/DO12 input or output | CU | 1 | Output |  |
| p0743 | DI/DO13 | CU | r0899.6 | Power-on inhibit active | Vector |
| p0748.13 | Invert DI/DO13 | CU | 1 | Inverted |  |
| p0728.13 | Set DI/DO13 input or output | CU | 1 | Output |  |
| p0744 | DI/DO14 | CU | 1 | +24 V | CU |
| p0748.14 | Invert DI/DO14 | CU | 0 | Not inverted |  |
| p0728.14 | Set DI/DO14 input or output | CU | 1 | Output |  |
| p0745 | DI/DO15 | CU | r2138.7 | Ack. fault | Vector |
| p0748.15 | Invert DI/DO15 | CU | 0 | Not inverted |  |
| p0728.15 | Set DI/DO15 input or output | CU | 1 | Output |  |
| p2103 | Acknowledge fault 1 | TM31 | 0 |  | TM31 |
| p2104 | Acknowledge fault 2 | TM31 | r4022.3 | TM31 DI3 | TM31 |
| p4030 | DO0 | TM31 | r0899.11 | Pulses enabled | Vector |
| p4031 | DO1 | TM31 | r2139.3 | Fault | Vector |
| p4048.1 | Invert DO1 | TM31 | 1 | Inverted |  |
| p4038 | DO8 | TM31 | r0899.0 | Ready to start | Vector |
| p4028.8 | Set DI/DO8 input or output | TM31 | 1 | Output |  |
| p4039 | DO9 | TM31 | 0 |  | TM31 |
| p4028.9 | Set DI/DO9 input or output | TM31 | 0 | Input |  |
| p4040 | DO10 | TM31 | 0 |  | TM31 |
| p4028.10 | Set DI/DO10 input or output | TM31 | 0 | Input |  |
| p4041 | DO11 | TM31 | 0 |  | TM31 |
| p4028.11 | Set DI/DO11 input or output | TM31 | 0 | Input |  |

## Parameter macro p0700 = 7: NAMUR (70007)

This macro is used to set the NAMUR terminal block as the default command source.

Table A-4 Parameter macro p0700 = 7: NAMUR

| Sink |  |  | Source |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | Description | DO | Parameter | Description | DO |
| p0840[0] | ON/OFF1 | Vector | r4022.0 | TM31 DI0 | TM31 |
| p0844[0] | No OFF2_1 | Vector | r4022.4 | TM31 DI4 | TM31 |
| p0845[0] | No OFF2_2 | Vector | r0722.3 | CU DI3 | CU |
| p0848[0] | No OFF3_1 | Vector | r4022.5 | TM31 DI5 | TM31 |
| p0849[0] | No OFF3_2 | Vector | 1 |  | Vector |
| p0806 | Inhibit LOCAL mode | Vector | 0 |  | Vector |
| p0810 | Command Data Set selection CDS bit 0 | Vector | 0 |  | Vector |
| p0852 | Operation enable | Vector | 1 |  | Vector |
| p0854 | Control requested | Vector | 1 |  | Vector |
| p0922 | PROFIdrive PZD telegram (message frame) selection | Vector | 999 | Free telegram (message frame) configuration |  |
| p1020 | Fixed speed setpoint selection, bit 0 | Vector | r4022.1 | TM31 DI1 | TM31 |
| p1021 | Fixed speed setpoint selection, bit 1 | Vector | r4022.2 | TM31 DI2 | TM31 |
| p1035 | Motorized potentiometer (MOP) raise setpoint | Vector | r4022.1 | TM31 DI1 | TM31 |
| p1036 | Motorized potentiometer (MOP) lower setpoint | Vector | r4022.2 | TM31 DI2 | TM31 |
| p1113 | Direction of rotation reversal | Vector | r4022.6 | TM31 DI6 | TM31 |
| p1140 | RFG enable | Vector | 1 |  | Vector |
| p1141 | Start RFG | Vector | 1 |  | Vector |
| p1142 | n_set enable | Vector | 1 |  | Vector |
| p2103 | Acknowledge fault 1 | Vector | 0 |  | Vector |
| p2104 | Acknowledge fault 2 | Vector | r4022.3 | TM31 DI3 | TM31 |
| p2106 | Ext. fault_1 | Vector | r0722.1 | CU DI1 | CU |
| p2107 | Ext. fault_2 | Vector | 1 |  | Vector |
| p2112 | Ext. alarm_1 | Vector | r0722.0 | CU DIO | CU |
| p2116 | Ext. alarm_2 | Vector | 1 |  | Vector |
| p0738 | DI/DO8 | CU | 1 | +24 V | CU |
| p0748.8 | Invert DI/DO8 | CU | 0 | Not inverted |  |
| p0728.8 | Set DI/DO8 input or output | CU | 1 | Output |  |
| p0739 | DI/DO9 | CU | 1 | +24 V | CU |
| p0748.9 | Invert DI/DO9 | CU | 0 | Not inverted |  |
| p0728.9 | Set DI/DO9 input or output | CU | 1 | Output |  |
| p0740 | DI/DO10 | CU | 1 | +24 V | CU |
| p0748.10 | Invert DI/DO10 | CU | 0 | Not inverted |  |
| p0728.10 | Set DI/DO10 input or output | CU | 1 | Output |  |

A. 2 Parameter macros

| Sink |  |  | Source |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | Description | DO | Parameter | Description | DO |
| p0741 | DI/DO11 | CU | 1 | +24 V | CU |
| p0748.11 | Invert DI/DO11 | CU | 0 | Not inverted |  |
| p0728.11 | Set DI/DO11 input or output | CU | 1 | Output |  |
| p0742 | DI/DO12 | CU | 1 | +24 V | CU |
| p0748.12 | Invert DI/DO12 | CU | 0 | Not inverted |  |
| p0728.12 | Set DI/DO12 input or output | CU | 1 | Output |  |
| p0743 | DI/DO13 | CU | r0899.6 | Power-on inhibit active | Vector |
| p0748.13 | Invert DI/DO13 | CU | 1 | Inverted |  |
| p0728.13 | Set DI/DO13 input or output | CU | 1 | Output |  |
| p0744 | DI/DO14 | CU | 1 | +24 V | CU |
| p0748.14 | Invert DI/DO14 | CU | 0 | Not inverted |  |
| p0728.14 | Set DI/DO14 input or output | CU | 1 | Output |  |
| p0745 | DI/DO15 | CU | r2138.7 | Ack. fault | Vector |
| p0748.15 | Invert DI/DO15 | CU | 0 | Not inverted |  |
| p0728.15 | Set DI/DO15 input or output | CU | 1 | Output |  |
| p2103 | Acknowledge fault 1 | TM31 | 0 |  | TM31 |
| p2104 | Acknowledge fault 2 | TM31 | r4022.3 | TM31 DI3 | TM31 |
| p4030 | DO0 | TM31 | r0899.11 | Pulses enabled | Vector |
| p4031 | DO1 | TM31 | r2139.3 | Fault | Vector |
| p4048.1 | Invert DO1 | TM31 | 1 | Inverted |  |
| p4038 | DO8 | TM31 | r0899.0 | Ready to start | Vector |
| p4028.8 | Set DI/DO8 input or output | TM31 | 1 | Output |  |
| p4039 | DO9 | TM31 | 0 |  | TM31 |
| p4028.9 | Set DI/DO9 input or output | TM31 | 0 | Input |  |
| p4040 | DO10 | TM31 | 0 |  | TM31 |
| p4028.10 | Set DI/DO10 input or output | TM31 | 0 | Input |  |
| p4041 | DO11 | TM31 | 0 |  | TM31 |
| p4028.11 | Set DI/DO11 input or output | TM31 | 0 | Input |  |

## Parameter macro p0700 = 10: PROFIdrive NAMUR (70010)

This macro is used to set the PROFIdrive NAMUR interface as the default command source.

Table A- 5 Parameter macro p0700 $=10$ : PROFIdrive NAMUR

| Sink |  |  | Source |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | Description | DO | Parameter | Description | DO |
| p0840[0] | ON/OFF1 | Vector | 0 | Assignment with p0922 $=20$ | Vector |
| p0844[0] | No OFF2_1 | Vector | 1 | Assignment with p0922 = 20 | Vector |
| p0845[0] | No OFF2_2 | Vector | r0722.3 | CU DI3 | CU |
| p0848[0] | No OFF3_1 | Vector | 0 | Assignment with p0922 $=20$ | Vector |
| p0849[0] | No OFF3_2 | Vector | 1 |  | Vector |
| p0806 | Inhibit LOCAL mode | Vector | 0 |  | Vector |
| p0810 | Command Data Set selection CDS bit 0 | Vector | 0 |  | Vector |
| p0852 | Operation enable | Vector | 1 | Assignment with p0922 $=20$ | Vector |
| p0854 | Control requested | Vector | 1 | Assignment with p0922 $=20$ | Vector |
| p0922 | PROFIdrive PZD telegram (message frame) selection | Vector | 20 | PROFIdrive NAMUR |  |
| p1020 | Fixed speed setpoint selection, bit 0 | Vector | 0 |  | Vector |
| p1021 | Fixed speed setpoint selection, bit 1 | Vector | 0 |  | Vector |
| p1035 | Motorized potentiometer (MOP) raise setpoint | Vector | 0 |  | Vector |
| p1036 | Motorized potentiometer (MOP) lower setpoint | Vector | 0 |  | Vector |
| p1113 | Direction of rotation reversal | Vector | 0 | Assignment with p0922 $=20$ | Vector |
| p1140 | RFG enable | Vector | 1 | Assignment with p0922 $=20$ | Vector |
| p1141 | Start RFG | Vector | 1 | Assignment with p0922 = 20 | Vector |
| p1142 | n_set enable | Vector | 1 | Assignment with p0922 = 20 | Vector |
| p2103 | Acknowledge fault_1 | Vector | 0 | Assignment with p0922 $=20$ | Vector |
| p2104 | Acknowledge fault_2 | Vector | 0 |  | Vector |
| p2106 | Ext. fault_1 | Vector | r0722.1 | CU DI1 | CU |
| p2107 | Ext. fault_2 | Vector | 1 |  | Vector |
| p2112 | Ext. alarm_1 | Vector | r0722.0 | CU DIO | CU |
| p2116 | Ext. alarm_2 | Vector | 1 |  | Vector |
| p0738 | DI/DO8 | CU | 1 | +24 V | CU |
| p0748.8 | Invert DI/DO8 | CU | 0 | Not inverted |  |
| p0728.8 | Set DI/DO8 input or output | CU | 1 | Output |  |
| p0739 | DI/DO9 | CU | 1 | +24 V | CU |
| p0748.9 | Invert DI/DO9 | CU | 0 | Not inverted |  |
| p0728.9 | Set DI/DO9 input or output | CU | 1 | Output |  |
| p0740 | DI/DO10 | CU | 1 | +24 V | CU |
| p0748.10 | Invert DI/DO10 | CU | 0 | Not inverted |  |
| p0728.10 | Set DI/DO10 input or output | CU | 1 | Output |  |

A. 2 Parameter macros

| Sink |  |  | Source |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | Description | DO | Parameter | Description | DO |
| p0741 | DI/DO11 | CU | 1 | +24 V | CU |
| p0748.11 | Invert DI/DO11 | CU | 0 | Not inverted |  |
| p0728.11 | Set DI/DO11 input or output | CU | 1 | Output |  |
| p0742 | DI/DO12 | CU | 1 | +24 V | CU |
| p0748.12 | Invert DI/DO12 | CU | 0 | Not inverted |  |
| p0728.12 | Set DI/DO12 input or output | CU | 1 | Output |  |
| p0743 | DI/DO13 | CU | r0899.6 | Power-on inhibit active | Vector |
| p0748.13 | Invert DI/DO13 | CU | 1 | Inverted |  |
| p0728.13 | Set DI/DO13 input or output | CU | 1 | Output |  |
| p0744 | DI/DO14 | CU | 1 | +24 V | CU |
| p0748.14 | Invert DI/DO14 | CU | 0 | Not inverted |  |
| p0728.14 | Set DI/DO14 input or output | CU | 1 | Output |  |
| p0745 | DI/DO15 | CU | r2138.7 | Ack. fault | Vector |
| p0748.15 | Invert DI/DO15 | CU | 0 | Not inverted |  |
| p0728.15 | Set DI/DO15 input or output | CU | 1 | Output |  |
| p2103 | Acknowledge fault 1 | TM31 | 0 |  | TM31 |
| p2104 | Acknowledge fault 2 | TM31 | 0 |  | TM31 |
| p4030 | DO0 | TM31 | 0 |  | Vector |
| p4031 | DO1 | TM31 | 0 |  | Vector |
| p4038 | DO8 | TM31 | 0 |  | Vector |
| p4028.8 | Set DI/DO8 input or output | TM31 | 0 | Input |  |
| p4039 | DO9 | TM31 | 0 |  | TM31 |
| p4028.9 | Set DI/DO9 input or output | TM31 | 0 | Input |  |
| p4040 | DO10 | TM31 | 0 |  | TM31 |
| p4028.10 | Set DI/DO10 input or output | TM31 | 0 | Input |  |
| p4041 | DO11 | TM31 | 0 |  | TM31 |
| p4028.11 | Set DI/DO11 input or output | TM31 | 0 | Input |  |

## Parameter macro p1000 = 1: PROFIdrive (100001)

This macro is used to set the default setpoint source via PROFIdrive.

Table A- 6 Parameter macro p1000 = 1: PROFIdrive

| Sink |  |  | Source |  |  |
| :--- | :--- | :---: | :--- | :--- | :---: |
| Parameter | Description | DO | Parameter | Description | DO |
| p1070 | Main setpoint | Vector | r2050[1] | PROFIdrive PZD2 | Vector |
| p1071 | Main setpoint scaling | Vector | 1 | $100 \%$ | Vector |
| p1075 | Supplementary setpoint | Vector | 0 |  | Vector |
| p1076 | Supplementary setpoint scaling | Vector | 1 | $100 \%$ | Vector |

## Parameter macro p1000 = 2: TM31 terminals (100002)

This macro is used to set analog input 0 on customer terminal module TM31 as the setpoint source.

Table A- $7 \quad$ Parameter macro p1000 = 2: TM31 terminals

| Sink |  |  | Source |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Parameter | Description | DO | Parameter | Description | DO |
| p1070 | Main setpoint | Vector | r4055 | AI0 TM31 | TM31 |
| p1071 | Main setpoint scaling | Vector | 1 | $100 \%$ | Vector |
| p1075 | Supplementary setpoint | Vector | 0 |  | Vector |
| p1076 | Supplementary setpoint scaling | Vector | 1 | $100 \%$ | Vector |

## Parameter macro p1000 = 3: Motorized potentiometer (100003)

This macro is used to set the motorized potentiometer as the setpoint source.

Table A- 8 Parameter macro p1000 = 3: Motorized potentiometer

| Sink |  |  | Source |  |  |
| :--- | :--- | :---: | :--- | :--- | :--- |
| Parameter | Description | DO | Parameter | Description | DO |
| p1070 | Main setpoint | Vector | r1050 | Motorized potentiometer | Vector |
| p1071 | Main setpoint scaling | Vector | 1 | $100 \%$ | Vector |
| p1075 | Supplementary setpoint | Vector | 0 |  | Vector |
| p1076 | Supplementary setpoint scaling | Vector | 1 | $100 \%$ | Vector |

## Parameter macro p1000 = 4: Fixed setpoint (100004)

This macro is used to set the fixed setpoint as the setpoint source.

Table A-9 Parameter macro p1000 = 4: Fixed setpoint

| Sink |  |  | Source |  |  |
| :--- | :--- | :--- | :--- | :--- | :---: |
| Parameter | Description | DO | Parameter | Description | DO |
| p1070 | Main setpoint | Vector | r1024 | Fixed speed setpoint effective | Vector |
| p1071 | Main setpoint scaling | Vector | 1 | $100 \%$ | Vector |
| p1075 | Supplementary setpoint | Vector | 0 |  | Vector |
| p1076 | Supplementary setpoint scaling | Vector | 1 | $100 \%$ | Vector |

## Index

## 3

3-contactor bypass (option L29), 115
3 -mass model, 573

## A

A7850 - External alarm 1, 594
Accessory kit
Original roof screws, 50
Acknowledge fault from the AOP, 290
Actual speed value filter, 432
Acyclic communication, 303
Determining drive object numbers, 311
Error values in parameter responses, 308
Parameter request and parameter response, 305
Parameter request and response, 306
Additional customer terminal block (option G61), 161
Additional SMC30 Sensor Module (option K52), 160
Alarms, 594
ALL STOP, coast to stop (option N55), 120
Analog inputs, 105, 264
Analog outputs, 106, 456
AOP
Setpoint ramp-down time, 289
Setpoint ramp-up time, 289
Starting setpoint, 289
AOP setpoint, 289
AOP30, 226
Application classes, 297
Area of application, 27
Armature short-circuit braking
External, 493
Internal, 495
Automatic restart, 478
Automatic speed controller optimization, 462
Auxiliary supply, 81
115 V AC, 82
24 V DC, 82
Auxiliary voltage, 107

## B

Basic commissioning
Entering basic parameters, 234
Entering encoder data, 231
Entering motor data, 230
Motor identification, 236
Selecting motor type, 230
Basic information
BICO technology, 253
Binector Input (BI), 254
Binector Output (BO), 254
Command data set (CDS), 248
Connector Input (CI), 254
Connector Output (CO), 254
Copy motor data set (MDS), 252
Copying the command data set (CDS), 252
Copying the drive data set (DDS), 252
Data sets, 247
Drive data set (DDS), 249
Drive objects, 246
Encoder data set (EDS), 250
Interconnecting signals, 255
Motor data set (MDS), 251
Parameter categories, 244
Parameter types, 243
Parameters, 243
Basic information about the drive system, 243
BICO technology, 253
Interconnecting signals, 255
Bimetallic NC contact, 570
Binector Input (BI), 254
Binector Output (BO), 254
Blade fuse
Replacement, 641
Block diagram, 32
Blocking protection, 565
Brake control
Extended, 549
Simple, 510
Braking unit, 25 kW (option L61), 124
Braking unit, 50 kW (option L62), 124
Bypass
Synchronized with overlap, 541
Synchronized without overlap, 544
Without synchronization, 546
Bypass function, 540

## C

Cabinet anti-condensation heating (option L55), 119
Cabinet illumination with service socket
(option L50), 118
Cable lengths, 68
Cable lugs, 67
CAN bus, 139
CBC10, 139
CBC10 Communication Board
CAN bus, 139
CBE20, 142
CBE20 Ethernet Communication Board (option
G33), 142
CDS (command data set), 248
Copy, 252
CDS changeover via AOP, 290
Center of gravity of the cabinet, 49
Certification, 5
Changing languages, 286
Checklist
Electrical installation, 56
Mechanical installation, 42
Cleaning, 598
Command data set, 248
Command sources
General information, 242
PROFIdrive, 260
TM31 terminals, 262
Communication
Communication services, 397
I\&M, 353
Used port numbers, 397
via PROFIdrive, 295
Communication interfaces
Parallel operation, 399
Conductor cross-sections, 68
Connector Input (CI), 254
Connector Output (CO), 254
Control Interface Module
Message frame size FX, replacing, 604
Message frame size GX, replacing, 606
Message frame size HX, replacing, 608
Message frame size JX, replacing, 610
Control power supply, 115 V AC, 5 A (option N70), 137
Control Unit CU320-2 DP, 82, 83
Control Unit CU320-2 PN, 168
Control via PROFIBUS, 330
Crane transport aid, 49
Disassembling, 50
CU320-2 DP, 83
CU320-2 PN, 168
CU320-2 PN Control Unit, 168

Current controller adaptation, 451
Current setpoint filter, 450
Customer service, 4
Customer terminal module, 97
Customer terminal module, connection overview, 102
Customer terminal module, front view, 101
Cyclic communication, 298

## D

Data sets, 247
Data transmission
PROFINET, 341
Date of manufacture, 35
DC braking, 496
DCC, 28, 403
DDS (drive data set), 249
Copy, 252
Decrease key, 288
Derating behavior with increased pulse frequency, 501
Derating data, 651
Current derating as a function of the pulse
frequency, 654
Decreasing the ambient temperature and the output current, 652
Installation altitudes over 6,600 ft and up to
$16,500 \mathrm{ft}$ ( 2000 m to 5000 m ) above MSL, 652
Permissible output current as a function of the
ambient temperature, 651
Using an isolation transformer, 653
Design, 29
Determining drive object numbers, 311
Determinism, 338
Diagnostics, 582
LEDs, 582
Parameters, 589
Diagnostics channels, 317
Digital inputs, 103, 104
Digital inputs/outputs, 87, 89, 108, 172, 174
Digital outputs, 459
Direction of motor rotation, 72
Direction reversal, 407, 506
Disconnecting the basic interference suppression
module, 76
Drive Control Chart, 403
Drive Control Chart (DCC), 28
Drive data set, 249
Drive objects, 246, 246
DRIVE-CLiQ interface, 86, 171
Droop, 442
dv/dt filter plus voltage peak limiter (option L10), 110

## $E$

EDS (encoder data set), 250
Efficiency optimization, 469
EIP, 370
Electrical installation
Checklist, 56
Electromagnetic compatibility
EMC-compliant design, 64
Introduction, 62
Noise emissions, 63
Operational reliability and noise immunity, 62
Electromagnetic fields, 20
Electrostatic sensitive devices, 23
EMERGENCY OFF category 0 (option N57), 120
Emergency operation, 526
EMERGENCY STOP category 1 (option N59), 122
EMERGENCY STOP category 1 (option N60), 123
Enclosed chassis type C, design, 31
Enclosed drive type A, design, 30
Encoder data set, 250
Encoder with gear factor, 238
Energy savings indicator, 514
Error values in parameter responses, 308
Essential service mode, 526
Ethernet interface, 144, 220
EtherNet/IP, 370
Commissioning the drive, 371
Connect the drive device, 370
Create generic I/O module, 370
Integrating the drive into an Ethernet network, 381
Make the communication settings, 371
Extended braking control, 549
Extended monitoring functions, 554
External alarm 1, 594
External fault 1, 595
External fault 2, 596
External fault 3, 596
External supply, 81

## F

F7860 - External fault 1, 595
F7861 - External fault 2, 596
F7862 - External fault 3, 596
Factory setting, 239
Fan
Message frame size FX, replacing, 628
Message frame size GX, replacing, 630
Message frame size HX, replacing, 632
Message frame size JX, replacing, 636
Fan voltage, adjustment, 73

Fast magnetization, 471
Faults, 594
Faults and alarms, 292, 594
Forwarding, 259
Propagation, 259
Faults and alarms, 292, 594
Features, 28
Feeder for external auxiliaries / motor blower
(option L17), 114
Field Service, 4
Filter mats, replacing, 603
Firmware update, 647
Firmware, upgrading, 647
Fixed setpoints, 267
Fixed speed setpoints, 267
Floor levelness, 44
Flying restart, 481
Fast flying restart, 484
Fast flying restart with voltage measurement via
VSM10, 485
With an encoder, 485
Without an encoder, 482
Forming the DC link capacitors, 645
Friction characteristic, 491
Fuse
Auxiliary power supply (-F11, -F12), 640
Fans -T1 -F10 / -T1 -F11, 640
Internal 230 V AC supply (-F21), 640
LV HRC fuse, replacing, 641

## G

G20, 139
G33, 142
G51, 145
G61, 161
G65, 161
Gear factor, 238
Ground fault test, 487

## H

High overload, 656
Hotline, 4

## I

I\&M, 353
${ }^{12}$ t motor model, 571
Identification \& Maintenance, 353
IF1, 399

IF2, 399
Increase key, 288
Increasing the output frequency, 498
Inhibit AOP LOCAL mode, 290
Input contactor (option L13), 113
Installation
Connection to the foundation, 51
Lifting from the transport pallet, 47
Motor connection from above, 52
Installation device, 600
Installation location, 43
Insulation monitor (option L87), 135
IO controller, 337
IO device, 337
IO supervisor, 337
IT power network, 76

## J

Jog, 288
JOG, 288

## K

K01, 162
K50, 151
K51, 159
K52, 160
K82, 163
K82, terminal module for activating Safe Torque Off
and "Safe STOP 1, 163
K87, 164
K88, 166
K95, 168
Kinetic buffering, 474
Know-how protection, 519
Activating, 521
Changing password, 523
Copy protection, 524
Deactivating, 522
Device replacement, 524
OEM exception list, 523
KTY, 570

## L

L10, 110
L13, 113
L17, 114
L29, 115
L30, 117

L50, 118
L55, 119
L61, 124
L62, 124
L87, 135
L96, 134
L97, 134
Line-side surge arrester (option L96), 134
Load monitoring, 554
Loading firmware (operator panel), 648
LOCAL/REMOTE key, 287
Lockout/Tagout, 17
Low overload, 655
LV HRC fuse
Replacement, 641

## M

M39, 53
M78, 52
Maintenance, 598
Maintenance and servicing, 597
MBAP, 389
MDS (motor data set), 251
Copy, 252
Mechanical door lock (slam latch) (option M39), 53
Mechanical installation
Checklist, 42
Media redundancy, 344
Memory card
Slot, 96, 178
Menu
AOP diagnostics, 284
AOP30 settings, 277
Basic commissioning, 275
Battery status, 284
Battery symbol, 284
Commissioning/service, 275
Complete commissioning, 275
Control settings, 277
Curve recorder, 276
Curve recorder settings, 280
Database contents, 284
Database statistics, 286
Database version, 284
Date format, 282
Define operation screen, 278
Device commissioning, 275
Display settings, 277
DO name display mode, 283
Drive commissioning, 275
Drive diagnostics, 276

Fault memory/Alarm memory, 274
Keyboard test, 285
LED test, 285
Motor identification, 275
Normalization to motor current, 283
Operation screen, 271
Reset AOP settings, 283
Reset fan operating time, 275
Screenshots, 285
Set date, 281
Set time, 281
Software version, 284
Sprachauswahl/Language selection, 286
Structure, 270
Message frame selection, user-defined, 299
Message frames and process data, 299
Minimum speed, 408
Modbus Application Header, 389
Modbus TCP, 383
Activate via interface X1400, 385
Activate via interface X150, 384
Communication via data set 47, 392
Function codes used, 389
Mapping tables, 386
Modbus register to the parameters of the Control
Unit, 386
Parameterizing communication for X1400, 386
Parameterizing communication for X150, 385
Read and write access, 389
Reading and writing parameters, 391
Moment of inertia estimator, 556
Accelerated estimation, 560
Speed controller adaptation, 560
Monitoring functions, 562
Motor changeover, 488
Motor data identification, 463
Motor data set, 251
Motor identification, 462
Motorized potentiometer, 266

## N

N55, 120
N57, 120
N59, 122
N60, 123
N70, 137

## 0

OFF key, 287
ON key, 287
Online operation with STARTER, 333
Open actual speed value, 444
Operating hours counter, 504
Operating lock / Parameterization lock key, 291
Operation on an ungrounded power network, 76
Operation screen, 271
Operator panel, 226
Overview, 269
Operator panel, replacing the battery, 643
Option codes, 36
Option K95, 168
Option M90 (crane transport aid), 49
Original roof screws, 50
Output terminals, 455
Overload capability, 655
Overload responses, 563

## P

Parallel operation of communication interfaces, 399
Parameter request and parameter response, 305
Parameter request and response, 306
Parameter reset, 239
Resetting parameters via AOP30, 239
Resetting parameters via Starter, 239
Parameterization errors, 294
Permanent-magnet synchronous motors, 452
Power block
Lifting lugs, 601
Message frame size FX, replacing, 612
Message frame size GX, replacing, 615
Message frame size HX, replacing, 618
Message frame size JX, replacing, 623
Power connections, 66
Connecting the motor and power cables, 70
Power module protection, 562
Power supply, internal, 75
Pre-control, 560
Preparation
Mechanical installation, 43
PROFIBUS, 325
Address switches, 92, 331
Bus terminating resistor, 92, 326
Connectors, 91, 326
Diagnostics, 320
Setting the address, 93, 330
Setting the PROFIBUS address, 330
PROFIBUS connection, 90, 325

PROFIBUS diagnostics data, 320
Channel-related diagnostics, 323
Data sets DS0/DS1 and diagnostics alarm, 324
Identifier-related diagnostics, 322
Standard diagnostics, 321
Status messages/module status, 322
PROFIdrive, 295
Acyclic communication, 303
Application classes, 297
Controller, 296
Cyclic communication, 298
Device classes, 295
Drive unit, 296
Message classes, 317
Message classes for PROFINET, 318
PROFIBUS message classes, 320
Supervisor, 296
PROFlenergy, 348
Certification, 348
Commands, 350
PROFINET
Connection channels, 342
Data transmission, 341
Diagnostics, 318
Structure example of a system redundancy, 346
System redundancy, 345
PROFINET interface, 177
PROFINET IO, 337
Addresses, 339
Device name (NameOfStation), 340
Identification \& Maintenance, 353
IP address, 340
IP address assignment, 340
MAC address, 339
RT and IRT, 338
PROFINET IO with IRT, 339
PROFINET IO with RT, 339
Propagation, 259
Propagation type, 259
Protective functions, 562
PT100, 570
PT100 monitor (option L97), 134
PT1000, 570
PTC, 570
Pulse frequency wobbling, 502

Quality, 29

## R

Ramp-function generator, 410
Ramp-function generator tracking, 411
Rating plate, 34
Data, 35
Date of manufacture, 35
Option codes, 36
Real-time communication, 338
Reference model, 438
Relay outputs, 109
Repairs, 4
Replacement
Automatic firmware update, 646
Control Interface Module, frame size FX, 604
Control Interface Module, frame size GX, 606
Control Interface Module, frame size HX, 608
Control Interface Module, frame size JX, 610
Fan, frame size FX, 628
Fan, frame size GX, 630
Fan, frame size HX, 632
Fan, frame size JX, 636
Fault codes, 646
Filter mats, 603
Installation device, 600
Lifting lugs, 601
Operator panel, 643
Operator panel battery, 643
Power block, frame size FX, 612
Power block, frame size GX, 615
Power block, frame size HX, 618
Power block, frame size JX, 623
Replacing components, 603
Replacing the operator panel, 643
Residual risks, 25
Resonance damping, 420
Ring topology, 344
Scalance, 344
Rotating measurement, 466
Shortened, 468
Runtime, 504

## S

S5 - Selector for voltage/current AIO, AI1, 106
Safe Brake Adapter, 166
230 V AC, 166
Safe Brake Adapter 230 V AC (option K88), 166
Safe brake control, 166
Safety instructions
Electromagnetic fields, 20

Electrostatic sensitive devices, 23
General safety instructions, 18
Safety license for one axis (option K01), 162
Saving the parameters permanently, 294
SBC (Safe Brake Control), 166
Sensor Module Cabinet-Mounted SMC30
(option K50), 151
Serial interface (RS232), 94, 176
Service, 29
Service and Support, 4
Servicing, 599
Setpoint addition, 406
Setpoint channel, 406
Setpoint sources, 264
Analog inputs, 264
Fixed speed setpoints, 267
General information, 242
Motorized potentiometer, 266
Setting the PROFIBUS address, 330
Shield connection, 98
Shipping and handling indicators, 45
Shock indicator, 45
Tilt indicator, 45
Shock indicator, 45
Short-circuit test, 487
Shortened rotating measurement, 468
Signal connections, 97
Simple brake control, 510
Simulation mode, 505
SINAMICS Link, 356
Activation, 364
Bus cycle, 358
Commissioning, 360
Communication failure, 367
Configuration example, 365
Diagnostics, 367
Number of nodes, 358
Receive data, 357
Receiving data, 363
Requirements, 356
Send data, 357
Sending data, 361
Topology, 358
Transmission time, 357
Skip frequency bands, 408
Slip compensation, 421
SMC30, 151
SMC30: connection examples,
Soft starter bypass (option L30), 117
Spare parts, 4
Speed controller, 433
Speed controller adaptation, 440

Speed controller feedfoward control, 436
Speed controller optimization, 466
Speed limiting, 409
Stall protection, 566
Standstill measurement, 463
STARTER, 182
Access point, 218
Commissioning, 185
Creating a project, 185
DEVICE, 219
Installation, 184
Online operation via PROFINET, 333
S7ONLINE, 219
Target device selection:, 218
Transferring the drive project, 219
User interface, 184
STARTER via Ethernet, 220
Parameters, 225
Setting the IP Address of the drive, 222
Setting the IP address of the PG/PC interface, 221
Storage, 40
Support, 4
Switching between clockwise and counter-clockwise
rotation, 288
Switching unit systems (SI/US/\%), 508
Synchronization, 513
System redundancy, 345
Configuring, 346
Diagnostics LEDs, 346
Example, 346

## T

Technical specifications, 657
General, 650
Type A, 380 to 480 V AC, 3 phase, 658
Type A, 500 to 600 V AC, 3 phase, 667
Type C, 380 to 480 V AC, 3 phase, 661
Type C, 500 to 600 V AC, 3 phase, 670
Technical support, 4
Technology controller, 537
Temperature sensor, 106
Temperature sensor connection
Control Interface Module, 569
Sensor Module, 568
TM31, 567
Temperature sensor evaluation, 567
3-mass model, 573
Bimetallic NC contact, 570
${ }^{12 t}$ motor model, 571
KTY, 570
PT100, 570

PTC, 570
Wire-break monitoring, 570
Terminal Module TM150, 145
Test pulse evaluation, 487
Thermal monitoring, 563
Thermal motor models, 571
Thermal motor protection, 567
Tightening torques, 599
Tilt indicator, 45
TM150, 145
Connecting, 146
Forming groups, 578
Protective earth connection and shield support, 148
Sensor failure in a group, 580
Temperature evaluation, 579
Temperature measurement, 575
Temperature sensor types, 576
TM31, 97
TM31 wired to customer terminal block (option
G65), 161
TM31, connection overview, 100
TM31, front view, 99
TM54F, 164
TM54F Terminal Module, 164
TM54F Terminal Module (option K87), 164
Tool, 47, 60, 599
Torque control, 446
Torque limiting, 448
Transport, 39
Transport eyebolts, 49

## U

Ungrounded power network, 76
Unpacking, 47

## V

V/f (V/Hz) control, 414
Vdc control, 473
Vdc_max control, 476
Vdc_min control, 474
Vector control
With an encoder, 431
Without an encoder, 424
Vector speed/torque control with/without an encoder, 423

Voltage boost, 417
At startup, 419
During acceleration, 419
Permanent, 418
Voltage Sensing Module VSM10 (option K51), 159
VSM10, 159

## W

Web server, 530
Login, 532
Logout, 533
Start page, 532
User-defined Web pages, 531
Wire-break monitoring, 570
Write protection, 517

## X

X100, 86, 171
X101, 86, 171
X102, 86, 171
X103, 86, 171
X122, 87, 172
X126, 90
X127, 93, 175
X132, 89, 174
X140, 94, 176
X1400, 144
X150, 177
X451 (CAN bus), 141
X452 (CAN bus), 141
X520, 103
SMC30, 155
X521, 105
SMC30, 156
X522, 106
X530, 104
X531
SMC30, 156
X540, 107
X541, 108
X542, 109

## Additional information

Siemens:
www.siemens.com
Industry Online Support (service and support):
www.siemens.com/online-support
IndustryMall:
www.siemens.com/industrymall

Siemens AG
Process Industries and Drives
Large Drives
Postbox 4743
90025 Nuremberg
Germany


[^0]:    1) NO: NO contact
[^1]:    1) If a temperature sensor has not been installed, a value of $-200^{\circ} \mathrm{C}$ is displayed.
[^2]:    1) For messages, which cannot be assigned to any particular component
[^3]:    1) Tel. word = telegram word
[^4]:    1) The technology controller parameters can only be accessed if, in the STARTER project, also the "Technology controller" function module is activated.
[^5]:    ${ }^{1)}$ Any individual behaviors of the LED OPT are described at the respective Option Board.

