A Bosch Company

IndraDrive

Power Supply Basic PSB-21
Functions

Application Manual
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Edition 02

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1.1 Trademark information

Trademark information

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Tab. 1-1: Trademark information

1.2 About this documentation

Editions of this documentation

<table>
<tr><th>Edition</th><th>Release date</th><th colspan="2">Notes</th></tr>
<tr><td rowspan="8">01</td><td rowspan="8">2018-11</td><td colspan="2">First edition
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• New chapter: chapter 2.6 "Performance data" on page 18
• New parameters, see Parameter Description
• Corrections (φ instead of phi)</td></tr>
</table>

Tab. 1-2: Record of revisions

The Safety Instructions in the available application documentation contain specific signal words (DANGER, WARNING, CAUTION or NOTICE) and, where required, a safety alert symbol (in accordance with ANSI Z535.6-2011).

The signal word is intended to draw the reader's attention to the safety instruction and describes the hazard severity.

The safety alert symbol (a triangle with an exclamation point), which precedes the signal words DANGER, WARNING and CAUTION, is used to alert the reader to personal injury hazards.

⚠ DANGER

Non-compliance with this safety instruction **will** result in death or serious personal injury.

⚠ WARNING

Non-compliance with this safety instruction **can** result in death or serious personal injury.

⚠ CAUTION

Non-compliance with this safety instruction can result in moderate or minor personal injury.

NOTICE

Non-compliance with this safety instruction can result in property damage.

This box contains important information that should be taken into consideration.

This symbol highlights useful tips and tricks.

Your feedback

Your experience is important to improve our products and documentations.

If you want to report errors or suggest changes to this documentation, please send your feedback to the following e-mail address:

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1.3 How to use this documentation

1.3.1 Structure of the functional description

Functional descriptions of IndraDrive firmware are divided in defined chapters. Individual topics of the firmware description are assigned to the chapters according to its content.

The description of the respective firmware functionality is basically divided into the following sections:

- Brief description
- Functional description
- Commissioning notes
- Diagnostic and status messages, monitoring functions

Within one subject, these sections are always contained in the mentioned order, but for practical and formal reasons they are not always existing or may have a different title.

Brief description

The brief description contains an overview of the firmware function or the subject of the section. The brief description can contain, for example, general basics, the most important features of the function, overviews and application examples. Parameters and diagnostics part of this function are listed at the end of the brief description.

Functional description

The "Functional description" section explains the operating principle of the respective function in an application-oriented way. The relevant parameters are described with regard to their settings and effects. The parameter configuration is only explained in detail where this is necessary for the description of the function. As a basic principle, the functional description contains references to the separate documentations for parameters and diagnostic messages.

The detailed description of the parameters, their function and structure is contained in the separate documentation "Rexroth IndraDrive, Parameters".

The detailed description of the diagnostic messages, their causes and remedies is contained in the separate documentation "Rexroth IndraDrive, Diagnostic Messages".

Commissioning notes

The "Notes on commissioning" or "Notes on parameterization" section provides the user with the steps required for commissioning the function, similar to a checklist. The necessary parameter settings are described in compact form and, if necessary, instructions are given for activating the function and the diagnostic messages of the immediate functional sequence are mentioned.

Diagnostic and status messages, monitoring functions

The "Diagnostic and status messages" section (also "Monitoring functions", if necessary) summarizes the diagnostic messages and possible status displays available for the respective function and describes them briefly. If there are function-specific monitoring functions, they are also described in this section.

The detailed description of the diagnostic messages, their causes and remedies is contained in the separate documentation "Rexroth IndraDrive, Diagnostic Messages".

1.3.2 Markers and terms

The complete functionality of the IndraDrive firmware is divided into functional packages (base packages and optional expansion packages). The scope of the available functions does not only depend on the hardware design, but in the majority of cases also on the variant and characteristic of the firmware.

The descriptions of the master communication, the controller functions and the operation modes have a marker containing information on the availability of this functionality in the respective functional package of the firmware, e.g.:

Assignment to the functional firmware package, see chapter "Supported operation modes"

Terms

The application-specific scalability of the hardware and firmware provides a multitude of possibilities. For detailed information, the following terms are used in the Functional Description:

- Firmware **range**, e.g. IndraDrive
- Firmware **variant**, e.g. PSB, MPB
- Firmware **version**, e.g. PSB-**20**VRS, MPM-**18**VRS
- Firmware **type**, e.g. FWA-INDRV*-PSB-20VRS-D5

1.3.3 Cross references

Descriptions that are part of other IndraDrive documentations (Parameter Description, Description of Diagnostic Messages, Project Planning Manuals ...) are only repeated in detail in exceptional cases. Cross references indicate the source for more detailed information.

For cross references to other sections or documentations, we make the following distinction:

- References to sections within this documentation are specified by indicating the title of the respective section and the designation of the superordinate topic, if necessary (both can be easily found using the index).

- References to another documentation are also signaled by the "info icon" if they are not contained in a note, in a table or in parentheses.

1.3.4 Documentations

A list of referenced documentation can be found under chapter 2.7 "Documentations" on page 19.

1.4 Definitions of terms

Axis processor The axis processor is a micro processor in which the control algorithms to operate the actor (e.g. a motor) are running.

Installation An installation consists of several devices or systems interconnected for a defined purpose and on a defined site which, however, are not intended to be placed on the market as a single functional unit.

Drive A drive (electric drive) consists of a drive controller with an electric motor.

Electric drive system An electric drive system comprises all components from mains supply to motor shaft; this includes, for example, electric motor(s), motor encoder(s), supply units and drive controllers, as well as auxiliary and additional components, such as mains filter, mains choke and the corresponding lines and cables.

User A user is a person installing, commissioning or using a product which has been placed on the market.

Application documentation Application documentation comprises the entire documentation used to inform the user of the product about the use and safety-relevant features for configuring, integrating, installing, mounting, commissioning, operating, maintaining, repairing and decommissioning the product. The following terms are also used for this kind of documentation: Operating Instructions, Commissioning Manual, Instruction Manual, Project Planning Manual, Application Description, etc.

B sample To a large extent, the B sample comes with the technical function. However, there are restrictions, e.g. insufficient testing. Therefore, errors or product variations are to be expected. The product may only be used after a prototype agreement was signed.

Electrical equipment Electrical equipment encompasses all devices used to generate, convert, transmit, distribute or apply electrical energy, such as electric motors, transformers, switching devices, cables, lines, power-consuming devices, circuit board assemblies, plug-in units, control cabinets, etc.

Negative-sequence control Unbalanced mains can be mathematically separated into a positive-sequence system and a negative-sequence system. To control a current in an unbalanced mains, in addition to the known mains current control for the positive-sequence system ("balanced component"), control for the negative-sequence system ("unbalanced component") is required. The negative-sequence control includes all elements necessary for controlling the current in the negative-sequence system.

Device A device is a finished product with a defined function, intended for users and placed on the market as an individual piece of merchandise.

Manufacturer The manufacturer is an individual or legal entity bearing responsibility for the design and manufacture of a product which is placed on the market in the individual's or legal entity's name. The manufacturer can use finished products, finished parts or finished elements, or contract out work to subcontractors. However, the manufacturer must always have overall control and possess the required authority to take responsibility for the product.

Incompatibility Incompatible new functions or incompatible functional enhancements produce a device behavior which does not correspond to the previous version.

Island grid An island grid supplies a limited area and is not connected to the public grid system or other power networks. The power supply company has to control the balance between consumed and generated power in the island grid. An energy storage system can be used. The operator of an island grid can determine individual standards for the island grid. These standards can deviate from rules of public power supply companies.

Compatibility Compatibility of a new function or functional enhancement means that, for example, a parameter file from a previous version can be used in the new firmware.

Component A component is a combination of elements with a specified function, which are part of a piece of equipment, device or system. Components of the electric drive and control system are, for example, supply units, drive controllers, mains choke, mains filter, motors, cables, etc.

Machine A machine is the entirety of interconnected parts or units at least one of which is movable. Thus, a machine consists of the appropriate machine drive elements, as well as control and power circuits, which have been assembled for a specific application. A machine is, for example, intended for processing, treatment, movement or packaging of a material. The term "machine" also covers a combination of machines which are arranged and controlled in such a way that they function as a unified whole.

Mains operation / island grid mode Mains operation and island grid mode are differentiated. In mains operation, the grid system defines the grid properties. Supply units that supply a grid system have to synchronize their voltages and frequencies to the existing grid system. In island grid mode, however, the supply unit defines the properties of the island grid. The supply unit controls the voltage and frequency in the island grid and thus assumes a "grid generator function". The power output is determined by the loads and, where applicable, other supply units in the island grid.

Patch A patch corrects errors in the firmware.

Product Examples of a product: Device, component, part, system, software, firmware, among other things.

Project Planning Manual A Project Planning Manual is part of the application documentation used to support the sizing and planning of systems, machines or installations.

Qualified persons As defined by this application documentation, qualified persons comprises individuals familiar with the installation, mounting, commissioning and operation of the components of the electric drive and control system, as well as with the associated risks, and who are qualified in their field. The following qualifications are required, among other things:

- Training, instruction or authorization to safely switch electric circuits and devices on and off, to ground and to label them.
- Training or instruction on the maintenance and the use of appropriate safety equipment.
- First aid training.

Qualified personnel for handling functionally safe products Individuals configuring, commissioning and operating functionally safe products must have the knowledge specified under "Qualified persons". Additionally, these individuals must be familiar with technical safety concepts as well as prevailing standards and regulations in the field of functional safety.

Release, firmware/Runtime release With a new firmware release, compatible functional enhancements are provided or errors in the firmware were corrected. The firmware release is encrypted in the type code at position "RS" in AXS-V-VS**RS**.

Control system A control system comprises several interconnected control components placed on the market as a single functional unit.

Technology Function The ctrlX DRIVE Technology Function refers to the PLC firmware function which allows the axis processor of the ctrlX DRIVE system to use customized PLC programs or ready-made technology apps.

Grid system A grid system is a large-scale, supraregional network of power plants (with respect to electric power). It is operated by a power supply company that is responsible for the mains and thus also specifies the rules for mains supply.

Version, firmware/Runtime version A new firmware version comprises basic changes in the scope of functions compared to the previous version. The scope of functions may also contain incompatible changes. The firmware version is encrypted in the type code at position "VS" in AXS-V-**VS**RS.

2 System overview

2.1 Terms, basic principles

2.1.1 Parameters

Communication between master and controller is realized, with a few exceptions, by using parameters.

Parameters are used for:

- Setting the configuration
- Parameterizing the control loop
- Triggering and controlling functions and commands
- Transmitting command values and actual values (according to requirements, cyclically or acyclically)

All operating data are mapped to parameters. The parameters can be identified using the IDN. They can be read and transferred, if required. The user write access to parameters depends on the properties of the respective parameter and the current communication phase. The firmware checks specific parameter values (operating data) for validity.

2.1.2 Data storage and parameter handling

Data memory

Several non-volatile data memories are available in an IndraDrive system:

- In the controller
- In the programming module/control panel

In addition, a volatile data memory (working memory) is available in the controller.

Condition as supplied

Condition as supplied of the Rexroth drive components:

- The controller memory contains controller-specific parameter values.
- The programming module / control panel contains the firmware.

Storing the application-specific parameter values

- The application-specific parameter values are stored in the programming module / control panel. Due to the limited number of writing cycles of non-volatile storage media, application-specific parameter values can be stored in the working memory (volatile memory) of the controller, too.
- With "IDST" service tool parameter values can be saved on an external data carrier.

Saving parameter values

Saving application-specific parameter values is required in the following cases:

- After initial commissioning of IndraDrive
- Before replacing the controller for servicing (if possible)

Application-specific parameter values can be saved using:

- "IndraWorks Ds/D/MLD" commissioning tool

  → Saving parameter values on external data carrier
- Control master

  → Saving parameter values on master-side data carrier

Parameter IDN lists

The controller supports master-side saving of parameter values by listing parameter identification numbers (IDNs). Using these lists guarantees complete storage of the application-specific parameter values. It is also possible to determine IDN lists defined by the customer.

Loading parameter values

Parameter values need to be loaded in the following cases:

- Commissioning series machines
  → Loading the parameter values saved after initial commissioning
- Reestablishing a defined initial state
  → Reloading the parameter values saved after initial commissioning
- Replacing the controller for servicing
  → Loading the parameter values saved before servicing

Options for loading parameter values to the controller:

- "IndraWorks Ds/D/MLD" commissioning tool
  → Loading the parameter values from an external data carrier
- "IDST" service tool
  → Loading the parameter values from an external data carrier
- Control master
  → Loading the parameter values from a master-side data carrier

Checksum of parameter values

By way of checksum comparison, the control master can determine whether the values of the application-specific parameter values currently active in the controller correspond to the values saved on the master side.

2.1.3 Password

IndraDrive controllers provide the possibility to protect parameter values against accidental or unauthorized change by using a password. With regard to write protection, there are 3 groups of writable parameters:

- Parameters that are generally write-protected, such as hardware code parameters, error memory, etc. ("administration parameters"). The values of these parameters guarantee the correct function and performance of the controller.
- Parameters the customer can combine in groups and protect them with a so-called customer password. This allows protecting parameter values that are used for adjusting the controller, after having determined them.
- All other writable parameters that are not contained in the above-mentioned groups. They are not write-protected.

Types of passwords

The firmware allows the write protection for parameter values to be activated and deactivated using three hierarchically different passwords:

- **Customer password**

  The parameter values of a parameter group combined by the customer can be protected.
- **Control password**

  Parameters protected by a customer password are writable; "administration parameters" remain read-only.
- **Master password**

  All writable parameters, including "administration parameters" and parameters protected by a customer password, can be changed.

2.1.4 Commands

Commands are used to activate and control complex functions or monitoring features. The higher-level master can start, interrupt and clear commands.

Each command is assigned to a parameter. The command execution can be controlled using the parameter. During the execution of the command the display of the control panel reads "Cx", "C" representing the diagnostic command message and "x" representing the number of the command.

☞ Each command that was started has to be actively cleared again.

All commands available are stored in parameter "S-0-0025, IDN-list of all procedure commands".

Types of commands

There are the following different types of commands:

- **Control commands**
  - Can only be started when drive enable has been set
  - deactivate the active operation mode during its execution.
- **Monitoring commands**
  - Activate or deactivate monitoring features or functions.
- **Administration commands**
  - carry out administration tasks,
  - Cannot be interrupted

2.1.5 Operation modes

The selection of operation modes defines which command values will be processed in which way. The operation mode does not determine how these command values are transmitted from the master to the controller.

One of the operation modes that are defined in parameters is always active if the conditions below are fulfilled:

- Control section and power section are ready for operation
- Drive enable signal sees a positive edge
- Command value input is followed
- No control command active
- No error reaction is carried out

The display of the control panel reads "LB" or "LF" (supply unit) when an operation mode is active. The list of implemented operation modes is stored in parameter "S-0-1705.0.1, List of the operating modes" (supply unit).

See also chapter "Operation modes"

2.1.6 Warnings

Depending on the active operation mode and the parameter settings, many monitoring functions are carried out. If a state is detected that permits correct operation, but if continued will result in the occurrence of an error and the automatic shutdown of the output stage, the firmware generates a warning message.

Warning classes

Warnings are classified in different warning classes which determine whether or not an automatic reaction is carried out by the warning being generated. The warning class can be recognized by the diagnostic message. Warnings cannot be cleared. The messages are pending until the condition that triggered the warning is no longer fulfilled.

2.1.7 Errors

Depending on the active operation mode and the parameter settings, many monitoring functions are carried out. If a state is detected that affects or prevents correct operation, the firmware generates an error message.

Error classes

Errors are assigned to various error classes that differ based on the different error reactions. The error class can be recognized by the diagnostic message number.

Diagnostic message number	Error class
F2xxx	Non-fatal error
F4xxx	Interface error
F8xxx	Fatal error
F9xxx	Fatal system error

Tab. 2-1: Overview of error classes

☞ Apart from the mentioned error classes that can occur during operation, errors can occur when the devices are booted up and during firmware download. These errors are displayed on the control panel with a short diagnostic text rather than with a diagnostic message number of the "Fxxxx" pattern. Booting and firmware download errors are described in the separate documentation"Troubleshooting guide" (diagnostic description).

Error reactions

If drive enable has been set and an error state is detected, the execution of an error reaction is automatically started. The diagnostic message number "Fxxxx" flashes on the display of the control panel.

Clearing an error message

Error messages are not automatically cleared; instead, there is a procedure for this depending on the severity of the error; see the separate "Troubleshooting Guide" documentation (description of diagnostic messages).

For example, if the error state persists, the error message is immediately generated again.

Clearing error messages when drive enable has been set

If an error occurs during operation with drive enable having been set, an error reaction is carried out. At the end of each error reaction, drive enable is removed and the output stage is switched off.

To reactivate control,

- clear the error message and
- set a 0-1-edge for drive enable again.

Error memory

The diagnostic message numbers of occurring errors are written to an error memory. This memory contains the diagnostic message numbers of the last errors that occurred and the time when they occurred. Errors caused by the control voltage being switched off are not stored in the error memory.

The diagnostic message numbers in the error memory are mapped to parameter "P-0-0192, Error memory of diagnostic numbers" and can be displayed by the control panel. Using the "IndraWorks Ds/D/MLD" commissioning tool, it is possible to display the diagnostic message numbers and the respective times at which the errors occurred.

2.2 IndraDrive product range

The table below shows how the PSB derivative is integrated in the relations between control sections and power sections, firmware derivatives and possible technology modules.

Product range IndraDrive Version 20, Version 21		Firmware						Signal processing IndraDrive Controls V2				Technologies			
Product line		PSB-21	PSB-20	MPE-2x	MPB-2x	MPC-2x	MPM-2x	Economy	Basic	Advanced	Multi-axis (Basic)	STO & SBC	SafeMotion & CIP Safety	MLD-S/D	MLD-M / CCD
IndraDrive C / M	HCS02	-	-	X	X	X	-	X	X	X	-	O	O	O	O
	HCS03	-	-	X	X	X	-	X	X	X	-	O	O	O	O
	HCS04.2	-	-	X	X	X	-	X	X	X	-	O	O	O	O
	HMS	-	-	X	X	X	-	X	X	X	-	O	O	O	O
	HMD	-	-	-	-	-	X	-	-	-	X	O	O	-	-
IndraDrive Mi Distributed drives	KMV03	X	X	-	-	-	-	-	X	-	-	-	-	O	-
	KMS03-B (Basic)	-	-	-	X	-	-	-	X	-	-	O	O	O	-
	KMS02-B (Basic)	-	-	-	X	-	-	-	X	-	-	O	O	O	-
	KSM02-B (Basic)	-	-	-	X	-	-	-	X	-	-	O	O	O	-
IndraDrive Cs	HCS01-E (Economy)	-	-	X	-	-	-	X	-	-	-	O	-	-	-
	HCS01-B (Basic)	-	-	-	X	-	-	-	X	-	-	O	O	O	-
	HCS01-A (Advanced)	-	-	-	-	X	-	-	-	X	-	O	O	O	O
IndraDrive	HCQ02 / HCT02	-	-	-	-	-	X	-	-	-	X	-	-	-	-
IndraDrive ML	HMV05	X	X	-	-	-	-	-	X	-	-	-	-	O	-
	HMS05	-	-	-	X	X	-	-	X	X	-	O	O	O	O

X Selectable
O Optional
\- Not available

Tab. 2-2: Product range IndraDrive - Version 20, Version 21

2.3 Firmware, overview

2.3.1 Firmware variants

For the IndraDrive range, there are different application-related firmware types available that are characterized by their scope of functions and their performance.

Besides the firmware derivatives for converter and inverter devices, the "PSB" derivative was implemented for supply units. Thus, the following firmware variants are provided:

- FWA-INDRV*-MPB-21VRS-D5
- FWA-INDRV*-MPC-21VRS-D5
- FWA-INDRV*-MPE-21VRS-D5

- FWA-INDRV*-MPM-21VRS-D5
- FWA-INDRV*-PSB-21VRS-D5

"MP" stands for Multi Purpose, "PS" stands for Power Supply. "B", "C", "E" and "M" identify the performance and functionality of the firmware:

- MPB: **Single-axis** firmware with **BASIC** performance and functionality plus MLD-S functions
- PSB: Supply unit firmware with **BASIC** performance and functionality plus MLD-S functions
- C: **Single-axis** firmware with **ADVANCED** performance and functionality plus CCD + MLD-M functions
- E: **Single-axis** firmware with **ECONOMY** performance and functionality
- M: **Double-axis/multi-axis** firmware with **BASIC** performance and functionality

☞ The advanced performance or economy performance variant is only available for axis firmware.

The "IndraWorks Ds/D/MLD" commissioning tool is available for commissioning these firmware variants.

2.3.2 Organizing the firmware

For the application-specific definition of the functionality, the firmware functions are divided into different "functional packages". It is divided into a **generally available base package**and optional **additional functional packages**.

☞ The scope of functions of the functional packages and their possible combinations are described in section "Overview of functions/ functional packages".

2.4 Overview of functions/functional packages

2.4.1 Overview

General information

The application-specific scope of usable functions of the **FWA-INDRV*-MP*-21VRS** drive firmware depends on

- the existing device configuration

- and -

- the licensed functional firmware packages.

☞ Depending on the hardware design, the scope of firmware functionality can be determined according to the respective application (scalability of the firmware functionality). The scope of corresponding parameters depends on the available functions.

Scaling of supplier functionality

Firmware scaling by control section configuration

Some IndraDrive supply units are equipped with option card slots. Depending on the available optional cards, it is possible to activate certain functions (incl. corresponding parameters), e.g.:

- Master communication
- I/O extension

Firmware scaling by functional packages

The firmware functionality is divided into the following package groups:

- Base package
- Optional expansion packages:
  - Alternative functional packages (extension package mains function, extension package DC/DC converter)
  - Additive functional package (IndraMotion MLD)

The base package is avaiable without any access enable. Using the additive expansion package, however, requires licensing.

> The desired scope of firmware functions should preferably be defined when the firmware is ordered. In individual cases, it is possible to provide access enable subsequently (additional licensing) or to reduce it, see also section "Enabling functional packages".

The figure below contains an overview of the possibilities of PSB firmware scaling by functional packages:

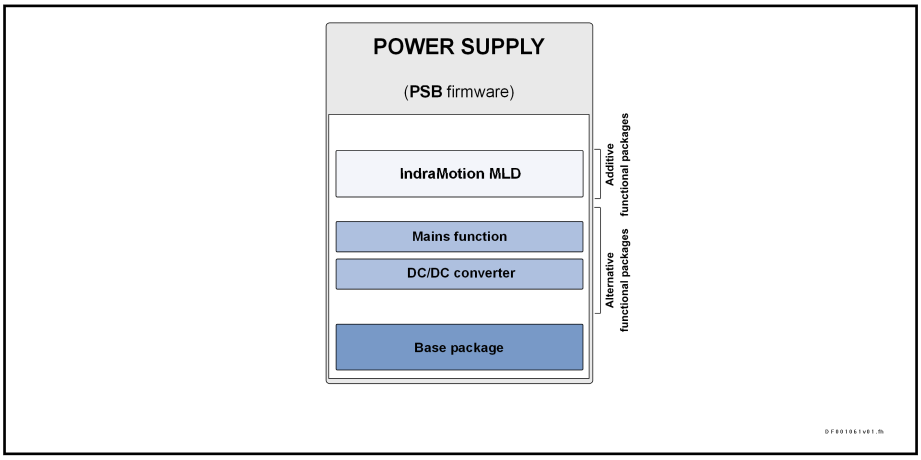


Fig. 2-1: Functional packages of the IndraDrive firmware PSB-21

Brief description of the functional packages

The overall functionality of an IndraDrive supply unit is divided into groups of functions, the so-called "functional packages". The FWA-INDRV*-PSB-21VRS firmware supports the functional packages listed below.

Alternative functional packages

Alternative functional packages[1] are available:

- Mains function

  In addition to the base package, functions for energy supply in low-voltage and medium-voltage systems and functions of the island grid operation.

  Additionally available functions:

  - Advanced mains monitoring
  - Active power limit
  - Frequency-dependent active power limit
  - Reactive power command value input depending on the active power
  - Island grid mode

1) These functional packages cannot be activated simultaneously (only individually)!

- DC/DC converter

  In addition to the base package, functions to operate the control unit as DC/DC converter.

  Additionally available functions:

  – DC voltage control

  – DC current control

Additive functional packages

There is also an additional functional package available:

- IndraMotion MLD

☞ An additive functional packages can be activated in addition to any available alternative package.

Firmware types

Structure of the firmware type designation

The type designation of the IndraDrive firmware consists of the following type code elements:

	IndraDrive firmware	Base package of variant (depending on control section)	Version	Release	Language	OL/CL	Alternative expansion packages	Additive expansion packages
Supply unit	FWA-INDRV*	-PSB-	21	VRS-	D5-	N-	xxx-	xx

Tab. 2-3: Basic structure of the firmware type designation

Function-specific abbreviations in type designation of IndraDrive firmware

Base package (application and performance):

- PSB → supply unit firmware with Basic performance

Alternative functional packages:

- NNN → No alternative functional package
- MSE → Functional package "Mains function"
- DCE → Functional package "DC/DC converter"

Additive expansion package:

- NN → No additive extension package
- ML → IndraMotion MLD free programming

☞ The sales representative in charge will help you with the currently available firmware types.

2.4.2 Base packages

General information

In the base packages of the firmware, the minimum scope of functionalities is available. They contain the basic functions of a supply unit firmware and a number of other fundamental functions.

Basic functions

The following basic functions are available for every device and contain the fundamental basic functions of a supply unit:

- Extensive diagnostic functions:

  - Internal generation of diagnostic messages
  - Monitoring function
  - Patch function
  - Status displays, status classes
  - Oscilloscope function
  - Option card ID
  - Parameter value check
  - Operating hours counter, diagnostic memory, error memory
- Options for integrated energy and power measurement
- Undervoltage monitoring
- Output of control signals
- Limitations that can be parameterized

Availability of the optional device functions

The overview below shows the availability of the optional device functions.

Optional device function	Functional package
Digital inputs/outputs	Contained in base package
Mains function	Independent extension package (MSE)
DC/DC converter	Independent extension package (DCE)
IndraMotion MLD	Independent expansion package (ML)

Tab. 2-4: Availability of the optional device functions

To use a functional package, it has to have been activated (enabled). The currently enabled functional packages are displayed in parameter "P-0-2004, Active functional packages".

See also "Enabling functional packages"

2.4.3 Additive functional packages

General information

So-called additive functional packages are part of the optional expansion packages. Additive functional packages can be used in addition to the basic function (additive activation).

At present, **IndraMotion MLD** (drive-integrated PLC and technology functions) is available as an additive functional package (in different designs).

IndraMotion MLD (drive-integrated PLC)

Additive functional package

The following design of the additive functional package is available:

- The **"ML"** design allows Rexroth IndraMotion MLD-S / MLD-M to be freely programmed.

See documentation "Rexroth IndraDrive, Rexroth IndraMotion MLD (2G) as of MPx-18, Application Manual" (DOK-INDRV*-MLD3-**VRS*-AP; mat. no.: R911338914) and "Rexroth IndraMotion MLD (2G) Libraries as of MPx18, Reference Book" (DOK-INDRV*-MLD-SYSLIB3-RE; mat. no.: R911338916).

2.5 Master communication overview

The **PSB-21VRS** firmware supports the following interfaces for master communication:

- Sercos
- PROFIBUS-DP
- EtherNet/IP interface
- PROFINET
- Analog-Interface
- EtherCAT
- CANopen
- POWERLINK

2.6 Performance data

2.6.1 Levels of control performance

For the control performance of the IndraDrive range, there are basically three different levels with regard to the clock rates (cycle times):

- **Advanced** performance

  High control performance by shorter clock rates for the control loops and the signal processing of inputs and outputs or drive-integrated PLC (IndraMotion MLD).
- **Basic** performance

  Standard control performance by medium internal clock rates for the control loops and the signal processing of inputs/outputs or drive-integrated PLC (IndraMotion MLD).
- **Economy** performance

  Low control performance due to reduced clock rates for the control loops and the signal processing of inputs/outputs.

☞ The PSB supply unit firmware only supports the Basic performance option and the Advanced performance option.

Use the parameter S-0-1709.0.152, bit 8, to switch the performance (0: Basic, 1: Advanced).

2.6.2 Performance and clock rates

In this documentation, the clock rate data refer to the following characteristic values:

- Current controller clock $T_{A\_current}$
- Voltage controller clock $T_{A\_voltage}$
- Position controller clock $T_{A\_position}$
- Cycle time of PLC (IndraMotion MLD) T_{MLD}

The table below contains an overview of the clock rates depending on the respective control performance and controller or control section design.

Controller	Allowed operating modes	Performance level	f_{PWM}	$T_{A\_current}$	$T_{A\_voltage}$	$T_{A\_position}$	T_{MLD}
KMV03	Mains operation Island grid mode	Basic	10.1 kHz	99 µs	250 µs	500 µs	1000 µs
		Advanced[1)]			125 µs	250 µs	1000 µs
HMV05	Mains operation Island grid mode	Basic	3.8 kHz	131 µs	250 µs	500 µs	1000 µs
		Advanced[1)]			125 µs	250 µs	1000 µs
		Basic	4.2 kHz	119 µs	250 µs	500 µs	1000 µs
		Advanced[1)]			125 µs	250 µs	1000 µs
HMS05 as DC/DC converter	DC/DC converter	Basic	4.0 kHz	125 µs	250 µs	500 µs	1000 µs
		Advanced			125 µs	250 µs	1000 µs
		Basic	6.0 kHz	83 µs	250 µs	500 µs	1000 µs
		Basic	8.0 kHz	125 µs	250 µs	500 µs	1000 µs
		Advanced			125 µs	250 µs	1000 µs

1) not allowed in combination with negative-sequence control

Tab. 2-5: Overview of clock rates (cycle times or PWM switching frequencies)

2.7 Documentations

2.7.1 Drive systems, system components

Drive systems, system components

Title Rexroth IndraDrive …	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
…Cs Drive Systems with HCS01	Project Planning Manual	HCS01******-PRxx-EN-P	322210
…Mi Drive Systems with KCU02 KSM02, KMS02/03, KMV03	Project Planning Manual	KCU02+KSM02-PRxx-EN-P	335703
Drive Systems with HMV01/02 HMS01/02, HMD01, HCS02/03	Project Planning Manual	SYSTEM*****-PRxx-EN-P	309636
Supply Units, Power Sections HMV, HMS, HMD, HCS02, HCS03	Project Planning Manual	HMV-S-D+HCS-PRxx-EN-P	318790
ML, Drive Systems with HMU05	Project Planning Manual	Hxx05******-PRxx-EN-P	344279
Drive Controllers Control Sections CSB01, CSH01, CDB01	Project Planning Manual	CSH********-PRxx-EN-P	295012

Title Rexroth IndraDrive …	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
Control Sections CSE02, CSB02, CDB02, CSH02	Project Planning Manual	Cxx02******-PRxx-EN-P	338962
Additional Components and Accesso-ries	Project Planning Manual	ADDCOMP****-PRxx-EN-P	306140

1) In the document typecodes, "xx" is a placeholder for the current edition of the documentation (example: PR01 is the first edition of a Project Planning Manual)

Tab. 2-6: Documentations – drive systems, system components

2.7.2 Firmware

Title Rexroth IndraDrive ...	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
MPx-21 Functions	Application manual	MP*-21VRS**-APxx-EN-P	385758
MPx-20 Functions	Application Manual	MP*-20VRS**-APxx-EN-P	345608
MPx-20 Version Notes	Release Notes	MP*-20VRS**-RNxx-EN-P	345606
PSB-21 Functions	Application manual	PSB-21VRS**-APxx-EN-P	385754
PSB-20 Functions	Application manual	PSB-20VRS**-APxx-EN-P	345610
MPx-18 Functions	Application Manual	MP*-18VRS**-APxx-EN-P	338673
MPx-18 Version Notes	Release Notes	MP*-18VRS**-RNxx-EN-P	338658
MPx-17 Functions	Application Manual	MP*-17VRS**-APxx-EN-P	331236
MPx-17 Version Notes	Release Notes	MP*-17VRS**-RNxx-EN-P	331588
MPx-16 Functions	Application Manual	MP*-16VRS**-APxx-EN-P	326767
MPx-16 Version Notes	Release Notes	MP*-16VRS**-RNxx-EN-P	329272
Parameters from MPx-16 and PSB	Reference Book	GEN1-PARA**-RExx-EN-P	328651
Diagnostics from MPx-16 and PSB	Reference Book	GEN1-DIAG**-RExx-EN-P	326738

Title Rexroth IndraDrive ...	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
Rexroth IndraMotion MLD Libraries as of MPx-17	Reference Book	MLD-SYSLIB2-RExx-EN-P	332627
Rexroth IndraMotion MLD Libraries as of MPx-18	Reference Book	MLD-SYSLIB3-RExx-EN-P	338916
Rexroth IndraMotion MLD MPx-17 and above	Application Manual	MLD2-**VRS*-APxx-EN-P	334351
Rexroth IndraMotion MLD MPx-18 and above	Application Manual	MLD3-**VRS*-APRS-EN-P	338914

1) In the document typecodes, "xx" is a placeholder for the current edition of the documentation (e.g.: RE02 is the second edition of a Reference Book)

Tab. 2-7: Documentations – firmware

3 Master communication

⚠ WARNING **Dangerous movements! Danger to life, risk of injury, serious injury or property damage!**

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine's range of motion (e.g., by using safety fences, safety guards, protective coverings, light barriers).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.

3.1 Process data coupling

3.1.1 System overview

Component	Task
Control	• Executing the user code • Generating and processing the process data • Configuring the field device at runtime • Abstraction of coupling between control and field device • If necessary, abstraction of similar field devices of different manufacturers
Process data coupling	• Adjusting the process data between control and field device • Transmitting the non-cyclical data
Field device	• Processing the field application on the basis of the process data (command values) • Updating the process data on the field side (actual values) • Providing non-cyclical data for configuration

Tab. 3-1: Overview of components and tasks

The table shows the components relevant for fulfilling an automation task between control and field device.

These components have different functions:

The control executes the user code and generates command values for the field devices in accordance with the actual states. In addition, the field devices are configured at runtime.

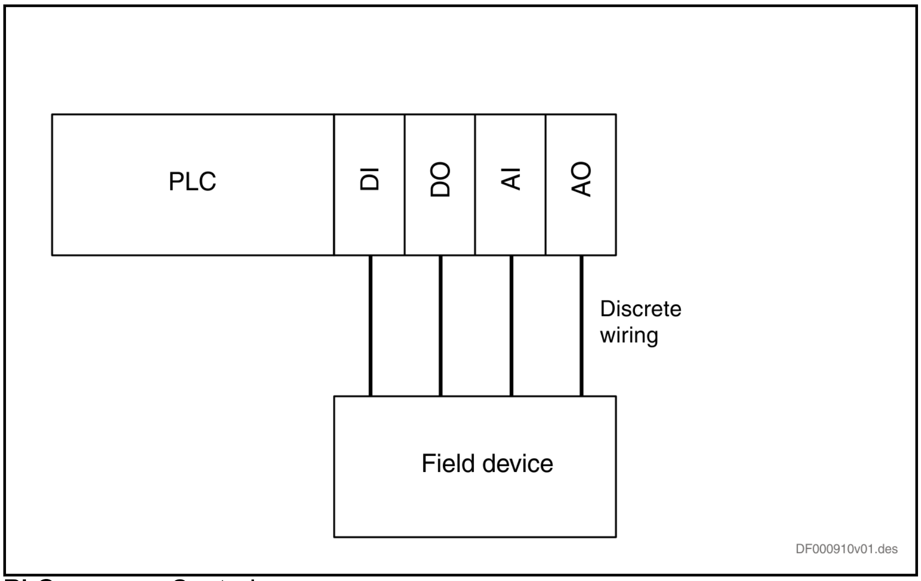
The field devices process the command values generated by the control and provide actual values from the field for the control application.

The parapgraphs below describe the different options of how process data are coupled between control and field device.

3.1.2 Types of process data coupling

Coupling via discrete wiring

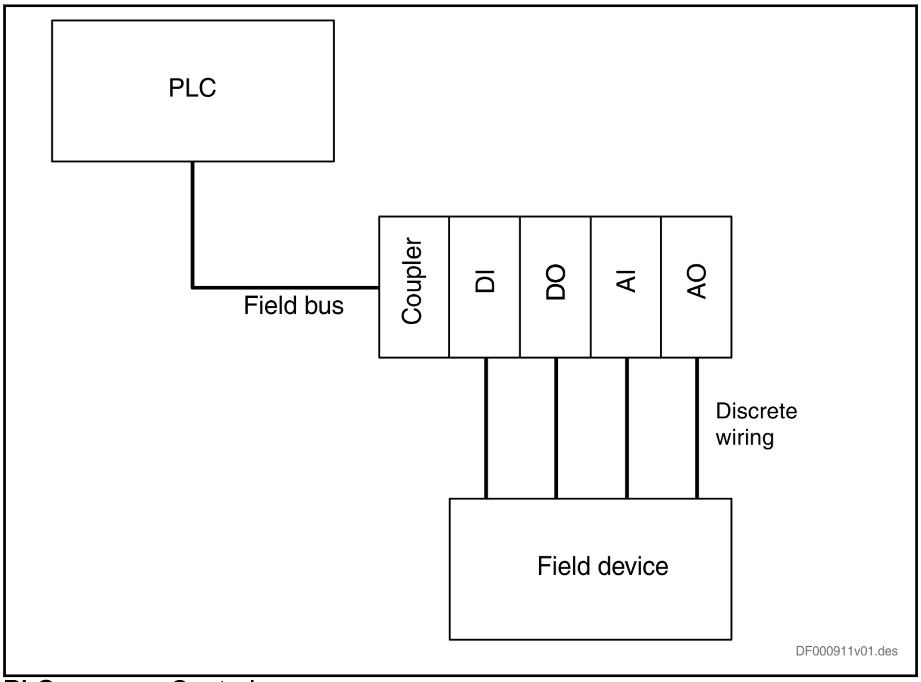
The typical type of process data coupling is coupling via discrete wiring.



PLC Control
DI Digital input
DO Digital output
AI Analog input
AO Analog output

Fig. 3-1: Coupling the process data via discrete wiring

The control and state signals are exchanged via digital inputs and outputs at the field device and the control. The command values and actual values for the actual field application, such as command velocity and actual velocity of a drive, are input via analog inputs and outputs. The inputs and outputs of the control can also be distributed inputs and outputs:



PLC	Control
DI	Digital input
DO	Digital output
AI	Analog input
AO	Analog output

Fig. 3-2: Coupling the process data via discrete wiring at a distributed I/O

Coupling via field bus

The following process data can be digitally coupled via a field bus:

- State signals
- Control signals
- Process- and application-related command values
- Process- and application-related actual values

Depending on the field bus capabilities, transmission takes place in a demand-based, cyclic or synchronous way. Besides mere process data transmission, the field bus can also be used to synchronize control and field device.

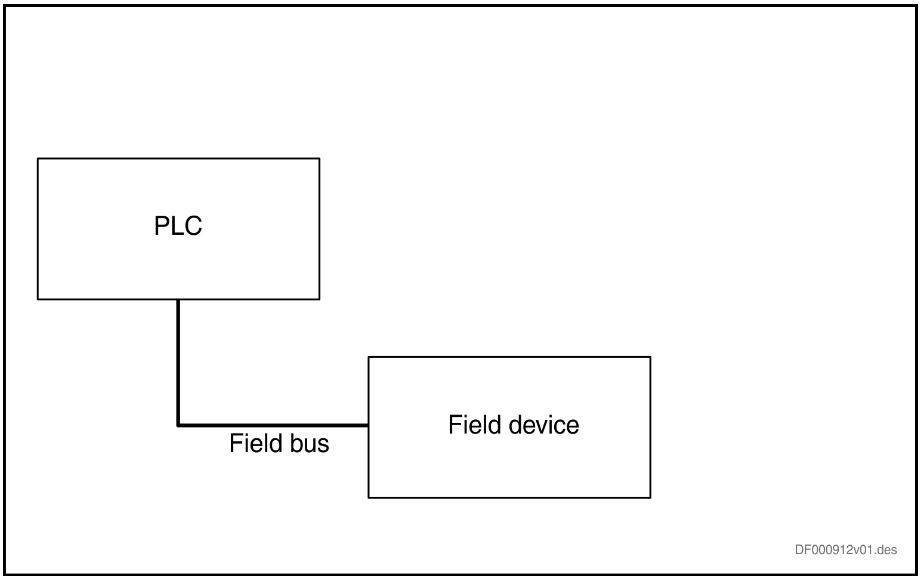


Fig. 3-3: Process data coupling using field bus

Local process data coupling

Besides the already described process data input from a remote control, locally controlling the field application using a control locally integrated in the field device is also possible.

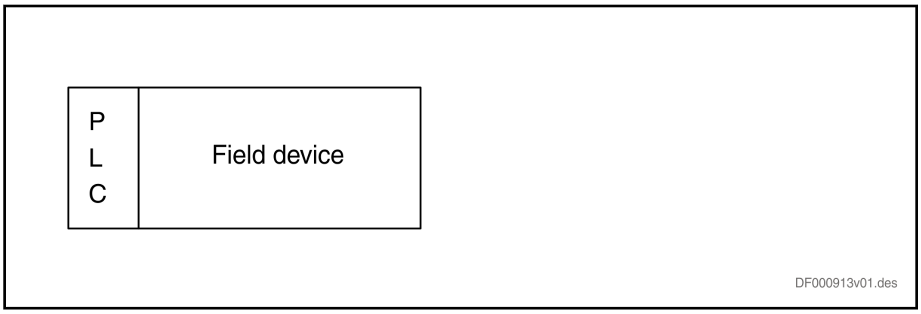


Fig. 3-4: Local process data coupling

In this case, the local control takes over the processing of the user code and thereby the generation of the control values and command values.

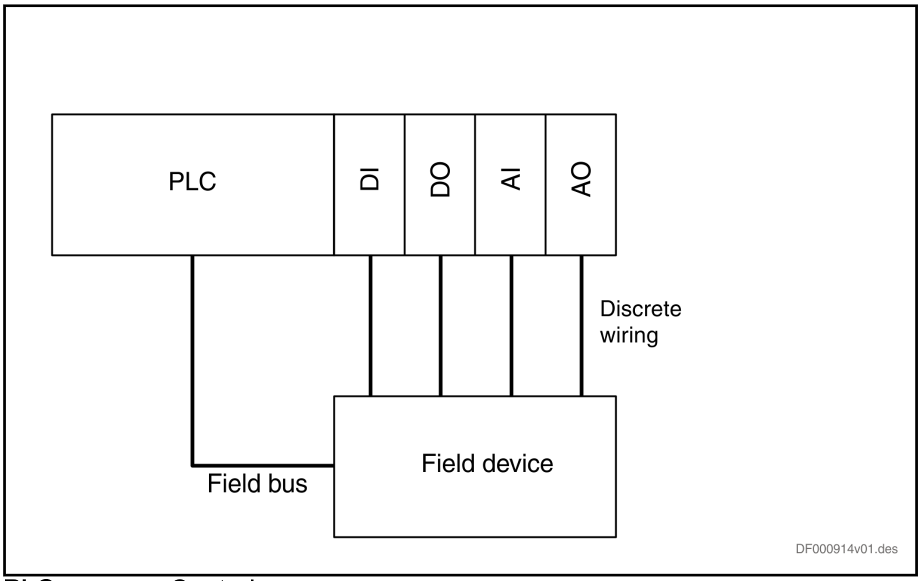
Hybrid coupling

General information

Besides the typical process data coupling, there are hybrid types.

Field bus and discrete wiring

The figure below shows a characteristic of hybrid process data coupling. In this example, the control signals and state signals and parts of the process data are exchanged via digital and analog inputs and outputs at control and field device. Furthermore, the advantages of coupling via a field bus are used for synchronization, for example. In addition, pieces of information can be exchanged via diagnostics and on parameterizations.



PLC	Control
DI	Digital input
DO	Digital output
AI	Analog input
AO	Analog output

Fig. 3-5: Hybrid process data coupling via field bus and discrete wiring

Hybrid coupling via field bus and local input

The figure below shows another characteristic of hybrid process data coupling. The application code is executed in different devices. The basic control of the field device is carried out in a superimposed control. The locally running control implements the local process data adjustment in the field device.

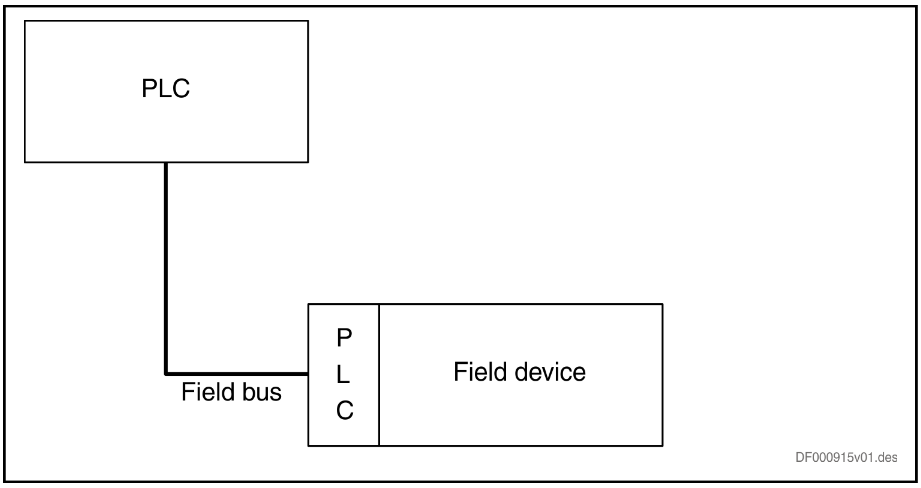


Fig. 3-6: Hybrid coupling via field bus and local input

3.2 Basic functions of master communication

3.2.1 Brief description

General information

With IndraDrive devices, the same basic functions of master communication apply to:

- MultiEthernet interface with

- Sercos
- EtherCAT®
- PROFINET®
- EtherNet/IP™

- Field bus interface
- Analog-Interface

The protocol is selected or deactivated using "P-0-4089.0.1, Master communication: Protocol".

IP engineering can also be carried out via the MultiEthernet interface. This function is maintained after the master communication has been switched off. When the EtherCAT® protocol has been activated, IP engineering cannot be carried out, because it is not supported by EtherCAT®; EoE (Ethernet over EtherCAT) can be used for EtherCAT® instead.

Notes on parameter access

The following mechanisms are available for controls that cannot access 4-byte EIDN parameters:

- 4-byte EDINs in the device with Sercos element and Sercos instance = 0 can be used as 2-byte IDN. Example: Parameter P-0-4089.0.1 via P-0-2310.
- The following 4-byte EIDNs with Sercos element or Sercos instance unequal 0 are mapped to the assigned 2-byte IDN parameters.

4-byte EIDN parameter	2-byte IDN parameter
P-0-4089.0.1, Master communication: Protocol	P-0-2310, Master communication: Protocol
P-0-4089.0.2, Master communication: Device name	P-0-2311, Master communication: Device name
P-0-4089.0.3, Device address	P-0-2303, Device address
P-0-4089.0.4, Active device address	P-0-2304, Active device address
P-0-4089.0.10, Master communication: MAC address device	P-0-2312, Master communication: MAC address device
P-0-4089.0.11, Master communication: MAC address Port1	P-0-2313, Master communication: MAC address Port1
P-0-4089.0.12, Master communication: MAC address Port2	P-0-2314, Master communication: MAC address Port2
P-0-4089.0.13, Master communication: IP address	P-0-2315, Master communication: IP address
P-0-4089.0.14, Master communication: Network mask	P-0-2316, Master communication: Network mask
P-0-4089.0.15, Master communication: Gateway address	P-0-2317, Master communication: Gateway address

Tab. 3-2: Parameters for configuring the master communication

Using the above-mentioned mechanisms, all parameters can thus be accessed via 2-byte IDNs. The CCD configuration parameters represent the only exception.

Features

When the field bus card (PROFIBUS®) has been plugged in, it is only possible to change between inactive master communication and PROFIBUS® master communication. Switching to Sercos®, EtherCAT®, EtherNet/IP™ or PROFINET® is not possible.

- Protocol selection via the control panel or "P-0-4089.0.1, Master communication: Protocol"
- IP engineering is supported depending on the protocol

- Master communication Engineering is supported depending on the protocol
- **Command processing**

  → Device commands to be externally activated (via master communication, "Engineering over IP" or control panel)
- **Device control** (state machine)

  → Individual state machines for master communication and device
  - According to the variant of master communication, the master communication state machine has a different functionality and complexity. The communication-specific states are distinguished and mapped to the status words of the corresponding master communication (e.g. for Sercos: "S-0-0135, Drive status word"; "S-0-1045, Sercos: Device Status (S-Dev)".
  - The device state machine is independent of the variant of master communication and maps the device-specific states to parameter "S-0-0424, Status parameterization level". We always distinguish between the operating mode (OM) and the parameter mode (PM).
- **Extended control options**
  - Signal control word (S-0-0145) and signal status word (S-0-0144)

  See chapter "Control options / additional functions".

☞ The state machine of the master communications is briefly outlined in this section; it will be described in detail, i.e. including the individual status transitions, in the main chapter of the respective master communication.

Parameters involved

The following parameters are used independent of the variant of master communication:

Parameters for state machine and phase switching

- S-0-0011, Class 1 diagnostics
- S-0-0012, Class 2 diagnostics
- S-0-0014, Interface status
- S-0-0420, C0400 Activate parameterization level procedure command
- S-0-0422, C0200 Exit parameterization level procedure command
- S-0-0423, IDN-list of invalid data for parameterization levels
- S-0-0424, Status parameterization level
- P-0-4086, Master communication status
- P-0-4088, Master communication: Drive configuration

Operation mode parameters

- S-0-1709.0.1, Primary operation mode
- S-0-1709.0.2, Secondary operation mode 1
- S-0-1709.0.3, Secondary operation mode 2
- S-0-1709.0.4, Secondary operation mode 3

Control and status words specific to Sercos

For the "Sercos" interface, the following **additional** parameters are used:

- S-0-1720.0.01, Power supply control word

  Alias:

  P-0-2714, Power supply control word

- S-0-1720.0.02, Power supply status word
  Alias:
  P-0-2715, Power supply status word

Diagnostic messages involved

- C0100 Communication phase 3 transition check
- C5200 Communication phase 4 transition check
- C0200 Exit parameterization level procedure command
- C0400 Activate parameterization level 1 procedure command

3.2.2 Protocol selection

Protocol selection The protocol is selected via P-0-4089.0.1. The setting can either be selected via the menu in the "Display" or via the commissioning tool "IndraWorks".

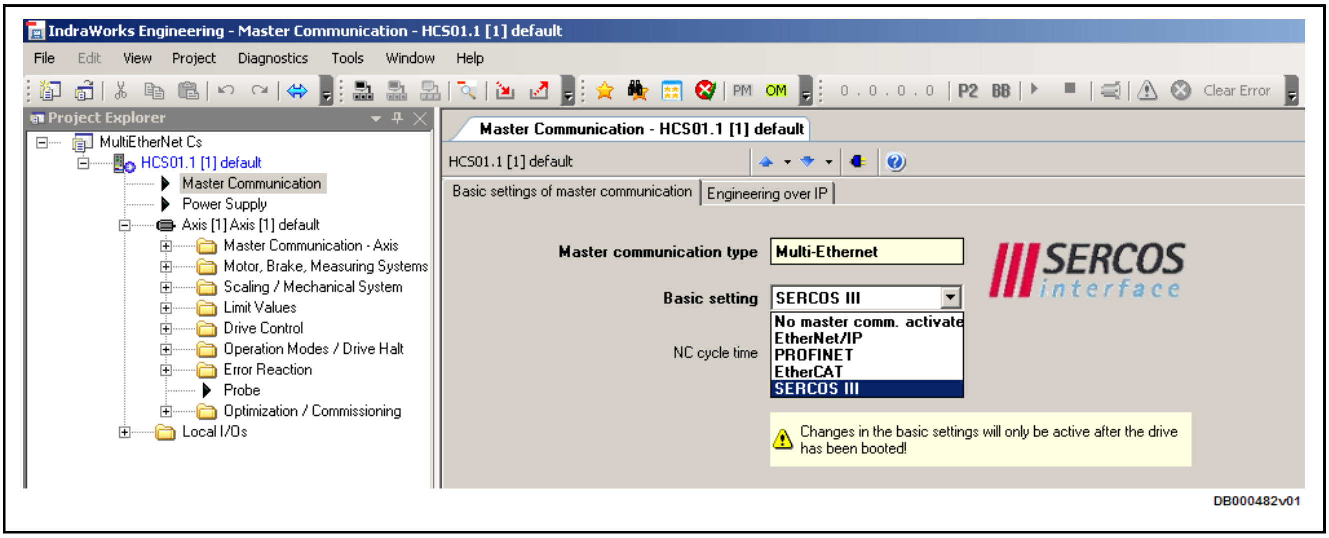


Fig. 3-7: MultiEthernet, protocol selection

After the parameter "P-0-4089.0.1, Master communication: Protocol" was changed, IndraDrive has to be rebooted. If the reboot is not carried out and one tries to switch to the operating mode (OM), the drive signals "C0299 Configuration changed. Restart".

3.2.3 Command processing

Overview

Commands are used to control complex functions in IndraDrive. For example, the "switching preparation phase 3 to 4" function is defined as a command.

> ☞ All commands available in the device are stored in parameter "S-0-0025, IDN-list of all procedure commands".

Types of commands There are 2 different types of commands:

- **Control commands**
  – Can cause automatic drive motion
  – Can only be started when drive enable has been set
  – Deactivate the active operation mode during its execution
- **Administration commands**

– Carry out administration tasks
– Cannot be interrupted

Command execution

General information

When executing the command, comply with the following:

- Belonging to each command there is a parameter with which the command execution can be controlled.
- The higher-level master can start, interrupt and clear commands.
- While a command is being executed, the diagnostic message "Cx" is displayed while "x" represents the number of the command.
- Each command started by the master has to be actively cleared again.

NOTICE **Damage to the internal memory (flash) caused by cyclic command execution (write accesses to the flash)!**

⇒ During the execution of some commands (see description of the respective diagnostic command message; e.g. "C0500 Reset class 1 diagnostics, error reset"), data are written to the internal memory (flash), too. This memory, however, only allows a limited number of write accesses. Therefore, it should be made sure that such write accesses are not carried out too often (a maximum of approx. 100,000 writing cycles).

Controlling the command execution

The command execution is controlled and monitored by command input and command acknowledgment. In the input IndraDrive is informed on whether the command execution is to be started, interrupted or completed. The input takes place via the operating data of the respective parameter.

Commands are started or terminated by:

- Directly writing data to the respective command parameter (e.g. "S-0-0099, C0500 Reset class 1 diagnostics" in command "C0500 Reset class 1 diagnostics, error reset") via master communication

- or -

- A 0-1 edge when the command was assigned to a digital input

  Also see chapter:

  – "Configurable signal control word"
  – "Digital inputs/outputs"

Possible command inputs

For command execution, we distinguish the following inputs (= content of command parameter):

- 0: Not set and not enabled
- 1: Interrupted
- 3: Set and enabled

Command acknowledgment

In the command acknowledgment, IndraDrive informs about the current state of the command execution. The current state is contained in the data status of the command parameter.

☞ The command status can be obtained by executing a command to write data to the parameter element 1 (data status) of the command parameter.

Command status

The command status can be:

- 0x0: Not set and not enabled
- 0x7: In process
- 0xF: error, command execution impossible
- 0x5: Command execution interrupted
- 0x3: Command executed correctly

Command change bit

For master-side detection of a change of the command acknowledgment by IndraDrive, the "command change bit" (KA bit) is available for Sercos in parameter "S-0-0135, Drive status word".

- The supply unit sets this bit when the command acknowledgment changes from the "in process (0x7)" state to one of the following states:
  – Error, command execution impossible (0xF)

  - or -

  – Command correctly executed (0x3)
- The bit is deleted when the master deletes the input (0x0), i.e. writes "0" to the parameter of the command.

☞ The command change bit is only set if the command was activated via the master communication.

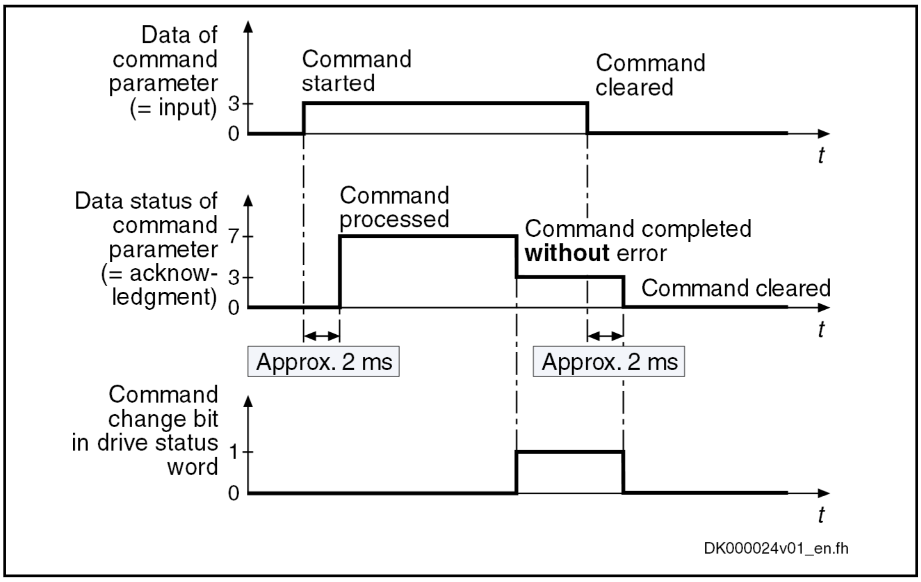


Fig. 3-8: Input, acknowledgment and command change bit in the case of correct execution

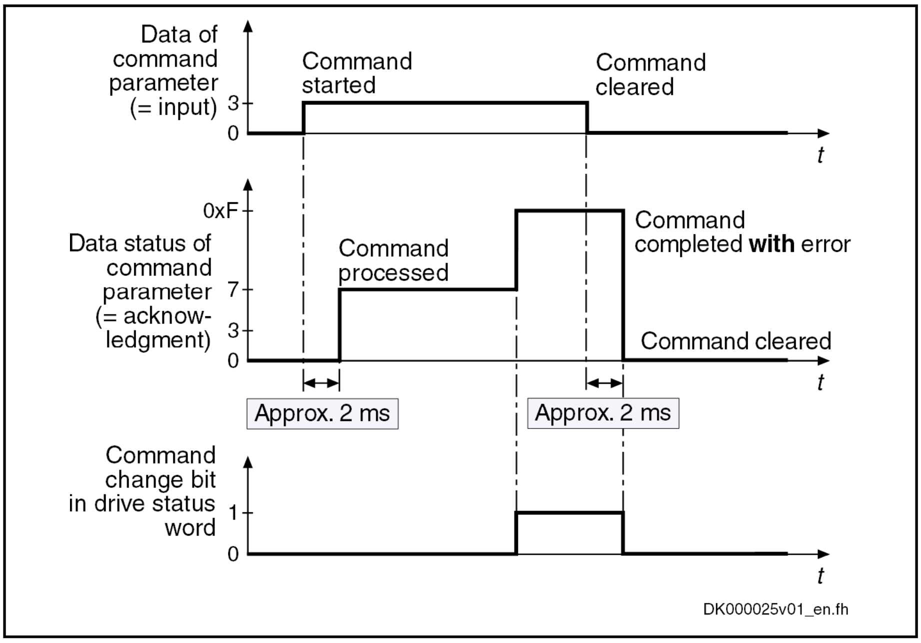


Fig. 3-9: Input, acknowledgment and command change bit in the case of incorrect execution

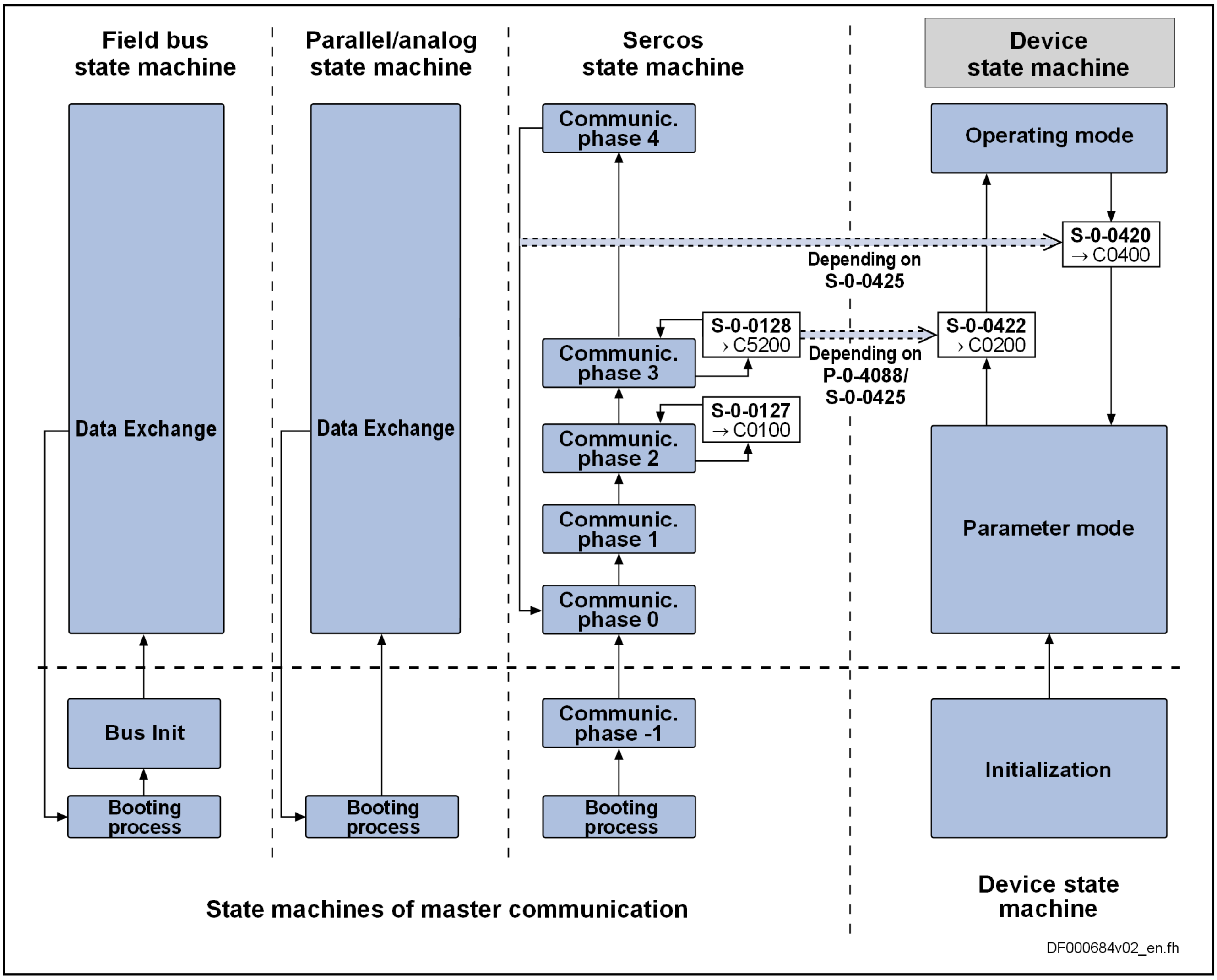
3.2.4 Device control and state machines

Overview

The supply unit state (e.g., supply error) represents a specific internal and external behavior of IndraDrive. It can be exited by defined events (e.g., commands, switching of operation modes). Corresponding state transitions are assigned to the events. The state transitions or the interaction of the control and status bits are called state machine.

It is distinguished between:

- Device-internal state machine (defines the device-specific states which determine the behavior of the device)
- State machine of master communication



S-0-0127,	C0100 Communication phase 3 transition check
S-0-0128,	C5200 Communication phase 4 transition check
S-0-0420,	C0400 Activate parameterization level 1 procedure command
S-0-0422,	C0200 Exit parameterization level procedure command
S-0-0425,	C0200 Exit parameterization level procedure command
P-0-4088,	Master communication: Drive configuration

Fig. 3-10: Overview: State machines of master communications and device

Device-internal state machine

Parameter mode/operating mode

For the device-internal state machine we distinguish the following states:

- Parameter mode (PM)

  → Allows write access to all device parameters which are not password-protected

- Operating mode (OM)

  → Only allows write access to all device parameters which can be changed in operation and preferably can be cyclically transmitted

Switching

It is possible to change between these two states using the following commands:

- S-0-0420, C0400 Activate parameterization level procedure command

- S-0-0422, C0200 Exit parameterization level procedure command

During switching, comply with the following:

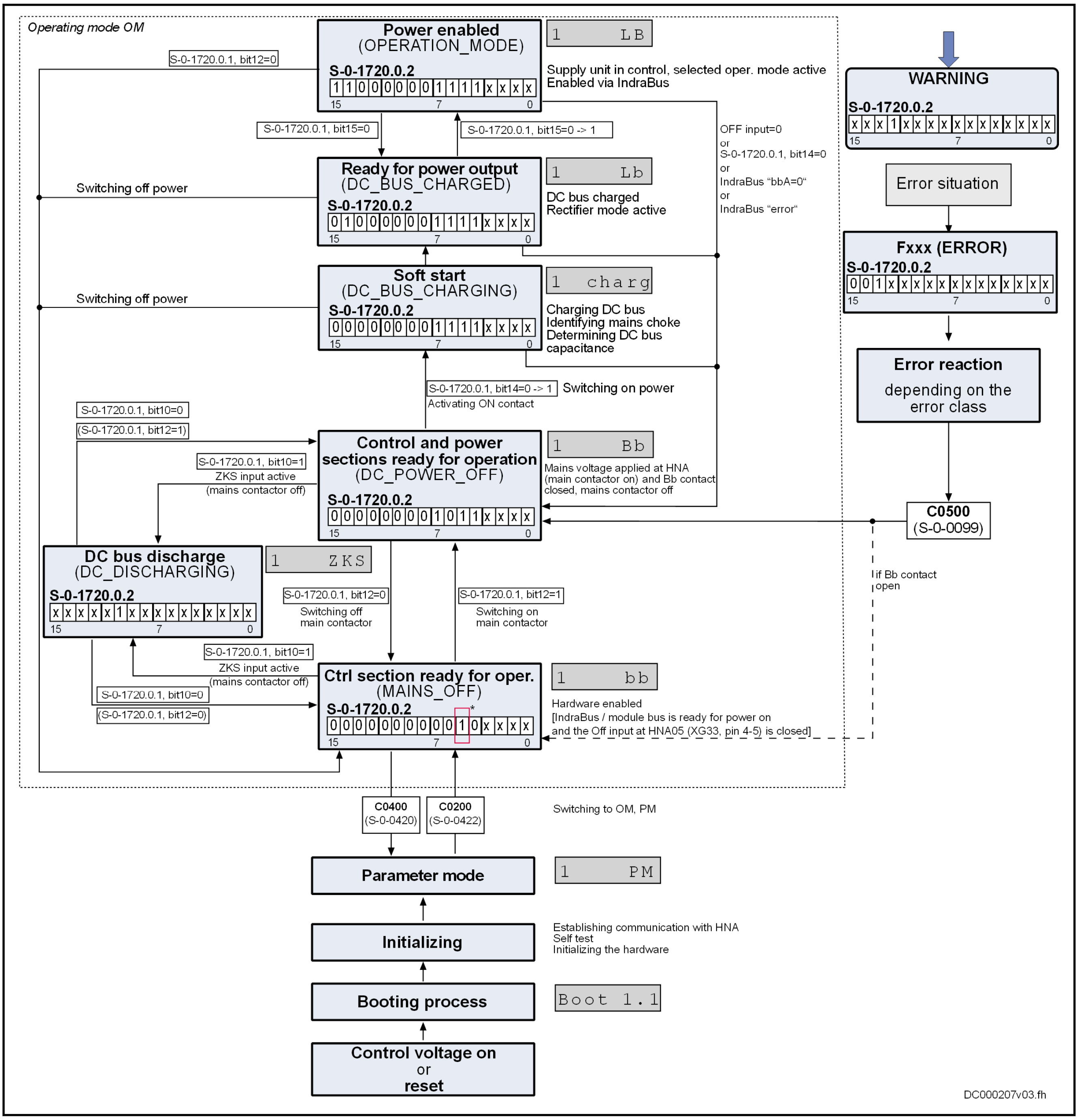
- Switching is generally possible by directly executing the transition commands S-0-0420 or S-0-0422.
- In the MultiEthernet interface, the state machine of the master communication is connected to the device-internal state machine. This means that when master communication is switched (communication phase 2 → communication phase 4 or back), the device-internal state machine is also switched. Via parameter "P-0-4088, Master communication: Drive configuration", this dependency can be deactivated.

Control word and status word

The device-specific states are mapped to the following parameter:

- S-0-0424, Status parameterization level

State machine of the device



*	If the Off input at HNA05 (XG33, pin 4-5) is not connected or interrupted, bit 5 remains on logic 0.
DCb	DC bus
HNA	Mains connection module

Fig. 3-11: Device control (general state machine)

Also see "Timing diagrams for device control".

For the state machine of master communication, we distinguish 2 characteristics which differ with regard to their functionality and complexity:

- Sercos state machine

- Field bus state machine

The following sections only describe the most important states which are described in detail in the section of the respective master communication.

Sercos state machine

For the "Sercos" master communication, the following states specific to this communication type are distinguished:

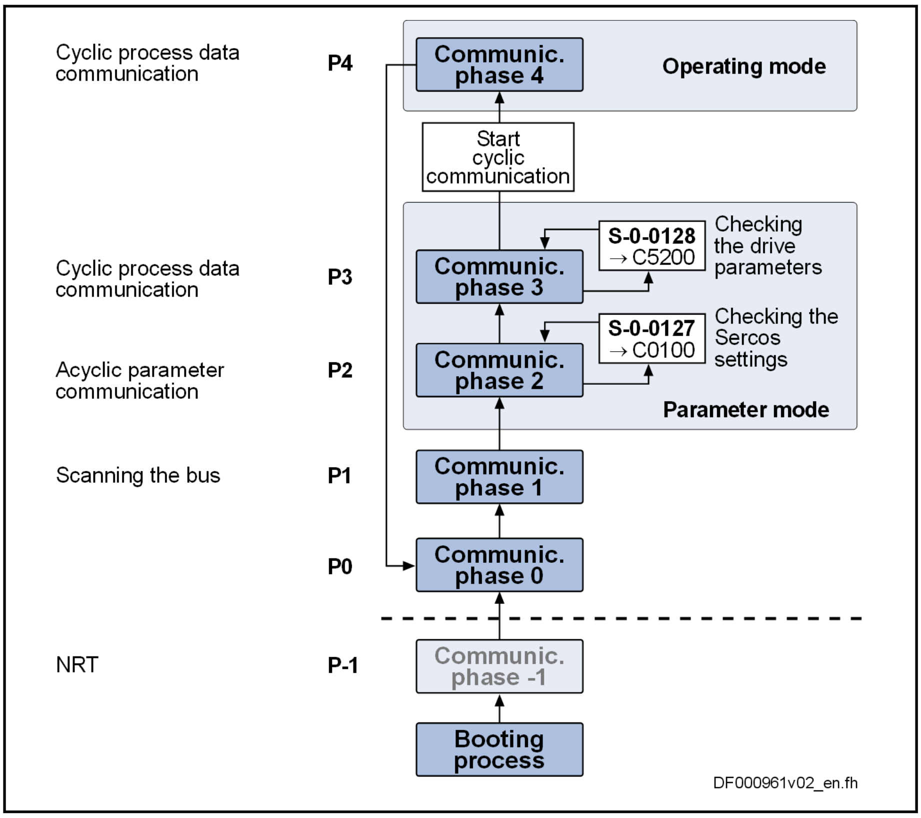


Fig. 3-12: State machine of the communication phases of the device according to the Sercos specification

See also chapter "Sercos" in the functional description.

The currently valid communication phase is contained in parameter "S-0-0014, Interface status" (bit 0…2).

Field bus state machine

For the field bus master communication, we distinguish the following states specific to this communication type:

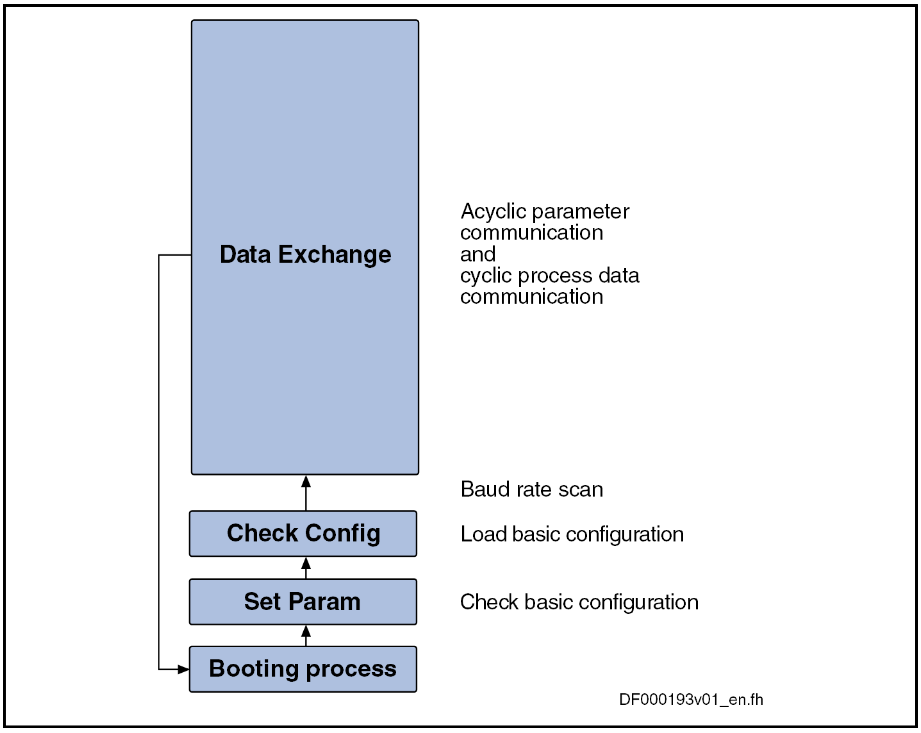


Fig. 3-13: State machine for field bus interfaces

See also sections on the respective variants of the field bus master communication.

Communication phases of master communication

The supported communication phases, as well as the handling of the switching between the communication phases (e.g. parameter and operating mode), depend on the master communication that is used.

☞ The currently valid communication phase is contained in parameter "S-0-0014, Interface status" (bit 0…2).

Communication phases according to Sercos specification

According to **Sercos specification**, the individual communication phases (states) have the following significance:

- **P-1**: In this phase, the device can communicate via standard Ethernet mechanisms.
- **P0**: The master determines the topology (ring/line) in P0. The slaves determine their topology addresses and communicate the addresses to the master with the set Sercos address. At the end of P0, the master knows the used Sercos addresses and their position in the topology.
- **P1**: In P1, the service channels of the connected slaves are initialized by the master.
- **P2**: In phase 2, the device can be completely parameterized.

  The following types of parameters **can only be changed in phase 2**:

  – Communication parameters (according to Sercos)

  – Configuration of power supply control

  – All factory-specific settings (can only be changed via master password)
- **P3**: When changing from P2 → P3, only the parameters that can be changed in phase 2 (see above) are checked.

In phase 3, the following parameters can be changed:

- Parameters for operating mode configuration
- Error reaction settings
- Scaling and polarity parameters, position data format, modulo value
- Configuration of analog and digital inputs/outputs
- Configuration of switch-on / switch-off sequence of drive enable (waiting times, ...)

☞ The parameter mode is divided into phase 2 and 3 according to the Sercos specification. In phase 3, the limit values for all scaling-dependent parameters are not yet known. When these parameters are written in phase 3, the extreme value check is only carried out during phase switch to phase 4.

- **P4**: In phase 4, the so-called "Operating mode", only cyclic data can be changed, the configuration parameters cannot be changed anymore. Switching to the operating mode always causes all functions available in the device to be reinitialized.

During **phase switching**, comply with the following:

- After the device has been switched on, it does not automatically go to the operating mode, but has to be switched to this mode by the master.
- This switching of the device to the operating mode is closely connected to establishing the readiness for operation.
- The procedure comprises several steps and is controlled by the master by presetting communication phases -1 to 4 and starting/completing the following commands:
  - S-0-0127, C0100 Communication phase 3 transition check
  - S-0-0128, C5200 Communication phase 4 transition check

☞ Sercos devices support **all 5 communication phases** (as well as NRT phase). According to the Sercos specification, switching takes place by specifying the communication phase via the master.

Communication phases for field bus interface

For devices with **field bus interface**, there only is the status "Data Exchange", apart from the basic initialization. In the status "Data Exchange", the following device states are distinguished:

- Parameter mode
- Operating mode

Communication phases for analog interface

Basically, the same communication phases apply to devices with **analog interface** as for devices with field bus interface.

Switching always takes place when the transition check commands are executed.

☞ After IndraDrive has been switched on, it automatically changes to the operating mode!

Control and status words of master communication

The control word and status word of the respective master communication are an essential part of the communication between the master communication master and IndraDrive.

Depending on the master communication, different parameters are used:

- S-0-1720.0.1, Power supply control word

  Alias:

  P-0-2714, Power supply control word
- S-0-1720.0.2, Power supply status word

  Alias:

  P-0-2715, Power supply status word

Commands and diagnostic messages for mode change and phase switch

Distinguishing the commands

According to the desired action, the commands are related to the following groups:

- Commands for changing between parameter mode and operating mode:
  – S-0-0420, C0400 Activate parameterization level procedure command
  – S-0-0422, C0200 Exit parameterization level procedure command
- Commands for transition preparation to communication phases 3 and 4 (with Sercos only):
  – S-0-0127, C0100 Communication phase 3 transition check
  – S-0-0128, C5200 Communication phase 4 transition check

☞ With Sercos, the command C0200 (S-0-0422) is automatically called during the execution of command C5200 (S-0-0128). This is why a diagnostic command message C02xx can be displayed after the command C5200 has been started.

Communication Phase 3 Transition Check

By executing the command "S-0-0127, C0100 Communication phase 3 transition check", a number of checks and parameter conversions are carried out that can possibly cause the listed diagnostic command messages:

- Checking validity of parameters required for switching to phase 3

  If one of these parameters has never been written or the backup was carried out incorrectly, the error message "C0101 Invalid parameters (-> S-0-0021)" is generated. The IDNs of the faulty parameters are listed in parameter "S-0-0021, IDN-list of invalid operation data for CP2". These parameters have to be set valid by writing correct values to them.
- Checking device configuration
- Checking telegram configuration, especially in the case of configured telegrams

  In this case a check is run to find out whether the parameters selected for the configurable data block in the cyclic command value channel (MDT) or actual value channel (AT) may be configured and whether the allowed length of the configurable data blocks is complied with.
- If necessary, checking timing parameters for Sercos communication in phases 3 and 4 for validity and compliance with boundary conditions.
- Limit value check of communication parameters and system

Communication phase 4 transition check or "Exit parameterization level procedure" command

With the command "S-0-0128, C5200 Communication phase 4 transition check" bzw. "S-0-0422, C0200 Exit parameterization level procedure command", the following checks and initializations are carried out that can possibly cause the listed command errors:

- Checking whether functional package selection was changed
  - C0299 Configuration changed. Restart

    → Device has to be rebooted before it is possible to switch to the operating mode (OM)
- Checking validity of parameters required for subsequent initializations
  - C0201 Invalid parameters (->S-0-0423)
  - C0212 Invalid control section data (->S-0-0423)
- Checking device configuration
  - C0223 Invalid settings for controller cycle times
- If necessary, check parameters for field bus communication for validity and compliance with boundary conditions
  - C0229 Field bus: IDN for cycl. command val. not configurable
  - C0230 Field bus: Max. length for cycl. command val. exceeded
  - C0231 Field bus: IDN for cycl. actual val. not configurable
  - C0232 Field bus: Length for cycl. actual values exceeded
  - C0233 Field bus: Tcyc (P-0-4076) incorrect
  - C0234 Field bus: P-0-4077 missing for cycl. command values
- Limit value check
  - C0202 Parameter limit error (->S-0-0423)
  - C0203 Parameter conversion error (->S-0-0423)
- Initializing fine interpolator
  - C0258 Error in relation TNcyc (S-0-0001) to fine interpol.
- Checking interface configuration
  - C0242 Multiple configuration of a parameter (->S-0-0423)
- Checking master communication
  - C0251 Error during synchronization to master communication
- Checking whether boot error is present or firmware download has been carried out
  - C0298 Impossible to exit parameterization level

Checking whether it was possible to switch CCD group without error:

C0266 Incorrect CCD phase switch

"Error-free" message

When IndraDrive has reached communication phase 4 without error, the display reads "bb". The corresponding diagnostic message is:

- A0013 Ready for power on

3.3 Control options / additional functions

3.3.1 Configurable signal control word

Brief description

The signal control word allows individual control bits, that are available in different parameters, to be written by a freely configurable collective parameter.

The configurable signal control word is used to accept a maximum of 16 copies of bits from other device parameters.

Possible applications

This functionality can be used, for example,

- for setting bits in device parameters and for starting commands via the cyclic channel (master communication),
- for defining an application-specific combination of 16-bit wide control and status words which can then be transmitted in the cyclic data channel.

☞ For Sercos and field bus interfaces the parameter "S-0-0145, Signal control word" has to be configured in the cyclic data so that the configured control bits are evaluated.

Parameters involved

- S-0-0027, Configuration list for signal control word
- S-0-0145, Signal control word
- S-0-0329, Assign list signal control word
- S-0-0399, IDN-list of configurable data in signal control word

Notes on commissioning for the signal control word

Selection list

Only parameters contained in "S-0-0399, IDN-list of configurable data in signal control word" can be assigned to parameter "S-0-0027, Configuration list for signal control word".

Configuring the IDNs

In parameter "S-0-0027, Configuration list for signal control word", the IDNs of those parameters are specified that are to be configured using the signal control word (= targets).

The position of an IDN in this list defines which bit is assigned to which IDN (targets) in the signal control word. For example, the first list element determines the parameter to which bit 0 of the signal control word is assigned.

Configuring the bit numbers

Which bit of the selected parameters (= targets in parameter S-0-0027) is set (or cleared) by the signal control word, has to be defined in parameter "S-0-0329, Assign list signal control word".

☞ The number of entries in S-0-0329 determines how many entries are processed of S-0-0027. It is necessary to make sure that the lists in S-0-0027 and S-0-0329 have the same length.

Bit numbers from "0" (LSB) to "31" (MSB) can be entered.

☞ A maximum of 16 bits can be configured. The configuration always has to be carried out from the least significant to the most significant bit. In other words, the position of the bit copy in the signal control word results from the continuous configuration in parameter "S-0-0027, Configuration list for signal control word".

Exceptions

- If the assigned parameter is a command, the bit number in parameter "S-0-0329, Assign list signal control word" is not relevant.

> ☞ When cross communication is used in the "CCD system mode", parameter "S-0-0145, Signal control word" is used for mapping the control bits not contained in parameter "S-0-0134, Master control word". That is why this parameter, in the CCD system mode, has already been configured by default in the cyclic master data telegram (MDT → S-0-0024)! In addition, other bits have been permanently configured so that in this case the user can only define the bits 12 to 15!

Diagnostic messages and error messages

When entering data in the parameters "S-0-0027, Configuration list for signal control word" and "S-0-0329, Assign list signal control word", the following checks are run:

- If an IDN specified in parameter S-0-0027 is not contained in parameter "S-0-0399, IDN-list of configurable data in signal control word", the error message ""0x7008 Invalid data" is generated.

> ☞ In this case, only those inputs up to the faulty element are accepted!

3.3.2 Configurable signal status word

Brief description

The configurable signal status word is used to accept a maximum of 16 copies of bits from other device parameters. The user can thereby freely configure a bit list with status bits. This allows a bit list to be defined which contains all the important pieces of status information of IndraDrive for the control unit.

Parameters involved

- S-0-0026, Configuration list for signal status word
- S-0-0144, Signal status word
- S-0-0328, Assign list signal status word
- S-0-0398, IDN-list of configurable data in signal status word

Notes on commissioning for the signal status word

Configuring the IDNs

In parameter "S-0-0026, Configuration list for signal status word", the IDNs of those parameters are indicated that contain the original bits (sources). The parameters that can be entered in the configuration list are contained in parameter "S-0-0398, IDN-list of configurable data in signal status word". The position of an IDN in the list determines the bit in the signal status word the IDN applies to. For example, the first list element determines from which parameter the bit 0 of the signal status word is taken.

Configuring the bit numbers

Which bit of the parameters selected in "S-0-0026, Configuration list for signal status word" is copied to the signal status word has to be defined in "S-0-0328, Assign list signal status word".

> ☞ The number of entries in S-0-0328 determines how many entries are processed of S-0-0026. It is necessary to make sure that the lists in S-0-0026 and S-0-0328 have the same length.

Bit numbers from "0" (LSB) to "31" (MSB) can be entered.

Das Signal status word can have the following configuration:

Bit no. in signal status word (S-0-0144)	IDN of original parameter in S-0-0026	Bit no. of original parameter in S-0-0328	Significance
0	S-0-0424	0	Status parameterization level

Tab. 3-3: Example of configuration of the signal status word

☞ A maximum of 16 bits can be configured. The configuration always has to be carried out from the least significant to the most significant bit. In other words, the position of the bit copy in the signal status word results from the continuous configuration in parameter "S-0-0026, Configuration list for signal status word".

☞ When cross communication is used in the "CCD system mode", parameter "S-0-0144, Signal status word" is used for mapping the control bits not contained in parameter "S-0-0135, Drive status word". That is why this parameter, in the CCD system mode, has already been configured by default in the cyclic drive telegram (AT → S-0-0016)! In addition, other bits have been permanently configured so that in this case the user can only define the bits 12 to 15!

Diagnostic messages and error messages

When entering data in the parameters "S-0-0328, Assign list signal status word" and "S-0-0026, Configuration list for signal status word", the following checks are run:

- Check whether the IDN specified in S-0-0026 has variable data length (list parameter) or a so-called online read function. If yes, the service channel error message "0x7008 Invalid data" is generated.

  Parameters with online read functions generally are parameters with physical units (voltages and currents), as well as the parameters "S-0-0135, Drive status word" and "S-0-0011, Class 1 diagnostics".

☞ In this case, only those inputs up to the faulty element are accepted!

3.4 Operation with master communication switched off

As an alternative to master communication, supply units can also be controlled via digital inputs and outputs. For this purpose, the master communication interface has to be deactivated using the parameter "P-0-4089.0.1, Master communication: Protocol".

Control is carried out using the parameter "S-0-1720.0.150, Power supply ON/OFF". Observe the following aspects:

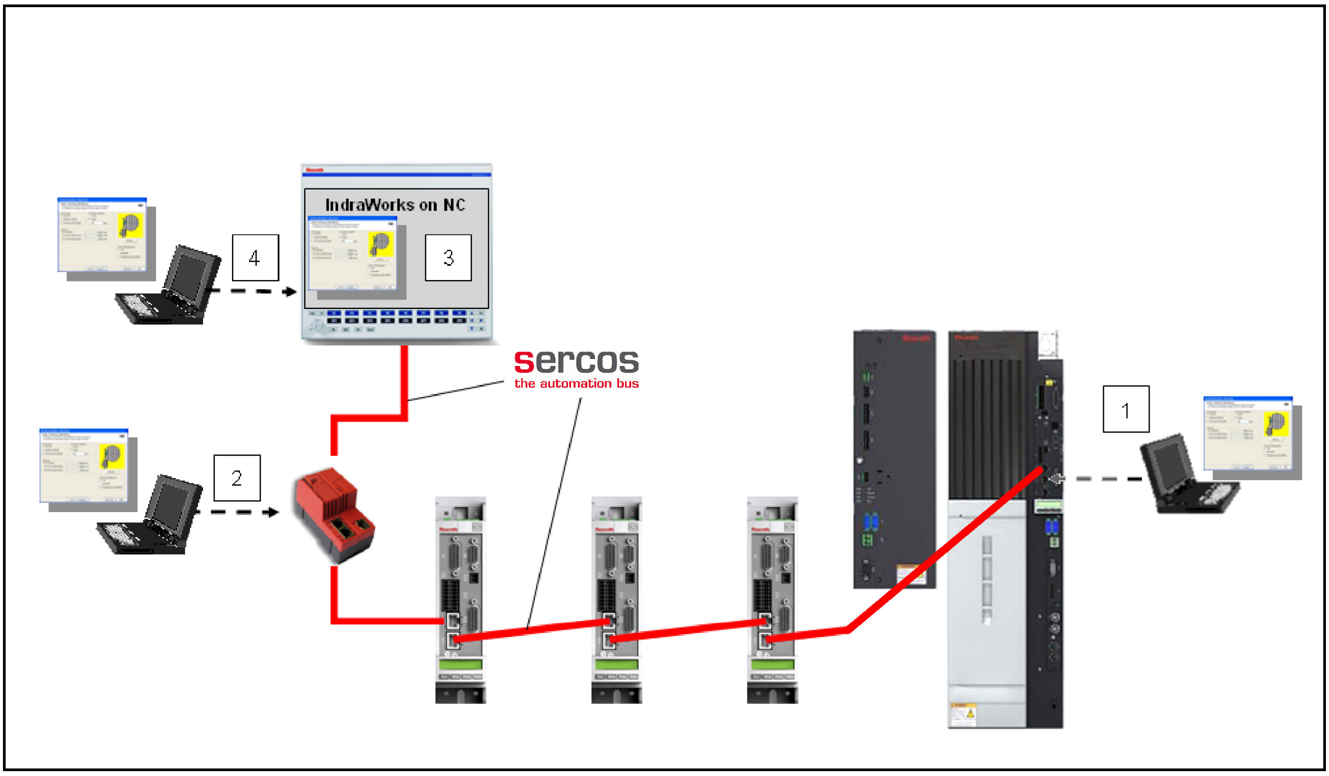
- For the KMV supply unit, the corresponding bits of the above parameter have to be assigned to the digital inputs of the device.
- For the supply unit with HMU, the digital inputs of HNA are automatically mapped to the parameter represented above. Control is directly carried out using the digital inputs of HNA (see Project Planning Manual).

When power is switched on, the DC bus is charged via the soft start device and the supply unit switches to the primary operation mode. By default this is the "voltage control" mode.

3.5 Sercos

3.5.1 Brief description

Topology



1	Engineering via free Sercos port of a device at the bus
2	Engineering via optional Sercos netSWITCH
3	Engineering via IndraWorks on Sercos control
4	Engineering via routing using control unit (if routing control is available)

Fig. 3-14: Engineering options via Sercos

It is possible to operate IndraDrive controllers with a MultiEthernet interface (ET) or the optional module "Sercos" as Sercos master communication. Via these modules, it is possible to exchange real-time data with a Sercos master.

We distinguish the following communication channels:

- **Cyclic data channel**

  → Channel for cyclic transmission of useful data (**process data**) in real time
- **Acyclic data channel** (service channel)

  → Channel for acyclic transmission of useful data (**service data**)
- **Non-real-time channel (NRT channel)**

  → Defined time slot within the cycle time for transmission of standard Ethernet telegrams

General features

- Baud rate 100 Mbit/s
- Cyclical exchange of command values and actual values in equal time intervals

- Data transfer via Ethernet cable (CAT5e-copper)
- Service channel for parameterization and diagnostics
- Free configuration of telegram contents
- Synchronization between time command value takes effect and feedback acquisition starting time for all devices on a ring
- Overall synchronization of all connected devices

Firmware-specific features

			BASIC PSB-21VRS
Voltage controller clock	$T_{voltage}$	µs	**125/250**
Master communication cycle time	min	µs	**250/500**
	max	ms	65
Motion data for MDT/AT respectively [excl. 2 byte connection control word (C_Con)]	$T_{Sercos}=T_{position}$	Byte	**26**
		IDN	12
	$T_{Sercos}>T_{position}$	Byte	50
		IDN	16
CC connections [excl. 2 byte connection control word (C_Con)]		Byte	12
		IDN	2
Safety connections		Byte	10
		IDN	SMP container

Tab. 3-4: Sercos identification numbers

- IndraDrive supports 6 connections, 2 between control unit and device and 4 CC connections for direct communication with one or several other nodes

CC connections or connections for exchanging Safety data were implemented in this firmware version in accordance with the Sercos specification (SCP V1.1.2). For use and configuration, refer to technical note "TN_332_CC-Verbindungen_SERCOS3_EIDN.pdf"

Hardware requirements

Axis addressing

The axis address can be set directly using the control panel of the device. This can be done using the so-called Easy Menu (see also "Standard control panel").

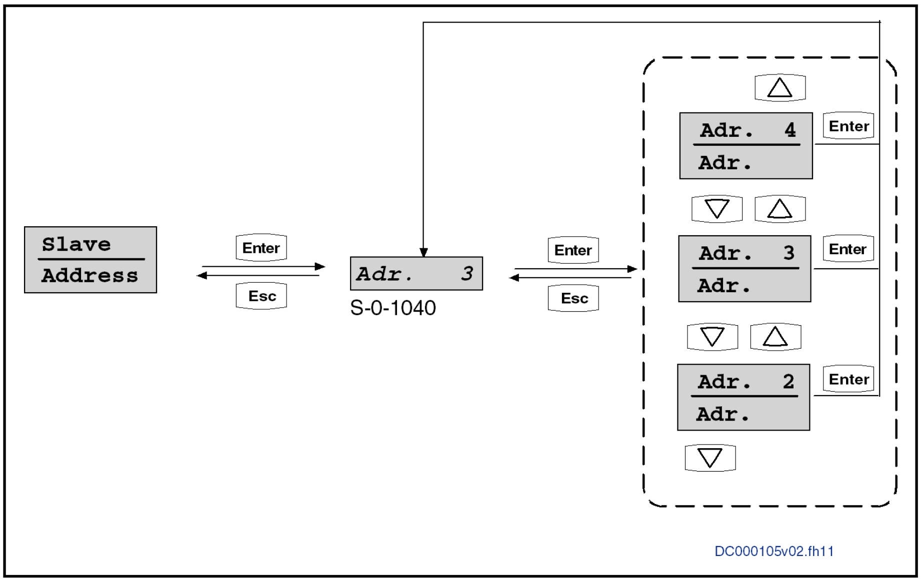


Fig. 3-15: Submenu for "Slave___" "_Addresss"

Optionally, the address can be directly changed or displayed using the parameter "S-0-1040, Drive address of master communication". With Sercos, the address can be set remotely and automatically via the master using remote address assignment. This function has to be supported by the master, e.g. the CCD master. On this topic, see chapter "Cross communication (CCD)". The topology address of the device determined in communication phase 0 (CP0) is displayed in parameter "S-0-1042, Sercos: Topology index".

The axis address is always displayed in the left side of the standard display of the control panel.

Parameters involved

Specific parameters for Sercos communication:

- S-0-1000, Sercos: SCP Type & Version
- S-0-1002, Sercos: Communication Cycle time (tScyc)
- S-0-1003, Sercos: Allowed MST losses
- S-0-1005, Sercos: Minimum feedback processing time (t5)
- S-0-1006, Sercos: AT0 transmission starting time (t1)
- S-0-1007, Sercos: Feedback acquisition capture point (t4)
- S-0-1008, Sercos: Command value valid time (t3)
- S-0-1009, Sercos: Device Control (C-Dev) offset in MDT
- S-0-1010, Sercos: Lengths of MDTs
- S-0-1011, Sercos: Device Status (S-Dev) offset in AT
- S-0-1012, Sercos: Length of ATs
- S-0-1013, Sercos: SVC offset in MDT
- S-0-1014, Sercos: SVC offset in AT
- S-0-1015, Sercos: Ring delay
- S-0-1016, Sercos: Slave delay (P/S)
- S-0-1017, Sercos: NRT transmission time
- S-0-1019, Master comm. engineering over IP: MAC address
- S-0-1020, Master comm. engineering over IP: IP address
- S-0-1021, Master comm. engineering over IP: Network mask

- S-0-1022, Master comm. engineering over IP: Gateway address
- S-0-1023, Sercos: SYNC jitter
- S-0-1024, C5300 Sercos: SYNC delay measuring procedure command
- S-0-1026, Sercos: Version of communication hardware
- S-0-1027.0.1, Sercos: Requested MTU
- S-0-1027.0.2, Sercos: Effective MTU
- S-0-1028, Sercos: Error counter MST-P/S
- S-0-1031, Sercos: Signal assignment TSx
- S-0-1034, Sercos: PHY error counter Port1 and Port2
- S-0-1035, Sercos: Error counter Port1 & Port2
- S-0-1035.0.1, Sercos: Error counter P&S
- S-0-1036, Sercos: Inter Frame Gap
- S-0-1037, Sercos: Slave Jitter
- S-0-1040, Drive address of master communication
- S-0-1041, Sercos: AT Command value valid time (t9)
- S-0-1042, Sercos: Topology index
- S-0-1044, Sercos: Device Control (C-Dev)
- S-0-1045, Sercos: Device Status (S-Dev)
- S-0-1046, Sercos: Slave addresses of the device
- S-0-1047, Sercos: Maximum Consumer Activation Time
- S-0-1050.x.1, Sercos Connection: Connection setup
- S-0-1050.x.2, Sercos Connection: Connection number
- S-0-1050.x.3, Sercos Connection: Telegram assignment
- S-0-1050.x.4, Sercos Connection: Max. length of connection
- S-0-1050.x.5, Sercos Connection: Current length of connection
- S-0-1050.x.6, Sercos Connection: Configuration list
- S-0-1050.x.7, Sercos Connection: Connection class
- S-0-1050.x.8, Sercos Connection: Connection control (C-Con)
- S-0-1050.x.9, Sercos Connection: State
- S-0-1050.x.10, Sercos Connection: Producer cycle time
- S-0-1050.x.11, Sercos Connection: Allowed data losses
- S-0-1050.x.12, Sercos Connection: Error counter data losses
- S-0-1050.x.20, Sercos Connection: IDN allocation of real-time bit
- S-0-1050.x.21, Sercos Connection: Bit allocation of real-time bit
- S-0-1051, Sercos Connection: Image of connection setups
- S-0-1060.x.1, Sercos Connectiontype: Default configuration
- S-0-1060.x.2, Sercos Connectiontype: Configuration mask
- S-0-1060.x.3, Sercos Connectiontype: Max. quantity of conn. Capability
- S-0-1060.x.4, Sercos Connectiontype: Max. Length of Connection
- S-0-1060.x.6, Sercos Connectiontype: Configurable IDNs
- S-0-1060.x.7, Sercos Connectiontype: Min. processing time
- S-0-1060.x.10, Sercos Connectiontype: Minimum producer cycle time

Diagnostics involved

- A0000 Communication phase 0
- A0001 Communication phase 1
- A0002 Communication phase 2
- A0003 Communication phase 3
- A0008 Sercos: NRT-Mode
- E4020 Sercos: Ring interruption (FF to LF)
- F4001 Sync telegram failure
- F4002 RTD telegram failure
- F4003 Invalid communication phase shutdown
- F4004 Error during phase progression
- F4005 Error during phase regression
- F4006 Phase switching without ready signal
- F4017 Sercos: Incorrect sequence during phase switch
- F4020 Sercos: Cable break (L+F to NRT)

3.5.2 Functional description

Sercos diagnostic LED

In IndraDrive, a diagnostic LED in accordance with the Sercos specification is implemented, see also chapter "Diagnostic and status messages".

Blinking code												Function	P
												No Sercos Telegrams (NRT mode)	6
Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	CP0	6
Or-ange	Green	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	CP1	6
Or-ange	Green	Or-ange	Green	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	CP2	6
Or-ange	Green	Or-ange	Green	Or-ange	Green	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	Or-ange	CP3	6
Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	CP4	6
Green		Green		Green		Green		Green		Green		CPx →Loop-back	5
Red	Or-ange	Red	Or-ange	Red	Or-ange	Red	Or-ange	Red	Or-ange	Red	Or-ange	Application-re-lated C1D	4
Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green	S-Dev.Bit15 (MST warning)	3
Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	C1D of Communication	2

Blinking code												Function	P
Or-ange		Or-ange		Or-ange		Or-ange		Or-ange		Or-ange		C-Dev.Bit15 (Identification)	1
Red		Red		Red		Red		Red		Red		Internal watch-dog has triggered	0

P Display priority (1 = highest)
Black LED is off
CP communication phase

Tab. 3-5: Supported blinking codes and their significance to the diagnostic LED correspond to the Sercos specification

3.5.3 Sercos timing

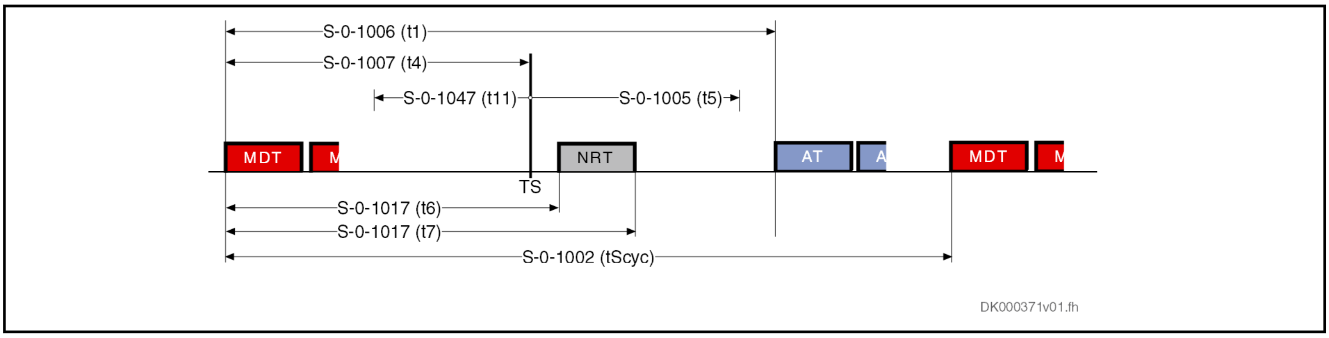
In IndraDrive, the process data are processed in a synchronous way. The characteristic of synchronous processing is that a master, via timing parameters, can exactly define the time of actual value determination (and command value acceptance). For the calculation, IndraDrive provides its time conditions via parameters. The master sets the point in time of processing as TS (S-0-1007, Sercos: Feedback acquisition capture point (t4)).

In the parameter "S-0-1005 Sercos: Minimum feedback processing time (t5)", a slave specifies its maximum processing time (tmp-P) as a producer.

Rule: Process data (actual values) are transmitted in the AT block for which the maximum processing time is **completely** within the beginning of the AT block and the synchronization time TS.

The slave specifies its maximum activation time (tmp-C) as consumer in parameter "S-0-1047 Sercos: Maximum Consumer Activation Time".

Rule: Process data (command values) are taken from the telegram block (MDT and/or AT) for which the maximum activation time is **completely** within its telegram block end and the synchronization time TS.



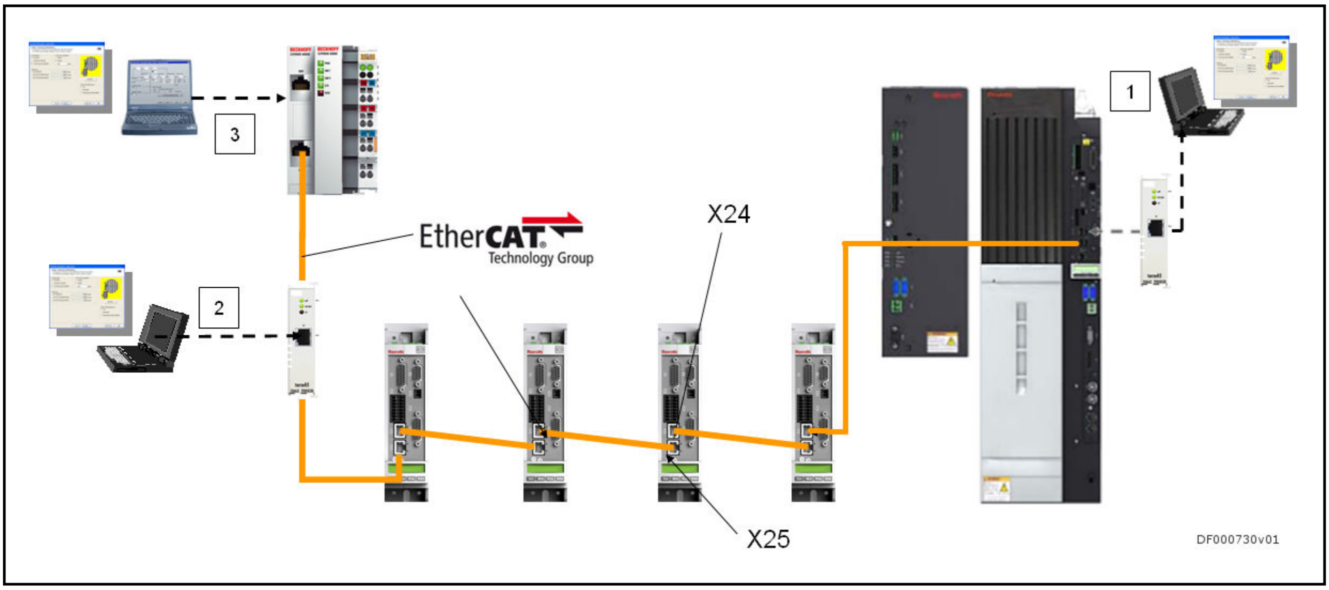
MDT Master data telegram
AT Response telegram
NRT Non real-time
TS Synchronization time
S-0-1002 Sercos: Communication Cycle time (tScyc)
S-0-1005 Sercos: Minimum feedback processing time (t5)
S-0-1006 Sercos: AT0 transmission starting time (t1)
S-0-1007 Sercos: Feedback acquisition capture point (t4)
S-0-1047 Sercos: Maximum Consumer Activation Time
S-0-1017 Sercos: NRT transmission time; start (t6)
S-0-1017 Sercos: NRT transmission time; end (t7)

Fig. 3-16: Telegrams

3.6 EtherCAT®

3.6.1 Brief description

Topology



1	Engineering using EoE via optional Ethernet switch port
2	Engineering using EoE via optional Ethernet switch port
3	Engineering using ADS interface via third-party control or Engineering using EoE (control includes switch port)

Fig. 3-17: Engineering options with EtherCAT®

IndraDrive controllers with MultiEthernet interface (ET) can be operated as EtherCAT® master communication. Via these modules it is possible to exchange real-time data with an EtherCAT® master. The "Servo Drive Profile over EtherCAT® (SoE)" is supported, it is based on the drive profile from the SERCOS II specification.

We distinguish the following communication channels:

- **Cyclic data channel** (process data)

  → Data container for cyclic transmission of useful data (**process data**) in real time
- **Acyclic data channel** (service channel)

  → EtherCAT® mailbox method for acyclic transmission of useful data (**service data**)
- **Non-real time channel** [Ethernet over EtherCAT® (EoE)]

  → Transmission of Ethernet telegrams via an EtherCAT® mailbox method [Ethernet over EtherCAT® (EoE)]

General features

- Baud rate 100 Mbit/s
- Data transmission via Ethernet cable (CAT5e-copper)
- Topology: "Line"
- Access to 16 bit Sercos parameters of the device via "SoE" protocol ("Servo Drive Profile over EtherCAT®" protocol)
- EtherCAT® mailbox method for parameterization and diagnostics
- Cyclic data exchange of command values and actual values

- Free configuration of telegram contents
- Max. length of the configurable MDT/AT data, 15 IDNs with max. 48 bytes; if bus clock = position clock, the max. length is reduced by half to 24 bytes
- Cycle time: min. 500 μs (multiples of the position cycle time can be set)
- Optional synchronization via "distributed clock synchronization" (exact adjustment of distributed clocks)
- Synchronization between time command value takes effect and feedback acquisition starting time for all devices on a ring when using Distributed Clocks
- Overall synchronization of all connected devices to the master when using Distributed Clocks
- Non-synchronous operation without synchronization via "Distributed Clock" is possible
- "CAN over EtherCAT®" (CoE) is not supported
- Only released in conjunction with "Beckhoff-TwinCAT"

Axis addressing

The axis address can be set directly using the control panel of the device. This can be done using the so-called Easy Menu, see also"Standard control panel". Alternatively, the address can be directly changed or displayed via the parameter "P-0-4089.0.3, Device address". The topology address of the device is assigned by the master and displayed in parameter "P-0-4089.0.4, Active device address", and cannot be changed. For EtherCAT®, this address us used as the "device identification value/2nd Address".

Parameters involved

- P-0-4089.0.3, Device address
- P-0-4089.0.4, Active device address

- S-0-0002, Sercos cycle time (TScyc)
- S-0-0005, Minimum feedback acquisition time (T4min)
- S-0-0007, Feedback acquisition starting time (T4)
- S-0-0014, Interface status
- S-0-0015, Telegram type parameter
- S-0-0016, Configuration list of AT
- S-0-0024, Configuration list of MDT
- S-0-0029, MDT error counter
- S-0-0097, Mask class 2 diagnostics
- S-0-0098, Mask class 3 diagnostics
- S-0-1720.0.01, Power supply control word

  Alias:

  P-0-2714, Power supply control word
- S-0-1720.0.02, Power supply status word

  Alias:

  P-0-2715, Power supply status word
- S-0-0185, Length of the configurable data record in the AT
- S-0-0186, Length of the configurable data record in the MDT
- S-0-0187, List of configurable data in the AT
- S-0-0188, List of configurable data in the MDT

- S-0-0301, Allocation of real-time control bit 1
- S-0-0303, Allocation of real-time control bit 2
- S-0-0305, Allocation of real-time status bit 1
- S-0-0307, Allocation of real-time status bit 2
- S-0-0413, Bit number allocation of real-time control bit 1
- S-0-0414, Bit number allocation of real-time control bit 2
- S-0-0415, Bit number allocation of real-time status bit 1
- S-0-0416, Bit number allocation of real-time status bit 2

Diagnostic messages involved

- C0101 Invalid parameters (-> S-0-0021)
- C0104 Config. IDN for MDT not configurable
- C0105 Maximum length for MDT exceeded
- C0106 Config. IDNs for AT not configurable
- C0107 Maximum length for AT exceeded
- C0108 Time slot parameter > Sercos cycle time
- C0112 Set timing not permissible
- C0113 Relation TNcyc (S-0-0001) to TScyc (S-0-0002) error
- C0114 T4 > TScyc (S-0-0002) - T4min (S-0-0005)
- C0201 Invalid parameters (->S-0-0423)
- C0299 Configuration changed. Restart
- E4005 No command value input via master communication
- F4002 RTD telegram failure
- F4009 Bus failure

3.6.2 Notes on commissioning

Rexroth provides a commissioning manual which explains the essential steps for commissioning an IndraDrive device with EtherCAT® at BECKHOFF TwinCAT (see documentation "Rexroth IndraDrive, IndraDrive with EtherCAT, Example with Beckhoff TwinCAT", DOK-INDRV*-ECAT*BECK**-CO, mat. no.: R911341345).

Diagnostic LEDs

☞
- The LED H24 at IndraDrive is used to diagnose the EtherCAT® communication.
- To diagnose the physical EtherCAT® connection, the PHY LEDS at the RJ45 connectors of the master communication module are used.

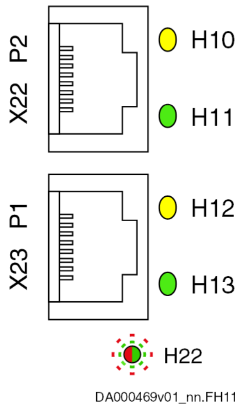


Fig. 3-18: ET, display elements

Display elements of optional module ET:

- Two LEDs (H10, H11 und H12, H13) at each connection point
- One bicolor LED (H24)

The significance of the LED displays depends on the field bus system.

LED	Significance	Color/flashing pattern	Description
H10, H12	None	-	With EtherCAT, these LEDs have no function
H11, H13	Link	Off	No connection to the network
		Permanently lit green	Connection to network available, but no telegram exchange (EtherCAT bus inactive)
		Flickering green	Connection to network available with telegram exchange (EtherCAT bus active)

LED	Significance	Color/flashing pattern	Description
H24	Status INIT	Off	• Cyclic process data and acyclic data channel are not transmitted • No error
	Status PRE-OPERATIONAL	GN -- 1) Flashing green	Acyclic data channel is transmitted
	Status SAFE-OPERATIONAL	GN -- -- -- -- -- 1) Green, one LED lighting up	Acyclic data channel is transmitted
	Status OPERATIONAL	Permanently lit green	Cyclic process data and acyclic data channel are transmitted
	Configuration error	RD -- 1) Flashing red	General EtherCAT configuration error
	Synchronization error	RD -- -- -- -- -- 1) Red, one LED lighting up	• The device has not been synchronized to the EtherCAT master • Communication error of the device
	Timeout - watchdog	RD -- RD -- -- -- -- -- 1) Red, two LEDs lighting up	• Timeout while cyclic process data are monitored • Watchdog of the EtherCAT master

1) Flashing pattern: One square corresponds to a duration of 200 ms; the arrow marks the end of a cycle; abbreviations on the squares: GN = LED permanently lit green, RD = LED permanently lit red, -- = LED is off

Tab. 3-6: EtherCAT® display elements

The yellow PHY-LED is not used in EtherCAT®

Pulse-pause relation of the diagnostic LEDs

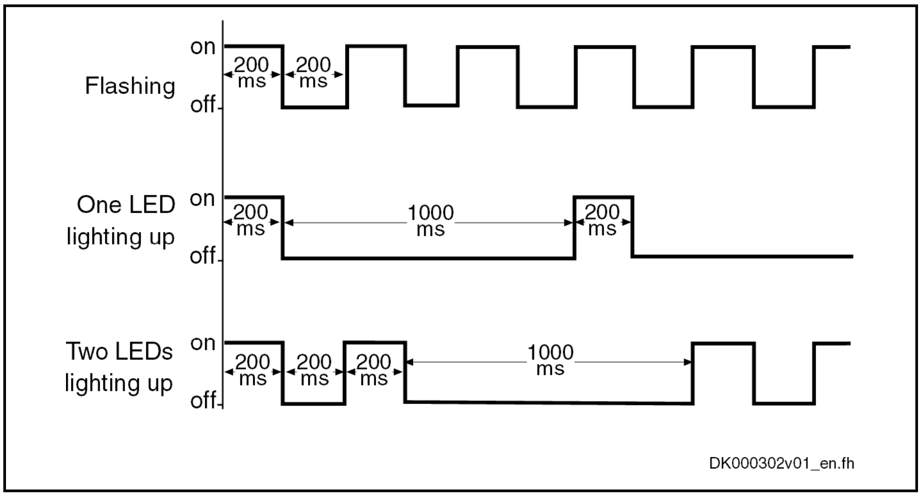
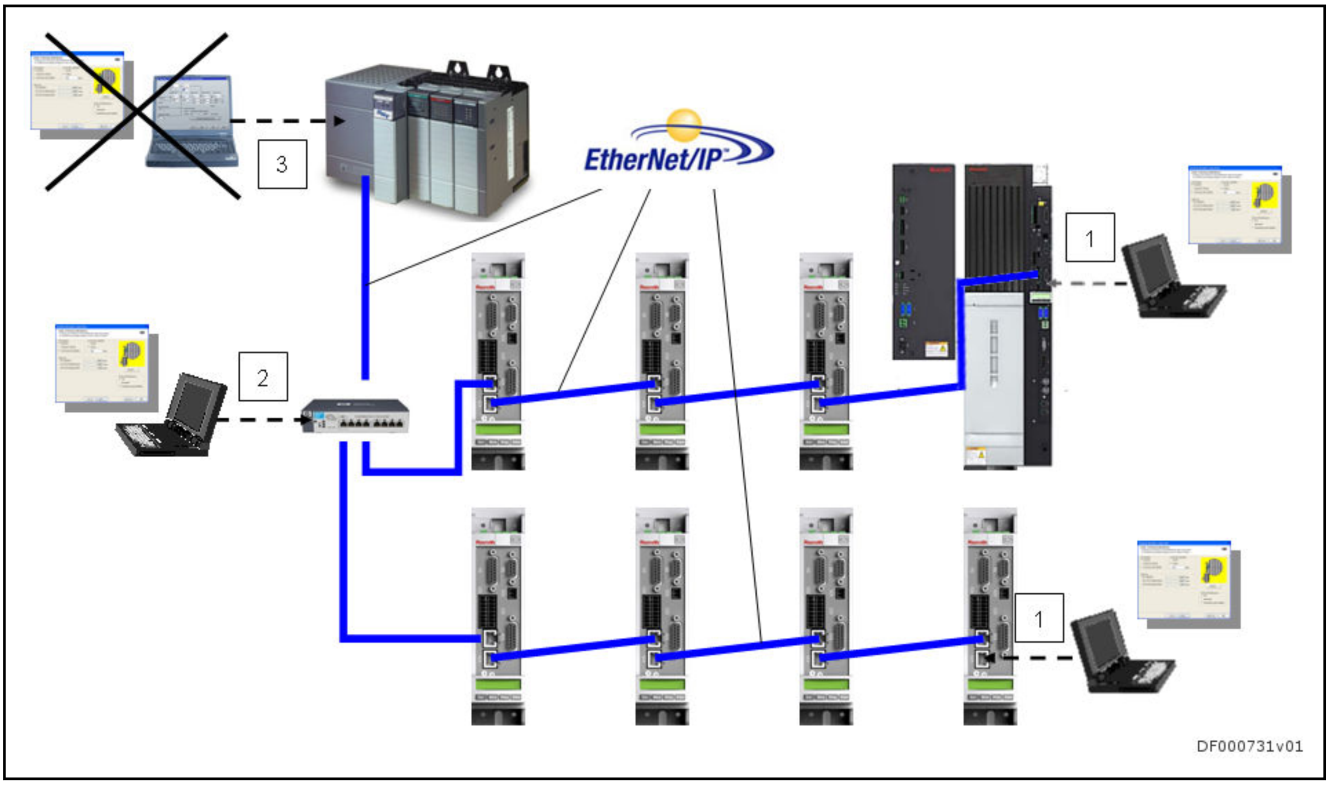


Fig. 3-19: Pulse-pause relation

3.7 EtherNet/IP(TM) interface

3.7.1 Brief description

Topology



1	Engineering via inactive EtherNet/IP™ port of a node at the bus
2	Engineering using optional industrial Ethernet switch
3	Engineering using third-party control is not possible

Fig. 3-20: EtherNet/IP(TM) topology

IndraDrive controllers with MultiEthernet interface can be operated as EtherNet/IP™ master communication. This module can be used to exchange real-time data with an EtherNet/IP™ scanner.

Real-time data can be transmitted via this interface using an I/O connection (Class 1 connection).

To achieve high system flexibility, all data are accessible via objects. With Ethernet/IP™ interfaces, these objects can be addressed via class, instance and attribute. Some of these objects can be assigned to the I/O connection as real-time data and thus be cyclically transmitted. There is also the option of transmitting via "Explicit Message", but no objects defined in the real-time channel (P-0-4081) may be written by the master via "Explicit Message".

Features

- Baud rate 100 MBit/s (full duplex)
- Data transmission via Ethernet cable (CAT5e-copper)
- Topologies: "Star", "line" (with integrated cut through switch)
- Autonegotiation is supported; the transmission rate listed above is required
- Profile type is "Generic Device", specified in ODVA 2.0 (**O**pen **D**eviceNet **V**endors **A**ssociation)
- EtherNet/IP™ Level 2 server
- Cyclic exchange via "Ethernet/IP™ I/O messaging" (Class 1)
- Acyclic data exchange via "Ethernet/IP™ Unconnected Explicit Messaging" and "Explicit Messaging" (Class 3)
- The smallest supported cycle time (API → Actual Packet Interval) is 2 ms.
- Configurable cyclic data up to 15 parameters (incl. field bus control word and field bus status word) in both data directions (max. 48 bytes or 24 words)

☞
- It is recommended that the industrial Ethernet network not be coupled with a company network (office communications). (Alternatively, a Level 3 router can be used to connect the industrial Ethernet network to a company network.)
- It is recommended that only switches with cut through method be used for industrial Ethernet communication.
- It is recommended that a star topology with cable type AWG22 or shielded cables be used, particularly for cables that exit the control cabinet and for cables longer than 10 meters.

Axis addressing

With EtherNet/IP the master communication address is an IP address. It is set in "P-0-4089.0.13, Master communication: IP address".

☞ The device address set in "P-0-4089.0.3, Device address" is applied to the parameter "P-0-4089.0.4, Active device address" after the device has been restarted. This address is shown on the display and is not relevant for the EtherNet/IP communication!

Parameters involved

- P-0-4073, Field bus: Diagnostic message
- P-0-4074, Field bus: Data format
- P-0-4075, Field bus: Watchdog
- P-0-4076, Field bus: Process data - updating clock
- P-0-4079, Field bus: Baud rate
- P-0-4088, Master communication: Drive configuration

- P-0-4089.0.2, Master communication: Device name
- P-0-4089.0.10, Master communication: MAC address device
- P-0-4089.0.13, Master communication: IP address
- P-0-4089.0.14, Master communication: Network mask
- P-0-4089.0.15, Master communication: Gateway address

Profile type parameters

Apart from mere communication parameters, parameters are used in conjunction with the profile types.

See "Profile types (with field bus interfaces)"

Parameters for extended communication

Additional parameters are used for extended communication.

See the following sections:

- "Configurable signal control word"
- "Configurable signal status word"

Diagnostic messages involved

- C0229 Field bus: IDN for cycl. command val. not configurable
- C0230 Field bus: Max. length for cycl. command val. exceeded
- C0231 Field bus: IDN for cycl. actual val. not configurable
- C0232 Field bus: Length for cycl. actual values exceeded
- C0233 Field bus: Tcyc (P-0-4076) incorrect
- C0234 Field bus: P-0-4077 missing for cycl. command values
- C0299 Configuration changed. Restart
- E4005 No command value input via master communication
- E4006 Communication module overload
- E4011 Communication watchdog: Overload of cyclic communication
- F4009 Bus failure
- F4011 Communication watchdog: Overload of cyclic communication

3.7.2 Configuration of the Ethernet/IP (TM) slaves

EDS File

For each EtherNet/IPP™ device, an EDS file (*.EDS) is required which contains the data required for operating the device at the field bus. This file is required for each node when configuring the bus masters supporting the EDS file.

The EDS file for IndraDrive is an ASCII file with the name "IndraDrive_EIP_MPx18.EDS".

Setting the IP address of the slave

The setting is either selected manually or via a menu, or via the "IndraWorks" commissioning tool.

The IP address for the EtherNet/IP™ adapter is saved in parameter "P-0-4089.0.13, Master communication: IP address", the subnet mask in parameter "P-0-4089.0.14, Master communication: Network mask" and the gateway address in parameter "P-0-4089.0.15, Master communication: Gateway address".

> The device address set in "P-0-4089.0.3 Device address" is applied to the parameter "P-0-4089.0.4 Active device address" after the device has been restarted. This address is shown on the display and is not relevant for the EtherNet/IP communication!

> This IP address is only relevant for communication with the scanner! The engineering address (S-0-1020, Master comm. engineering over IP: IP address) has to be used for Engineering (e.g., IndraWorks).

Configuring the cyclic data

Parameters for configuring the cyclic data (P-0-4080 and P-0-4081) can contain a maximum of 15 elements each. The maximum length is limited to 24 words.

Setting options via "P-0-4076, Field bus: Process data - updating clock", min. 2 ms, max. 65 ms (can be set in steps of 1 ms).

> The parameter "P-0-4076, Field bus: Process data - updating clock" is used to set the update cycle with which the data from the MultiEthernet interface are applied to the device and vice versa.

3.7.3 Specification of the EtherNet/IP(TM) interface

With the EtherNet/IP™ interface switched on, IndraDrive works as a level 2 device. This means that the device makes available one server each for implicit messages (Class 1) and explicit messages (Class 3). Explicit messages are limited to standard objects.

The implemented Ethernet/IP™ object directory contains the objects specified for a "Generic device":

- Identity Object (0x01)
- Message Router Object (0x02)
- Ethernet Link Object (0xF6)
- TCP/IP Object (0xF5)
- Port Object (0xF4)
- Connection Manager Object (0x06)
- Assembly Object (0x04)

3.7.4 Cyclic communication via the process data channel (Class 1)

EtherNet/IP(TM) connection types

With IndraDrive as EtherNet/IP™ slave, parameters can be cyclically transmitted via an I/O container. Use an "Exclusive Owner Connection" (transport class-1) or a "Listen Only Connection" (transport class-1) to access the parameters.

With the "Exclusive Owner Connection", the EtherNet/IP™ input image is transmitted to the device by way of "point-to-point" connection. The output image can be transmitted by way of "point-to-point" or "multicast" connection.

With an already existing "Multicast-Exclusive Owner Connection", a second master can, with a "Listen Only Connection", read the EtherNet/IP™ output image of IndraDrive. In this case, a "heartbeat connection point" is used as consuming connection point, and the same connection point as for the "exclusive owner connection" is used as producing connection point.

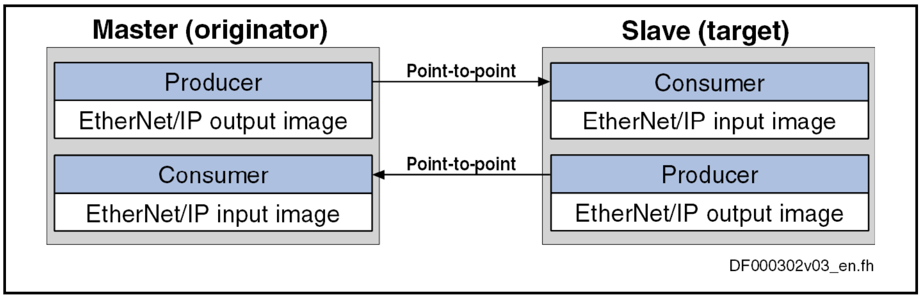


Fig. 3-21: EtherNet/IP(TM) connection type "point-to-point"

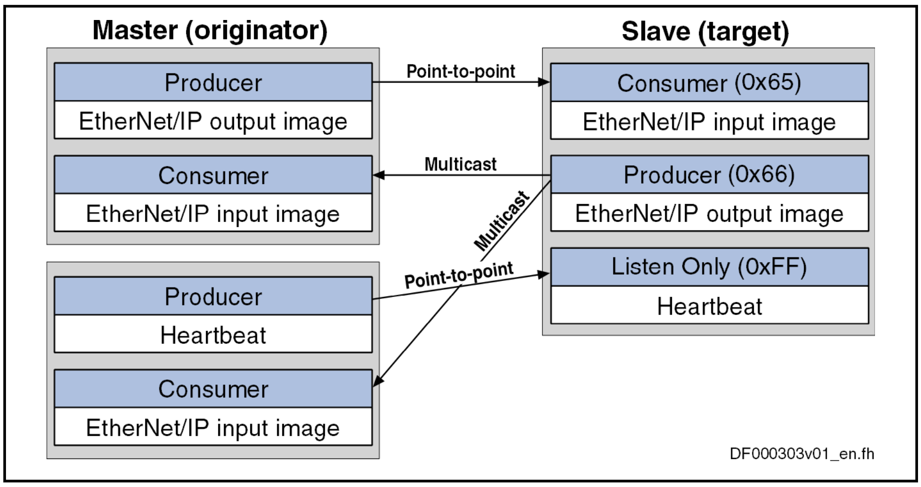


Fig. 3-22: EtherNet/IP(TM) connection type "multicast"

For the cyclic I/O data channel ("Implicit Message"), IndraDrive makes available a consumer and producer, i.e. it consumes the command values from the master and produces the actual values for the master.

Communication in this case runs via a UDP protocol; the direction from master to slave is transmitted with unicast telegrams, the opposite direction is transmitted with multicast telegrams.

Characteristic of the cyclic data transmission

Features

- The lowest cycle time supported by IndraDrive (API → Actual Packet Interval) is 2 ms.
- Der "Idle/Run header" of the EtherNet/IP™ interface is supported (32 bit). The header is not visible in the cyclic I/O image of IndraDrive. The reaction of IndraDrive to the Idle/Run Header is defined via the settings of the setting-up mode (easy startup mode).
- The consumer instance of IndraDrive monitors the cyclic transmission of the master output image via a so-called "TimeOut" time which the master determines when the connection is established.

The monitoring time is calculated according to the formula below:

$$t = TM \times API$$

$$TM = 2^{(TMV + 2)}$$

t	monitoring time (in ms)
TM	TimeOut Multiplier
API	Actual Packet Interval
TMV	TimeOut Multiplier value

Fig. 3-23: Calculating the monitoring time in two steps

Examples

TMV	TM	API (in ms)	t (in ms)
0	4	2	8
0	4	5	20
1	8	2	16
1	8	5	40
2	16	2	32
3	32	2	64
4	64	5	320
2	16	10	160

Tab. 3-7: Exemplary values for the monitoring time

In most of the configuration user interfaces, it is possible to directly enter the "TimeOut multiplier", the user then does not have to take the first formula into consideration.

Configuring the cyclic process data

Configure the cyclic channel by parameterizing "P-0-4080, Field bus: Config. list of cyclic actual value data ch." and "P-0-4081, Field bus: Config. list of cyclic command value data ch.".

On the level of Ethernet/IP™ communication, a static output assembly instance (class 4, instance 101) and a static input assembly instance (class 4, instance 102) are created in the cyclic channel. The data direction in this case is written from the master's point of view. If the parameterization of P-0-4080 and P-0-4081 is changed, new assembly instances are created during the transition from parameter mode (PM) to operating mode (OM) or when changing the data length of a CCD slave. Thus, the communication is interrupted.

3.7.5 Acyclic parameter access via "Explicit Message" (Class 3 / UCM)

General information on parameterization

To enable parameterization via EtherNet/IP™ interface, all IDN parameters can be reached via a manufacturer-specific class object with the corresponding instances for each IDN parameter. The IDN parameters can be addressed either via an "unconnected explicit message" (UCM) or via a "connected explicit message" (class 3).

By using acyclic parameter access via "Explicit Message" (Class 3/UCM), only IDN parameters can be accessed. EIDN, see also "Notes on parameter accesses"

It is not possible to operate the field bus control word via an "explicit message". To enable axis control, the cyclic data channel has to be used in the higher-level control unit in accordance with the specification "Class 1 Connection", or the corresponding logic has to be programmed with permanent control in MLD. If the control does not have a "class 1 connection", no axis control takes place without MLD.

Addressing

For EtherNet/IP communication, the objects are addressed according to the following pattern:

Class → Instance → Attribute

Class All parameters of a sub-device (e.g., supply unit) are mapped to the manufacturer-specific classes 100 (0x64) + sub-device index; i.e. sub-device 0 --> class 100, sub-device 1 --> class 101,…, sub-device 98 --> class 198.

Instance The instance number is identical to the IDN of the parameter.

Bit	Significance
15	**0**: Standard data (standardized) **1**: Product data (specified by the manufacturer)
14 … 12	Parameter sets from 0 to 7
11 … 0	Data block number from 0 to 4095

Tab. 3-8: Structure of the IDN

The instance number can be calculated with the following formula:

$$\text{Inst} = (32768 \times \text{type}) + (4096 \times \text{set}) + \text{block}$$

Inst instance number
type parameter type (0 for S-parameters and 1 for P-parameters)
set set number
block Data block number

Fig. 3-24: Calculating the instance number

Attribute The format of the parameter depends on the attribute number.

The operating data can have four different formats:

- Data length 2 byte → **W**
- Data length 4 byte → **L**
- ASCII text with max. length of 64 bytes →**T**

There are three types of parameters:

- Single parameters
- Command parameters
- List parameters

Independent of its type, each parameter has these attributes (read-only):

No.	Name	Function	Format
0	Number of elements	Number of supported elements	W
1	IDN	Sercos identity number (IDN)	T[8]
2	Name	Parameter name	T [60]
3	Attribute	Display mode of the parameter	L
4	Unit	Parameter unit	T [12]

No.	Name	Function	Format
5	Min. input value	Min. possible value of the data	W/L/T
6	Max. input value	Max. possible value of the data	W/L/T

Tab. 3-9: Basic attributes of a parameter

Depending on its type, each parameter has other attributes of different significance:

No.	Name/function	Format
7	Operating data	W/L/T
8	Max. number of list elements / length of text	L
9	Actual number of list elements / length of text	L
10	Pointer to the element, accessed from the next access to element 11 - 20.	L
11	Action for 1 list element (list pointer is moved along)	W/L/T
12	Action for 2 list element (list pointer is moved along)	W/L/T
13	Action for 3 list element (list pointer is moved along)	W/L/T
14	Action for 4 list element (list pointer is moved along)	W/L/T
15	Action for 5 list element (list pointer is moved along)	W/L/T
16	Action for 6 list element (list pointer is moved along)	W/L/T
17	Action for 7 list element (list pointer is moved along)	W/L/T
18	Action for 8 list element (list pointer is moved along)	W/L/T
19	Action for 9 list element (list pointer is moved along)	W/L/T
20	Action for 10 list element (list pointer is moved along)	W/L/T

Tab. 3-10: Type-dependent attributes of a parameter

Accessing single parameters

The value can be accessed by writing and reading the operating data of the parameter. For single parameters, the number of attributes is the value "7".

Accessing texts

The value can be accessed by writing and reading the operating data of the parameter. The maximum length of the text and the actual length of the text can be read with attributes 8 and 9. Additionally, a text can be treated like a 1-byte list. During the access to parameter texts, the number of attributes results in value "20".

Accessing command parameters

A command can be started by writing "3" to the operating data, the command status is obtained by read-accessing the operating data. With access to command parameters, the number of attributes is the value "7".

Accessing list parameters

The maximum list size can be determined by reading the maximum quantity of data of the parameter (attribute 8). The real size is stored in the actual quantity of data of the parameter (attribute 9) and can be modified unless the list is write-protected. All data refer to the parameter format. The pointer to the data (attribute 10) determines which data in the list is processed. If the value of the data is zero, the pointer is automatically modified in the following situations:

- Zero is loaded when changing from another parameter to this parameter.
- After each access to the operating data, the pointer is incremented by the number of elements which were read.

By accessing attribute 11, one element is processed, when accessing attribute 12, two elements are processed etc. up to attribute 20 for processing 10 elements. The pointer is increased by the processed elements. With access to list parameters, the number of attributes is the value "20".

> ☞ For successful access to the operating data, the pointer has to be smaller than the actual length.

Example

The parameters "S-0-0398, IDN-list of configurable data in signal status word" has 18 list elements and is to be read:

- Calculate instance with formula

  Input:

  – P-parameter → type = 1
  – Parameter set 0 → set = 0
  – Data block number 72 → block = 72

  → Instance = 32840
- Read: class 100, instance 32840, attribute 9 = 18 (actual length)
- Write: class 100, instance 32840, attribute 10 = 0 (list pointer)
- Read: Class 100, instance 32840, attribute 11 = element 0

  → List pointer now automatically pointing to 1
- Read: class 100, instance 32840, attribute 20 = elements 1 to 10

  → List pointer now automatically positioned on 11
- Read: Class 100, instance 32840, attribute 12 = element 11, 12

  → List pointer now automatically pointing to 13
- Read: Class 100, instance 32840, attribute 15 = elements 13 to 17

  → List pointer now automatically positioned on 18
- Read: class 100, instance 32840, attribute 10 = 18 (pointer)

Another access to the operating data would not supply any data without loading the list pointer again (list pointer = actual length). The number of attributes supplies the value "20".

Storing list elements

List elements are not directly stored in permanent form. Storage takes place by one of the following actions:

- Writing the last element of the list
- Read-accessing the list
- Accessing a different parameter
- Abortion of connection

When the control voltage fails, all changes which were not stored are cleared!

Error codes at parameter access

When a vendor-specific error occurs during parameter access, the additional error code provides information on the cause of the error.

The following table lists the most important error codes.

Error no. (hex)	Significance
0x03	Invalid parameter value • Value is smaller than minimum input value • Value is greater than maximum input value • Incorrect value • Invalid indirect addressing • Procedure command not executable (invalid or false parameters)
0x0E	Parameter cannot be changed
0x0F	Parameter is password-protected
0x10	Parameter is write-protected • Parameter is write-protected at this time • Parameter write-protected, as cyclically configured in MDT • parameter is write protected at this time, due to other settings (parameter, operation mode, drive enable...) • Command can currently not be executed (e.g., in this phase procedure command cannot be activated)
0x13	Parameter transmitted too short
0x15	Parameter transmitted too long
0x1F	• Procedure command already active • Procedure command not interruptible

Tab. 3-11: Error codes and their significances at parameter access

3.7.6 Diagnostic and status messages

Diagnostic message via display

The diagnostic displays via LED (module status, network status), required according to EtherNet/IP™ specification, have been implemented by the corresponding display messages and the network status LED.

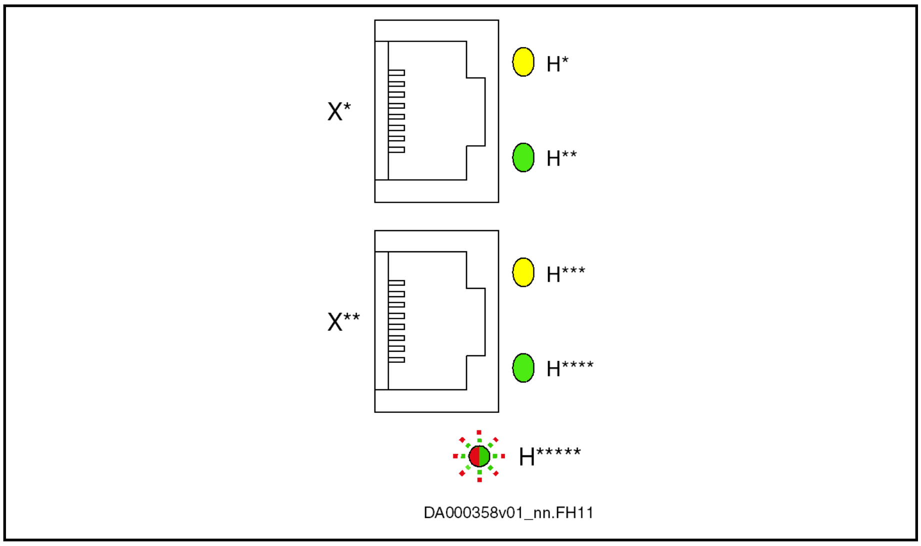


Fig. 3-25: ET, display elements

Display elements of optional module ET:

- Two LEDs (H10, H11 und H12, H13) at each connection point
- One bicolor LED (H24)

The significance of the LED displays depends on the field bus system.

Module status Since the EtherNet/IP™ functionality is not an individual module, the module status is covered by the error messages of the device.

Network status The network status of the EtherNet/IP™ unit is displayed via the "Network status LED"

LED	Significance	Color	Description
H10, H12	Status	 Permanently lit yellow	Data transmission running
H11, H13	Link	 Permanently lit green	Connection to network available

LED	Significance	Color	Description
H24	Not active	Off	Interface has been switched off (24V supply) or has no IP address
	Not connected	Flashing green	Interface has an IP address, but no connection
	Connected	Permanently lit green	Connection to network available, data transmission running
	Timeout	Flashing red	Existing connection was aborted
	Invalid IP address	Permanently lit red	Assigned IP address is already used by another device
	Self test	Flashing red-green	After switching on, interface carries out a self test

Tab. 3-12: EtherNet/IP™ display elements

Diagnostic messages of IndraDrive

IndraDrive diagnostic messages and their significances in conjunction with Ethernet/IP™ master communication:

- E4005 No command value input via master communication

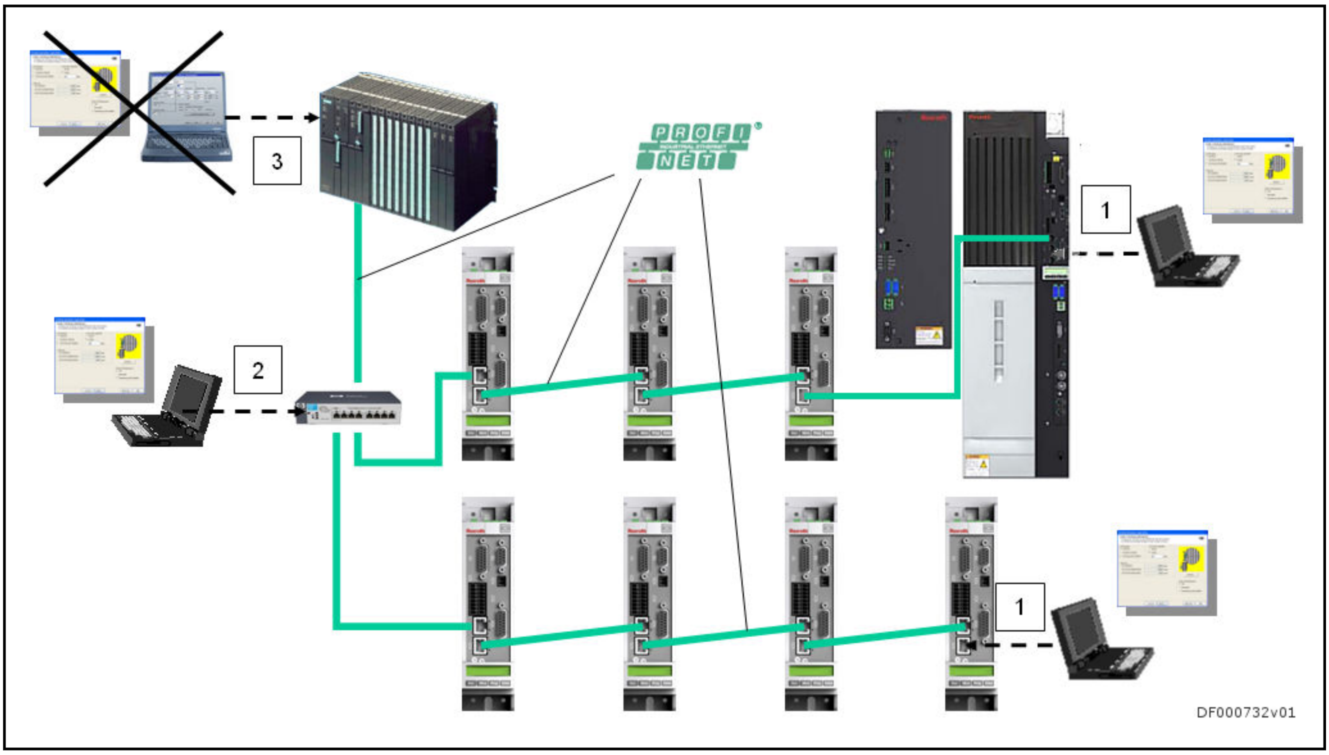
  → The master is in stop mode and the EtherNet/IP™ stack is in "IDLE" state or the master has specifically aborted the I/O connection and the EtherNet/IP™ stack thereby is in the "CLOSED" state.
- F4009 Bus failure

  → The master has not received any telegram within the watchdog time. The watchdog time is calculated from the "Time Out" formula explained under 1.4.2.

3.8 PROFINET®

3.8.1 Brief description

Topology



1	Engineering via inactive PROFINET® port of a node at the bus
2	Engineering using optional industrial Ethernet switch
3	Engineering using third-party control via TCI is not possible

Fig. 3-26: Engineering options with PROFINET®

IndraDrive controllers with MultiEthernet interface (ET) can be operated with PROFINET® master communication. Via this module it is possible to exchange real-time data with a PROFINET® controller.

The field bus provides data containers in which useful data can be cyclically transmitted. This section is referred to as **cyclic data channel** (PROFINET®).

The cyclic data channel is divided as follows:

- One (optional) **device-specific parameter channel** for reading and writing of all parameters via PROFINET®.

> ☞ The **device-specific parameter channel** does not fulfill any "real-time properties"!

- One (optional) **safe, axis-specific process data channel** (PROFIsafe).

> ☞ The **safe, axis-specific process data channel** is not available in PSB21VRS. For configuration, however, the module "F-Module not used" has to be integrated!

- One **axis-specific process data channel** (real-time channel) which contains specified information that can be directly interpreted by the receiver.

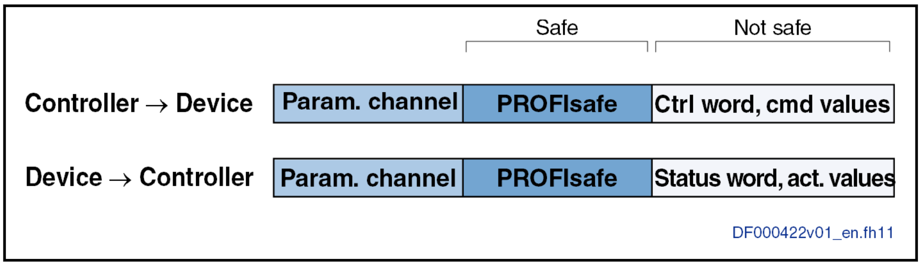


Fig. 3-27: Cyclic data channel overview

☞ To simplify field bus communication, there are PLC function blocks for different programmable logic controllers (PLCs) available. The function blocks support the basic functionalities of the axis-specific process data channel and device-specific parameter channel. The principles applied can be easily used for other PROFINET® controllers.

Features

The PROFINET® device interface with MultiEthernet interface has the following features:

- Ethernet in accordance with IEEE 802.3 and prioritization in accordance with IEEE 802.1Q
- Baud rate 100 Mbit/s
- Data transmission via Ethernet cable (CAT5e-copper)
- Topologies: "Star", "line" (with integrated cut through switch)
- Assignment of the IP addresses via DCP protocol (**D**iscovery and **B**asic **C**onfiguration)
- The smallest supported cycle time (I/O cycle updating time) is 2 ms.

☞ The IO cycle updating time is written by the control unit and is the time cycle in which the process data from the PROFINET network are applied to the MultiEthernet interface and written in the other direction.

- Configurable cyclic data up to 15 parameters (incl. field bus control word and field bus status word) in both data directions (max. 48 bytes or 24 words)
- Setting options via "P-0-4076, Field bus: Process data - updating clock", min. 2 ms, max. 65 ms (can be set in steps of 1 ms).

☞ The parameter "P-0-4076, Field bus: Process data - updating clock" is used to set the update cycle with which the process data from the MultiEthernet interface are applied to the device and vice versa.

In the planning, assembly and commissioning of an installation, the following guidelines are referred to (designation: PROFINET trilogy):

- Planning guideline
- Assembly guideline
- Commissioning guideline

The guidelines are provided by the administrative office of the PNO (PROFIBUS Nutzerorganisation e. V.).

It is recommended that

- the industrial Ethernet network not be coupled with a company network (office communications). (Alternatively, a Level 3 router can be used to connect the industrial Ethernet network to a company network.)
- only switches with cut through method be used for industrial Ethernet communication
- a star topology with cable type AWG22 or shielded cables be used, particularly for cables that exit the control cabinet and for cables longer than 10 meters

- Additional optional parameter channel in the cyclic channel with up to 16 bytes (8 words)
- LED for diagnosing PROFINET® status (network status)
- LEDs for displaying the link/activity status
- CCA and RT_CLASS_1 are supported
- Diagnostic messages and alarms are not used due to reasons of compatibility with IndraDrive with the PROFIBUS® master communication module.
- PROFINET® IRT is not supported.
- Operation in PROFINET® IRT networks is not possible
- Supported field bus profile is 0x0000: "no profile" selected

Axis addressing

A node in PROFINET is addressed using the so-called device name. This name is saved in P-0-4089.0.2 and can be changed there.

The device address set in "P-0-4089.0.3, Device address" is applied to the parameter "P-0-4089.0.4, Active device address" after the device has been restarted. This address is shown on the display and is not relevant for the PROFINET communication!

Parameters involved

Communication parameters

Specific parameters for communication via PROFINET®:

- P-0-4089.0.11, Master communication: MAC address Port1
- P-0-4089.0.12, Master communication: MAC address Port2

Parameters for general communication via field bus interfaces:

- P-0-4073, Field bus: Diagnostic message
- P-0-4074, Field bus: Data format
- P-0-4075, Field bus: Watchdog
- P-0-4076, Field bus: Process data - updating clock

- P-0-4079, Field bus: Baud rate
- P-0-4083, Parameter channel: Length
- P-0-4083.0.1, Parameter channel: Configuration
- P-0-4088, Master communication: Drive configuration
- P-0-4089.0.2, Master communication: Device name
- P-0-4089.0.10, Master communication: MAC address device
- P-0-4089.0.13, Master communication: IP address
- P-0-4089.0.14, Master communication: Network mask
- P-0-4089.0.15, Master communication: Gateway address

Profile type parameters

Apart from mere communication parameters, parameters are used in conjunction with the profile types.

See "Profile types (with field bus interfaces)"

See also "Engineering/diagnostic interfaces"

Parameters for extended communication

Additional parameters are used for extended communication.

See the following sections:

- "Configurable signal control word"
- "Configurable signal status word"

Diagnostic messages involved

- C0229 Field bus: IDN for cycl. command val. not configurable
- C0230 Field bus: Max. length for cycl. command val. exceeded
- C0231 Field bus: IDN for cycl. actual val. not configurable
- C0232 Field bus: Length for cycl. actual values exceeded
- C0233 Field bus: Tcyc (P-0-4076) incorrect
- C0234 Field bus: P-0-4077 missing for cycl. command values
- C0299 Configuration changed. Restart
- E4005 No command value input via master communication
- E4006 Communication module overload
- E4011 Communication watchdog: Overload of cyclic communication
- F4009 Bus failure
- F4011 Communication watchdog: Overload of cyclic communication
- F4012 Incorrect I/O length

3.8.2 Configuring the PROFINET® slave

Device data sheet for IndraDrive

As every other PROFINET® device, IndraDrive controllers have to be configured in the field bus controller. This requires the corresponding device data sheet (GSDML) "**GSDML-V2.1-Bosch Rexroth AG-011F-Indradrive_xxVxx-xxxxxxxx.xml**" that has to be included in the project ("YYYYMMDD" represents the creation date of the GSDML file). This GSDML file is required for each node when configuring the bus controller.

> The device master file for IndraDrive controllers supports all hardware types and the activation of functional packages.

IndraDrive controllers assign four slots to their data or up to 31 slots in case of devices operated via the CCD group (1CCD master + 9 CCD slaves). The device have to be configured. Each device in the in the CCD group has an F-module, one input module and one output module: A slot is a module location.

Each slot has a certain module assignment that has to be complied with for correct configuration.

- Slot 1: Parameter channel
- Slot 2: F-module axis 0 (optional für PROFIsafe)
- Slot 3: Inputs axis 0
- Slot 4: Outputs axis 0
- Slot 5: F-module axis 1 (only for devices operated at the CCD group)
- Slot 6: F-module axis 1 (only for devices operated at the CCD group)
- Slot 7: Outputs axis 1 (only for devices operated at the CCD group)
- Slot X: F-module axis X (according to number of CCD devices)
- Slot Y: Inputs axis X (according to number of CCD devices)
- Slot Z: Outputs axis X (according to number of CCD devices)

The default configuration stored in the device data sheet "Input 1 Word" and "Output 1 Word" (single-axis device) without safety technology and without parameter channel. For IndraDrive, this setting is active after loading the default values.

☞ During the installation of "IndraWorks MLD", the device master file is stored in the "C:\Program Files\REXROTH\IndraWorks\DeviceDataSheets\IndraDrive\Profibus" directory by default.

Module 1: Parameter channel

These modules are of the input/output module type and marked with "ParamCh". If no parameter channel is required, the "ParamCh not used" module has to be selected.

If IDN parameters or EIDN parameters are to be written via the parameter channel, observe the following aspects:

- IDN parameters

  To write a 2-byte IDN parameter (e.g., P-0-0002), include the "ParamCh 5 Words" module and configure it accordingly in the parameter "P-0-4083.0.1, Parameter channel: Configuration".
- EIDN parameters

  To write a 4-byte EIDN parameter (e.g., P-0-0002.0.0), include the "ParamCh 6 Words" module and configure it accordingly in the parameter "P-0-4083.0.1, Parameter channel: Configuration".

☞ The parameter channel length is displayed in parameter "P-0-4083, Parameter channel: Length" in bytes.

In case of an incorrect configuration of the command/actual values, the error "F4012 Incorrect I/O length" is displayed.

F-module

Slot 2 is assigned with the empty module "F-Module not used".

Inputs module

In these modules, the length of the input data is set in words. The module identifier is "Input". For successful data exchange of the axis-specific process data channel, the set length has to equal the value in parameter "P-0-4082, Field bus: Length of cyclic actual value data channel", specifying the length in bytes.

Even in case of an incorrect input data length, the device-specific parameter channel can be used for communication.

If the configuration of the controller does not correspond to the one of the IndraDrive controller, the IndraDrive device will generate the error message "F4012 Incorrect I/O length".

Outputs module

In these modules, the length of the input data is set in words. The module identifier is "Output". The length of the output data that was set has to correspond with the value of parameter "P-0-4071, Field bus: Length of cyclic command value data channel".

If the configuration of the controller does not correspond to the one of the IndraDrive controller, the IndraDrive device will generate the error message "F4012 Incorrect I/O length".

Modules 5 to 31

The modules 5 to 31 are provided for devices operated at the CCD group.

Displaying the device name/IP address of the IndraDrive device

The device name of the IndraDrive device assigned with the "device baptism" is displayed in parameter "P-0-4089.0.2, Master communication: Device name". When exchanging a device, the device name can be set manually via this parameter using IndraWorks (see "Replacing the controller"). The IP settings permanently assigned to the device during configuration are displayed in the following parameters:

- P-0-4089.0.13, Master communication: IP address
- P-0-4089.0.14, Master communication: Network mask
- P-0-4089.0.15, Master communication: Gateway address

In case of "temporary assignment" configuration (assigned by the controller during start-up), the IP address "0.0.0.0" is displayed in the parameters.

The device address set in "P-0-4089.0.3 Device address" is applied to the parameter "P-0-4089.0.4 Active device address" after the device has been restarted. This address is shown on the display and is not relevant for the PROFINET communication!

The IP address is only relevant for communication with the controller! The engineering address (S-0-1020, Master comm. engineering over IP: IP address) has to be used for Engineering (e.g., IndraWorks).

Configuring the process data channel

Standard process data channel (non-safe)

The user can freely configure the cyclic data in the standard process data channel according to the process requirements.

Configuration list of cyclic actual value data channel

In parameter "P-0-4080, Field bus: Config. list of cyclic actual value data ch.", the structure and therefore the number of words and their assigned objects (indices) for the process input data (device → controller) are mapped. The controller can use this configuration in order to locate the individual real-time data in the field bus.

Configuration list of cyclic command value data channel

The structure of the process output data (controller → device) is mapped in parameter "P-0-4081, Field bus: Config. list of cyclic command value data ch.". This allows the current structure and thus the assignment in the field bus to be read via the parameter channel.

☞ It is possible to configure up to 15 real-time parameters (incl. control word or status word) at the bus in each data direction (max. 48 bytes or 24 words).

PROFIsafe process data channel (safe)

☞ The **safe, axis-specific process data channel** is not available in PSB21VRS. For configuration, however, the module "F-Module not used" has to be integrated!

Length of the process data channel (real-time data channel)

Standard process data channel (non-safe)

Within the cyclic channel, the parameter channel (optional) and the process data channel, in which the real-time data of IndraDrive are transmitted, are arranged.

The PROFINET® device interface enables flexible configuration of the process data channel, the length of the process data channel thereby changes accordingly.

☞ The currently active length is contained in the parameters "P-0-4082, Field bus: Length of cyclic actual value data channel" and "P-0-4071, Field bus: Length of cyclic command value data channel".

The process data channel (real-time data channel) can only have words or double words, but not bytes, as data types. Length, however, is specified in bytes for the sake of compatibility with other bus systems.

The length of the process data channel results from the content of the configuration lists "P-0-4080, Field bus: Config. list of cyclic actual value data ch." or"P-0-4081, Field bus: Config. list of cyclic command value data ch." and is contained in the following parameters:

- P-0-4071, Field bus: Length of cyclic command value data channel
- P-0-4082, Field bus: Length of cyclic actual value data channel

The setting is calculated from the contents of the parameters P-0-4080 and P-0-4081 and takes effect as the device runs up to the operating mode.

☞ Please note that a change in the length of the process data channel also requires a change in the controller configuration. The length of the process data channel that was set therefore has to comply with the configured length in the controller. Otherwise, the error message "F4012 Incorrect I/O length" is generated.

3.8.3 Cyclic communication via process data channel

Communication cycle time

The smallest supported cycle time (I/O cycle updating time) is 2 ms. The time is specified by the control. The cycle time describes the cycle in which the PROFINET network data is applied or written to the MultiEthernet interface.

Setting options via "P-0-4076, Field bus: Process data - updating clock", min. 2 ms, max. 65 ms (can be set in steps of 1 ms).

☞ The parameter "P-0-4076, Field bus: Process data - updating clock" is used to set the update cycle with which the data from the MultiEthernet interface are applied to the device and vice versa.

Axis-specific process data channel

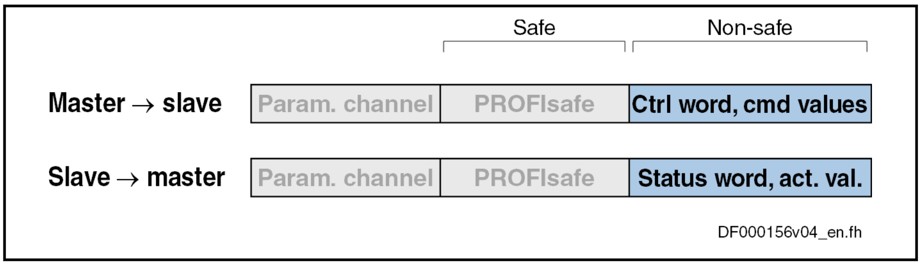


Fig. 3-28: Position of the non-safe process data channel in the cyclic data channel

Processing the cyclic data

The internal processing of the command values and actual values is carried out synchronously with the control clock. As the communication via PROFINET® RT was not cycle-synchronously, the master communication is not intended for cycle-synchronous operating modes such as "position control with cyclic command value specification" but is only intended for positioning operating modes and the operating mode "velocity control".

☞ There is no limit value check for the cyclically transmitted command values and they are stored in volatile form.

Configuring the cyclic data

The cyclic data have to be configured in the parameter mode. This configuration is described in the section "Configuring the PROFINET® slave".

Safe, axis-specific process data channel (PROFIsafe)

General information

☞ The **safe, axis-specific process data channel** is not available in PSB21VRS.

Parameter channel in the cyclic channel (device-specific)

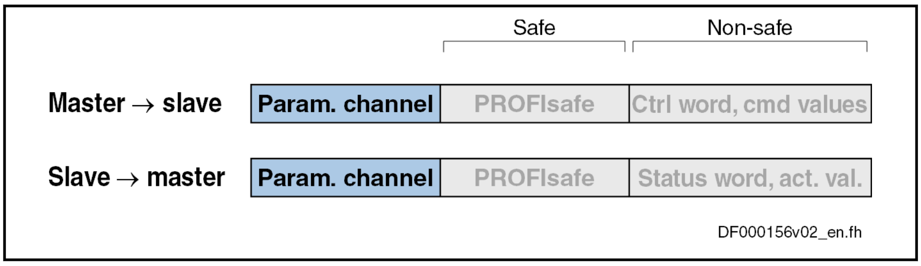


Fig. 3-29: Position of the parameter channel in the cyclic data channel

Using the parameter channel, IndraDrive can be parameterized via the field bus. The parameter channel is part of the cyclic data.

For IndraLogic and Siemens S7, functions blocks are available which implement the parameter channel protocol. This allows the user to ignore the parameter channel details.

The parameter channel is described in the Technical Note "TN_40_Bosch_Rexroth PROFIBUS_PROFINET_Parameterkanal_V1.x".

☞ The parameter channel is always at the beginning of the cyclic data channel. The length of the parameter channel is configured in the controller and in the device. For configuration, use parameter "P-0-4083.0.1, Parameter channel: Configuration".

☞ It is not possible to operate the field bus control word via the optional parameter channel. To enable axis control, the cyclic data channel has to be used in the higher-level control unit or the corresponding logic has to be programmed with permanent control in MLD. If the control does not have a cyclic data channel, no axis control is possible without an MLD.

3.8.4 Monitoring functions and diagnostic functions

Diagnostic options

For a simple diagnostics of the network status, a network status LED is available.

The following table shows the possible states:

Message on display	Significance
Continuously off	The device does not have a valid IP address or has been switched off.
Flashing green	The device has run up with a valid IP address, but does not have a cyclic connection.
Continuously green	The I/O connection has been established without error.
Flashing red	The existing I/O connection was canceled unexpectedly (e.g. watchdog).
Continuously red	The "Duplicate IP address check" showed that the set IP address already exists in the network.
Flashing green/red	The device is running up and carries out a self test.

Tab. 3-13: Overview of diagnostic messages for PROFINET® communication

Error codes of PROFINET® communication

Parameter channel errors

The table below contains an overview of the possible parameter channel error messages and their significance:

Error code	Significance
0x0082	quantity of all transmitted data is too low, i.e. less than 4 bytes
0x0083	quantity of data still to be transmitted is greater than the internal buffer
0x0088	the length of the valid data indicated in the control word is longer than the parameter channel
0x008C	status conflict, a new request was sent although there are still data to be transmitted
0x008D	The length of data to be transmitted indicated in the control word is incorrect
0x008E	The EIDN/IDN access type specified in control word bit 15 does not comply with the access type specified in P-0-4083.0.1

Tab. 3-14: Parameter channel errors overview

Parameter access errors

The table below contains an overview of the possible parameter access errors and their significance; the error values are transmitted in word format:

Error no. (hex)	Significance
0x1001	No IDN
0x1009	Invalid access to element 1
0x2001	No name
0x2004	Name cannot be changed (read only)
0x3004	Attribute cannot be changed (read only)
0x4001	No units
0x4004	Unit cannot be changed (read only)
0x5001	no minimum input value
0x5004	minimum input value cannot be changed (read only)
0x6001	no maximum input value
0x6004	maximum input value cannot be changed (read only)
0x7002	Operation data transmission too short
0x7003	Operation data transmission too long
0x7004	operation data cannot be changed (read only)
0x7005	operation data is write-protected at this time (e.g. communication phase)
0x7006	operation data is smaller than minimum input value
0x7007	operation data is greater than maximum input value
0x7008	IDN is not supported, invalid bit numbers or bit combination
0x7009	operation data write protected by a password
0x700A	operation data is write protected, it is configured cyclically
0x700B	Invalid indirect addressing (e.g., data container, list handling)
0x700C	operation data is write protected, due to other settings (e.g., parameter, operation mode, drive enable, drive on etc.)
0x7010	Procedure command already active
0x7011	Procedure command not interruptible
0x7012	Command can currently not be executed (e.g., in this phase the command cannot be activated)
0x7013	Procedure command not executable (invalid or false parameters)
0x9001	Input cannot be identified as application
0x9002	Parameter type error
0x9003	Invalid data record number
0x9004	invalid data block number
0x9005	Data element number invalid
0x9006	error in R/W flag
0x9007	Invalid character in the data

Tab. 3-15: Parameter access errors overview

3.9 POWERLINK

3.9.1 Brief description

☞ The POWERLINK function is only available upon request.

Topology

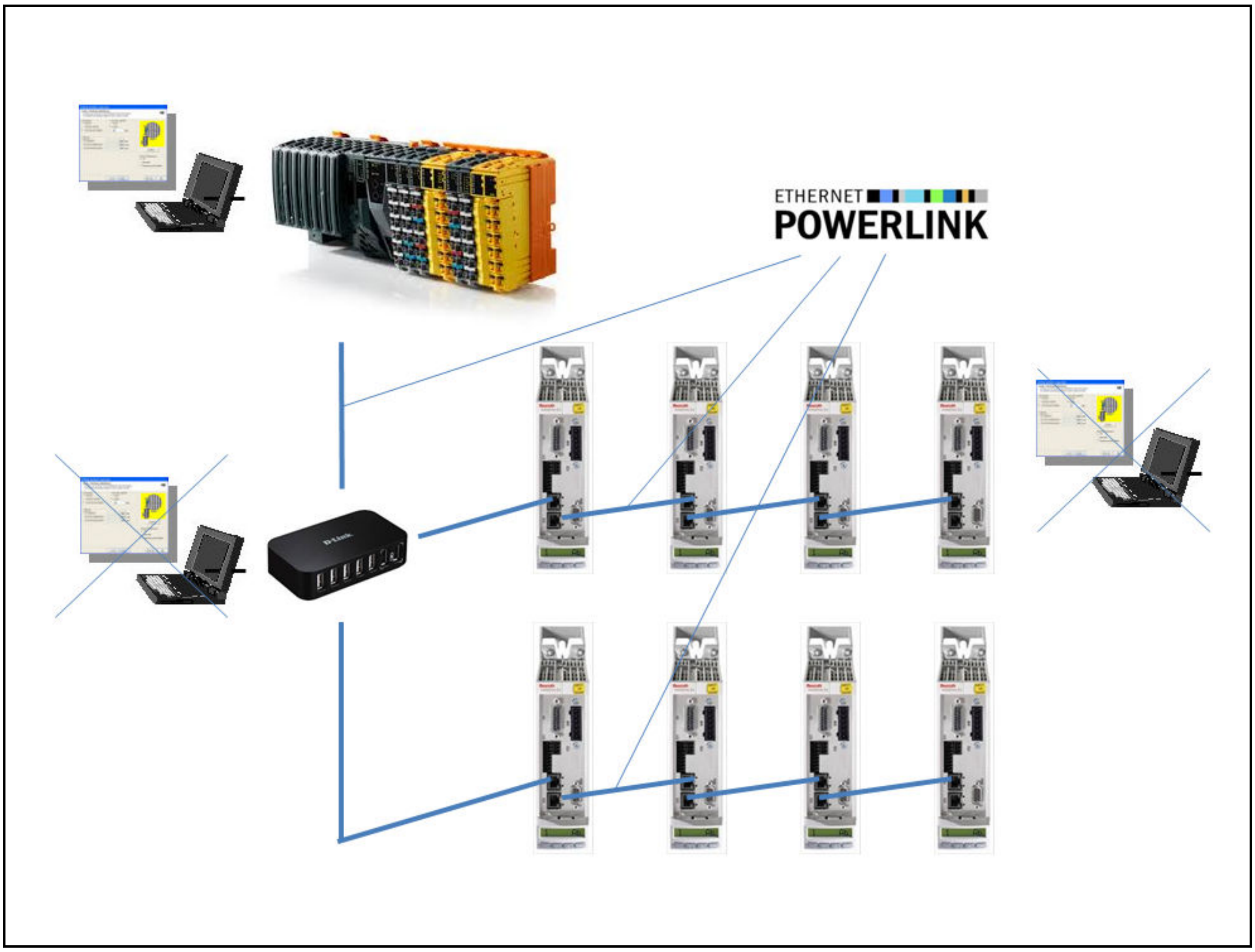


Fig. 3-30: POWERLINK, topology

IndraDrive controllers with MultiEthernet interface can be operated with Ethernet POWERLINK master communication. Real-time data can be exchanged with a Powerlink Managing Nodes via this module.

Features

- Baud rate 100 Mbit/s (semi-duplex)
- Data transmission via Ethernet cable (CAT5e-copper)
- Topology: "Star", "line" (with integrated cut through switch)
- Depending on the variant that is used and the performance that has been set, the smallest supported cycle time is 250 µs. Generally, integral multiples of the position controller cycle time can be set. Any cycle time is supported in non-synchronized operation.

- Configurable cyclic data up to a maximum of 15 parameters (incl. profile-dependent control word and status word) in both data directions (max. 48 bytes or 24 words)

☞ In case of POWERLINK, decoupling of communication and application state machines is not possible.

The mapping of the individual communication objects to P-parameters of the drive and the mapping of the S- and P-parameters to CANopen objects is described in the Parameter Description.

Ethernet POWERLINK addressing

Each Ethernet POWERLINK node (MN, CN and router) has an unequivocal Node ID within an Ethernet POWERLINK segment. The node ID is configured via parameter "P-0-4089.0.3, Device address". The value that was set is applied as active Node ID when the drive is booted. The currently active Node ID is displayed via parameter "P-0-4089.0.4, Active device address". If drive controller has an address selector switch, the setting of the switch is always displayed in P-0-4089.0.3. The node IDs 1 to 239 are used for a "Controlled Node".

The Node ID of a CN can be set either using hardware switches or via software configuration.

IP addressing

Each Ethernet POWERLINK node has an IPv4 address, a subnet mask and a default gateway. This IP address is used both for bus addressing and for mere IP communication in the Basic Ethernet mode.

- **IPV4 address**

  The Ethernet POWERLINK network is a class C network with the address 192.168.100.x

  The host ID of the IPv4 address has to be identical to the Node ID of the node. That is to say the last byte of the IP address has to have the same value as the Ethernet POWERLINK Node ID.

  Host ID value range of the drive: 1-239

  192.168.100.POWERLINK Node ID

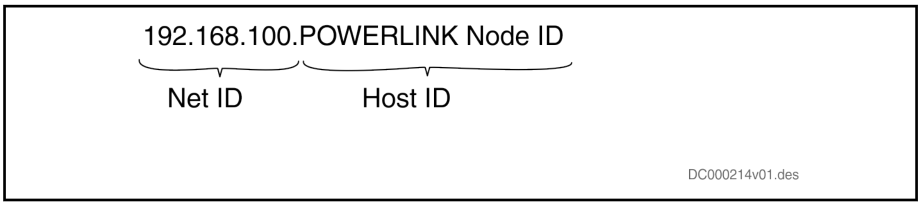


Fig. 3-31: IPV4 address

Subnet mask

The subnet mask of an Ethernet POWERLINK has to be 255.255.255.0.

Default gateway

The default gateway has to be the IP address 192.168.100.240, corresponding to the IP address of the Managing Node in the POWERLINK network.

Diagnostic messages involved

- A0004 Initialization
- A0005 Pre-Operational
- A0025 Basic ethernet mode
- A0026 Ready to operate
- C0229 Field bus: IDN for cycl. command val. not configurable
- C0230 Field bus: Max. length for cycl. command val. exceeded
- C0231 Field bus: IDN for cycl. actual val. not configurable
- C0232 Field bus: Length for cycl. actual values exceeded

- C0233 Field bus: Tcyc (P-0-4076) incorrect
- E4005 No command value input via master communication
- E4006 Communication module overload
- E4011 Communication watchdog: Overload of cyclic communication
- F4011 Communication watchdog: Overload of cyclic communication
- F4012 Incorrect I/O length
- C0201 Invalid parameters (->S-0-0423)
- C0299 Configuration changed. Restart

3.9.2 Notes on commissioning

Status/ERROR LED

The bicolor BUS LED, H24 at the controller housing is used for Ethernet POWERLINK communication diagnostics.

Bus state	LED color	LED control
OFF, INITIALISATION, NOT_ACTIVE	Green	LED off
BASIC_ETHERNET	Green	LED on, flickering
PRE_OPERATIONAL_1	Green	LED on, single flash
PRE_OPERATIONAL_2	Green	LED on, double flash
READY_TO_OPERATE	Green	LED on, triple flash
OPERATIONAL	Green	LED on
STOPPED	Green	LED on, blinking
State machine error	Red	LED on
No error	Red	LED off

Tab. 3-16: H24 blinking codes for Ethernet POWERLINK

Timing

POWERLINK can processes the process data in IndraDrive synchronously or cyclically.

- Synchronous processing

  If synchronous processing is desired, only integral multiple of the position cycle time that was set is possible for the bus.
- Cyclic processing

  If it suffices to process the process data cyclically, the synchronous processing can be deactivated. This is parameterized by activating bit 0 in "P-0-4089.0.5, Master communication: Configuration". POWERLINK cycle times such as 400 µs, 800 µs etc. are then possible.

3.10 PROFIBUS-DP

3.10.1 Brief description

IndraDrive controllers with PROFIBUS interface (PB) can be operated as PROFIBUS slaves in a PROFIBUS installation. Via these PROFIBUS components, it is possible to exchange real-time data with a PROFIBUS-DP master.

Cyclic data channel (PROFIBUS-DP)

The field bus provides data containers in which useful data can be cyclically transmitted. This section is referred to as cyclic data channel.

The cyclic data channel is subdivided as follows:

- One (optional) **device-specific parameter channel** for reading and writing of all IndraDrive parameters via PROFIBUS-DP.

> The **device-specific parameter channel** does not comply with any "real-time properties"!

- One (optional) **safe, axis-specific process data channel** (PROFIsafe).

> The **safe, axis-specific process data channel** is not available in PSB21VRS. For configuration, however, the module "F-Module not used" has to be integrated!

- One **axis-specific process data channel** (real-time channel) which contains specified information that can be directly interpreted by the receiver.

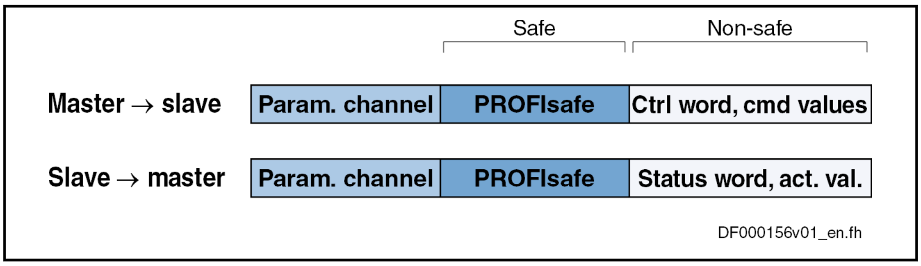


Fig. 3-32: Cyclic data channel overview

> To simplify field bus communication, Rexroth makes available PLC function blocks for different programmable logic controllers (PLCs). The function blocks support the basic functionalities of the axis-specific process data channel and device-specific parameter channel. The principles applied can be easily used for other field bus masters.

Features

The slave PROFIBUS-DP interface with PROFIBUS-Interface (PB) master communication module has the following features:

- **RS485 interfaces according to IEC 61158-2** are supported
- All **data rates according to IEC 61158-2** are supported, with exclusive use of PROFIBUS-DP (9.6 kBaud, 19.2 kBaud, 45.45 kBaud, 93.75 kBaud, 187.5 kBaud, 500 kBaud, 1.5 MBaud, 3 MBaud, 6 MBaud, 12 Mbaud)
- Automatic baud rate detection
- Configurable cyclic data up to 15 parameters (incl. field bus control word and field bus status word) in both data directions (max. 48 bytes or 24 words)
- Setting options for P-0-4076: min. 2 ms, max. 65 ms (can be set in steps of 1 ms)

> The parameter "P-0-4076, Field bus: Process data - updating clock" is used to set the update cycle with which the process data from the PROFIBUS interface are applied to or from the device.

- Additional optional parameter channel in the cyclic channel with up to 16 bytes (8 words)

- Monitoring of the cyclic data exchange (watchdog function)
- LED for diagnosing the PROFIBUS interface
- Supported DPV0 services:
  - Slave_Diag (read diagnostic data)
  - Get_Cfg (read configuration data)
  - Set_Prm (transmit parameterization data)
  - Chk_Cfg (check configuration data)
  - Data Exchange (transfer I/O data)
  - Global Control (synchronization)
  - RD_Outp (read output data)
  - RD_Inp (read input data)
- Supported DPV1 Class 1 services
  - DDLM_Initiate (establishment of connection)
  - DDLM_Read (acyclic read access)
  - DDLM_Write (acyclic write access)
  - DDLM_Abort (terminating the connection)
  - DDLM_Idle (connection monitoring)
- Up to two DPV1 class 2 connections are supported
- TCI (Tool Calling Interface) support

Addressing

The address can be set directly using the display of the device. This can be done using the so-called Easy Menu.

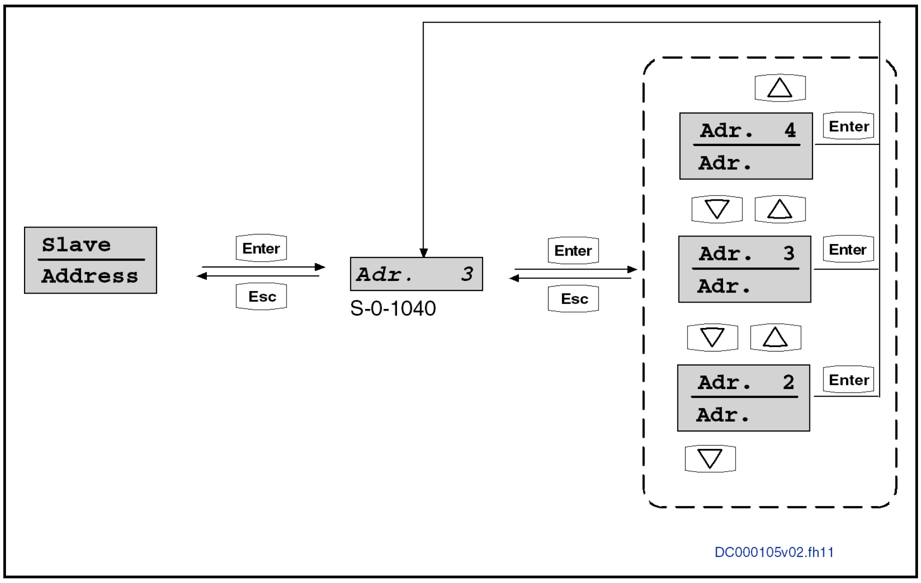


Fig. 3-33: Submenu for "Slave___" "_Addresss"

Optionally, the address can be directly changed or displayed using the parameter "S-0-1040, Drive address of master communication".

The address is always displayed in the left side of the standard display of the control panel.

Parameters involved

Communication parameters

Specific parameters for communication via PROFIBUS-DP:

- P-0-4069, Field bus: Module diagnosis

Parameters for general communication via field bus interfaces:

- P-0-4073, Field bus: Diagnostic message
- P-0-4074, Field bus: Data format
- P-0-4075, Field bus: Watchdog
- P-0-4076, Field bus: Process data - updating clock
- P-0-4079, Field bus: Baud rate
- P-0-4083, Parameter channel: Length
- P-0-4083.0.1, Parameter channel: Configuration

Profile type parameters

Apart from mere communication parameters, parameters are used in conjunction with the profile types.

See "Profile types (with field bus interfaces)"

Parameters for extended communication

Additional parameters are used for extended communication.

See the following sections:

- "Configurable signal control word"
- "Configurable signal status word"

Diagnostic messages involved

- C0229 Field bus: IDN for cycl. command val. not configurable
- C0230 Field bus: Max. length for cycl. command val. exceeded
- C0231 Field bus: IDN for cycl. actual val. not configurable
- C0232 Field bus: Length for cycl. actual values exceeded
- C0233 Field bus: Tcyc (P-0-4076) incorrect
- C0234 Field bus: P-0-4077 missing for cycl. command values
- E4005 No command value input via master communication
- F4009 Bus failure
- F4012 Incorrect I/O length

3.10.2 Configuring the PROFIBUS-DP slave

Device data sheet for IndraDrive

Like every other PROFIBUS slave, IndraDrive controllers have to be configured in the field bus master. This requires the corresponding device master file (GSD) "**RX**0107.GSD**" that has to be included in the project ("**" represents the version number of the GSD file). This GSD-file, when configuring the bus master, is required for each node.

The device master file for IndraDrive controllers supports all hardware types and the activation of functional packages.

IndraDrive controllers assign four slots to their data (in case of single axis devices) or up to 25 slots in case of devices operated via the CCD group (1CCD master + 7 CCD slaves). The devices have to be configured. Each device in the in the CCD group has an F-module, one input module and one output module: A slot is a module location. In the example: A parameter channel module is inserted in Slot 1. The parameter channel module can have different lengths as described.

With single-axis devices, IndraDrive controllers assign their data to four slots into which certain modules have to be plugged.

- Slot 1: Parameter channel
- Slot 2: F-module axis 0 (optional für PROFIsafe)
- Slot 3: Inputs axis 0
- Slot 4: Outputs axis 0
- Slot 5: F-module axis 1 (only for devices operated at the CCD group)
- Slot 6: Inputs axis 1 (only for devices operated at the CCD group)
- Slot 7: Outputs axis 1 (only for devices operated at the CCD group)
- Slot X: F-module axis X (according to number of CCD devices)
- Slot Y: Inputs axis X (according to number of CCD devices)
- Slot Z: Outputs axis X (according to number of CCD devices)

The default configuration stored in the device data sheet "Input 1 Word" and "Output 1 Word" (single-axis device) without safety technology and without parameter channel. For configurators that are supporting the GSD version 03 or higher, this default configuration is automatically set. This setting active in IndraDrive after loading of the default values.

The device data sheet also contains the IDN assigned to the IndraDrive controller by the PROFIBUS User Oganization :

- Ident. no. 107 hex

☞ During the installation of "IndraWorks MLD", the device data sheet is stored by default in the directory "C:\Program Files \REXROTH\IndraWorks\DeviceDataSheets\IndraDrive\Profibus".

Module 1: Parameter channel

These modules are of the input/output module type and marked with "ParamCh". If no parameter channel is required, the "ParamCh not used" module has to be selected.

If IDN parameters or EIDN parameters are to be written via the parameter channel, observe the following aspects:

- IDN parameters

  To write a 2-byte IDN parameter (e.g. P-0-4006), include the "ParamCh 5 Words" module and configure it accordingly in the parameter "P-0-4083.0.1, Parameter channel: Configuration".
- EIDN parameters

  To write a 4-byte EIDN parameter (e.g., P-0-4006.0.0), include the "ParamCh 6 Words" module and configure it accordingly in the parameter "P-0-4083.0.1, Parameter channel: Configuration".

☞ The parameter channel length is displayed in parameter "P-0-4083, Parameter channel: Length" in bytes.

In case of an incorrect configuration of the command/actual values, the error "F4012 Incorrect I/O length" is displayed.

The device automatically recognizes the configuration of the master and adjusts accordingly. Thus, parameterization by the master is therefore always possible even in case of incorrect configuration of the command value/actual values. This enables parameter download from the master after a device was replaced.

F-module

Slot 2 is assigned with the empty module "F-Module not used".

Inputs module

In these modules, the length of the input data is set in words. The module identifier is "Input". For successful data exchange of the axis-specific process data channel, the set length has to equal the value in parameter "P-0-4082, Field bus: Length of cyclic actual value data channel", specifying the length in bytes.

Even in case of an incorrect input data length, the device-specific parameter channel can be used for communication.

If the configuration of the master does not correspond to the one of the IndraDrive controller, IndraDrive device will generate the error message "F4012 Incorrect I/O length".

Outputs module

In these modules, the length of the input data is set in words. The module identifier is "Output". The length of the output data that was set has to correspond with the value of parameter "P-0-4071, Field bus: Length of cyclic command value data channel".

If the configuration of the master does not correspond to the one of the IndraDrive controller, IndraDrive device will generate the error message "F4012 Incorrect I/O length".

Modules 5 to 31

The modules 5 to 31 are provided for devices operated at the CCD group. In case of single-axis devices, the empty modules "F-Module not used", "Input not used" or "Output not used" should be assigned to these modules.

Configuring the process data channel

Standard process data channel (non-safe)

The user can freely configure the cyclic data in the standard process data channel according to the process requirements.

For the profile types "freely configurable mode" (P-0-4084 = 0xFFFE) , "operating mode neutral" (P-0-4084 = 0xFFFD), "I/O mode" (P-0-4084 = 0xFF82), "I/O mode" (P-0-4084 = 0xFF92 velocity specification) or "no profile" (P-0-4084 = 0x0000), a default configuration is specified that can be changed by the user.

See also "Profile types (with field bus interfaces)"

Configuration list of cyclic actual value data channel

In parameter "P-0-4080, Field bus: Config. list of cyclic actual value data ch.", the structure and therefore the number of words and their assigned objects (indices) for the process input data (slave → master) are mapped. The master can use this configuration in order to locate the individual real-time data in the field bus.

Configuration list of cyclic command value data channel

The structure of the process output data (master → slave) is mapped in parameter "P-0-4081, Field bus: Config. list of cyclic command value data ch.". This allows the current structure and thus the assignment in the field bus to be read via the parameter channel.

It is possible to configure up to 15 real-time parameters (incl. control word or status word) at the bus in each data direction (max. 48 bytes or 24 words).

PROFIsafe process data channel (safe)

The **safe, axis-specific process data channel** is not available in PSB21VRS. For configuration, however, the module "F-Module not used" has to be integrated!

Length of the process data channel (real-time data channel)

Standard process data channel (non-safe)

Within the cyclic channel, the parameter channel (optional) and the process data channel, in which the real-time data of the device are transmitted, are arranged.

The PROFIBUS slave interface enables flexible configuration of the process data channel, the length of the process data channel thereby changes accordingly.

> ☞ The currently active length is contained in the parameters "P-0-4082, Field bus: Length of cyclic actual value data channel" and "P-0-4071, Field bus: Length of cyclic command value data channel".

The process data channel (real-time data channel) can only have words or double words, but not bytes, as data types. Length, however, is specified in bytes for the sake of compatibility with other bus systems.

The length of the process data channel can range between 1...24 words or 2...48 bytes in either direction.

The length of the process data channel results from the content of the configuration lists "P-0-4080, Field bus: Config. list of cyclic actual value data ch." or"P-0-4081, Field bus: Config. list of cyclic command value data ch." and is contained in the following parameters:

- P-0-4071, Field bus: Length of cyclic command value data channel
- P-0-4082, Field bus: Length of cyclic actual value data channel

The setting is calculated from the contents of the parameters P-0-4080 and P-0-4081 and takes effect as the device runs up to the operating mode.

> ☞ Please note that a change in the length of the process data channel also requires a change in the master configuration. The length of the process data channel that was set therefore has to comply with the configured length in the master. Otherwise, the error message "F4012 Incorrect I/O length" is generated.

3.10.3 Cyclic communication via process data channel

Communication cycle time

The communication cycle time results from the baud rate set in the master. This baud rate is transmitted to the slave and displayed in parameter "P-0-4079, Field bus: Baud rate".

The parameter "P-0-4076, Field bus: Process data - updating clock" is used to set the update cycle with which the data from the PROFIBUS® interface are applied to the device and vice versa. Due to performance reasons, retain the default settings.

Valid values for "P-0-4076 Field bus: Process data - updating clock": min. 2 ms, max. 65 ms (can be changed in steps of 1 ms)

Axis-specific process data channel

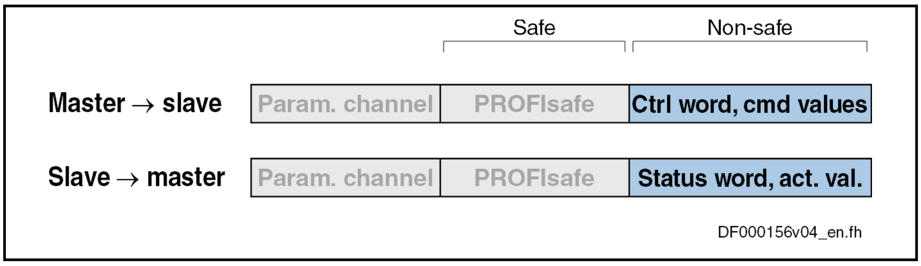


Fig. 3-34: Position of the non-safe process data channel in the cyclic data channel

Processing the cyclic data

The internal processing of the command values and actual values is carried out synchronously with the control clock. As the communication via PROFINET DP was not cycle-synchronously, the master communication is not intended for cycle-synchronous operating modes such as "position control with cyclic command value specification" but is only intended for positioning operating modes and the operating mode "velocity control".

> There is no limit value check for the cyclically transmitted command values and they are stored in volatile form.

Configuring the cyclic data

The cyclic data have to be configured in the parameter mode. This configuration is described in the section "Configuring the PROFIBUS-DP slave".

Safe, axis-specific process data channel (PROFIsafe)

General information

> The **safe, axis-specific process data channel** is not available in PSB21VRS.

PROFIsafe configuration

Configuration of the control unit

In PSB21VRS, the **safe, axis-specific process data channel** is not available; it is therefore necessary to include the following PROFIsafe module (blank module) in the control unit configuration:

- F-module not used

  This axis does not exchange any data via PROFIsafe.

Parameter channel in the cyclic channel (device-specific)

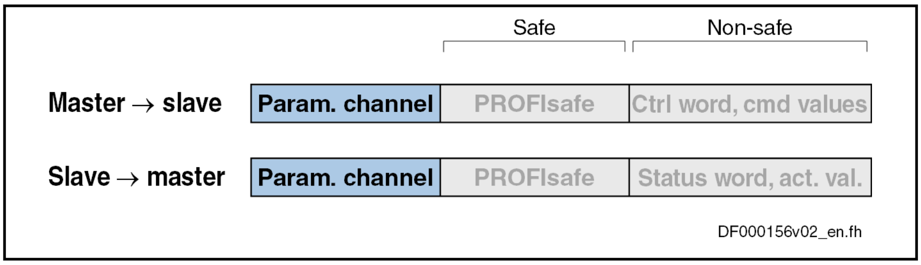


Fig. 3-35: Position of the parameter channel in the cyclic data channel

Using the parameter channel, the device or the devices can be parameterized via the field bus. The parameter channel is part of the cyclic data.

For IndraLogic and Siemens S7, functions blocks are available which implement the parameter channel protocol. This allows the user to ignore the parameter channel details.

The parameter channel is described in the Technical Note "TN_40_Bosch_Rexroth PROFIBUS_PROFINET_Parameterkanal_V1.x".

The parameter channel is always at the beginning of the cyclic data channel. The length of the parameter channel is configured in the master and applied by the device to parameter "P-0-4083, Parameter channel: Length".

It is not possible to operate the field bus control word via the optional parameter channel. To enable axis control, the cyclic data channel has to be used in the higher-level control unit or the corresponding logic has to be programmed with permanent control in MLD. If the control does not have a cyclic data channel, no axis control is possible without an MLD.

3.10.4 Acyclic data exchange (DPV1)

Overview of acyclic communication

DP master class 1

An acyclic communication relation of type "MSAC_C1" to the DP master class 1 (MSAC_C1) is supported. The following DP services are available for this communication relationship:

- DDLM_Read (MSAC1_Read)
- DDLM_Write (MSAC1_Write)

DP master class 2

Two acyclic communication relations of type "MSAC_C2" to the DP master class 2 (MSAC_C2) are supported. The following DP services are available for this communication relationship:

- DDLM_Initiate (MSAC2_Initiate)
- DDLM_Abort (MSAC2_Abort)
- DDLM_Read (MSAC2_Read)
- DDLM_Write (MSAC2_Write)

3.10.5 Monitoring functions and diagnostic functions

Monitoring functions

Watchdog for cyclic communication

As a standard, the time required for the watchdog monitoring function is automatically calculated and configured by the configuration program of the master. It is displayed in parameter "P-0-4075, Field bus: Watchdog" (in ms).

The input "0" in parameter "P-0-4075, Field bus: Watchdog" indicates that the watchdog monitoring is disabled.

F4012 Incorrect I/O length

If the error message "F4012 Incorrect I/O length" is generated, IndraDrive is in the PROFIBUS state "Data_Exchange"; the LED display "H30" is active. The parameter channel is working, but the data of the input and output modules are not processed internally.

Diagnostic options

The state of the field bus master communication of an IndraDrive device is diagnosed via the

- LED display "H30" on font panel of the controller

  - and -

- Diagnostic parameter "P-0-4073, Field bus: Diagnostic message".

Diagnostic LED "H30"

The LED display "H30" is active when the device is in the PROFIBUS state "Data_Exchange". This means that real-time data are exchanged between IndraDrive and master.

Parameter for field bus diagnostics

The parameter "P-0-4073, Field bus: Diagnostic message" contains the state of the field bus master communication in plain text. The contents of parameter P-0-4073 have the following significance:

Text	Significance
"OFFLINE"	Initialization value of the diagnostic message
"Power-On"	PROFIBUS-DP has been detected as master communication and the hardware is checked.
"Baud-Search"	The hardware is okay; the PROFIBUS interface is monitored in order to recognize the baud rate used.
"Wait-Prm"	The baud rate has been found, the device waits for a parameterization telegram of the master that contains its IDN (contained in the device data sheet).
"Wait-Cfg"	IndraDrive has received a valid parameterization telegram and now waits for the configuration telegram in which the master tells the drive which modules it is expecting for input/output configuration.
"Data-Exch WD+"	The device has received a valid configuration, it exchanges real-time data with the master. The communication is monitored by a watchdog.
"Data-Exch WD-"	The device has received a valid configuration. It exchanges real-time data with the master without the communication being monitored by a watchdog.

Tab. 3-17: Significances of the entries in parameter P-0-4073

Error codes of PROFIBUS communication

Parameter channel errors

The table below contains an overview of the possible parameter channel error messages and their significance:

Error code	Significance
0x0082	Number of all transmitted data is too low, i.e. less than four bytes
0x0083	quantity of data still to be transmitted is greater than the internal buffer
0x0088	the length of the valid data indicated in the control word is longer than the parameter channel
0x008C	status conflict, a new request was sent although there are still data to be transmitted
0x008D	The length of data to be transmitted indicated in the control word is incorrect
0x008E	The EIDN/IDN access type specified in control word bit 15 does not comply with the access type specified in P-0-4083.0.1

Tab. 3-18: Parameter channel errors overview

DPV1 errors

The following table provides an overview of the possible DPV1 error messages and their significance:

Error code	Significance	Designation acc. to DPV1 standard
0x80 0xA0 0x00	The read request has a length of more than 10 bytes.	DPV1, access, read error
0x80 0xA1 0x00	The write request has a length of more than 11 bytes.	DPV1, access, write error
0x80 0xA9 0x00	DPV1 service not supported	DPV1, application, feature not supported
0x80 0xB0 0x00	No access to index 47.	DPV1, access, invalid index
0x80 0xB1 0x00	There is no DPV1 header available.	DPV1, access, write length error
0x80 0xB2 0x00	No access to slot 0.	DPV1, access, invalid slot
0x80 0xB3 0x00	Access is only allowed to the object value.	DPV1, access, type conflict
0x80 0xB5 0x00	Parameter request not yet received, therefore response not yet available.	DPV1, access, state conflict
0x80 0xB6 0x00	The parameter cannot be written.	DPV1, access, access denied
0x80 0xB8 0x00	Only one parameter must be processed during an access.	DPV1, access, invalid parameter
0x80 0xC0 0x00	The request is still being processed, the read request has to be repeated.	DPV1, resource, read constrain conflict

Tab. 3-19: Overview DPV1 errors

Parameter access errors

The table below contains an overview of the possible parameter access errors and their significance; the error values are transmitted in word format:

Error no. (hex)	Significance
0x1001	No IDN
0x1009	Invalid access to element 1
0x2001	No name
0x2004	Name cannot be changed (read only)
0x3004	Attribute cannot be changed (read only)
0x4001	No units
0x4004	Unit cannot be changed (read only)
0x5001	no minimum input value
0x5004	minimum input value cannot be changed (read only)
0x6001	no maximum input value
0x6004	maximum input value cannot be changed (read only)
0x7002	Operation data transmission too short

Error no. (hex)	Significance
0x7003	Operation data transmission too long
0x7004	operation data cannot be changed (read only)
0x7005	operation data is write-protected at this time (e.g. communication phase)
0x7006	operation data is smaller than minimum input value
0x7007	operation data is greater than maximum input value
0x7008	IDN is not supported, invalid bit numbers or bit combination
0x7009	operation data write protected by a password
0x700A	operation data is write protected, it is configured cyclically
0x700B	Invalid indirect addressing (e.g., data container, list handling)
0x700C	Date is currently read-only due to other settings (e.g., parameter, operation mode, drive enable, RF, ...)
0x7010	Procedure command already active
0x7011	Procedure command not interruptible
0x7012	Command can currently not be executed (e.g., in this phase the command cannot be activated)
0x7013	Procedure command not executable (invalid or false parameters)
0x9001	Input cannot be identified as application
0x9002	Parameter type error
0x9003	Invalid data record number
0x9004	invalid data block number
0x9005	Data element number invalid
0x9006	error in R/W flag
0x9007	Invalid character in the data

Tab. 3-20: Parameter access errors overview

3.11 CANopen-based communication

3.11.1 General information

Communication Objects (0x1000 to 0x1FFF)

The communication objects are described in the CANopen standard DS301. Within the CANopen communication, these objects have one of the following functions:

- Access to drive parameters
- Constants
- Read-only objects

The table below contains an overview of the **objects specified** for CANopen communication:

IDN	CANopen objects	Description
P-0-3600.0.1	0x1000	CANopen: Device type
P-0-3601.0.1	0x1001	CANopen: Error register
P-0-3603.0.1	0x1006	CANopen: Communication cycle period
P-0-3604.0.1	0x1008	CANopen: Manufacturer device name
P-0-3604.0.2	0x1009	CANopen: Manufacturer hardware version
P-0-3604.0.3	0x100A	CANopen: Manufacturer software version
P-0-3606.0.1	0x1018.0	CANopen: Identity object
P-0-3606.0.2	0x1018.1	CANopen: Vendor ID
P-0-3606.0.3	0x1018.2	CANopen: Product Code
P-0-3606.0.4	0x1018.3	CANopen: Revision Number
P-0-3606.0.5	0x1018.4	CANopen: Serial Number
P-0-3602.0.1	0x1005	CiA301: COB-ID SYNC message
P-0-3605.0.1	0x100C	CiA301: Guard time
P-0-3605.0.2	0x100D	CiA301: Life time factor
P-0-3605.0.3	0x1014	CiA301: COB-ID EMCY
P-0-3605.0.4	0x1016.0	CiA301: Consumer heartbeat time
P-0-3605.0.5	0x1016.1	CiA301: Heartbeat description
P-0-3605.0.6	0x1017	CiA301: Producer heartbeat time
P-0-3607.0.1	0x1200.0	CiA301: 1st SDO server parameter
P-0-3607.0.2	0x1200.1	CiA301: COB-ID client -> server (rx)
P-0-3607.0.3	0x1200.2	CiA301: COB-ID server -> client (tx)
P-0-3608.0.1	0x1400.0	CiA301: RPDO communication parameter
P-0-3608.0.2	0x1400.1	CiA301: COB-ID used by RPDO
P-0-3608.0.3	0x1400.2	CiA301: Transmission type RPDO
P-0-3608.1.1	0x1401.0	CiA301: RPDO communication parameter
P-0-3608.1.2	0x1401.1	CiA301: COB-ID used by RPDO
P-0-3608.1.3	0x1401.2	CiA301: Transmission type RPDO
P-0-3608.2.1	0x1402.0	CiA301: RPDO communication parameter
P-0-3608.2.2	0x1402.1	CiA301: COB-ID used by RPDO
P-0-3608.2.3	0x1402.2	CiA301: Transmission type RPDO
P-0-3608.3.1	0x1403.0	CiA301: RPDO communication parameter
P-0-3608.3.2	0x1403.1	CiA301: COB-ID used by RPDO
P-0-3608.3.3	0x1403.2	CiA301: Transmission type RPDO
P-0-3609.0.1	0x1600.0	CiA301: RPDO mapping parameter
P-0-3609.0.2	0x1600.1	CiA301: RPDO: 1st application object
P-0-3609.0.3	0x1600.2	CiA301: RPDO: 2nd application object

IDN	CANopen objects	Description
P-0-3609.0.4	0x1600.3	CiA301: RPDO: 3rd application object
P-0-3609.0.5	0x1600.4	CiA301: RPDO: 4th application object
P-0-3609.1.1	0x1601.0	CiA301: RPDO mapping parameter
P-0-3609.1.2	0x1601.1	CiA301: RPDO: 1st application object
P-0-3609.1.3	0x1601.2	CiA301: RPDO: 2nd application object
P-0-3609.1.4	0x1601.3	CiA301: RPDO: 3rd application object
P-0-3609.1.5	0x1601.4	CiA301: RPDO: 4th application object
P-0-3609.2.1	0x1602.0	CiA301: RPDO mapping parameter
P-0-3609.2.2	0x1602.1	CiA301: RPDO: 1st application object
P-0-3609.2.3	0x1602.2	CiA301: RPDO: 2nd application object
P-0-3609.2.4	0x1602.3	CiA301: RPDO: 3rd application object
P-0-3609.2.5	0x1602.4	CiA301: RPDO: 4th application object
P-0-3609.3.1	0x1603.0	CiA301: RPDO mapping parameter
P-0-3609.3.2	0x1603.1	CiA301: RPDO: 1st application object
P-0-3609.3.3	0x1603.2	CiA301: RPDO: 2nd application object
P-0-3609.3.4	0x1603.3	CiA301: RPDO: 3rd application object
P-0-3609.3.5	0x1603.4	CiA301: RPDO: 4th application object
P-0-3614.0.1	0x1800.0	CiA301: TPDO communication parameter
P-0-3614.0.2	0x1800.1	CiA301: COB-ID used by TPDO
P-0-3614.0.3	0x1800.2	CiA301: Transmission type TPDO
P-0-3614.0.4	0x1800.3	CiA301: Inhibit time TPDO
P-0-3614.0.6	0x1800.5	CiA301: Event timer TPDO
P-0-3614.1.1	0x1801.0	CiA301: TPDO communication parameter
P-0-3614.1.2	0x1801.1	CiA301: COB-ID used by TPDO
P-0-3614.1.3	0x1801.2	CiA301: Transmission type TPDO
P-0-3614.1.4	0x1801.3	CiA301: Inhibit time TPDO
P-0-3614.1.6	0x1801.5	CiA301: Event timer TPDO
P-0-3614.2.1	0x1802.0	CiA301: TPDO communication parameter
P-0-3614.2.2	0x1802.1	CiA301: COB-ID used by TPDO
P-0-3614.2.3	0x1802.2	CiA301: Transmission type TPDO
P-0-3614.2.4	0x1802.3	CiA301: Inhibit time TPDO
P-0-3614.2.6	0x1802.5	CiA301: Event timer TPDO
P-0-3614.3.1	0x1803.0	CiA301: TPDO communication parameter
P-0-3614.3.2	0x1803.1	CiA301: COB-ID used by TPDO
P-0-3614.3.3	0x1803.2	CiA301: Transmission type TPDO
P-0-3614.3.4	0x1803.3	CiA301: Inhibit time TPDO

IDN	CANopen objects	Description
P-0-3614.3.6	0x1803.5	CiA301: Event timer TPDO
P-0-3615.0.1	0x1A00.0	CiA301: TPDO mapping parameter
P-0-3615.0.2	0x1A00.1	CiA301: TPDO: 1st application object
P-0-3615.0.3	0x1A00.2	CiA301: TPDO: 2nd application object
P-0-3615.0.4	0x1A00.3	CiA301: TPDO: 3rd application object
P-0-3615.0.5	0x1A00.4	CiA301: TPDO: 4th application object
P-0-3615.1.1	0x1A01.0	CiA301: TPDO mapping parameter
P-0-3615.1.2	0x1A01.1	CiA301: TPDO: 1st application object
P-0-3615.1.3	0x1A01.2	CiA301: TPDO: 2nd application object
P-0-3615.1.4	0x1A01.3	CiA301: TPDO: 3rd application object
P-0-3615.1.5	0x1A01.4	CiA301: TPDO: 4th application object
P-0-3615.2.1	0x1A02.0	CiA301: TPDO mapping parameter
P-0-3615.2.2	0x1A02.1	CiA301: TPDO: 1st application object
P-0-3615.2.3	0x1A02.2	CiA301: TPDO: 2nd application object
P-0-3615.2.4	0x1A02.3	CiA301: TPDO: 3rd application object
P-0-3615.2.5	0x1A02.4	CiA301: TPDO: 4th application object
P-0-3615.3.1	0x1A03.0	CiA301: TPDO mapping parameter
P-0-3615.3.2	0x1A03.1	CiA301: TPDO: 1st application object
P-0-3615.3.3	0x1A03.2	CiA301: TPDO: 2nd application object
P-0-3615.3.4	0x1A03.3	CiA301: TPDO: 3rd application object
P-0-3615.3.5	0x1A03.4	CiA301: TPDO: 4th application object

Tab. 3-21: Specified CANopen Objects

☞ Other communication objects of CANopen Interface are listed in the relevant EDS file.

Manufacturer-specific objects (0x2000 to 0x3FFF)

Manufacturer-specific objects

All parameters of the drive can be reached via the manufacturer-specific objects. The S-parameters are addressed via the objects 0x2000 to 0x2FFF, the P-parameters via the objects 0x3000 to 0x3FFF. The manufacturer-specific objects have the following structure:

subindex	Description
0	Number of sets of the parameter (1 or 8)
1	Operating data set 0
2	Operating data set 1 (if available)
3	Operating data set 2 (if available)
4	Operating data set 3 (if available)
5	Operating data set 4 (if available)

subindex	Description
6	Operating data set 5 (if available)
7	Operating data set 6 (if available)
8	Operating data set 7 (if available)
10	index of list pointer
11	list element to which element 10 points (only for list parameter)
12...18	list element to which element 10 points (if 8 parameter sets available); only for list parameter
21	Parameter name
22…28	name of parameter (if 8 parameter sets available)
31	attribute of parameter
32…38	attribute of parameter (if 8 parameter sets available)
41	Parameter unit
42…48	unit of parameter (if 8 parameter sets available)
51	minimum value of parameter
52…58	minimum value of parameter (if 8 parameter sets available)
61	maximum value of parameter
62…68	maximum value of parameter (if 8 parameter sets available)
71	maximum length of list parameter
72…78	maximum length of list parameter (if 8 parameter sets available)
81	actual length of list parameter
82…88	actual length of list parameter (if 8 parameter sets available)

Tab. 3-22: Structure of manufacturer-specific objects

List access

The complete list of a list parameter can be read or written by accessing the operating data of the parameter.

To access individual list elements, it is possible to set a list index (subindex 10) and access the respective list element of the list index via subindex 11 (to subindex 18). With each access via subindex 11 (to subindex 18), the list index is incremented by one element. This allows a continuous part of a list to be processed in the case of repeated access to subindex 11 (to subindex 18).

With one of the following actions, the list index is reset to the first element:

- Change of parameter set
- Change of parameter
- Abortion of connection

For each list element access which does not start from the first element, it is therefore necessary to set the list index.

If the length of the list has to be changes, this can be corrected by changing the actual length of the list parameter (subindex 81…88).

The maximum list length can be read via the subindices 71…78.

With one of the following actions, the parameter value is stored:

- Writing to last element
- Change to a different parameter
- Change of parameter set
- Reading the same parameter
- Abortion of connection

The changes are discarded when the control voltage fails.

4 Mains connection

⚠ WARNING **Dangerous movements! Danger to life, risk of injury, serious injury or property damage!**

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine's range of motion (e.g., by using safety fences, safety guards, protective coverings, light barriers).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.

4.1 Mains connection overview

The mains connection components of a supply unit with active power output stage (regenerative mains inverter) usually consist of mains filter and mains choke. The higher the performance class the higher the size and complexity. High performances therefore require mains chokes consisting of multiple individual components. The system is supplied with power via a three-phase mains connection.

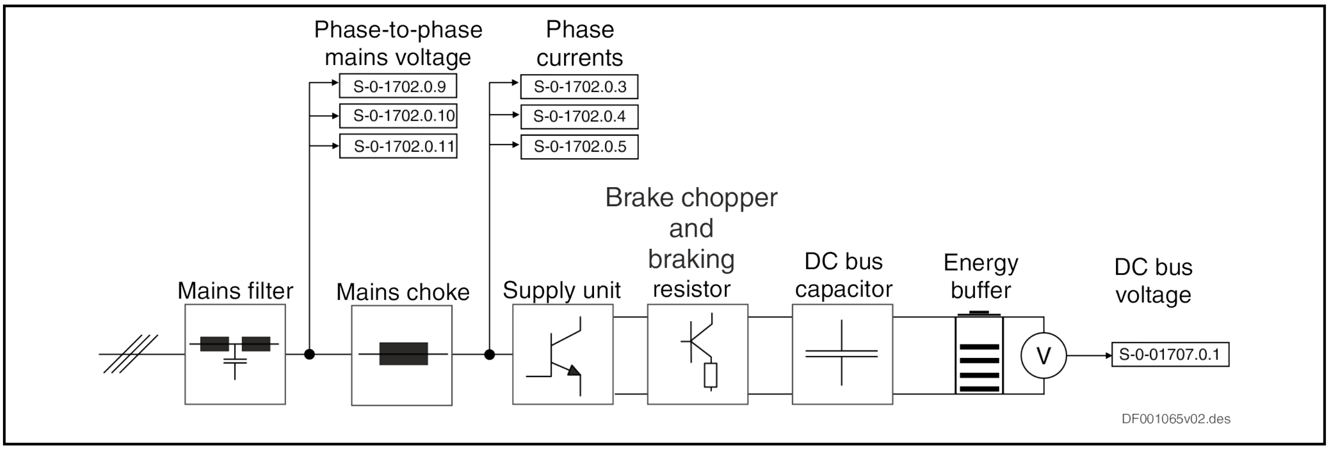


Fig. 4-1: Supply unit mains connection overview

Different status variables are measured for power supply control and diagnostics:

- Mains phase voltages at the output terminal connectors of the mains filter (sampling: current controller clock):
  - S-0-1702.0.9, Mains voltage Phase to Phase L1-L2
  - S-0-1702.0.10, Mains voltage Phase to Phase L2-L3
  - S-0-1702.0.11, Mains voltage Phase to Phase L3-L1
- Mains phase currents at the input of the supply unit (sampling: current controller clock):
  - S-0-1702.0.3, Phase current L1
  - S-0-1702.0.4, Phase current L2
  - S-0-1702.0.5, Phase current L3
- DC bus voltage (S-0-1707.0.1) on the output side of the supply unit power output stage (sampling: voltage controller clock).

In addition, the following status variables are made available on the basis of the measured variables:

- Mains phase voltages rms values:
  - S-0-1702.0.17, Mains voltage Phase to Phase L1-L2 RMS value
  - S-0-1702.0.18, Mains voltage Phase to Phase L2-L3 RMS value
  - S-0-1702.0.19, Mains voltage Phase to Phase L3-L1 RMS value
- Mains current rms value (S-0-1702.0.2)

Mains power (S-0-1702.0.13) The mains power (S-0-1702.0.13) displays the current power consumption from the mains. The display for the mains power is filtered with a PT1 filter with adjustable time constant. The filter time constant can be set in parameter "S-0-1702.0.155, Mains power filter time constant".

Soft start Using a soft start device the uncharged DC bus is first of all charged to the rectified value. The design of the soft start device depends on the hardware.

DC bus capacitor Supply units have an integrated DC bus capacitor. An external additional capacitor can be optionally added to it.

Braking resistor The design of the braking resistor depends on the hardware. If an integrated braking resistor is not available, an external braking resistor can be optionally connected.

Energy buffer Optionally, an external energy buffer (Kinetic Buffer, UPS) can be operated at the DC bus, In the case of mains failure, it makes available energy to supply drives.

Communication The IndraBus/module bus is used for communication between the supply unit and other devices connected to the DC bus. Independent of the master communication, information on error situations is exchanged via this bus without delay.

4.2 Type of mains connection, power supply

The type of supply unit mains connection differs depending on the hardware used. We basically distinguish between

- IndraDrive ML (supply unit with HMU05) and
- IndraDrive Mi (KMV03 supply unit).

The mains connection components can be functionally distinguished as follows:

- Mains filter
- Mains choke, consisting of
  - Preconnected choke
  - Mains capacitor
  - Commutation choke
- Soft start device

The above functionality classification reveals nothing about the structural design. For the detailed system structure please see the respective Project Planning Manual.

Status of power supply The current status of power supply is represented by the state machine of the supply unit [see chapter "State machine of the device" on page 36

chapter 3.2.4 "Device control and state machines" on page 33]. Any change of states is performed using the parameter "S-0-1720.0.1, Power supply control word", or in the case of automatic supply unit run-up by switching on the main contactor and mains contactor. The supply unit signals the current state via the parameter "S-0-1720.0.2, Power supply status word".

Soft start

When the mains supply power is switched on, the DC bus is charged via a soft start device. It limits the input current (mains current) to a device-depending limit value. The soft start device contains one of the following charging circuits:

- Resistance charge
- Constant current source

The charging circuit type is contained in the parameter "P-0-0809, Properties of charging circuit". The maximum DC bus capacitance is limited by the charging ability of the soft start device.

The soft start causes a charging time between the activation of the mains voltage and the minimum voltage in the DC bus required for power output. Charging time and charging curve are monitored during the soft start. In case of error, the error message "F2816 Softstart fault power supply unit" is generated. If the soft start is successfully completed, the supply unit goes to the "ready for power output" state ("S-0-1720.0.2, Power supply status word", bit 14 = 1).

Identifying the controlled system

When power is switched on, the DC bus capacitance is determined during the soft start. If "S-0-1732.0.1, DC bus capacitance, measured" contains the value 0 (corresponding to condition as supplied), the DC bus capacitance determined during soft start is applied to S-0-1732.0.1. If the value in S-0-1732.0.1 is unequal 0, the value of S-0-1732.0.1 remains unchanged.

When power is switched on, the inductance of the commutation choke is determined after successful soft start. If "S-0-1731.0.20, Inductance at commutation choke" contains the value 0 (corresponding to condition as supplied), the inductance determined after soft start is applied to S-0-1731.0.20. If the value of S-0-1731.0.20 is unequal 0, the value of S-0-1731.0.20 remains unchanged.

The values in S-0-1732.0.1 and S-0-1731.0.20 are used for calcluating the control parameters by way of the command "C0710 Command Load power-supply specific controller values". If S-0-1732.0.1 or S-0-1731.0.20 contains the value 0, this command is automatically executed.

DC bus capacitance validation check

If the currently measured DC bus capacitance deviates from the value in "S-0-1732.0.1, DC bus capacitance, measured" by more than ±30%, a logbook entry is generated for diagnostic purposes. The value in S-0-1732.0.1 is still used for calculating the control parameters.

Commutation choke inductance validation check

The measured value of the commutation choke inductance is compared to the typical value stored in the power section. In case it deviates by more than -30% or +100%, a logbook entry is generated for diagnostic purposes. The value in S-0-1731.0.20 is still used for calculating the control parameters.

Choke check

To check the wiring of the commutation choke, the phase angle of the connected mains is determined using a PWM test pattern. The resulting mains angle is compared to the mains angle of the PLL. In case it deviates by more than ±30°, the error message "F8813 Connection error mains choke" is generated.

IndraBus/module bus

The so-called IndraBus or module bus establishes a signal exchange between IndraDrive devices independent of the master communication. This allows error information to be exchanged without delay between the individual devices to facilitate a coordinated error reaction. The designs of IndraBus and module bus are different. Whether IndraBus or module bus is used depends on the device. It is not possible to directly connect the two bus systems. The following pieces of status information are transmitted:

Status information	Bus system		Module bus priority
	IndraBus	Module bus	
Supply error reset	-	■	High
Supply error	■	■	↑
Inverter error	■	■	↑
DC bus voltage error, mains failure	■	■	↑
Supply overload warning	-	■	↑
Ready for power output	-	■	↑
All nodes without error	-	■	↑
DC bus short circuit blocked	■	-	Low

Tab. 4-1: IndraBus and module bus status information

The pieces of module bus status information have a hierarchical order, the information of the highest priority determines the signal state. IndraBus can transmit multiple signal states in parallel. The supply unit generates the following pieces of status information:

- Supply error
- DC bus voltage error, mains failure
- Supply overload warning (module bus only)
- Ready for power output (module bus only)
- All nodes without error (module bus only)
- DC bus short circuit blocked (IndraBus only)

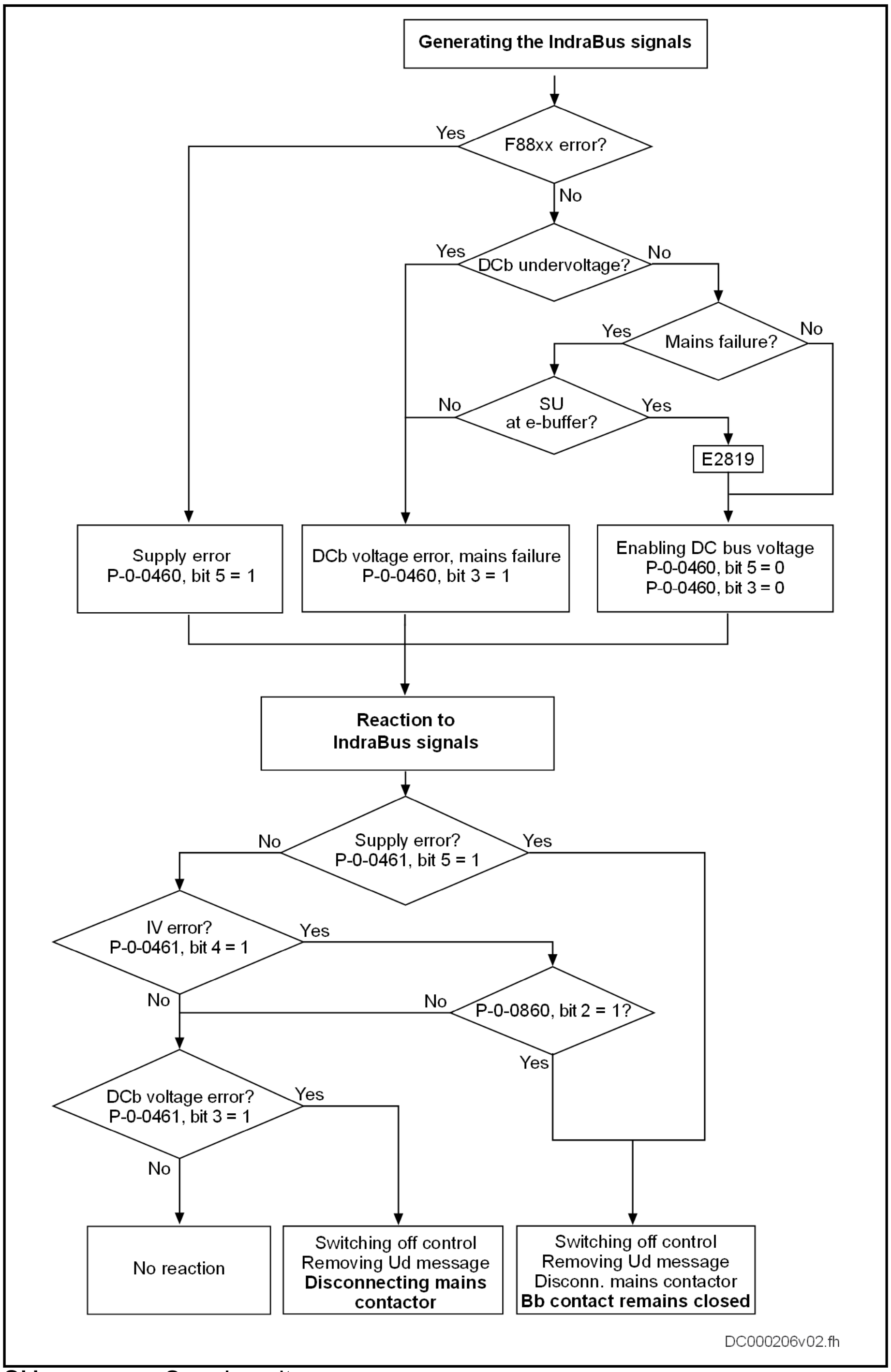
The status information "supply error reset" (module bus only) and "inverter error" are not generated by supply units. In contrast to the module bus, IndraBus is safe from cable break. If cable break is detected or IndraBus has not been wired, the error message "F2087 Module group communication error" is generated.

Status information relevant to a coordinated error reaction within a module group exists for both bus systems:

- Supply error
- DC bus voltage error, mains failure
- Inverter error

The behavior regarding module bus/IndraBus can be divided into

1. the generation of the status information and
2. the reaction to the currently active status information.



SU	Supply unit
e-buffer	Energy buffer
DCb	DC bus
IV	Inverter
Ud message	Signals via IndraBus/module bus that DC bus is ok and ready for power output

Fig. 4-2: Generation and reaction to signals of module bus/IndraBus

Disconnection from the supply in the case of drive errors can be parameterized using "P-0-0860, Converter configuration". If the function has been activated and the "inverter error" information is signaled via the IndraBus/module bus, the supply unit is powered off. The mains contactor is disconnected and the Bb contact is not opened.

The parameter "P-0-0460, Module group, control word" displays the information currently signaled via the IndraBus/module bus by a supply unit. The parameter "P-0-0461, Module group, status word" displays the current state of the IndraBus/module bus.

☞ The disconnection of the mains contactor has the same effect as mains failure and thus causes power enable to be removed. The "DC bus voltage error, mains failure" is thereby signaled via the IndraBus/module bus, and drives in the same module group react according to the "undervoltage in DC bus" function.

4.3 Mains monitoring

The firmware of the supply unit cyclically monitors internal status variables of the system and generates an error message if the expected value and the actual value differ accordingly. The following monitoring functions are available:

- Mains frequency monitoring
- Mains overvoltage monitoring
- Mains undervoltage monitoring
- Phase failure monitoring
- Mains failure monitoring
- Ground fault monitoring
- DC bus voltage monitoring
- Mains overcurrent monitoring
- Protection against oscillation in DC bus

Mains synchronization

The mains synchronization determines mains frequency including rotary field direction (S-0-1702.0.12), mains integral (S-0-1702.0.152), mains angle (S-0-1702.0.150) and mains voltage peak value (S-0-1702.0.1).

If the difference between the nominal mains angle and the current angle of the phase voltages is greater than the mains angle tolerance (S-0-1703.0.154), the error message "F2802 Error in mains synchronization" is generated. The F2802 error causes power enable to be switched off. The "Ud message" is removed, "DC bus voltage error, mains failure" is signaled via module bus/IndraBus.

Mains frequency monitoring

The parameter "S-0-1702.0.12, Mains frequency" is the result of the mains synchronization, the value is filtered. The allowed value is between 43 and 67 Hz.

The mains frequency is subject to very little variation, the mains synchronization can readjust a maximum change of 4 Hz/s (continuous change over this period).

Mains overvoltage

By way of mains overvoltage monitoring the mains voltage is monitored with regard to the maximum allowed value. The maximum allowed mains voltage depends on the hardware (500 V or 690 V devices). The implemented monitoring function has two steps:

1. Monitoring the mains voltage peak value (S-0-1702.0.1) filtered with 100 ms. If the displayed value is greater than 110% of the maximum nominal mains voltage peak value, the error message "F2815 Overvoltage in mains" is generated.

The overvoltage threshold for 500 V devices is:

500 V*1.10*sqrt(2)=778 V

or for 690 V devices:

690 V*1.10*sqrt(2)=1073 V

2. Monitoring the current (unfiltered) mains phase voltages. If a measured value exceeds 115% of the maximum mains peak value three times in succession, the error message "F8815 Overvoltage in mains" is generated.

   The overvoltage threshold for 500 V devices is:

   500 V*1.15*sqrt(2)=813 V

   or for 690 V devices:

   690 V*1.15*sqrt(2)=1122 V

   This is done to detect rapidly increasing mains voltage, e.g. during regeneration.

The F2815 error causes power enable to be switched off and the mains contactor to be disconnected. The "Ud message" is removed, "DC bus voltage error, mains failure" is signaled via module bus/IndraBus. The F8815 error is a critical error and causes the Bb contact to be opened. "Supply error" is signaled via module bus/IndraBus.

☞ Distributed IndraDrive Mi (KMV) supply module does not have a Bb contact.

Mains undervoltage

By way of mains undervoltage monitoring the mains voltage (phase-to-phase mains voltage) is monitored with regard to the minimum allowed value. The minimum allowed mains voltage cannot be parameterized. The minimum allowed mains voltage is:

220 V*sqrt(2)*0,85 = 264 V

The mains voltage peak value (S-0-1702.0.1) filtered with 100 ms is monitored. If the displayed value is smaller than the minimum nominal mains voltage peak value (264 V), the warning "E2814 Undervoltage in mains" is generated. This is done to detect slowly decreasing mains voltage.

Phase failure

By way of phase failure monitoring amplitude differences of the mains voltages are detected. The input values of phase failure monitoring are the rms values of the mains phase voltages. Monitoring is carried out on the basis of EN61000-4-27. If the criteria mentioned here are not met with a time increased by 20%, a phase failure is assumed and the warning "E2818 Phase failure" is generated.

Mains failure

By way of mains failure monitoring a mains failure is detected. The condition for mains failure is: unfiltered mains peak voltage smaller than 50V.

If mains failure is detected, the warning "E2819 Mains failure" is generated. If the mains failure takes longer than two seconds, the error message "F2819 Mains failure" is generated. The F2819 error causes power enable to be switched off and the mains contactor to be disconnected. The "Ud message" is removed, "DC bus voltage error, mains failure" is signaled via module bus/IndraBus.

Ground fault monitoring

By way of ground fault monitoring a short circuit between ground and one of the three phases is detected. The measured phase currents are used as the input values for monitoring.

If the sum of the phase currents exceeds a device-depending threshold (approx. 40% of the device's nominal current, for the exact value please see the

Project Planning Manual), the output stage is switched off and the error message "F8033 Ground fault in motor line" is generated. If the current does not decay in spite of the output stage having been switched off, the error message "F8833 Ground fault current (does not decay)" is generated and power is swiched off. The Bb contact is opened.

☞ Distributed IndraDrive Mi (KMV) supply module does not have a Bb contact.

DC bus voltage monitoring

By way of DC bus voltage monitoring an undervoltage or overvoltage in the DC bus is detected. The actual DC bus voltage value (S-0-1707.0.1) is used as the input value.

If the DC bus voltage decreases to a value smaller than P-0-0114 (minimum value: 75% of mains peak when switching on), the error message "F2026 Undervoltage in power section" is generated. The F2026 error causes power enable to be switched off and the mains contactor to be disconnected. The "Ud message" is removed, "DC bus voltage error, mains failure" is signaled via module bus/IndraBus.

If the DC bus voltage increases up to 40 V below the maximum allowed values (910 V in case of 500 V devices or 1220 V in case of 690 V devices), the output stage is switched off and the warning"E8025 Overvoltage in power section") is generated. If the DC bus voltage falls below the limit value, the output stage is switched back on and the warning disappears.

If the DC bus voltage keeps increasing and exceeds the maximum allowed value (910 V in case of 500 V devices or 1220 V in case of 690 V devices), the error message "F8817 Overvoltage in power section" is generated. The F8817 error is a critical error and causes the Bb contact to be opened. "Supply error" is signaled via module bus/IndraBus. The maximum allowed DC bus voltage depends on the device, the exact value is contained in the type data of the power section.

☞ Distributed IndraDrive Mi (KMV) supply module does not have a Bb contact.

Protection against overcurrent

By way of overcurrent monitoring the output stage is protected against overcurrent. The measured mains phase currents are used as the input values for monitoring. There are four stages:

1. If the mains current exceeds 120% of the peak current, the output stage is switched off and the warning "E8028 Overcurrent in power section" is generated. If the current falls below the limit value, the output stage is switched back on and the warning disappears.
2. If the mains current exceeds 140-150% of the peak current, the output stage is switched off and the error message "F8028 Overcurrent in power section" is generated.
3. If the current keeps increasing (5- to 10-fold device type current) so that the inverter changes to analog mode, the output stage is switched off and the error message "F8060 Overcurrent in power section" is generated.
4. If the current does not decay in spite of the output stage having been switched off, the error message "F8860 Overcurrent in power section (does not decay)" is generated. The error causes power supply to be switched off and the Bb contact to be opened. "Supply error" is signaled via module bus/IndraBus.

☞ Distributed IndraDrive Mi (KMV) supply module does not have a Bb contact.

Protection against oscillation in DC bus

The AC component in the DC bus is monitored to protect the DC bus capacitors against too high current loads. If the AC component exceeds a device-depending threshold (value is contained in the type data of the power section: maximum allowed voltage ripple on the DC bus voltage), the error message "F2027 Excessive oscillation in DC bus" is generated.

5 Power supply control

⚠ WARNING **Dangerous movements! Danger to life, risk of injury, serious injury or property damage!**

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine's range of motion (e.g., by using safety fences, safety guards, protective coverings, light barriers).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.

5.1 Power supply control overview

Power supply control has a so-called cascade structure that is shown in the figure below.

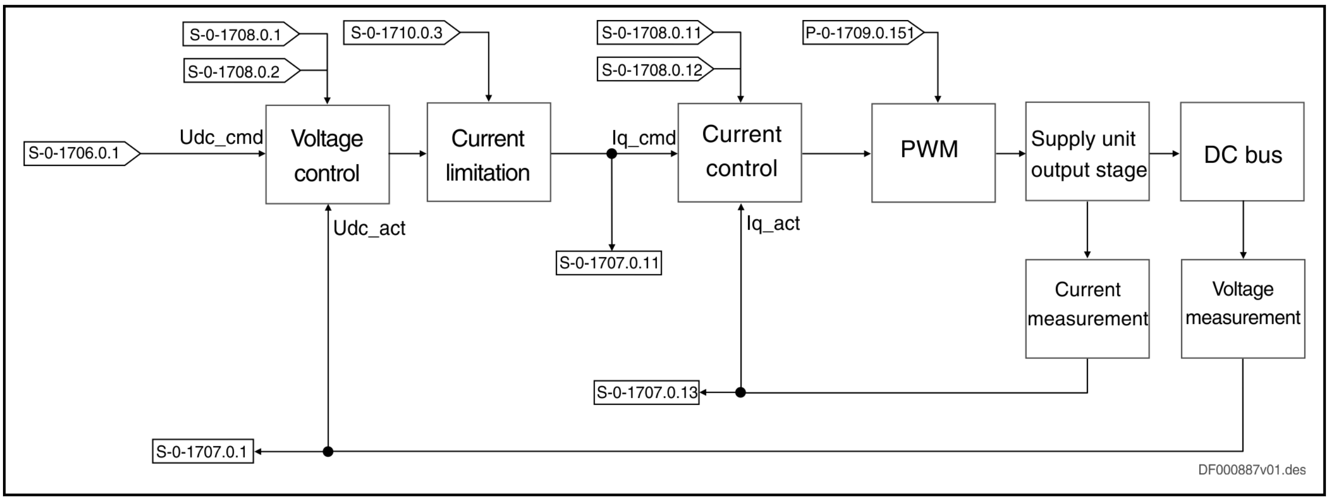


Fig. 5-1: Schematic diagram of the supply unit control loops

The current control loop or current and voltage control loop is closed depending on the active operation mode.

5.2 DC bus voltage control

In the case of supply units with active power output stage, the DC bus voltage can be flexibly controlled with regard to a value within a certain voltage range. Insulated-gate bipolar transistors (IGBTs) are used for this purpose. The control provides the following advantages:

- DC bus voltage is independent of the mains voltage
- Energy regeneration to the mains
- More or less sinusoidal current consumption from the mains
- Utilization of high motor speeds due to high DC bus voltage

Control loop structure

The following control loop structure is the basis of voltage control. If necessary, the structure is expanded depending on the operation mode.

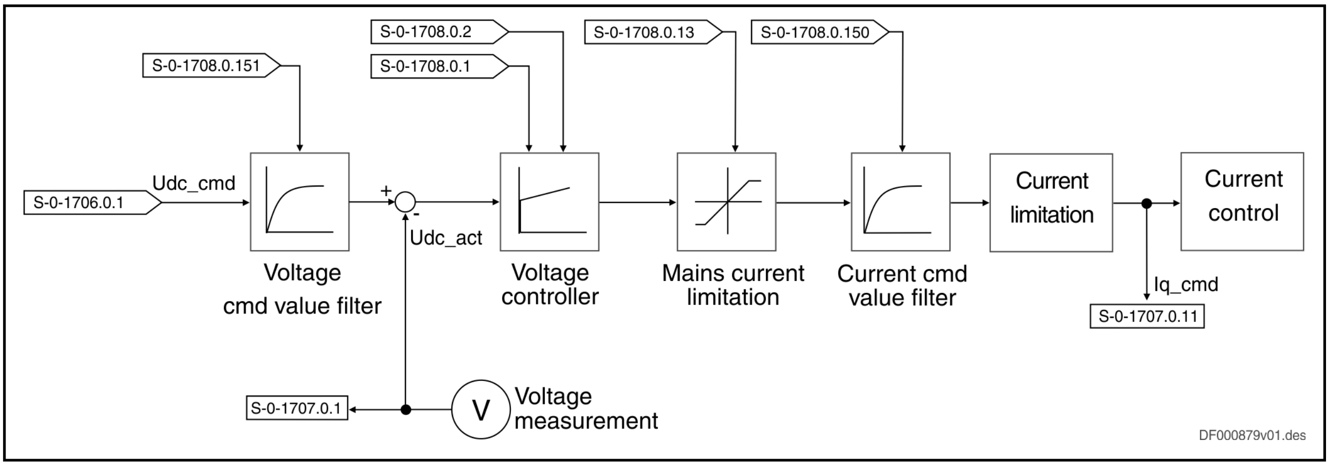


Fig. 5-2: Schematic diagram of voltage control loop for controlling the DC bus voltage

The actual DC bus voltage value (S-0-1707.0.1) is measured and taken into account as the feedback value in the calculation of the control difference. The voltage controller has been designed as a PI controller. It can be configured using the proportional gain and the integral action time.

To limit the mains current, the bipolar current limit value (S-0-1708.0.13, Bipolar mains current limit value) or the unipolar current limit values ("S-0-1708.0.15 Positive mains current limit value", "S-0-1708.0.16, Negative mains current limit value") can be adjusted. In this context, the lowest value of the 3 above-mentioned parameters becomes active.

Parameterization example:

S-0-1708.0.13: 110%

S-0-1708.0.15: 140%

S-0-1708.0.16: 140%

110% Bipolar mains current limit value is active

S-0-1708.0.13: 110%

S-0-1708.0.15: 140%

S-0-1708.0.16: 40%

→ 110% Positive mains current limit value (regenerative), 40% negative mains current limit value (feeding) are active

S-0-1708.0.13: 200%

S-0-1708.0.15: 130%

S-0-1708.0.16: 50%

→ 130% Positive mains current limit value (regenerative), 50% negative mains current limit value (feeding) are active

The voltage and current command value filters have been designed as PT1 filters. The firmware-side calculation of the corresponding default values can be triggered using the "load power-supply specific controller values" command.

Voltage command value

The voltage command value (S-0-1706.0.1) can be cyclically configured and arbitrarily input within the command value range. The command value range results from the mains voltage and the maximum DC bus voltage.

The minimum voltage command value is 110% of the mains voltage peak value. If a value smaller than the minimum command value is input, the DC bus voltage is dynamically increased.

Control parameters

The default values of the voltage controller parameters are calculated according to the symmetrical optimum:

$$K_P = \frac{1}{\alpha} \frac{C_{DC}}{T_u} \frac{2}{3} \frac{U_{DC}}{\hat{U}}; \quad T_N = \alpha^2 T_u$$

K_p	Proportional gain
T_N	Integral action time
α	Damping factor
C_{DC}	DC bus capacitor
Tu	Voltage control loop substitute time constant
U_{DC}	DC bus voltage
Û	Mains peak

Fig. 5-3: Calculating control parameters of voltage controller according to the symmetrical optimum

The value of the total DC bus capacitance used, that is automatically determined via the identification of the controlled system, is used for calculation. The damping factor depends on the controller mode configuration in "S-0-1709.0.152, Power supply control, configuration". It is distinguished between

- standard control (dynamic voltage controller with the objective of a constant DC bus voltage) with a low damping factor and
- Smart Energy Mode (slow voltage controller with the objective of little mains activity) with a high damping factor.

To improve the controller dynamics, the P-gain of the voltage controller is adjusted in accordance with the ratio between DC bus voltage and mains peak.

The voltage control loop parameters are calculated according to the above formula by executing "C0710 Command Load power-supply specific controller values". The time constants of the current command value filters, as well as the current limit values, are determined depending on the controller mode (see chapter 6.2 "Voltage control" on page 116).

Cycle time

The cycle time of the voltage controller is 250 µs and cannot be configured.

5.3 Current limitation

To protect them from overload, supply units have a current limitation that consists of two parts:

- Absolute current limitation (depending on device, limit values comply with continuous and peak currents of output stage)
- Dynamic current limitation (depending on load, implemente by way of temperature model)

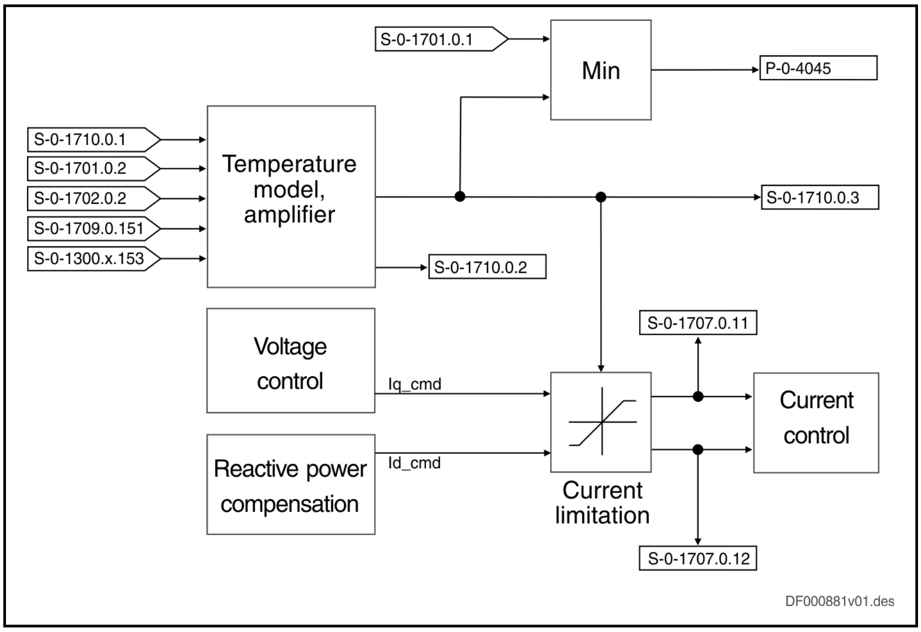


Fig. 5-4: Schematic diagram of dynamic current limitation of supply unit

Absolute limitation

The maximum values for continuous and peak current result from the device-specific current data of the output stage.

The maximum possible continuous current corresponds to the nominal current of the amplifier (S-0-1701.0.1) that basically depends on the size of the device and the switching frequency of the output stage. The maximum possible peak current corresponds to the maximum current of the amplifier (S-0-1701.0.2).

Dynamic limitation

Depending on the amplifier load calculated using the temperature model, the effective peak current is dynamically limited to a value smaller than the maximum current of the amplifier. If the effective peak current (S-0-1710.0.3) is smaller than the nominal current of the supply unit (S-0-1701.0.1), the maximum possible continuous current (P-0-4045) is additionally limited to the effective peak current.

Temperature model

The input values of the temperature model are the status variables

- measured heat sink temperature of the power output stage,
- application-specific total current of the device from the vector sum of active-current generating and reactive-current generating component,

as well as the static variables

- switching frequency of the power output stage,
- thermal type data of the power section,
- maximum current of the amplifier.

With a model calculation, the output stage load is determined from them, and the effective peak current is limited depending thereon. If the current limitation is active, the warning "E8057 Device overload, current limit active" is generated. It is impossible for the user to parameterize the dynamic current limitation.

5.4 Mains current control

The mains current control has been included in the DC bus voltage control and designed by analogy with the field-oriented current control of a motor. The control has the following features:

- Separate control of the active-current generating and reactive-current generating component of the mains current
- Compensation of the cross coupling of the d and q axes to increase dynamics
- Feedforward of the measured mains voltage

Control loop structure

The following control loop structure is the basis for current control:

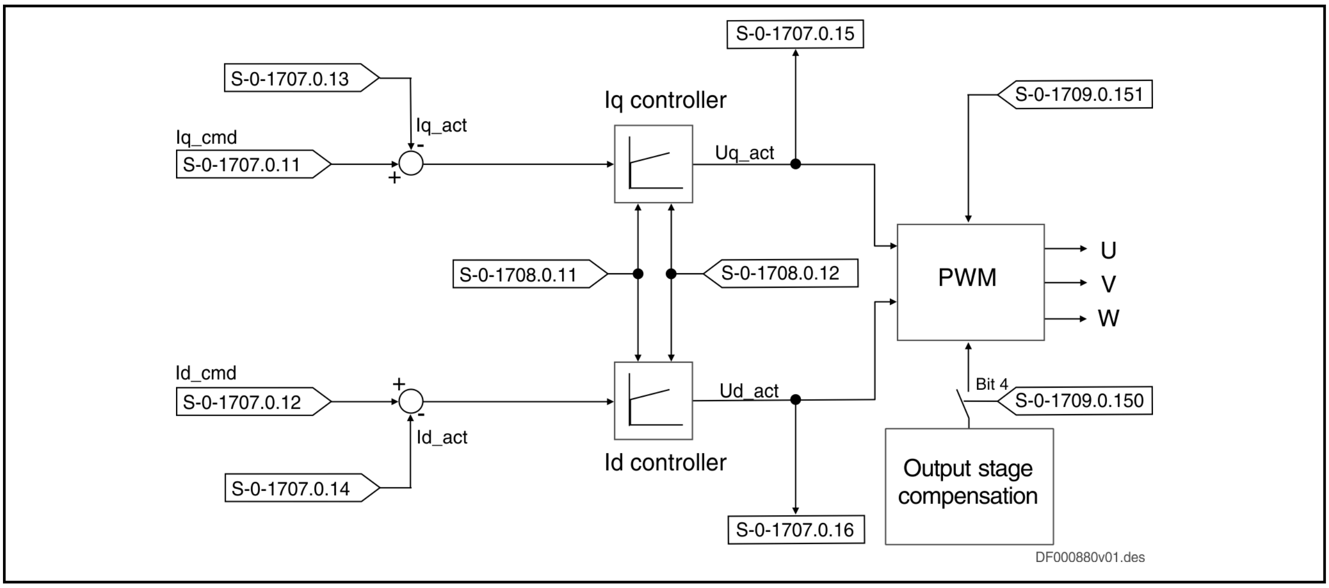


Fig. 5-5: Schematic diagram of the current control loop for controlling the mains current

The basic principle of mains synchronous current control is independent control of the current components orthogonal to one another

- I_q (active-current generating component) and
- I_d (reactive-current generating component).

Here the mains angle determined from the mains phase voltages is the reference value between the three-phase mains and the transformed dq system.

The I_q and I_d currents transformed from the mains phase currents are used as actual values for calculating the control difference. The U_q and U_d voltages generated at the output of the controller are input values of PWM. In order that a regenerative mode with sinusoidal currents is possible, the DC bus voltage at least has to have the level of the mains peak.

The current controller has been designed as a PI controller. It can be configured using the proportional gain and the integral action time. The firmware-side calculation of the corresponding default values can be triggered using "C0710 Command Load power-supply specific controller values".

Current command value

The command value of the active-current generating component is the limited output value of the voltage controller or as an alternative can be cyclically preset. The reactive-current generating component normally is controlled to zero. A value unequal zero can be specified for reactive-current compensation.

Control parameters

The default values of the current controller parameters are calculated according to the symmetrical optimum:

$$K_p = \frac{L}{2T_i}; \quad T_N = 4T_i$$

K_p	Proportional gain
T_N	Integral action time
L	Inductance of the mains choke
T_i	Current control loop substitute time constant

Fig. 5-6: Calculating control parameters of current controller according to the symmetrical optimum

The value of the mains choke, that is automatically determined via the identification of the controlled system, is used for calculation. The current control loop parameters are calculated according to the above formula by executing "C0710 Command Load power-supply specific controller values".

Output stage compensation

The output stage compensation is a voltage feedforward. The voltage drop at the power transistors of the output stage is compensated by an additive voltage command value at the output of the current controller. The function is active by default. This has the following advantages:

- Higher current control dynamics with small currents
- Higher current control loop limit frequency

If the function is deactivated using S-0-1709.0.150 bit 4, this results in a higher load of the current controller since it has to compensate the voltage error of the output stage.

Cycle time

The cycle time of the current controller depends on the switching frequency of the power output stage. At a switching frequency of 4.2 kHz, the current controller runs twice per switching period, at a switching frequency of 10.1 kHz, the current controller only runs once per switching period. The switching frequency depends on the device and cannot be changed. The following switching frequencies are supported:

Power output stage switching frequency	Current controller cycle time
4.2 kHz	119 µs
10.1 kHz	99 µs

Tab. 5-1: Cycle time of current control depending on switching frequency of the power output stage

The switching frequency of the power output stage is displaye in parameter S-0-1709.0.151.

5.5 Reactive power compensation

5.5.1 Introduction

The total power a device takes from the mains is the so-called apparent power. It is made up of the geometric sum of

- active power and
- reactive power, consisting of
  - fundamental wave reactive power (phase shift between current and voltage, due to capacitive and inductive components) and
  - distortion reactive power (harmonics, due to switching actions of power semiconductors).

Only the active power can be converted into other power forms and is available as mechanical power at the motor shaft. The reactive power, however, causes mains-side high-frequency interference and generally leads to a higher mains connected load.

It is therefore the objective to minimize the reactive power. For this purpose, a device is used that determines the currently required reactive power and compensates it actively.

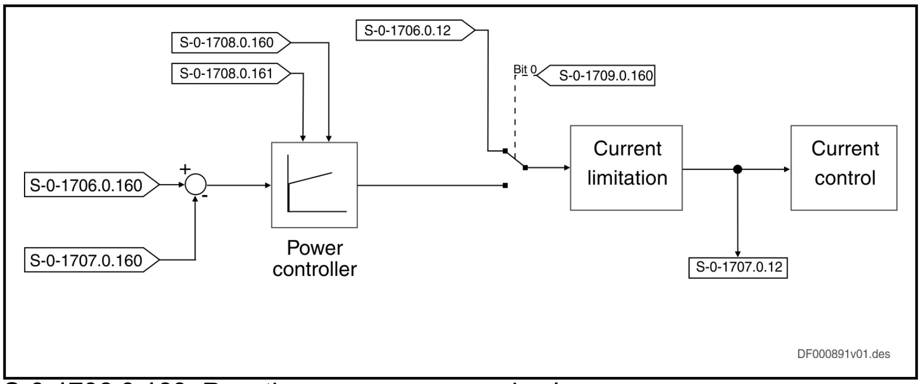
5.5.2 Compensating the fundamental wave reactive power

The function for compensating the fundamental wave reactive power corrects the phase shift between the fundamental wave of mains voltage and the fundamental wave of mains current, a fundamental wave power factor of one ($\cos \varphi_1 = 1$) being aimed at. The following methods are available:

1. Compensation of reactive power by specifying a reactive current
2. Compensating the reactive power of the supply unit and the mains connection components (mains filter and mains choke) using reactive power control
3. Compensating the reactive power of the supply unit and external loads using reactive power control

Control loop structure

All methods are based on the following control loop structure:



S-0-1706.0.160 Reactive power, command value
S-0-1707.0.160 Reactive power, actual value
S-0-1708.0.160 Reactive power controller, proportional gain
S-0-1708.0.161 Reactive power controller, integral action time
S-0-1706.0.12 Reactive-current generating component, command value
S-0-1709.0.160 Reactive power controller, control word
S-0-1707.0.12 Effective reactive-current generating component, cmd value

Fig. 5-7: Schematic diagram of control loop structure for controlling the reactive power.

The power controller has been designed as a PI controller. It can be configured using the parameters "S-0-1708.0.160, Reactive power controller, proportional gain" and "S-0-1708.0.161, Reactive power controller, integral action time".

The reactive power control is switched off by default (S-0-1709.0.160, bit 0 = 0). Therefore, none of the methods for reactive power compensation is active if the reactive-current generating command value component (S-0-1706.0.12, Reactive-current generating component, command value) has the value zero.

Compensating the reactive power by inputting a reactive current

If the reactive power control has been switched off (S-0-1709.0.160, bit 0 = 0), a reactive current can be input via the parameter S-0-1706.0.12 to put reactive power compensation into effect.

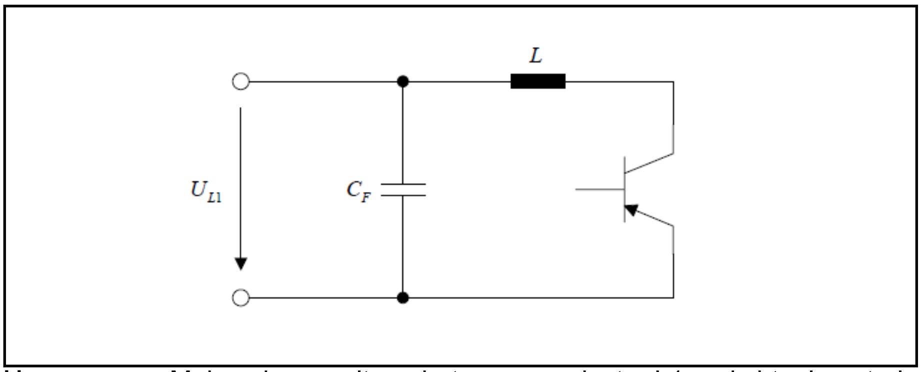
The reactive power or the $\cos \varphi_1$ has to be measured externally, and a higher-level control unit performs the calculation, as well as the cyclic input of the reactive current. If necessary, this requires higher-level reactive power control.

Compensating the reactive power of the mains connection components

If the reactive power control has been activated (S-0-1709.0.160, Reactive power controller, control word bit 0 = 1) and the determination of the reactive power of the mains connection components is active (S-0-1709.0.160, bit 1 = 0), the reactive powers of the supply unit, mains filter and mains choke are compensated.

The firmware calulates the total reactive power of the supply unit and mains connection components from the electrical characteristic values of the mains filter and mains choke, as well as the measured mains phase currents and mains voltages. The calculated value is transmitted to the power controller as the actual value (S-0-1707.0.160). To compensate the calculated reactive power, the command value zero has to be input for the power controller (S-0-1706.0.160 = 0).

The parameter "S-0-1731.0.22, Equivalent capacitance of mains connection" is used for calculating the total reactive power. The (single-phase) equivalent capacitance between mains connection and mains choke referred to the neutral point has to be input here.



U_{L1}	Mains phase voltage between conductor L1 and virtual neutral point
L	S-0-1731.0.20, Inductance at commutation choke
C_F	S-0-1731.0.22, Equivalent capacitance of mains connection

Fig. 5-8: Simplified single-phase equivalent circuit diagram of mains connection

Compensating the reactive power of external loads

If the reactive power control has been activated ("S-0-1709.0.160, Reactive power controller, control word" bit 0 = 1) and the reactive power determination of the mains connection components has been switched off (S-0-1709.0.160, bit 1 = 1), only the reactive power of the supply unit is compensated.

On the basis of the measured mains phase currents and mains voltages the reactive power of the supply unit is calculated and transmitted to the power controller as the actual value (S-0-1707.0.160). A higher-level control unit can additionally compensate the reactive power of external loads by cyclically inputting the command value S-0-1706.0.160.

If the command value zero is input, only the reactive power of the supply unit is compensated. The control unit has to determine the appropriate command value for compensating the reactive power of the mains connection components and other external loads. The reactive power or the cos φ_1 for calculating the total reactive power has to be measured externally.

6 Operation modes

⚠ WARNING **Dangerous movements! Danger to life, risk of injury, serious injury or property damage!**

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine's range of motion (e.g., by using safety fences, safety guards, protective coverings, light barriers).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.

6.1 Overview of operation modes

It is possible to configure up to four different operation modes in the supply unit. They are assigned via the following parameters:

- S-0-1709.0.1, Primary operation mode
- S-0-1709.0.2, Secondary operation mode 1
- S-0-1709.0.3, Secondary operation mode 2
- S-0-1709.0.4, Secondary operation mode 3

The coding of the corresponding operation mode has to be entered in the above parameters. The parameter "S-0-1705.0.1, List of operation modes" contains all supported operation modes. The supply unit firmware supports the following operation modes:

Operation mode	Coding	Diagnostics
Voltage control	0x0013	A0500
Voltage control, floating DC bus voltage	0x8033	A0500
Rectifier mode, load-dependent	0x0037	A0506
Current control	0x0001	A0501
Island grid mode, open-loop controlled	0x8100	A0530[1)]
Island grid mode, closed-loop controlled	0x8107	A0530[1)]
(DC) current control	0x8201	A0540[2)]
(DC) voltage control	0x8203	A0540[2)]

1) The operation modes is only available if the optional functional package "mains function" has been enabled. Refer to chapter 2.4 "Overview of functions/functional packages" on page 14

2) The operation modes is only available if the optional functional package "DC/DC converter" has been enabled. Refer to chapter 2.4 "Overview of functions/functional packages" on page 14

Tab. 6-1: Supported operation modes of supply unit firmware

The operation mode is selected and activated using the power supply control word (S-0-1720.0.1). Setting the enable signal (bit 15) activates the preselected operation mode. As a feedback the power supply status word (S-0-1720.0.2, Power supply status word) shows the active operation mode and the display of the control panel reads "LB" or "LF" in case of island grid mode closed loop-controlled/open loop-controlled and (DC) current/voltage control.

6.2 Voltage control

In the "voltage control" mode, the DC bus voltage is controlled with regard to the command value S-0-1706.0.1.

The control loop structure from "Control loop structure" on page 107 is used. The voltage control mode depends on the configuration of the voltage control loop parameters. It is distinguished between

- standard control and
- Smart Energy Mode.

The mode is parameterized via the so-called controller mode in parameter S-0-1709.0.152 bit 0. Using "C0710 Command Load power-supply specific controller values", appropriate values are automatically assigned to the voltage control loop parameters, depending on the preselected controller mode. The following parameters are written by executing the command:

- S-0-1706.0.1, DC bus voltage command value
- S-0-1708.0.151, Voltage command value filter, time constant
- S-0-1708.0.1, DC bus voltage controller, proportional gain
- S-0-1708.0.2, DC bus voltage controller, integral action time
- S-0-1708.0.13, Bipolar mains current limit value
- S-0-1708.0.15, Positive mains current limit value
- S-0-1708.0.16, Negative mains current limit value
- S-0-1708.0.150, Mains current command value filter, time constant

Standard control

In the controller mode "standard control" (S-0-1709.0.152, bit 0 = 0), the DC bus voltage should be as constant as possible and should only drop slightly, even in the case of high load peaks. For this purpose, the voltage control loop parameters are set as follows:

- Time constant of voltage command value filter is 1 ms
- Current command value filter is switched off
- Voltage controller is set to dynamic (small damping factor)
- Mains current limit values are identical to device peak current

The voltage command value is set to the default value of 750 V (500 V devices) or 1100 V (690 V devices). However, it can be changed at any time by the user or a higher-level control unit.

Smart Energy Mode

In the controller mode "Smart Energy Mode" (S-0-1709.0.152, bit 0 = 1), the mains pollution should be kept to a minimum, if possible. This is achieved by reducing the mains-side peak current. As a result, the DC bus voltage drops considerably at high load peaks. The voltage control loop parameters are set as follows:

- Time constant of voltage command value filter is 1 ms
- Time constant of current command value filter is one mains period
- Voltage controller is set to slow (big damping factor)
- The mains current limit value bipolar is 110% of the nominal device current
- The positive and the negative mains current limit values are identical to the device peak current

The voltage command value is set to the default value of 750 V (500 V devices) or 1100 V (690 V devices). However, it can be changed at any time by the user or a higher-level control unit.

When using the Smart Energy Mode, allow for sufficient DC bus capacitance so that the DC bus voltage does not leave the allowed operating range (lower limit: mains peak, upper limit: braking resistor switch-on threshold).

Control parameters

After "C0710 Command Load power-supply specific controller values" has been executed, all voltage control loop parameters can be changed as required and thus optimized with regard to the specific application. However, this might considerably change the behavior of control, and the objective of the controller mode that has been set might not be achieved.

☞ After the controller mode has been changed, the command "Load power-supply specific controller values" has to be executed so that correct values are assigned to the voltage control loop parameters.

6.3 Voltage control, floating DC bus voltage

In the "voltage control, floating DC bus voltage" mode, the DC bus voltage floats within a lower command value for supply and an upper command value for regeneration. Control is inactive within this range and only switched on if the DC bus voltage leaves this range.

Control loop structure

The control loop structure from fig. 5-2 "Schematic diagram of voltage control loop for controlling the DC bus voltage" on page 108 is used as a basis, and the structure is expanded by the generation of the command value.

Properties

This operation mode aims at limiting the mains activity to a minimum. The following cases of operation are distinguished:

- Actual DC bus voltage value (S-0-1707.0.1) smaller than lower DC bus voltage threshold (S-0-1708.0.152): voltage control active, supply command value (S-0-1706.0.152) takes effect.
- Actual DC bus voltage value (S-0-1707.0.1) greater than upper DC bus voltage threshold (S-0-1708.0.153): voltage control active, regeneration command value (S-0-1706.0.153) takes effect.
- Actual DC bus voltage value within lower and upper DC bus voltage threshold: voltage control inactive.

In addition, voltage control is activated to protect the device if the mains current is greater than the maximum allowed diode current.

The configuration is very flexible, since the command values and thresholds can be set as required. Make sure that the values are valid. Thus, this operation mode can be parameterized with regard to the specific application.

Control parameters

☞ This operation mode uses the control parameter values of the "standard control" controller mode (see chapter 6.2 "Voltage control" on page 116).

All voltage control loop parameters can be changed as required and thus optimized with regard to the specific application. However, this might considerably change the behavior of control.

6.4 Rectifier mode, load-dependent

In the "rectifier mode, load-dependent" the power output stage is switched off. The control of the DC bus voltage is inactive and the supply unit works as a rectifier. The DC bus voltage value corresponds to the rectified value of the mains voltage.

The power output stage is switched on as follows:

1. The mains current exceeds the maximum allowed diode current (threshold value is specified in P-0-2610.0.10 [HMV05] or P-0-4059, element 18 [KMV03] or depending on the temperature model)

   or

2. the DC bus voltage exceeds the command value parameterized in "S-0-1706.0.1, DC bus voltage command value".

The supply unit hereby goes to the boost converter mode and the DC bus voltage is controlled with regard to the command value. The control loop structure from "Control loop structure" on page 107 is active. The control is switched off if the diode current falls below the maximum allowed value again or the DC bus voltage reaches the command value.

The supply unit automatically goes to the boost converter mode to protect the device against overload and for protection against DC bus overvoltage.

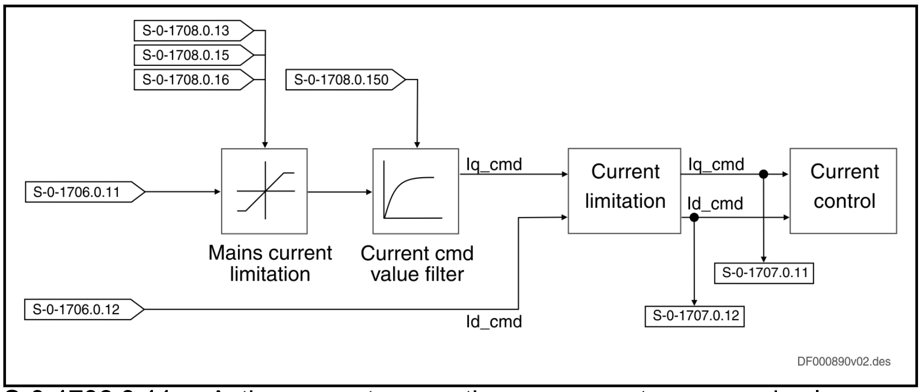
- The reactive power compensation cannot be used in this operation mode.
- The mains currents are not sinusoidal in rectifier mode.

6.5 Mains current control

In the operation mode "mains current control", the active current generating command value and the reactive-current generating command value can be specified separately.

Control loop structure

The control loop structure from "Control loop structure" on page 111 is used as a basis, and the structure is expanded by the generation of the command value.



S-0-1706.0.11, Active-current generating component, command value
S-0-1706.0.12, Reactive-current generating component, command value
S-0-1707.0.11, Effective active-current generating component, command value
S-0-1707.0.12, Effective reactive-current generating component, cmd value
S-0-1708.0.13, Bipolar mains current limit value
S-0-1708.0.15, Positive mains current limit value
S-0-1708.0.16, Negative mains current limit value
S-0-1708.0.150, Mains current command value filter, time constant

Fig. 6-1: Schematic diagram of command value adjustment in the current control mode

The command value for the active-current generating component goes through current limitation and PT1 filter and then takes effect as a command value at the input of current control.

NOTICE **Uncontrolled rise of DC bus voltage.**

If the "mains current control" mode is accidentally activated, this can cause the DC bus voltage to rise in an uncontrolled way. Power will only be disconnected if the maximum allowed DC bus voltage is exceeded (see "DC bus voltage monitoring" on page 104).

6.6 Island grid mode, open-loop controlled/island grid mode, closed-loop controlled

The operation modes "Island grid mode, open-loop controlled" and "Island grid mode, closed-loop controlled" are only available if the optional functional package "mains function" has been enabled. Refer to chapter 2.4.1 "Overview" on page 14

For a detailed overview of these operation modes, refer to chapter chapter 7.3 "Island grid" on page 128.

6.7 DC current control / DC voltage control

The operation modes "DC current control" and "DC voltage control" are only available if the alternative functional package "DC/DC converter" has been enabled. Refer to chapter 2.4.1 "Overview" on page 14

For a detailed overview of these operation modes, refer to chapter 7.4 "DC/DC converter mode" on page 145.

7 Advanced supply unit functions

7.1 E-Stop

7.1.1 General information

The E-Stop function is used to shut down the drive via a hardware input. It thus provides an option to switch off the drive in parallel with master communication in case of an emergency. The E-Stop function causes drive enable to be switched off in the drive. The E-Stop does not take effect in KMV. However, an E-Stop signal can be input via a hardware input at KMV or KMV can transmit the E-Stop signal.

☞ The E-Stop function is only available for KMV03, but not for HMV05.

For IndraDrive Mi there are different safety zones. A safety zone consists of a safety zone beginner and one or several safety zone nodes. These zones are equivalent to the zones for the E-Stop.

Inputting an E-Stop signal at KMV

The E-Stop function is wired at KMV and transmitted to KSM/KMS via the hybrid cable. For this purpose

- configure KMV as a zone beginner (X141 equipped with RKB0033 cable or not connected, P-0-0249=2)
- and assign a digital input at KMV (X37.4 or X38.4) to P-0-0223 (P-0-0300)

KMV transmitting an E-Stop signal

KMV transmits the E-Stop signal of the previous safety zone.

There are two possible procedures:

- Configure KMV as zone beginner (X141 equipped with RKB0033 cable or not connected, P-0-0249=2)
- "P-0-0223, E-Stop input" not entered in any element of P-0-0300

or

- Configure KMV as zone node (X141 equipped with RBS0023 connector, P-0-0249=1)
- "P-0-0223, E-Stop input" not entered in any element of P-0-0300

Parameters involved

- P-0-0223, E-Stop input
- P-0-0249, E-Stop and safety zones
- P-0-0300, Digital inputs, assignment list

7.2 Additional functions for mains supply

7.2.1 Brief description

Mains supply is characterized by the permanent regeneration of energy to the power grid (low-voltage or medium-voltage grid). The DC bus is the energy source. Country-specific standards and the regulations of the power supply company apply to mains supply to power grids.

Example of a German standard or code of practice:

VDE-AR-N 4105 Power plants connected to the low-voltage distribution network - Technical requirements for the connection to and parallel operation of power plants at low-voltage distribution networks (08/2011, low voltage: nominal voltage ≤ 1 kV)

☞ Using the additional functions for mains supply does not ensure that the country-specific standards and regulations of the power supply company are complied with.

The implemented additional functions for mains supply are characterized by the following properties:

- General properties
  – Permanent regeneration of energy to the power grid
- Properties resulting from normal DC bus voltage control mode [see chapter 6.2 "Voltage control" on page 116]
  – DC bus voltage control
  – Automatic synchronization to the power grid
  – Detection of an existing power grid
  – Mains disconnection in case the power grid fails
  – Making available reactive power
- Specific properties of the additional functions for mains supply:
  – Reduction of the regenerated active power in the case of overfrequency according to characteristic (see chapter "Limiting and reducing active power flow to the mains depending on frequency" on page 123)
  – Dynamic input of the maximum regenerated active power by the power supply company (see chapter "Limiting the active power flow to the mains" on page 124)
  – Support of a freely definable cos(φ) characteristic / reactive power generation depending on active power flow (see chapter "Reactive power command value specification depending on the active power" on page 125)
  – Advanced mains monitoring / voltage and frequency monitoring (see chapter "Advanced mains monitoring" on page 127)

☞ The additional functions for the mains supply are provided in the firmware ≥ PSB21VRS. Enable the functional package "MSE" requiring a license (also see chapter 2.4 "Overview of functions/ functional packages" on page 14).

System structure

Energy can be fed to the low-voltage grid or to the medium-voltage grid.

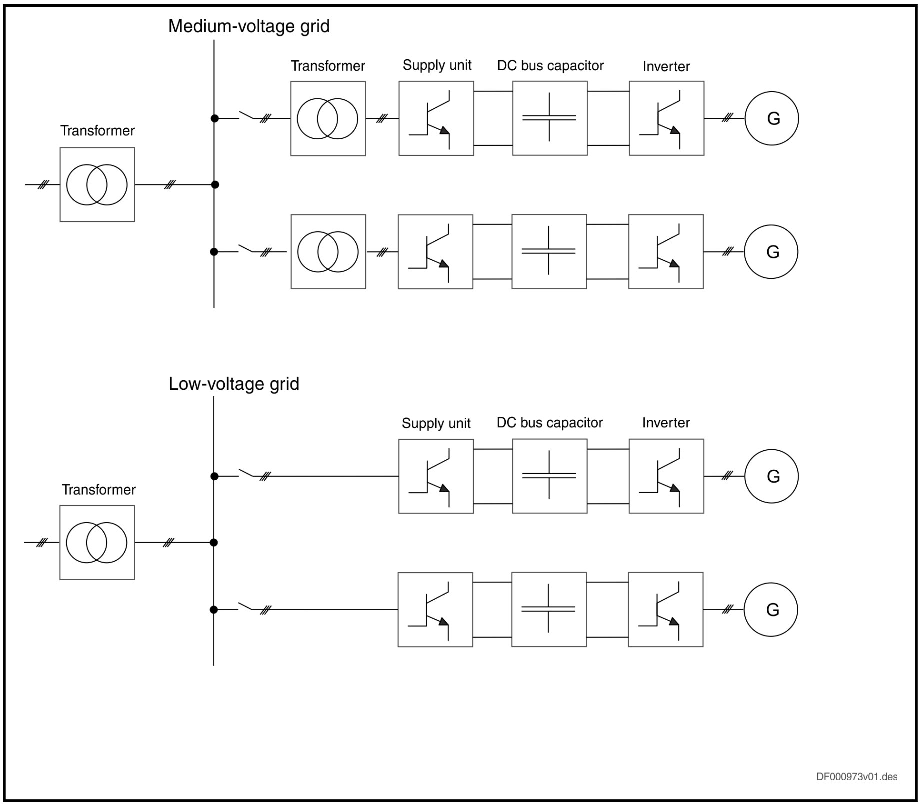


Fig. 7-1: Setup for connection to medium- and low-voltage grid

Direct connection to the low-voltage grid does not require a transformer, so there are no specific requirements.

Connection to the medium-voltage grid is only possible via transformer, since the KMV03 and HMV05 devices have been sized for mains connection voltages of at most 500 V and 690 V. In operation with transformer only the synchronization to the power grid is supported without transformer.

7.2.2 Functional description

Limiting and reducing active power flow to the mains depending on frequency

By limiting and reducing the active power flow to the mains depending on frequency, the active power can be reduced linearly with the mains frequency in the case of mains overfrequencies.

> The limitation of the active power only takes effect in the case of regeneration to the power grid.

The presently generated active power P_M (at the time the mains frequency $f_{power\ reduction\_start}$ (S-0-1712.0.181) is exceeded, value is frozen) is reduced (if frequency rises) or increased (if frequency is reduced) with a gradient of $K_{power\ reduction\_gradient}$ (S-0-1712.0.182) of P_M per Hz. However, it can only be increased if power was reduced beforehand.

If $f_{mains} > f_{power\ reduction\_start}$ then

- $P_{max,freq} = P_M - (K_{power\ reduction\_gradient} * P_M) * (f_{mains} - f_{power\ reduction\_start})$
  else
- $P_{max,freq} = P_{max,device}$

If the mains frequency falls below the value $f_{power\ reduction\_start}$ again and the possible regenerative power at this time is greater than the active power P_M (frozen value), the increase in the active power regenerated back to the mains can be limited with a gradient of $K_{allowed\_active\ power\ increase\_after\_power\ reduction}$ (S-0-1712.0.183).

This function does not cause the mains to be automatically disconnected, if the mains frequency falls below the allowed value or the allowed mains frequency is exceeded.

This function has to be activated in the mains supply configuration word (S-0-1712.0.150).

Parameters involved:

- S-0-1712.0.150, Mains supply configuration word
  - Bit 2: Frequency-depending limitation of active power flow to mains
- S-0-1712.0.181, Power reduction starting frequency
- S-0-1712.0.182, Power reduction gradient
- S-0-1712.0.183, Allowed active power increase after power reduction

Example of application from VDE-AR-N 4105:2011-08

Parameterization example:

S-0-1712.0.150, bit 2 = 1

S-0-1712.0.181: 50.20

S-0-1712.0.182: 40.00

S-0-1712.0.183: 10.00

This parameterization results in the pictured active power reduction in the case of mains overfrequency:

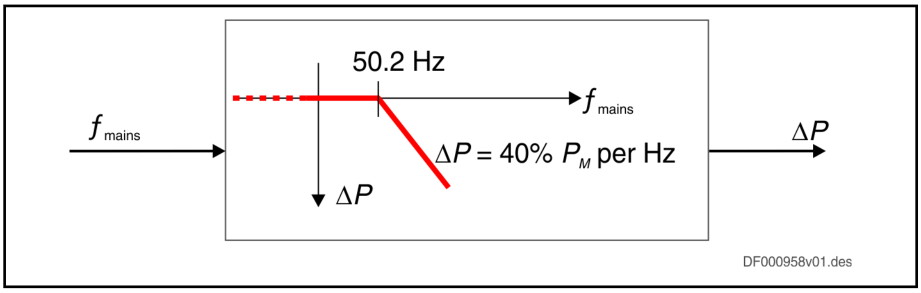


Fig. 7-2: Active power reduction in the case of mains overfrequency in accordance with VDE-AR-N 4105:2011-08

If f_{mains} > 50.2 Hz then

- $P_{max,freq} = P_M - (0.4 * P_M) * (f_{mains} - 50.2)$

  else
- $P_{max,freq} = P_{max,device}$

If the mains frequency falls below the value 50.2 Hz again and the possible regenerative power at this time is greater than the active power P_M (frozen value), the increase in the active power supplied to the mains cannot exceed a gradient of 10% of the maximum active power of the power plant per minute.

Limiting the active power flow to the mains

Use the parameter S-0-1713.0.180 to limit the active power flowing from the supply unit to the power grid. The power flow from the power grid to the supply unit is not limited.

This function has to be activated in Mains supply configuration word (S-0-1712.0.150).

If the frequency-depending limitation of the active power flow to the mains (see chapter "Limiting and reducing active power flow to the mains depending on frequency" on page 123) is additionally activated in Mains supply configuration word (S-0-1712.0.150), the following relation applies:

$P_{regen\_max} = \min(P_{max,input}, P_{max,freq})$

$P_{max,input}$ can be input via parameter (S-0-1713.0.180).

$P_{max,freq}$ is determined via the frequency-depending characteristic (see chapter "Limiting and reducing active power flow to the mains depending on frequency" on page 123).

Parameters involved:

- S-0-1712.0.150, Mains supply configuration word
  – Bit 1: Limiting the active power flow to the mains
- S-0-1713.0.180, Active power limit value, mains supply

The device's nominal active power is used as the default value for the active power limit value.

Example of application from VDE-AR-N 4105:2011-08

In power plants with a performance of > 100 kW, it has to be possible to reduce the active power in steps of at most 10% of the power plant's maximum active power. This power reduction has to be possible, in every operating status and from every working point, with regard to a command value specified by the power supply company. The power output has to be immediately reduced to the required command value, or within one minute at most.

Reactive power command value specification depending on the active power

By reactive power command value input depending on the active power, the reactive power can be generated in accordance with the preset active power-dependent cos(φ) characteristic (S-0-1712.0.190) and (S-0-1712.0.191). If the active power changes, the reactive power is automatically adjusted in accordance with the specified active power-dependent cos(φ) characteristic.

The reactive power command value for reactive power control is calculated using the following equation:

$Q = P * \mathrm{sqrt}[\, 1 / (\cos(\varphi))^2 - 1)$

Information for presetting the active power-dependent cos(φ) characteristic (S-0-1712.0.190 for power and S-0-1712.0.191 for cos(φ))

S-0-1712.0.190 defines the active power axis for the cos(φ) characteristic. The cos(φ) axis is given by S-0-1712.0.191.

- S-0-1712.0.190, Active power-dependent cos(phi) characteristic: performance

  At least two list values have to be input. The numer of list values has to comply with the one in S-0-1712.0.191. Positive active power flows from the power grid to the supply unit.

  The active power values have to be entered in equidistant form.

  The active power values have to be entered as scaled to the nominal active power of the power plant (S-0-1712.0.192, Nominal active power of power plant). The nominal active power of the power plant can be the nominal active power of the device at the max. That is why the nominal active power of the device is used as default value for S-0-1712.0.192, Nominal active power of power plant. If the nominal active power of the power plant is smaller than the nominal active power of the device, S-0-1712.0.192, Nominal active power of power plant has to be adjusted accordingly.

- S-0-1712.0.191, Active power-dependent cos(phi) characteristic: cos(phi)

  At least two list values have to be input. The number of list values has to comply with the one in S-0-1712.0.190.

  Positive cos(φ) values cause inductive behavior. Negative cos(φ) values cause capacitive behavior.

Generally, the following applies: Linear interpolation occurs between the values of the characteristics. For values working points defined outside of the first or last row, a reactive power command value is used in accordance with the limit working point, i.e. the last value also takes effect beyond the range.

This function has to be activated in "S-0-1712.0.150, Mains supply configuration word".

Parameters involved:

- S-0-1712.0.150, Mains supply configuration word
  - Bit 3: Reactive power command value input depending on the active power
- S-0-1707.0.161, Effective reactive power command value
- S-0-1712.0.190, Active power-dependent cos(phi) characteristic: performance
- S-0-1712.0.191, Active power-dependent cos(phi) characteristic: cos(phi)

Example of application from VDE-AR-N 4105:2011-08

It has to be possible to operate power plants in the voltage tolerance band U_{Nenn} ±10% with an active power output of > 20% of the rated active power with a displacement factor range of cos(φ) = $0.9_{capacitive}$ to cos(φ) = $0.9_{inductive}$. If the power supply company specifies a characteristic, each command value resulting from the characteristic has to be automatically adjusted at the power plant within 10 seconds.

If the active power changes, the reactive power has to be automatically adjusted in accordance with the specified cos(φ).

Parameterization example:

S-0-1712.0.150, bit 3 = 1

S-0-1712.0.190

List element 0: 0.000

List element 1: 0.500

List element 2: 1.000

S-0-01712.0.191

List element 0: 1.000

List element 1: 1.000

List element 2: 0.900

This parameterization results in the cos(φ) characteristic pictured in fig. 7-3 "Example of cos(φ) = f(P) characteristic from VDE-AR-N 4105:2011-08" on page 127.

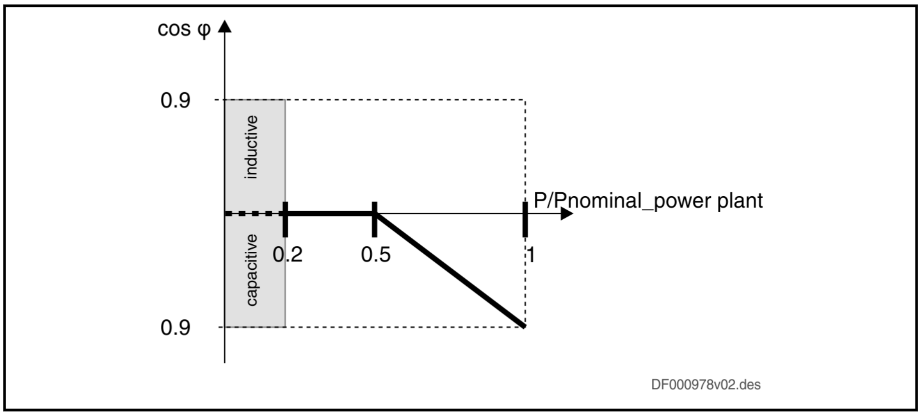


Fig. 7-3: Example of cos(φ) = f(P) characteristic from VDE-AR-N 4105:2011-08

Advanced mains monitoring

Disconnection from the mains has to take place in the case of inadmissible voltage and frequency values. For this purpose, the mains can be monitored using the following functions:

- Voltage reduction protection U<

  (slow undervoltage detection)
  - S-0-1712.0.160,
  - If one of the three phase voltage rms values falls below the threshold value that has been set and the response delay defined in S-0-1712.0.170 has elapsed, the F2814 error is output.
- Voltage reduction protection U<<

  (fast undervoltage detection)
  - S-0-1712.0.161,
  - If one of the three phase voltage rms values falls below the threshold value that has been set, the F2814 error is output.
- Voltage increase protection U>

  (slow overvoltage detection)
  - S-0-1712.0.162,
  - The F2815 error is output if one of the three phase voltage rms values filtered during 10 minutes exceeds the threshold value that has been set.
- Voltage increase protection U>>

  (fast overvoltage detection)
  - S-0-1712.0.163,
  - If one of the three phase voltage rms values exceeds the threshold value that has been set, the F2815 error is output.
- Frequency reduction protection f<

  (fast underfrequency detection)
  - S-0-1712.0.164,
  - If the mains frequency falls below the threshold value that has been set, the F2811 error is output.
- Frequency increase protection f>

  (fast overfrequency detection)

- S-0-1712.0.165,
- If the mains frequency exceeds the threshold value that has been set, the F2812 error is output.

> ☞ The advanced mains monitoring functions are based on the standardized grid and system protection. However, the implemented grid and system protection is not entirely compliant. If grid and system protection is required, it has to be implemented using an external grid and system protection.

This function has to be activated in the mains supply configuration word (S-0-1712.0.150).

Parameters involved:

- S-0-1712.0.150, Mains supply configuration word
  - Bit 0: Activating advanced mains monitoring
- S-0-1712.0.160, Voltage reduction protection U< threshold value
- S-0-1712.0.161, Voltage reduction protection U<< threshold value
- S-0-1712.0.162, Voltage increase protection U>threshold value
- S-0-1712.0.163, Voltage increase protection U>> threshold value
- S-0-1712.0.164, Frequency reduction protection f< threshold value
- S-0-1712.0.165, Frequency increase protection f>threshold value
- S-0-1712.0.170, Voltage reduction protection U< response delay

Diagnostics involved:

- F2811 Mains connection overtemperature
- F2812 Mains overfrequency
- F2814 Undervoltage in mains
- F2815 Overvoltage in mains

7.3 Island grid

7.3.1 Introductory definitions of terms

Grid system

A grid system is a large-scale, supraregional network of power plants (with respect to electric power). It is operated by a power supply utility that is responsible for the mains and thus also specifies the rules for mains supply.

Island grid

An island grid supplies a limited area and is not connected to the public interconnected system or other power networks. The power supply company has to control the balance between consumed and generated power in the island grid. An energy storage system can be used. The operator of an island grid can determine individual standards for the island grid. These standards can deviate from rules of public power supply companies.

Mains operation/island grid mode

In the following, it is differentiated between mains operation and island grid mode In mains operation, the grid system defines the grid properties. Supply units that supply a grid system have to synchronize their voltages and frequencies to the existing grid system. In island grid mode, however, the supply unit defines the properties of the island grid. The supply unit controls the voltage and frequency in the island grid and thus assumes a "grid generator function". The power output is determined by the loads and, where applicable, other supply units in the island grid.

7.3.2 Supply units in island grid mode

Features of the island grid mode

Operation as grid generator is possible in island grid mode. This means instead of the DC bus voltage, the mains voltage and the mains frequency are controlled. Characteristic curves allow for stable island grid mode with more generators (e.g., diesel generators) in an island grid without other communication connections. Thus, the supply unit can set up island grids and reliably operate these grids (as the only grid generator or together with other generators) and if required, synchronize them with external grids.

Requirement for island grid mode: the DC bus voltage is specified or controlled by one of the connected generators (generator-inverter, battery, photovoltaic module, ...).

Essential island grid functions:

- Closed-loop mains voltage control and closed-loop mains frequency control (operation mode: island grid mode, closed-loop controlled)
- Open-loop mains voltage control and open-loop mains frequency control (operation mode: island grid mode, open-loop controlled)
- Stationary and dynamic load distribution to other energy generators in the grid via characteristic curves
- Use the function "Island grid black start" to establish and maintain a self-sufficient island grid.
- Use the function "island grid synchronization to an external mains" to connect an island grid to an external mains. To do this, change the voltage amplitude and the frequency of the island grid in operation and adjust them to the external mains before closing the main contactor.
- Characteristics for frequency and voltage control of the grid including load distribution
- Hybrid mode: dynamic switching between island grid mode and mains operation

Supported hardware

The island grid mode is only available in supply units supported by firmware ≥ PSB21VRS. The supply units KMV03 (IndraDrive Mi product group) and HMV05 are supported.[1)] (IndraDrive ML product range).

The island grid mode is provided in firmware ≥ PSB21VRS . Enable the functional package "MSE" requiring a license (also see chapter 2.4 "Overview of functions/functional packages" on page 14).

These supply units can be referred to as "intelligent" supply units. They have a bus address, different parameters to parameterize functions, a device control word and a device status word.

Refer to the relevant project planning manual for information on "intelligent" supply units.

- KMV03: Project Planning Manual with material number R911335703
- HMV05: Project Planning Manual with material number R911344279

The following figure shows the HMV05 hardware structure during the start in island grid mode:

1) HMV05 is the designation of a supply unit consisting of HNA05 mains connection module, HMU05 universal inverter and CSB02.5 control section with firmware for supply units (FWA-INDRV-PSB-…). HMV05 is not an official product designation and is used for documentation purposes only.*

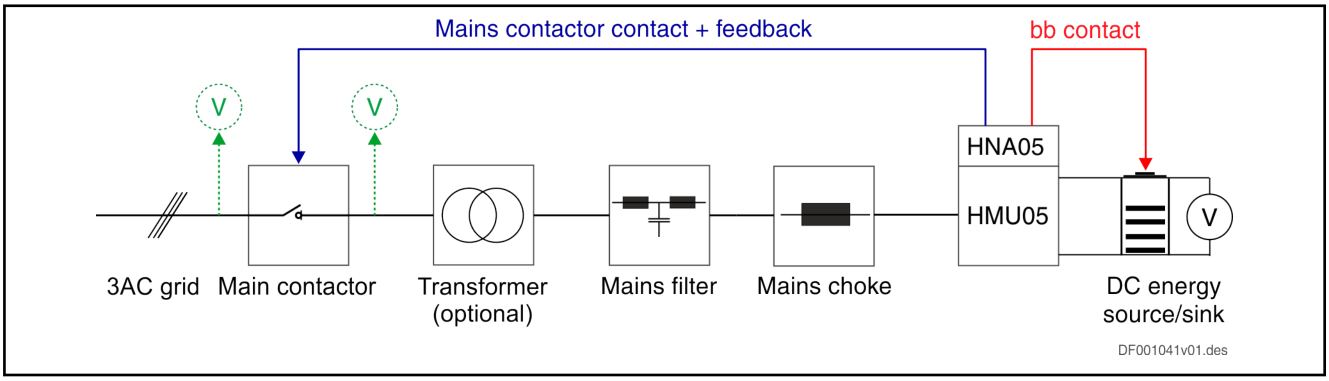


Fig. 7-4: HMV05 during start in island grid mode

The following figure shows the KMV03 hardware structure during the start in island grid mode:

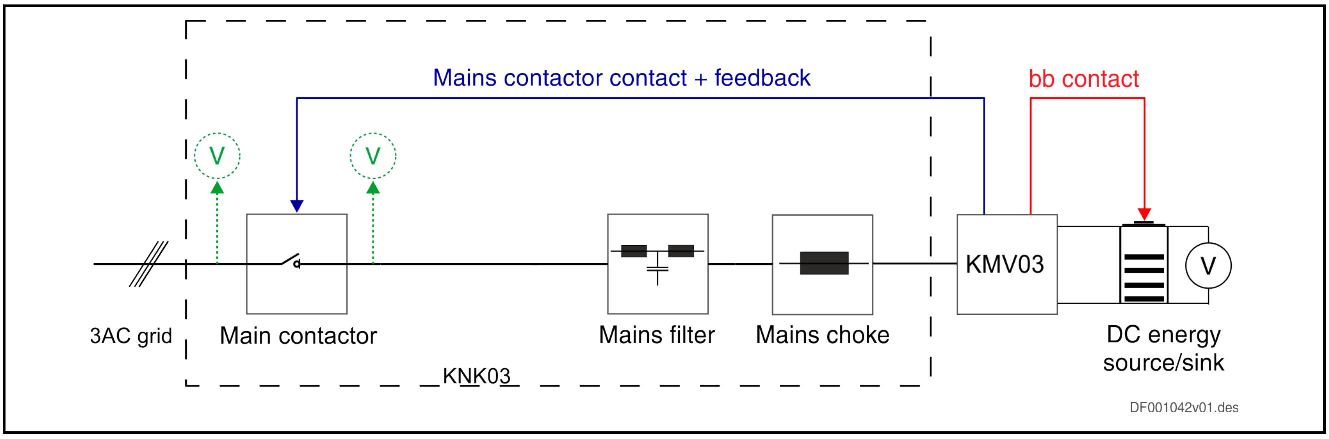


Fig. 7-5: KMV03 during start in island grid mode

The following figure shows the HMV05 hardware structure during the start in mains mode:

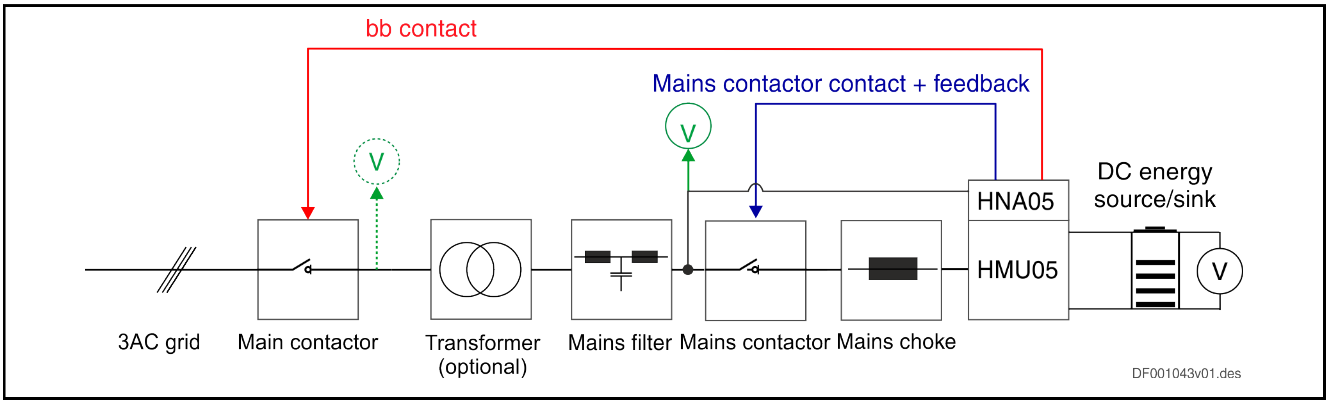


Fig. 7-6: HMV05 hardware structure during start in mains mode

The following figure shows the KMV03 hardware structure during the start in mains mode:

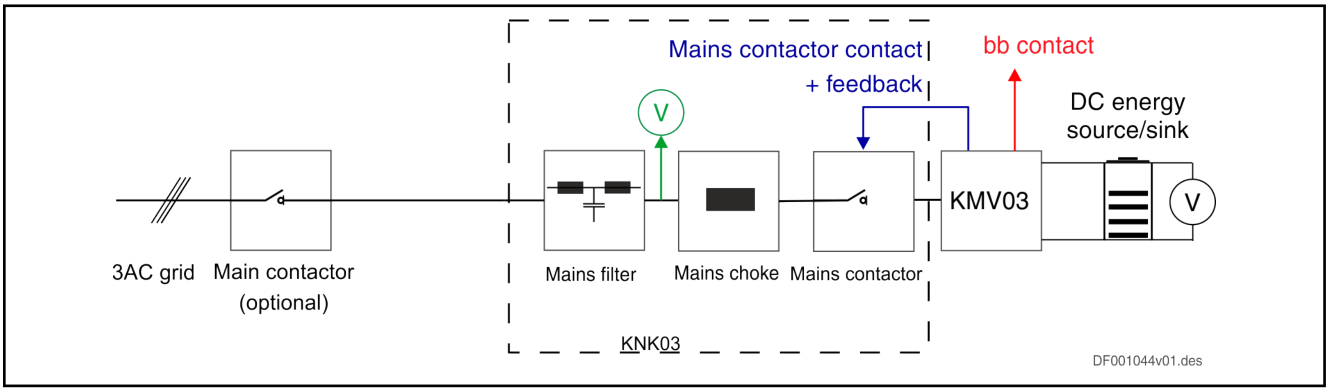


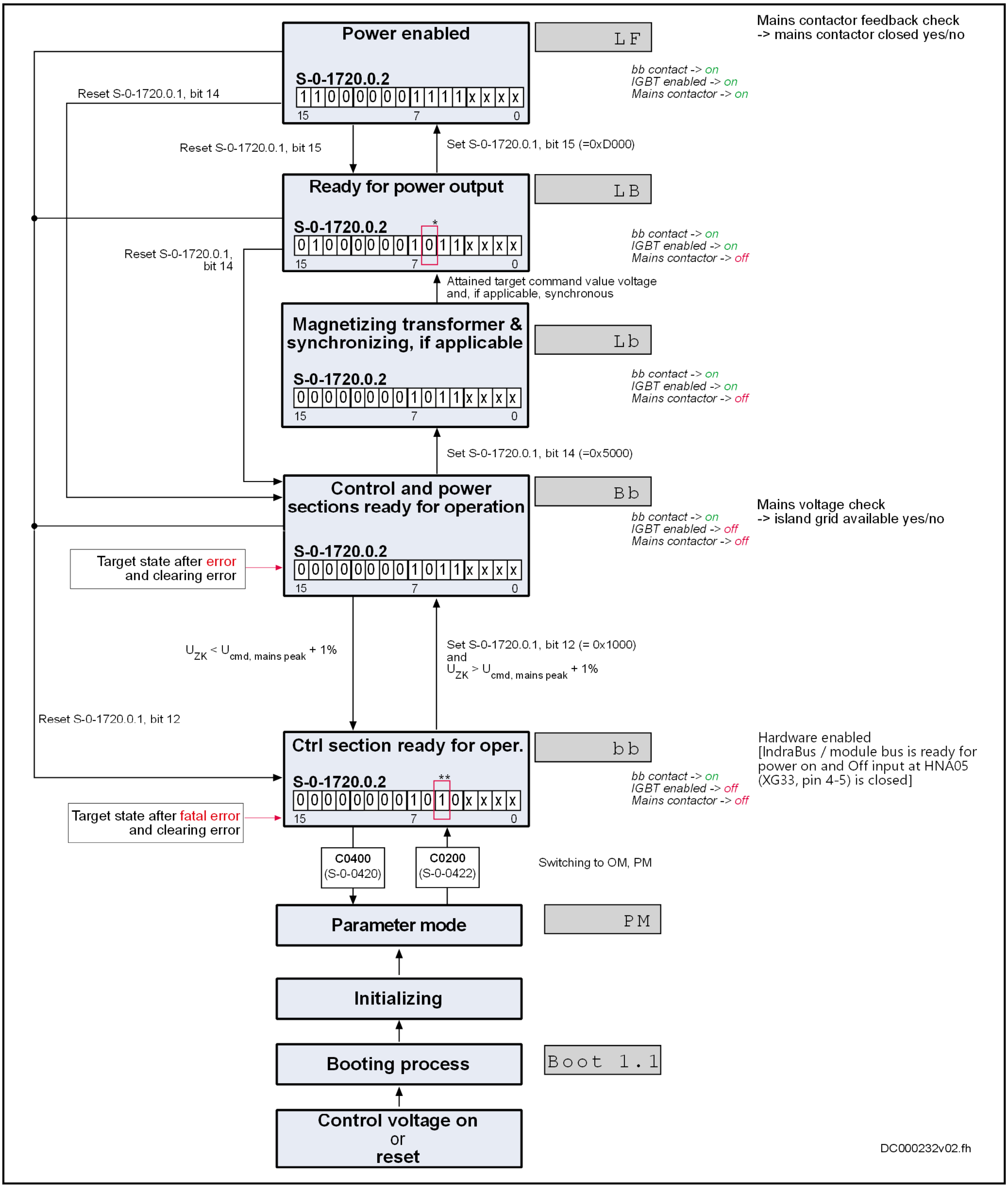
Fig. 7-7: KMV03 hardware structure during start in mains mode

Supply unit: State machine

Supply units with island grid support contain two state machines: a state machine for mains operation and a state machine for island grid mode. In parameterization mode PM, it is decided which state machine is to be used.

The supply unit starts in island grid mode, if bit 0..3 = 1 in "S-0-1715.0.150, Basic configuration of supply unit".

The following figure illustrates the state machine in island grid mode:



* Special case for "Ready for power output", S-0-1720.0.2, bit 6 = 1: Point of mains voltage measurement is 0. The operation mode package D is active, the mains contactor is already closed during transition from Bb to LB. For more details, see section Black start in island grid on page "Black start in island grid" on page 138

** Special case for "Control section ready for operation", S-0-1720.0.2: If the Off input at HNA05 (XG33, pin 4-5) is not connected or interrupted, bit 5 remains on logic 0.

Fig. 7-8: State machine in island grid mode

The supply unit starts in mains mode, if bit 0..3 = 0 in "S-0-1715.0.150, Basic configuration of supply unit".

fig. 3-11 " Device control (general state machine)" on page 36 shows the state machine in mains operation.

Supply unit: Operating states

Subsequently, the operating states are in island grid mode:

Supply unit island grid mode		
bb	A0534 Ctrl section ready for oper., DC bus voltage not available	
Bb	A0505 Power supply module ready for operation	DC bus voltage available
Lb	A0533 Island grid, voltage build-up	Magnetizing the transformer and, if required, synchronization with available island grid
LB	A0532 Island grid, ready for power output	Magnetizing the transformer and synchronization completed
LF	A0530 Island grid mode	Island grid voltage is available for loads

Tab. 7-1: Operating states in island grid mode

In the following table, the operating states in mains operation are listed for comparison:

Supply unit mains operation		
bb	A0504 Control section ready for oper., mains voltage not available	
Bb	A0505 Power supply module ready for operation	Mains voltage available
charg	A0503 DC bus charging active	DC bus charging
Lb	A0502 Supply module in operation	DC bus charging completed
LB	A0500 Supply module in voltage control	Selected operation mode active

Tab. 7-2: Operating states in island grid mode

Supply unit: Operation mode packages

Overview of the operation mode packages:

Operation mode Bit 0..3 of S-0-1715.0.150 0: Mains operation 1: Island grid mode	Dynamic operation mode change in case of Island grids Bit 8 of S-0-1715.0.150 0: not allowed 1: allowed	Operation modes	Selection	Pack-age
0	0	Primary + secondary	• DC bus voltage control • DC bus voltage control, floating • Rectifier mode • Mains current control	A
0	1	Primary + secondary	• DC bus voltage control • DC bus voltage control, floating • Rectifier mode • Mains current control • Island grid mode, closed-loop controlled • No black start possible	B
1	0	Primary	• Island grid mode, open-loop controlled • Island grid mode, closed-loop controlled	C
1	1	Primary + secondary	• DC bus voltage control • DC bus voltage control, floating • Rectifier mode • Mains current control • Island grid mode, closed-loop controlled • Black start possible	D

Tab. 7-3: Overview of the operation mode packages

Bits 0..3 and 8 of "S-0-1715.0.150 Basic configuration of supply unit" define the operation mode package (A, B, C or D). Only the operation modes available in the selected operation mode package can be assigned to the primary and secondary operation modes in parameterization mode PM. In the operating mode OM, a dynamic change between primary and secondary operation modes with their selected operation modes is possible. Exception: operation mode package C.

For dynamic switching (primary and secondary operation mode switching) between mains operation and island grid mode, enable bit 8 "Dynamic operation mode change in case of island grids allowed" in parameter "S-0-1715.0.150, Basic configuration of supply unit".

☞ In the case of the operation mode packages B, C and D, the specified power is positive if the power flow direction is: DC bus to the (island) grid. In the case of the operation mode package A, the positive power flows from the (island) grid to the DC bus.

7.3.3 Detailed properties of island grid mode

Mains voltage measurement

In contrast to mains operation at the grid system, no mains phase has to be determined in island grid mode. Thus, mains voltage measurement is not necessarily required. For mains voltage control/mains frequency control and for synchronization to an existing island grid, mains voltage measurement is mandatory. The mains voltage measurement can be connected to different points in the voltage circuit, see the following figure:.

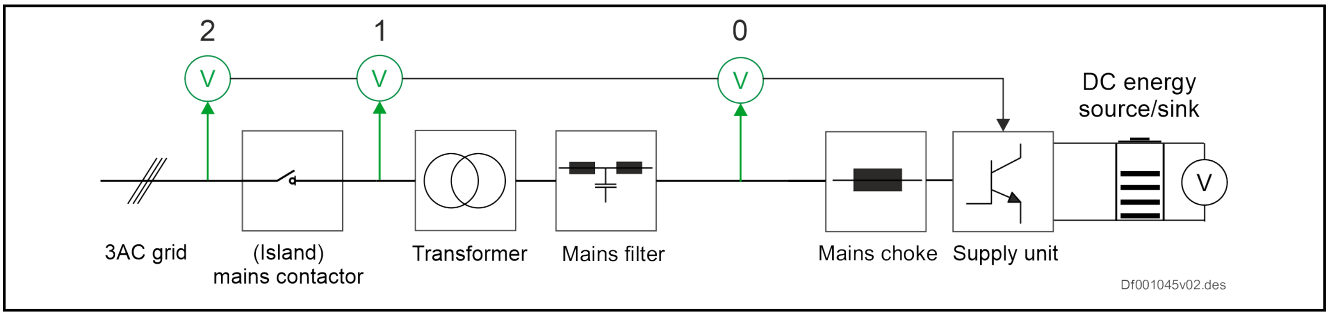


Fig. 7-9: Possible points for mains voltage measurement

The point for mains voltage measurement is specified by the following configuration parameters:

S-0-1715.0.150, Basic configuration of supply unit

- Bits 7..4 = 0: Mains voltage measurement on primary side (supply unit) of transformer
- Bits 7..4 = 1: Mains voltage measurement on secondary side (load side) of transformer
- Bits 7..4 = 2: Mains voltage measurement after main contactor on island grid side or load side

Parameter "S-0-1715.0.150, Basic configuration of supply unit" only allows certain combinations, see the following table:

Bit 0..3 of S-0-1715.0 .150	Bit 8 of S-0-1715.0 .150	Package	Possible points of Mains voltage measurement (Bits 7..4 of S-0-1715.0.150)	Notes
0	0	A	0	Only mains operation
0	1	B	0	Hybrid operation
1	0	C	1, 2	Only island grid mode
1	1	D	0	Hybrid operation

Tab. 7-4: Allowed configurations of "S-0-1715.0.150 "

Open-loop mains voltage control and open-loop mains frequency control

A constant voltage and a constant frequency is output by the supply unit in the open loop mains voltage control (S-0-1716.0.160) and the open loop mains frequency control (S-0-1716.0.161). The voltage waveform is sinusoidal and displaced by 120° (3-phase).

The maximum voltage output by the supply unit, including an optionally available transformer is defined in S-0-1716.0.162 as protection against overvoltage. The gear ratio of the optionally available transformer is taken into consideration.

Parameters involved:

- S-0-1716.0.160, Island grid voltage command value
- S-0-1716.0.161, Island grid frequency command value
- S-0-1716.0.162, Island grid voltage, maximum value

Closed-loop mains voltage control and closed-loop mains frequency control

In case of the mains voltage control and the mains frequency control, the mains voltage and the mains frequency is controlled depending on the respective power. The command value input is specified by characteristic curves. The following figure shows the characteristic curve for mains frequency command value input as a function of the active mains power:

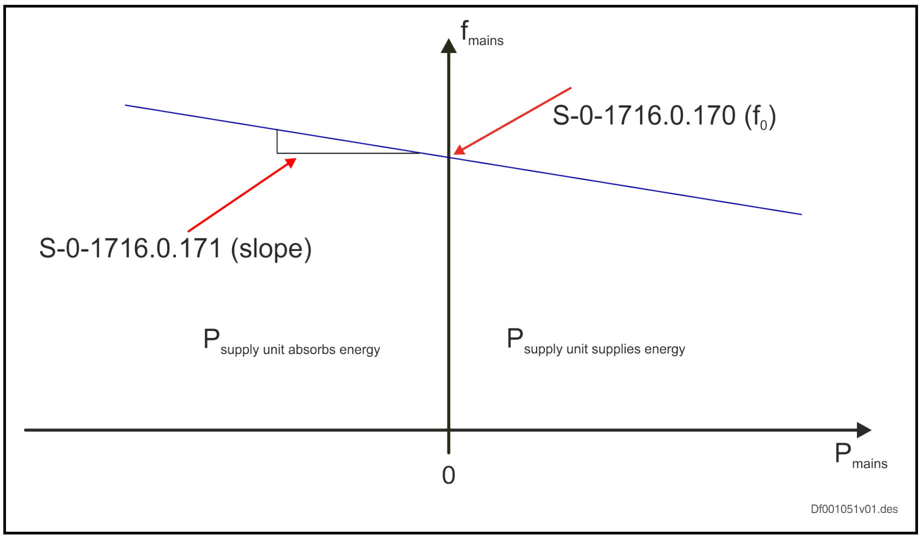


Fig. 7-10: f-P characteristic

The following figure shows the characteristic curve for mains voltage command value input as function of the active mains power:

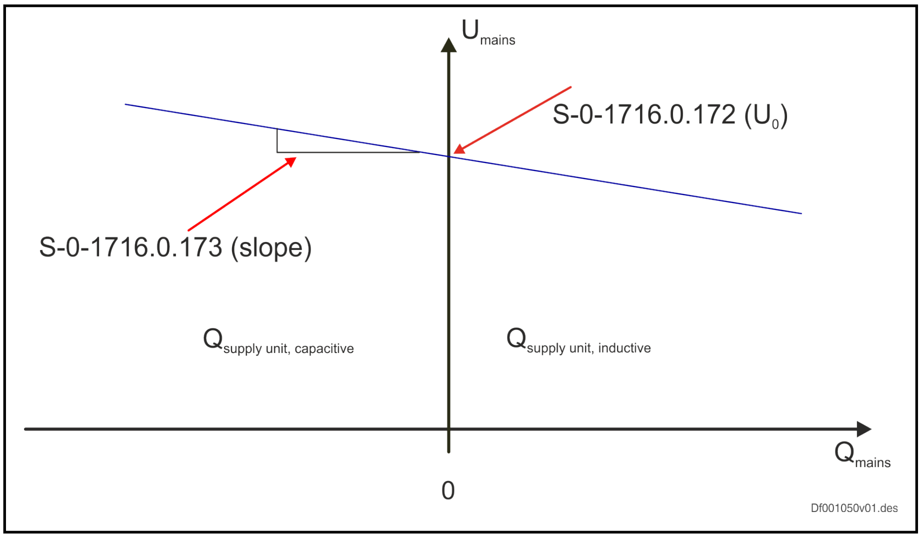


Fig. 7-11: U-Q characteristic

No communication has to be established between the members of an island grid supply group by using the characteristic curves, as stable mains operation is ensured by lowering the open loop mains frequency and open loop mains voltage.

The following parameters are available to parameterize the characteristic curves:

- S-0-1716.0.170, f-P characteristic: f_0
- S-0-1716.0.171, f-P characteristic: Slope
- S-0-1716.0.172, U-Q characteristic: U_0
- S-0-1716.0.173, U-Q characteristic: Slope

The slope for the f-P characteristic and the slope for the U-Q characteristic refer to the nominal values of supply unit power.

The maximum voltage output by the supply unit, including an optionally available transformer is defined in S-0-1716.0.162 as protection against overvoltage. The gear ratio of the optionally available transformer is taken into consideration.

As long as the closed-loop mains voltage control and the closed-loop mains frequency control are disabled, i.e. the supply unit has not yet reached state LF or A0530, the following command values are active for the voltage output:

- S-0-1716.0.160, Island grid voltage command value
- S-0-1716.0.161, Island grid frequency command value

During the phase progression in LF, a command value jump can sporadically occur. A jump can occur if f_0 differs considerably from the command value of the island grid frequency or if U_0 differs considerably from the command value of the island grid voltage. Another reason can be if the island grid has a considerable load right from the start.

The values of the characteristic curve for the island grid voltage are not directly specified but are specified via a voltage controller. Thus, the dynamics of the command value change can be adjusted.

The voltage controller is configured via the following parameters:

- "S-0-1716.0.180, Voltage controller proportional gain" (K_p)
- "S-0-1716.0.181, Voltage controller integral action time" (T_n)

The characteristic curve values for the island grid frequency are not specified directly either but are specified via a simple filter.

The filter can be configured via the following parameter:

- S-0-1716.0.183, Filter time constant, island grid frequency, ctrler output

The characteristic curve mode can be disabled via "S-0-1716.0.150, Island grid mode control word", bit 0. In this case, closed-loop control is performed with regard to the specified command values ("S-0-1716.0.160, Island grid voltage command value" and "S-0-1716.0.161, Island grid frequency command value"). A performance-dependent adjustment does not take place.

Island grid synchronization to an external mains

To synchronize two grids (e.g. supply and island grid), a phase controller is required, eliminating the phase difference. This is required if an island grid is detected during the magnetization phase Lb and if subsequently, an activation is to be facilitated or if the active island grid is to be adjusted to another mains.

The phase controller is configured via the following parameters:

- "S-0-1716.0.184, Phase controller proportional gain" (K_p)
- "S-0-1716.0.185, Phase controller integral action time" (T_n)

If a synchronization to an external mains has to be performed, set bit 1 to 1 in parameter "S-1-1716.0.150, Island grid mode control word". As a synchronization to an external mains is only possible in case of a disabled characteristic curve operation, bit 0 has to be set to 1 in parameter "S-0-1716.0.150, Island grid mode control word". If both mains are synchronous, the main connector is closed and bit 0 is set to 1 in parameter "S-0-1717.0.150, Island grid mode status word". If the characteristic curve mode is to be used or is required by the system, it has to be enabled again, i.e. bit 0 has to be set to 0 in parameter "S-0-1716.0.150, Island grid mode control word".

For synchronization to a mains, an external measuring device is required (e.g. power measuring terminal), determining the voltage and phase difference. The values determined for voltage and phase difference have to be cyclically written by an external measuring device or a higher-level control to the following parameters:

- "S-0-1718.0.160, External synchronization, voltage difference" [in V, momentary values of the phase-to-phase mains voltage as reference value]

  A command value minus the actual value is expected. This means, target voltage minus the voltage of the island grid system.
- "S-0-1718.0.161, External synchronization, phase shift" [in °, mains phase as reference value]

  A command value minus the actual value is expected. This means, target phase minus the phase of the island grid system.

After synchronization has been completed successfully, bit 0 is set to 1 in parameter "S-0-1717.0.150, Island grid mode status word". The voltage difference and the phase difference and not evaluated anymore. The cyclic data transmission is not required anymore.

Black start in island grid

This function refers to the build-up of the island grid voltage, starting from voltage zero with an opened main contactor to the external grid. Usually, a component black start (DC 24-V-supply) is required. A self-sufficient island grid can be established and maintained.

☞ Upon a black start, the supply unit always generates a clockwise mains.

As a sudden connection of the island grid voltage is to be avoided, the island grid voltage is slowly increased until it has reached its command value (S-0-1716.0.160). In case a mains transformer is available, the slow voltage rise is simultaneously used to magnetize the mains transformer. The rise time constant for the island grid build-up can be parameterized via "S-0-1716.0.186, Filter time constant, voltage build-up".

Upon the start of the supply unit, it is verified if mains voltage has already been applied. If **no mains detected** (mains voltage < command value island grid voltage * 0.05), the condition of a black start is met.

Case 1: Point of mains voltage measurement is 1 and the operation mode package C is active

If the DC bus voltage is within its tolerance limits, the island grid voltage is slowly increased until it has reached its command value. The supply unit can subsequently be switched to LF and thus close the main contactor if the voltage output by the supply unit is also measured at 1. If this is not the case, the supply unit remains in LB.

Case 2: Point of mains voltage measurement is 2 and the operation mode package C is active

If the DC bus voltage is within its tolerance limits, the island grid voltage is slowly increased until it has reached its command value. The supply unit can subsequently be switched to LF and thus close the main contactor if no voltage is measured at 2. If this is not the case, the supply unit remains in LB.

Case 3: Point of mains voltage measurement is 0 and the operation mode package D is active

The mains contactor is already closed during the transition from Bb to LB in this special case. After the mains contactor was closed, the island grid voltage is slowly increased until its command value is reached. No other action is carried out during the transition from LB to LF.

However, if a **mains is detected** (mains voltage ≥ command value island grid voltage * 0.05), the behavior of the supply unit depends on the selected operation mode.

Case 1: Selected operation mode = island grid mode, closed-loop controlled

In case the mains is available and if the mains is to be controlled, the supply unit synchronizes to the existing mains. This is not a real black start (see "Island grid synchronization to an external mains" on page 137).

Case 2: Selected operation mode = island grid mode, open-loop controlled

In case the mains is available and if the mains is to be controlled, the supply unit outputs the error "F2803 Black start impossible" The supply unit does not go into operation.

Parameters involved:

- S-0-1716.0.186, Filter time constant, voltage build-up

DC bus voltage supply

The DC voltage applied to the DC bus has to be controlled by other devices, such as the generator-side inverter, or by other sources (e.g., by a battery). Devices providing the DC bus voltage have to ensure that the DC bus voltage remains in the defined limits.

Depending on the island grid-side load of the supply unit, the DC bus has to be supplied with energy. The DC bus can be an energy sink as well as an energy source. If energy flows from the island grid via the supply unit to the DC bus, it has to be ensured that this energy is dissipated. For example, if the DC bus is provided by a battery, the battery has to be charged in this case. If the DC bus is provided by devices that cannot absorb energy, such as a diesel generator, the energy has to be converted to heat by a braking resistor.

If the DC bus voltage leaves the defined tolerance limits, diagnostic messages are output:

- E8025 Overvoltage in power section

  In case of overvoltage in the DC bus, the output stage of the supply unit is locked. The supply unit reports warning E8025. If the DC bus voltage exceeds the maximum allowed DC voltage, there is an overvoltage in the DC bus. The maximum allowed DC voltage depends on the device and is stored in the device as a device base parameter.
- F2026 Undervoltage in power section

  In case of undervoltage in the DC bus, the output stage of the supply unit is locked. The supply unit reports error F2026. If the DC bus voltage falls below (island grid command voltage * √2 * 1.01), there is undervoltage in the DC bus.

Mains transformer

If a mains transformer is used between the supply unit (HMV05/KMV03) and the island grid (of the load) to transform the voltage , the mains transformer has to be magnetized before connecting the supply unit to the island grid. The mains transformer has to be magnetized if the mains transformer is part of the island grid supply unit and is also disconnected from the mains when shutting down the system. Without magnetization by the supply unit, very high transformer inrush currents would flow when shutting down the system. These inrush currents can sporadically result in impermissible mains pollution or in an overcurrent shutdown by the supply unit.

The firmware: ≥ PSB21VRS is responsible for the magnetization operation. Moreover, the transformer data can optionally be taken into consideration; consequently, the transformer is part of the supply unit in the overall view.

The static transformation data are required to take the transformer into consideration:

- Phase offset between primary and secondary side
- Voltage ratio between primary and secondary side

Configure the following parameters:

- S-0-1715.0.160, Transformer vector group
- S-0-1715.0.161, Primary side transformer voltage
- S-0-1715.0.162, Secondary side transformer voltage

☞ Only the vector groups Dy5, Dyn5, Dy11 and Dyn11 are supported.

The vector group is entered according to the following scheme:

S-0-1715.0.160, bit 3..0: Characteristic value

0x0: characteristic value 0

0x5: characteristic value 5

0x6: characteristic value 6

0xB: characteristic value 11

S-0-1715.0.160, bit 7..4: Neutral conductor

0x0: no neutral conductor lead out

0x1: neutral conductor lead out

S-0-1715.0.160, bit 11..8: Secondary side connection

0x0: no input

0x1: delta connection (d)

0x2: star connection (y)

0x3: zig-zag connection (z)

S-0-1715.0.160, bit 15..12: Primary side connection

0x0: no input

0x1: delta connection (D)

0x2: star connection (Y)

Examples:

- Dy5 = 0x1205
- Dyn5 = 0x1215
- Dy11 = 0x120B
- Dyn11 = 0x121B

☞ When entering a vector group of 0x0000, firmware ≥ PSB21VRS does not take a transformer into consideration.

In the case of a real transformer, the phase offset and the voltage ratio change with the transformer load. If the mains voltage is measured at the secondary side of the transformer, this effect is compensated for by the control.

If no mains voltage measurement is available at the secondary side of the transformer, the transformer secondary voltage has to be estimated for the synchronization of the transformer secondary voltage to the island grid.

The following variables are required:

- S-0-1715.0.170, Transformer magnetizing inductance
- S-0-1715.0.171, Resistance on primary side of transformer
- S-0-1715.0.172, Leakage inductance on primary side of transformer

The mains voltage errors and phase errors are determined by approximation. After the synchronization has been completed, these errors are still used, irrespective of the actual load of the transformer.

The dynamic transformer model can be disabled if the leakage inductance and the resistance are set to 0 and the main inductance has a value unequal to 0.

Current offset compensation

A DC offset in the phase currents can result in saturation of a connected, unloaded or lightly loaded transformer. This can result in current harmonics or oscillations with high amplitudes. This becomes evident by the flow of the currents. However, partially also by unpleasant noises.

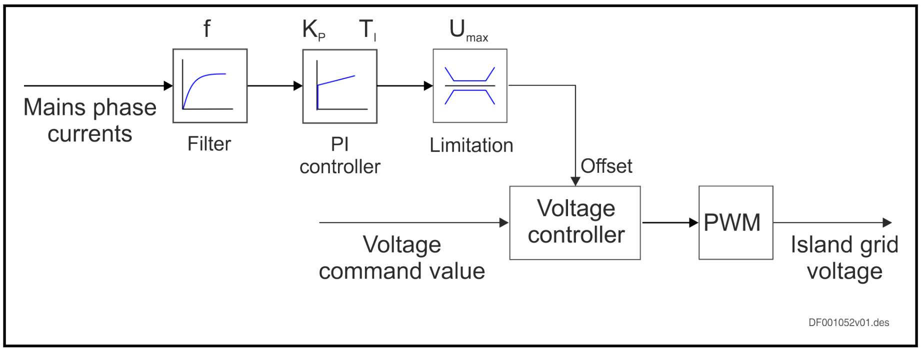


Fig. 7-12: Current offset compensation

To compensate for a DC offset in phase current, a PI controller is used. A filter separates the DC offset from the higher-frequency components. To control the maximum amplitude of the DC offset control, a limit can be parameterized.

Parameters involved:

S-0-1716.0.190, Current offset compensation: Proportional gain

S-0-1716.0.191, Current offset compensation: Integral action time

S-0-1716.0.192, Current offset compensation: Cutoff frequency

S-0-1716.0.193, Current offset compens.: Bipolar ctrler output limitation

The function can be enabled via bit 2 of parameter "S-0-1716.0.150, Island grid mode control word".

Short circuit behavior

If a short circuit occurs on the load side, the behavior depends on the level of the short circuit current:

- If the short circuit current is lower than the continuous current of the island grid sources, the short circuit current continues to flow until the short circuit is resolved by a fuse. The island grid voltage is not affected.

- If the short circuit current is higher than the continuous current of the island grid sources, level and duration of the short circuit current are decisive:
  – If the maximum thermal loading capacity of the supply unit is exceeded, the supply unit locks the output stage and reports the fatal error "F8060 Overcurrent in power section".
  – If a device-specific overcurrent threshold is exceeded, the supply unit reports the warning "E8028 Overcurrent in power section".
  – In all other cases, the system goes into a current-controlled state and the voltage output at the supply unit is reduced so that max. the current limit value of the temperature model is flowing and min. the continuous current. The supply unit reports the warning "E8057 Device overload, current limit active". The closed-loop mains voltage control and the closed-loop mains frequency control, as well as the open-loop mains voltage control and the open-loop mains frequency control, go to the current-controlled state.

☞ If the fuse is not promptly triggered in case of a short-circuit, the standardized mains tolerance limits are violated. Thus, an undefined working point occurs for the connected loads. To prevent this, advanced mains monitoring can be enabled (see chapter "Advanced supply unit functions/additional functions for mains supply").

Behavior of bb contact

If the supply unit starts in island grid mode ("S-0-1715.0.150, Basic configuration of supply unit" bit 0..3 = 1), the bb contact is closed if the supply unit is in state bb and is ready for connection of the external DC bus voltage.

If the supply unit starts in mains operation ("S-0-1715.0.150, Basic configuration of supply unit" bit 0..3 = 0), the bb contact is closed if the supply unit is ready for mains connection or if "Close main contactor" has been selected.

Module bus/IndraBus

If the supply unit starts in island grid mode ("S-0-1715.0.150, Basic configuration of supply unit" bit 0..3 = 1), the module bus/IndraBus has to be disabled in the supply unit. For this purpose, set bit 15 = 1 in parameter "P-0-0118, Power supply, configuration".

7.3.4 Typical fields of application

Case 1: Hybrid operation with DC bus precharge

- Operation mode package B (i.e. start in mains operation)
- With/without transformer (transformer does not have to be taken into account)
- DC bus precharge at grid system or island grid by different source
- Synchronization with grid system or island grid by different source during DC bus precharge
- Mains current control at grid system or island grid by different source
- Dynamic switching to island grid with characteristic curve operation as the only source or as supporting source

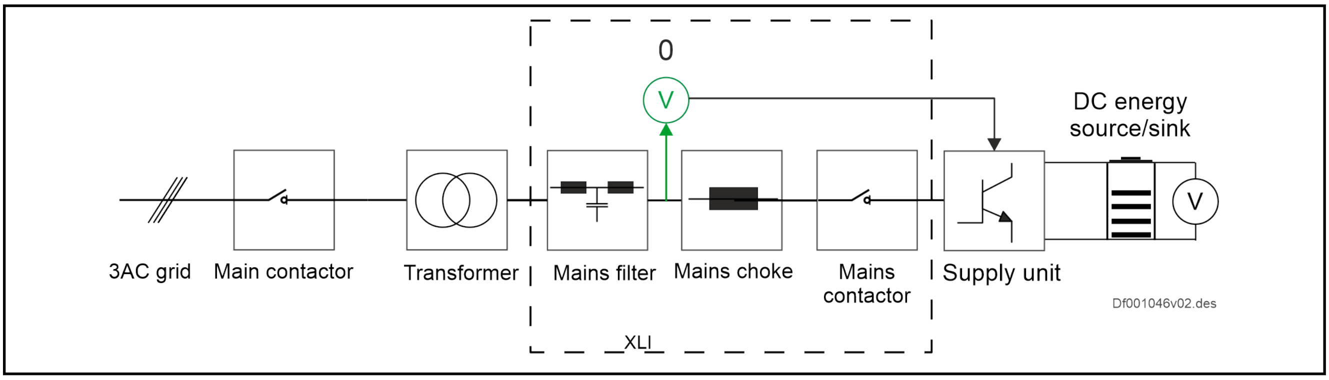


Fig. 7-13: Hybrid operation with DC bus precharge

Case 2: Hybrid mode with black start

- Operation mode package D (i.e. start in island grid mode)
- With/without transformer (if required, take ideal gear ratio and ideal phase offset into consideration)
- Black start with DC bus energy
- Generating island grid in characteristic curve operation
- Another island grid source synchronizes to the island grid
- Dynamic switching to mains current control in the case of supply by other island grid source

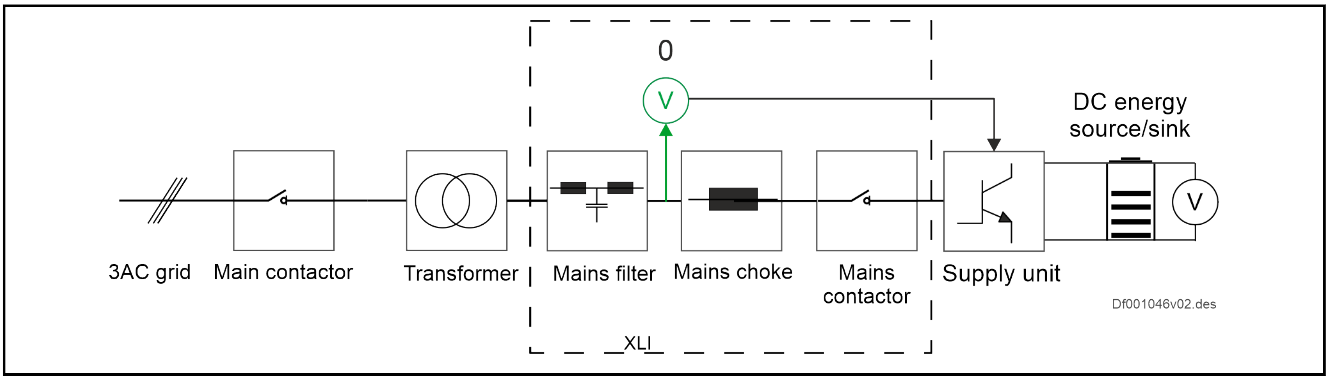


Fig. 7-14: Hybrid mode with black start

Case 3: Simple island grid mode

- Operation mode package C (i.e. start in island grid mode)
- With/without transformer (if required, take ideal gear ratio and ideal phase offset into consideration)
- No other sources in the island grid
- Black start
- Island grid mode with characteristic curves

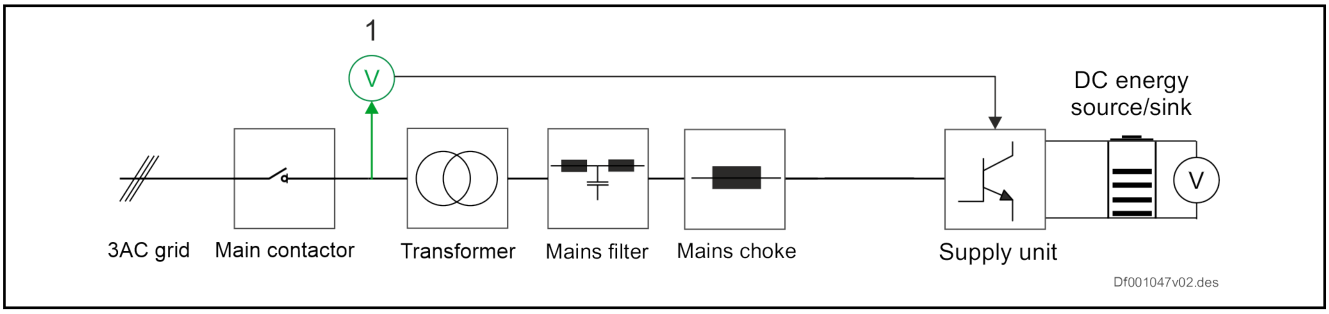


Fig. 7-15: Simple island grid mode (point of mains voltage measurement is 1)

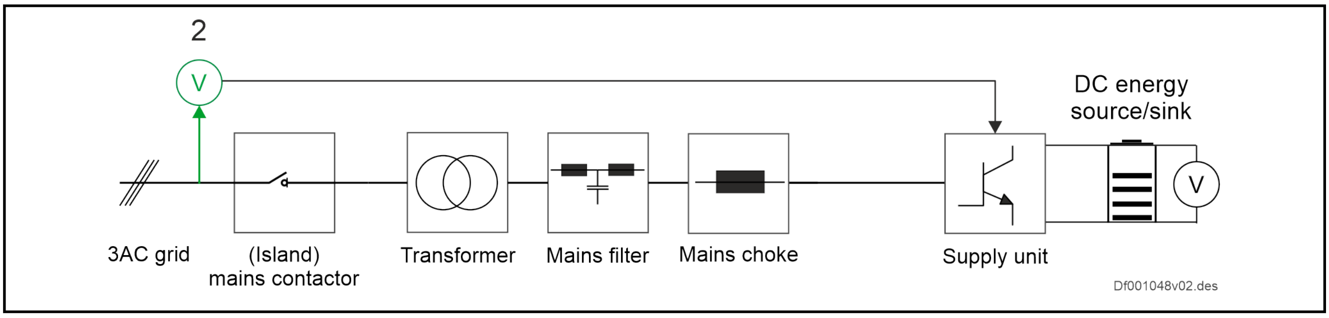


Fig. 7-16: Simple island grid mode (point of mains voltage measurement is 2)

Case 4: Island grid mode

- Operation mode package C (i.e. start in island grid mode)
- With/without transformer (requirement: take ideal transformation ratio and ideal phase offset into consideration)
- Assumption: Voltage error of transformer is negligible (transformer is unloaded during synchronization procedure)
- If necessary, other sources in the island grid
- With/without black start
- Island grid mode with characteristic curves

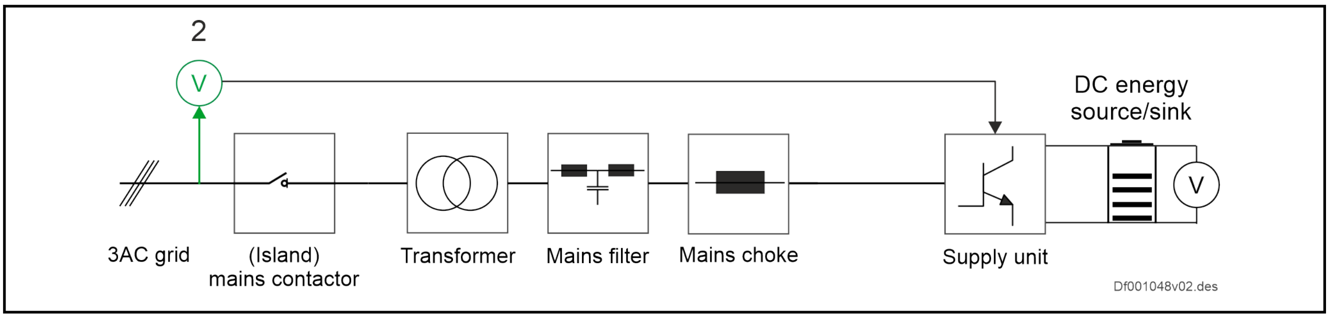


Fig. 7-17: Island grid mode

Case 5: Island grid mode with synchronization by external measurement

- Operation mode package B, C or D
- Operation with a real transformer (voltage error of transformer has to be taken into account) and other source in the island grid
- Or synchronization of the island grid to a different grid
- For the purpose of synchronization, an external measuring device cyclically provides phase and voltage errors for the phase and voltage controller in the supply unit
- During synchronization, operation without characteristic curve; subsequently operation with characteristic curve is possible

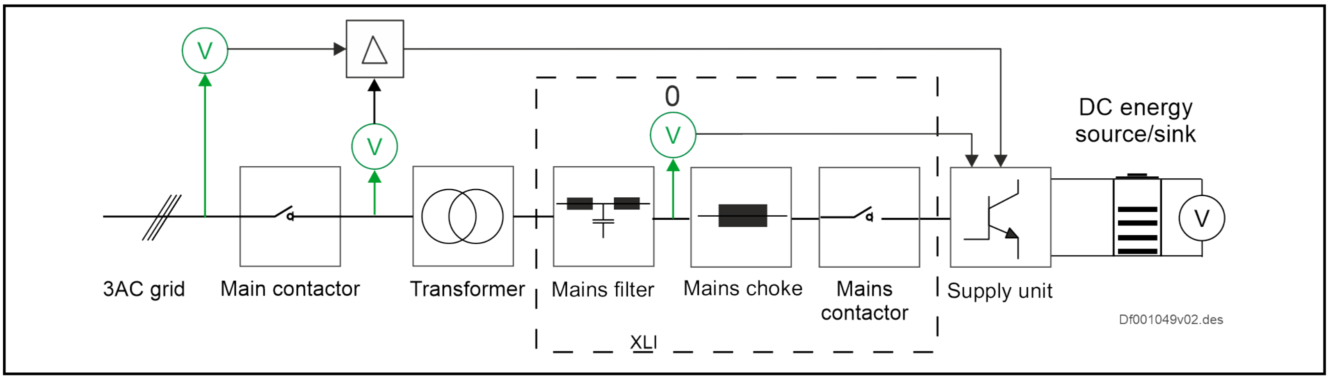


Fig. 7-18: Island grid mode with synchronization by external measurement

7.4 DC/DC converter mode

7.4.1 DC/DC converter mode

A DC/DC converter is a converter, converting DC voltage to a DC voltage of a different level.

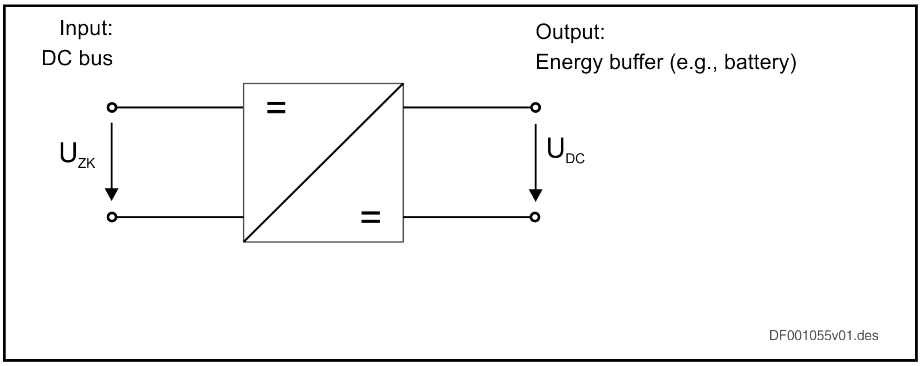


Fig. 7-19: DC/DC converter

If the output voltage is higher than the input voltage, this is referred to as "boost converter". If the output voltage is reduced with regard to the input voltage, this is referred to as "buck converter".

Features of the DC/DC converter mode

In DC/DC converter mode, the electric energy flow between two DC systems is controlled.

Main use case: The electric energy flow is controlled and flows from the DC bus to an energy buffer or from an energy buffer back to the DC bus. That is why the DC/DC converter is ideal to charge or discharge batteries or super-caps.

Another use case: Connecting the DC energy power plants (e.g. solar power systems or fuel cells) at a DC bus.

Coupling of DC grids of different voltages is possible.

Essential DC/DC converter functions:

- Bi-directional energy flow in both directions (from DC bus to energy buffer or from energy buffer to DC bus)
- Buck converter ($U_{DC} < U_{ZK}$)
- Two-quadrant operation is supported
- Precharging of existing capacitors at the output
- Operation modes:

– DC voltage control (DC output voltage)
– DC current control (DC output current)

Supported hardware

The basis for the DC/DC converter is an inverted on which the firmware of the supply unit is loaded.

The DC/DC converter mode is supported by the HMU05 inverter (IndraDrive ML product group) and the CSB02.5 control section. Note: DC/DC converter mode is only possible with HMU05 inverters, supporting parallel operation. In contrast to mains operation and island grid mode, the mains connection module HNA05 is not required anymore in DC/DC controller mode.

The DC/DC converter mode is provided with firmware ≥ PSB21VRS. Enable the functional package "DCE" requiring a license (also see chapter 2.4 "Overview of functions/functional packages" on page 14).

The following figure shows the HMU05 hardware structure in DC/DC converter mode:

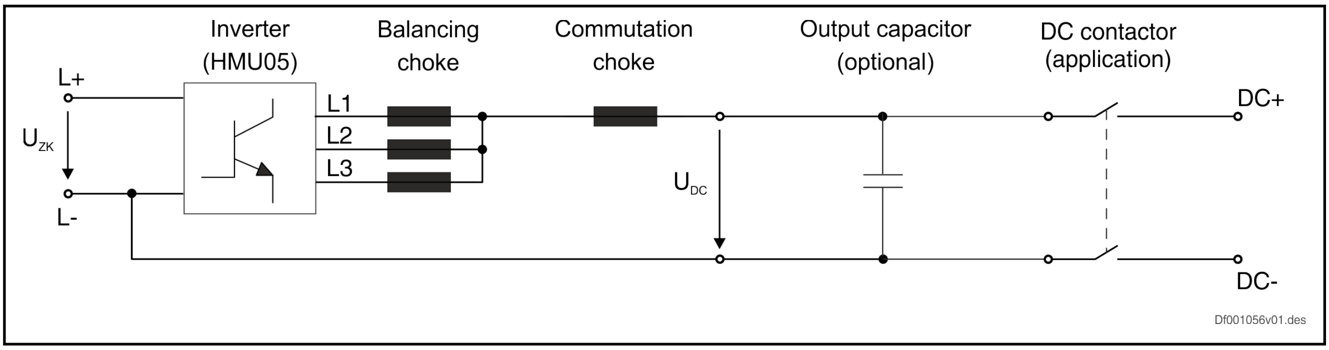


Fig. 7-20: HMU05 as DC/DC converter

Due to the circuit configuration, only a low DC output voltage can be generated (buck converter). The system limits the voltage level, the DC output voltage can as a maximum reach to the level of the DC bus voltage.

The polarity of the DC output voltage cannot be changed in case of this configuration. Result: a 2-quadrant operation.

The DC output current can be determined via the phase current measurements in the inverter. However, an external voltameter is required for measuring the DC output voltage. The determined DC output voltage has to be read in via an analog input at the inverter. Parameter "S-0-1742.0.160, DC voltage feedback value" has to be entered as target value for the DC output voltage measurement when configuring the analog input.

7.4.2 Operation modes

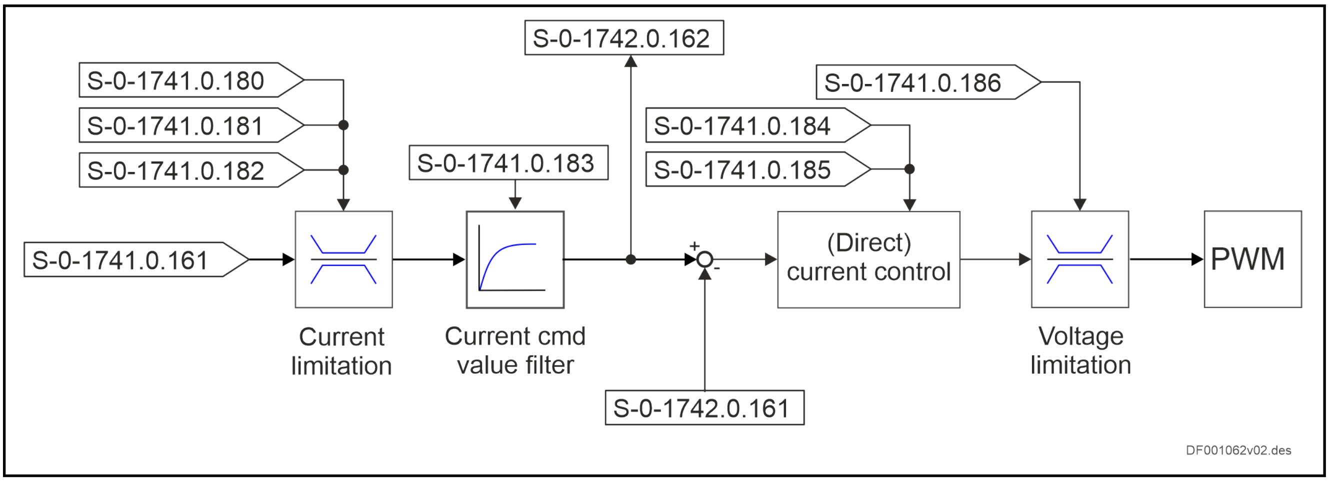
To enable the DC/DC converter mode, change the basic configuration in paramterization mode (PM). Set bits 0..3 to 2 in parameter "S-0-1715.0.150, Basic configuration of supply unit". A device restart is mandatory. With active DC/DC converter mode, the bits 0..3 have the value 2 in parameter "S-0-1717.0.151, Supply unit status".

In case of active DC/DC converter mode, the following options are available for the primary operation mode and the 3 secondary operation modes.

- DC current control:

  A current command value is specified for the DC/DC converter (by a higher-level control unit) via parameter "S-0-1741.0.161, DC current command value". The DC output current is closed-loop controlled.

The following figure shows an overview of the control loop structure including the relevant parameters.



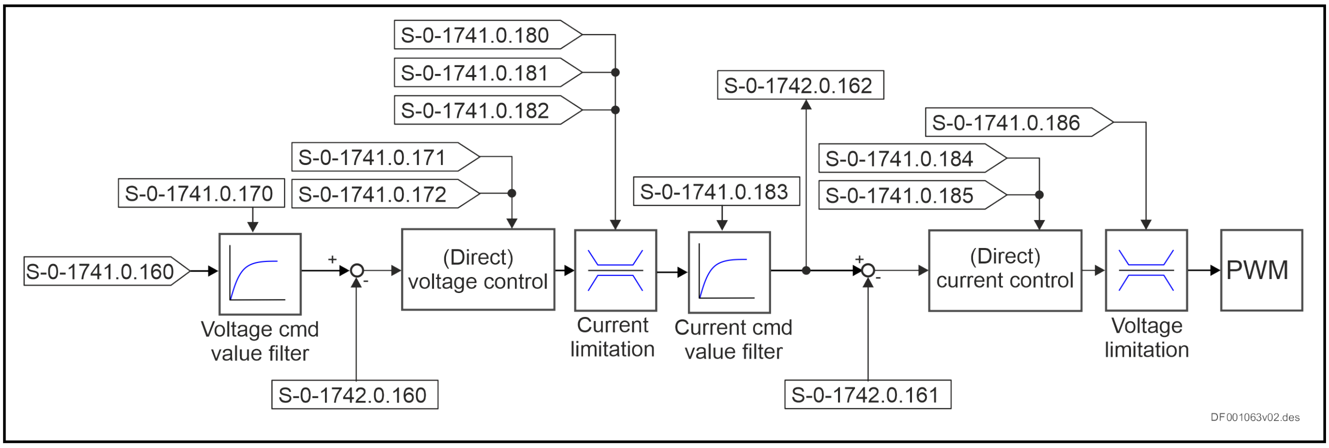
S-0-1741.0.161	DC current command value
S-0-1741.0.180	Bipolar DC current limit value
S-0-1741.0.181	Positive DC current limit value
S-0-1741.0.182	Negative DC current limit value
S-0-1741.0.183	DC current command value filter, time constant
S-0-1742.0.161	Actual value of DC current
S-0-1742.0.162	DC current, effective command value
S-0-1741.0.184	DC current controller proportional gain
S-0-1741.0.185	DC current controller integral action time
S-0-1741.0.186	DC current controller output limitation
S-0-1707.0.1	Actual DC bus voltage

Fig. 7-21: Schematic diagram of the current control loop

- DC voltage control:

  A voltage command value is specified for the DC/DC converter (by a higher-level control unit) via parameter "S-0-1741.0.160, DC voltage command value". The DC output voltage is controlled. Control is implemented as a cascade control system. This means, voltage control specifies a current command value for the subordinate current control.

The following figure shows an overview of the cascade control system with current control loop and voltage control loop, including the relevant parameters.



S-0-1741.0.160 DC voltage command value
S-0-1741.0.161 DC current command value
S-0-1741.0.170 DC voltage command value filter, time constant
S-0-1741.0.171 DC voltage controller proportional gain
S-0-1741.0.172 DC voltage controller integral action time
S-0-1741.0.180 Bipolar DC current limit value
S-0-1741.0.181 Positive DC current limit value
S-0-1741.0.182 Negative DC current limit value
S-0-1741.0.183 DC current command value filter, time constant
S-0-1742.0.161 Actual value of DC current
S-0-1742.0.162 DC current, effective command value
S-0-1741.0.184 DC current controller proportional gain
S-0-1741.0.185 DC current controller integral action time
S-0-1741.0.186 DC current controller output limitation
S-0-1707.0.1 Actual DC bus voltage

Fig. 7-22: Schematic diagram of the voltage control loop

☞ As protection against overvoltage, the maximum DC output voltage that the controller may provide is defined in "S-0-1741.0.186, DC current controller output limitation". Due to losses in the output stage of the controller, deviations can occur. These deviations can result in the actual voltage limitation exceeding the parameterized value by several volts.

The DC/DC converter is connected to the DC bus (comparable to an axis) and thereby shows the same behavior as an axis with regard to the module bus/IndraBus, bb relay control and DC bus. The energy source (e.g. battery system, HMV05, ...) is used to control the DC bus voltage. It is assumed that the energy provided for the DC bus is always sufficient. Control of the DC bus voltage is not possible in DC/DC converter mode. Monitoring of the DC bus is not provided either (only overvoltage cut-off).

7.4.3 DC/DC converter operating states

In the following, the operating states in DC/DC converter mode are listed.

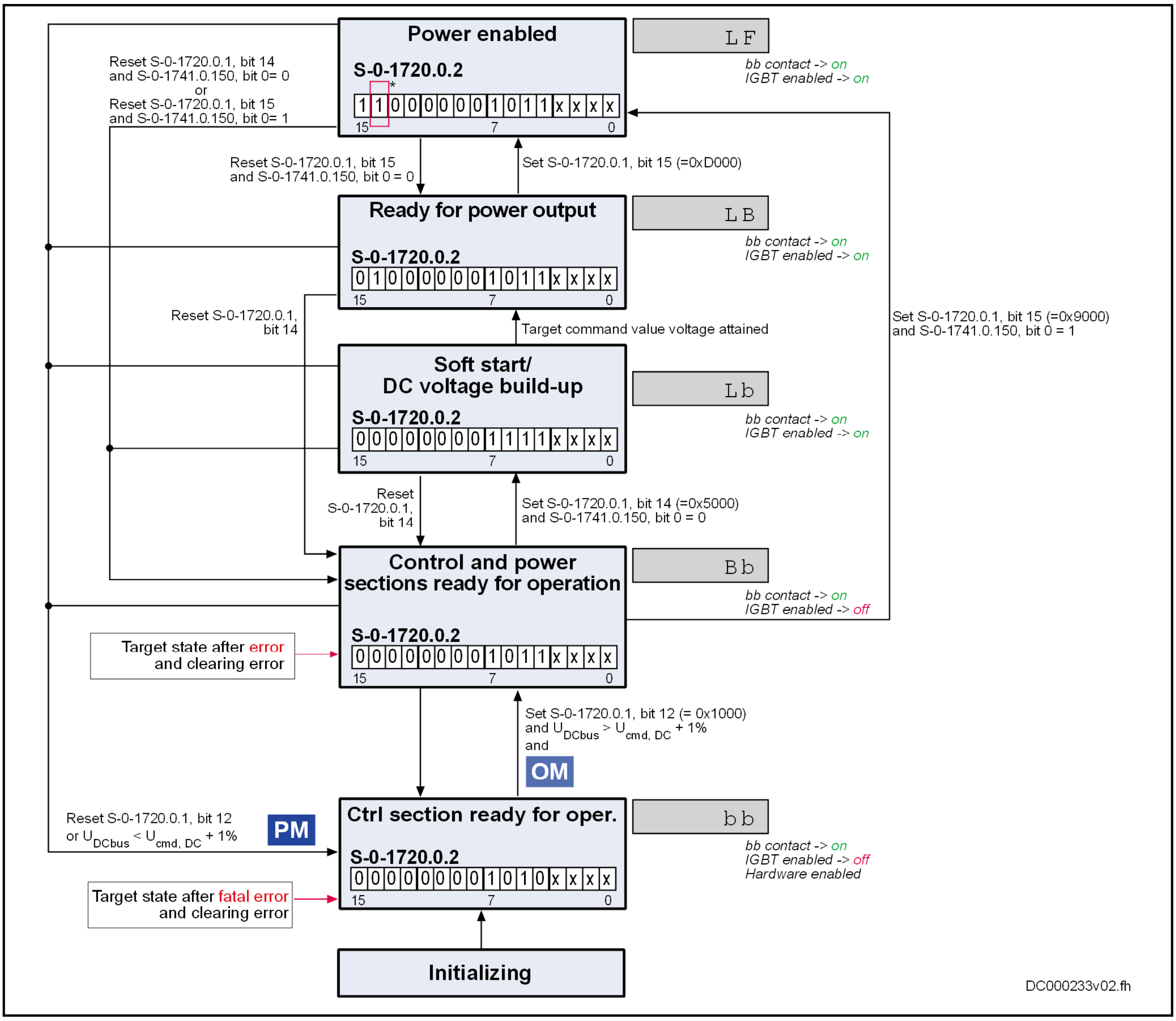
DC/DC converter mode		
bb	A0534 Ctrl section ready for oper., DC bus voltage not available	
Bb	A0505 Power supply module ready for operation	DC bus voltage available

DC/DC converter mode		
Lb	A0543 DC voltage build-up	The DC output voltage is slowly controlled to the command voltage to load a potentially existing output capacitor in a controlled manner.
LB	A0542 DC supply, ready for power output	DC output voltage build-up completed
LF	A0540 DC mode active	DC output voltage is available to the loads

Tab. 7-5: Operating states in DC/DC converter mode

7.4.4 DC/DC converter state machine

The following figure shows the state machine in DC/DC converter mode:



* Bit 14 of S-0-1720.0.2 is 0, if the DC voltage build-up is disabled (i.e. in S-0-1741.0.150 bit 0 = 1).

Fig. 7-23: State machine in DC/DC converter mode

7.4.5 DC output voltage build-up

It has to be assumed that the circuit of the DC output voltage contains a considerable capacity. Consequently, abruptly connecting a DC voltage to the output DC voltage circuit is not possible since this would result in overcurrent. Analog to precharging the DC bus, the DC output voltage has to be increased slowly. This is achieved by means of the DC voltage control loop. The control loop increases the voltage using a controlled DC current. The level of the current is limited to the maximum device current by the DC current controller. If the capacity in the DC output circuit has already been partially charged, charging to the target command value takes place in the same manner.

If the optionally installed capacitor is missing on DC-side, the voltage build-up can be disabled via bit 0 of parameter "S-0-1741.0.150, DC/DC converter control word". Set bit 0 to 1 to disable the voltage build-up.

7.4.6 DC contactor

The DC contactor has to operated via a higher-level control. Control via the supply unit firmware is not provided.

8 Optional device functions

⚠ WARNING **Dangerous movements! Danger to life, risk of injury, serious injury or property damage!**

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine’s range of motion (e.g., by using safety fences, safety guards, protective coverings, light barriers).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.

8.1 Availability of the optional device functions

For an overview that illustrates in which base or functional packages the respective optional device functions are available, see chapter "Overview of functions/functional packages, Availability of the optional device functions".

8.2 Error reaction

Depending on the operation mode that is used and specific parameter settings, the controller carries out monitoring functions. The controller generates an error message if a state is detected that no longer allows correct operation.

Errors are classified into error classes. The error class is represented by the first two digits of the diagnostic message number.

If the controller is in control (drive enable was set) and an error occurs, it automatically starts an error reaction. This error reaction depends on

- The error class of the error that occurred
- The setting of parameter P-0-0860, Converter configuration

☞ In the case of supply section errors, the supply unit is powered off. The mains contactor is disconnected and in the case of fatal errors the "Bb contact" is additionally opened.

Error classes There are different error classes with increasing priority. They lead to different reactions regarding power off and the signaling of errors via IndraBus/module bus.

Error situation	Error reaction of the supply section
Device signals F2xxx	Error-specific reaction
Device signals F28xx	Power off; IndraBus/module bus signal "DC bus voltage error, mains failure" is generated
Device signals F4xxx	No reaction
Device signals F8xxx	Error-specific reaction
Device signals F88xx	Power off, "Bb contact" is opened; IndraBus/module bus signal "supply error" is generated

Error situation	Error reaction of the supply section
Device signals F9xxx	Power off, "Bb contact" is opened; IndraBus/module bus signal "supply error" is generated
IndraBus/module bus signals "supply error"	Power off, "Bb contact" is opened
IndraBus/module bus signals "inverter error"	Depending on P-0-0860 bit 2: 1: Power off, open "Bb contact" 0: no reaction

Tab. 8-1: Error reactions of the controller depending on error class and IndraBus/module bus

In case of errors affecting the supply section of the device (Fx8xx), the power supply is generally switched off. If a fatal error of the supply section has occurred, the "Bb contact" is additionally opened.

8.3 DC bus short circuit

The "DC bus short circuit" (ZKS) function is available for discharging the DC bus. This function discharges the DC bus via the braking resistor. ZKS can only be carried out if a braking resistor is available within the drive system. The following hardware dependencies have to be taken into account:

- The KMV supply unit has an internal braking resistor and ZKS is controlled using "S-0-1720.0.1, Power supply control word" bit 10.
- Supply units with HMU do not have an internal braking resistor. ZKS in this case has to be implemented via an external braking transistor module (HLT) and in connection with an external braking resistor (HLR). The control is implemented via the digital inputs of HLT and HNA (see Project Planning Manual).

As long as the supply unit is connected to the mains, ZKS is blocked via the IndraBus signal "DC bus short circuit blocked". If the feedback contact of the mains contactor signals mains disconnected, ZKS is enabled.

The DC bus is discharged at the limit load of the braking resistor using a two-state controller at the warning threshold. If ZKS is active and the load has reached the warning threshold, discharging is switched off. If the load falls 10% below the warning threshold, discharging is switched back on.

The discharging status can be diagnosed via "S-0-1720.0.2, Power supply status word" bit 10.

8.4 Rexroth IndraMotion MLD (integrated PLC)

8.4.1 Brief description

Assignment to functional firmware package: Expansion packages **IndraMotion MLD** (order code **ML**)

The expansion package "IndraMotion MLD" provides the function of a PLC integrated in the supply unit in accordance with IEC 61131-3 with the following scope of functions:

- **Integrated logic control**
  - Compliant with IEC-61131-3
  - Online change

  - Debugging
- Basis for technology functions

  Loading and using self-contained PLC programs (technology functions) by Rexroth.

☞ This functionality expansion is described in detail in the separate documentation "Rexroth IndraMotion MLD (2G) as of MPx-18" (DOK-INDRV*-MLD3-**VRS*-AP**-EN-P; mat. no. R911338914).

All libraries available in IndraMotion MLD are described in the separate documentation "Rexroth IndraMotion MLD (2G) Libraries as of MPx-18" (DOK-INDRV*-MLD-SYSLIB3-RE**-EN-P; mat. no. R911338916). Please observe that functions available for motion axes cannot be used with the PSB firmware. In the attempt to command a function block that is not supported, the Error output is set at this function block.

Firmware requirements

The "IndraMotion MLD" function can be activated in the **FWA-INDRV*-PSB-21VRS-D5** firmware. For this purpose, the functional package **ML** has to be enabled.

See also:

- "Overview of functions/functional packages"
- "Enabling functional packages"

Features/characteristic values

The functional package "IndraMotion MLD" includes the following general features/characteristic values:

- It is possible to configure up to 4 different user tasks. Possible task types:
  - Periodic (minimum cycle time: 2 ms)
  - Freewheeling (permanently cyclic)
  - Event-triggered (minimum reaction time: 2 ms)
- Memory resources:
  - Internal code memory: 2 MB (program, constants, management)

☞ 66% thereof can be used for the project. The rest is reserved for online change.

  - Data memory: 3 MB (variables, instances, management)
  - Storage of the boot project: 650 kB in parameters
  - Retain memory: 472 bytes (including persistent variables)
- The PLC integrated in the supply unit (IndraMotion MLD) has communication interfaces to …
  - ... the device-internal (local) inputs/outputs or parameters.
  - ... an external control (e.g., field bus PLC) via a master communication interface (sercos, field bus, ...).
  - ... an external operator panel (HMI).
- Parameters for general purpose:
  - Parameters for process image: PII inputs
    - 20 input words of 2 bytes each

  - 8 input words of 4 bytes each
- Parameters for process image: POI outputs
  - 20 output words of 2 bytes each
- Global registers (4 bytes)
  - 32 buffered parameters
  - 32 unbuffered parameters
- List parameters (4 bytes)
  - 1 list register with 8192 values (not buffered)
  - 3 list registers with 1024 values (buffered)
- 2 global text registers with 255 characters each
- Display format of the global registers that can be parameterized
- Name, unit and limit values of the global registers can be configured via PLC functions

- Other features:
  - Extensive debug options (Single-Step, Watch, Force/Write, Breakpoints, Powerflow)
  - File access from the PLC (saving source code on µSD card, …)
  - Configuration of symbols for accessing parameters and for accessing PLC variables of the HMI
  - Access to Ethernet interface

Parameters involved

PLC parameters for general purpose:

- P-0-1350, PLC control word
- P-0-1351, PLC status word
- P-0-1352, PLC user program administration data
- P-0-1361, PLC program name
- P-0-1363, PLC project info
- P-0-1367, PLC configuration

User program (filing):

- P-0-1353, PLC user program area 0
- P-0-1354, PLC user program area 1
- P-0-1355, PLC user program area 2
- P-0-1356, PLC user program area 3
- P-0-1357, PLC user program area 4
- P-0-1358, PLC user program area 5

Process input images PIIs

- P-0-1390, PLC input WORD0 AT %IB0
  to
  P-0-1409, PLC input WORD19 AT %IB38
- P-0-1440, PLC input DWORD25 AT %IB100
  to
  P-0-1447, PLC input DWORD32 AT %IB128

Process output images POIs

- P-0-1410, PLC output WORD0 AT %QB0

to

P-0-1429, PLC output WORD19 AT %QB38

Global PLC registers, unbuffered:

- P-0-1270, PLC Global Register A0
  to
  P-0-1301, PLC Global Register A31

Global text registers, unbuffered:

- P-0-1387, PLC Global Register AT0
  to
  P-0-1388, PLC Global Register AT1

Global list register, unbuffered:

- P-0-1368, PLC Global Register AL0

Global PLC registers, buffered:

- P-0-1370, PLC Global Register G0
  to
  P-0-1385, PLC Global Register G15
- P-0-1316, PLC Global Register G16
  to
  P-0-1331 PLC Global Register G31

Global list registers, buffered:

- P-0-1389, PLC Global Register GL0
- P-0-1311, PLC Global Register GL1
- P-0-1312, PLC Global Register GL2

To configure the display format of the registers:

- P-0-1386, PLC display format Global Register

8.4.2 Notes on installation / system configuration

Installation

To install "IndraMotion MLD" on the PC, it is necessary to install the current version of the **"IndraWorks MLD" commissioning tool** on the PC.

The **PLC programming system "IndraLogic"** has been integrated in the **"IndraWorks MLD" commissioning tool**. Both systems can be used simultaneously and in parallel access the supply unit or the PLC function.

System configuration

The system configuration of "IndraMotion MLD" is carried out using a PC with "IndraWorks MLD" installed that communicates with the supply unit via TCP/IP communication.

The projects are filed on the PC. The generated binary code is loaded to the control section of the supply unit and stored in parameters.

8.4.3 Function blocks for PSB firmware derivative

All libraries are available for the PSB firmware for supply units. However, the function blocks of the "MX_PLCopen" library, which are intended specifically for motion axes, cannot be used.

In the attempt to command a function block that is not supported, the Error output is set at this function block.

8.4.4 Overview of the function of parameters for general purpose

The following parameters are available for communication between "IndraMotion MLD" and "external devices":

- Global Registers G0 to G31 (buffered)

  → P-0-1370 bis P-0-1385 und P-0-1316 bis P-0-1331

  → Global registers with a data length of 4 bytes; parameters as registers with individual values for data exchange of the PLC with the supply unit or a higher-level PLC or control unit
- Global Registers A0 to A31 (unbuffered)

  → P-0-1270 bis P-0-1301

  → Parameters for data exchange (input and output data) of the PLC with a higher-level control unit or HMI
- Global Text Registers AT (unbuffered)

  → P-0-1387, P-0-1388

  → Freely usable text parameter with a maximum of 255 characters plus terminating zero character
- Global list registers GL (buffered)

  → P-0-1389, P-0-1311, P-0-1312

  → List parameters with 1024 elements (4 bytes each) for data exchange of the PLC with an external control or HMI
- Global list register AL (unbuffered)

  → P-0-1368

  → List parameters with 8192 elements (4 bytes each) for data exchange of the PLC with an external control or HMI
- Process input images PIIs

  → P-0-1390 to P-0-1409 (2 bytes each → word-wise)

  → P-0-1440 to P-0-1447 (4 bytes each → double word-wise)

  → Parameters contain the process image of the PLC inputs (PIIs); Before the beginning of the task, the PLC reads the values in the PIIs and updates the process image of the inputs.
- Process output images POIs

  → P-0-1410 to P-0-1429 (2 bytes each → word-wise)

  → Parameters contain the process image of the PLC outputs (POIs); at the end of the task, the PLC writes the value from the POIs to the outputs

8.5 Digital inputs/outputs

8.5.1 Brief description

General information

In their basic variant, all devices of the IndraDrive ML range already have configurable digital inputs/outputs.

Hardware requirements

The table below shows the number and function of the digital inputs/outputs.

Control section type	Control section		"DA" option		
	Number of standard inputs (probe inputs thereof)	Number of switchable Inputs/outputs	Number Inputs	Number Outputs	Number of switchable Inputs/outputs
CSB02.5B	11 (2)	5	6	6	2
KMV03	4 (2)	4	DA option is not possible		

Tab. 8-2: Control section, number of inputs/outputs

For further hardware properties, see the respective Project Planning Manual.

Features

- Sampling of digital inputs and outputs or transmitting data to them is done every 500µs.
- Configurable digital inputs/outputs with effective direction that can be freely set to some extent (input or output):
- Probe inputs are queried in steps of µs
- All inputs/outputs refer to the level of 0 V (LOW) or 24 V (HIGH)
- Multiple assignments for an input possible with multiple parameters
- An output can be used simultaneously as an input on the same parameter.
- Signal states of digital inputs/outputs are mapped to their respective individual parameters.
- Digital outputs can be directly controlled by the control master, if not used on supply unit side

Parameters involved

- S-0-0398, IDN-list of configurable data in signal status word
- S-0-0399, IDN-list of configurable data in signal control word

Digital inputs

- P-0-0300, Digital inputs, assignment list
- P-0-0301, Digital inputs, bit numbers
- P-0-0303, Digital inputs, input image of device
- P-0-0306, Digital inputs, assignment connector and pin
- P-0-0307, Digital inputs, input image sub-device

Digital outputs

- P-0-0304, Digital outputs, output image of device
- P-0-0310, Digital outputs, assignment list
- P-0-0311, Digital outputs, bit numbers
- P-0-0312, Digital outputs, assignment sub-device
- P-0-0313, Digital outputs, output image sub-device
- P-0-0316, Digital outputs, assignment connector and pin

Diagnostic messages involved

- F2010 Error when initializing digital I/O (-> S-0-0423)

8.5.2 Functional description

General information

☞ Each individual input or output can be assigned to parameters of the supply unit. The IDN of the allowed parameters can be found in the IDN lists of S-0-0398 and S-0-0399.

Cases to distinguish for determining source or target

Depending on whether an IDN is parameterized in the parameter "P-0-0300, Digital inputs, assignment list" or "P-0-0310, Digital outputs, assignment list", the IDN entry is used as a target or source.

- **Input of a supply unit (sub-device)**

  In the case of an input, the bit configured in the parameter "P-0-0301, Digital inputs, bit numbers" of an IDN (target parameter) defined in P-0-0300 is written with the logic value (0 or 1) provided at the input of the sub-device (P-0-0307).
- **Output of a supply unit (sub-device)**

  In the case of an output, the content of the bit configured in "P-0-0311, Digital outputs, bit numbers" is taken from the IDN (source parameter) determined in P-0-0310 and transmitted to the output of the sub-device (P-0-0313).

☞ If P-0-0300[i] = "S-0-0000", the respective entry in P-0-0301 is ignored. If P-0-0310[i] = "S-0-0000" is parameterized, the respective entry in P-0-0311 is irrelevant!

- **Access of the supply unit to a hardware input**

  The parameter P-0-0306 is used to assign any hardware input to the input image of the supply unit (P-0-0307). For the double-row X35 connector of the CSB02.5B control section this means that the row has to be specified in addition to the connector and pin. For digital input 14, for example, the value 35207 has to be parameterized. 35 for the connector designation, 2 for the second row and 07 for the PIN of the connector.
- **Writing a hardware output**

  The output image of the supply unit (P-0-0313) is linked to any hardware output using P-0-0312 and P-0-0316.

Status image of the assigned parameters of the supply unit

☞ The following parameters can be used as a status image of the assigned parameters:

- P-0-0307, Digital inputs, input image sub-device
- P-0-0313, Digital outputs, output image sub-device

Status of device-side inputs/outputs

☞ The signal status of the digital inputs/outputs is displayed in the following parameters:

- P-0-0303, Digital inputs, input image of device
- P-0-0304, Digital outputs, output image of device

Deactivation

To deactivate an input, the IDN "S-0-0000" can be entered in parameter P-0-0300 in the respective list element. Alternatively, the corresponding list element can be written with "0" in P-0-0306.

When deactivating an output, the corresponding list element can be written with the IDN "S-0-0000" in parameter P-0-0310, or the corresponding list element can be written with "0" in parameter P-0-0312 or P-0-0316.

Validity check of configuration lists

When a new assignment list is input or an element of the list is changed, all entries are checked for validity. If an entry is invalid (i.e. no allowed IDN entered) only this invalid entry is rejected.

☞ Incorrect entries are rejected when the list is checked and set to the respective default value.

Direct access to digit. Inputs/Outputs of the Control Section via Master Communication

Accessing digital inputs/outputs

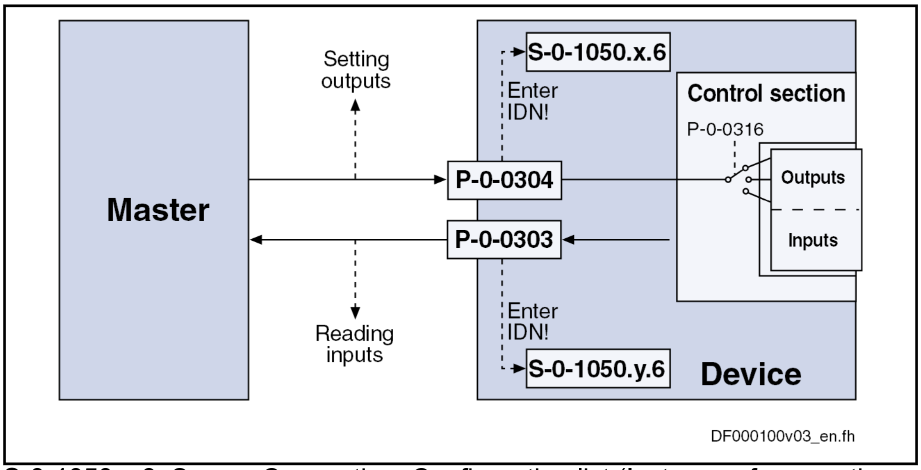
In order to directly actuate ("set") the digital outputs of the device via the master communication or directly query ("read out") the digital inputs, the parameters "P-0-0303, Digital inputs, input image of device" and "P-0-0304, Digital outputs, output image of device" can be included in the cyclic data of the master communication.

Prerequisites:

- Including parameter P-0-0303 in the group of cyclic actual values (Sercos: S-0-1050.y.6, Sercos connection: Configuration list; field bus: "P-0-4080, Field bus: Config. list of cyclic actual value data ch.")
- Including parameter P-0-0304 in the group of cyclic command values (Sercos: S-0-1050.x.6, Sercos connection: Configuration list; field bus: "P-0-4081, Field bus: Config. list of cyclic command value data ch.")
- Deactivating the axis access to the digital inputs/outputs is required. For this purpose, the list element assigned to the digital input is set to 0 in P-0-0306, accordingly in P-0-0312 for digital outputs.
- For the digital outputs it is additionally required to assign connector and PIN using P-0-0316.
- In the same way it is possible to address the digital inputs/outputs via the signal control word or status word.

☞ The digital outputs can only be directly controlled if they are not used on the supply unit side.

The figure below illustrates the access to the digital inputs/outputs of the control section via the master communication by the example of Sercos.



S-0-1050.x.6	Sercos Connection: Configuration list (Instance of connection produced by the slave)
S-0-1050.y.6	Sercos Connection: Configuration list (Instance of connection produced by the slave)
P-0-0303	Digital inputs, input image of device
P-0-0304	Digital outputs, output image of device
P-0-0316	Digital outputs, assignment connector and pin

Fig. 8-1: Accessing digital inputs/outputs of the control section via Sercos master communication

Behavior if master communication fails

If the cyclic communication fails, the value "0" is written to the parameters; this means that those digital outputs are deleted to which the master transmits data via the cyclic communication.

8.5.3 Notes on commissioning

Configuring the inputs/outputs

Configuring the inputs/outputs via IndraWorks dialog

To configure the digital inputs/outputs, it is recommended to select the parameterization via IndraWorks supported by a dialog. The IndraWorks dialog to configure the digital inputs is called by double-clicking on "I/O X31/X32" in the Project Explorer.

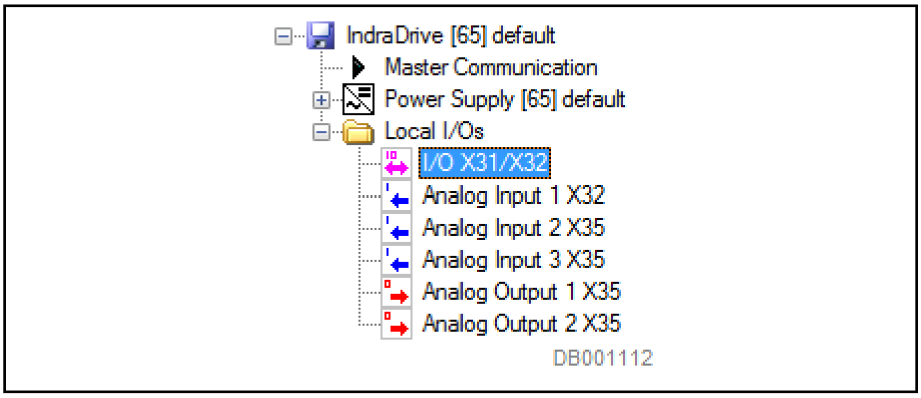


Fig. 8-2: Local I/Os in the Project Explorer with CSB02.5B control section

The following dialog will open in which the digital inputs/outputs can be parameterized.

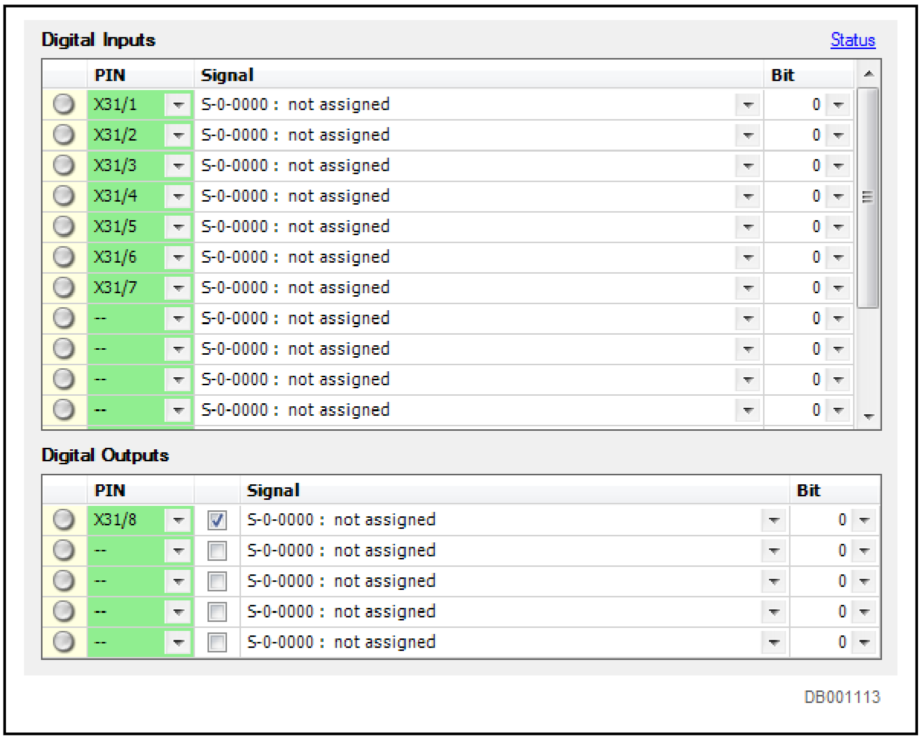


Fig. 8-3: "Digital inputs/outputs" dialog with CSB02.5B control section

Using the pull-down menus, the parameters and bit numbers can be assigned to the inputs/outputs of the device. In the "PIN" column, the interface pin from which input it is read or which output is set is parameterized.

An output is configured like an input. However, the check box has to be additionally ticked (see figure) for an output to configure the parameter P-0-0312 accordingly.

The LEDs at the left side of the dialog show the states of the individual inputs/outputs. By clicking "Status" the assignments of the interface connections are displayed in addition to the status.

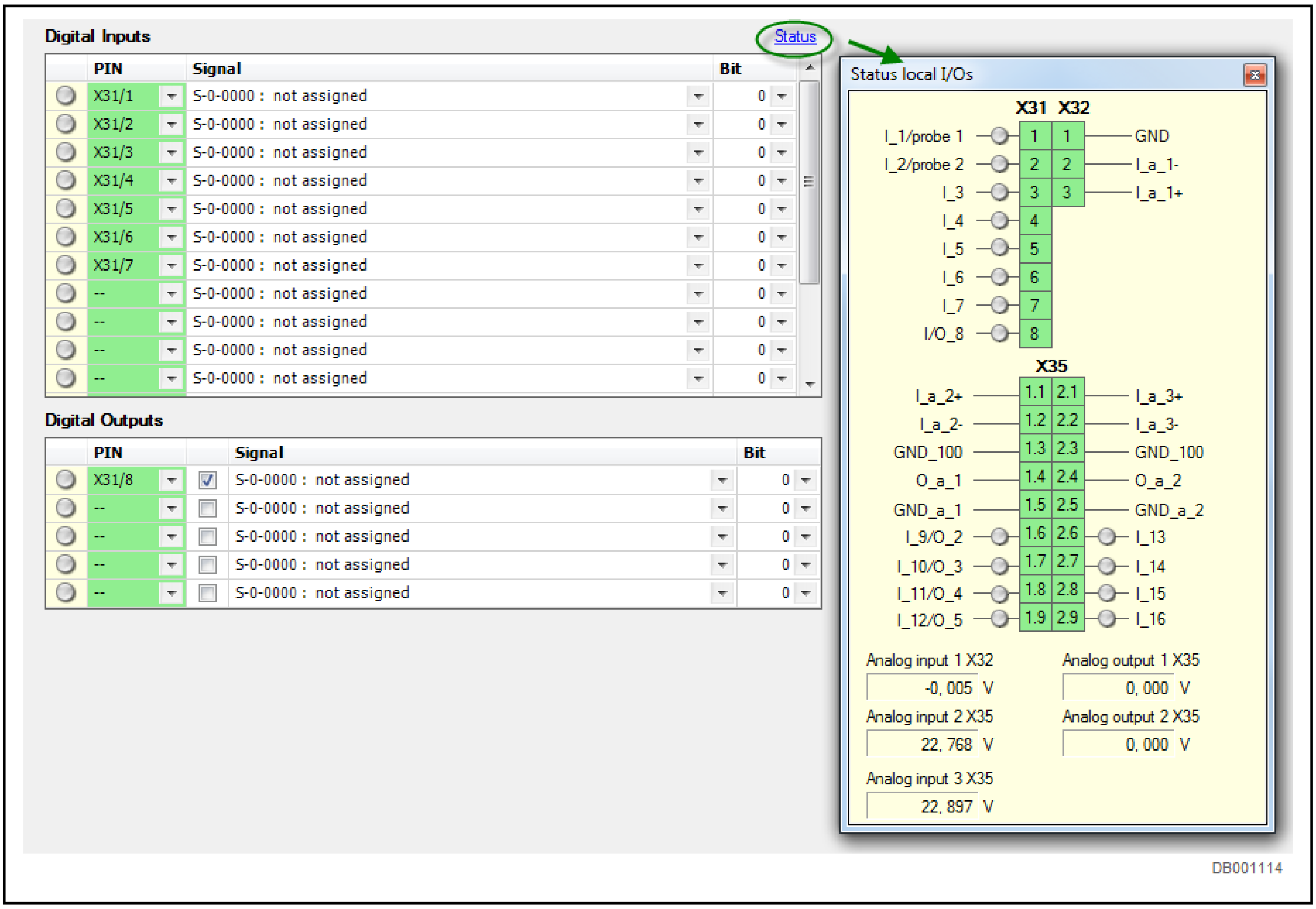


Fig. 8-4: Assignments of the interface connections

Configuring inputs via single parameter editor

As an alternative to the dialog-based parameterization of the digital inputs/outputs, the settings can be made directly in the parameters. It is required to call the single parameter editor in IndraWorks.

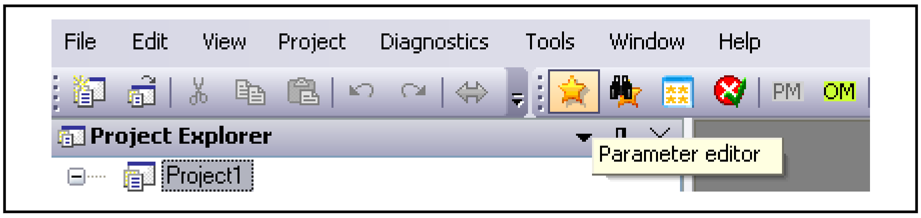


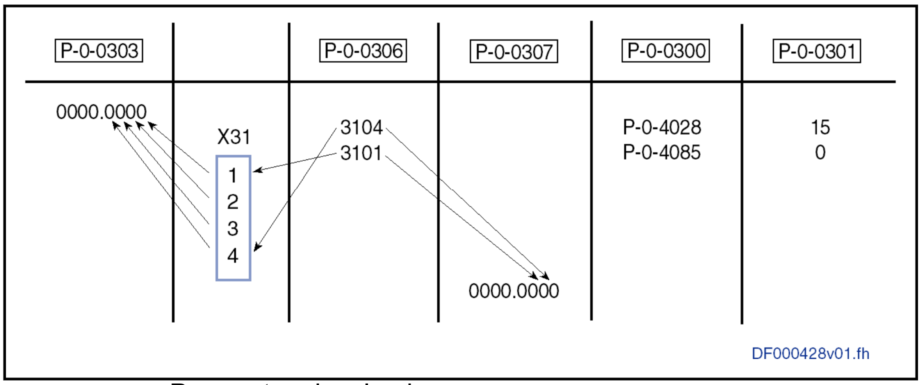
Fig. 8-5: Parameter editor

Using the single parameter editor, a parameter and a bit can be assigned to a selected input by entering the corresponding parameter IDN. The configuration procedure is described in the following.

Using parameter "P-0-0306, Digital inputs, assignment connector and pin", it is specified which pin of the relevant connector is copied to parameter "P-0-0307, Digital inputs, input image sub-device". Each bit of parameters P-0-0307 has a fixed assignment to the list elements of parameter P-0-0300 or P-0-0301, i.e. P-0-0307, bit 0 is applied to list element 0 of parameter P-0-0300 and P-0-0301, bit 1 is applied to list element 1 etc.

The identification numbers (IDN) of the target parameters are entered in list parameter "P-0-0300, Digital inputs, assignment list". The bits are selected via parameter "P-0-0301, Digital inputs, bit numbers".

The status of the interface is reflected in "P-0-0303, Digital inputs, input image of device".



Parameters involved:

P-0-0300, Digital inputs, assignment list
P-0-0301, Digital inputs, bit numbers
P-0-0303, Digital inputs, input image device
P-0-0306, Digital inputs, assignment connector and pin
P-0-0307, Digital inputs, input image sub device

Fig. 8-6: Digital inputs

Configuring outputs via single parameter editor

Using the single parameter editor, a selected bit of a parameter can be assigned to an output by entering the corresponding parameter IDN. The configuration procedure is described in the following.

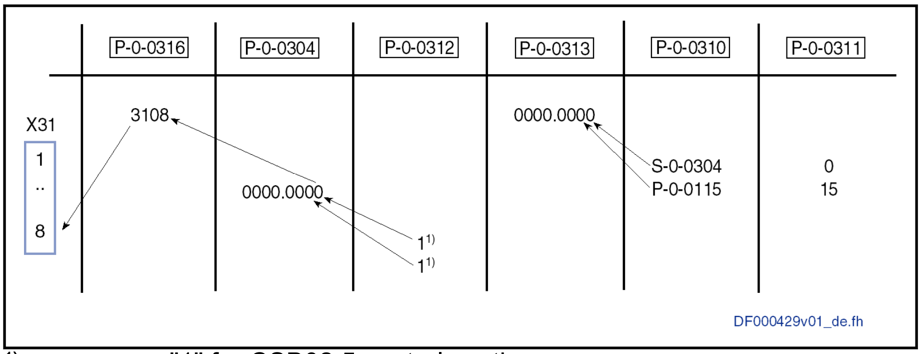
The identity numbers (IDN) of the source parameters are parameterized in list parameter"P-0-0310, Digital outputs, assignment list". The bits are selected via parameter "P-0-0311, Digital outputs, bit numbers".

Each list element of parameters P-0-0310 or P-0-0311 has a fixed assignment to the bits of parameter "P-0-0313, Digital outputs, output image subdevice", i.e. list element 0 of parameter P-0-0310 and P-0-0311 is applied to bit 0 of P-0-0313, list element 1 is applied to bit 1 etc.

The parameter "P-0-0312, Digital outputs, assignment sub-device" has to be written with "1" to assign the sub-device output image to the digitalen outputs.

Parameter "P-0-0304, Digital outputs, output image of device" reflects the status of the digital outputs. The list elements of parameter P-0-0312 are directly connected to the bits of P-0-0304. This assignment is analogous to P-0-0310.

Use parameter "P-0-0316, Digital outputs, assignment connector and pin", determine to which pins of the connectors the respective bits of P-0-0304 are copied.



1) "1" for CSB02.5 control sections

Parameters involved:

P-0-0310, Digital outputs, assignment list
P-0-0311, Digital inputs, bit numbers
P-0-0304, Digital outputs, output image device
P-0-0316, Digital outputs, assignment connector and pin
P-0-0313, Digital outputs, output image sub device
P-0-0312, Digital outputs, assignment sub device

Fig. 8-7: Digital outputs

8.5.4 Diagnostic and status messages

Digital inputs/outputs on control section

States of digital inputs/outputs

The states (= signal states) of the digital inputs/outputs are displayed in the parameters P-0-0303 and P-0-0304:

- Bit set ("1")

  → At the assigned input/output, a HIGH level (+24 V) is provided.
- Bit not set ("0")

  → At the assigned input/output, a LOW level (0 V) is provided.

Checking for invalid bit numbers

When entering data in parameter P-0-0301 or P-0-0311, a check is run to find out whether the specified bit number is a valid bit of the parameter (IDN) configured in parameter P-0-0300 or P-0-0310.

The following applies:

- **2-byte** parameter → bit numbers between **0 and 15** allowed
- **4-byte** parameter → Bit numbers between **0 and 31** are valid

In case of invalid inputs or inputs/outputs that have not been configured yet, "0" is displayed as bit number.

8.6 Integrated command value generator

8.6.1 Brief description

The integrated command value generator can be used for commissioning and controller optimization. The command value generator is used to generate various signal shapes (square wave, sine, noise, sine sweep) that are added to the closed control loop as command values.

In conjunction with the integrated oscilloscope function, the integrated command value generator also provides the possibility of measuring the frequency response.

Features

- Possibility of generating different signal shapes that are added as command values to the respective controller command value (voltage or current)

  The following signal shapes are possible:
  - Square-wave signals
  - Sine signals
  - Noise signals
  - Modified sine signals
  - Sine sweep
- Generating the **voltage and current command values** in the voltage controller clock
- With regard to **amplitude and frequency**, generated command values can be freely defined

Parameters involved

- P-0-1150, Command value generator output
- P-0-1151, Command value generator, list of possible target parameters
- P-0-1152, Command value generator, target parameter assignment
- P-0-1153, Command value generator, control word
- P-0-1154, Command value generator, offset
- P-0-1155, Command value generator, amplitude
- P-0-1156, Command value generator, duration 1
- P-0-1157, Command value generator, duration 2
- P-0-1158, Command value generator, periodic time
- P-0-1159, Command value generator, sine sweep start frequency
- P-0-1160, Command value generator, sine sweep end frequency
- P-0-0028, Oscilloscope: Control word
- P-0-0031, Oscilloscope: Time resolution
- P-0-0032, Oscilloscope: Size of memory

- S-0-1706.0.1, DC bus voltage command value
- S-0-1706.0.11, Active-current generating component, command value
- S-0-1706.0.12, Reactive-current generating component, command value

8.6.2 Functional description

Setting/activating the function

Clock rate

The integrated command value generator provides the possibility of generating and adding voltage and current command values in the voltage controller clock for commissioning.

Activation

The command value generator is activated and controlled via parameter "P-0-1153, Command value generator, control word" by setting the enable bit. When the enable signal has been set, the generator generates command values.

In parameter P-0-1153, it is also possible to specify that the enabling of the command value generator is automatically deactivated in the case of errors. In this case, the enable signal has to be set again after each error or after the control voltage has been switched on.

Drive enable

In order that the generated command values take effect, drive enable has to be set.

This can be done in the following ways:

- Via a digital input
- Via the master communication

Selecting the target parameter

The identity number of the parameter is entered in parameter "P-0-1152, Command value generator, target parameter assignment" to which the output signal of the command value generator is applied to.

The IDNs of the possible target parameters for the generator output are specified in parameter ""P-0-1151, Command value generator, list of possible target parameters"

The following list shows possible target parameters to which the output signal of the command value generator (P-0-1150) can be assigned:

- S-0-1706.0.1, DC bus voltage command value
- S-0-1706.0.11, Active-current generating component, command value
- S-0-1706.0.12, Reactive-current generating component, command value

See also description of parameter "P-0-1151, Command value generator, list of possible target parameters"

☞ The unit and attribute of the generated signal are adjusted according to attribute and unit of the assigned parameter. S-0-0000, Dummy parameter can also be assigned as target parameter of the command value generated to use the command value generator as waveform generator.

☞ The target parameter is written in limited form according to its minimum and maximum values set while the signal in the command value generator output (P-0-1150) is output with the parameterized amplitude without restriction. If an amplitude is set which leads to the value exceeding the maximum value or dropping below minimum value of the target signal, the signal sequences in the command value generator output and in the target parameter do not match.

Selecting the signal shape

The shape of the desired output signal is determined using the respective bits in parameter "P-0-1153, Command value generator, control word".

It is possible to choose between the following command value signal shapes:

- Square-wave signals

  → Pulse generator with definable pulse/pause relationship, variable frequency and direct voltage component (offset)
- Sine signals

  → Sine generator generates signal up to theoretical maximum frequency of 2 kHz with variable frequency and direct voltage component (offset)
- Noise signals

  → Noise generator generates wide-band "white noise"; amplitude of the noise signal can be defined as a mere factor or using an envelope curve (= square-wave signal)

- **Modified sine signals**

  → Modified sine generator generates composite sine shape consisting of two joined half-waves of different signs and different periodic times
- **Sine sweep**

  → The sine sweep generator generates a sine whose frequency varies, with an amplitude and an offset. The frequency increases linearly from the starting frequency to the end frequency.

Advanced settings

Other possible settings in the control word of the command value generator:

- Activation of **periodic signal generation**

  → Selected signal is cyclically generated and output with a periodic time (frequency) that can be defined
- **Switch-off delay**

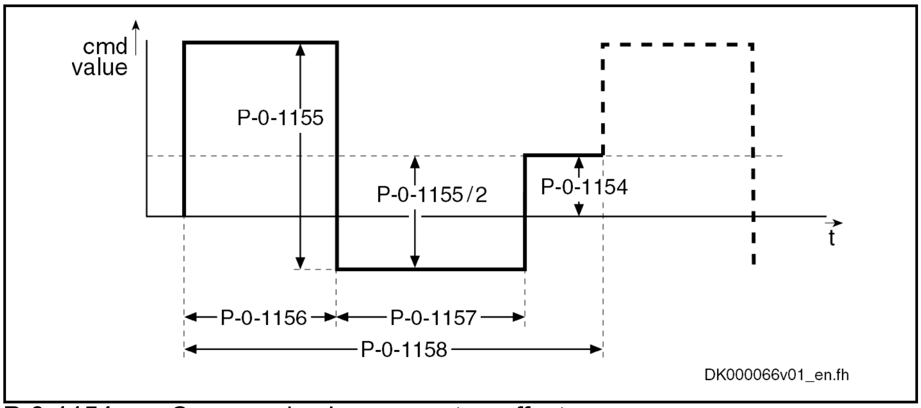
  → The deactivation of the command value generator (command value generator output = "0") can be delayed, i.e. the deactivation is delayed until the signal period is complete.

Pulse generator (for square-wave signal)

The pulse generator generates a square-wave signal that can be varied in the following properties:

- Frequency or periodic time of the signal
- Amplitude
- Offset (DC offset; positive/negative)
- Pulse/pause relationship

The exemplary figure below illustrates the output signal of the pulse generator with manual intervention:



P-0-1154	Command value generator, offset
P-0-1155	Command value generator, amplitude
P-0-1156	Command value generator, duration 1
P-0-1157	Command value generator, duration 2
P-0-1158	Command value generator, periodic time

Fig. 8-8: Output signal of pulse generator

☞ If periodic command value generation has been selected in the control word, parameter "P-0-1158, Command value generator, periodic time" determines the cycle time or periodic time.

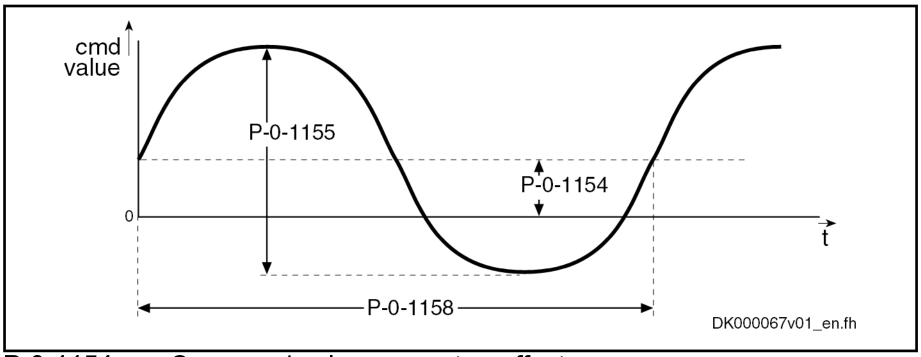
In the case of P-0-1158 = (P-0-1156) + (P-0-1157), the result is a periodic square-wave signal, if the periodic output has additionally been activated in the control word.

Sine generator

The sine generator generates a sine that can be varied in the following properties:

- Frequency or periodic time of the signal
- Amplitude
- Offset (DC offset; positive/negative)

The exemplary figure below illustrates the output signal of the sine generator with the possibilities of influencing:



P-0-1154 Command value generator, offset
P-0-1155 Command value generator, amplitude
P-0-1158 Command value generator, periodic time

Fig. 8-9: Output signal of sine generator

> The target parameter selected in parameter P-0-1152 determines the initial angle of the signal. For currents it is 90°.

Advanced settings

Advanced settings can be selected in parameter "P-0-1153, Command value generator, control word":

- In many cases it is important that the sine signal does not contain any offset (area under the curve). The deactivation of the command value generator can therefore be delayed until the period is complete (P-0-1153, bit 6).
- If no target parameter (P-0-1152 = S-0-0000) has been assigned to the output of the command value generator, the signal waveform can be switched from sine to cosine (P-0-1153, bit 9).

Noise generator

The method of the feedback shift register is used for generating the random numbers. In each sequence a bit for the output is generated which is set or cleared at random so to speak. The periodic time of the noise signal is set to 4095 clocks ($T_{A\_voltage}$).

> The generated noise signal is free of mean values over an entire period.

Output format (amplitude modulation)

There are the following options for outputting the pulse sequences:

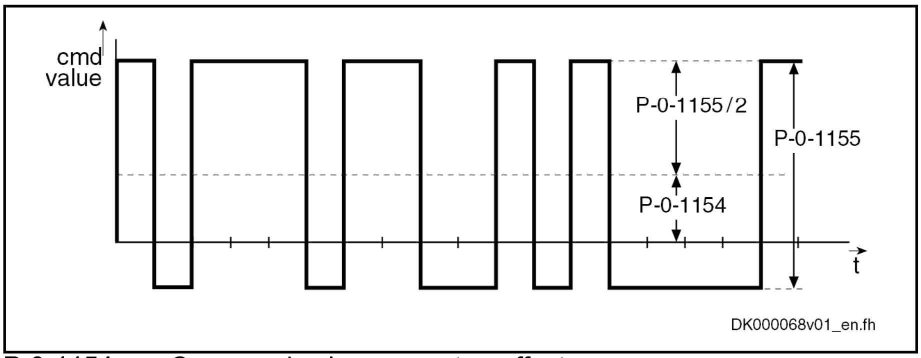
- Noise signal as square-wave signal with parameterizable amplitude and, if necessary, offset component

  → Amplitude is set to positive or negative according to the sign of the feedback shift register

- Noise signal with continuous amplitude

  → Feedback shift register is interpreted as numerical value and evaluated with amplitude

The exemplary figure below illustrates the output signal of the noise generator with the possibilities of influencing:



P-0-1154 Command value generator, offset
P-0-1155 Command value generator, amplitude

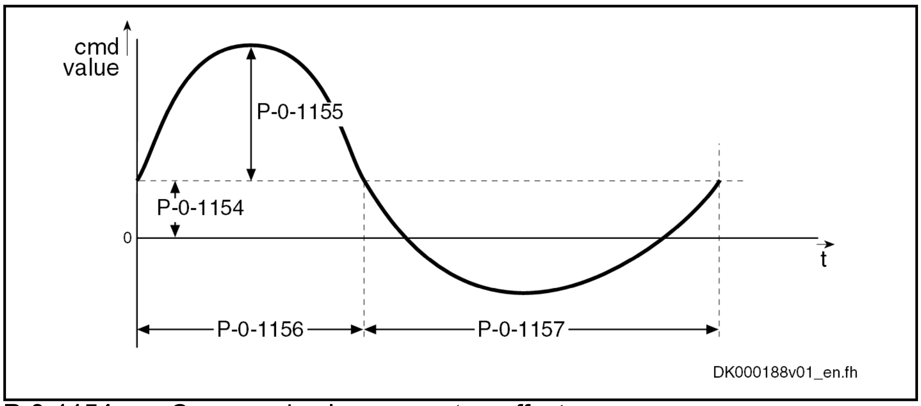
Fig. 8-10: Output signal of noise generator

Modified sine generator

In addition, a modified sine generator is available with two different half-waves of the same amplitude. The output signal of the generator can be varied in the following properties:

- Frequency or periodic time of the signal
- Duration of the first half-wave
- Duration of the second half-wave
- Amplitude
- Offset (DC offset; positive/negative)

The exemplary figure below illustrates the modifiable output signal of the sine generator with the possibilities of influencing:



P-0-1154 Command value generator, offset
P-0-1155 Command value generator, amplitude
P-0-1156 Command value generator, duration 1
P-0-1157 Command value generator, duration 2

Fig. 8-11: Output signal of noise generator

Sine sweep generator

The sine sweep generator generates a sine with varying frequency. The frequency increases linearly from the starting frequency to the end frequency ("sweep up") and decreases linearly down to the initial frequency ("sweep down").

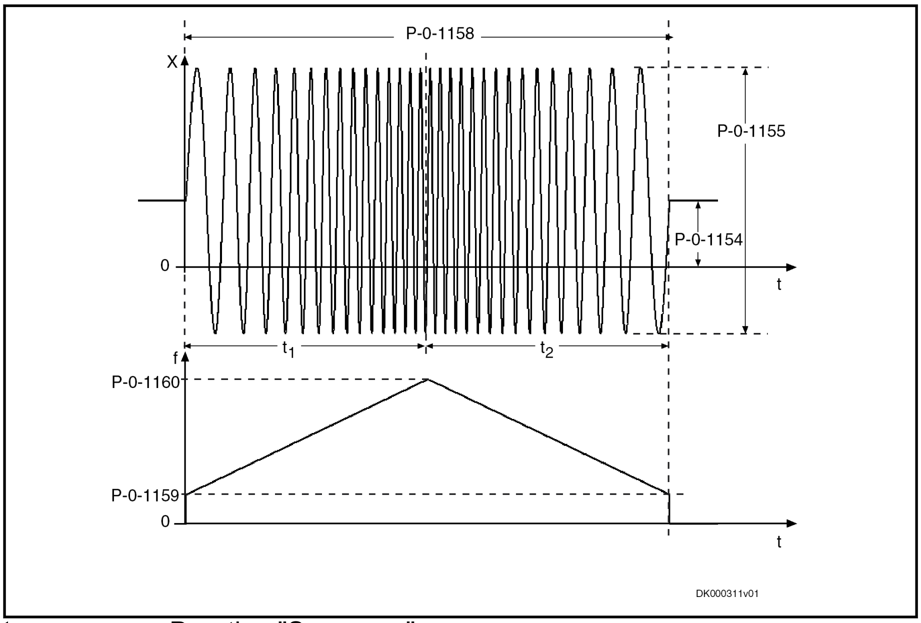
The following output signal properties can vary:

- Starting frequency
- End frequency
- Periodic time of signal (duration of "sweeping up" and "sweeping down" in total).
- Amplitude
- Offset (DC offset, positive/negative)

☞ The periodic time of the sweep must correspond to at least four-times the duration of the minimum frequency to be run through (starting and end frequency). Otherwise, the command value generator cannot generate any useful signals.

If, for example, 0.1 Hz is entered as a starting frequency and the end frequency is higher, the periodic time of the sweep must be at least 4 × 1/0.1Hz = 40 s.

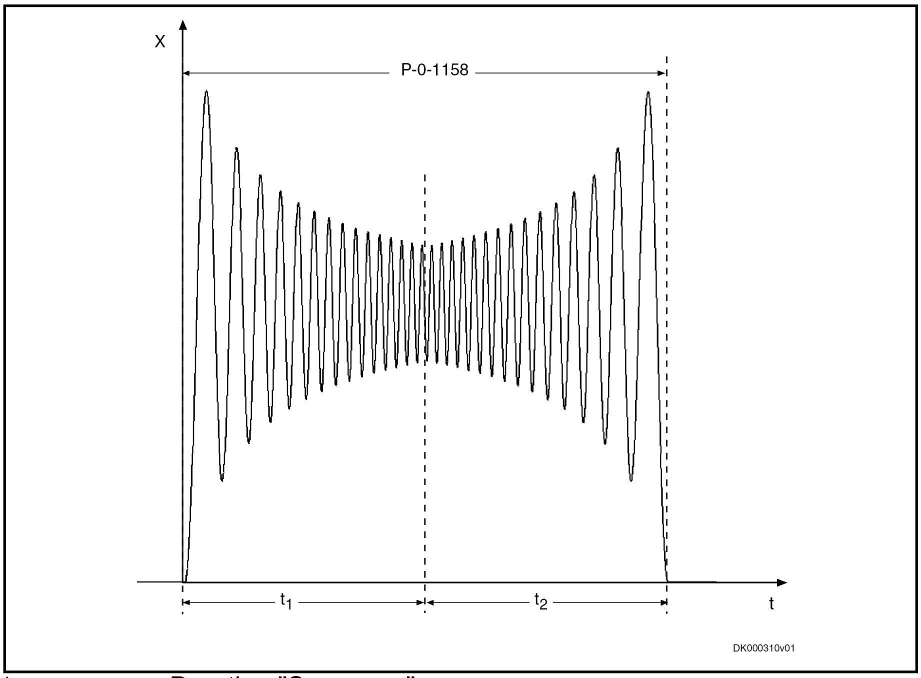
The exemplary figure below illustrates a sine sweep with manual intervention:



t_1	Duration "Sweep up"
t_2	Duration "Sweep down"
P-0-1154	Command value generator, offset
P-0-1155	Command value generator, amplitude
P-0-1158	Command value generator, periodic time
P-0-1159	Command value generator with sine sweep
P-0-1160	Command value generator, end frequency sine sweep

Fig. 8-12: Output signal of sine sweep generator

☞ The generated sine sweep without offset does not have any mean value during the entire periodic time "sweep up and sweep down"). During "sweeping up", the offset increases and decreases again during "sweeping down", as displayed in the following graphics.



t_1	Duration "Sweep up"
t_2	Duration "Sweep down"
P-0-1158	Command value generator, periodic time

Fig. 8-13: Integral sine sweep without offset (P-0-1154 = "0")

8.6.3 Notes on commissioning

Bandwidth and frequency response measurement

Frequency response measurement always requires the according wide-band excitation that is provided by the noise generator or sine sweep generator. In addition to the generation of the excitation signal, the recording of measured values (= sampling) is required which is carried out with the integrated oscilloscope function.

Consequently, it is required to adjust the recording time of the oscilloscope function to the periodic time of the excitation signal.

- Noise signal
  - Periodic time: T_R= 4096 * $T_{excitation}$ (cycle time of excitation)

    The cycle time of the excitation $T_{excitation}$ depends on the selected target parameter
    - Voltage and current command values: $T_{excitation}$= $T_{A\_voltage}$ (cycle time of voltage control)
  - Oscilloscope settings
    - Oscilloscope, time resolution: P-0-0031 = $T_{excitation}$
    - Oscilloscope, memory depth: P-0-0032 = 4096
    - Trigger settings
      - Trigger method: Signal trigger
      - PreTrigger: 0%
      - Trigger signal: P-0-1150
      - Edge: rising edge
      - Trigger value: P-0-1154 + P-0-1155/2

- Sine sweep

  Since a maximum of 4096 values are used for frequency response measurement in the oscilloscope, it is useful to coordinate the settings for the sine sweep and those of the oscilloscope.

  1. Select starting (P-0-1159) and end frequency (P-0-1160) of sine sweep
  2. Select oscilloscope settings
     - Oscilloscope, time resolution: Select P-0-0031 >= 1 / (2*P-0-1160)
     - Oscilloscope, memory depth: P-0-0032 = 4096
     - Trigger settings
       - Trigger method: Signal trigger
       - PreTrigger: 0%
       - Trigger signal: P-0-1150
       - Edge: rising edge
       - Trigger value: P-0-1154 + 0,1*P-0-1155
  3. Define periodic time sine sweep (P-0-1158): P-0-1158 = 2*P-0-0031*P-0-0032

     Since the parameterized periodic time (P-0-1158) with sine sweep is made up of the time for "sweeping up" and "sweeping down" combined, it is sufficient to record half of the periodic time.

In case of the noise signal, the band width of the excitation signal depends on the cycle time of the excitation $T_{excitation}$ the signal is generated with and in case of the sine sweep, on the end frequency (P-0-1160).

- Noise signal: Bandwidth excitation: $BW_{excitation}$ [Hz] =1 / (2*$T_{excitation}$);
- Sine sweep signal: Bandwidth excitation: $BW_{excitation}$ [Hz] = P-0-1160;

The overview below illustrates the possible excitation signals and measuring signals for the recording:

Control loop	Command value generator excitation signal	Cycle time of excitation $T_{excitation}$	Measuring signals of oscilloscope function
Current (I_q)	S-0-1706.0.11, Active-current generating component, command value	$T_{A\_voltage}$	S-0-1707.0.11, Effective active-current generating component, command value S-0-1707.0.13, Active-current generating component, actual value
Current (I_d)	S-0-1706.0.12, Reactive-current generating component, command value	$T_{A\_voltage}$	S-0-1707.0.12, Effective reactive-current generating component, cmd value S-0-1707.0.14, Reactive-current generating component, actual value
Voltage	S-0-1706.0.1, DC bus voltage command value	$T_{A\_voltage}$	S-0-1706.0.1, DC bus voltage command value S-0-1707.0.1, Actual DC bus voltage

$T_{A\_voltage}$ Voltage controller cycle time

Tab. 8-3: Signals for excitation and recording

☞ For bandwidth and frequency response measurements, a dialog is available in "IndraWorks Ds/D/MLD". This dialog automatically selects the settings for excitation and the measurement depending on the frequency response type.

Optimizing the controller

The integrated command value generator is very well suited for optimizing the control loops (current, voltage), since it generates a defined command value characteristic (e.g., pulse or square-wave signals).

Current controller

The field-oriented current controller that takes effect in closed-loop operation implements the following subfunctions:

- Closed-loop control of d-component (reactive-current generating current)
- Closed-loop control of q-component (active-current generating current)

To evaluate the current controller for the active-current generating control loop, excitation has to take place via parameter "S-0-1706.0.11, Active-current generating component, command value" and the parameters "S-0-1707.0.11, Effective active-current generating component, command value" and "S-0-1707.0.13, Active-current generating component, actual value" have to be recorded with the oscilloscope function.

To evaluate the current controller for the reactive-current generating control loop, excitation has to take place via parameter "S-0-1706.0.12, Reactive-current generating component, command value" and the parameters "S-0-1707.0.12, Effective reactive-current generating component, cmd value" and "S-0-1707.0.14, Reactive-current generating component, actual value" have to be recorded with the oscilloscope function.

Voltage controller

To evaluate the voltage controller, excitation has to take place via parameter "S-0-1706.0.1, DC bus voltage command value" and the parameters

S-0-1706.0.1 and "S-0-1707.0.1, Actual DC bus voltage" have to be recorded with the oscilloscope function.

9 Handling, diagnostic and service functions

⚠ WARNING	Dangerous movements! Danger to life, risk of injury, serious injury or property damage!

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine's range of motion (e.g., by using safety fences, safety guards, protective coverings, light barriers).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.

9.1 Parameters, basics

9.1.1 Properties/features of parameters

Brief description

The firmware of the controller firmware maps the controller via data in an internal calculation model. All operating data relevant therefor are mapped to parameters. An identification number (IDN) is assigned to each parameter. The IDN allows operating data to be accessed via

- of the engineering port

- or -

- a master communication interface suited for data transfer.

The operating data stored in parameters can be identified using the IDN. They can be read and transferred, if required. The user write access to parameters depends on the properties of the respective parameter and the current communication phase. The firmware checks specific parameter values (operating data) for validity.

Functional description

Parameter structure

Each parameter consists of seven data block elements.

Element no.	Description	Notes
1	Identification number (IDN)	Parameter identification/ reading of data status
2	Name	Can be changed by way of language selection
3	Attribute	Contains decimal places, data length, data type and display format, function
4	Unit	Can be changed by way of scaling or language selection
5	Minimum input value	Minimum input value of operating data

Element no.	Description	Notes
6	Maximum input value	Maximum input value of operating data
7	Operating data	Parameter value

Tab. 9-1: Data block elements of a parameter

See also "Definitions" in the separate documentation "Parameter description for IndraDrive controllers".

Writing and reading a parameter

All data block elements can be read via an appropriate master communication interface or at Engineering port. Only the operating data can be written, too.

The operating data of a parameter can be permanently write-protected or always resp. temporarily be written. This write access depends on

- the communication phase

- and -

- the activation of a password.

Error messages can occur during reading and writing of the operating date (see "Terms, basic principles: Error").

Data status

Each parameter has a data status. The data status contains information on:

- Validity/invalidity of the operating data (parameter value)
- Command states (command acknowledgement) for parameters used to enable commands (see "Terms, basic principles: Commands").

The controller checks the data status of the parameters for validity of the operating data when changing from parameter mode to operating mode. When this happens, the operating data (parameter values) of the parameters contained in the following list parameters are checked for validity:

- S-0-0018, IDN-list of operation data for CP2
- S-0-0019, IDN-list of operation data for CP3

The control master can query the IDNs of the parameters with invalid operating data (parameter values) via:

- S-0-0021, IDN-list of invalid operation data for CP2
- S-0-0022, IDN-list of invalid operation data for CP3
- S-0-0423, IDN-list of invalid data for parameterization levels

The data status is signaled when the control master executes a write command to the data block element no. 1 of a parameter. This allows state of a command which was started to be recognized by the control master.

See "Basic functions of master communication: Command processing"

Language selection

In parameter "S-0-0265, Language selection", set the language in which parameter names and text in units of parameter values will be displayed.

The language selected via parameter S-0-0265 will only take effect in parameter "S-0-0095, Diagnostic message", when the diagnostic message also changes once the language has been selected.

Notes on commissioning

During the controller-internal check of parameter values carried out when changing from parameter mode to operating mode, the following command errors can be reported:

- C0201 Invalid parameters (->S-0-0423)
- C0202 Parameter limit error (->S-0-0423)

- or -

- C0201 Invalid parameters (->S-0-0423)
- C0202 Parameter limit error (->S-0-0423)
- C0203 Parameter conversion error (->S-0-0423)

When errors of this category are detected, the IDNs of the parameters with the incorrect operating data are listed in:

- S-0-0021, IDN-list of invalid operation data for CP2
- S-0-0022, IDN-list of invalid operation data for CP3
- S-0-0423, IDN-list of invalid data for parameterization levels

A valid value has to be written to the listed IDNs. The value range limits are contained in the data block elements no. 5 and no. 6. The limits are directly displayed via the commissioning tool "IndraWorks Ds/D/MLD" when entering single parameters.

Language setting The desired display language of parameter names and text in units of parameter values has to be set in parameter

- S-0-0265, Language selection.

9.1.2 Loading, storing and saving parameters

Brief description

Parameters All relevant operating data are mapped to parameters and stored in the controller.

Data memory Several non-volatile data memories are available in an IndraDrive controller:

- In the controller
- In the motor encoder (depending on motor type)

In addition, the controller has a volatile data memory (working memory).

Condition as supplied Condition as supplied of the Rexroth drive components:

- The controller memory contains the firmware and the controller-specific parameter values.
- The motor encoder memory contains the encoder-specific and, depending on the motor type, the motor-specific parameter values.

Storing the application-specific parameter values The application-specific parameter values are stored in the controller. Due to the limited number of writing cycles of non-volatile storage media, application-specific parameter values can be stored in the working memory (volatile memory), too.

Saving parameter values Saving application-specific parameter values is required in the following cases:

- After initial commissioning of the machine axis or the motor
- Before replacing the controller for servicing (if possible)

Application-specific parameter values can be saved using:

- "IndraWorks Ds/D/MLD" commissioning tool → saving the parameter values on an external data carrier
- Control master → saving the parameter values on a master-side data carrier

Parameter IDN lists

The controller supports master-side saving of parameter values by listing parameter identification numbers (IDNs). Using these lists guarantees complete storage of the application-specific parameter values. It is also possible to determine IDN lists defined by the customer.

Loading parameter values

Parameter values need to be loaded in the following cases:

- Initial commissioning of the motor (loading the default values and motor-specific parameter values)
- Serial commissioning of machine axes at series machines (loading the parameter values saved after initial commissioning)
- Restoring a defined initial state (repeated loading of the values saved after initial commissioning)
- Replacing the controller for servicing (loading the current parameter values saved before servicing)

Options for loading parameter values to the controller:

- Motor encoder data memory → loading the parameter values by command or via the control panel during initial motor commissioning
- "IndraWorks Ds/D/MLD" commissioning tool → loading the parameter values from an external data carrier
- Control master → loading the parameter values from a master-side data carrier

Checksum of parameter values

By means of checksum comparison, the control master can determine whether the values of the application-specific parameter values currently active in the drive comply with the values saved on the master side.

Parameters involved

- S-0-0017, IDN-list of all operation data
- S-0-0192, IDN-list of all backup operation data
- S-0-0262, C07_x Load defaults procedure command
- S-0-0263, C2300 Load working memory procedure command
- S-0-0264, C2200 Backup working memory procedure command
- S-0-0269, Storage mode
- S-0-0270, IDN-list of selected backup operation data
- S-0-0293, C2400 Selectively backup working memory procedure command
- S-0-0326, Parameter checksum
- S-0-0327, IDN list of checksum parameter
- S-0-0531, Checksum of backup operation data
- P-0-0013, List of all IDNs not corresponding to default value
- P-0-0660.0.1, Configurable factory default values
- P-0-4023, C0400 Communication phase 2 transition
- P-0-4090, Configuration for loading default values

Diagnostic messages involved

Load defaults procedure:

- C0702 Default parameters not available
- C0703 Default parameters invalid

- C0704 Parameters not copyable
- C0706 Error when reading the controller parameters
- C0740 Command Activate field bus profile settings
- C0743 Error in activation of field bus profile settings
- C0750 Load defaults procedure command (factory settings)
- C0751 Parameter default value incorrect (-> S-0-0423)
- C0752 Locked with password
- C0761 Factory default values incorrect (->S-0-0423)
- C0799 An invalid index was set

Backup working memory procedure:

- C2202 Error when writing data to non-volatile memory
- C2200 Backup working memory procedure command

Load working memory:

- C2300 Load working memory procedure command
- C2301 Error when reading non-volatile memory
- C2302 Error when converting parameters

Selectively backup working memory procedure:

- C2400 Selectively backup working memory procedure command
- C2402 Error when saving parameters

Other diagnostic messages:

- F2100 Incorrect access to command value memory
- F2102 It was impossible to address I2C memory

Functional description

Data memory in the controller

All operating data referring to hardware are stored in the controller. They cannot be changed by the user.

Each circuit board is provided with a non-volatile memory. It carries the circuit board code and circuit board-specific operating data.

On the main circuit board there is a non-volatile memory (flash) and a volatile memory (working memory). The flash memory contains the circuit board-specific operating data.

In the RAM, an image of all data available in the drive (retain data, identification data and operating data) is contained.

Parameter mode and operating mode

Parameters the operating data of which can be changed, can be written with values in one or possibly several communication phases. We basically distinguish between

- Parameter mode (PM) and
- Operating mode (OM).

As a matter of principle, all parameters that can be changed can be written in the parameter mode.

"Load defaults procedure" command

Via the "S-0-0262, C07_x Load defaults procedure command" command, it is possible to set a defined initial status of the parameter values.

In case of controllers delivered with factory settings (ordering an additional FWS option), the factory settings are restored after the default values have been recovered successfully.

The scope of functions of this command can be specified using the configuration of parameter "P-0-4090, Configuration for loading default values":

- **Command selection** (bits 0...3):
  - Load default values (factory settings)

    Loading of non-volatile parameters to their default values.

    A software option can be purchased for each controller to assign individual parameters ex works with specific values. Instead of the default values, these values are loaded when using the “Load default values” option.
  - Load default values (MLD)

    Reset parameters (incl. boot project) of the drive-integrated PLC.
  - Enable field bus profile settings

    The field bus-dependent parameters are enabled depending on the profile

    → see "Profile types (with field bus interfaces)"
  - Load supply-specific controller default values (from PSB-20VRS)
  - Load application-specific default values (with MPx-20VRS and above)
- **Scaling of command execution** (bits 4...8):

  It is only possible to execute the command "load factory settings," "default values" and "field bus profile settings" in PM. The command cannot be executed if the drive is locked with a customer password, also see "C0752 Locked with password".

  The "load defaults procedure" command provides the option to load default values for all parameters or to selectively exclude the following groups:
  - Master communication parameters
  - MLD parameters
  - Engineering interface

See also description of parameter "P-0-4090, Configuration for loading default values"

Storage mode

Depending on "S-0-0269, Storage mode", the application-specific parameter values are stored in the controller in volatile form (in the RAM) or non-volatile form (in the flash memory).

Non-volatile storage is carried out with each write access to the respective operating data.

Volatile storage of parameter values is recommended when application-specific parameters are cyclically written. Otherwise, the service life of the non-volatile storage media is affected.

NOTICE	**Damage to the internal memory (flash) caused by cyclic command execution (write accesses to the flash)!**

During the execution of some commands (see description of the respective diagnostic command message; e.g. C0500), data is also written to the internal memory (flash). This memory, however, only allows a limited number of write accesses. For this reason, make sure that such write access is not carried out too often (approx. 100,000 writing cycles at most).

Parameter IDN lists

For saving the relevant application-specific parameter values the drive makes lists of IDNs available that support the complete backup of parameter group values:

- S-0-0192, IDN-list of all backup operation data
- S-0-0270, IDN-list of selected backup operation data

Parameter S-0-0192 contains a list of IDNs that cannot be modified. Parameter S-0-0270 contains an empty list where IDNs according to application-specific requirements can be entered.

For saving all parameter values, the controller provides the list of the IDNs of all parameters in

- S-0-0017, IDN-list of all operation data

To identify the parameters whose value has changed compared to their default value, the drive makes provides parameter

- P-0-0013, List of all IDNs not corresponding to default value

"Backup working memory" or "selectively backup working memory" command

If the option "volatile memory" was set in parameter "S-0-0269, Storage mode" , the values of the parameters contained in the list parameter S-0-0192 can be saved in the non-volatile memory upon start of "S-0-0264, C2200 Backup working memory procedure command".

If the parameter values of the list of S-0-0270 are to be saved, "S-0-0293 , C2400 Selectively backup working memory procedure command" has to be activated. Unless the storage mode (S-0-0269) is changed, the values once saved in the flash memory via the commands C2200 or C2400 remain unchanged.

"Load working memory procedure" command

By means of "S-0-0263, C2300 Load working memory procedure command", the values of the non-volatile flash memory are copied to the volatile RAM.

☞ This only makes sense when volatile storage mode was set (S-0-0269) and parameter values were saved in the controller-internal flash memory!

Saving application-specific parameter values

To backup the application-specific parameter values, e.g. after initial commissioning, there are the following options:

- **Commissioning tool "IndraWorks Ds/D/MLD"**

  → The parameter values of the list of S-0-0192 are stored on an external data carrier (hard disk, floppy disk or the like); the target is assigned via the tool menu. Requirement: Engineering has to be connected to the drive.

- **Control master**

  → The parameter values of the list of S-0-0192 or S-0-0270 and/or other parameters, if necessary, are stored on a master-side data carrier by command of the control master.

Loading application-specific parameter values

To load saved parameter values or transmit axis-specific parameter values to controllers of other axes, there are the following possibilities:

- **Commissioning tool "IndraWorks Ds/D/MLD"**

  → The parameter values (according to list of S-0-0192) stored on an external data carrier (hard disk, floppy disk or the like) are loaded to the controller; source assignment is carried out via the menu of the tool. Requirement: an established Engineering connection to the controller.

- **Control master**

→ The parameter values of the list of S-0-0192 or S-0-0270 and/or other parameters, if necessary, are loaded from a master-side data carrier to the controller by command of the control master.

Parameter checksum via list parameter S-0-0327

When reading out parameter "S-0-0326, Parameter checksum", the check sum of all parameter values is generated whose IDN is contained in parameter "S-0-0327, IDN list of checksum parameter". Changes in the parameter settings can be detected by comparing the checksums.

By comparing the checksum of the parameter values currently active in the drive to a checksum value stored at the time of parameter saving, it is possible to determine whether the active application-specific parameter values are correct.

By default, no IDNs have been entered in parameter S-0-0327!

Parameter checksum via list parameter S-0-0192

When reading out parameter "S-0-0531, Checksum of backup operation data", the checksum of the parameters is generated whose IDN is contained in parameter"S-0-0192, IDN-list of all backup operation data".

☞ In list parameter S-0-0192, the ident numbers (IDN) of the parameters are stored whose values are axis-specific or supply unit-specifically and that have to be loaded to the drive for correct operation of the respective axis or to the respective supply unit.

When the system has been set up completely, the checksum for each controller can be read via parameter S-0-0531. The control master can store these values. By comparing the checksum which was saved to the new checksum which was read, it is possible to find out whether data relevant to operation have changed.

Notes on commissioning

Initial commissioning

To start the initial commissioning of a machine axis or of a supply unit , ensure that the relevant firmware is active in the controller. For this purpose, read the following parameter:

- S-0-0030, Manufacturer version.

If the desired firmware is not available in the controller, carry out a firmware update or firmware upgrade (see "Firmware replacement").

Loading default values

If the desired firmware is available in the controller, load default firmware values by executing the following steps:

1. Select specifications in parameter "P-0-4090, Configuration for loading default values"
2. Start "S-0-0262, C07_x Load defaults procedure command"

Respective diagnostic command message:

- C0750 Load defaults procedure command (factory settings)

Respective diagnostic messages in the case of possible command errors:

- C0751 Parameter default value incorrect (-> S-0-0423)
- C0752 Locked with password

See also "Initial commissioning/serial commissioning"

- S-0-0262, C07_x Load defaults procedure command

NOTICE	By executing this command, control loop parameter values that have already been optimized are possibly overwritten!

Enter optimized control loop parameter values again!

☞ Due to an automatic reset, the parameter "P-0-4090, Configuration for loading default values Configuration for loading default values" is preset correctly!

Respective diagnostic messages in the case of possible command errors:

- C0702 Default parameters not available
- C0703 Default parameters invalid
- C0704 Parameters not copyable
- C0706 Error when reading the controller parameters

See also "Initial commissioning/serial commissioning"

With storage mode "volatile storage"

If the option "Volatile memory" is selected in parameter "S-0-0269, Storage mode", parameter values are not automatically saved in the controller-internal flash memory. After a complete input, the application-specific parameter values therefore have to be saved controller-internally in the flash memory by

- Start "S-0-0264, C2200 Backup working memory procedure command"

This guarantees that the parameter values compatible with the axis are automatically loaded to the controller's working memory from the flash memory after the supply unit or the drive iis switched on again.

Respective diagnostic command message:

- C2200 Backup working memory procedure command

Respective diagnostic messages in the case of possible command errors:

- C2202 Error when writing data to non-volatile memory

After all application-specific parameter values are saved (C2200), it is also possible to only save selected parameter values in the flash memory. These parameters are overwritten with a current value. This is done by

- starting "S-0-0293, C2400 Selectively backup working memory procedure command"

The C2400 command can be used for internally saving a parameter group whose values have to be optimized again during operation. It is advisable to determine the IDNs of this parameter group by clearing IDNs that are not required from the default setting of the list parameter

- S-0-0270, IDN-list of selected backup operation data

☞ With "volatile storage" mode, the command C2200 has to be executed at least once before starting the command C2400, because otherwise default values will remain in the flash memory for certain parameters.

Respective diagnostic command message:

- C2400 Selectively backup working memory procedure command

Respective diagnostic messages in the case of possible command errors:

- C2402 Error when saving parameters

Loading and saving parameter values via control master or "IndraWorks Ds/D/MLD"

A master communication interface or the Engineering port of the controller can be used for loading and saving parameter values via the control master or "IndraWorks Ds/D/MLD".

Loading saved parameter values acc. to list parameter S-0-0192 to reestablish the initial status after initial commissioning is impossible in the case of drives with absolute value encoder and modulo scaling (see note).

NOTICE

The parameter value backup created after initial commissioning according to S-0-0192 cannot restore the initial parameter state. The actual position value after the loading process would be incorrect, but this cannot be detected on the controller side!

In the case of drives with absolute value encoder and modulo scaling, the backup of parameter values made after initial commissioning according to S-0-0192 cannot be loaded for restoring the initial parameter state!

For how to reestablish the initial status of parameters for drives with absolute value encoder and modulo scaling, see "Initial commissioning/serial commissioning"!

Communication phase 2 or the parameter mode has to be activated to successfully load parameters.

- P-0-4023, C0400 Communication phase 2 transition

Respective diagnostic command message:

- C0400 Activate parameterization level 1 procedure command

☞ The drive returns to the operating mode by successive start of the commands "S-0-0127, C0100 Communication phase 3 transition check" und "S-0-0128, C5200 Communication phase 4 transition check"!

When reading and writing individual parameters via the control master or "IndraWorks Ds/D/MLD" (without command), the following error messages can occur:

- F2100 Incorrect access to command value memory
- F2102 It was impossible to address I2C memory

9.1.3 IDN lists of parameters

General information

Some of the parameters stored in the controller contain, as their operating data (parameter value), a list of IDNs of drive parameters/supply unit parameters corresponding to a specific, given criterion. These so-called IDN lists enable targert-oriented handling of drive parameters/supply unit parameters by the master or a commissioning software.

IDN list of all operation data (S-0-0017)

Parameter "S-0-0017, IDN-list of all operation data" contains the IDNs of all parameters available in the controller.

IDN list of all backup operation data (S-0-0192)

Parameter "S-0-0192, IDN-list of all backup operation data" contains the IDNs of all parameters that are stored in the non-volatile memory [MultiMediaCard (MMC) or flash memory]. These parameters are required for correct operation of the controller. With the master or a commissioning software, it is possible to use this IDN list for creating a backup copy of the drive parameters/supply unit parameters.

IDN list of invalid operation data for phase 2 (S-0-0021)

In parameter "S-0-0021, IDN-list of invalid operation data for CP2", the IDNs of those parameters are automatically entered which the firmware detects as being invalid when executing the command "S-0-0127, C0100 Communication phase 3 transition check".

Parameters are detected to be invalid, if:

- Their checksum does not match the operating data [the checksum is stored together with the operating data in a non-volatile memory (flash memory, amplifier or motor encoder data memory)]

- or -

- their operating data is outside of the minimum or maximum input limits

- or -

- their operating data violates specific validation rules.

In any event, the parameters entered in "S-0-0127, C0100 Communication phase 3 transition check" upon negative acknowledgement of command "S-0-0021, IDN-list of invalid operation data for CP2" have to be corrected.

IDN list of invalid operation data for phase 3 (S-0-0022)

In parameter "S-0-0022, IDN-list of invalid operation data for CP3", the IDNs of the parameters detected as invalid or as configured incorrectly by the firmware, are automatically entered when executing the "S-0-0128, C5200 Communication phase 4 transition check" command.

Parameters are detected to be invalid, if:

- their checksum does not match the operating data [the checksum is stored together with the operating data in a non-volatile memory (flash memory, amplifier or motor encoder data memory)]

- or -

- their operating data is outside of the minimum or maximum input limits

- or -

- their operating data violates specific validation rules.

Parameters are detected to be incorrectly configured, if

- they were configured more than once for writing by a cyclic interface.

In any event, the parameters entered in "S-0-0128, C5200 Communication phase 4 transition check" upon negative acknowledgement of command "S-0-0022, IDN-list of invalid operation data for CP3" have to be corrected.

IDN list of invalid data for parameterization levels (S-0-0423)

When the command "C0200 Exit parameterization level procedure command" is executed, the drive parameters/supply unit parameters are checked and converted. If errors occur during this check, the IDNs of the faulty parameters are written to the list parameter "S-0-0423, IDN-list of invalid data for parameterization levels".

IDN-list of operation data for CP2 (S-0-0018)

The IDNs that are checked for validity when the command "S-0-0127, C0100 Communication phase 3 transition check" is executed are stored in the operating data of parameter "S-0-0018, IDN-list of operation data for CP2".

IDN list of operation data for communication phase 3 (S-0-0019)

The IDNs that are checked for validity when the command "S-0-0128, C5200 Communication phase 4 transition check" is executed are stored in the operating data of parameter "S-0-0019, IDN-list of operation data for CP3".

IDN list of all command parameters (S-0-0025)

The ident numbers of all the command parameters available in the controller are stored in the operating data of parameter "S-0-0025, IDN-list of all procedure commands".

IDN list of the operating data to be backed up selectively (S-0-0270)

The IDNs of parameters that are to be saved when command "S-0-0270, IDN-list of selected backup operation data" is executed are stored in the parameter "S-0-0293, C2400 Selectively backup working memory procedure command".

IDN-list of password-protected operation data (S-0-0279)

Parameter "S-0-0279, IDN-list of password-protected operation data" contains the IDNs of the parameters that can be protected by a customer password (S-0-0267). By default, no IDNs have been entered in this parameter.

IDN list of checksum parameters (S-0-0327)

Parameter "S-0-0327, IDN list of checksum parameter" contains the IDNs of parameters from which the content of parameter "S-0-0326, Parameter checksum" is to be generated. By default, no IDNs have been entered in this parameter.

IDN list of all parameter values not corresponding to the default value (P-0-0013)

All parameters the operating data of which was changed with regard to the default value are stored in parameter "P-0-0013, List of all IDNs not corresponding to default value".

9.2 Using a password

9.2.1 Brief description

IndraDrive controllers provide the possibility to protect parameter values against accidental or unauthorized change by using a password. With regard to write protection, there are 3 groups of writable parameters:

- Parameters that are generally write-protected, such as motor parameters, hardware code parameters, encoder parameters, error memory, etc. ("administration parameters"). The values of these parameters guarantee the correct function and performance of the controller.
- Parameters the customer can combine in groups and protect them with a so-called customer password. This allows to protect parameter values that are used for adjusting the drive or the supply unit to the axis, after having determined them.
- All other writable parameters that are not contained in the above-mentioned groups. They are not write-protected.

The firmware allows the write protection for parameter values to be activated and deactivated using three hierarchically different passwords:

- **Customer password**

  → The parameter values of a parameter group combined by the customer can be protected.
- **Control password**

  → Parameters protected by a customer password are writable; "administration parameters" remain read-only.
- **Master password**

  → All writable parameters, including "administration parameters" and parameters protected by a customer password, can be changed.

> ☞ The customer password can be defined by the customer, the control password and the master password are defined by the manufacturer!

Parameters involved

- S-0-0192, IDN-list of all backup operation data
- S-0-0267, Password
- S-0-0279, IDN-list of password-protected operation data
- P-0-4064, Password level

9.2.2 Functional description

The write protection for parameter values is activated and deactivated using the three hierarchically different passwords and by an input in parameter "S-0-0267, Password".

Customer password

By a password defined by the customer, the parameters of a parameter group to be defined can be protected against unauthorized or accidental write access.

The customer password has to comply with the following conditions:

- At least 3 characters long
- A maximum of 10 characters long
- May only contain the characters a…z, A…Z and the numbers 0…9

The group of parameters the values of which can be protected by the customer password is defined in parameter "S-0-0279, IDN-list of password-protected operation data". By default, parameter S-0-0279 does not contain any IDN. In the list parameter S-0-0279 it is possible to enter parameter IDNs according to application-specific requirements.

> ☞ The customer password is not obligatory! If it has not been activated, the values of the parameters listed in the list parameter S-0-0279 can still be written.

Control password

After entering the firmware-specific control password specified by the manufacturer, it is also possible to write parameters protected by a customer password. The control password allows the NC control unit to ignore the write protection by the individual (unknown) customer password.

> ☞ The control password valid for the respective firmware is only available from the manufacturer on demand!

Master password

The master password is also defined by the manufacturer, but is exclusively available to the Rexrothdevelopment and service staff.

☞ The master password is secret! It must not be used on the control unit side or by the customer, as it also allows changing the values of "administration parameters" (motor parameters, hardware code parameters, encoder parameters, error memory, etc.).

Activating/deactivating the write protection

By default, the value "007" is entered in "S-0-0267, Password". The write protection is activated and deactivated using the customer password according to the following procedure:

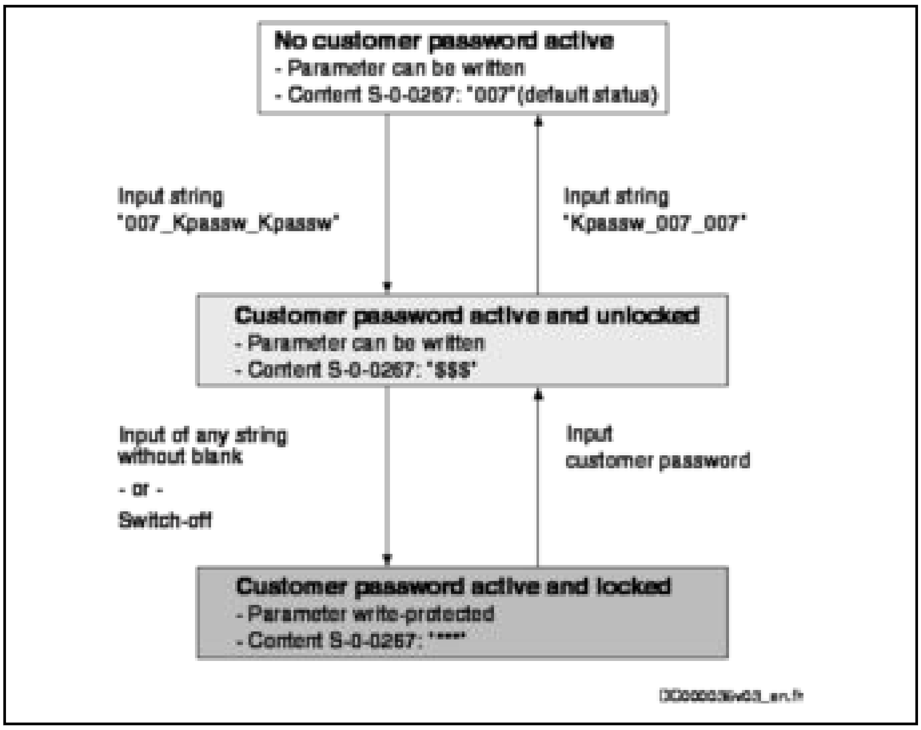


Fig. 9-1: Activating and deactivating the write protection using the customer password

The write protection activated via customer password is deactivated using the control password by entering the control password in S-0-0267. The write protection required by the customer can be activated again by entering any string in S-0-0267.

The write protection for all parameters that can basically be written can only be deactivated using the master password and the right to do this is exclusively reserved to the Rexroth development and service staff!

NOTICE

Incorrect control of motors when changing parameter values write-protected on the firmware side ("administration parameters")!

⇒ The master password must not be used on the control unit side or by the customer!

9.2.3 Notes on commissioning

Define the IDNs of the group of parameters the values of which are to be write-protected in parameter

- S-0-0279, IDN-list of password-protected operation data.

The customer-side write protection via the customer password for the parameters contained in S-0-0279 can be activated and deactivated by writing the parameter

- S-0-0267, Password.

☞ Observe the conditions for defining the customer password!

If the active write protection for the parameters defined in S-0-0279 is to be disabled on the master side or without knowledge of the customer password, enter the control password in parameter

- S-0-0267, Password.

☞ Ask the manufacturer for the control password!

Status query for write protection

The current status of the write protection can be queried via parameter

- P-0-4064, Password level.

Diagnostics

In an attempt to write data to a write-protected parameter, an error code is transmitted to the Sercos master via the non-cyclic data channel, according to the Sercos specification. The master then recognizes that the respective parameter is write-protected and that it is impossible to write data to it.

9.3 Diagnostic system

9.3.1 Coded diagnostic messages

Brief description

The controller provides different diagnostic functions that are divided into two groups:

- Detecting and displaying the current state by using the internal, priority-dependent generation of diagnostic messages

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☞ From MPx-18/PSB-20, the diagnostic message number is generated in accordance with the Sercos specification. For this purpose, the bits 31-24 in the parameter "S-0-0390, Diagnostic message number" are written, too; these bits were always "0" in previous versions. In the control panel and in IndraWorks dialogs, these bits are hidden so the display remains unchanged there.

If the diagnostic messages are to be displayed in S-0-0390 as in the previous versions, bit 0 has to be set in "P-0-0006, Diagnostic message configuration".

- Collective messages for various status messages

Additionally, there are parameters for all important operating data whose values can be transmitted both via master communication (e.g., Sercos) and a parameterization interface (RS-232/485 in the ASCII protocol or SIS protocol; see "Serial communication").

Parameters involved

- S-0-0030, Manufacturer version
- S-0-0095, Diagnostic message
- S-0-0140, Controller type
- S-0-0390, Diagnostic message number

- S-0-1302.0.3, Application type

  (S-0-0142 only exists as a legacy (or alias) parameter for S-0-1302.0.3.)

Internal generation of diagnostic messages

Operating states, activities and reactions of the device are detected by internal generation of diagnostic messages and appear in coded form on the display of the control panel. In addition, these diagnostic messages can be transmitted to a master (control) and displayed and evaluated in a service and commissioning software (e.g., "IndraWorks Ds/D/MLD").

We distinguish the following categories of diagnostic messages (kinds of diagnostic messages):

- Error
- Warnings
- Commands/command errors
- Status displays/operating states

Generally, the current diagnostic message with the highest priority is displayed at the following locations in the device:

- **Control panel display**

  → The diagnostic message number and, if applicable, text appears on the 8-digit display of the standard control panel.

- **Parameter "S-0-0095, Diagnostic message"**

  → This parameter, in the form of plain text, contains the operating status at present relevant. Preceding the text is the respective content of parameter S-0-0390 in short form.

- **Parameter "S-0-0390, Diagnostic message number"**

  → The diagnostic message number shown on the display in short form is stored in this parameter.

Priorities of display

The following priorities apply for displaying the current diagnostic message:

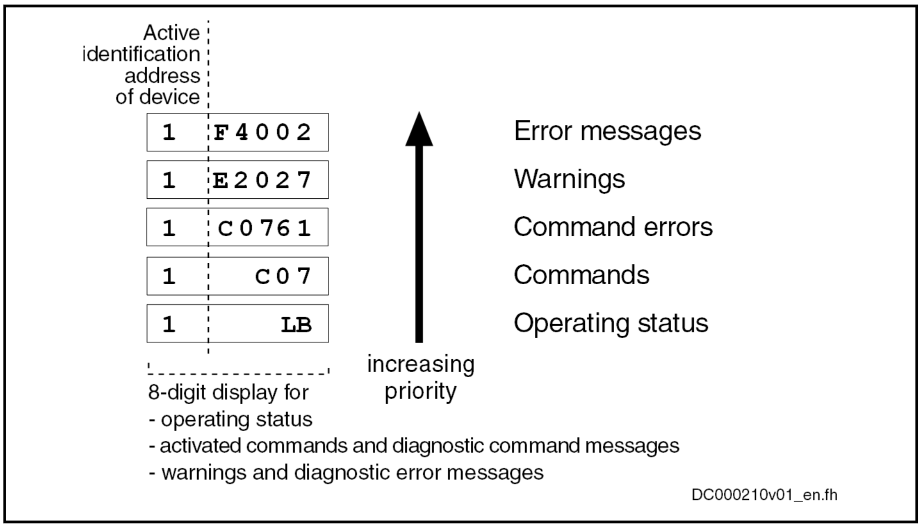


Fig. 9-2: Priorities of displays (with exemplary displays)

The documentation "Troubleshooting Guide (description of diagnostic messages)" contains an overview of all diagnostic messages and their significance.

Structure of a diagnostic message

General information

Every diagnostic message consists of

- Diagnostic message number

  - and -

- diagnostic text.

The diagnostic message for the error "F2818 Phase failure" for example, has the following structure:

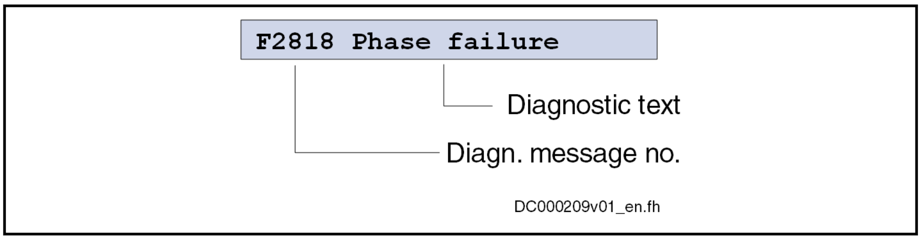


Fig. 9-3: Structure of a diagnostic message

On the control panel display,"F2818" is flashing. In parameter "S-0-0390, Diagnostic message number", the diagnostic number is displayed in hexadecimal form (for the example: 0xC00F2818). The diagnostic message number and the diagnostic text appear in the parameter "S-0-0095, Diagnostic message" as a string "F2818 Phase failure".

Diagnostic message on the control panel display

The diagnostic message number appears on the 8-digit display of the standard control panel. This allows the current operating status of the device to be recognized quickly and without using a communication interface.

As a matter of principle, the following applies:

- Status displays (P0, LB, lb …) are displayed in right-aligned form
- Warnings, command errors and other error messages are flashing

Kind of diagnostic message	Diagnostic message number	Display
Error	F2xxx	F2xxx
Command	C20C0200	C02
Command error	C02xx	C02xx
Warning	E2xxx	E2xxx
Operating status e.g. communication phase 1	C30A0001	P1
Operating status e.g. drive ready	C00A0012	Ab
Operating status e.g. selected operation mode is active	C00A0101	AF

Tab. 9-2: Overview of diagnostic messages displayed

The current operation mode is not shown on the display. If the device follows the preset operation mode and no command was activated, the display reads "AF". in case of a supply unit, "LB" or "LF" is displayed.

Diagnostic message in plain text

The diagnostic message in plain text contains the diagnostic message number followed by the diagnostic message text. It can be read via parameter "S-0-0095, Diagnostic message" and directly displayed on an operator interface as a language-dependent description of the device state.

The diagnostic message in plain text is switched to the selected language via parameter "S-0-0265, Language selection"

Diagnostic message number

The diagnostic message number contains only the diagnostic number without the diagnostic text. It can be read via parameter "S-0-0390, Diagnostic message number" and is a language-independent possibility of determining and displaying the device state on an operator interface.

Display text of diagnostic message

The display text of a diagnostic message is the text appearing on the display of the control panel. The text is displayed together with the diagnostic number in "S-0-0095, Diagnostic message".

Language selection

Via parameter "S-0-0265, Language selection", it is possible to define or change the language of diagnostic message texts.

📖 See also parameter description "S-0-0265, Language selection"

9.3.2 Status classes, status displays, control parameters

General information

In IndraDrive there are many parameters with important status information (bit lists). Some of the bits contained in these lists can be used for configuring real-time status bits and additionally can be assigned to digital outputs or to the configurable signal status word.

See "Digital inputs/outputs"

See "Configurable signal status word"

IndraDrive differentiates the error, warning and message states (status classes).

There are parameters with a direct relation to the status of the sequence of different drive functions (fixed status displays) and control parameters to control the functions of the controller (control parameters).

Status classes

Brief description

IndraDrive differentiates between 3 states (error, warning and message) for which there is status information. To make the status information available, there are so-called class diagnostics parameters (S-0-0011, S-0-0012), which contain the respective status bits.

In addition to these class diagnostics parameters, there are change bits contained in the status word of the field bus (e.g. S-0-0135 for Sercos) which display changes in one of the above-mentioned class diagnostics parameters (collective information).

Features

- Class diagnostics parameter for **Errors** (cf. S-0-0011)
- Class diagnostics parameter for **Warnings** (cf. S-0-0012)

- **Change bits in status word** of master communication (e.g. S-0-0135 in case of Sercos)
- **Change bits** of class 2 and 3 (S-0-0097 and S-0-0098) can be masked in the status word of the master communication (e.g. S-0-0135 for Sercos) to suppress individual bits or status messages

Parameters involved

- S-0-0011, Class 1 diagnostics
- S-0-0012, Class 2 diagnostics
- S-0-0097, Mask class 2 diagnostics
- S-0-0098, Mask class 3 diagnostics
- S-0-0135, Drive status word

Functional description

Class diagnostics parameters

- **S-0-0011, Class 1 diagnostics** (status parameter for device errors)
  - In case a device error occurs, the bit assigned to the error is set in parameter S-0-0011. An individual bit is assigned in S-0-0011 to errors defined according to Sercos.

    Manufacturer-specific errors cause bit 15 to be set in parameter S-0-0011 (see also description of parameter "S-0-0011, Class 1 diagnostics").
  - In case a device error occurs, bit 13 (device lock-out; error in class 1 diagnostics) is simultaneously set in the status word of the field bus (S-0-0135 for Sercos).

☞ All bits in class 1 diagnostics are cleared by executing the command C0500 (reset class 1 diagnostics).

See description of parameter "S-0-0099, C0500 Reset class 1 diagnostics"

- **S-0-0012, Class 2 diagnostics** (status parameter for device warnings)
  - In case a device warning occurs, the bit assigned to the warning is set in parameter S-0-0012. A separate bit is assigned in S-0-0012 to warnings defined according to Sercos.

    Manufacturer-specific warnings cause bit 15 to be set in parameter S-0-0012 (see also description of parameter "S-0-0012, Class 2 diagnostics").
  - In case a device warning occurs, bit 12 (class 2 diagnostics change bit) is simultaneously set in the status word of the field bus (S-0-0135 for Sercos), if the content of S-0-0012 changes (i.e. at least one bit toggles).
  - The bits in parameter S-0-0012 are automatically cleared when the warning disappears. The change bit in the status word of the master communication (S-0-0135 for Sercos) remains set, however, until parameter S-0-0012 has been read once.

☞ Via parameter "S-0-0097, Mask class 2 diagnostics", warnings can be masked in terms of their effect on the change bit.

Change bits in device status word

If the state of a bit in parameter "S-0-0012, Class 2 diagnostics" changes, the change bit for class 2 diagnostics is set in the field bus status word (e.g., S-0-0135 for Sercos). A change bit in the status word (bit 12) is always set due to a change of the parameter content of S-0-0012. This enables the master to recognize very quickly whether a change occurred in S-0-0012.

A read access to one of the two parameters clears the respective change bit again.

Masking the change bits

Using the parameter "S-0-0097, Mask class 2 diagnostics", certain bits can be masked in terms of their effect on the change bit of the status word (bit 12).

The figure below illustrates the principle of masking by way of an example:

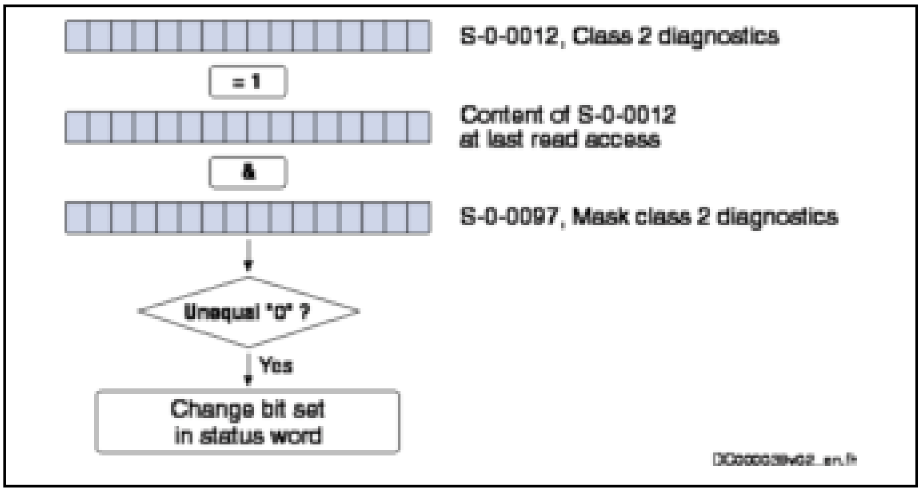


Fig. 9-4: Generating the change bit of class 2 diagnostics

Fixed status displays

Function-related status parameters

In IndraDrive there are parameters the content of which has a direct relation to the status of the sequence of different device functions. These parameters are used to display the current status information of the assigned function.

The following parameters are available for function-related status display:

- S-0-0014, Interface status

  This parameter displays the state of the communication phase transition and the cyclic communication.
- S-0-0135, Drive status word

  This is the status word of the master communication (Sercos) and contains all essential status information for the master.
- P-0-0223, E-Stop input

  The status of the E-Stop input is displayed (see also "E-Stop function").
- P-0-4029, Diagnostic report SCSB module

  Parameter to read out settings and states of the master communication (in Sercos).
- P-0-4086, Master communication status

  This parameter displays control information of the master communication for handling phase switch, drive enable etc., defined during initialization.

Status parameters for real-time status bits

The status parameter below only contains one bit and can therefore be used for configuring real-time status bits (see "Sercos"):

- S-0-0337, Status "P >= Px"

Control parameters

Apart from the parameters for status display, there are parameters available in the controller that are used to control the drive functions/supply unit functions.

9.3.3 Operating hours counter

Brief description

There are operating hours counters available in IndraDrive that separately record the operating times for control section and power section. The respective operating time is displayed in the parameters P-0-0190 or P-0-0191. These times are directly stored from the control section or power section so that assignment is maintained also for servicing.

Parameters involved

- P-0-0190, Operating hours control section
- P-0-0191, Operating hours power section

The parameter "P-0-0190, Operating hours control section" displays the operating time of the control section. The unit is seconds.

The time the controller had been switched on is considered to be the operating time of the control section.

The parameter "P-0-0191, Operating hours power section" displays the operating time of the power section with drive enable having been set. The unit is seconds.

The time during which the output stage has been enabled is considered to be the operating time of the power section.

☞ By default, the devices are set to a defined value before delivery. Thus, they can specify the total runtime of a component in service.

9.3.4 Error memory (power section and control section)

Brief description

In IndraDrive all errors occurred are recorded in an error memory on the control section. If an error occurs in the power section, it is additionally stored in a separate error memory on the power section. It is thereby made sure that the relevant information is still available on the power section after the power section and control section have been separated.

☞ If an error occurs, the diagnostic message number and the current count of the operating hours counter are automatically saved.

Parameters involved

- S-0-0390, Diagnostic message number
- P-0-0190, Operating hours control section
- P-0-0191, Operating hours power section
- P-0-0192, Error memory of diagnostic numbers
- P-0-0193, Error memory operating hours of control section
- P-0-0194, Error memory power section

☞ The contents of the parameters P-0-0192 and P-0-0193 are stored on the control section. The content of parameter P-0-0194 is stored on the power section.

Functional description

Error memory in control section

If the device detects as state class 1 diagnostics error, a bit is set in parameter "S-0-0011, Class 1 diagnostics" and bit 13 (drive controller) in "P-0-0115, Device control: Status word" or bit 13 (supply unit) in "S-0-1720.0.2, Power supply status word".

To allow more detailed diagnostics

- the diagnostic message number appears on the display and is stored in parameter "S-0-0390, Diagnostic message number" (in "hex format"),
- the plain text of the diagnostic message is stored in parameter "S-0-0095, Diagnostic message",
- the content of parameter "P-0-0190, Operating hours control section" is stored in parameter "P-0-0193, Error memory operating hours of control section" upon error detection
- the diagnostic message number belonging to the error according to parameter "S-0-0390, Diagnostic message number" is stored in parameter "P-0-0192, Error memory of diagnostic numbers" in the same order.

The parameters P-0-0192 and P-0-0193 have a stack structure and contain, in chronological order, the diagnostic message numbers or the counts of the operating hours counter of the last **50 errors** that occurred.

☞ The count of the operating hours counter at the time the last error occurred is entered at the top of parameter P-0-0193, and the diagnostic message number of the last error occurred at the top of parameter P-0-0192.

Error memory in power section

If the error concerns the power section, it is additionally stored in parameter "P-0-0194, Error memory power section".

The last 13 errors that occurred and the respective count of the operating hours counter (see P-0-0191) are stored in this parameter.

The error "F8060 Overcurrent in power section", for example, is an error which could occur in the power section. This error would be displayed both in parameter P-0-0193 and in parameter P-0-0194.

9.3.5 Load preview

Brief description

Power dissipation occurs when operating electric controllers. For electrical equipment and electrical components, there is a maximum allowed operating temperature due to the materials used up to which the equipment can be operated safely in the long term. This temperature determines the allowed continuous load of the electrical components.

Overload capacity

The temperature rise of electrical components based on current supply runs in parallel with their thermal time constants. As long as the maximum allowed operating temperature has not been reached, an electrical component can be overloaded, that is to say short-term operation with more than the allowed continuous load. This causes the temperature rise to occur more quickly but does not pose a problem as long as the permissible operating temperature is not exceeded.

If the allowed operating temperature is reached, the overload must be reduced to the allowed continuous load so that the electrical component is not damaged. The IndraDrive system features overload limiting functions for the various drive components relevant to performance:

- Inverter of the controller
- Braking resistor of the supply unit

Protective functions

The functions for protection against inadmissible load are provided on the hardware or firmware side:

- Hardware-side temperature measurement at the controller's heat sink
- Firmware-side temperature model calculation for temperatures at temperature-sensitive components not measurable on the hardware side.

With hardware-side temperature measurement, only the temperature rise processes that occur in the seconds range can be recorded. The temperature rise that happens more quickly can only be monitored using firmware-side model calculation anyway.

Overload limitation

The high overload capacity of electrical components can only be implemented such that operational safety is ensured by using temperature model calculation and automatic overload limits:

- Current limitation by controller temperature model (inverter)
- Current limitation by temperature model
- Power limitation by braking resistor temperature model

Load preview

Limits that intervene automatically do protect the electrical components from damage, but also affect the power output of the component and can lead to disconnection due to resulting errors or rejects during processing. Early detection and reporting of threatening limitations is possible with the "load preview" function for the temperature model calculations mentioned above:

- Running the machining cycle with the heaviest load
- Determining the difference of the load curve (difference between maximum value and start value)
- Determining a threshold value of the load at which the expected load difference is still just possible without reaching the limit
- Signaling when the thermal load has reached the defined threshold value.

Parameters involved

- S-0-1710.0.2, Thermal device load
- P-0-0141, Thermal drive load
- P-0-0441, Thermal drive load warning threshold
- P-0-0465, Maximum value thermal drive load
- P-0-0467, Maximum value thermal load of braking resistor
- P-0-0469, Prewarning threshold of therm. load of braking resistor
- P-0-0844, Thermal load of braking resistor

Diagnostic messages involved

- E2061 Device overload prewarning
- E2820 Braking resistor overload prewarning

Functional description

Thermal load

The temperature modules of the firmware determine the thermal load of the

- inverter of the controller
- Braking resistor of the controller

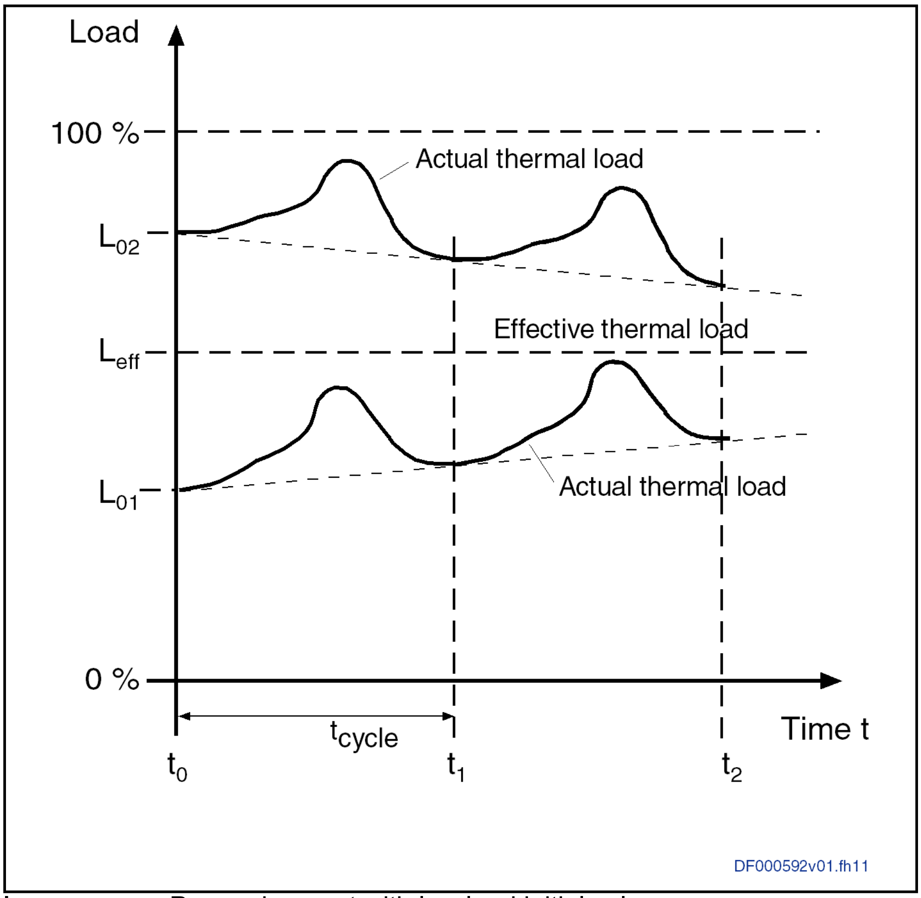
The thermal load of these components is displayed in

- S-0-1710.0.2, Thermal device load
- P-0-0141, Thermal drive load
- P-0-0844, Thermal load of braking resistor

Estimating the continuous load

These parameters can also be assigned with values for test purposes to estimate the effective continuous load to be expected by running load cycles. Compare the load at the end or at the start of one or several load cycles:

- Falling value: Pre-assigned value was higher than the effective continuous load to be expected
- Rising value: Pre-assigned value was lower than the effective continuous load to be expected

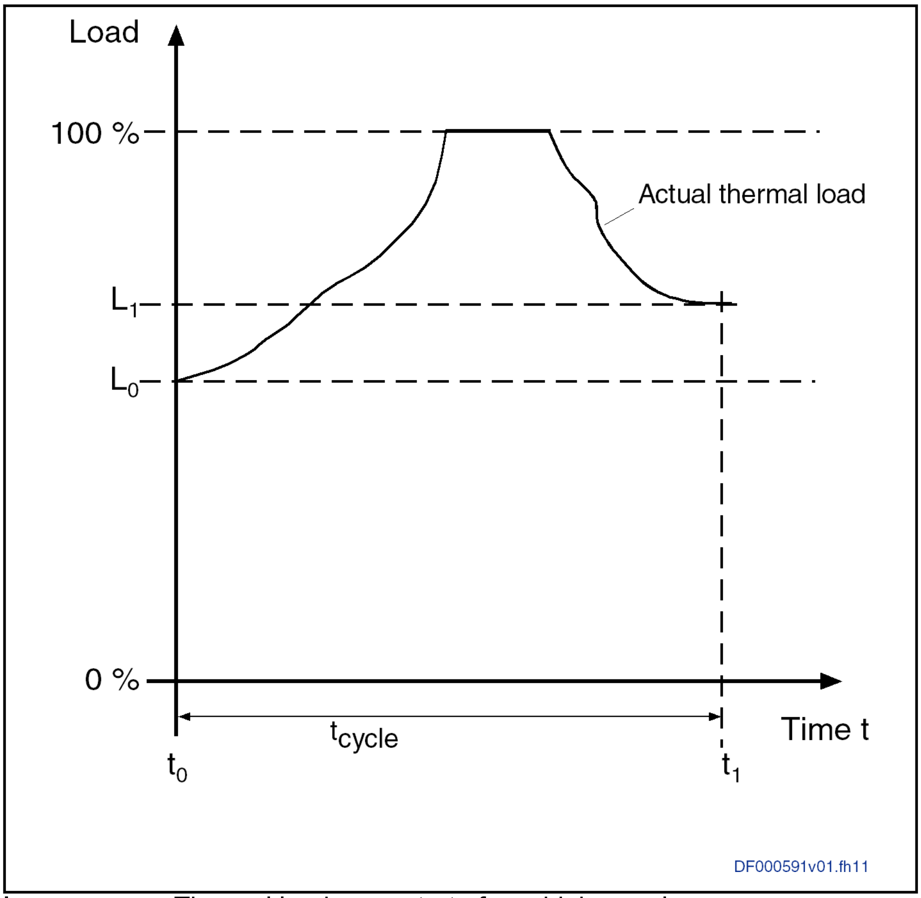


L_{01}	Pre-assignment with low load initial value
L_{eff}	Effective thermal load, theoretical final value
L_{02}	Pre-assignment with high initial load value

Fig. 9-5: Schematic load curves with different load pre-assignment

Conditions for estimating the continuous load

It is possible to estimate the continuous load if the duration of the load cycle is within the range of the thermal time constant of the respective component (milliseconds to seconds with controllers and braking resistors). With frequent repetition of the load cycle, it is possible to slowly increase the level of load before the limitation intervenes, particularly with controllers with high intensities of current, if the effective continuous load is closer to 100% than the load rise of a load cycle:



L_0	Thermal load upon start of machining cycle
Thermal load	Thermal load of the component
L_1	Thermal load at the end of the machining cycle

Fig. 9-6: Exemplary load curve of a load cycle with intervening limitation

Maximum load value and load preview

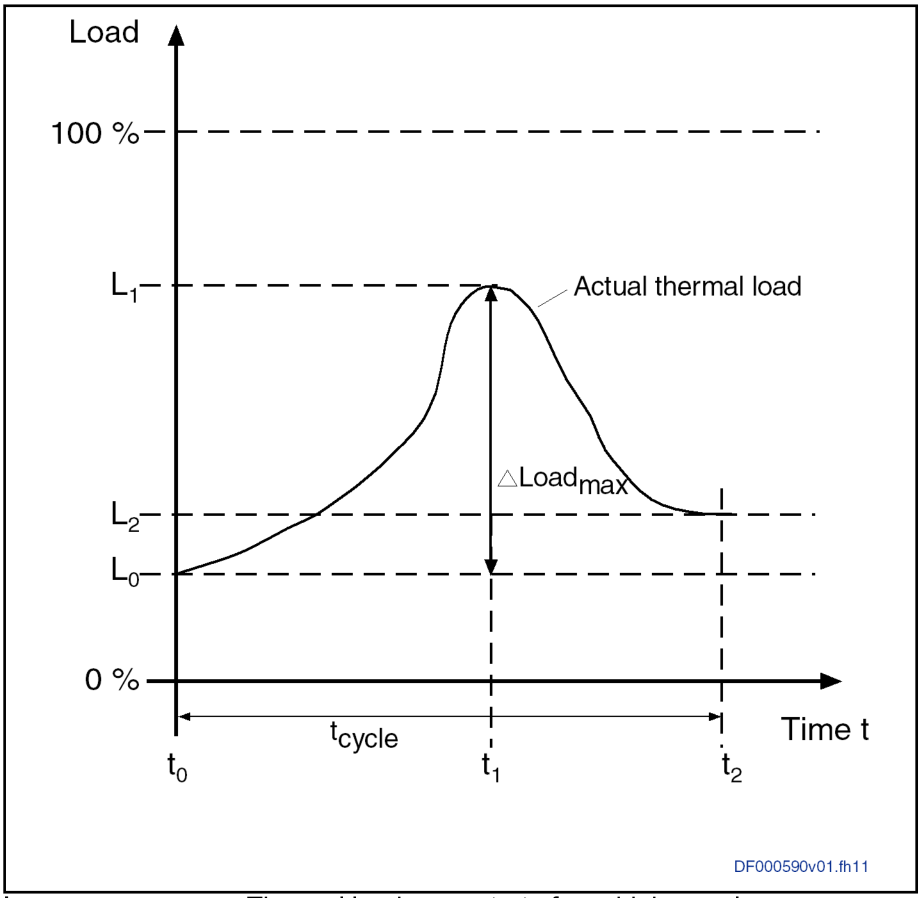
Load rises are generated when running load cycles. The minimum value of the load is saved in firmware parameters.

- P-0-0465, Maximum value thermal drive load
- P-0-0467, Maximum value thermal load of braking resistor

Only KMV03 has an integrated braking resistor.

Load rise

Repeatedly saving maximum values can be forced by entering the value "0" in these parameters. The maximum value of the next load cycle is saved. The difference between maximum value and start value of the thermal load is the "load rise":



L_0	Thermal load upon start of machining cycle
L_1	Maximum value of load (is saved)
Actual thermal load	Thermal load of the component
L_2	Thermal load at the end of the machining cycle

Fig. 9-7: Exemplary load rise of a load cycle

Load preview "Load preview" is possible by setting the appropriate prewarning threshold. Thus, a message is generated when, at the next expected load rise, the thermal load comes close to 100% and the electrical component risks that a limitation intervenes. The threshold value can be set in:

- P-0-0441, Thermal drive load warning threshold
- P-0-0469, Prewarning threshold of therm. load of braking resistor

$$\text{Prewarning threshold} \leq 100\%-(\Delta Load_{max})=100\%-(L_1-L_0)$$

L_0	Thermal load upon start of machining cycle
$\Delta Load_{max}$	Load rise of machining cycle to be expected
L_1	Maximum value of machining cycle load

Fig. 9-8: Calculating the limit value for the prewarning threshold

The prewarning threshold to be entered has to be smaller than the limit value (safety distance).

Signaling "limitation risk" Reaching the prewarning threshold is reported by a warning message:

- E2061 Device overload prewarning
- E2820 Braking resistor overload prewarning

The prewarning is displayed in "S-0-0012, Class 2 diagnostics" and has to be read out by the control master. Expected: Activation of limit after responding to the prewarning upon the next regular machining cycle. The control master can now take preventive action.

Overview of thermal protective functions and associated diagnostic messages

Module	Diagnostics	Cause	Drive reaction	Status bit	Display
KNK03 mains connection components	E2841 Prewarning: Mains connection overtemperature	Temperature sensor temperature > prewarning threshold (device-specific threshold)	F2841 after 30 s or after 1.1 s if temperature sensor = bimetal	S-0-0012 bit 1	P-0-0816
	F2841 Shutdown: Mains connection overtemperature	Temperature sensor temperature > switch-off threshold (device-specific threshold)	Power supply switched off	S-0-0011 bit 1	P-0-0816
	E2822 Mains connection temperature monitoring defective	Temperature sensor temperature ≤ 40°C	F2822 after 30 s	S-0-0012 bit 1	P-0-0816
	F2822 Mains connection temperature monitoring defective	Temperature sensor temperature ≤ 40°C	Power supply switched off	S-0-0011 bit 1	P-0-0816
Amplifier	F2020 Low device temperature error	Ambient temperature too low. The specified performance data apply at an ambient temperature of 0 °C and above.	The device temperature measured in the power section is too low and does not allow the output stage to be operated. The supply unit refuses to charge the DC bus.	S-0-0011 bit 1	S-0-0384
	E2061 Device overload prewarning	Amplifier temperature model Load > P-0-0441	None	S-0-0012 bit 1	S-0-1710.0.2 or P-0-0141
	E8057 Device overload, current limit active	Amplifier temperature model Load > 100%	Output current limitation	S-0-0012 bit 0	S-0-1710.0.2 or P-0-0141
	E2050 Device overtemp. prewarning	Temperature sensor Temperature > prewarning threshold (device-specific threshold)	F2018 after 30 s	S-0-0012 bit 1	S-0-0384
	E2040 Device overtemperature 2 prewarning		F2040 after 30 s		P-0-0816
	F2018 Warning, device overtemperature shutdown	Temperature sensor Temperature > switch-off threshold (device-specific threshold)	Power supply switched off	S-0-0011 bit 1	S-0-0384
	F2040 Device overtemperature 2 shutdown				P-0-0816

Module	Diagnostics	Cause	Drive reaction	Status bit	Display
Brake resistor	E2820 Braking resistor overload prewarning	Temperature model Load > P-0-0469	None	S-0-0012 bit 1	P-0-0844
	F2820 Braking resistor overload	Temperature model Load > 110%	"P-0-0119, Best possible deceleration" and power supply switched off	S-0-0011 bit 1	P-0-0844

Tab. 9-3: Thermal protective functions of IndraDrive and associated diagnostic messages

Notes on commissioning

Procedure for estimating the effective continuous thermal load

In case of controllers and in the braking resistor, the effective thermal load can be estimated as follows:

- Prior to running the load cycle, the thermal load value is written with an estimated start value for effective continuous load. Note the start value.
- After the machining cycle is completed, compare the load value to the noted start value.
  - In case of a load rise, enter a much higher start value for the next machining cycle
  - In case of a load drop, enter a much lower start value for the next machining cycle
- Repeat until the load is approximately the same before and after the machining cycle, using adjusted start values. Consequently, the load value corresponds to the thermal continuous load caused by this load cycle.

The stored maximum value of thermal load should not have reached 100% if the component is to operate without the risk of a limitation.

Procedure for setting the load preview

The effective continuous load of high-current controllers and braking resistors of high energy storage capacities can only be estimated very imprecisely by observing a few load cycles. An accurate statement can only be made via the temperature sensor. However, a long-term operation via the 5-fold duration of the thermal time constant is required.

The "load preview" can be advantageously used to avoid load-related intervention of limitations. It is possible to recognize in advance from when the component runs the risk of being limited in its power output.

Procedure:

- Write "0" for the maximum value of the thermal load before running the load cycle.
- After the machining cycle has been completed, note the value of the thermal load and automatically subtract it from the saved maximum value. Subtract the difference value of 100%, if required, reduce the remaining value due to safety reasons and enter the value in the parameter of the prewarning threshold.
- Query the message of the reached prewarning threshold in the bit of S-0-0012 and take appropriate measures on the control before running the next machining cycle.

9.4 Control panel

9.4.1 Brief description

IndraDrive controllers are equipped with a control panel with the exception of IndraDrive Mi controllers. The control panel front, the so-called "control panel" consists of a display and four keys below it. The display shows operating states, command and error diagnoses, as well as present warnings.

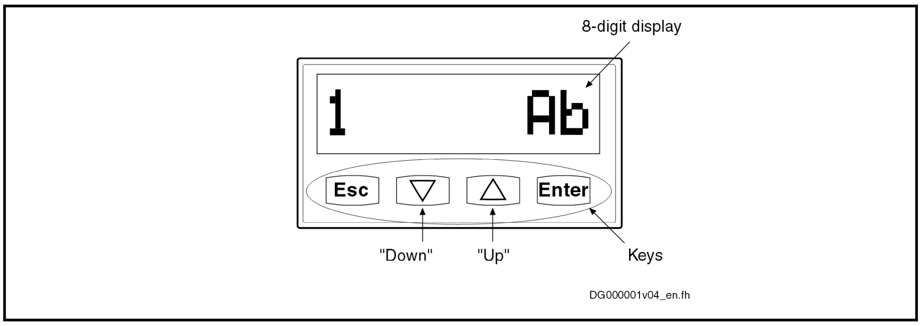


Fig. 9-9: Schematic illustration of the IndraDrive control panel

The four keys can be used to display extended diagnostic messages and trigger simple commands (in addition to master communication, IndraWorks or NC control). The menus are all in English; any present diagnostic and error messages are displayed in the language set in parameter "S-0-0265, Language selection".

Display options of the control panel

The display of the IndraDrive controller automatically shows

- Status of the master communication
- Operating status
- Commands and diagnostic command messages
- Warnings and diagnostic error messages
- Extended displays such as contents of type designation of firmware active in the device or safety technology code (if safety technology option available)

Control panel variants

There are the following control panel variants

1. Standard control panel
2. Standard control panel incl. slot for optional memory card
3. Advanced control panel incl. slot for optional memory card

   In addition to the functions of the standard control panel, the Advanced control panel has an extended retain data memory for MLD. Using the Advanced control panel requires an IndraDrive Advanced.
4. VCP operator terminal, optional

   As an option, an operator terminal can additionally be connected to the drive via an Ethernet connection. VCP operator terminals are freely programmable, i.e. it is possible to implement application-dependent settings and diagnostic messages.

Setting options using the control panel

The following settings can be made using the control panel:

- Setting the controller address (address of master communication)
- Setting the master communication protocol
- Setting IP addresses for engineering

Activating commands via the control panel

Only one command is supported für supply units. It can be activated using the control panel:

- Activating "S-0-0262, C07_x Load defaults procedure command" (loading controller parameters or basic parameters)

Configuring the control panel

The main menu can be accessed using the Enter key. The control panel can be configured to a limited extent:

- It is possible to choose between the edit mode and the view mode of the control panel.
  - "P-0-0680, Control panel: Configuration", bit 14 = 0, Edit Mode,

    changes can be made using the control panel.
  - "P-0-0680, Control panel: Configuration", bit 14 = 1, View Mode,

    the entry via the control panel is locked. If the modification screen is activated on the display for a date which can be changed, the "Edit disabled" message is generated, it is not possible to change the value.

    However, a temporary edit mode can be activated by keeping ESC +ENTER pressed for 8 seconds. If the main menu is started in this way, parameters can be adjusted as usual.
- Before a value is changed, the additional query "Ok?" is displayed. It has to be confirmed with the ENTER key before a value is actually changed. This is to prevent accidental changes.
- Bit 15 = "1" in "P-0-0680, Control panel: Configuration" can be used to deactivate the output of diagnostic texts. In this case, the diagnostic message number is always output, the diagnostic text is not displayed.

9.4.2 Functional description

Programming module types

Programming modules

A compatible programming module is provided with each controller. The programming module contains the specific firmware for the drive controller. The firmware can be used for each particular performance (Economy, Basic and Advanced). Thus, each programming module is derivative-specific and cannot be used for a device with a different derivative (e.g. basic programming module on economy device).

If the display is plugged in incorrectly by mistake, the corresponding error (F9200) is displayed and the device does not boot up.

Additionally, each display contains the application-relevant data that are backed up in case of a control voltage drop. This allows a device to be easily replaced in case the hardware is defective, unless the display itself has been damaged.

The control panel contains four keys, Enter, Esc, Up and Down. Additionally, a display unit is available with eight characters and 7x5 pixels. Difference between the programming modules: optional functions and different coloration.

As a standard, the Advanced device is supplied with the Advanced programming module.

The programming module is available in three configurations:

1. **Standard programming module**

   These programming modules have been supplied up to now. They will be entirely replaced by the standard programming module incl. the memory card slot. The **missing** memory card slot on the left side of the module differentiates this module from other variants. The programing module contains the device firmware and the application-relevant memory.

2. **Standard programming module incl. memory card slot**

   All new Economy and Basic devices are supplied with an enhanced standard programming module featuring an additional memory card slot for the optional memory card.

   As for the standard programming module, the firmware and the application-relevant memory is contained on the programming module. In addition, machine-relevant data can be stored on the optional memory card. With Basic devices the optional memory can be addressed from MLD (saving and loading application-relevant data/files).

   It can be visually distinguished from the sandard programming module by a small slot on its left-hand side provided for an optional memory card (µSD card). The programming module structure is identical tot he advanced programming module structure. To ensure an easier identification between advanced programming module standard programming module including the memory card slot, the keys of the programming modules in different colors. The keys of this module are gray, the chassis is light gray.

3. **Advanced programming module incl. memory card slot**

   All Advanced devices are provided with a so-called Advanced programming module. In addition to the memory card slot for the optional memory card, the Advanced programming module contains an internal memory extension for the MLD retain data. The retain data memory for MLC was extended to 31728 bytes.

   As for the standard programming module, the firmware and the application-relevant memory is contained on the programming module. Additionally, machine-relevant data can be saved on the optional memory card.

   The programming module structure is identical tot he advanced programming module structure. To ensure an easier identification between advanced programming module and standard programming module including the memory card slot, the keys of the programming modules in different colors. The keys of this module are blue, the chassis is light gray.

VCP operator terminal

Using the Engineering interface of the controller, it is also possible to connect an independent **VCP operator terminal** that can, for example, be integrated in the front of the control cabinet.

VCP operator terminals are separate components (terminals) that can be used in addition to the control panel. They can be connected to the controller via Ethernet.

VCPs can be programmed by users. All parameters of the controller and variables of MLD can be accessed.

Handling

Elements in this documentation

Overview of the elements used in the drawings below and their meanings:

1 bb	Standard display
Enter	Enter key - Apply change - Go to subordinate menu

Esc	ESC key - Reset changes - Go to superordinate menu
△ ▽	Arrow keys - Go to next/previous entry in the menu - Change value by one unit
Device Info	Flashing display The text regularly switches between both elements. The text displayed requires more than 8 characters.
Quick Setup opt. parameterizable IBN menu	Gray display Element is options and is displayed depending on the device or the setting.
Esc + Enter	Escape menu The shortcut ESC + Enter is used for unlocking in active view mode. First press the ESC key, then additionally the Enter key.
IP-Address: 192.168.0.1	Display (continuous text) The text is output as continuous text. The value is exemplary and depends on the hardware and the settings.

Tab. 9-4: Elements

Menu selection

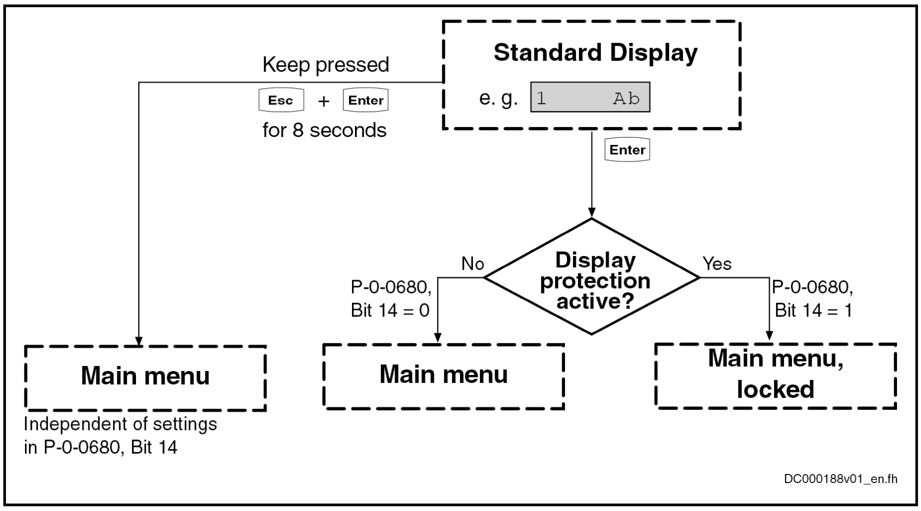


Fig. 9-10: Menu selection, depending on "P-0-0680, Control panel: Configuration"

Navigating in the menu

Get from the standard display to the main menu by pressing Enter. Different sub menus can subsequently be accessed via the Enter key.

The menu contains a "View level" in which information is visualized. If parameter information is displayed that can be modified, press the Enter key again to activate the Edit level. Use the Up and Down keys to change the current value in the Edit level.

The change only becomes valid if the "Enter" key is pressed again. The Edit level can be exited using the "ESC" key, changes are not applied.

When exiting the Edit level, the View level is reached automatically by verifying the realized changes again.

Displaying continuous texts

If information exceeding a length of eight characters (e.g. the IP address), the text is output as running text. The text is repeated until exiting the menu using the "Esc" key.

Running text is displayed as follows:

Fig. 9-11: Operator panel display, representation of continuous text

Quick browsing

When the Up or Down key is pressed for a long time to change numerical values (e.g., changes in the drive address), the display automatically keeps browsing. When keeping the key pressed for five seconds, the maximum scrolling velocity is reached. This allows for a quick change between large values.

Consecutive browsing

When the end of the value range of a data to be changed has been reached, or the last menu item, browsing automatically continues in the same direction with the first element. When changing a position from 10 to 250 in an IP address, it is recommended to scroll back to reach the desired value in steps of 15 instead of steps of 240.

Access protection

There are two options for restricting access via the operator panel:

- **Standard password protection**

  Parameters can be write-protected via standard password mechanisms. These parameters are password-protected and can only be changed if the correct password has been entered. Parameters contained in the control panel are also affected by this mechanism.

- **Display protection**

  Additionally, it is possible to lock the display. Set bit 14 in "P-0-0680, Control panel: Configuration" to do this.

Display protection is activated:

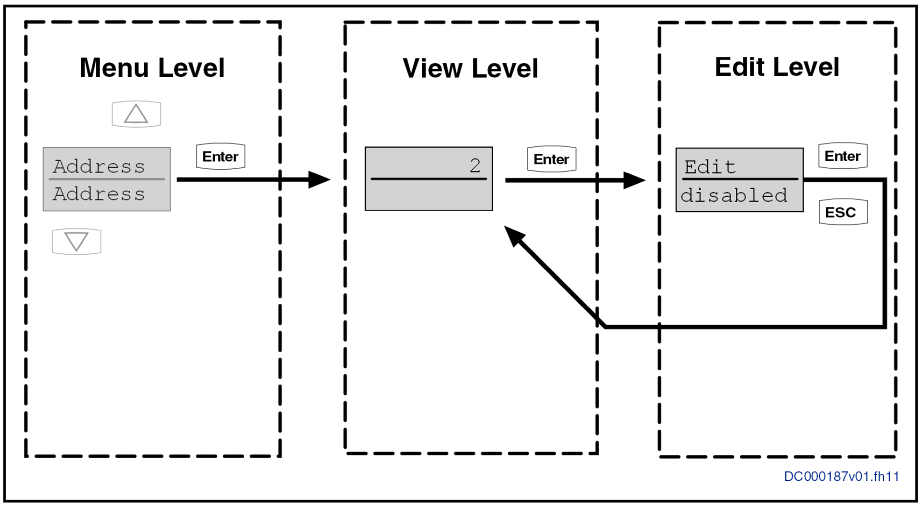
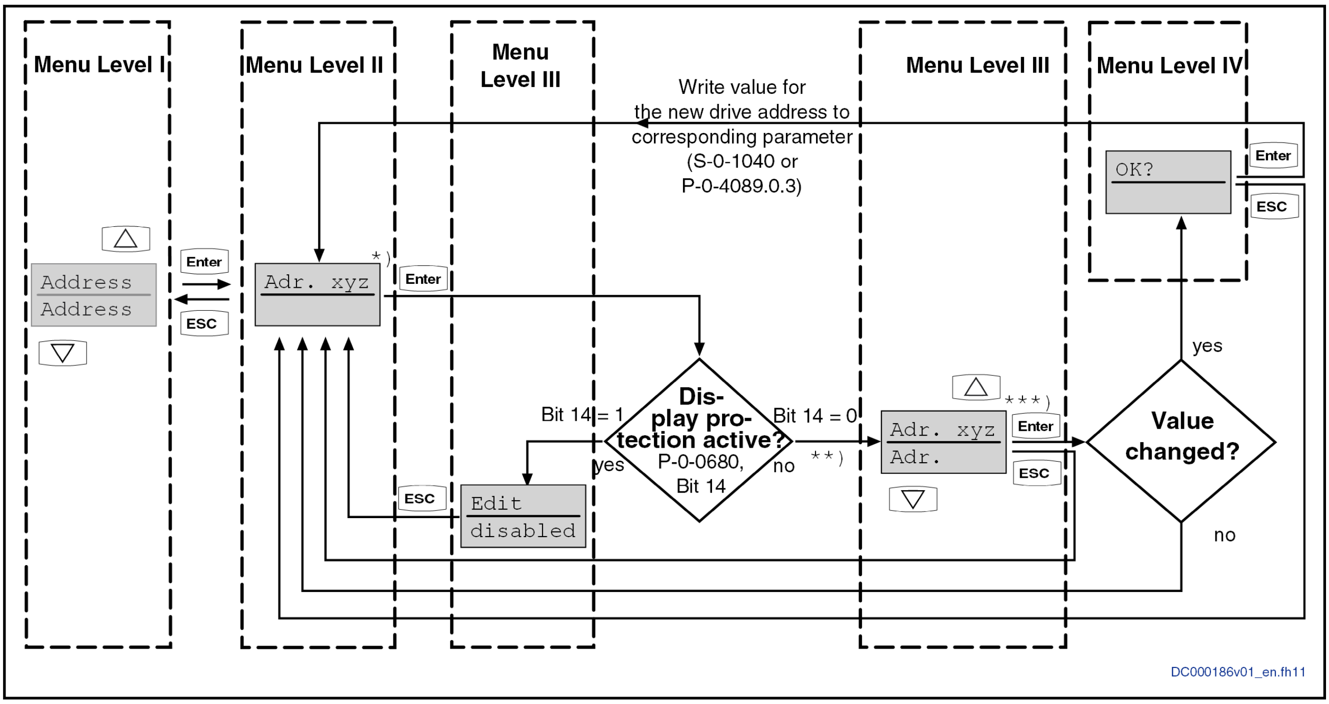


Fig. 9-12: Example: Active display protection

The display protection can be temporarily deactivated via the display in which the ESC + Enter key has been pressed for 8 seconds in the standard display. When returning to the standard display, the display protection is activated again.

Acknowledgment

If a value is changed from the operator panel, it has to be confirmed. The display shows "OK?". The value is applied with the "Enter" key and the Edit Level or View Level is exited. Use the "ESC" key to return to the Edit Level or View Level.



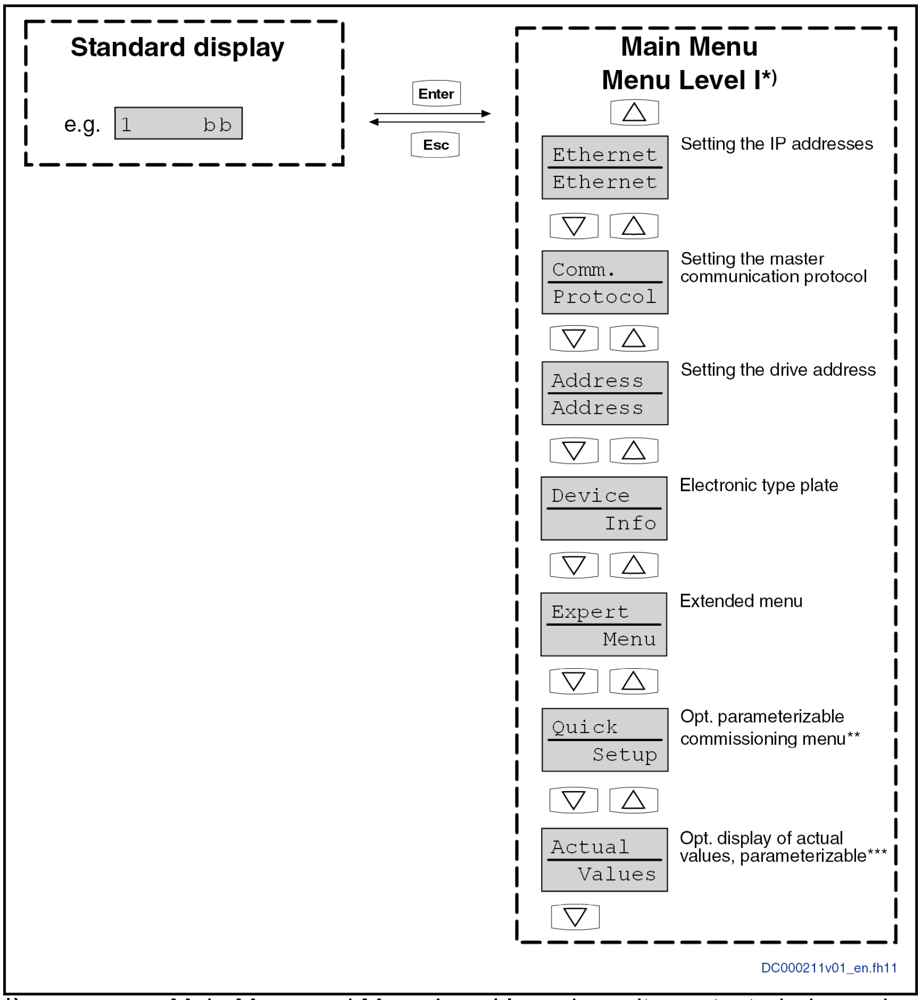
*)	"Adr. xyz" stands for the address to be entered "xyz"
**)	To change from the active display protection (View Mode) to the Edit Mode, go back to the standard display and unlock the View Mode from there by pressing ESC with ENTER key for 8 seconds.
***)	A new address is set using the Up and Down key.

Fig. 9-13: Acknowledging or implementing Edit/View Mode using changing a value as an example

Menu structure overview

The display features a standard display that shows axis-specific states and diagnostics. The standard display also shows errors that can be directly cleared via the display, if the cause of the error was removed.

The main menu can be accessed from the standard display by pressing the "Enter" key.



*) Main Menu and Menu Level I can be write-protected, depending on the setting in "P-0-0680, Control panel: Configuration"
**) Can be configured using "P-0-0680.0.1, Control panel: Config. list of changeable app. parameters"
***) Can be configured using "P-0-0680.0.2, Ctrl panel: Config. list of app. parameters to be displayed"

Fig. 9-14: Overview of display menu structure

Standard display

Structure of the display

The display is functionally divided into 2 areas, the display of the active address of the drive in the respective master communication and in the case of errors/warnings, the display of current operating status corresponding to the content of S-0-0390. If the state with the highest priority is a warning or an error, the display flashes and displays the diagnostic text in the language selected in parameter S-0-0265. By default, the diagnostic text (content parameters S-0-0095) is output as running text. Output as running text can be deactivated using bit 15 of parameter "P-0-0680, Control panel: Configuration". Once the running text has been displayed, the display changes to the master communication address an the error number until the error or the warning is not pending anymore or until it has been deleted.

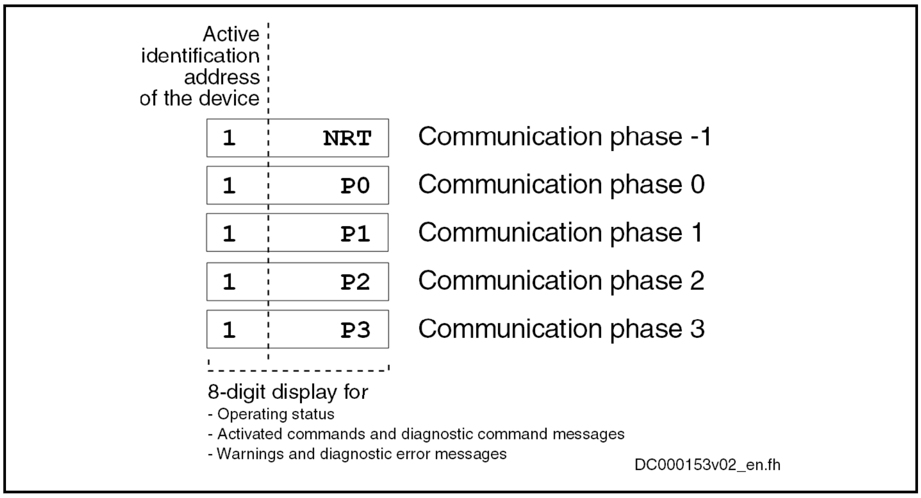
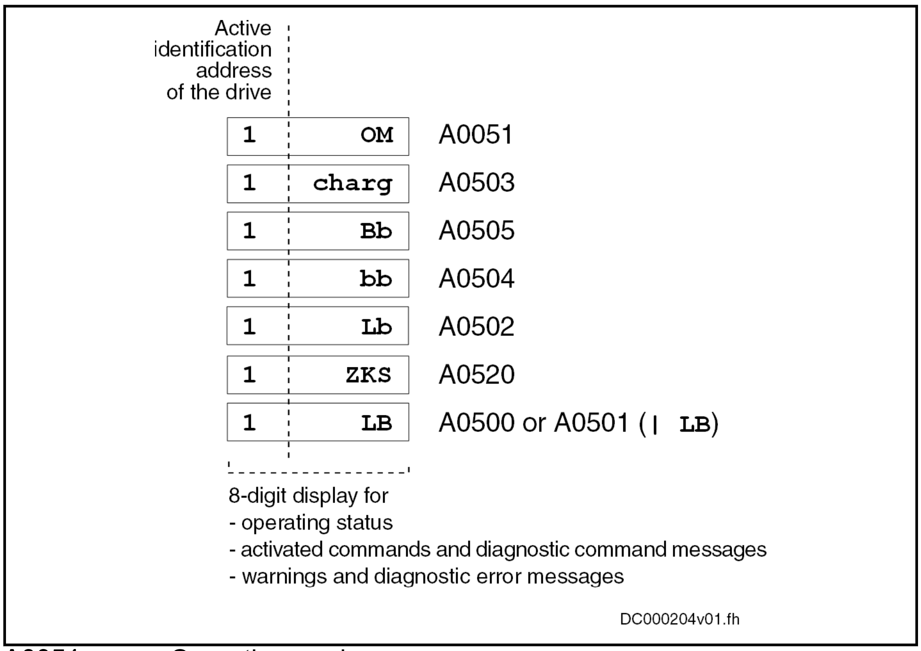


Fig. 9-15: Display during switching up of the phase of the master communication



A0051	Operating mode
A0500	Supply module in voltage control
A0501	Supply module in current control
A0502	Supply module in operation
A0503	DC bus charging active
A0504	Control section ready for oper., mains voltage not available
A0505	Power supply module ready for operation
A0520	DC bus quick discharge active

Fig. 9-16: Display of operating states is exemplary of a supply unit in mains operation

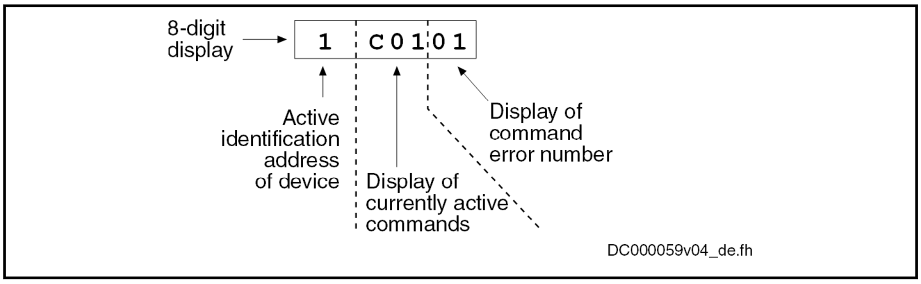


Fig. 9-17: Explanation of command error displays

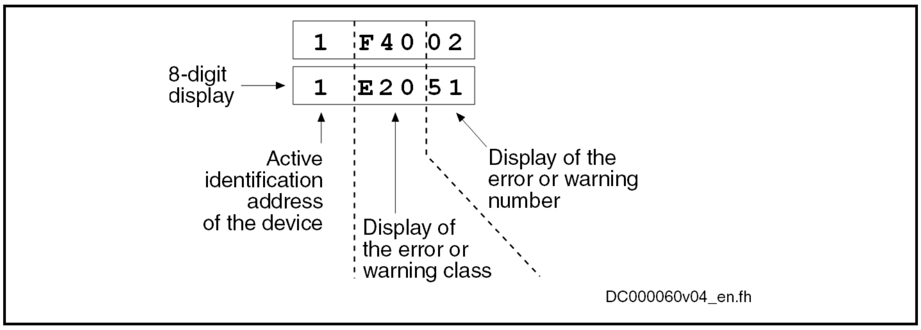


Fig. 9-18: Explanation of error and warning displays

Priorities of display

The displays have priorities, as it is not possible to display various messages simultaneously.

The display shows the current drive status with the highest priority.

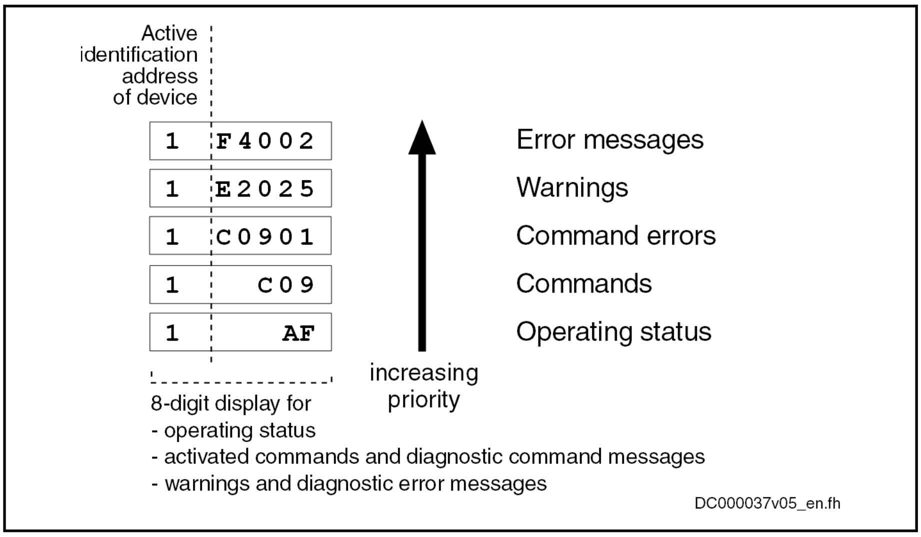


Fig. 9-19: Priorities of displays (with exemplary displays)

Displaying the controller address

The controller address is displayed in the standard display on the display. A 3-digit controller address is supported on the display. A controller address > 99 is output as continuous text.

The displayed controller address depends on the type of addressing. It is distinguished between device-oriented addressing (P-0-4089.0.3) or a slave-oriented addressing (S-0-1040).

The table below shows the parameters used for the relevant addressing type:

Master communication	Read access	Write access
Sercos	S-0-1040	S-0-1040
EtherCAT	P-0-4089.0.3	P-0-4089.0.3

Master communication	Read access	Write access
PROFINET	P-0-4089.0.3	P-0-4089.0.3
EtherNet/IP	P-0-4089.0.3	P-0-4089.0.3
PROFIBUS	P-0-4089.0.3	P-0-4089.0.3
Analog/parallel interface	P-0-4089.0.3	P-0-4089.0.3

Tab. 9-5: Parameters of controller address depending on master communication

Pertinent parameters:

S-0-1040, Drive address of master communication

P-0-4089.0.3, Device address

Main menu

General information

By default, the main menu has 6-8 menu entries. They are "Ethernet", "Comm. Protocol", "Address", "Device Info" and "Expert Menu". Additionally, two optional menu items "Quick Setup" and "Actual Values" have to be available. However, these menu items are only available in case of a certain parameterization.

Overview of standard menu entries:

Control panel text:	Note / information:
Ethernet	Under this menu, the set IP settings are displayed for Engineering connections. If required, they can be changed. The menu structure below "Ethernet" varies depending on the hardware used.
Comm. Protocol	This submenu displays the currently selected master communication protocol. It is possible to change or deactivate the protocol in this menu.
Address	This submenu shows the current controller address. The address can be changed, if required.
Device Info	This submenu displays information about the used hardware, e.g. firmware string (S-0-0030). No settings can be selected in this submenu.
Expert Menu	More complex functions are available under this menu item, e.g. "Load defaults procedure command".

Overview of the optional menu items:

Control panel text:	Note / information:
Quick setup	This optional submenu contains entries parameterized by the user. Each entry contains a scaled value directly linked to a parameter, also see "P-0-0680.0.1, Control panel: Config. list of changeable app. parameters".
Actual Values	This optional submenu contains entries parameterized by the user. Each entry contains a scaled value directly linked to a parameter.

Ethernet

The settings to the individual Engineering interfaces can be found here.

The IP address, the subnet mask and the standard gateway can be set. The physical MAC address (cannot be changed) is also contained here.

Depending on the hardware type, more or less submenus are available in menu level II.

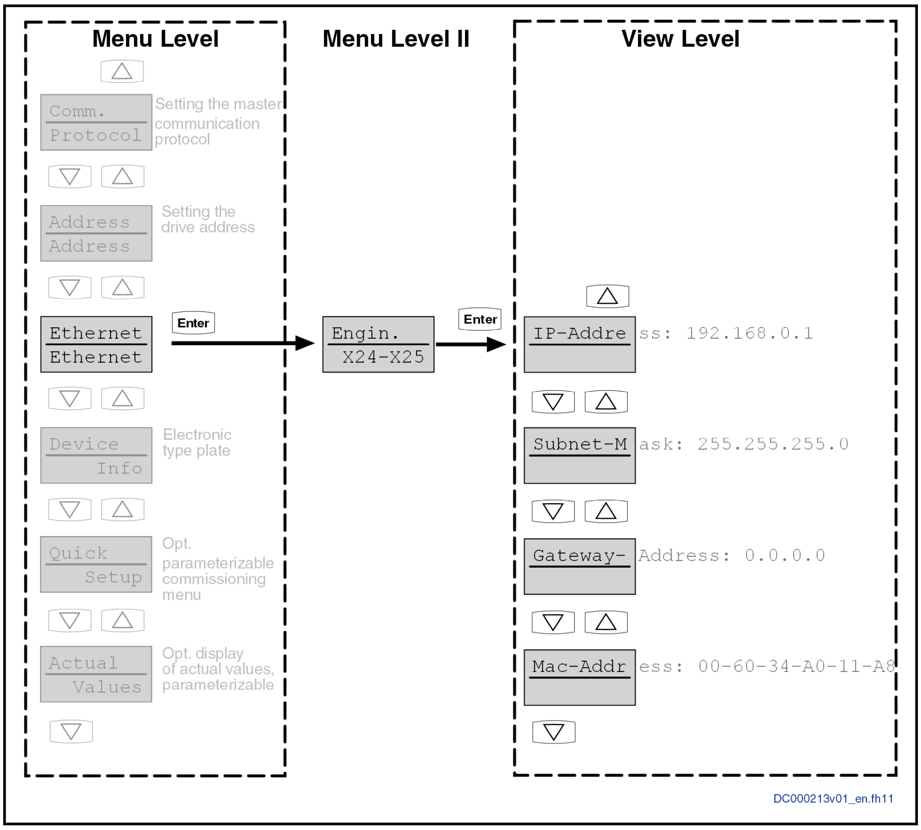


Fig. 9-20: "Ethernet" submenu

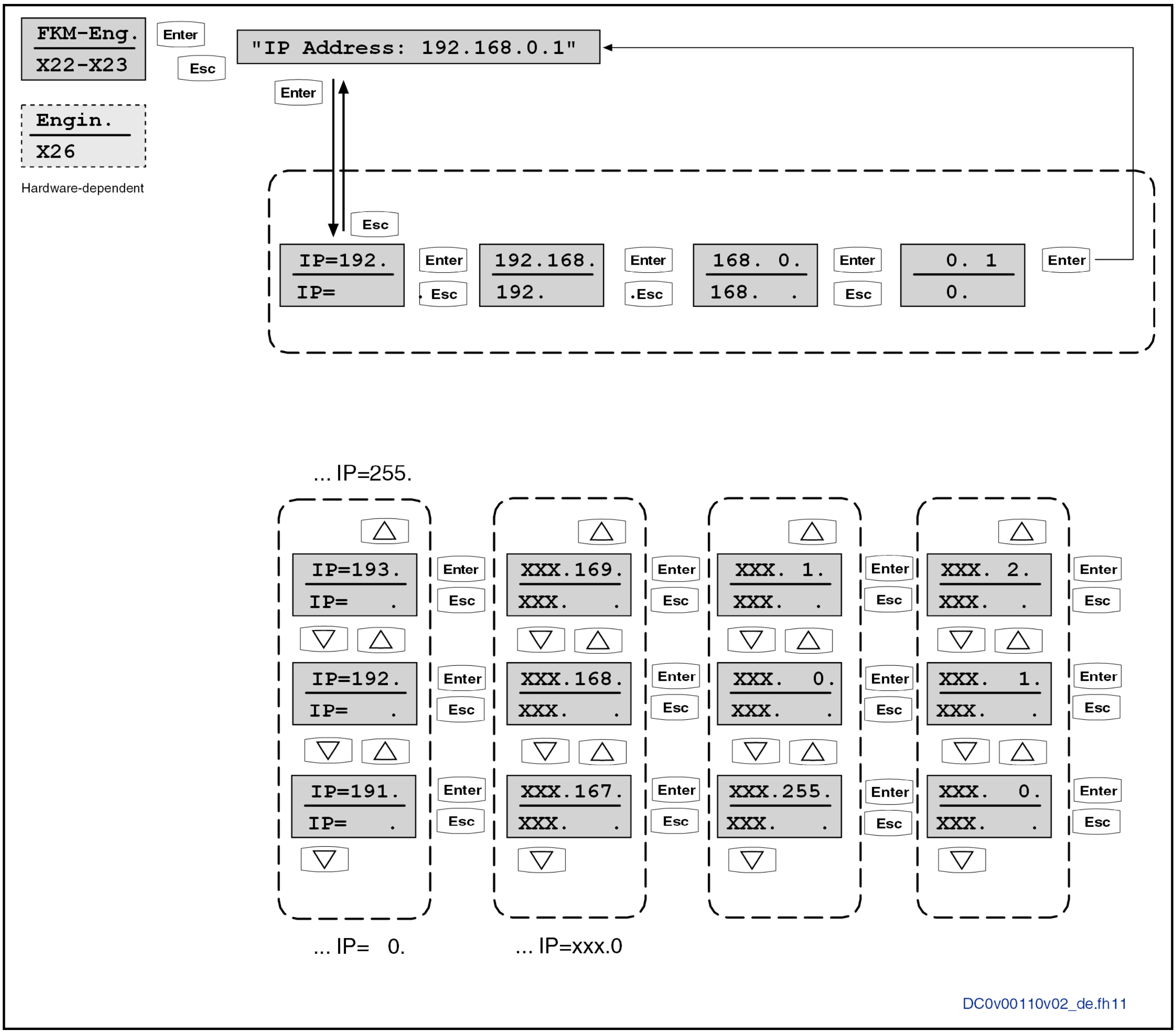


Fig. 9-21: Example for setting the IP address for "FKM-Eng. X22-X23"

Automatically assigning the subnet mask

If the IP address is changed via the display, the subnet mask is automatically changed in three specific networks. The following table shows the dependencies:

IP address	Subnet mask
C-class mains: 192.x.x.x	255.255.255.0
B-class mains: 172.x.x.x	255.255.0.0
A-class network wtih 10.x.x.x	255.0.0.0

If this setting has to be adjusted, it can be changed via the display of the subnet mask.

Automatically activating the IP addresses

If min. one setting is changed in the IP addresses, the command "C6100 Command Activate IP settings" is started when exiting the menu level II via the "Esc" key and the changed IP settings are set to valid.

Only changes confirmed in an Edit level using the "Enter" key are set to valid. If no changes were made or if all changes have been canceled again using the "ESC" key, the command is not executed.

Comm. Protocol

This menu contains different elements, depending on the master communication hardware. See figure "Comm. Protocol" on page 215.

The currently selected master communication protocol is displayed on the View level. By pressing the Enter key again, the protocol can be changed in the case of the MultiEthernet option. Otherwise, the master communication protocol can be activated/deactivated here.

If the controller is used as stand along device without master communication connection, use "not act." as master communication protocol.

The figure shows the menu structure of an IndraDrive Cs Basic without optional master communication option.

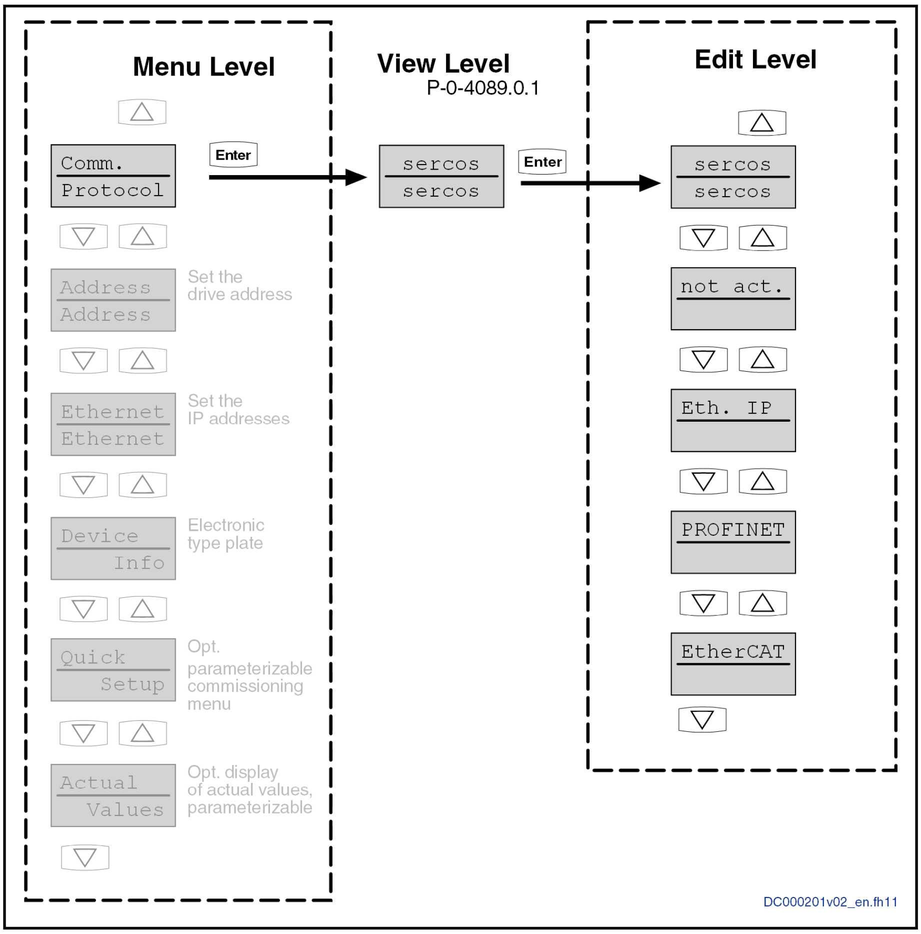
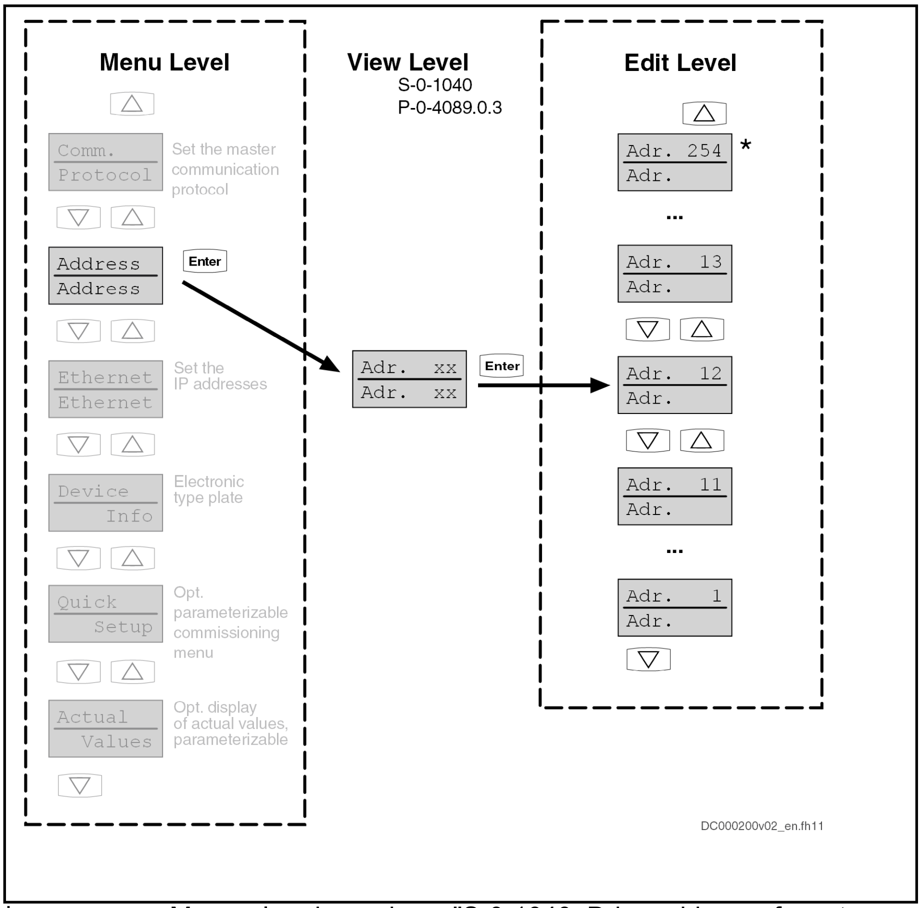


Fig. 9-22: Address submenu for "Comm. Protocol" of IndraDrive Cs Basic in standard characteristic

Options in Edit Level in case of different hardwares:

Address

The currently selected controller address is contained below "Address". Depending on the addressing type, the drive address is "S-0-1040, Drive address of master communication" or "P-0-4089.0.3, Device address" This address is used for logic identification of the controller by the superordinate control. In case of an incorrect configuration, the control detects that a controller with incorrect configuration is contained in the link.



* Max. value depends on "S-0-1040, Drive address of master communication", "P-0-4089.0.3, Device address"

Fig. 9-23: "Address" submenu

Device Info Under "Device Info",identification data, such as the firmware version can be found. Hardware information, too, can be found in this menu, e.g., type code, material number and serial number.

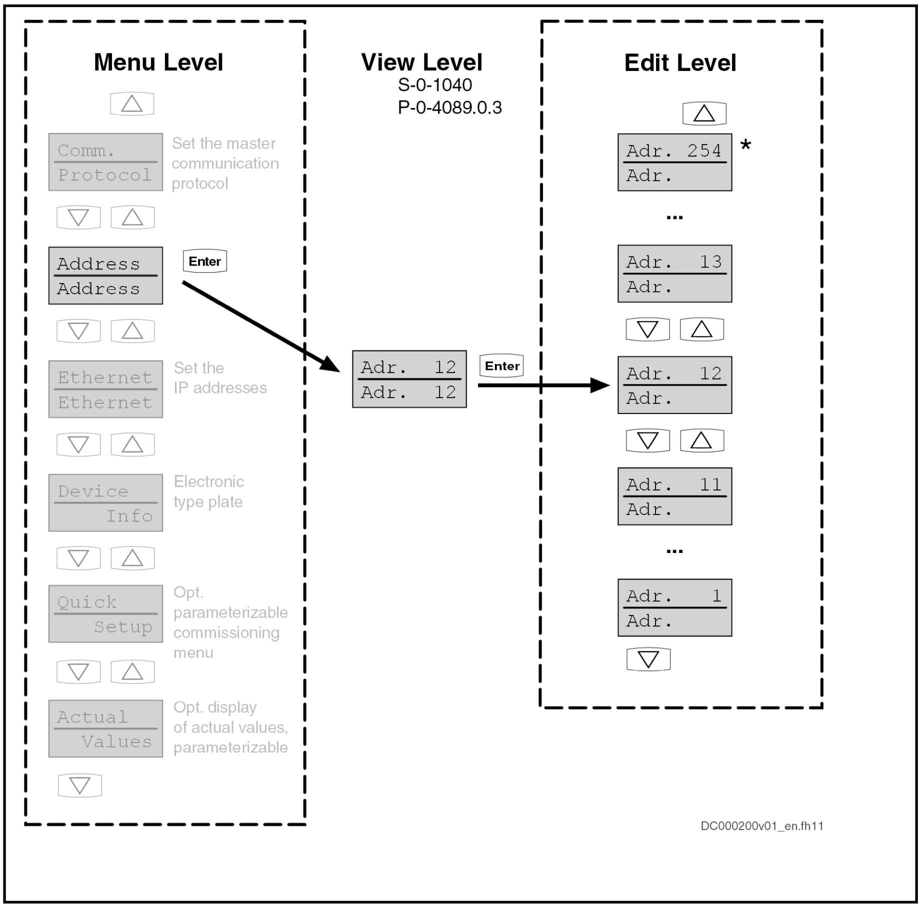


Fig. 9-24: "Device Info" submenu

Assigning the entries in the "Device Info" menu to the parameters used

Device type	Menu	Entry	Parameter used
Supply unit (HMV05) Single device	Power Unit	Type name	S-0-1300.0.4
		HW revision	S-0-1300.0.8
		Order number	S-0-1300.0.11
		Serial number	S-0-1300.0.12
	Control Unit	Type name	S-0-1300.1.4
		HW revision	S-0-1300.1.8
		Order number	S-0-1300.1.11
		Serial number	S-0-1300.1.12
	Power Unit 1	Type name	S-0-1300.50.4
		HW revision	S-0-1300.50.8
		Order number	S-0-1300.50.11
		Serial number	S-0-1300.50.12
	Mains adapter	Type name	S-0-1300.80.4
		HW revision	S-0-1300.80.8
		Order number	S-0-1300.80.11
		Serial number	S-0-1300.80.12

Device type	Menu	Entry	Parameter used
Supply unit (HMV05) Device from parallel connection	Power Unit	Type name	S-0-1300.0.4
		HW revision	S-0-1300.0.8
		Order number	S-0-1300.0.11
		Serial number	S-0-1300.0.12
	Control Unit	Type name	S-0-1300.1.4
		HW revision	S-0-1300.1.8
		Order number	S-0-1300.1.11
		Serial number	S-0-1300.1.12
	Power Unit 1	Type name	S-0-1300.50.4
		HW revision	S-0-1300.50.8
		Order number	S-0-1300.50.11
		Serial number	S-0-1300.50.12
	Power Unit n	Type name	S-0-1300.5n.4
		HW revision	S-0-1300.5n.8
		Order number	S-0-1300.5n.11
		Serial number	S-0-1300.5n.12
	Mains adapter	Type name	S-0-1300.80.4
		HW revision	S-0-1300.80.8
		Order number	S-0-1300.80.11
		Serial number	S-0-1300.80.12

Tab. 9-6: Structure of Device Info menu depending on the device

Pertinent parameters:

S-0-1300.x.9, Software version

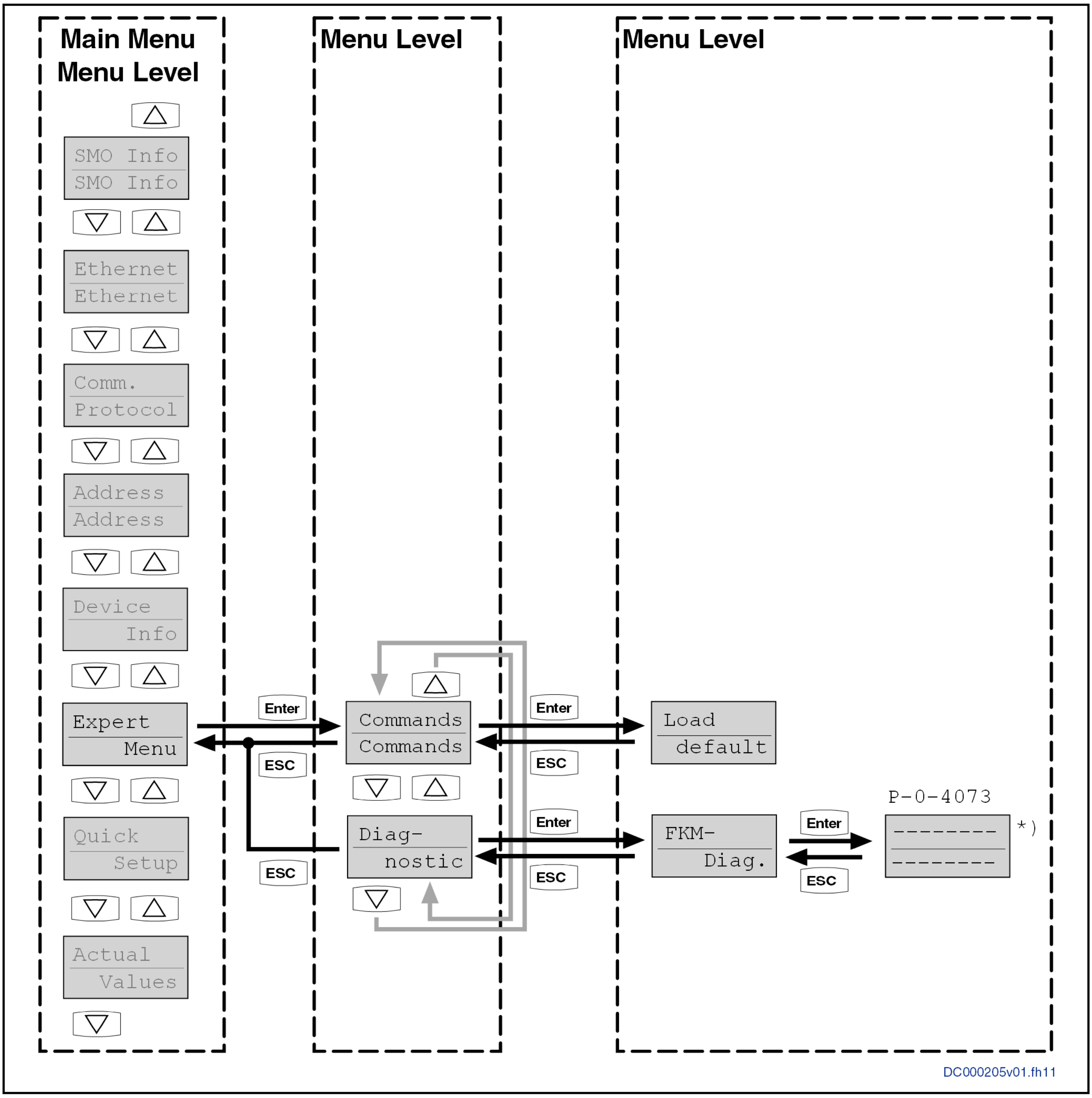
S-0-1300.x.4, Device Name

S-0-1300.x.8, Hardware version

S-0-1300.x.11, Order Number

S-0-1300.x.12, Serial Number

Expert Menu with Commands and Diagnostic submenu



*) This parameter contains the state of the field bus status machine in plain text. The diagnostic message depends on the field bus used and is based on the nomenclature used in the standard.

Fig. 9-25: Expert Menu with Commands and Diagnostic submenu

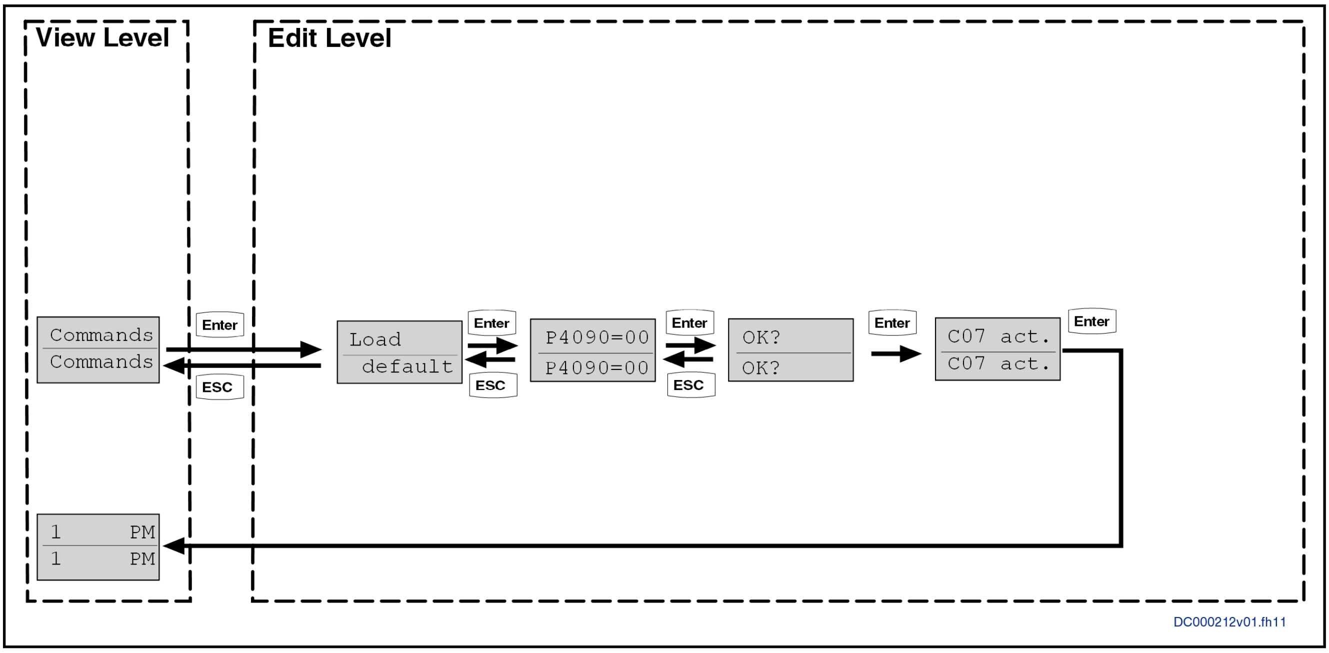


Fig. 9-26: Loading the basic parameters

Quick setup

"Quick Setup" is an optional submenu with entries parameterizable on the user side. Each entry contains a scaled value directly linked to a parameter, also see "P-0-0680.0.1, Control panel: Config. list of changeable app. parameters".

Actual Values

Predefined default value for supply units:

The "Actual Values" (P-0-0680.0.2) menu item of the supply units is initialized with a predefined menu structure (default value P-0-0680.0.2). The following parameters are displayed:

- S-0-1702.0.1, Mains voltage peak value
- S-0-1702.0.2, Mains current
- S-0-1702.0.13, Mains power
- S-0-1707.0.1, Actual DC bus voltage
- S-0-1710.0.2, Thermal device load

☞ Current (A), voltage (V) and load (%) are displayed without decimal places. Example: 53.3% load is displayed as "+0053".

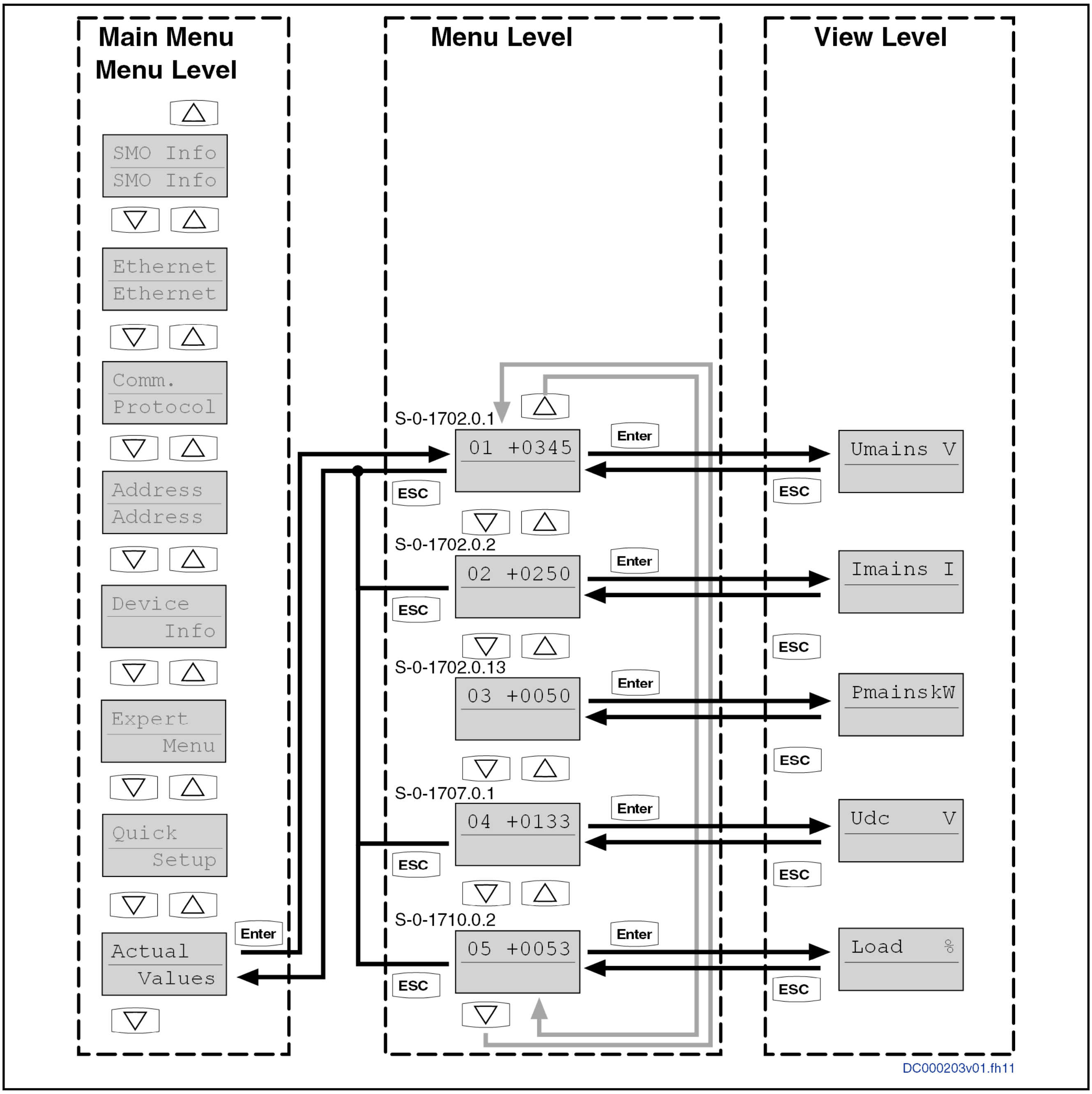


Fig. 9-27: Default menu structure "Actual"-"Values" for PSB derivative

"Actual Values" is a submenu with entries parameterizable on the user side. Each entry contains a scaled value directly linked to a parameter, also see "P-0-0680.0.2, Ctrl panel: Config. list of app. parameters to be displayed".

"P-0-0680.0.2, Ctrl panel: Config. list of app. parameters to be displayed" has a default value for supply units.

9.5 Firmware replacement

9.5.1 Brief description

Basic principles

Explanation of terms The following cases are distinguished for firmware replacement:

- **Release update**

  An old firmware release contained in the device (e.g. PSB21**V04**) is replaced by a new firmware release (z. B. PSB21**V06**).
- **Version upgrade**

  The old firmware version contained in the device is replaced by a new firmware version (example: PSB**19**V10 is replaced by PSB21V06).

☞ The following chapters regarding the release update and firmware upgrade exclusively apply to devices of the IndraDrive Cs type, as well as control sections (CSB02, CSH02, CDB02, CSE02) and IndraDrive Mi (KSM02, KMS02). This information does **not** apply to IndraDrive HCQ / HCT, but is described in the separate documentation "Rexroth IndraMotion MTX micro12VRS System Description" (DOK-MTXMIC-SYS*DES*V12-PR01-EN-P, mat. No. R911334369).

Procedure

Firmware for IndraDrive can be replaced using the following hardware and software:

- Computer with FireFox or Internet Explorer web browser or
- Computer with "IndraWorks" software or
- Computer with TFTP client
- IndraDrive Service Tool (IDST) (with MPx18V10 and above)

☞ "IndraDrive Service Tool (IDST)" allows the controller system to be accessed, e.g. for remote diagnostics. Besides, authorized users can handle different service cases with IDST, such as replacing drive components, loading parameters or updating/ upgrading the firmware.

Further information on "IndraDrive Service Tool (IDST)" is described in the separate documentation "Rexroth IndraDrive Service Tools IMST/IDST" (DOK-IM*MLD-IMSTIDSTV13-RE**-EN-P; mat. no. R911342652).

☞ The "IndraWorks" commissioning software can be ordered from Rexroth.

The scope of supply of "IndraWorks" contains a documentation which describes the operation of the program.

To be noticed

After every firmware replacement (release update and version upgrade), check the following parameters for validity:

- P-0-2003, Selection of functional packages
- P-0-4089.0.1, Master communication: Protocol

It might possibly be necessary to set them valid during the first run-up after the firmware replacement.

Preparations and conditions for firmware replacement

Preparing the firmware replacement

Make the following preparations for firmware replacement:

1. Controller must be on (24 V supply).
2. The controller should **not** be in operating mode (communication phase 4).

3. It is recommended to save the backup parameters before replacing the firmware (see Functional Description "Loading, storing and saving parameters").

General notes on how to proceed

Observe the following points when carrying out the firmware replacement:

- For firmware replacement via IndraWorks or IndraDrive Service Tool (IDST), Ethernet communication with the controller has to be possible. (IDST is available with MPx18V10 or from PSB20V14 and above.)
- Do not switch off the 24 V control voltage while replacing the firmware.
- The firmware replacement always has to be carried out completely.

Communication types

Depending on the activated bus system (cf. P-0-4089.0.1), the Engineering communication works in different ways. The settings and conditions have to be made and complied with according to the bus system used. For further information see "chapter TCP/IP communication".

Via the programming module, the active IP settings can be viewed or adjusted, if necessary (see Functional Description "Standard control panel").

☞ After the IP settings have been changed, the device has to be restarted to activate the settings. If several devices have been connected via the master communication bus, make sure that an unequivocal IP address is assigned to each node.

IP configuration in the Easy Menu

See functional description "Standard control panel"

IP settings on the computer

See Microsoft help, keyword "LAN connection"

9.5.2 Firmware release update

General information

Before the firmware release update, it is recommended to save the backup parameters of the drive!

☞ If the firmware is replaced at a device activated in a safety-related way, this procedure has to be recorded in the machine logbook, together with the axis identifier, configuration type data and parameterization type data.

Firmware release update with computer

☞ When the safety technology options S3 or S4 are used, the system checks whether firmware and parameter set are compatible. This prevents the safety technology from being operated with an incompatible parameter set. Incompatible changes typically do not occur in the case of a release update. In the case of an incompatibility, it is possible to either

- continue with the existing parameterization by reloading the originally available firmware, or
- continue with the new firmware by way of initial commissioning (incl. loading of basic parameters for SMO contained therein)

1. Connect the controller to the computer (recommended: Cat5e Ethernet cable)
2. Load firmware

   There are three possibilities of performing a firmware release update using a computer:

- Using IndraWorks
- With a TFTP client
- Via the supplied IDST web interface.

  This option only applies to firmware updates of MPx18V10 and from PSB20V14. IDST is not available for older versions.

1. *Firmware download with IndraWorks*

   1.1 Call "IndraWorks".

   1.2 Load project for the corresponding controller or create new project. To do this, address the controller via Ethernet.

   1.3 Switch project "online".

   1.4 Select/highlight controller and call "Firmware management" in context menu.

   A new window opens and firmware currently available in controller is displayed.

   1.5 Highlight new firmware (*.ibf file) in the upper part of the dialog and start firmware download via "Download" button.

   Firmware download runs automatically and all required firmware components are loaded to controller.

   1.6 After firmware download has been completed, close "Firmware management" window.

2. *Firmware download using a TFTP client*

   2.1 The firmware update service is provided via a TFTP server. The command for transmitting the firmware is the "put" command. The TFTP client has to transmit the file in the binary format.

☞ It is possible to carry out a firmware release update **without IndraWorks** with any TFTP client supporting this command (e.g., Windows command line program "tftp.exe").

Example (with "Microsoft Windows consoles TFTP client"):

To carry out a firmware release update, only a "put" request is transmitted. Do not use an optional alternative name for the file on the target. The IP address of IndraDrive has to be specified as the target (the standard is 192.168.0.1): `tftp -i 192.168.0.1 put FWA-INDRV_-MPB-17V12-D5.ibf`

The parameter "-i" means that the file is to be transmitted in binary form.

See also functional description: "Firmware download via TFTP server"

3. *Firmware download with IDST (with MPx18V10 or PSB20V14)*

   3.1 Enter IP address of IndraDrive in web browser

   3.2 Log in as service user at web interface

   3.3 In navigation tree on the left side select "Firmware update" dialog in "Service" folder

   3.4 Select new firmware by clicking "Search" button, firmware update is started by clicking download button

3. Restart controller

At the end of the update, IndraWorks and IDST automatically provide the option to restart IndraDrive using the reboot command S-0-1350. As an alternative, IndraDrive can be restarted by resetting the control voltage

4. Put machine into ready-for-operation status again according to machine manufacturer's instructions.
5. Check controller functions.

9.5.3 Firmware version upgrade

General information

When firmware in a controller is replaced by firmware of a **more recent version**, this is called firmware version upgrade (e.g. FWA-INDRV*-PSB-**19**V06 replaced by FWA-INDRV*-PSB-**21**V04-D5).

☞ **Before** the firmware version upgrade is carried out, all parameters have to be saved (e.g., with "IndraWorks"). **After** the firmware replacement, the parameters have to be restored, because the command "C07_1 Load defaults procedure command (factory settings)" is carried out automatically. After the desired parameter file was loaded, the controller is ready for operation again.

Saving parameter values

Before the firmware upgrade, all application-specific parameter values have to be saved on a data carrier. The parameter backup can be carried out via:

- **"IndraWorks" commissioning software**

  → Saving parameter values on external data carrier

- or -

- IndraDrive Service Tool (IDST) (from MPx18V10 or PSB20V14)

  → Saving parameter values on external data carrier

- or -

- **Control master**

  → Saving parameter values on master-side data carrier

Version upgrade with "IndraWorks"

Requirements

The following requirements should have been fulfilled in order that carrying out the firmware version upgrade with "IndraWorks" makes sense:

- Existing Ethernet connection between PC and controller
- The current parameterization of the controller was saved.

Firmware upgrade with "IndraWorks"

Carrying out the firmware version upgrade with "IndraWorks" requires the following steps:

1. **Load firmware**

   1.1 Call "IndraWorks".

   1.2 Load project for the corresponding controller or create new project. To do this, address the controller via Ethernet.

   1.3 Switch project "online".

   1.4 Select/highlight controller and call "Firmware management" in context menu.

   A new window opens and firmware currently available in controller is displayed.

1.5 Highlight new firmware (*.ibf file) in the upper part of the dialog and start firmware download via "Download" button.

Firmware download runs automatically and all required firmware components are loaded to controller.

1.6 After firmware download has been completed, close "Firmware management" window.

1.7 Reboot controller

2. **Set controller into ready-for-operation state**

⇒ Switch project "online".

After project has been switched "online", a message sometimes signals that "IndraWorks" could not establish communication to the controller via Ethernet interface, since controller-internal settings for Ethernet communication were reset.

⇒ In this case, reconfigure communication via "Search for devices" button!

⇒ As firmware in the controller no longer complies with the version stored in project, a corresponding message is displayed. Select desired option in dialog to provide the controller in the project again and allow re-establishing the communication to device.

⇒ Manually set functional package and master communication protocol via corresponding parameters.

⇒ Activate command "C07_1Load defaults procedure command (factory settings)". All buffered parameters are thereby set to their default values.

3. **Load parameter values**

⇒ Load parameter file which was saved!

⇒ Switch off the controller and restart it so that the parameterization becomes active.

4. **Put machine into ready-for-operation state**

⇒ Put machine into ready-for-operation state again according to machine manufacturer's instructions!

⇒Check controller functions!

9.5.4 Possible problems during firmware replacement

General information

After an incomplete firmware update, the drive controller possibly is no longer operable.

Firmware replacement is carried out incompletely, if one of the following situations occurs during the sequence of firmware replacement:

- 24 V supply of control section is switched off
- Connection to the controller is interrupted (e.g., defective interface cable)
- Update software / computer crashes

If there is no valid firmware available in the control section, the loader is started. The text "LOADER active! IP address: 192.168.0.1" appears on the display in light writing. With the loader, it is possible to replace the firmware of the control section.

☞ Upon successful firmware replacement in the control section, a restart has to be carried out.

Firmware replacement in control section in the case of error

The following steps are required for loading the firmware to the control section in the case of error:

1. Call "IndraWorks".
2. In the menu, call the firmware management under **Service ▸ Firmware management.**

   A new window opens in which firmware file last used is displayed on PC.
3. Select the "Download via Ethernet" tab.
4. Set IP address "192.168.0.1".
5. Highlight desired firmware (*.ibf file) and start firmware download via **Download** button.
6. Firmware download runs automatically and all required firmware components are loaded to the controller.
7. After firmware download has been completed, close "Firmware management" window.
8. Restart the controller.

9.6 Replacing the controller

9.6.1 Overview

A controller of the IndraDrive range consists of the components power section, control section and programming module / control panel (incl. firmware). The control section can be configured with additional components (e.g., optional safety technology module). The control section and power section are firmly connected to each other. Only Rexroth service engineers or especially trained users are allowed to replace individual components. The paragraphs below describe how to replace the complete drive controller.

☞ The controller has to be replaced by a device of identical type. This is the only way to ensure that the originally configured functions can be used in unchanged form.

When using devices with integrated safety technology, make sure by organizational measures that only an authorized person replaces the device, e.g., by a lockable control cabinet. Also make sure that the device replacement is not carried out for several axes at a time to avoid accidentally interchanging the axes.

A device intended for replacement that has already been in operation (thus is not in the factory-new condition as supplied), has to be brought to the condition as supplied again ["load defaults procedure (factory settings)", command C0750] before it is used.

The figure below illustrates the basically required individual steps.

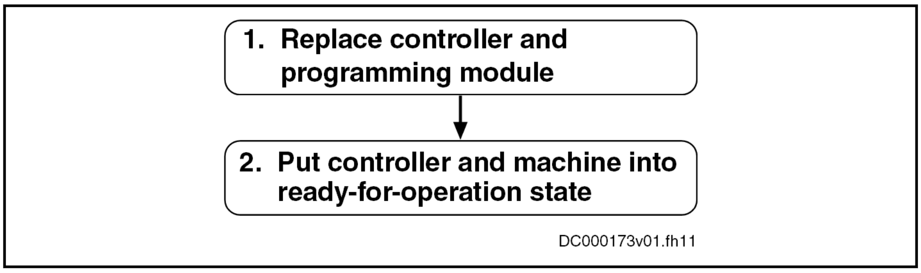


Fig. 9-28: Sequence of drive controller replacement

☞ "IndraDrive Service Tool (IDST)" allows the controller system to be accessed, e.g. for remote diagnostics. Besides, authorized users can handle different service cases with IDST, such as replacing drive components, loading parameters or updating/ upgrading the firmware.

Further information on "IndraDrive Service Tool (IDST)" is described in the separate documentation "Rexroth IndraDrive Service Tools IMST/IDST" (DOK-IM*MLD-IMSTIDSTV13-RE**-EN-P; mat. no. R911342652).

9.6.2 How to proceed when replacing drive controllers

Replacing the drive controller and the programming module

1. Open the main switch
2. Make sure the main switch cannot be switched on again.
3. Make sure drive controller is de-energized.

   WARNING! Lethal electric shock from live parts with more than 50 V! Before working on live parts: De-energize system and secure power switch against unintentional or unauthorized reconnection. Wait at least **30 minutes** after switching off the supply voltages to allow **discharging**. Make sure voltage has fallen below 50 V before touching live parts!
4. Separate connection lines from controller.
5. Dismount drive controller from control cabinet.
6. Dismount programming module / control panel
   - With IndraDrive C/M/Cs: Pull off programming module / control panel from defective device.
   - With IndraDrive Mi: Remove programming module (X107) from defective device, note down positions of address selector switches S4 and S5 (address selector switches below connections X103.1 and X103.2).
7. Mount programming module / control panel
   - With IndraDrive C/M/Cs: Plug programming module / control panel of defective device onto new controller.
   - With IndraDrive Mi:
     1. Set the address selector switches in the same way as for the defective device.
     2. Dismount cover above slot X107.
     3. Plug programming module of defective device onto replacement device.
     4. Mount cover above slot X107.

NOTE: Damage to the programming module caused by penetrating dirt or moisture. When mounting the cover of X107, make sure that the sealing ring is undamaged and is seated correctly.

8. Mount new controller.

☞ The controller has to be replaced by a device of identical type. This is the only way to ensure that the originally configured functions can be used in unchanged form.

---

9. Connect device according to machine circuit diagram

Putting drive controller and machine into ready-for-operation state

1. Restore control voltage.
2. Put machine into ready-for-operation state again according to the machine manufacturer's instructions.
3. Activate safety technology (only with active Safe Motion with S3/S4 option)

   With single-axis devices, the following message appears on the display of the control panel during the booting process:

   "**Load new Safety?**"

   With double-axis devices, the following message appears on the display of the control panel during the booting process:

   "**.1 Load new Safety?**" for Axis 1 or "**.2 Load new Safety?**" for Axis 2

   Pressing the "Enter" key at the control panel acknowledges the message. The safety technology parameters are now loaded from the control panel to memory of the optional safety technology module.

☞ IndraDrive Mi does not feature a control panel. This is why the parameter image of safety technology has to be activated by executing the command "P-0-3231.0.3, C8300 SMO: Command Activate parameter image", e.g., using IndraDrive Service Tool (IDST).

The error "F8330, SMO: Configuration data record has not been activated" generated during boot-up signals that the active image identifier on the programming module does not comply with the image identifier that was stored on the safety technology hardware. After the command C8300 has been successfully executed, the error has to be cleared using the "clear error" command (C0500). The command execution is described in the Functional Description of the firmware, see chapter "Command processing".

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4. Check controller functions.
5. Check safety technology parameters (only with active Safe Motion with S3/S4 option)

   Completing the process, it is necessary to check, with activated safety technology, whether the correct safety technology parameters have been loaded for the drive.

   The replacement of the device has to be recorded in the machine logbook. For this purpose, the data of the following safety technology parameters have to be accordingly documented and checked for correctness (these data can be queried via the control panel in the "SMO Info" menu. For IndraDrive Mi, the data have to be read, e.g. by means of the

IndraDrive Service Tool (IDST), because IndraDrive Mi does not feature a control panel):

- P-0-3230, SMO: Password level
- P-0-3235.0.1, SMO: Active axis identifier
- P-0-3234.0.1, SMO: Configuration checksum
- P-0-3234.0.2, SMO: Operating hours at last change of configuration
- P-0-3234.0.3, SMO: Configuration change counter
- P-0-3234.0.4, SMO: Parameterization checksum
- P-0-3234.0.5, SMO: Operating hours at last change of parameterization
- P-0-3234.0.6, SMO: Parameterization change counter

9.6.3 Possible problems during controller replacement

Display defective or programming module defective

If the programming module / the display is defective, the parameter values saved after initial commissioning have to be loaded.

NOTICE **The parameter values saved after initial commissioning are not generally suited for reestablishing the operatability of the drive after a device has been replaced!**

Check actual position values and active target position before setting drive enable!

When firmware and controller parameters are to be transmitted to the replacement controller, the required firmware and a parameter backup of the respective controller must be available.

1. Reestablish the control voltage supply of the controller.
2. Carry out firmware update, see also chapter "Firmware replacement"
3. Via the "IndraWorks" commissioning tool or the control master, load parameter file to controller:
   - "IndraWorks" commissioning tool

     Load parameter values saved after initial commissioning to controller.
   - "IDST" service tool

     Load parameter values saved after initial commissioning to controller.
   - Control master

     Load controller-specific parameter values saved after initial commissioning [according to list parameters "S-0-0192, IDN-list of all backup operation data" and "P-0-0195, IDN list of retain data (replacement of devices)"].

☞ With active Safe Motion, initial or serial commissioning of the drive controller is required after the programming module has been replaced!

9.7 Enabling functional packages

9.7.1 Brief description

The user can scale the scope of functionality of the IndraDrive firmware. This allows the scope of firmware functions to be adjusted to the respective requirements and, if necessary, reduced in its complexity.

The functionality is scaled by licensing (enabling) optional expansion packages that are available in addition to the standard base package of the respective IndraDrive firmware.

See also "Overview of functions/functional packages"

Features

- Activated functional packages displayed in parameter "P-0-2004, Active functional packages"
- Firmware type designation in parameter "S-0-0030, Manufacturer version" dynamically adjusted to the active functional packages displayed in P-0-2004
- Functional packages activated/deactivated via parameter
- count of operating hours counter is stored upon the last change of access enable

Parameters involved

- S-0-0030, Manufacturer version
- S-0-1350, C6400 Reboot command
- P-0-2002, Oper. hours of contr. sect. at change of functional packages
- P-0-2003, Selection of functional packages
- P-0-2004, Active functional packages

Diagnostic messages involved

- C0202 Parameter limit error (->S-0-0423)
- C0299 Configuration changed. Restart

9.7.2 Functional description

Changing the active functional package selection

The functionality of the firmware is divided into several functional packages. By enabling certain packages, it can be adjusted to the requirements of the respective application.

Basically, there are the following options for subsequently scaling the functionality:

- **Reducing** the already licensed scope of functions in order to reduce the complexity of the firmware
- **Expanding** the scope of functions originally ordered (additional licensing)

☞ Non-licensed functional packages cannot be used. Enabling functional packages which are not part of the originally ordered scope of functions requires additional licensing that is not free of charge! If a non-licensed function is used, any guarantee on the part of Rexroth will expire.

If access enable for functional packages is changed, the count of the operating hours counter is stored in parameter P-0-2002. The Rexroth staff can therefore provide evidence of non-licensed functions that have been enabled.

Parameter P-0-2003 is available to select the functional packages. Parameter P-0-2004 is used to display the activated packages. The following assignment applies:

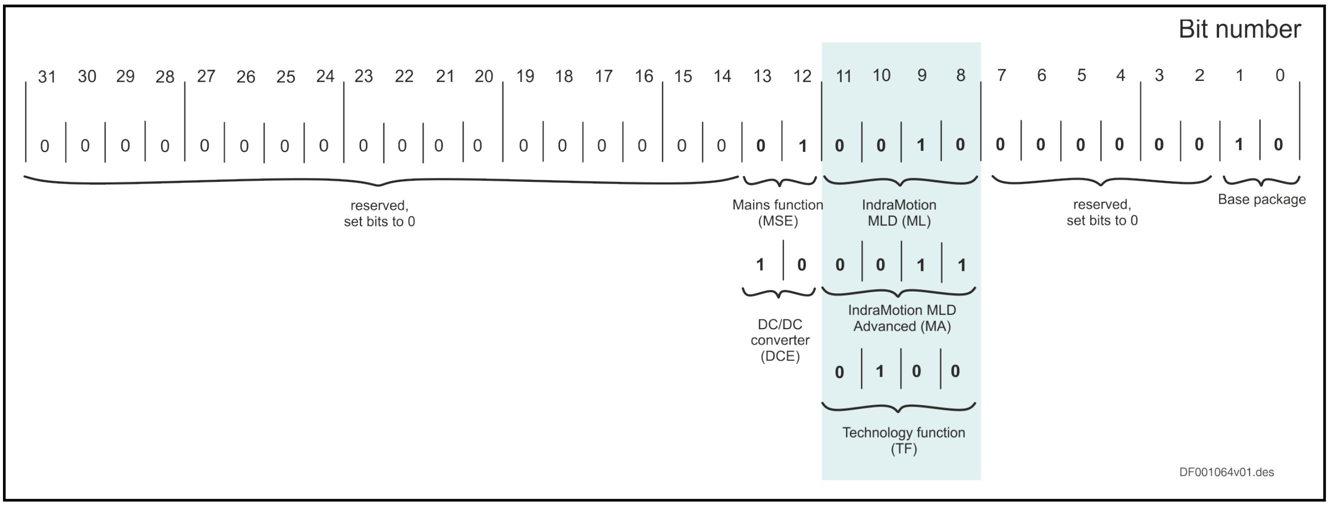


Fig. 9-29: Selecting the functional packages via parameter P-0-2003

Bit No.	Name of package (Bit = 1: package has been selected)
1 to 0	10: Base package All other bit combinations are reserved
7 to 2	Reserved, set bits to 0
11 to 8	0010: Additional package "IndraMotion MLD" (ML) 0011: Additional package "IndraMotion MLD Advanced" (MA) 0100: Additional package "Technology function" (TF) All other bit combinations are reserved
13 to 12	01: Additional package "Mains function" (MSE) 10: Additional package "DC/DC converter" (DCE) All other bit combinations are reserved
31 to 14	Reserved, set bits to 0

Tab. 9-7: Selecting the functional packages via parameter P-0-2003

The figure below illustrates the interaction of the parameters involved in the enabling of functional packages.

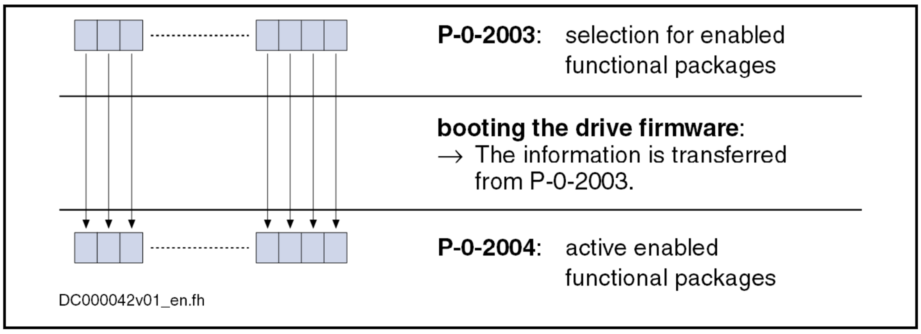


Fig. 9-30: Interaction of parameters for functional package selection

The table below shows the presently possible combinations for input in parameter "P-0-2003, Selection of functional packages". Whether the respective combination can be used, depends on the available hardware design.

Functional package selection	Content of P-0-2003
Base package without expansion packages	0x0000 0002
Base package with IndraMotion MLD (ML))	0x0000 0202
Base package with IndraMotion MLD Advanced (MA)	0x0000 0302
Base package with Technology function (TF)	0x0000 0402
Base package with Mains function (MSE)	0x0000 1002
Base package with DC/DC converter (DCE)	0x0000 2002
Base package with IndraMotion MLD (ML) and Mains function (MSE)	0x0000 1202
Base package with IndraMotion MLD Advanced (MA) and Mains function (MSE)	0x0000 1302
Base package with Technology function (TF) and Mains function (MSE)	0x0000 1402
Base package with IndraMotion MLD (ML) and DC/DC converter (DCE)	0x0000 2202
Base package with IndraMotion MLD Advanced (MA) and DC/DC converter (DCE)	0x0000 2302
Base package with Technology function (TF) and DC/DC converter (DCE)	0x0000 2402

Tab. 9-8: Possible combinations of functional packages of the PSB-21 firmware.

☞ Changes in parameter "P-0-2003, Selection of functional packages" will only be applied after the device has been rebooted.

Reducing the active functional packages

The user can at any time reduce the scope of functions of the firmware by deactivating individual functional packages. For this purpose, the bits assigned to the functional packages that are not required are reset in parameter "P-0-2003, Selection of functional packages".

Subsequent expansion (additional licensing)

The required functions are normally licensed by ordering the IndraDrive firmware. At delivery, the licensed functions are specified as the firmware type on the type plate of the control section and in addition internally registered by Rexroth.

In individual cases, it is possible make an additional licensing, if other functions than the ones contained in the ordered and paid functionality are required. The procedure is described in the following section "Notes on commissioning".

9.7.3 Notes on commissioning

Condition as supplied

When a device is delivered, the licensed functional packages have been enabled. The firmware type printed on the firmware type plate has to comply with the content of parameter "S-0-0030, Manufacturer version".

> The content of parameter S-0-0030 can be read via the standard control panel (see "chapter 9.4 "Control panel" on page 203").

Reducing the functionality

The functionality is scaled by selecting functional packages through an entry in parameter "P-0-2003, Selection of functional packages".

The scaling can be changed by directly writing the parameter via the master communication or using the corresponding dialog in the "IndraWorks" commissioning tool.

The time of change is recorded by an entry in "P-0-2002, Oper. hours of contr. sect. at change of functional packages". Any change in parameter P-0-2003 will only take effect after the booting process was repeated. The active functional packages will then be displayed in parameter "P-0-2004, Active functional packages".

Additional licensing (expanding the functionality)

If the firmware originally ordered and delivered does not contain all required functions, it is possible to subsequently enable further functional packages. This requires additional licensing that is not free of charge.

> For test purposes, it is possible to enable non-licensed functional packages via parameter P-0-2003 for a limited time (2 weeks at most).
>
> **If a non-licensed functional package is used permanently, any guarantee on the part of Rexroth will expire!**

How to proceed for additional licensing

For additional licensing proceed as follows:

1. Enable desired functional packages in parameter P-0-2003
2. Reboot device and check content of P-0-2004 (content has to comply with that of P-0-2003!)
3. Read firmware type from parameter "S-0-0030, Manufacturer version" and write it down. This parameter displays current firmware configuration defined via P-0-2003.
4. Read serial number of control section from "P-0-1511, Circuit board code control section" (list element 3) and write it down
5. Send purchase order to Rexroth indicating serial number (from P-0-1511) and desired firmware configuration (from S-0-0030)
6. Receive adjusted firmware type plate from Rexroth to stick it on type plate of control section so that content of S-0-0030 complies with firmware designation on type plate

If no functional package has been previously enabled by the customer, the additional licensing can start with step 4. In step 5, the desired new firmware configuration then cannot be read from parameter S-0-0030, but has to be taken from the overview of firmware types (see chapter 9.7 "Enabling functional packages" on page 232).

☞ For handling the purchase order, please contact your Rexroth sales representative!

Scope of supply

The scope of supply consists of

- ordered new firmware type as FWA file incl. parameter file as a file and
- adjusted firmware type plate (to stick on).

9.7.4 Verifying the enabled functional packages

When the transition command "C0200 Exit parameterization level procedure command" is executed, a check is run to find out whether the value entered in parameter "P-0-2003, Selection of functional packages" corresponds to valid enabled packages. If not, the diagnostic command message C0202 is generated and the parameter IDN "P-0-2003, Selection of functional packages" is entered in the list parameter "S-0-0423, IDN-list of invalid data for parameterization levels".

If the enabled functional packages have been changed, the device has to be rebooted so that the change becomes active and is applied to parameter P-0-2004. When the transition command "C0200 Exit parameterization level procedure command" is executed, a check is run to find out whether the value entered in parameter P-0-2003 corresponds to the value in parameter P-0-2004. If there is a difference, the diagnostic command message "C0299 Configuration changed. Restart" is output.

9.8 Extended diagnostic functions

9.8.1 Patch function

Brief description

The patch function can be used for reading and writing any storage location (or internal variable) as a data object via the master communication, the analog output or the oscilloscope function.

In conjunction with the analog output or the oscilloscope function, this functionality can be used for locating errors.

The PLC patch function is used by development staff and instructed users to diagnose internal signal states and internal data of the PLC.

☞ When using the patch display in the oscilloscope, consider that the patch address is assigned first and then the oscilloscope signal. This has to be repeated after every change in the patch address.

☞ Since it is a **function for exclusive use by the development staff**, the patch display parameters P-0-0485 and P-0-0491 write-protected with the master password.

The configuration parameters of the patch function are **not saved in the flash**, but are lost when the drive is switched off.

Parameters involved

General patch function:

- P-0-0480, Patch function 1, source pointer
- P-0-0481, Patch function 1, attribute
- P-0-0482, Patch function 1, bit mask

- P-0-0483, Patch function 1, exponent
- P-0-0485, Patch function 1, display
- P-0-0486, Patch function 2, source pointer
- P-0-0487, Patch function 2, attribute
- P-0-0488, Patch function 2, bit mask
- P-0-0489, Patch function 2, exponent
- P-0-0491, Patch function 2, display

Functional description of general patch function

Read access (displaying internal storage locations/signals)

The patch function allows any storage location to be transformed into a data object that can be read via the master communication. A memory location is specified by parameters "P-0-0480, Patch function 1, source pointer" and "P-0-0486, Patch function 2, source pointer". The access to this address is configured via bits 0 to 2 of parameters "P-0-0481, Patch function 1, attribute" and "P-0-0487, Patch function 2, attribute". INT4 reads a 4-byte integer value starting from the source pointer, INT2/INT1 read 2 bytes or 1 byte accordingly. FLOAT8 reads an 8-byte floating-point value (DOUBLE), FLOAT4 reads 4 bytes accordingly (FLOAT).

Due to the processor architecture, the possible memory access is subject to certain restrictions. A 4-byte access, for example, is only allowed for storage locations the address of which can be divided by 4. The table below contains a complete overview of the allowed and prohibited memory accesses.

☞ If the access mode is to be changed via bits 0 to 2 of the patch attribute parameters (P-0-0481/P-0-0487), this is only possible if the patch source pointer that has just been set (P-0-0480/ P-0-0486) allows the new access mode (see table).

Access as...	Possible access to source addresses that ...		
	... can be divided by 4 (DWORD-aligned)	... can be divided by 2, but not by 4 (WORD-aligned)	... do not have any particular alignment (BYTE-aligned)
INT4	■	-	-
INT2	■	■	-
INT1	■	■	■
FLOAT8	■	-	-
FLOAT4	■	-	-

■ Access allowed
- Access prohibited

Tab. 9-9: Possible access modes of the patch function

The desired display format is set via bits 4 to 7 of the patch attribute (P-0-0481/P-0-0487).This allows the value read to be interpreted as a signed or unsigned decimal number, as a hexadecimal number or as a binary number. When selecting "BOOL" as display type, "1" is output when a value unequal zero was read, otherwise "0" is displayed.

If a storage location is read as integer and output in a non-float format, the value read is ANDed with the bit mask set via the patch bit mask parameters (P-0-0482/P-0-0488). By default, the mast is set to "0xFFFFFFFF" so that the read value is not changed.

When a storage location is read as a float value and a non-float format is selected for display, the value read is multiplied with $10^{-exponent}$. This allows an adjustment to be made to the displayed value range (-2147483648 to 2147483647, value range of a "signed int"). The exponent can be set via the parameters"P-0-0483, Patch function 1, exponent" or "P-0-0489, Patch function 2, exponent".

☞ If the value read and scaled with the exponent is outside the possible range of display, one of the extreme values is displayed. In this case, it is necessary to select a different exponent.

Write access (changing internal storage locations/signals)

In analogy to read access, it is possible to write any storage location. A bit mask possibly set (P-0-0482/P-0-0488) is taken into account (ANDed) as is a preset patch exponent (P-0-0483/P-0-0489).

☞ Please note that in the "BOOL" display mode, it is not possible to write the storage location, as it is not possible to assign an unequivocal numerical value to the value "TRUE" (displayed as "1"). Each value unqual to zero is interpreted as "TRUE".

NOTICE **Write access in INT1 mode to even addresses can result in an undefined behavior of the hardware.**

As in the case of read access, odd addresses in the case of write access are only allowed in the INT1 mode. In contrast to read access, the write access is directly carried out as a byte access. Therefore, avoid activating addresses outside the DRAM in this way, because this can lead to undefined hardware behavior.

9.9 Oscilloscope function

9.9.1 Brief description

The oscilloscope function can be used to record drive-internal and external status variables (parameter contents). This function can be effectively used both for initial commissioning and debugging. Its functionality can be compared to that of a 4-channel oscilloscope.

The total scope of the oscilloscope function is divided into the following function blocks:

- **Measured value recording**

  It is possible to record 8 channels at the same time, the signals being selected by configuring signal selection lists (IDN lists).
- **Configuration (basic settings)**

  The control/status block determines the basic functions (start/stop, time resolution, size of memory, operation mode). The current state (state diagram) of the oscilloscope is continuously transmitted to the master.
- **Trigger function**

  Besides extensive trigger functions, the drive provides the possibility of triggering at different signals and events in the drive.

Features

The oscilloscope function is characterized by the following features:

- **Measured value recording**
  - Up to 8 channels with up to 8192 measured values each (the total should not exceed 32,768 measured values)
  - User-defined time resolution in steps of the position controller clock (see "Performance data")
  - Signal selection by indicating the IDN of the respective parameter
  - Data of the SMO option Sx (S3, S4, S5, SB and SD) can at maximum be updated and recorded in the cycle time of the SMO application cycle (t = 1 ms)
- **Configuration (basic settings)**
  - Multi-channel display in "IndraWorks Ds/D/MLD"
  - More than 100 different measuring and trigger signals (cf. P-0-0149)
  - Up to 4 PLC variables can be recorded using PLC patch variables
  - Expanded oscilloscope function using 2 patch functions
  - Expanded oscilloscope function using 2 average value filters for display
- **Trigger function**
  - Trigger signal selection by indicating the parameter IDN
  - Internal trigger or external trigger
  - External trigger with trigger offset determination for synchronizing multiple-axis measurements
  - Unit of trigger level adjusting to trigger signal selection
  - Possibility of triggering at internal memory contents with patch signal
  - Possibility of triggering at PLC variable with patch signal
  - Time stamp for trigger time is mapped to parameter "P-0-0035.0.1, Oscilloscope: Trigger time".
- **Trend mode**

  It is possible to switch from a single measurement (Single Shot) to a continuous measurement (trend mode).
  - Recording of up to 4 channels in a cyclic mode
  - Signal selection via the previous parameters
  - Values are administrated in a buffer memory and cyclically called
  - IndraWorks can read this buffer memory and display it continuously
  - Time resolution can only be set and signals can only be selected if the trend mode has been switched off
  - Allowed time resolutions have to be multiples of 2 ms
  - Single Shot mode cannot be used in parallel

Parameters involved

- P-0-0020, Oscilloscope: Operation mode
- P-0-0136, Oscilloscope: Manual trigger signal
- P-0-0279, Oscilloscope: Trend mode, time resolution
- P-0-0280, Oscilloscope: Trend mode, list of measured values

Control/status:

- P-0-0028, Oscilloscope: Control word
- P-0-0029, Oscilloscope: Status word
- P-0-0031, Oscilloscope: Time resolution
- P-0-0032, Oscilloscope: Size of memory
- P-0-0149, Oscilloscope: Signal selection list
- P-0-0150, Oscilloscope: Number of valid measured values
- P-0-0269, Oscilloscope: Channel number setting

Measuring channels:

- P-0-0021, Oscilloscope: List of measured values 1
- P-0-0022, Oscilloscope: List of measured values 2
- P-0-0023, Oscilloscope: Signal selection 1
- P-0-0024, Oscilloscope: Signal selection 2
- P-0-0145, Oscilloscope: List of measured values 3
- P-0-0146, Oscilloscope: List of measured values 4
- P-0-0147, Oscilloscope: Signal selection 3
- P-0-0148, Oscilloscope: Signal selection 4
- P-0-0274, Oscilloscope: List of measured values 5
- P-0-0275, Oscilloscope: List of measured values 6
- P-0-0270, Oscilloscope: Signal selection 5
- P-0-0271, Oscilloscope: Signal selection 6
- P-0-0276, Oscilloscope: List of measured values 7
- P-0-0277, Oscilloscope: List of measured values 8
- P-0-0272, Oscilloscope: Signal selection 7
- P-0-0273, Oscilloscope: Signal selection 8

Trigger function:

- P-0-0025, Oscilloscope: Trigger mask
- P-0-0026, Oscilloscope: Trigger signal selection
- P-0-0027, Oscilloscope: Trigger level
- P-0-0030, Oscilloscope: Trigger edge
- P-0-0033, Oscilloscope: Number of measured values after trigger event
- P-0-0035, Oscilloscope: Trigger control offset
- P-0-0036, Oscilloscope: External trigger signal
- P-0-0037, Oscilloscope: Internal trigger signal

9.9.2 General information on the oscilloscope function

Sequence of a measurement (state diagram)

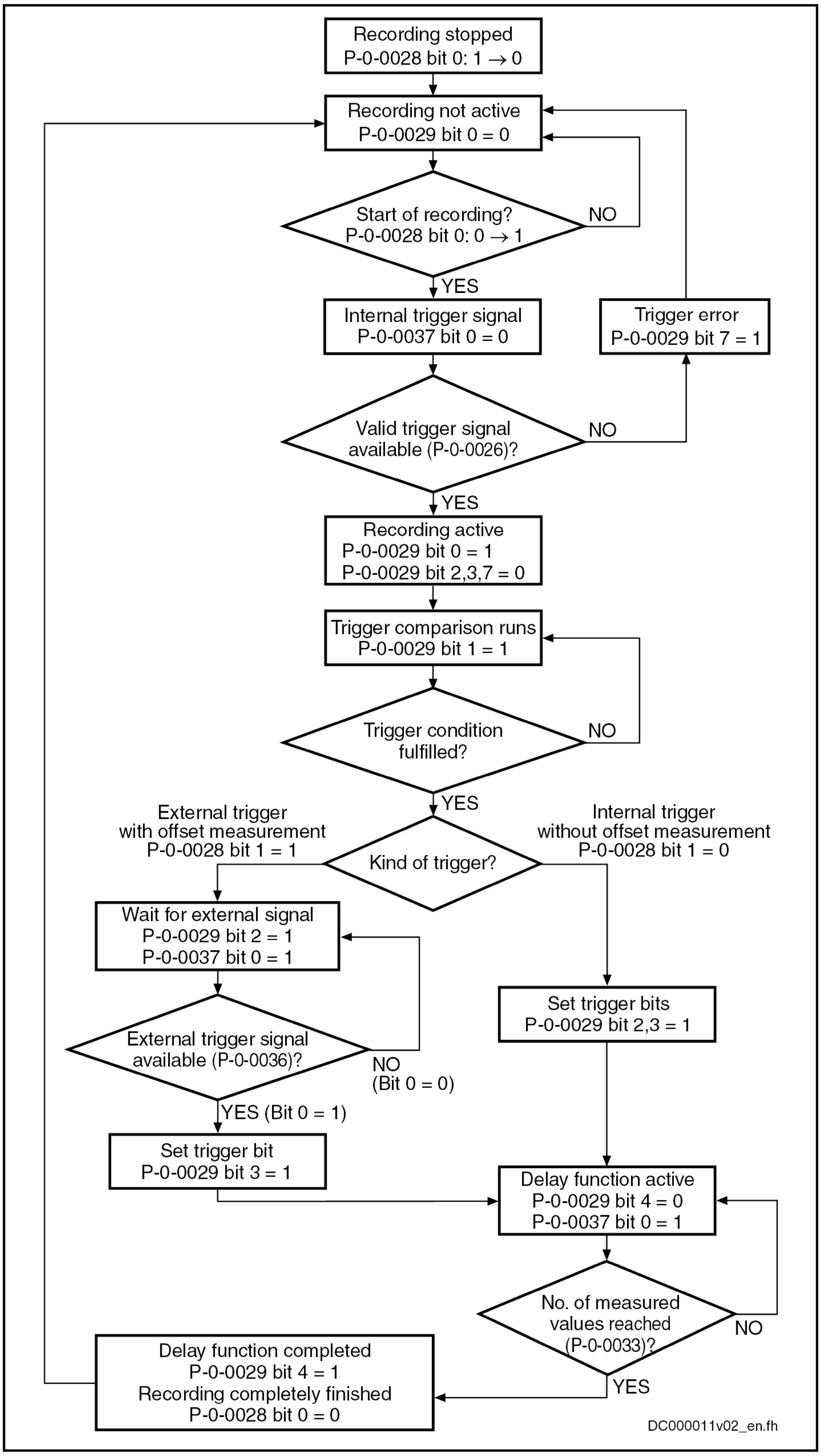


Fig. 9-31: State diagram of oscilloscope function

Configuring the measured value channels

A measured value channel is configured by inputting the IDN of the desired parameter in the respective signal selection parameter:

- P-0-0023, Oscilloscope: Signal selection 1
- P-0-0024, Oscilloscope: Signal selection 2
- P-0-0147, Oscilloscope: Signal selection 3
- P-0-0148, Oscilloscope: Signal selection 4
- P-0-0270, Oscilloscope: Signal selection 5
- P-0-0271, Oscilloscope: Signal selection 6
- P-0-0272, Oscilloscope: Signal selection 7
- P-0-0273, Oscilloscope: Signal selection 8

Signal selection list (P-0-0149)

All IDNs contained in parameter "P-0-0149, Oscilloscope: Signal selection list" can be entered.

P-0-0149 contains all parameters that are suitable as trigger signal (P-0-0026) or measuring signal (P-0-0023, P-0-0024, P-0-0147, P-0-0148, P-0-0270, P-0-0271, P-0-0272, P-0-0273). By reading P-0-0149, the master can recognize the signals that can be recorded in the drive.

☞ Currently, all cyclically configurable parameters (> 100) are contained in the list!

Example of signal selection

Example of the signal selection of the oscilloscope function:

- "S-0-0051, Position feedback value of encoder 1" is selected as signal to be recorded
- Position feedback value of encoder 1 (S-0-0051) is written to parameter "P-0-0023, Oscilloscope: Signal selection 1"

→ If the requirements have been complied with, position feedback value of axis 1 is recorded in the oscilloscope and transmitted to the master.

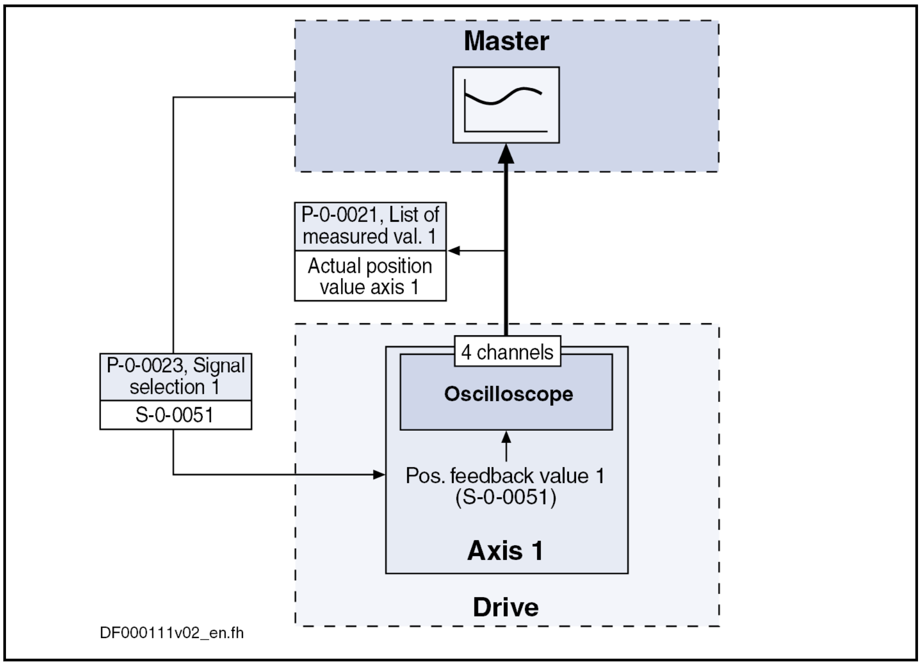


Fig. 9-32: Example of signal selection

Extended oscilloscope function (patch function)

Apart from recording parameter contents via the oscilloscope function, the drive provides the option to record internal signals, e.g. memory addresses (patch fucntion).

☞ Using the patch function is only possible with the information on the structure of the internal data memory. Therefore, this function can only be used effectively by the development staff of the IndraDrive firmware.

To record internal signals (memory address contents), "P-0-0485, Patch function 1, display" or "P-0-0491, Patch function 2, display" have to be configured in one of the signal selection parameters (P-0-0023, P-0-0024, P-0-0147, P-0-0148, P-0-0270, P-0-0271, P-0-0272, P-0-0273).

☞ The patch function has to be parameterized before the assignment as trigger or measuring signal. Following the assignment in the signal selection, the address is copied from the patch function. This means that an address can only be changed subsequently if it is re-assigned to the signal parameter.

See also "Patch function"

Activating the oscilloscope function

The oscilloscope function is activated/deactivated using the parameter "P-0-0028, Oscilloscope: Control word".

P-0-0028, bit 0:

- Bit 0 = 1 → starting a measurement
- Bit 0 = 0 → stopping a measurement

Setting bit 0 in P-0-0028 activates the oscilloscope function, i.e. the recording of measured values of the selected signal starts. The oscilloscope function waits for the selected trigger edge or level to occur. At detection of a valid edge the measured values keep being written to the measured value memory until the number of measured values defined in "P-0-0033, Oscilloscope: Number of measured values after trigger event" has been reached (delay function).

☞ With Sercos master communication, start of signal recording and of trigger evaluation are delayed until the next feedback acquisition starting time T4 (S-0-0007 or S-0-1007).

This causes the recording data and the data in the AT telegram to be identical and multiple drives at one Sercos bus to simultaneously start recording within one Sercos cycle.

☞ This is only possible as long as the time resolution is smaller or equal to the Sercos cycle. If the time resolution is greater, asynchronous behavior occurs in case of delay when receiving the start signal that is smaller than the time resolution and which is a multiple of the Sercos cycle.

After the defined number of measured values has been recorded, the "delay function completed" bit (bit 4) is set in parameter "P-0-0029, Oscilloscope: Status word". The recording is complete and automatically terminated. Bit 0 in parameter P-0-0028 is reset and the list of measured values can be read.

Depending on the parameterization of the size of memory, the time resolution, the number of measured values after trigger event and the point of time the trigger event occurs, the entire measured value memory for the current measurement is not always written.

This means that there may still be old measured values in the memory that are not valid for the current measurement!

9.9.3 Trigger function

Trigger signal selection

The drive provides extensive and flexible triggering options.

Triggering at standard signals

The trigger signal is selected in parameter "P-0-0026, Oscilloscope: Trigger signal selection" by directly entering parameter IDNs. Only IDNs are allowed that are contained in the list "P-0-0149, Oscilloscope: Signal selection list".

If there is no valid trigger signal available when the oscilloscope function is activated, bit 7 is set for "trigger error" in parameter "P-0-0029, Oscilloscope: Status word".

"P-0-0026, Oscilloscope: Trigger signal selection" determines which signal is to be monitored for parameterized edge change or threshold value.

Triggering at any signal

Besides the triggering of parameter contents, the drive provides the possibility of recording any internal signal, i.e. memory addresses (patch function).

Using the patch function is only possible with the information on the structure of the internal data memory. Therefore, this function can only be used effectively by the development staff of the IndraDrive firmware.

Patch function

In order to trigger to internal signals (memory address contents), configure the parameters "P-0-0485, Patch function 1, display" or "P-0-0491, Patch function 2, display" in P-0-0026.

It can also be triggered to a PLC variable in a symbol-based way.

See also "Patch function"

Internal or external trigger

Select the trigger type in parameter "P-0-0028, Oscilloscope: Control word".

P-0-0028, Bit 1:

- Bit 1 = 0 → Internal trigger without offset measurement
- Bit 1 = 1 → External trigger with offset measurement

Trigger event

The trigger event is the point of time at which trigger signal (P-0-0026) and trigger level (P-0-0027) are matching, taking the determined trigger edge into account (P-0-0030). When the trigger event occurs, the internal trigger is released.

Internal trigger (without offset measurement)

When "internal trigger" is selected (P-0-0028; bit 1 = 0), the external trigger source P-0-0036, bit 0) is not taken into account. Until the trigger event is reached, the current state of the "signal/trigger level" comparison is displayed in "P-0-0029, Oscilloscope: Status word".

When the trigger event has been reached, the "internal trigger event" bit is set in parameter "P-0-0029, Oscilloscope: Status word" and recording is continued until the defined number of measured values after trigger event (P-0-0033) has been reached. Only then is the "delay function completed" bit set (P-0-0029; bit 4). Setting this bit terminates the complete recording. Independent of the trigger source, the bit indicates the end of the recording.

When internal trigger source has been selected, the status bit "trigger function completed" (P-0-0029, bit 3) is set simultaneously with the bit for "internal trigger event" (P-0-0029, bit 2) (see state diagram).

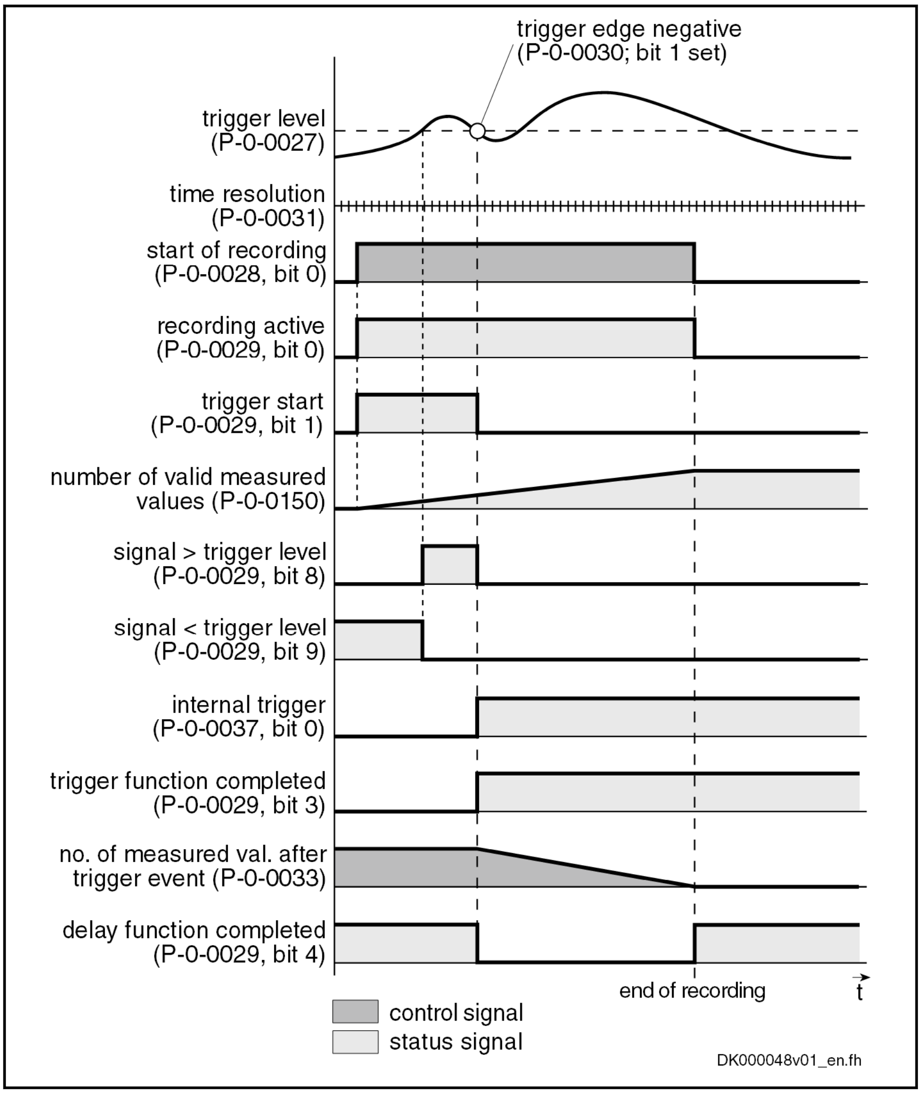


Fig. 9-33: Internal trigger without offset measurement (P-0-0028; bit 1 = 0)

☞ Parameterizing P-0-0036 (external trigger signal) in "P-0-0026, Oscilloscope: Trigger signal selection" allows the internal trigger function to be triggered by the external trigger input.

External trigger with offset measurement

When the kind of trigger "external trigger with offset measurement" (P-0-0028; bit 1 = 1) has been selected, the internal and external trigger are used for the master axis.

When "external trigger" has been selected, the behavior, until the internal trigger event has been reached, corresponds to the behavior for the case when trigger source "internal trigger" has been selected. Until the external trigger signal occurs (P-0-0036; bit 0), the trigger offset between both trigger events is determined and displayed in parameter P-0-0035. Then the "trigger function completed" (P-0-0029; bit 3) bit is set in the status word. The rest of the sequence is the same as in the case of internal trigger source without offset measurement.

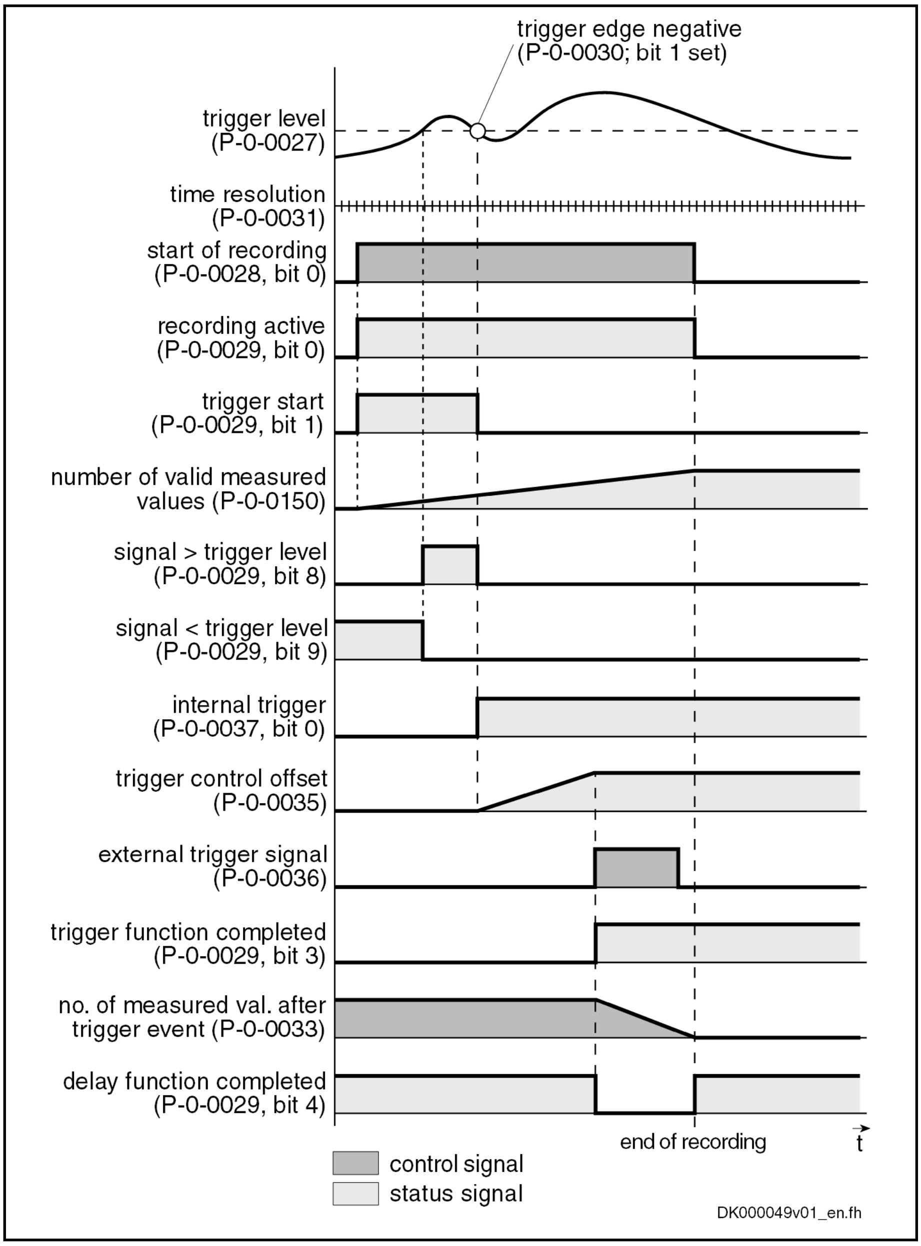


Fig. 9-34: External trigger with offset measurement (P-0-0028; bit 1 = 1)

Selecting the trigger edges

Trigger edge (P-0-0030)

In parameter "P-0-0030, Oscilloscope: Trigger edge" it is possible to set the edge of the trigger signal at which the internal trigger is released. The following options are available:

- Triggering at the **positive** edge

  It is triggered to a transition "smaller than or equal to → greater".
- Triggering at the **negative** edge

  It is triggered to a transition "greater than or equal to → smaller".
- Triggering at **both** edges

  It is triggered to a transition "smaller than or equal to → greater" and "greater than or equal to → smaller".

- Triggering when trigger signal **equals** trigger level

Even if both edges have been enabled, the trigger only starts if the value is exceeded or fallen below. In case of equality, the trigger is not started.

See description of parameter "P-0-0030, Oscilloscope: Trigger edge"

Setting the trigger delay

Trigger delay function

Via "P-0-0033, Oscilloscope: Number of measured values after trigger event", it is possible to reach a trigger delay independent of the preset trigger source (external/internal). For this purpose, the number of measured values that is to be recorded after the respective trigger event is set in parameter P-0-0033.

It is also possible to record measured values before the trigger event occurs (trigger delay function of an oscilloscope).

No data lying after the trigger event are recorded if "0" is input in P-0-0033. The trigger event is the last value in the list of measured values. If the value of the parameter P-0-0032 is input, no measured values lying before the trigger event are recorded. The trigger event is the first value in the list of measured values. The trigger event is always taken into account. In other words, if P-0-0033 has the value "0" or "1", the trigger event is the last value in the list of measured values.

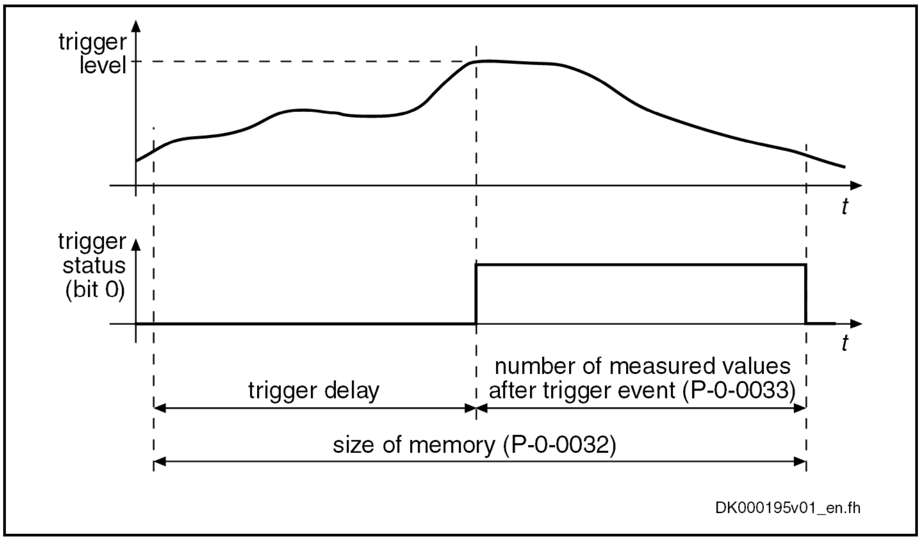


Fig. 9-35: Trigger delay: Number of measured values after trigger event

Extended trigger functions

Trigger mask (P-0-0025)

With Parameter"P-0-0025, Oscilloscope: Trigger mask", it is possible to trigger to certain events. For trigger signals with the "Bin" and "Hex" display formats, it is possible to mask the trigger signal and the trigger level.

See description of parameter "P-0-0025, Oscilloscope: Trigger mask"

Trigger level (P-0-0027)

The trigger threshold can be selected via parameter "P-0-0027, Oscilloscope: Trigger level". Attribute, unit etc. are adjusted to the selected trigger signal.

See parameter description "P-0-0027, Oscilloscope: Trigger level"

9.9.4 Manual trigger

Parameter P-0-0136 has to be used as manual trigger. The parameter P is cyclically configured and cannot be written anymore by the user. Note: Depending on the edge configuration, exceeding/falling below signalizes the trigger event (not reaching of the threshold). See chapter "Selecting the trigger edges" on page 246.

9.9.5 Trigger time

When the system time was not set via "P-0-0035.0.1, Oscilloscope: Trigger time", the system time at the trigger time can be read out. This way, the option to establish the trigger point retrospectively. This can be a useful function if monitoring is configured and the user wants to see when the trigger event occurred. It can be displayed as additional information via IndraWorks.

The system time is specified in Sercos time format (IEC 61588). As not all field buses support 8-byte parameters, the time is transmitted in an array with 2*32 bit. As data is usually transmitted in Little Endian, the first element contains the system time (fine) and the second element contains the system time (rough) according to parameters "S-0-1305.0.2 System fine time" and "S-0-1305.0.3, System coarse time".

9.9.6 Parameterizing the oscilloscope function

Recording duration

The recording duration is determined according to the following relationship:

$$t_A = (P\text{-}0\text{-}0031) \times (P\text{-}0\text{-}0032)$$

t_A	Recording duration (in µs)
P-0-0031	Oscilloscope: time resolution
P-0-0032	Oscilloscope: size of memory

Fig. 9-36: Determining the recording duration

Parameterizing the selection of measured values

For the oscilloscope function, it is possible to select 4 signals that are defined by the IDNs of their respective parameters and assigned to the following parameters:

- P-0-0023, Oscilloscope: Signal selection 1
- P-0-0024, Oscilloscope: Signal selection 2
- P-0-0147, Oscilloscope: Signal selection 3
- P-0-0148, Oscilloscope: Signal selection 4
- P-0-0270, Oscilloscope: Signal selection 5
- P-0-0271, Oscilloscope: Signal selection 6
- P-0-0272, Oscilloscope: Signal selection 7
- P-0-0273, Oscilloscope: Signal selection 8

Only parameter ident numbers contained in list parameter "P-0-0149, Oscilloscope: Signal selection list" are allowed.

The selected signal (parameter IDN) defines the unit of the data stored in the list of measured values.

Parameterizing the trigger function

See "Trigger function" above

Parameterizing time resolution and size of memory

The recording range or the recording duration can be adjusted to the measurement requirements via the following parameters:

- P-0-0031, Oscilloscope: Time resolution
- P-0-0032, Oscilloscope: Size of memory

Size of memory of oscilloscope function

The number of measured values is determined via "P-0-0032, Oscilloscope: Size of memory". A maximum of 8192 measured values per channel can be recorded.

Time resolution of oscilloscope function

The time distances in which measured values are recorded (sampling rate) is recorded via "P-0-0031, Oscilloscope: Time resolution". It is possible to select the time resolution on the time base of the position loop clock ($T_{osci} = N \times T_{A\_position}$; N = 1, 2, 3, 4, …).

The position loop cycle time depends on the control performance. The control performance in turn depends on the hardware design of the controller and the setting in parameter P-0-0556.

For the possible times please see "Performance data".

9.9.7 Parameterization of number of channels

Select the number of channels in parameter "P-0-0269, Oscilloscope: Channel number setting". Due to compatibility reasons, the minimum number of 4 channels has to be complied with. The maximum number can be set to 8 channels. In this case, the maximum nesting depth is reduced. The sum of all channels must not exceed 32768 measuring points. This means, the following combinations are possible:

Number of channels	Recording depth
1-4	8192
5	6553
6	5461
7	4681
8	4096

Tab. 9-10: Possible combinations of channel and nesting depth

☞ A change in parameter "P-0-0269, Oscilloscope: Channel number setting" is possible at any time as long as the oscilloscope is not switched on. Depending on the setting, the parameters for signal selection (P-0-0270, P-0-0271, P-0-0272, P-0-0273) and the parameters for measured value lists (P-0-0274, P-0-0275, P-0-0276, P-0-0278) are integrated in the oscilloscope function in the specified order. A change also has an impact on the maximum recording depth (also see parameter "P-0-0032, Oscilloscope: Size of memory").

Depending on the number, the respective parameters are identified for signal selection or for the measured value list.

9.9.8 Diagnostic and status messages

Status of the oscilloscope function

Parameter "P-0-0029, Oscilloscope: Status word" shows the current state of the oscilloscope function.

P-0-0029 contains e.g status information about:

- Start/end of recording
- Trigger function
- Status of trigger signal
- Delay function

See also parameter description "P-0-0029, Oscilloscope: Status word"

Via parameter "P-0-0037, Oscilloscope: Internal trigger signal", the master is informed about the status of the internal trigger. This parameter can be parameterized as real-time status information, both in the real-time channel of the interface and as hardware output.

Displaying the number of valid measured values

After a measurement, the parameter "P-0-0150, Oscilloscope: Number of valid measured values" displays the number of measured values in the ring buffer. If the ring memory was filled completely with the length specified in parameter "P-0-0032, Oscilloscope: Size of memory", the nesting depth is displayed in this parameter.

See also parameter description "P-0-0150, Oscilloscope: Number of valid measured values"

9.9.9 Trend mode

The trend mode allows for recording of up to 8 channels in a cyclic mode. The values are administered and called cyclically in the buffer storage. IndraWorks can read this memory and display it continuously. Since it is not necessarily an equidistant measurement, measured values are sometimes missing, e.g. due to a slow connection. These values are represented accordingly in the graphics.

To allow the trend mode to be used, the system time has to be activated. This time base is used to unequivocally assign the corresponding measuring points to a point in time.

The time resolution can only be set and signals can only be selected if the trend mode has been switched off. Only times that are multiples of 2 ms are allowed as time resolutions. If another value is entered, it is rounded down to the next possible value. Signal selection via previous parameters.

The trend mode is activated by setting P-0-0020, bit 5. The mode of the "conventional" oscilloscope cannot be used simultaneously. Trend recording is then activated via P-0-0028, bit 0. The trend also signals the activity in P-0-0029, bit 0.

9.9.10 Trigger time

Parameter "P-0-0035.0.1, " contains the current system time (see S-0-1305.0.1) of the time at which the oscilloscope function of the drive was triggered. The parameter contains the trigger time with a resolution of 100 ns. The parameter is filled with the content of parameter S-0-1305.0.1, System time when triggering the drive oscilloscope at the time of the control cycle start. Parameter P-0-0035.0.1 contains a 64 bit value which is structured as list with two 4-byte elements.

Element	Content
1	Trigger time (fine) (S-0-1305.0.2)
2	Trigger time (rough) (S-0-1305.0.3)

Tab. 9-11: Trigger time

Parameter "P-0-0035.0.1, Oscilloscope: Trigger time" is used for synchronization of measurements, as follows:

- If a simultaneous measurement on the PC and the drive is to be carried out. The system time of the drive has to be synchronized with the system time of the PC connected via IndraWorks.
- In case of simultaneous measurement on several drives. Synchronization via a bus master.
- Synchronization of Diagnostic Trace (event recordings via S-0-1303.0.x) and oscilloscope recordings.

10 Engineering/diagnostic interfaces

⚠ WARNING **Dangerous movements! Danger to life, risk of injury, serious injury or property damage!**

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine's range of motion (e.g., by using safety fences, safety guards, protective coverings, light barriers).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.

10.1 IndraMotion Diagnostic Tool (IDST)

"IndraMotion Diagnostic Tool (IDST)" is a web-based application, facilitating access to a control device system via an Ethernet connection.

OEMs, end users and account managers can access a drive system using IDST, e.g. for remote diagnostics. Besides, authorized users can handle different service cases with IDST, such as replacing drive components, loading parameters or updating/upgrading the firmware.

Further information on the "IndraMotion Diagnostic Tool (IDST)" is described in the documentation „Rexroth IndraMotion, MLD 13VRS, Service Tool“ (DOK-IM*MLD-IMSTIDSTV13-RE**-EN-P; mat. no. R911342652).

10.2 TCP/IP communication

10.2.1 Brief description

☞ The "TCP/IP Communication" section gives all necessary information for standard Ethernet communication. In addition to TCP/IP, communication via UDP/IP is also possible.

To prevent confusion with the "EtherNet/IP™ interface" master communication, the designation "Ethernet communication" was not used here. The term "IP communication" is used instead.

It is possible to communicate with an IndraDrive controller via standard Ethernet telegrams. These Ethernet telegrams contain TCP/IP or UDP/IP telegrams for application-side connection. For communication with the device, the CSMA/CD access method is applied. Interfaces for TCP/IP communication are suitable as connection options. This can be an inactive port of the master communication card (e.g., Sercos or EtherNet/IP™), a separate Engineering port (if available) or optionally an inactive port of the master communication interface of the CCD master.

The IP communication always respects the properties of the connected interface.

Example of Sercos master communication

For Sercos, in addition to the time-controlled transmission of Sercos-type Ethernet telegrams (MDT and AT), there is the Unified Communication Channel (UCC), with which IP telegrams are transmitted in a reserved time slot.

Therefore, for Sercos, another option for asynchronous data transmission is available in addition to the existing service channel, that is compatible with large data volumes due to the maximum lengths of user data of approx. 1500 bytes.

Possible applications

If the TCP/IP communication is used in the drive, different application options are available that are summarized in the following table.

Connection	Server application	Exemplary client applications
SIP protocol	Parameter access	IndraWorks Engineering
TFTP	Firmware update service	Carrying out a firmware update
HTTP	Web server	Displaying the IndraMotionServiceTool
FTP	File server	File access to the optional memory card (only available if an optional memory card is plugged during booting)

Tab. 10-1: Overview of the possible applications

Parameters involved

Command parameters:

- S-0-1048, C6100 Command Activate IP settings

IP parameters:

- S-0-1019, Master comm. engineering over IP: MAC address
- S-0-1020, Master comm. engineering over IP: IP address
- S-0-1021, Master comm. engineering over IP: Network mask
- S-0-1022, Master comm. engineering over IP: Gateway address
- P-0-1044, Master comm. engineering over IP: Status IP communication
- P-0-1530, Engineering: MAC address
- P-0-1531, Engineering: IP address
- P-0-1532, Engineering: Network mask
- P-0-1533, Engineering: Gateway address
- P-0-1535, Setting of IP communication
- P-0-1544, Engineering: Status IP communication
- P-0-1640, CCD: MAC address
- P-0-1641, CCD: IP address
- P-0-1642, CCD: Network mask
- P-0-1643, CCD: Gateway address
- P-0-1644, CCD: Status IP communication
- P-0-4089.0.10, Master communication: MAC address device
- P-0-4089.0.13, Master communication: IP address
- P-0-4089.0.14, Master communication: Network mask
- P-0-4089.0.15, Master communication: Gateway address

Diagnostic messages involved

- C6101 Incorrect IP settings
- F2190 Incorrect Ethernet configuration

10.2.2 Functional description

General information about the function

Components for TCP/IP communication

Each device contains at least one interface that can be used for direct IP communication. This can either be a MultiEthernet master communication interface, an Ethernet engineering interface (engineering port) or a Sercos master interface (CCD master).

Special feature of the MultiEthernet master communication interface: depending on the available hardware or the enabled master communication, this interface is referred to as "Engineering over IP" or as "Engineering port".

The interface is referred to as "Engineering over IP" in the following cases:

- Sercos
- EtherNet/IP™
- PROFINET® RT
- EtherCAT®

  A connection cannot be established with IndraWorks in connection with TwinCAT via the ADS interface or the EoE profile.
- Disabled master communication

☞ An IndraDrive drive controller device HCQ is only equipped with one Sercos master communication interface.

In case of an IndraDrive Cs Economy device, Sercos or EtherCAT® can be available as master communication.

The interface is referred to as "Engineering port" in the following cases:

- PROFIBUS DP
- CANopen

An additional interface option is required for the two master communications and the X24/X25 interfaces must exclusively be used as Engineering ports.

Configuration

In order to facilitate IP communication via an interface, at least the IP address and the network mask have to be configured for the interface.

For communication beyond the IP network, a gateway address can additionally be set.

This information is set for the device for each interface using individual, independent parameters.

Interface	IP address	Network mask	Gateway address
Engineering over IP	S-0-1020	S-0-1021	S-0-1022
Engineering port	P-0-1531	P-0-1532	P-0-1533
CCD master	P-0-1641	P-0-1642	P-0-1643

Tab. 10-2: Parameters for setting the IP configuration

Changes become active upon a drive restart or by enabling the drive command "C6100 Command Activate IP settings" .

☞ If there are several interfaces available for IP communication, select different IP networks.

In this case, the device is the IP router.

All IP addresses of IndraDrive automatically become active. Even in case of conflicts with other devices in the network, the drive is assigned its IP address. This behavior can be changed to a behavior compliant with standard RFC5227. Initially, IndraDrive verifies if the set address has already been assigned within the networks and only uses the address if it is not used by another device in the network.

This behavior is controlled via parameter "P-0-1535, Setting of IP communication".

> ☞ In case of an address conflict, the address specified in the drive is not activated. This means, the drive might not respond in the network. The address has to be corrected (e.g. manually, via the display).

Structure of the IP address

The IP address of a communication node always comprises of a network address (network ID) and a host address (host ID).

Class C networks (network mask 255.255.255.0) is used as default value. The network ID corresponds to the first three bytes of the IP address. The host ID is the fourth byte of the IP address.

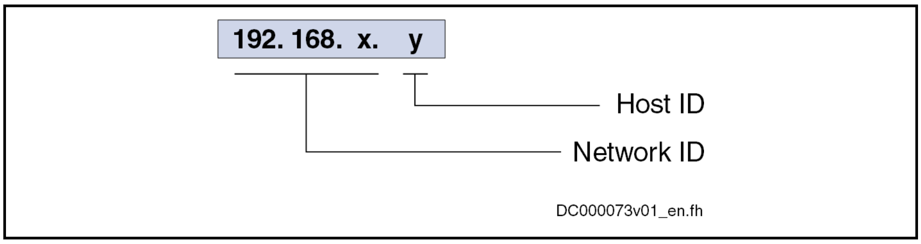


Fig. 10-1: Structure of the IP address

A "private" range should always be used for the address range of the IP communication with the drive. The defined ranges of the following networks are available

- Class A networks (10.x.x.x/8),
- Class B networks (172.16.x.x/12) or
- Class C networks (192.168.x.x/16).

It is recommended to use the private class C networks (192.168.x.x) for the IP address range or as default setting.

Interface	IP address	Network mask	Gateway address
Engineering over IP	192.168.0.<Master communication address>	255.255.255.0	192.168.0.254
Engineering port	192.168.1.<Master communication address>	255.255.255.0	192.168.1.254
CCD master	192.168.0.254	255.255.255.0	No default value

Tab. 10-3: Default values of IP configuration

> ☞ By way of "load basic parameters (factory settings)", the default values of the IP configuration are restored (see table).
>
> The configuration of the IP communication can be retained by selecting this option under "Load basic parameters".
>
> With the option "without engineering interface", the settings for the Engineering port remain unchanged. With the option "without master communication parameters", the settings for "Engineering over IP" are not changed.

Automatic settings

An automatism is used for the individual interfaces so that IP communication is also possible if no IP address is set by the user. This automatism is only available in case of set class C networks.

IP configuration of master communication interface

Automatically set IP configuration for Engineering over IP:

- **IP address:** 192.168.0.<MC address> [1]
- **Network mask:** 255.255.255.0
- **Gateway address:** 192.168.0.254

[1] If the MultiEthernet master communication interface is incorporated in a device with Sercos Master interface, 192.168.2.<MC address> is used as IP address.

IP configuration for Sercos master interface

Automatically set IP configuration for CCD master:

- **IP address:** 192.168.0.254
- **Network mask:** 255.255.255.0
- **Gateway address:** 0.0.0.0

IP configuration for Ethernet engineering interface

Automatically set IP configuration for Engineering port

- **IP address:** 192.168.1.<Master communication address>
- **Network mask:** 255.255.255.0
- **Gateway address:**192.168.1.254 [2]

[2] The gateway address is only set automatically if no MultiEthernet master communication interface is available in the device.

Manual setting

If it is required to use a different IP configuration, the settings can be manually adjusted. The setting can be selected separately for each interface in the device:

- by writing the relevant parameters via an active communication connection
- via the "Easy Menu" of the programming module in the "Ethernet" menu item

The changed settings are applied via command "C6100 Command Activate IP settings" or upon the device restart.

> The command C6100 is started automatically at the programming module when leaving the menu using the ESC key.
>
> IndraDrive Mi, IndraDrive HCQ and IndraDrive HCT do not contain a programming module. Thus, manual settings using the "Easy Menu" cannot be selected.

Available IP services

Different IP services are available in an IndraDrive controller, addressed via TCP or UDP. Via these services, the device can be parameterized, the drive firmware can be replaced, an MLD program can be loaded in the device, etc. The following table provides an overview of the IP services used in the drive, their IP ports and their configurability.

Communication	Port	Protocol	Port configurable?
IndraWorks drive programming	5002	TCP	No
IndraWorks drive programming	35021	TCP/UDP	No
IndraLogic MLC programming system	1740-1743[1)]	TCP	No
IndraLogic network variables	1202	UDP	Yes
TFTP	69	UDP	No
TFTP - other ports are dynamic	1023 ff	UDP	Yes
Telnet	23	TCP	No
FTP[2)]	20 and 21	TCP	No
Web server	80	TCP	No
ComServer	6042	TCP	No
Global port list "well known ports"	http://www.iana.org/assignments/port-numbers		

1) Port 1200 for MPx17
2) Only if an SC card is available in the device

Tab. 10-4: IP port list

By default, the listed IP services are enabled in the device. If individual services are not available anymore, they can be disabled via configuration parameter P-0-1535. The shutdown is only enabled by a reboot of the device.

Routing

In case of a device with more than one Ethernet interface (e.g.) IndraDrive Advanced (MPC), the drive automatically enabled the routing function between the interfaces. This means, both networks of the device including the connected devices can be addressed by the computer if the IP addresses at the computer and the drive are set correctly and if the route has been set manually.

If, e.g. a CCD link is used, it is possible to connect the computer at the Engineering port of IndraDrive Advanced and to address all devices (including the CCD slaves in the subordinate Sercos ring).

It can be set if the router is enabled or if the drive actively reserves the address range. The possible settings are stored in parameter P-0-1535.

10.3 Open Core Interface for drives

With "Open Core Interface for drives", Bosch Rexroth provides interfaces which allow for an easy connection of the machine automation to the higher-level IT automation.

For different programming environments, compatible function libraries are provided in an SDK (Software Development Kit). In these libraries, functions for direct access to all data and functions of the drive are contained.

"Open Core Interface for drives" provides the following options:

- Smart devices

  By using the smart devices and the installed apps, new operating concepts for systems can be developed.

The apps allow for access to all hardware functions of the smart devices such as the camera or the acceleration sensors. So they offer the entire control comfort of smart devices for the commissioning, operation and generation of diagnostic messages of IndraDrive and HydraulicDrive devices.

Open Core Interface for drives currently supports the Android, iOS and Windows Phone operating systems.

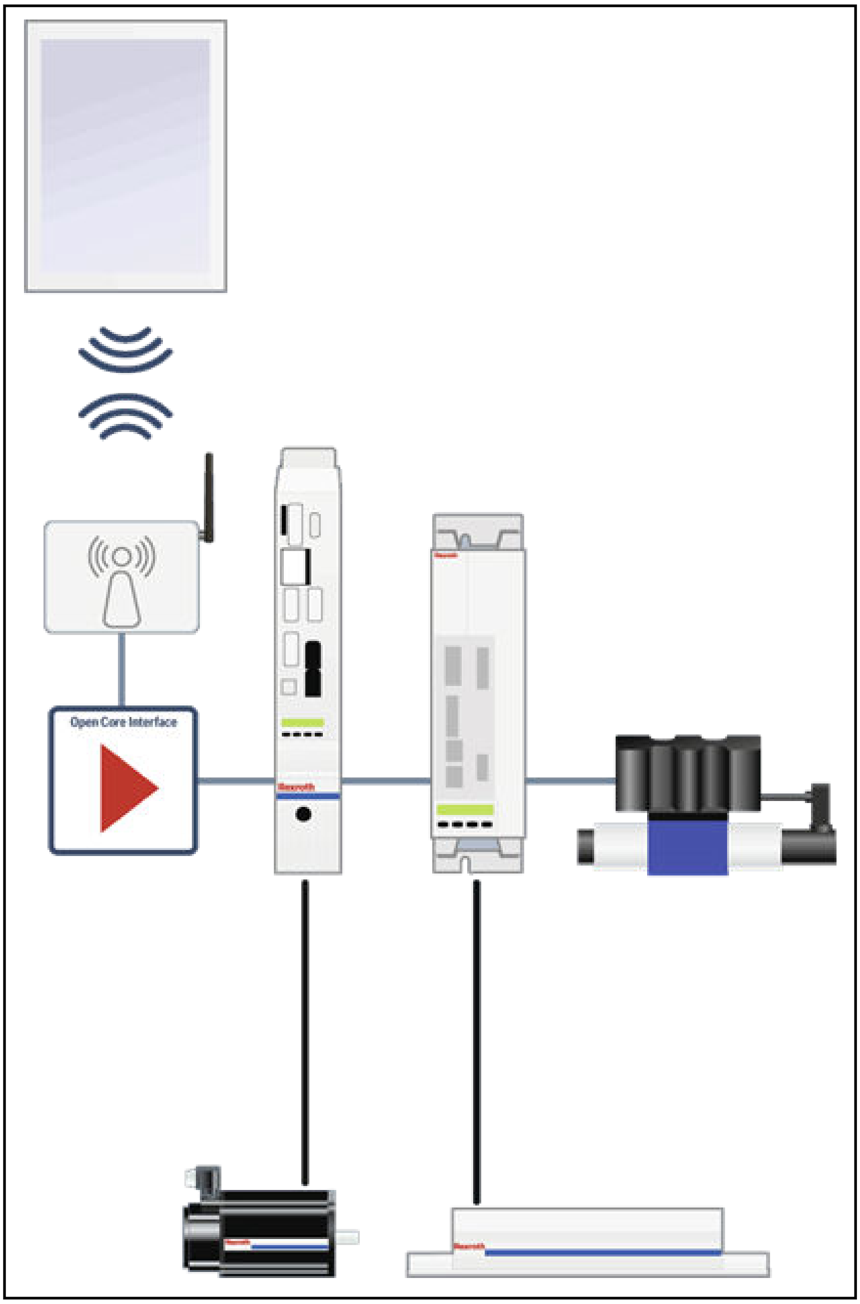


Fig. 10-2: Commissioning, operating and generating diagnostics of IndraDrive and HydraulicDrive devices via smart devices

- IT automation

  Open Core Interface in the IT automation domain refers to the use of PC-based solutions in the automation environment of a production machine.

For fast data exchange, connections to Windows and Linux-based development environments are provided in which high-level languages such as Java, C, C++ and C# are used for programming.

- Rapid Control Prototyping

  Open Core Interface provides all options for Rapid Control Prototyping, a design method for the closed-loop and open-loop control development. It is used for the early development of processes without a real machine and thus considerably contributes to cost-optimized and risk-minimized development. Rapid Control Prototyping is supported by LabVIEW, Simulink™, MATLAB®.

Information and support regarding "Open Core Interface" is available in the forum. Here, you can also ask members and the Bosch Rexroth experts.

10.3.1 Target platforms

With "eal_sdk" ("Easy Automation Library" "Software Development Kit"), Bosch Rexroth provides programming interfaces for the following target platforms:

- PC with Windows/PC-based control with LabVIEW
- PC with Linux as operating system
- (Mac OS upon request)
- Smart device with Android, iOS or Windows phone as operating system
- Linux-based controller (e.g., BeagleBone Black®, Raspberry pi®,...)

10.3.2 Supported devices

With "eal_sdk" you can create applications for configuring and controlling Bosch Rexroth drive controllers and frequency converters. Devices supporting the "Sercos Internet Protocol" (S/IP) (devices with Multi-Ethernet interface) are supported:

- Electric drive controllers of the IndraDrive Cs, IndraDrive C, IndraDrive M, IndraDrive Mi, IndraDrive ML ranges [with all control sections available in the product range (ECONOMY, BASIC and ADVANCED, single- and double-axis devices)]
- Hydraulic drive controllers "Integrated Axis Controller (IAC)", "Hydraulic Motion Control (HMC)"
- Frequency converters of EFC x610 type

10.3.3 Application options

One or several drives can be configured and controlled in star or line topology using the master communication interface, the Sercos master interface or the Engineering port.

With "Open Core Interface for drives", the following applications can be used:

- "Open Core Interface for drives" can replace a conventional control unit. Both the master communication and the commanding of the drive controller are performed by "Open Core Interface for drives".

The master communication has to be disabled for this use case.

- "Open Core Interface for drives" can be used in parallel with an active master communication (Sercos, PROFINET, EtherCAT with EoE, EtherNet/IP, Ethernet POWERLINK). In this case, the following applications may be implemented:

– As HMI interface; commanding is realized via an external PLC via the master communication protocol.
– As commissioning tool for loading a parameter file, replacing the drive firmware,...
– As diagnostics and debugging interface by using the firmware oscilloscope.
– As subsystem for drive-internal PLC (IndraMotion MLD).

☞ If the master communication is active, it is not possible to switch the drive in control (AF) via the OCI interface.

10.3.4 SDK: Requirements and installation

To use the "eal_sdk" ("Easy Automation Library" "Software Development Kit"), please perform the following steps:

1. Make sure to use one of the following systems:
   - Electric drive controller with IndraDrive firmware MPx-18 (or higher)
   - Hydraulic drive controller with HydraulikDrive firmware HDx20 (or higher)
   - Frequency converters of EFC x610 type
   - IndraMotion MLD control system in version 13VRS or higher
2. For commissioning and engineering of the drives, you need to install IndraWorks DS/IndraWorks MLD version 13VRS or higher. Alternatively, you can also use the "Drive tool" or "Drive tool EFC" application contained in the SDK.
3. Registering for the **Engineering Network**

   To download the "eal_sdk" SDK from the Bosch Rexroth Internet page, you have to register for the **Engineering Network**:
   1. Go to the internet page of Bosch Rexroth.
   2. Register on "myRexroth". (For a description of the registration process, please refer to the Engineering Network forum.)
   3. Open the internet webpage for "Open Core Engineering"
   4. After the registration is completed, the SDK "eal_sdk" is available in the Download area of **Engineering Network**.
4. Depending on the application, the device platform and operating system and the target device, integrate the "Easy Automation Library" contained in the SDK in your development environment.

10.3.5 SDK: Contents

The SDK "eal_sdk" is divided into different "tool boxes". Each tool box has an individual sub directory in the SDK. The functions supported by the "tool boxes" are basically identical. They differ with regard to the development environment and the operating system in which the development environment is used.

Each tool box does not only contain libraries, but also documentations and Application examples.

Supported functions of the tool boxes:

- System
  – Establish connection to the drive controller or the frequency converter
  – System information such as reading diagnostic data and firmware version
  – Firmware upload and download
- Parameter
  – Read and write parameters
  – Read parameter name, attributes, unit and status
  – Stopping and executing commands

- **PLC** (firmware version 20 and above)
  - Start, stop and reset the PLC
  - Read and write PLC status
  - Browse, read and write symbol variables
- **Motion**
  - General functions (activating drive enable, bringing the drive to the STOP state, drive-controlled homing)
  - Axis motions (preset velocity, moving to absolute position, moving by a distance in addition to the target position, moving by a distance from the current actual position)
- **Oscilloscope**
  - Configuring the oscilloscope channels
  - Configuring the oscilloscope trigger
  - Reading the oscilloscope data

The SDK is continuously developed; the following chapters provide an overview of the "eal_sdk" SDK version 2.0

☞ Since the development environments and operating systems may change, Bosch Rexroth does not assume any warranty for the proper functioning of the SDK.

EAL4Android

"EAL4Android" comprises an Android library and a "Mono for Android" app for configuring and controlling Bosch Rexroth drive controllers and frequency converters that support the "Sercos Internet Protocol" (S/IP).

System requirements: Java™ 32/64 bit, Android Studio

EAL4DotNet

The "EAL4DotNet" tool box allows functions of Bosch Rexroth drive controllers and frequency converters to be accessed by .NET libraries.

Supported operating systems of the target device: Windows XP/Vista/7/8, Android[1)], iOS[1)], Mac OS[1)], Linux[1)] [[1)]: using Mono]

Supported development environment: Microsoft Visual Studio 2005 or newer, Visual Studio with Xamarin extension, Xamarin Studio, RAD studio®

Supported programming languages: .NET (C#, VB, F#), VBA (for MS Excel, MS Access, MS PowerPoint, MS Word), Delphi

EAL4C

Using the "EAL4C" tool box, the functions of "EAL4DotNet" are converted into structural functions with Mono.

Supported operating systems of the target device: Windows XP/Vista/7/8, Linux with mono extension

Supported development environment: Eclipse, Microsoft Visual Studio, Qt, etc.

Supported programming languages: C/C++

EAL4Java

The tool box "EAL4Java" includes the "EAL4C" functionality as object-oriented Java classes in a package by using the native Java NDK library. EAL4Java allows EAL functions to be called from the Java runtime environment.

☞ Applications using the "EAL4Java" tool box can only run on the Java runtime environment under Windows and Linux.

Supported operating systems of the target device: Windows XP/Vista/7/8, Linux

Supported development environment: Eclipse

Supported programming languages: Java

EAL4LabVIEW

The "EAL4LabVIEW" tool box allows functions of Bosch Rexroth drive controllers and frequency converters to be accessed under LabVIEW.

Supported operating systems of the target device: Windows XP/Vista/7

Supported development environment: National Instruments LabVIEW

Supported programming languages: G (LabVIEW VI language)

10.3.6 Application examples

In the "Engineering Network" [Download→Apps (registration and login required)] and in the SDK, we provide different demo programs and apps.

For all demo programs and apps, the entire source code, the relevant project files, information about the use case, the requirements for execution and creation are provided.

In the following chapters, some examples are provided.

Windows application with Microsoft Visual Studio for controlling and monitoring "IndraDrive" controllers

In the Microsoft Visual Studio development environment, the Windows application "DriveTool" is developed.

Under ..\eal4DotNET\Samples\Sample - DriveTool, the "eal_sdk" SDK contains the "DriveTool" Windows application and also the source files.

"DriveTool" allows the following functions of "IndraDrive" range drive controllers to be accessed:

- Browsing available drives
- Establish connection to a drive via the Ethernet IP address
- Reading the power status and switching on power
- Restarting the drive
- Initializing the drive
- Reading the firmware type code
- Switching between operating mode and parameter mode:
- Homing the drive
- Clearing drive errors
- Reading and selecting the operating mode
- Reading and writing the motor velocity, position and torque

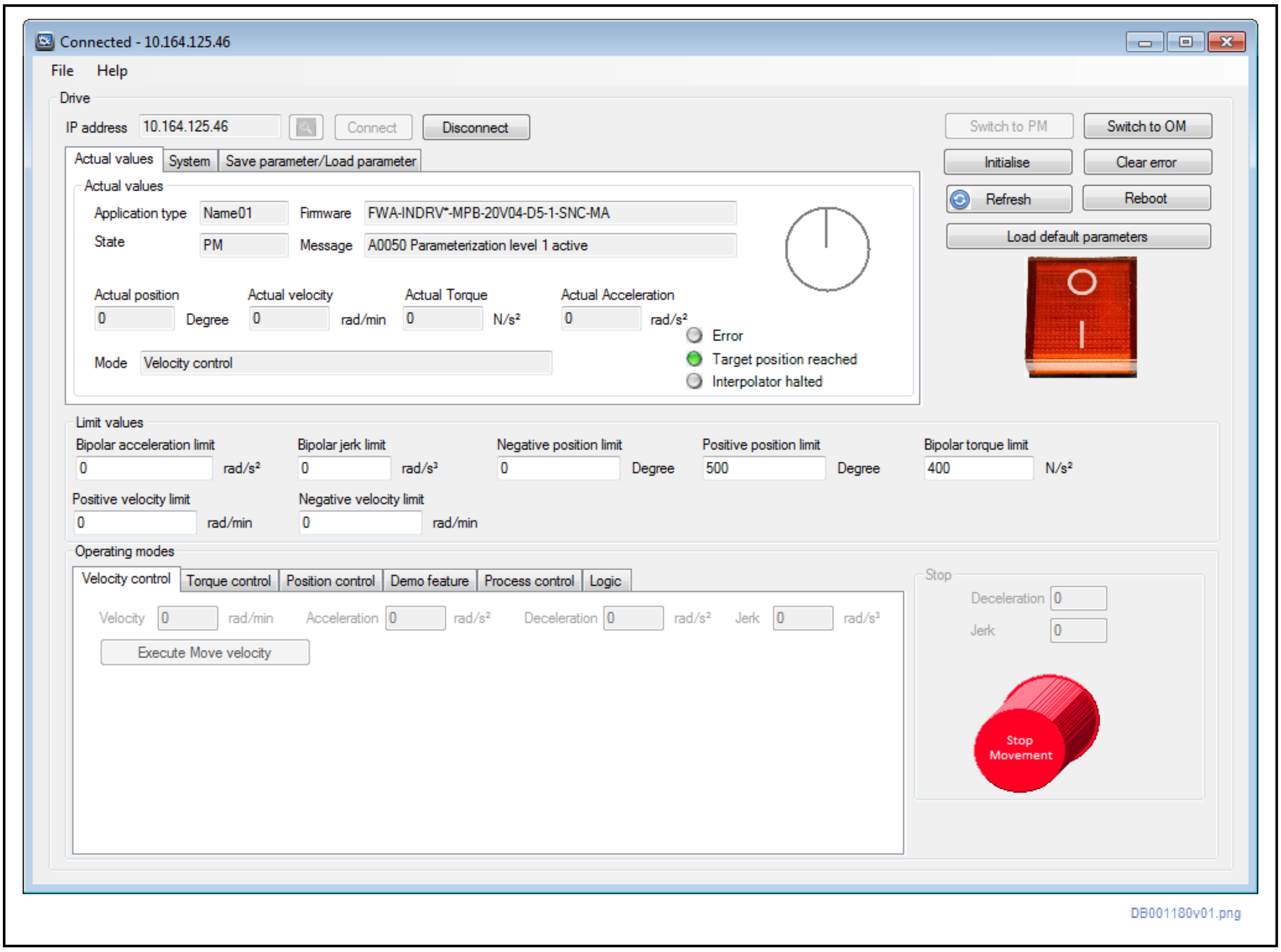


Fig. 10-3: "DriveTool"

Microsoft Excel file as user interface

The following example shows the integration of the "Open Core Interface for drives" in t he Microsoft office application Excel.

The Excel user interface allows the following functions to be accessed:

- Establish connection to a drive via the Ethernet IP address
- Switch on power
- Switching between operating mode and parameter mode:
- Writing the motor velocity, acceleration, deceleration and jerk

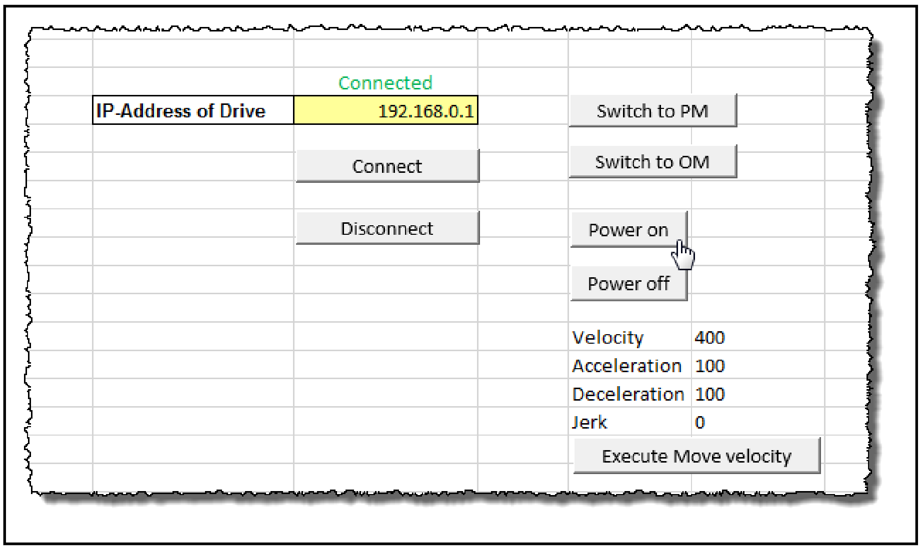


Fig. 10-4: Excel user interface

Windows application with Microsoft Visual Studio for recording device signals

In the Microsoft Visual Studio development environment, the Windows application "Oscilloscope" is developed.

In the application, you can configure, for example, the signal to be recorded, the sampling rate and the trigger to be used for commissioning, servicing and testing drive controllers.

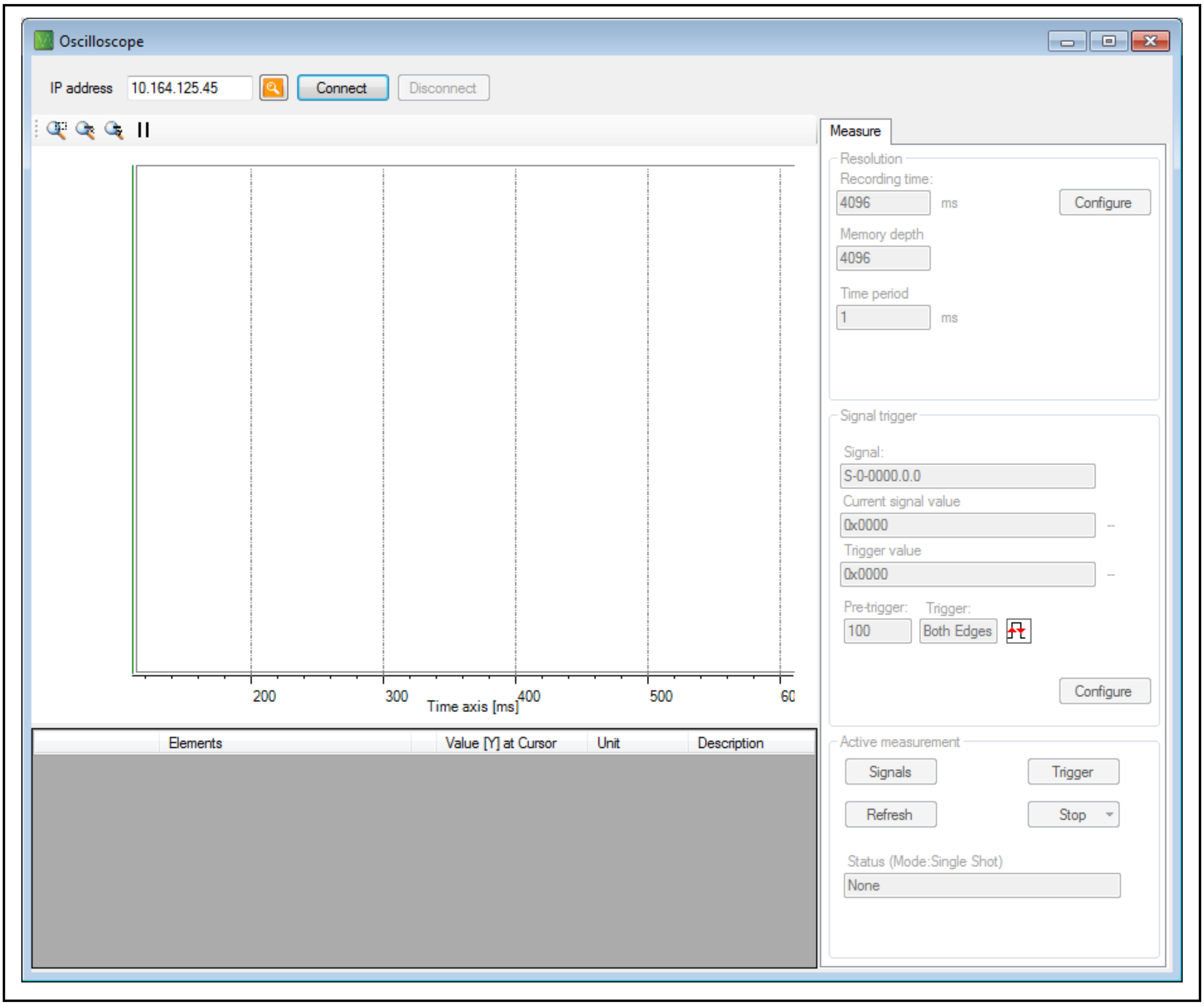


Fig. 10-5: Windows application "Oscilloscope"

Windows application with Microsoft Visual Studio for archiving and restoring firmware and parameter files

In the Microsoft Visual Studio development environment, the Windows application "Download tool" is developed.

Use the "Download tool" application to archive and restore firmware and parameter files of drive control devices of the "IndraDrive" product family.

The "download tool" can be operated in console mode and in GUI mode with graphic user interface.

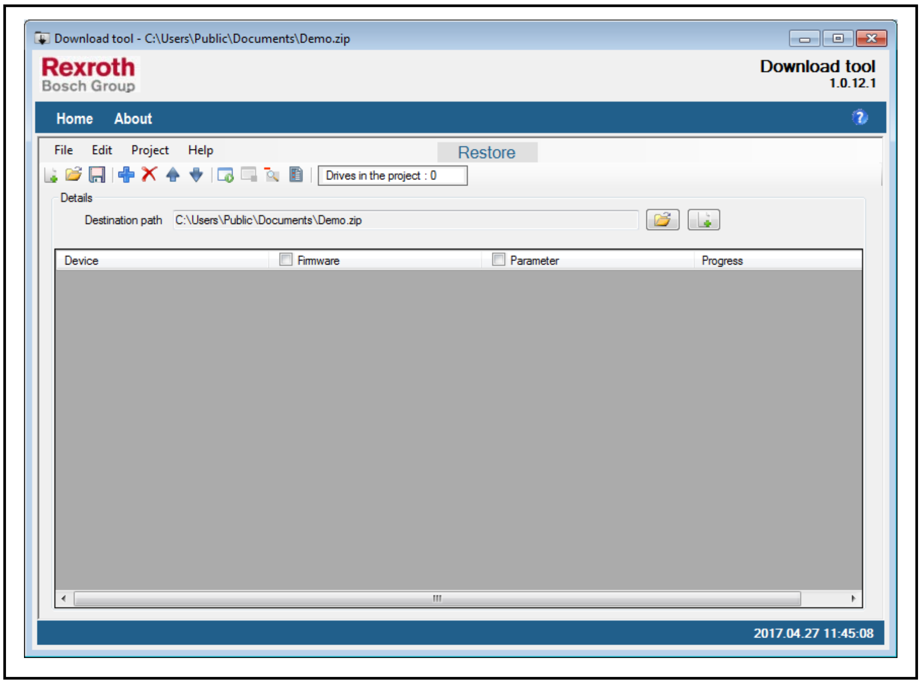


Fig. 10-6: Windows application "download tool" in GUI mode with graphic user interface

Android app

For Android, different demo apps with different functionalities are provided in the SDK:

- Travel motion
- Oscilloscope function
- Parameter backup
- Firmware update
- …

The demo apps are provided as APK (Android Package File).

To install the demo apps, you must permit the installation of apps not coming from the Goggle Play Store.

1. Open the settings on your smart phone and set the check mark at **Applications** ▸ **Unknown sources** (for some devices under **Safety** ▸ **Unknown sources**).

   CAUTION: The checkmark is a safety risk since apps from unknown sources may contain viruses.

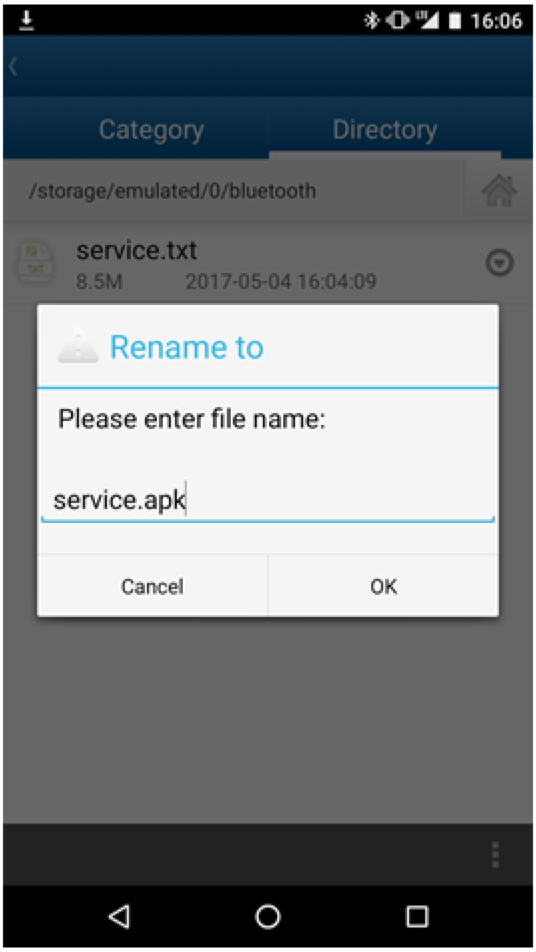
   ⇒ Only install apply of reliable sources.

   ⇒By default, disable the check mark.
2. The easiest option to transmit an APK from a computer to your smart phone is to use a USB cable.

   Transmission via Bluetooth is also possible. To do so, you have to rename the *.apk file extension before the transmission (e.g., *.txt).

3. After the transmission, the file has to be renamed *.apk on the smart phone.



4. Install the APK on your smart phone.

☞ To use "Open Core Interface for drives" on the smart phone, **you must in any case install the "service.apk"** APK for each application APK. "service.apk" is contained in the SDK in the "lib" subdirectory of the EAL4Android directory.

After the installation of "service.apk", find the app under **Settings ▸ Applications** as "EAL service".

Travel motion by entering command values

In the "demo app" (demoapp.apk), the travel motions are performed by entering command values (**MOVE VELOCITY**/**MOVE FREQUENCY**). Furthermore, limit values can be specified.

Here, the "demo app" (demoapp.apk) with the steps "Establishing connection to the drive controller" and "Calling the entry mask for velocity parameters":

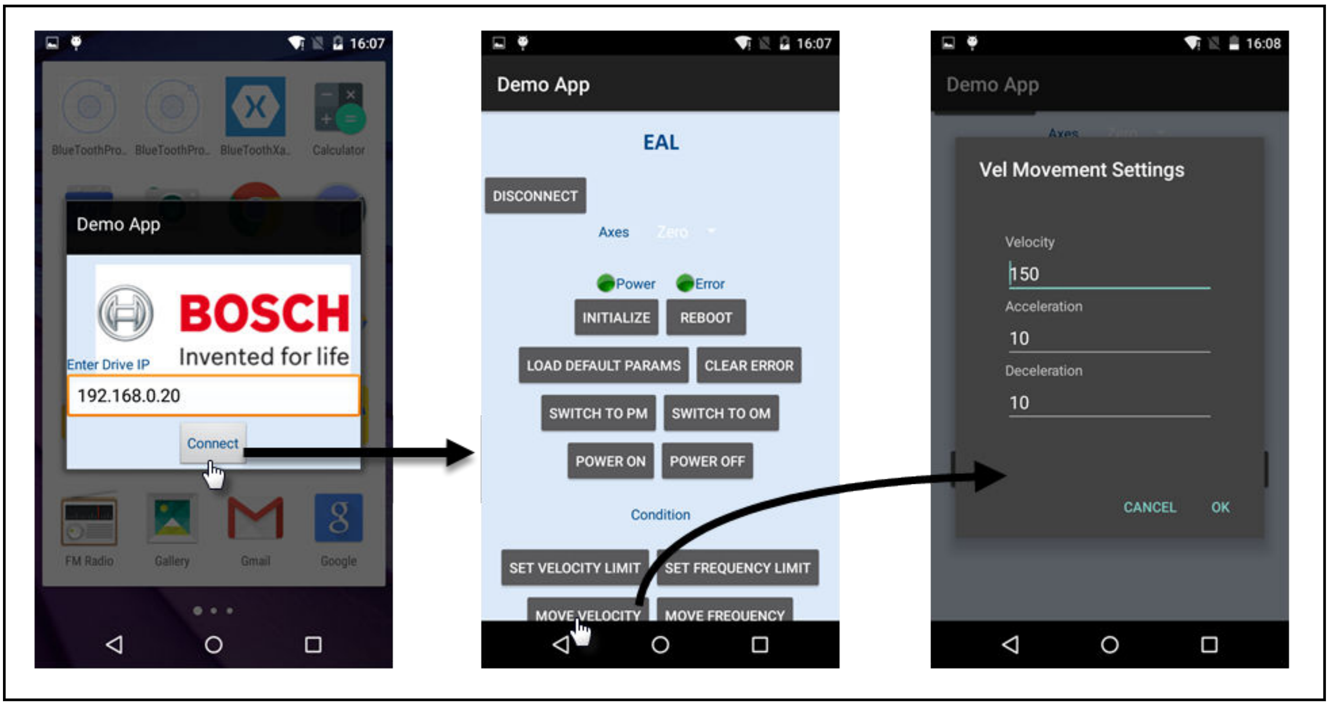


Fig. 10-7: "Establishing connection to the drive controller" and "Calling the entry mask for velocity parameters" in the "demo app"

Travel motion by rotary and tilting motion of the smart phone

To perform a travel motion of the drive, it is also possible to use the acceleration and position sensors of the smart phone. The figure below shows an app in which the drive is moved by rotary and tilting motions of the smart phone:

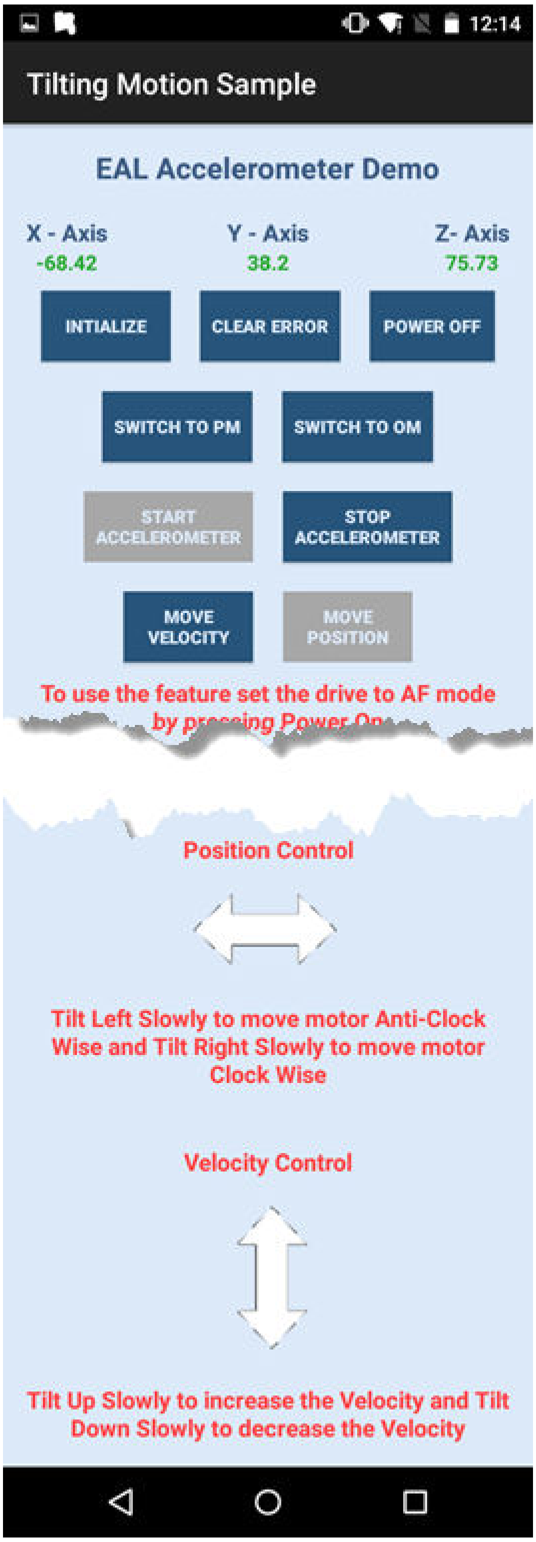


Fig. 10-8: *Demo app: Travel motions by rotary and tilting motion of the smart phone*

10.4 S/IP protocol

10.4.1 Brief description

Fields of application

S/IP facilitates easy access to drive parameters.

Typical fields of application are:

- Communication with the drive for Engineering via IndraWorks
- Replacing cyclic bus communication to control simple axis applications without real-time requirements, e.g. in positioning block mode or with drive-controlled positioning

Overview of functions

Features

- TCP/IP-based protocol
- The protocol focuses on the exchange of data and requires minimum administration overhead.
- User-defined busy timeout (time until the drive sends a defined response)
- User-defined lease timeout (time as of which the connection is enabled again if no new requests are made)
- Proprietary service for reading all parameter information in a request
- Up to 2 connections are possible simultaneously.

  In connection with CCD (refer to 10.2), it is possible to exchange data with the CCD slaves via an S/IP gateway in the CCD master as soon as the S/IP client cannot directly communicate with the CCD slaves and the CCD link is at least in phase 2. (Addressing of CCD master and specifying the slave index).

☞ The S/IP gateway can be used if a TCP/IP communication is established between the CCD master and the CCD slaves. If this is not possible, the considerably slower SIS protocol is used by the CCD master as an alternative to communicate with the CCD slaves. Thus, it is recommended to automatically assign the IP addresses in the CCD network (refer to "P-0-1800.0.1, CCD: Configuration").

Diagnostic messages involved

The following error messages have been defined, and the drive directly returns them in an individual service:

Name	Value in the telegram	Significance
CONNECTION_ERROR	1	Error when establishing the connection
ABORTED	2	Process was aborted
UNKNOWN_MESSAGE_TYPE	3	Message type in the header is unknown
SERVICE_SPECIFIC	4	Service-specific error, e.g. "Operation data is write protected"

Tab. 10-5: S/IP error classes

10.4.2 Functional description

General information

S/IP stands for Sercos Internet Protocol.

In the following, an overview over the services provided in the S/IP protocol and the individual services is explained. Sample requests and responses are presented in the "Notes on commissioning".

A service always contains a request and a response. The request is always transmitted from the client, the server (drive) can respond to a request with different responses. If the query can be processed and answered immediately, the drive directly sends the response to the request (usually: service number response = service number request + 1). If the drive is busy with another request, a busy response (service number: 68) can also be transmitted. If the telegram was formatted incorrectly, the service is not supported or if another error occurred, an exception response (service number: 67) is returned.

Each telegram is composed of a static part and a service-specific part. In the static part, a package number can be assigned to assign request and response. The service executed by this telegram is specified.

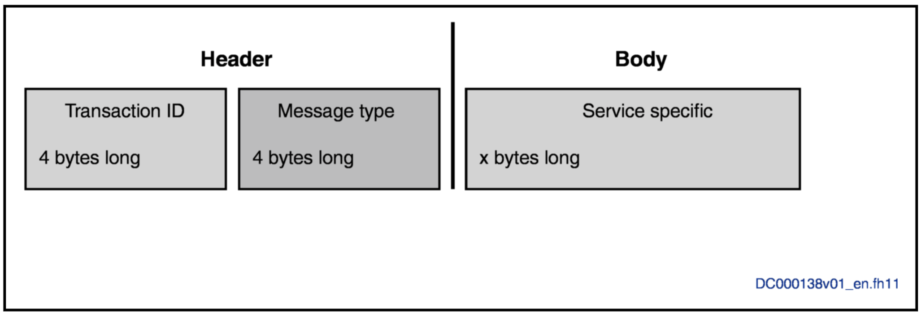


Fig. 10-9: Basic structure of an S/IP telegram

The header consists of 8 bytes:

- Byte 1-4 result in the "TransactionID", an identification number defining this request. This number is specified again in a response.
- Byte 5-8 define the "MessageType". The MessageType is the service number (list of services supported by the drive, see below). As currently only services with a length of 1 byte are used, the low byte is relevant.

Variable definitions

In addition to the data, the services "ReadEverything-Response" and "Read-Description-Response" send a 2-byte value that specifies which elements are valid in the response. This value "ValidElements" are composed as follows:

Bit	Description
0x01	Data status is valid
0x02	Description & DescriptionLength are valid
0x04	Attribute is valid
0x08	Unit and UnitLength are valid
0x10	Maximum value is valid
0x20	Maximum value is valid
0x40	Value and ValueLength are valid

Tab. 10-6: Valid elements

The "ReadEverything request", "ReadOnlyData request", "ReadOnlyDescription request", "ReadDataStatus request", "WriteData request" and "WriteDataBits request" services require information on which parameters the action is to be performed.

A 4-byte value has been transmitted to the drive. The structure corresponds to the following scheme.

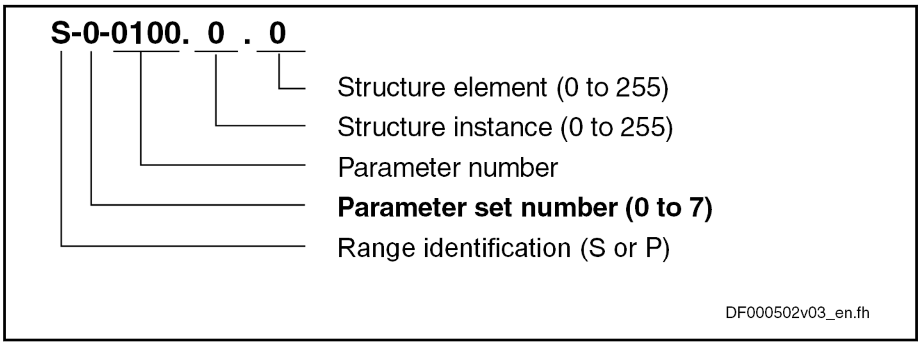


Fig. 10-10: Exemplary representation of a 4-byte IDN

Bit No.	Description		Value range	Notes
31-24	Parameter instance/structure instance (SI)		0-255	
23-16	Parameter element/ structure element (SE)	Sercos-defined SE	0-127	specified by Sercos (bit 15 = 0)
		product-specific SE	128-255	not in use
15	Sercos-specific or product-specific IDN (S or P)	Standard IDN (S-0-nnnn)	0	SE (0-127), SI and parameter number are specified via Sercos
		Product-specific IDN (P-0-nnnn)	1	product-specific parameter
14-12	Parameter set		0-7	see also "Parameter set switching"
11-0	Parameter number		0-4095	

Tab. 10-7: Structure of the 4-byte value

Supported services

The following table provides an overview of the services supported by the drive and the relevant "MessageType" for the request and the response.

Service name	Service number	
	Request	Response
Connect	63	64
Ping	65	66
Exception	-	67
Busy	-	68
ReadEverything	69	70
ReadOnlyData	71	72
ReadDescription	73	74
ReadDataStatus	87	88

WriteData	83	84
WriteDataBits	85	86
Nameplate	89	90

Tab. 10-8: Supported S/IP services of IndraDrive

Connect

Request

Structure:

Via the Connect service, the client connects to the drive. The MessageType "63" is send. Moreover, the so-called busy timeout and lease timeout times are suggested in this telegram.

- **Busy timeout:** Specifies how much time can lapse until a response telegram to a query is received.
- **Lease timeout:** Specifies after which time the drive automatically closes the connection if no new queries are received.

Moreover, it is specified which protocol version is used by S/IP to the communication. The drive supports specification 1.0, consequently, transmit value "1" in the "Version" array.

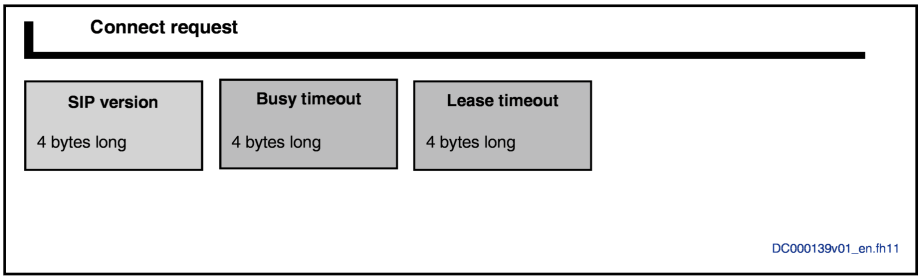


Fig. 10-11: Representation of a Connect request

Response

The Connect response is transmitted as a response to a Connect request, if the connection was established successfully. The service is identified with service number "64" and provides information on the connection:

- which busy timeout is actually used
- which lease timeout is actually used
- which protocol version is actually used
- an array of all supported requests of the drive

Byte offset	Length (BYTE)	Name	Significance	Example
0	4	Version	used protocol version of the drive	1
4	4	BusyTimeout	used busy timeout of the drive	500
8	4	LeaseTimeout	used lease timeout of the drive	15.000
12	4	NumberMessageTypes	Number of services supported by the drive	12
16	NumberMessageTypes * 4	MessageTypes	Array of 4-byte values containing the available services of the drive	-

Tab. 10-9: Connect response structure

Ping

Ping request

The ping request is identified via the service number "65". This request is an empty telegram (telegram with 0 byte user data). The service can be used to:

- maintain the connection, since the drive rejects the connection at the end of the Lease Timeout
- Measure the minimum time that a response from the drive requires

Ping response

The ping response is send as a response to a ping request The telegram does not contain any user data.

Busy & Exception

The "Busy" and "Exception" services are special services. These services can be send as response to any request.

Busy response

The busy response is send if the response telegram has not yet been send once the busy timeout has lapsed. The busy response does not contain any data. Setting the busy timeout to higher values can suppress the response. However, higher values do not ensure that no busy response is send.

Exception response

The exception response is send if a general error occurred in the communication. There are different reasons why an exception response is send.

ReadEverything

ReadEverything request

Use the ReadEverything request to query all parameter data collectively. The service is identified via the service number "69". The SlaveIndex and the SlaveExtension is required. The parameter to be read is transmitted.

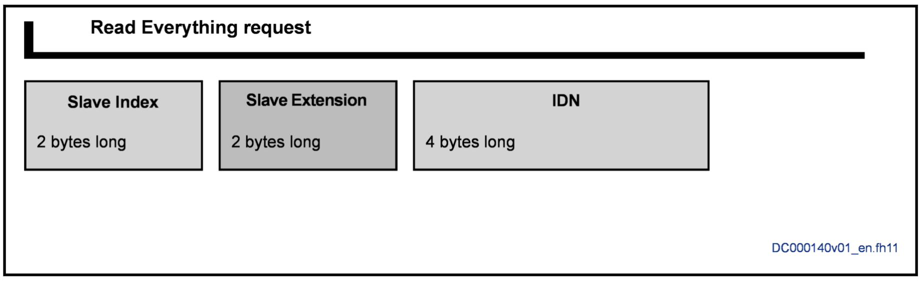


Fig. 10-12: Illustration of a ReadEverything request

Byte offset	Length (BYTE)	Name	Significance	Example
0	2	SlaveIndex	Only relevant for multi-axis devices (HCQ/HCT/CDB) or a subordinate CCD cross communication. 0..n: Local axis n+1..m: Remote axes m+1..k: I/O Devices etc., see also "P-0-4031, Overview of device addresses"	0
2	2	SlaveExtension	reserved - always 0	0
4	4	IDN	Parameter to be read	0x30

Tab. 10-10: Structure of ReadEverything request

ReadEverything response

The ReadEverything response contains data for the "ReadEverything request" query. The service is identified via the service number "70".

The following values are transmitted:

- Data status
- Attribute
- Minimum value and maximum value

- Maximum list length in bytes (in case of list parameters)
- Current data length in the parameter in bytes
- Current parameter unit length in bytes
- Current name length in bytes
- Parameter data in binary format
- Parameter unit as string
- Parameter name as string

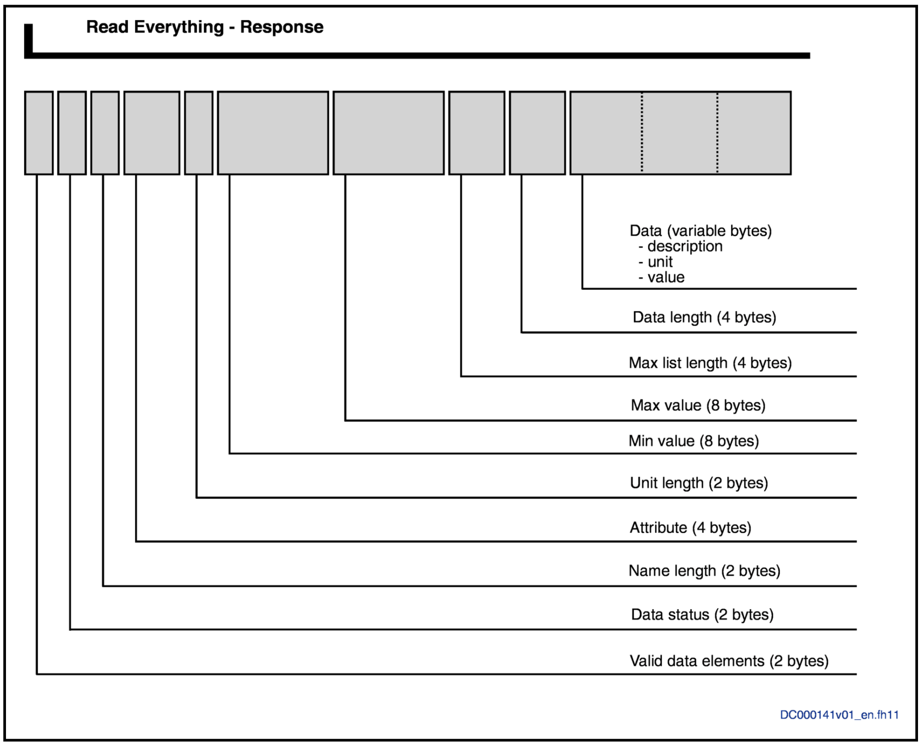


Fig. 10-13: Representation of the ReadEverything response

Byte offset	Length (BYTE)	Name	Significance	Example
0	2	ValidElements	Bit list in which valid elements are coded	0b0000.0000.0100.11111
2	2	DataStatus	Data status of the parameter (valid/invalid) or command status in command parameters	1
4	2	NameLength	Length of the string which contains the name of the parameter in the language set in S-0-0265	0x20
6	4	Attributes	The attribute of the parameter contains information on decimal places, display format, maximum length, write protection and whether the parameter is a command parameter	0x77560000
10	2	UnitLength	String length containing the parameter unit (depending on the scaling)	6
12	8	Min	Lower input limit of this parameter	-
20	8	Max	Upper input limit of this parameter	-

Byte offset	Length (BYTE)	Name	Significance	Example
28	4	MaxListLength	Maximum length of list parameter in bytes (only valid in case of list parameters)	8196
32	4	DataLength	Current parameter length	38
36	NameLength	Name	Parameter name	"Firmware version"
36 + Name-Length	UnitLength	Unit	Parameter unit	""
36 + Name-Length + Uni-tLength	DataLength	Data	Parameter value	"FWA-INDRV****"

Tab. 10-11: Structure of ReadEverything response

ReadOnlyData

ReadOnlyData request The data is read out via "ReadOnlyData request". The query of "ReadOnly-Data" is identical to the "ReadEverything request"; service number "71" is send in the header.

ReadOnlyData response The "ReadOnlyData response" is identified via service number "72". The following data is transmitted:

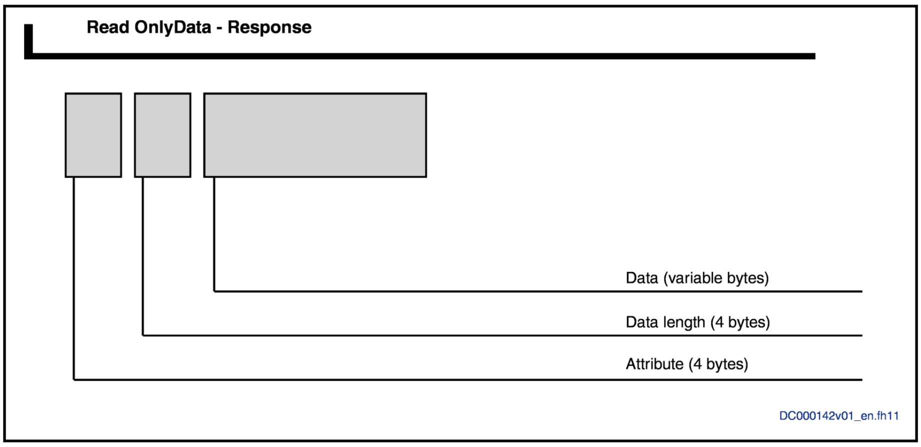


Fig. 10-14: Illustration of the ReadOnlyData response

Byte offset	Length (BYTE)	Name	Significance	Example
0	4	Attributes	attribute of parameter	0x77560000
4	4	Length	Data array length in bytes	2
4	Length	Data	Parameter data	0x1345

Tab. 10-12: Structure of ReadOnlyData response

ReadDescription

ReadDescription request The "ReadDescription request" is used to request all information on the parameter, with the exception of the operating data per se. The query of "ReadDescription" is identical to the "ReadEverything request", however, the service number "73" is used here.

ReadDescription response The "ReadDescription response" is identified via service number "74". The following data is transmitted:

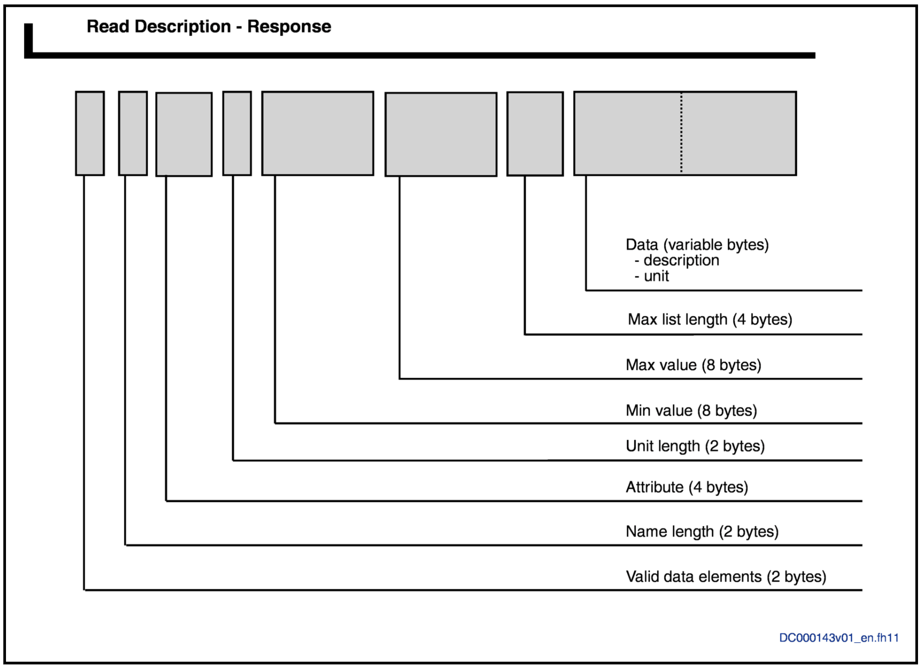


Fig. 10-15: Illustration of the ReadDescription response

Byte offset	Length (BYTE)	Name	Significance	Example
0	2	ValidElements	Bit list in which valid elements are coded	0b0000.0000.0100.11111
2	2	NameLength	Length of the string which contains the name of the parameter in the language set in S-0-0265	0x20
4	4	Attributes	The attribute of the parameter contains information on decimal places, display format, maximum length, write protection and whether the parameter is a command parameter	0x77560000
8	2	UnitLength	String length containing the parameter unit (depending on the scaling)	6
10	8	Min	Lower input limit of this parameter	-
18	8	Max	Upper input limit of this parameter	-
22	4	MaxListLength	Maximum length of list parameter in bytes (only valid in case of list parameters)	8196
26	4	DataLength	Current parameter length	38
30	NameLength	Name	Parameter name	"Firmware version"
30 + NameLength	UnitLength	Unit	Parameter unit	""

Tab. 10-13: Structure of ReadDescription response

ReadDataStatus

ReadDataStatus request

The data status can be read out directly via the "ReadDataStatus request". The query of "ReadDataStatus" is identical to the "ReadEverything request"; service number "87" is used.

ReadDataStatus response

The "ReadDataStatus response" is identified via service number "88". The following data is transmitted:

Byte offset	Length (BYTE)	Name	Significance	Example
0	2	DataStatus	Data status of the queried parameter	1

Tab. 10-14: Structure of ReadDataStatus response

WriteData

WriteData request

The data is read out via "WriteData". Service number "83" is used.

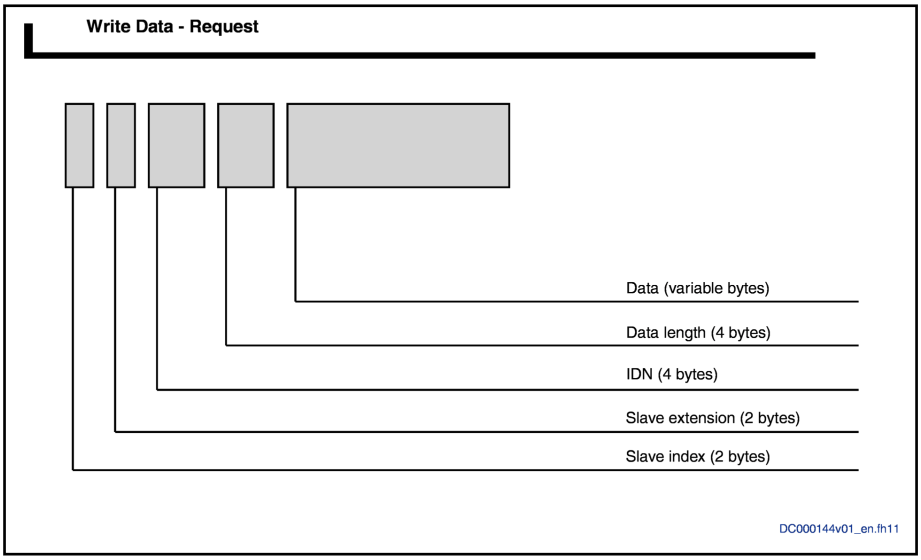


Fig. 10-16: Illustration of the WriteData request

Byte offset	Length (BYTE)	Name	Significance	Example
0	2	SlaveIndex	reserved - always 0	0
2	2	SlaveExtension	reserved - always 0	0
4	4	IDN	Parameter to be read	0x30
4	4	DataLength	Length of transmitted data	2
8	DataLength	Data	Operating data to be transmitted	0x1234

Tab. 10-15: Structure of WriteData request

WriteData response

The "WriteData response" is identified via service number "84". No data is transmitted.

WriteDataBits

WriteDataBits request

Use the "WriteDataBits request", individual parameter bits can be written individually. The "WriteDataBits" query is identified via service number "85".

Any number of bits of a parameter value can be written to a query. The bits written depend on the DataMask which forms part of the request. Thus, it is possible to change individual bits at any position in the parameter or to write all bits. The bits that are written have to selected at the corresponding position in the "DataMask". If bit 7 is to be written, bit 7 has to be set to 1 in the "DataMask".

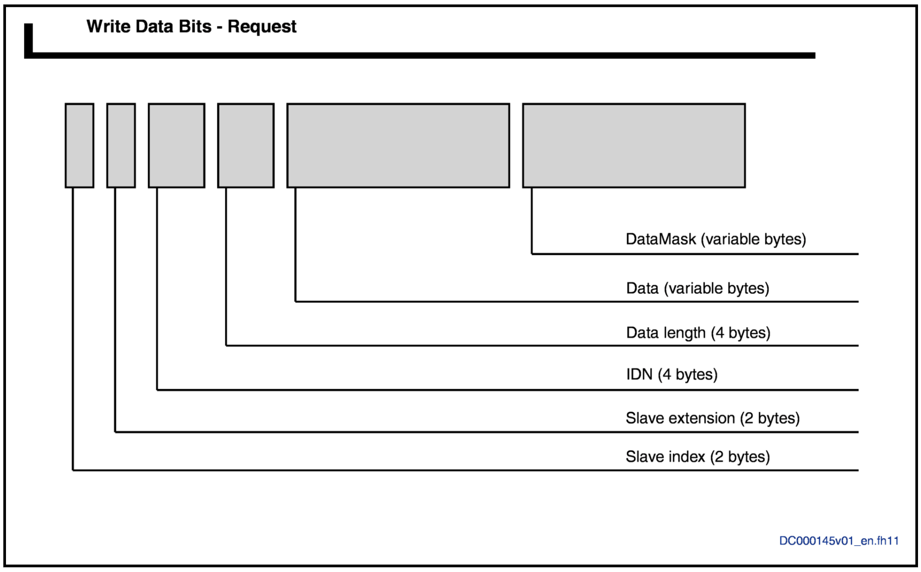


Fig. 10-17: Illustration of the WriteDataBits request

Byte offset	Length (BYTE)	Name	Significance	Example
0	2	SlaveIndex	reserved - always 0	0
2	2	SlaveExtension	reserved - always 0	0
4	4	IDN	Parameter to be read	0x30
4	4	DataLength	Length of transmitted data	2
8	DataLength	Data	Operating data to be transmitted	0x1234
8 + DataLength	DataLength	DataMask	The bits to be updated	

Tab. 10-16: Structure of WriteDataBits request

WriteDataBits response

The "WriteDataBits response" is identified via service number "86". No useful data are entered. In case of an error, an "Exception response" is returned instead of a WriteData response.

Nameplate

Nameplate request

In preparation

Nameplate response

In preparation

10.5 Firmware download via TFTP server

10.5.1 Brief description

Fields of application

If a firmware download is to be carried out, a TFTP server is available for this purpose. This makes it possible to download new firmware to the device.

Overview of functions

Identifying firmware

A special "ReadRequest" can be used to identify firmware in the device. For this purpose, the "firmware" string is transmitted in the "ReadRequest".

The response telegram contains a data package, the first four bytes of which are the control section circuit board code and the following content is the manufacturer version (cf. S-0-0030.0.0).

Firmware download

The download procedure is started using a WriteRequest. To do this, the drive has to be in PM. Here the "WriteRequest" also initiates the connection to the TFTP server.

Then "DataRequests" is used to download the firmware to the device. The device performs several checks:

- Can the new firmware file be used with this device (compatibility check)?
- Was the correct quantity of data transmitted (data integrity check)?
- Was the firmware file transferred correctly and was it valid (validity check)?

Error diagnostics

Any possible error that occurs during this procedure is returned via the ErrorFrame in the TFTP. The error text is available as a plain text.

Features

The TFTP server of an IndraDrive device has the following features:

- A TFTP connection does not know any authentication
- The following five package types are available in a TFTP connection:
  - "ReadRequest" (reading of files from server/drive starts)
  - "WriteRequest" (writing of files to server/drive starts)
  - "Data" (data are transmitted)
  - "Acknowledge" (data packages are confirmed)
  - "Error" (any type of error message)
- Each data package has to be confirmed with "Acknowledge" before the next data package is transmitted.

Diagnostic messages involved

Error are transmitted in plain text using "TFTP ErrorFrame" (see diagnostic description: "Firmware Download")

10.6 File handling by FTP via Ethernet

10.6.1 Brief description

Base package of all firmware variants in **open-loop and closed-loop** characteristic

Via an integrated FTP server, IndraDrive devices with Ethernet communication can access the data of the optional memory card by means of FTP connection. This allows reading or writing data/directories on the memory card.

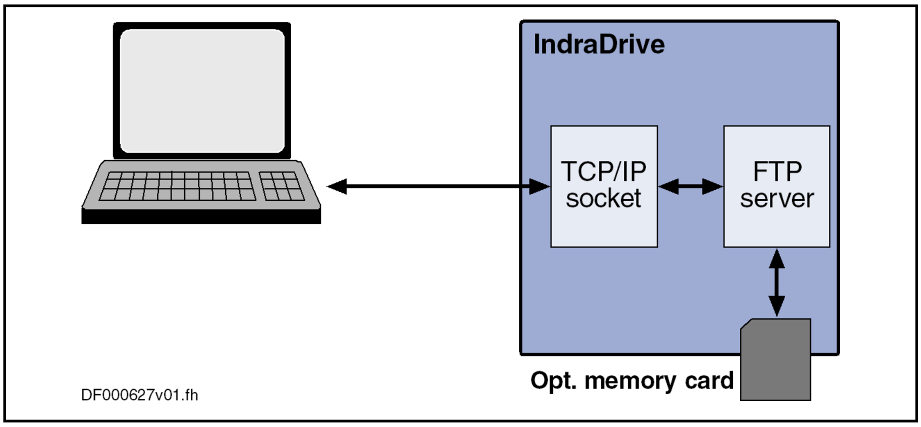


Fig. 10-18: Schematic illustration of FTP file handling

Features

The FTP server of an IndraDrive device has the following features:

- Two types of login to the FTP server:
  - Anonymous login (read-only data access)
  - User login (read and write access to data)
- A maximum of 2 simultaneous connections
- The effective transmission rate depends on processor load and current drive status

  The transmission rate is approx. 450 kbytes/s for download (STOR command) and 300 kbytes/s for upload (RETR command) with an active connection. If 2 FTP connections are simultaneously active (download or upload), the effective transmission rate is dramatically reduced in both directions.

Hardware requirements

The following hardware requirements must have been fulfilled:

- IndraDrive with Advanced Display
- Memory card plugged before booting up

If no memory card was recognized during boot-up, the parameter "P-0-4066, Card Identification Data" contains the value 0xFFFFFFFF.

Parameters involved

- P-0-4066, Card Identification Data

10.6.2 Functional description

Connections

A maximum of 2 connections to the FTP server can be simultaneously established.

Establishing the connection

After the drive has been booted up, the FTP connection is not active yet. To establish the connection, log on to the FTP server using the correct IP address.

Terminating the connection

When there is no more data traffic, the drive automatically terminates the FTP connection after 5 minutes. If the connection is to be maintained, the FTP command "NOOP" can be send cyclically.

File directories

The drive automatically creates the following directories if they are not yet available:

- USER
- BACKUP
- TOOLS

- PLC
- DOCUMENTATION
- TEMP

FTP logon

Each time the connection is established, it is necessary to log on to the FTP server. IndraDrive supports two types of logon, standard logon and anonymous logon.

Standard logon

For standard logon to the FTP server, log on under the user name "boschrexroth" with the password "boschrexroth" (logon according to Bosch Rexroth standard).

Upon successful standard logon, it is possible to access all files and directories of the memory card and carry out read access or write access.

After each logon, the FTP server opens the "USER" directory of the memory card.

Anonymous logon

Anonymous logon to the FTP server is possible, too. For this purpose, employ the user name "anonymous" and any e-mail address as a password (IndraDrive-specific logon). This type of logon provides read-only access to all data and directories of the memory card.

After each logon, the FTP server opens the "USER" directory of the memory card. This is the area in which the user data were stored.

FTP data handling

File date

Files created via FTP on the memory card are created there as a new file. The time from parameter "P-0-0197, System time" is used as the file date. The minimum date used as the start value is "01.01.2000".

File names

When selecting file names and directory names, comply with the following rules and restrictions:

- File names may only contain the following characters:
  - !#$%&'()+-0123456789=?
  - ABCDEFGHIJKLMNOPQRSTUVWXYZ[]^_
  - abcdefghijklmnopqrstuvwxyz{}~
- Files cannot begin with ".".
- The lengths of file names (incl. file path) cannot exceed 80 characters.

FTP commands

The FTP server accepts the commands contained in the following table. If commands are entered via a user interface (e.g., FTP client), some different commands are used (e.g., "dir" instead of "LIST"). In these cases, the FTP client converts the commands, which the user entered, to the below-mentioned syntax.

Command syntax	Description
USER xxxx	Log on with user name xxxx
PASS xxxx	Enter password xxxx
TYPE x	Entering the transmission type x = "A" für ASCII; x = "I" für IMAGE (binary)
STOR xxxx	Saving a file with name xxxx on the µSD card
RNFR xxxx RNTO yyyy	Rename file xxxx, new name yyyy
CWD xxxx	Change working directory to xxxx

Command syntax	Description
SYST	Request system information from FTP server
CDUP	Change working directory, go one level "up"
QUIT	Terminate the connection
STRU F	Set data structure type to "File"
APPE xxxx	Attach data to file xxxx or create file xxxx
LIST	Request directory structure from server
STAT	Request status message of current settings of TYPE, STRU and MODE
RMD xxxx	Delete directory xxxx
XRMD xxxx	delete directory xxxx
ACCT xxxx	Change user ID to xxxx
PORT xxxx	Transmit port number of host for data transfer
MODE S	Set transfer mode to "Stream"
ABOR	Cancel current transmission
NLST	Send a file list to client
HELP	Send a list of supported FTP commands to client
PWD	Show current working directory
XPWD	Show current working directory
MKD xxxx	Create directory xxxx
XMKD xxxx	Create directory xxxx
PASV	Open FTP server as "passive" connection
RETR xxxx	Send file xxxx to client
DELE xxxx	Delete file xxxx on server
NOOP	"No Operation"→ can be send periodically to maintain connection.

Tab. 10-17: Function commands for FTP data handling

11 Commissioning

⚠ WARNING **Dangerous movements! Danger to life, risk of injury, serious injury or property damage!**

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine's range of motion (e.g., by using safety fences, safety guards, protective coverings, light barriers).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.

11.1 Commissioning methods

Offline simulation or real mode. Unlike drive: Simulation mode and motion commissioning do not exist.

11.2 General schematic sequence for controlling the supply unit

Switching on

- Switching on 24V control voltage.
- Switching on mains voltage.
- Controlling the mains contactor.
- DC bus is charged via the soft start device.
- Enabling operation mode.
- Preselected operation mode is activated, axes at the DC bus can be operated.

Switching off

- Disabling operation mode and switching off mains contactor.
- Selecting the "ZKS" function to discharge the DC bus, if necessary.
- Switching off mains voltage.
- Switching off 24V control voltage.

11.3 Operation with master communication

11.3.1 Supply unit with HMU

Supply units of the IndraDrive ML device range consist of a universal inverter (HMU) and a mains connection module (HNA).

The master communication is configured in parameter "P-0-4089.0.1, Master communication: Protocol". Control via master communication in accordance with the state machine of the device [see chapter 3.2.4 "Device control and state machines" on page 33] using "S-0-1720.0.1, Power supply control word". Feedback via "S-0-1720.0.2, Power supply status word".

Switching on

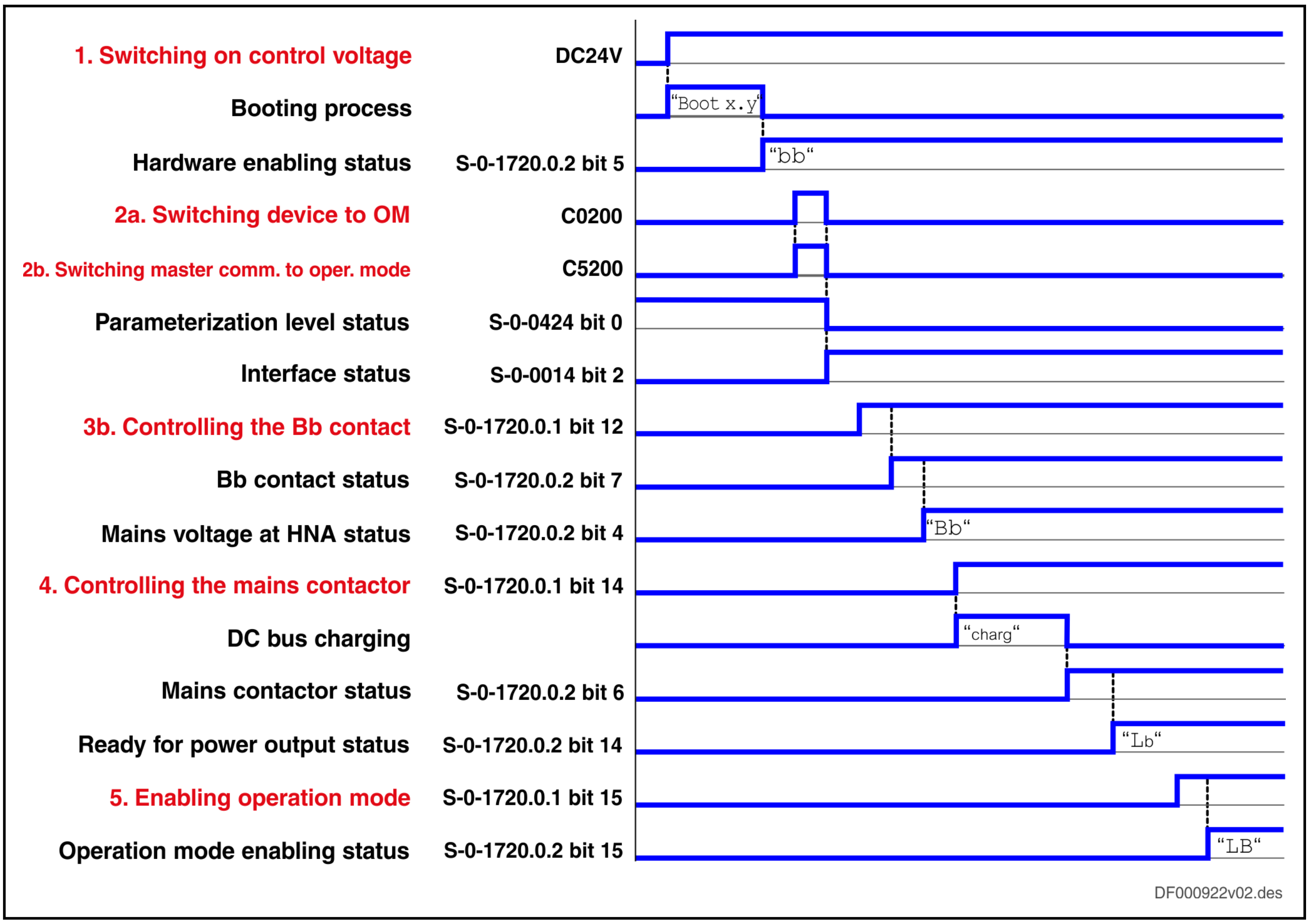


Fig. 11-1: Signal sequences when switching on via master communication, supply unit with HMU

Information on switching on via master communication for supply unit with HMU:

- Via the "Bb contact", the optional main contactor (additional contactor upstream) is enabled.
- The "Bb contact" is opened when the device is switched to PM or P2.
- The supply unit goes to the "Bb" state as soon as mains voltage has been applied to the input terminals of the mains connection module (HNA) and the voltage complies with the connection conditions.
- The DC bus is charged via the mains connection module (HNA).
- Only after the DC bus has been successfully charged is the mains contactor closed and the supply unit goes to the "Lb" state.
- When the supply unit displays "LB", the preselected operation mode is active and the drives at the DC bus can be operated.

Switching off

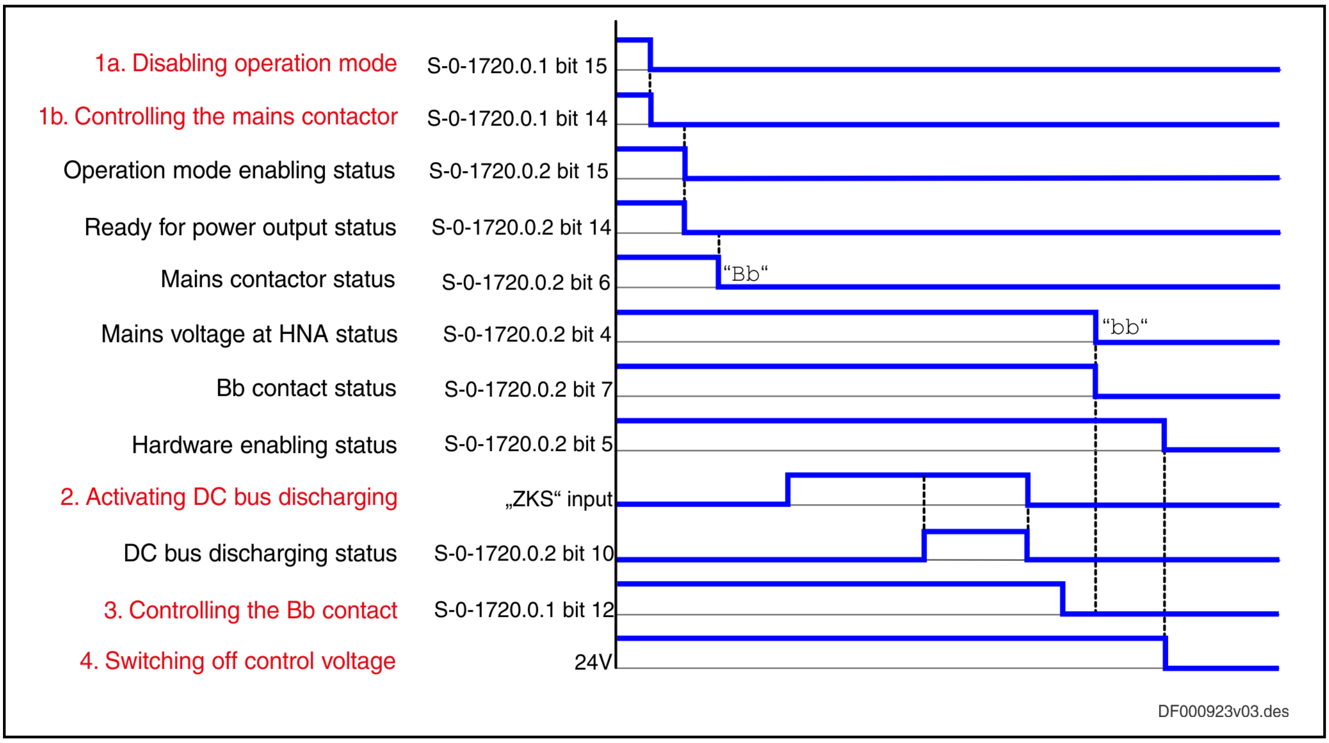


Fig. 11-2: Signal sequences when switching off via master communication, supply unit with HMU

Information on switching off via master communication for supply unit with HMU:

- The universal inverter (HMU) is not equipped with an internal braking resistor. Therefore, the "ZKS" function can only be executed if an external braking resistor (HLT plus HLR) has been connected to the DC bus.
- The "ZKS" function is controlled via the digital "ZKS" inputs at HNA and HLT.
- The status bit of DC bus discharge is set when the "ZKS" function is active and the DC bus has been de-energized.
- The "OFF" and "ZKS" inputs of the mains connection module (HNA) also take effect with active master communication.

⚠ WARNING **High electrical voltage on DC bus, even after 24V control voltage switched off!**

Use "ZKS" function or wait for DC bus to have automatically discharged. Ensure that the system is de-energized.

11.3.2 KMV supply unit

The master communication is configured in parameter "P-0-4089.0.1, Master communication: Protocol". Control via master communication in accordance with the state machine of the device [see chapter 3.2.4 "Device control and state machines" on page 33) using "S-0-1720.0.1, Power supply control word". Feedback via "S-0-1720.0.2, Power supply status word".

Switching on

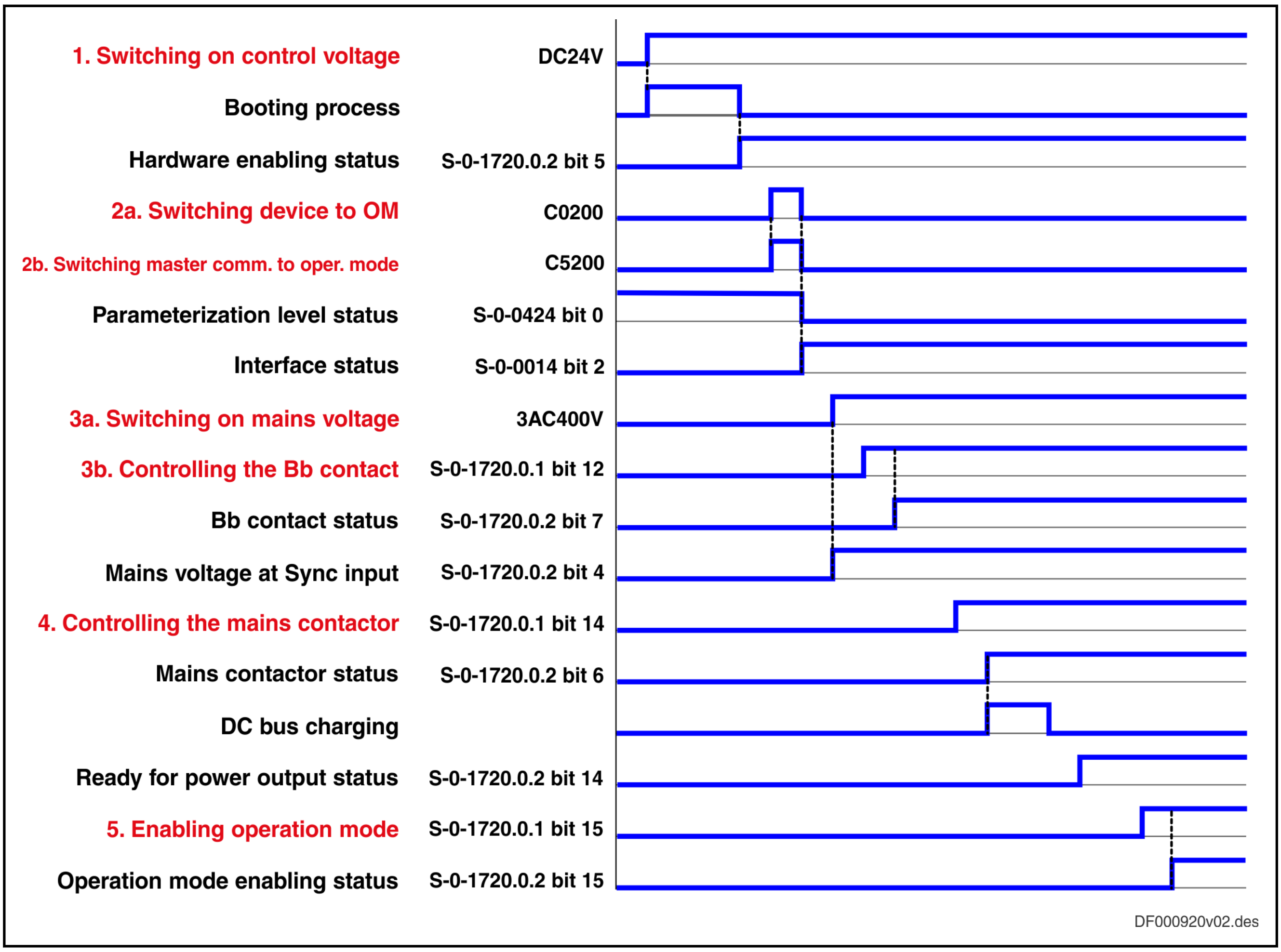


Fig. 11-3: Signal sequences when switching on via master communication, supply unit with KMV

Information on switching on via master communication for KMV supply unit:

- The distributed supply unit (KMV) does not feature a "Bb contact". Therefore, an optional main contactor (additional contactor upstream) cannot be switched on via the control word.
- In the switch-on sequence, control of the "Bb contact" via S-0-1720.0.1 bit 12 has to be taken into consideration, even if the contact does not physically exist.
- If mains voltage has been applied to the input terminals of the mains choke (KNK) and the voltage complies with the connection conditions, S-0-1720.0.2 bit 4 is set.
- After the mains contactor has been closed, the DC bus is charged via the internal braking resistor.

Switching off

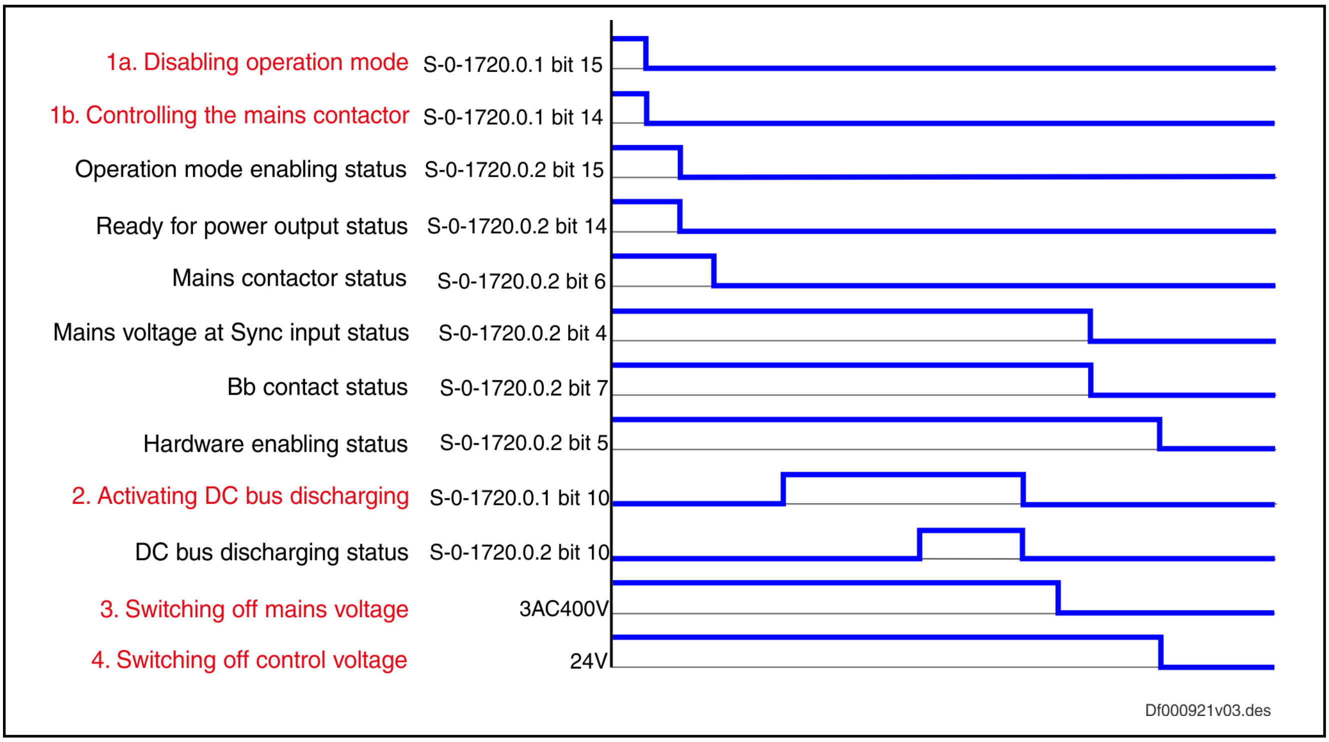


Fig. 11-4: Signal sequences when switching off via master communication, supply unit with KMV

Information on switching off via master communication for KMV supply units:

- The distributed supply unit (KMV) features an internal braking resistor used for the "ZKS" function.
- The "ZKS" function is activated using S-0-1720.0.1 bit 10.
- The status bit of DC bus discharge is set when the "ZKS" function is active and the DC bus has been de-energized.

⚠ WARNING **High electrical voltage on DC bus, even after 24V control voltage switched off!**

Use "ZKS" function or wait for DC bus to have automatically discharged. Ensure that the system is de-energized.

11.4 Operation without master communication

11.4.1 Supply unit with HMU

Supply units of the IndraDrive ML device range consist of a universal inverter (HMU) and a mains connection module (HNA).

If master communication has been deactivated (cf. P-0-4089.0.1), the supply unit can be controlled via the digital inputs of the mains connection module (HNA). The "ON", "OFF" and "Reset" inputs are copied to the parameter "S-0-1720.0.150, Power supply ON/OFF" without any additional configuration and evaluated by the firmware. For how to wire the inputs, please see the Project Planning Manual for HMU.

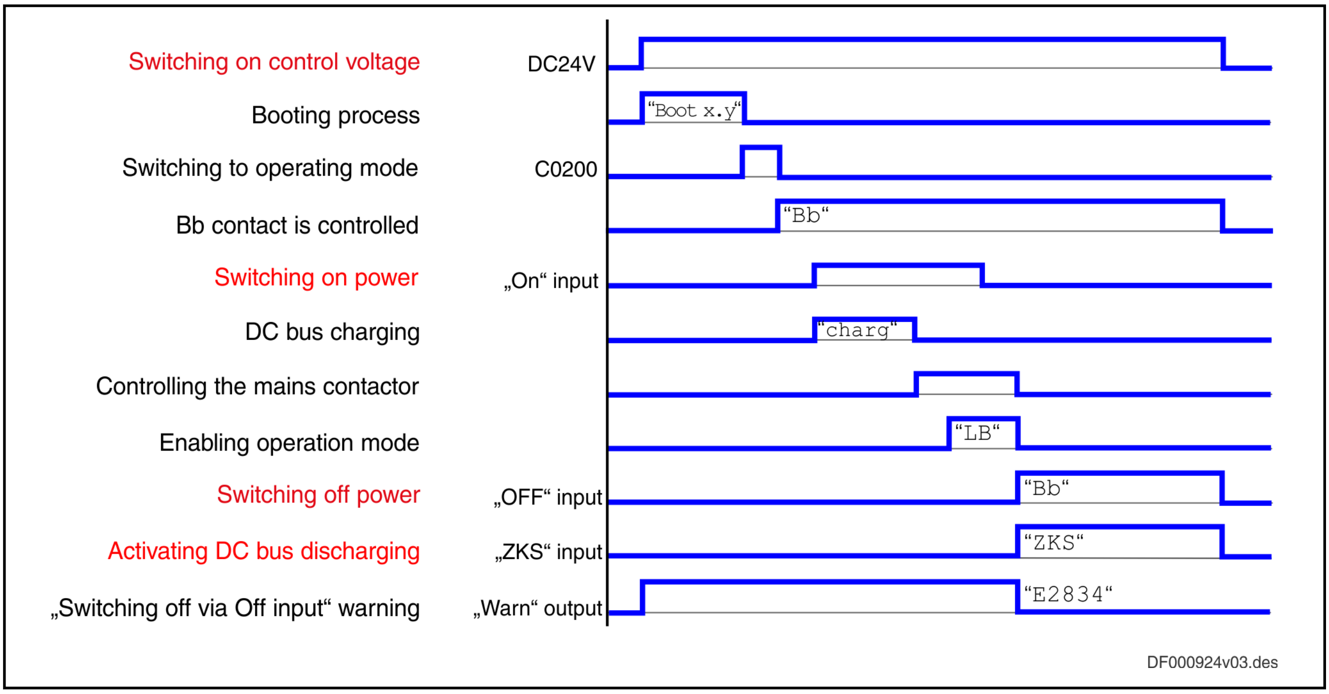


Fig. 11-5: Signal sequences for operation without master communication, supply unit with HMU

Information on operation without master communication for supply unit with HMU:

- The switching pulse at the "ON" input has to be present until the supply unit has reached the "LB" state.
- The universal inverter (HMU) is not equipped with an internal braking resistor. Therefore, the "ZKS" function can only be executed if an external braking resistor (HLT plus HLR) has been connected to the DC bus.
- If the "ZKS" input is activated, the mains contactor is automatically disconnected.
- If the "ZKS" function is active, the warning "E8034, Emergency-Stop activated" is generated.
- The "Warn" output and the LED at the mains connection module (HNA) are used for restricted diagnostics.

11.4.2 KMV supply unit

The KMV supply unit cannot be operated via the local I/Os. The device is controlled exclusively using "S-0-1720.0.1, Power supply control word".

11.5 Supply unit as PLC device

11.5.1 General information

Using supply units of type HMV05[1)] (Product range IndraDrive ML) and KMV03 (product range IndraDrive: Mi) are provided with supply units with separate master communication. These supply units can be operated with firmware PSB-2x.

1) HMV05 is the designation of a supply unit consisting of HNA05 mains connection module, HMU05 universal inverter and CSB02.5 control section with firmware for supply units (FWA-INDRV-PSB-...). HMV05 is not an official product designation and is used for documentation purposes only.*

Supply units of this type can be referred to as "intelligent" supply units. They have a bus address, different parameters to parameterize functions, a device control word and a device status word.

Refer to the relevant project planning manual for information on "intelligent" supply units.

- KMV03: Project Planning Manual with material number R911335703
- HMV05: Project Planning Manual with material number R911344279

Supply units with separate master communication are supported by IndraLogic XLC/IndraMotion MLC/IndraMotion MLD as PLC devices.

11.5.2 Parameterization

The supply unit can be created in the IndraWorks project by dragging and dropping it from the library window (folder "Periphery", folder for the relevant field bus) to the field bus node. For Sercos, find the relevant supply unit in the library of the periphery devices "Sercos".

The supply unit can be parameterized in IndraWorks Ds. (A parameterization via single parameters is possible via IndraLogic XLC/IndraMotion MLC.)

IndraLogic XLC / IndraMotion MLC: Right-click on the Sercos device and on "IndraWorks Ds here..." to directly call IndraWorks Ds.

As an option to "IndraWorks Ds here...", the communication between PC and supply unit can take place directly. The PC can be connected to a free port of the Sercos device or can communicate via a "Sercos III NetSwitch" (order no.: R911328254, HAWA HGS NS-S3-1NRT). Optionally, the IP communication can be routed via the control using the Windows command "route".

The parameters to be transmitted cyclically can be parameterized in IndraWorks below the Sercos node.

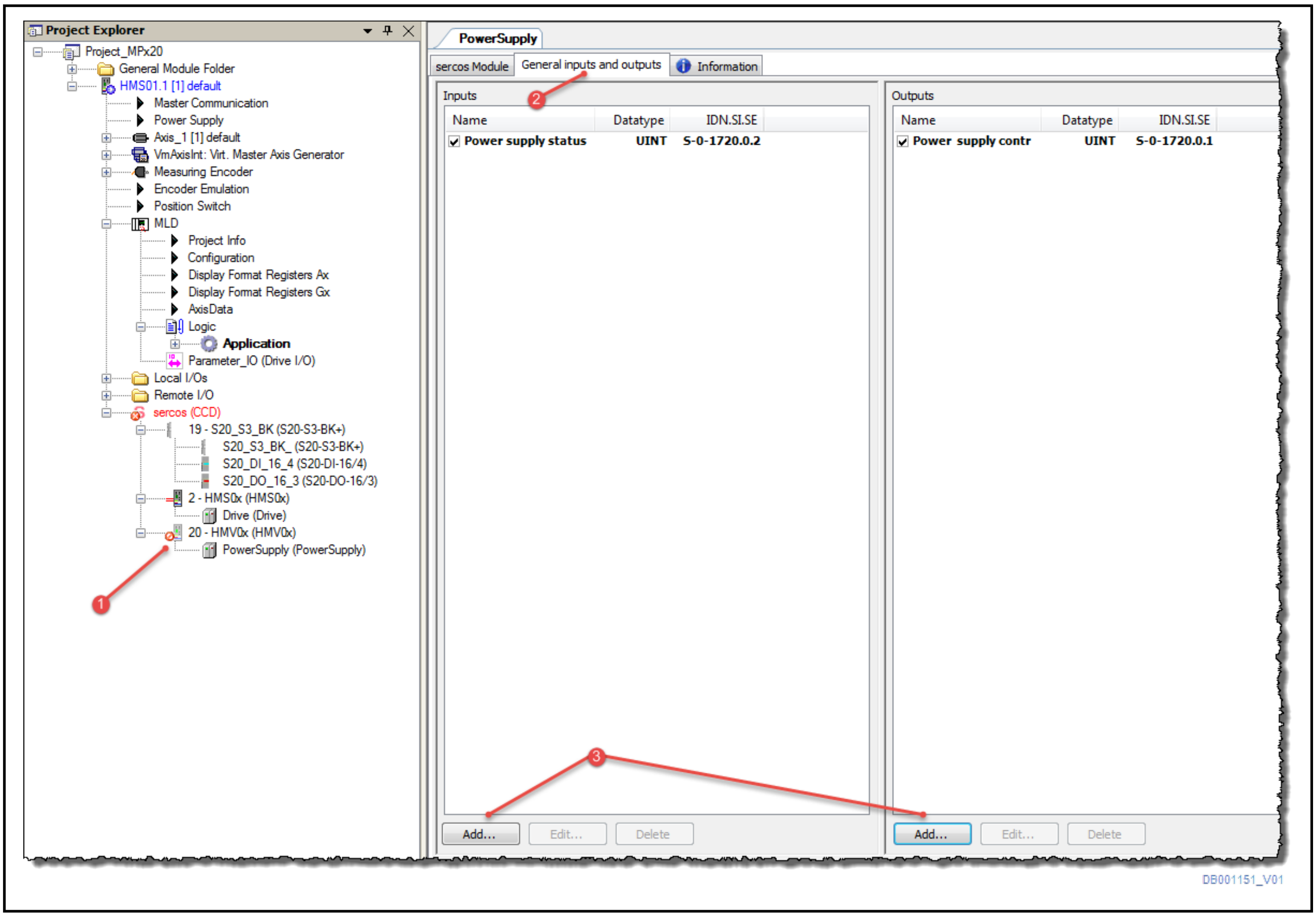
Establishing the connection and parameterizing the supply unit

When using "IndraWorks Ds here..." in IndraLogic XLC/IndraMotion MLC (right-click on the Sercos device), step 1 and 2 do not apply.

1. Connect the supply unit to a free Ethernet network connection or via a USB port using an Ethernet adapter. Set IP address of the Ethernet network connection or of the Ethernet adapter to the supply device area 172.31.x.x.
2. Start IndraWorks Ds. **Connection selection ▸ IP address search.** Connect to device.
3. If required, parameterize the supply unit again in IndraWorks Ds.

11.5.3 Configuring the cyclic data

Data to be cyclically transmitted can be configured in IndraWorks below the Sercos branch in the "General inputs and outputs" dialog.



1	Double-click on the PowerSupply node below the Sercos device
2	Select the "General inputs and outputs" tab
3	Select or delete parameters using "Add"

Fig. 11-6: Example configuration of the cyclic parameters in the drive telegram AT (inputs) and master data telegram MDT (outputs)

The examplary configuration is a minimum configuration. "S-0-1720.0.1, power supply control word" as PLC output is required to command the supply unit and "S-0-1720.0.2, power supply status word" as PLC input to read out the status.

☞ If the device description file contains the required information (e.g. which parameters can be configured cyclically, parameter name and attribute), the configurator provides a drop-down menu and proposes the required settings. If information is not available and not drop-down list is available, select the settings manually.

Configuring the cyclic data

1. Double-click on the supply unit node in the IndraWorks project. Select the "General inputs and outputs" tab.
2. "S-0-1720.0.2, power supply status word" has to be configured.

   In the S-0-1720.0.2 help, check the attribute:

   - Length: 2 bytes
   - Format: BIN

- Select "**Add**" at the inputs

3. Parameter "S-0-1720.0.1, power supply control word" has to be configured.

   In the S-0-1720.0.1 help, check the attribute:

   - Length: 2 bytes
   - Format: BIN
   - Select "**Add**" at the outputs

4. Assignment Variable ↔ Parameter

   The PLC variable parameter can be assigned in the "I/O image" tab. New variables can be generated or input and output parameters can be mapped to existing PLC variables.

   Change to "I/O image" tab. Enter the PLC variables in the "Variable" column as explained in Example configuration of the cyclic parameters in the drive telegram AT (inputs) and master data telegram MDT (outputs).

   The entered name is displayed in the "Channel" column in PLC variable assignment to configured parameters.

   Depending on the parameter attribute, the correct data type (with matching length; with or without sign) has to be selected in the PLC.

Data length in attribute	Format in attribute	Data type in PLC
2 bytes	BIN or HEX	WORD
4 bytes	BIN or HEX	DWORD
2 bytes	DEC_MV	INT
4 bytes	DEC_MV	DINT
2 bytes	DEC_OV	UINT
4 bytes	DEC_OV	UDINT

Tab. 11-1: Assignment parameter attribute ↔ data type in PLC

The variables are regenerated in this example:

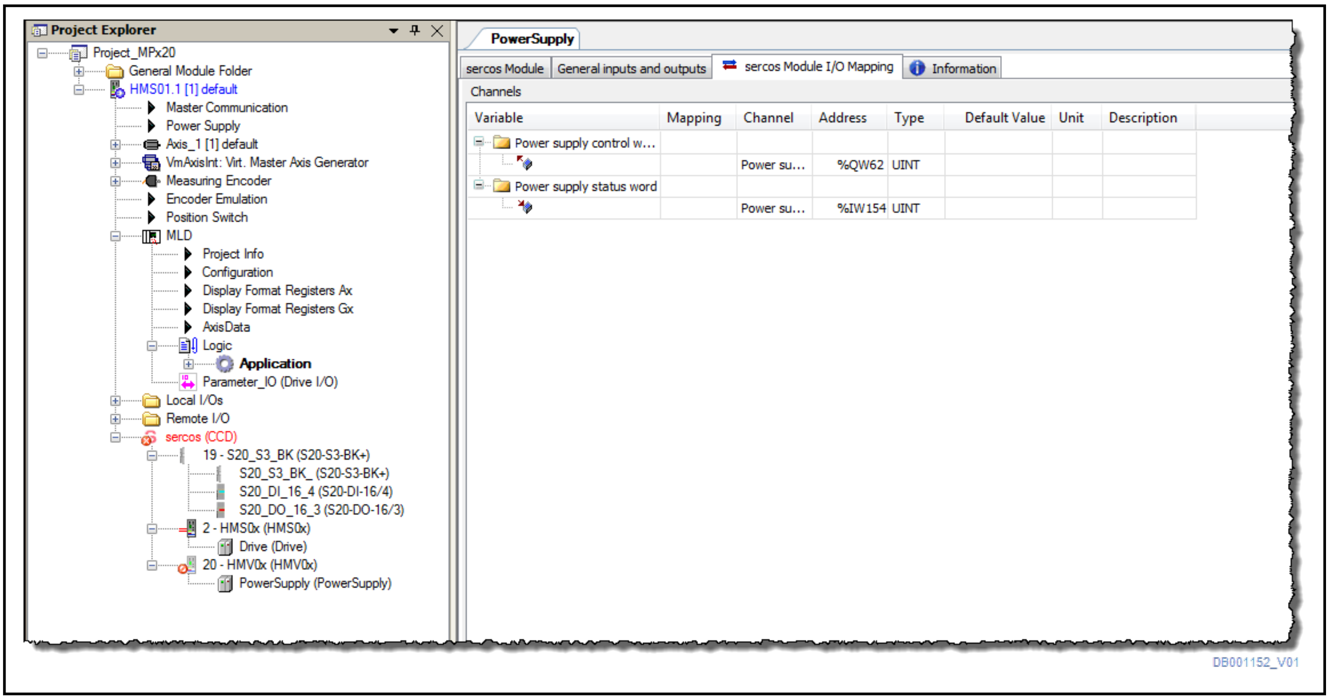


Fig. 11-7: PLC variable assignment to configured parameters

11.5.4 PLC programming

The configured PLC variables of the cyclically configured parameters for control and status word can be used in the PLC program.

As an option to a PLC program, supply units can be controlled via functions, provided in an IndraWorks library:

- **Library:** RMB_SercosIII_Util
- **Group:** PowerSupply
- **Target Systems:**

  IndraMotion MTX 14VRS

  IndraMotion MLC 14VRS, Function package PLC

  IndraMotion MLD with PSBx21

For the bit assignment of the supply units parameter (S-0-1720.0.1, Power supply control word / S-0-1720.0.2, Power supply status word), refer to the parameter description.

The supply units can be commanded in any cyclic task (e.g. "PlcTask" and "PlcProg").

Program example

Power on and power off is executed in the following example:

- **1. State "Switch on main contactor"**

  Control word: Set bit 12 (16#1000)

  Status word: Query bits 4, 5, 7 (16#00B0), advance state

- **2. State "Switch on main contactor (load DC)"**

  Control word: Set bits 12, 14 (16#5000)

  Status word: Query bits 4, 5, 6, 7 (16#40F0), advance state

- **3. State"Enable command operating mode"**

Control word: Set bits 12, 14, 15; Bit 8, Bit 9 are not set for primary operation mode (16#D000)

Status word: Query bits 4, 5, 6, 7, 14, 15 (16#C0F0)

Connected axes can be commanded

- **4. state "Power off"**

  Control word: delete all bits (16#0000)

PLC programming

1. Open the "PlcProg" program in the IndraWorks project.
2. Copy the program listing "Declaration" to the declaration part.
3. Copy the program listing "Implementation" to the implementation part. (Do not copy page break or delete it again after Copy&Paste).
4. Compiling, loading and starting of PLC program.
5. Setting the power requirement "bSetPower".
6. Verify if Power On has been executed (status word: Bits 4, 5, 6, 7, 14, 15).

⇒ From this program, parts can be copied and used for customized solving of a task.

Declaration

```
PROGRAM PlcProg
VAR
    iStatePowerSupply: INT;                         (* state for power supply *)
    bSetPower: BOOL;                                                       (* set power *)
END_VAR

VAR CONSTANT
    STATE_ENABLE_MAINS_CONTACTOR : INT := 1;        (* state enable mains contactor *)
    STATE_ENABLE_POWER_SUPPLY      : INT := 2;         (* state enable power supply, load dc voltage *)
    STATE_ACTIVATE_POWER_SUPPLY  : INT := 3;        (* state activate power supply *)
    STATE_POWER_OFF              : INT := 4;        (* state power off *)
END_VAR

(* S-0-1720.0.1 Power supply control *)                (* S-0-01720.0.2 Power supply status *)
(* Bit 15: power supply activation *)                  (* Bit 15: voltage boost ON/OFF *)
(* Bit 14: power supply enable *)                      (* Bit 14: DC bus okay *)
(* Bit 13: reserved *)                                 (* Bit 13: error *)
(* Bit 12: mains contactor *)                          (* Bit 12: warning *)
(* Bit 11: reserved *)                                 (* Bit 11: brake resistor *)
(* Bit 10: DC discharging *)                           (* Bit 10: DC discharging *)
(* Bit 09: selection of OpMode  *)                     (* Bit 09: selection of OpMode *)
(* Bit 08: selection of OpMode  *)                     (* Bit 08: selection of OpMode *)
(* Bit 07: reserved *)                                 (* Bit 07: feedback signal of mains contactor *)
(* Bit 06: reserved *)                                 (* Bit 06: mains barrage *)
(* Bit 05: reserved *)                                 (* Bit 05: hardware enable *)
(* Bit 04: reserved *)                                 (* Bit 04: mains status *)
(* Bit 03: reserved *)                                 (* Bit 03: reserved *)
(* Bit 02: reserved *)                                 (* Bit 02: reserved *)
(* Bit 01: reserved *)                                 (* Bit 01: reserved *)
```

Implementation

```
(* set power request and check status *)
IF bSetPower AND wStatusWord = 16#00A0 OR wStatusWord = 16#0020 THEN
  iStatePowerSupply  := STATE_ENABLE_MAINS_CONTACTOR;
ELSIF bSetPower AND wStatusWord = 16#00B0 THEN
  iStatePowerSupply := STATE_ENABLE_POWER_SUPPLY;
ELSIF bSetPower AND wStatusWord = 16#40F0 THEN
  iStatePowerSupply := STATE_ACTIVATE_POWER_SUPPLY;
ELSIF bSetPower AND wStatusWord = 16#C0F0 THEN
  iStatePowerSupply := STATE_POWER_OFF;
END_IF

(* state machine for power supply *)
CASE iStatePowerSupply OF

  STATE_ENABLE_MAINS_CONTACTOR: (* enable mains contactor *)
```

```
      wControlWord := 16#1000;   (* set bit 12 *)

      IF wStatusWord = 16#00B0 THEN    (* check bit 4, 5, 7 *)
        iStatePowerSupply := STATE_ENABLE_POWER_SUPPLY;
      ELSE
        iStatePowerSupply := STATE_ENABLE_MAINS_CONTACTOR;
      END_IF

  STATE_ENABLE_POWER_SUPPLY: (* enable power supply, load DC voltage *)

      wControlWord := 16#5000;    (* set bit 12, 14 *)

      IF wStatusWord = 16#40F0 THEN    (* check bit 4, 5, 6, 7 *)
        iStatePowerSupply := STATE_ACTIVATE_POWER_SUPPLY;
      ELSE
        iStatePowerSupply := STATE_ENABLE_POWER_SUPPLY;
      END_IF

  STATE_ACTIVATE_POWER_SUPPLY: (* enable poser supply, operation mode constant DC voltage *)

      wControlWord := 16#D000;     (* set bit 12, 14, 15 *)

      IF wStatusWord = 16#C0F0 THEN    (* check bit 4, 5, 6, 7, 14, 15 *)
        iStatePowerSupply := STATE_POWER_OFF;
      ELSE
        iStatePowerSupply := STATE_ACTIVATE_POWER_SUPPLY;
      END_IF

  STATE_POWER_OFF: (* power off *)

      IF NOT bSetPower THEN
        wControlWord := 16#0000;    (* reset bits *)
      END_IF

    IF NOT wStatuswort = 16#0040 THEN            (* check bit 6 *)
      iStatePowerSupply := STATE_POWER_OFF;
    END_IF

END_CASE
```

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Notes

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