Electric Drives and Controls | Hydraulics | Linear Motion and Assembly Technologies | Pneumatics | Service

Rexroth
Bosch Group

Rexroth IndraDrive MPx-17 Version Notes

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Edition 02

Release Notes

Title

Rexroth IndraDrive
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Version Notes

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Purpose of Documentation

The Version Notes contain an overview of the firmware function or the subject of the section. The Version Notes can contain, for example, general basics, the most important features of the function, overviews and examples of application.

The section "Notes on Application" contains the compatible and incompatible new functions and functional enhancements, as well as lists of new, modified and no longer existing parameters and diagnostic messages.

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1 General Information

The Version Notes contain

- the new functions and functional enhancements
- the new and modified parameters and those that no longer exist
- the new and modified diagnostic messages and those that no longer exist
- an overview of the firmware function or the subject of the section.

  Content can include general basics, the most important features of the function and overviews and examples of applications.

In the section "Notes on Application", the incompatible and compatible functions and functional enhancements are differentiated.

2 Important Directions for Use

2.1 Appropriate Use

2.1.1 Introduction

Rexroth products represent state-of-the-art developments and manufacturing. They are tested prior to delivery to ensure operating safety and reliability.

⚠ WARNING **Personal injury and property damage caused by incorrect use of the products!**

The products have been designed for use in the industrial environment and may only be used in the appropriate way. If they are not used in the appropriate way, situations resulting in property damage and personal injury can occur.

☞ Rexroth as manufacturer is not liable for any damages resulting from inappropriate use. In such cases, the guarantee and the right to payment of damages resulting from inappropriate use are forfeited. The user alone carries all responsibility of the risks.

Before using Rexroth products, make sure that all the pre-requisites for an appropriate use of the products are satisfied:

- Personnel that in any way, shape or form uses our products must first read and understand the relevant safety instructions and be familiar with appropriate use.
- If the products take the form of hardware, then they must remain in their original state, in other words, no structural changes are permitted. It is not permitted to decompile software products or alter source codes.
- Do not mount damaged or faulty products or use them in operation.
- Make sure that the products have been installed in the manner described in the relevant documentation.

2.1.2 Areas of Use and Application

Drive controllers made by Rexroth are designed to control electrical motors and monitor their operation.

Control and monitoring of the Drive controllers may require additional sensors and actors.

☞ The drive controllers may only be used with the accessories and parts specified in this documentation. If a component has not been specifically named, then it may neither be mounted nor connected. The same applies to cables and lines.

Operation is only permitted in the specified configurations and combinations of components using the software and firmware as specified in the relevant Functional Descriptions.

Drive controllers have to be programmed before commissioning, making it possible for the motor to execute the specific functions of an application.

Drive controllers of the Rexroth IndraDrive line have been developed for use in single- and multi-axis drive and control tasks.

To ensure application-specific use of Drive controllers, device types of different drive power and different interfaces are available.

Typical applications include, for example:

- Handling and mounting systems,
- Packaging and food machines,
- Printing and paper processing machines and
- Machine tools.

Drive controllers may only be operated under the assembly and installation conditions described in this documentation, in the specified position of normal use and under the ambient conditions as described (temperature, degree of protection, humidity, EMC, etc.).

2.2 Inappropriate Use

Using the Drive controllers outside of the operating conditions described in this documentation and outside of the indicated technical data and specifications is defined as "inappropriate use".

Drive controllers must not be used, if ...

- they are subject to operating conditions that do not meet the specified ambient conditions. This includes, for example, operation under water, under extreme temperature fluctuations or extremely high maximum temperatures.
- Furthermore, Drive controllers must not be used in applications which have not been expressly authorized by Rexroth. Please carefully follow the specifications outlined in the general Safety Instructions!

☞ Components of the drive system Rexroth IndraDrive are **products of category C3** (with restricted distribution) according to IEC 61800-3. These components are not provided for use in a public low-voltage mains supplying residential areas. If these components are used in such a mains, high-frequency interference is to be expected. This can require additional measures of radio interference suppression.

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3 Safety Instructions for Electric Drives and Controls

3.1 Definitions of Terms

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: User Guide, Operation Manual, Commissioning Manual, Instruction Manual, Project Planning Manual, Application Manual, etc.

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.

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

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.

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.

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.

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.

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.

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.

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 In terms of this application documentation, qualified persons are those persons who are familiar with the installation, mounting, commissioning and operation of the components of the electric drive and control system, as well as with the hazards this implies, and who possess the qualifications their work requires. To comply with these qualifications, it is necessary, among other things,

1) to be trained, instructed or authorized to switch electric circuits and devices safely on and off, to ground them and to mark them

2) to be trained or instructed to maintain and use adequate safety equipment

3) to attend a course of instruction in first aid

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

3.2 General Information

3.2.1 Using the Safety Instructions and Passing Them on to Others

Do not attempt to install and operate the components of the electric drive and control system without first reading all documentation provided with the product. Read and understand these safety instructions and all user documentation prior to working with these components. If you do not have the user documentation for the components, contact your responsible Rexroth sales partner. Ask for these documents to be sent immediately to the person or persons responsible for the safe operation of the components.

If the component is resold, rented and/or passed on to others in any other form, these safety instructions must be delivered with the component in the official language of the user's country.

Improper use of these components, failure to follow the safety instructions in this document or tampering with the product, including disabling of safety devices, could result in property damage, injury, electric shock or even death.

3.2.2 Requirements for Safe Use

Read the following instructions before initial commissioning of the components of the electric drive and control system in order to eliminate the risk of injury and/or property damage. You must follow these safety instructions.

- Rexroth is not liable for damages resulting from failure to observe the safety instructions.
- Read the operating, maintenance and safety instructions in your language before commissioning. If you find that you cannot completely understand the application documentation in the available language, please ask your supplier to clarify.
- Proper and correct transport, storage, mounting and installation, as well as care in operation and maintenance, are prerequisites for optimal and safe operation of the component.
- Only qualified persons may work with components of the electric drive and control system or within its proximity.
- Only use accessories and spare parts approved by Rexroth.
- Follow the safety regulations and requirements of the country in which the components of the electric drive and control system are operated.
- Only use the components of the electric drive and control system in the manner that is defined as appropriate. See chapter "Appropriate Use".
- The ambient and operating conditions given in the available application documentation must be observed.
- Applications for functional safety are only allowed if clearly and explicitly specified in the application documentation "Integrated Safety Technolo-

gy". If this is not the case, they are excluded. Functional safety is a safety concept in which measures of risk reduction for personal safety depend on electrical, electronic or programmable control systems.

- The information given in the application documentation with regard to the use of the delivered components contains only examples of applications and suggestions.

  The machine and installation manufacturers must

  - make sure that the delivered components are suited for their individual application and check the information given in this application documentation with regard to the use of the components,
  - make sure that their individual application complies with the applicable safety regulations and standards and carry out the required measures, modifications and complements.
- Commissioning of the delivered components is only allowed once it is sure that the machine or installation in which the components are installed complies with the national regulations, safety specifications and standards of the application.
- Operation is only allowed if the national EMC regulations for the application are met.
- The instructions for installation in accordance with EMC requirements can be found in the section on EMC in the respective application documentation.

  The machine or installation manufacturer is responsible for compliance with the limit values as prescribed in the national regulations.
- The technical data, connection and installation conditions of the components are specified in the respective application documentations and must be followed at all times.

National regulations which the user must take into account

- European countries: In accordance with European EN standards
- United States of America (USA):
  - National Electrical Code (NEC)
  - National Electrical Manufacturers Association (NEMA), as well as local engineering regulations
  - Regulations of the National Fire Protection Association (NFPA)
- Canada: Canadian Standards Association (CSA)
- Other countries:
  - International Organization for Standardization (ISO)
  - International Electrotechnical Commission (IEC)

3.2.3 Hazards by Improper Use

- High electrical voltage and high working current! Danger to life or serious injury by electric shock!
- High electrical voltage by incorrect connection! Danger to life or injury by electric shock!
- Dangerous movements! Danger to life, serious injury or property damage by unintended motor movements!
- Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electric drive systems!

- Risk of burns by hot housing surfaces!
- Risk of injury by improper handling! Injury by crushing, shearing, cutting, hitting!
- Risk of injury by improper handling of batteries!
- Risk of injury by improper handling of pressurized lines!

3.3 Instructions with Regard to Specific Dangers

3.3.1 Protection Against Contact With Electrical Parts and Housings

☞ This section concerns components of the electric drive and control system with voltages of **more than 50 volts**.

Contact with parts conducting voltages above 50 volts can cause personal danger and electric shock. When operating components of the electric drive and control system, it is unavoidable that some parts of these components conduct dangerous voltage.

High electrical voltage! Danger to life, risk of injury by electric shock or serious injury!

- Only qualified persons are allowed to operate, maintain and/or repair the components of the electric drive and control system.
- Follow the general installation and safety regulations when working on power installations.
- Before switching on, the equipment grounding conductor must have been permanently connected to all electric components in accordance with the connection diagram.
- Even for brief measurements or tests, operation is only allowed if the equipment grounding conductor has been permanently connected to the points of the components provided for this purpose.
- Before accessing electrical parts with voltage potentials higher than 50 V, you must disconnect electric components from the mains or from the power supply unit. Secure the electric component from reconnection.
- With electric components, observe the following aspects:

  Always wait **30 minutes** after switching off power to allow live capacitors to discharge before accessing an electric component. Measure the electrical voltage of live parts before beginning to work to make sure that the equipment is safe to touch.
- Install the covers and guards provided for this purpose before switching on.
- Never touch electrical connection points of the components while power is turned on.
- Do not remove or plug in connectors when the component has been powered.
- Under specific conditions, electric drive systems can be operated at mains protected by residual-current-operated circuit-breakers sensitive to universal current (RCDs/RCMs).
- Secure built-in devices from penetrating foreign objects and water, as well as from direct contact, by providing an external housing, for example a control cabinet.

High housing voltage and high leakage current! Danger to life, risk of injury by electric shock!

- Before switching on and before commissioning, ground or connect the components of the electric drive and control system to the equipment grounding conductor at the grounding points.

- Connect the equipment grounding conductor of the components of the electric drive and control system permanently to the main power supply at all times. The leakage current is greater than 3.5 mA.
- Establish an equipment grounding connection with a minimum cross section according to the table below. With an outer conductor cross section smaller than 10 mm^2 (8 AWG), the alternative connection of two equipment grounding conductors is allowed, each having the same cross section as the outer conductors.

Cross section outer conductor	Minimum cross section equipment grounding conductor Leakage current ≥ 3.5 mA	
	1 equipment grounding conductor	2 equipment grounding conductors
1,5 mm^2 (AWG 16)	10 mm^2 (AWG 8)	2 × 1,5 mm^2 (AWG 16)
2,5 mm^2 (AWG 14)		2 × 2,5 mm^2 (AWG 14)
4 mm^2 (AWG 12)		2 × 4 mm^2 (AWG 12)
6 mm^2 (AWG 10)		2 × 6 mm^2 (AWG 10)
10 mm^2 (AWG 8)		-
16 mm^2 (AWG 6)	16 mm^2 (AWG 6)	-
25 mm^2 (AWG 4)		-
35 mm^2 (AWG 2)		-
50 mm^2 (AWG 1/0)	25 mm^2 (AWG 4)	-
70 mm^2 (AWG 2/0)	35 mm^2 (AWG 2)	-
...	...	...

Fig.3-1: Minimum Cross Section of the Equipment Grounding Connection

3.3.2 Protective Extra-Low Voltage as Protection Against Electric Shock

Protective extra-low voltage is used to allow connecting devices with basic insulation to extra-low voltage circuits.

On components of an electric drive and control system provided by Rexroth, all connections and terminals with voltages between 5 and 50 volts are PELV ("Protective Extra-Low Voltage") systems. It is allowed to connect devices equipped with basic insulation (such as programming devices, PCs, notebooks, display units) to these connections.

Danger to life, risk of injury by electric shock! High electrical voltage by incorrect connection!

If extra-low voltage circuits of devices containing voltages and circuits of more than 50 volts (e.g., the mains connection) are connected to Rexroth products, the connected extra-low voltage circuits must comply with the requirements for PELV ("Protective Extra-Low Voltage").

3.3.3 Protection Against Dangerous Movements

Dangerous movements can be caused by faulty control of connected motors. Some common examples are:

- Improper or wrong wiring or cable connection
- Operator errors
- Wrong input of parameters before commissioning
- Malfunction of sensors and encoders
- Defective components
- Software or firmware errors

These errors can occur immediately after equipment is switched on or even after an unspecified time of trouble-free operation.

The monitoring functions in the components of the electric drive and control system will normally be sufficient to avoid malfunction in the connected drives. Regarding personal safety, especially the danger of injury and/or property damage, this alone cannot be relied upon to ensure complete safety. Until the integrated monitoring functions become effective, it must be assumed in any case that faulty drive movements will occur. The extent of faulty drive movements depends upon the type of control and the state of operation.

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

A **risk assessment** must be prepared for the installation or machine, with its specific conditions, in which the components of the electric drive and control system are installed.

As a result of the risk assessment, the user must provide for monitoring functions and higher-level measures on the installation side for personal safety. The safety regulations applicable to the installation or machine must be taken into consideration. Unintended machine movements or other malfunctions are possible if safety devices are disabled, bypassed or not activated.

To avoid accidents, injury and/or property damage:

- Keep free and clear of the machine’s range of motion and moving machine parts. Prevent personnel from accidentally entering the machine’s range of motion by using, for example:
  - Safety fences
  - Safety guards
  - Protective coverings
  - Light barriers
- Make sure the safety fences and protective coverings are strong enough to resist maximum possible kinetic energy.
- Mount emergency stopping switches in the immediate reach of the operator. Before commissioning, verify that the emergency stopping equipment works. Do not operate the machine if the emergency stopping switch is not working.
- Prevent unintended start-up. Isolate the drive power connection by means of OFF switches/OFF buttons or use a safe starting lockout.
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.

- Additionally secure vertical axes against falling or dropping after switching off the motor power by, for example,
  – mechanically securing the vertical axes,
  – adding an external braking/arrester/clamping mechanism or
  – ensuring sufficient counterbalancing of the vertical axes.
- The standard equipment **motor holding brake** or an external holding brake controlled by the drive controller is **not sufficient to guarantee personal safety**!
- Disconnect electrical power to the components of the electric drive and control system using the master switch and secure them from reconnection ("lock out") for:
  – Maintenance and repair work
  – Cleaning of equipment
  – Long periods of discontinued equipment use
- Prevent the operation of high-frequency, remote control and radio equipment near components of the electric drive and control system and their supply leads. If the use of these devices cannot be avoided, check the machine or installation, at initial commissioning of the electric drive and control system, for possible malfunctions when operating such high-frequency, remote control and radio equipment in its possible positions of normal use. It might possibly be necessary to perform a special electromagnetic compatibility (EMC) test.

3.3.4 Protection Against Magnetic and Electromagnetic Fields During Operation and Mounting

Magnetic and electromagnetic fields generated by current-carrying conductors or permanent magnets of electric motors represent a serious danger to persons with heart pacemakers, metal implants and hearing aids.

Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electric components!

- Persons with heart pacemakers and metal implants are not allowed to enter the following areas:
  – Areas in which components of the electric drive and control systems are mounted, commissioned and operated.
  – Areas in which parts of motors with permanent magnets are stored, repaired or mounted.
- If it is necessary for somebody with a heart pacemaker to enter such an area, a doctor must be consulted prior to doing so. The noise immunity of implanted heart pacemakers differs so greatly that no general rules can be given.
- Those with metal implants or metal pieces, as well as with hearing aids, must consult a doctor before they enter the areas described above.

3.3.5 Protection Against Contact With Hot Parts

Hot surfaces of components of the electric drive and control system. Risk of burns!

- Do not touch hot surfaces of, for example, braking resistors, heat sinks, supply units and drive controllers, motors, windings and laminated cores!
- According to the operating conditions, temperatures of the surfaces can be **higher than 60 °C** (140 °F) during or after operation.
- Before touching motors after having switched them off, let them cool down for a sufficient period of time. Cooling down can require **up to 140 minutes**! The time required for cooling down is approximately five times the thermal time constant specified in the technical data.
- After switching chokes, supply units and drive controllers off, wait **15 minutes** to allow them to cool down before touching them.
- Wear safety gloves or do not work at hot surfaces.
- For certain applications, and in accordance with the respective safety regulations, the manufacturer of the machine or installation must take measures to avoid injuries caused by burns in the final application. These measures can be, for example: Warnings at the machine or installation, guards (shieldings or barriers) or safety instructions in the application documentation.

3.3.6 Protection During Handling and Mounting

Risk of injury by improper handling! Injury by crushing, shearing, cutting, hitting!

- Observe the relevant statutory regulations of accident prevention.
- Use suitable equipment for mounting and transport.
- Avoid jamming and crushing by appropriate measures.
- Always use suitable tools. Use special tools if specified.
- Use lifting equipment and tools in the correct manner.
- Use suitable protective equipment (hard hat, safety goggles, safety shoes, safety gloves, for example).
- Do not stand under hanging loads.
- Immediately clean up any spilled liquids from the floor due to the risk of falling!

3.3.7 Battery Safety

Batteries consist of active chemicals in a solid housing. Therefore, improper handling can cause injury or property damage.

Risk of injury by improper handling!

- Do not attempt to reactivate low batteries by heating or other methods (risk of explosion and cauterization).
- Do not attempt to recharge the batteries as this may cause leakage or explosion.
- Do not throw batteries into open flames.
- Do not dismantle batteries.
- When replacing the battery/batteries, do not damage the electrical parts installed in the devices.
- Only use the battery types specified for the product.

☞ Environmental protection and disposal! The batteries contained in the product are considered dangerous goods during land, air, and sea transport (risk of explosion) in the sense of the legal regulations. Dispose of used batteries separately from other waste. Observe the national regulations of your country.

3.3.8 Protection Against Pressurized Systems

According to the information given in the Project Planning Manuals, motors and components cooled with liquids and compressed air can be partially supplied with externally fed, pressurized media, such as compressed air, hydraulics oil, cooling liquids and cooling lubricants. Improper handling of the connected supply systems, supply lines or connections can cause injuries or property damage.

Risk of injury by improper handling of pressurized lines!

- Do not attempt to disconnect, open or cut pressurized lines (risk of explosion).
- Observe the respective manufacturer's operating instructions.
- Before dismounting lines, relieve pressure and empty medium.
- Use suitable protective equipment (safety goggles, safety shoes, safety gloves, for example).
- Immediately clean up any spilled liquids from the floor due to the risk of falling!

☞ Environmental protection and disposal! The agents (e.g., fluids) used to operate the product might not be environmentally friendly. Dispose of agents harmful to the environment separately from other waste. Observe the national regulations of your country.

3.4 Explanation of Signal Words and the Safety Alert Symbol

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 Z535.6-2006).

The signal word is meant to draw the reader's attention to the safety instruction and identifies 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

In case of non-compliance with this safety instruction, death or serious injury **will** occur.

⚠ WARNING

In case of non-compliance with this safety instruction, death or serious injury **could** occur.

⚠ CAUTION

In case of non-compliance with this safety instruction, minor or moderate injury could occur.

NOTICE

In case of non-compliance with this safety instruction, property damage could occur.

4 Brief Functional Descriptions

4.1 System Overview

4.1.1 General Information

About This Documentation

Means of Representation in This Documentation

To make the reading of this documentation easier, the table below contains the means of representation and notations of recurring terms.

What?	How?	For example...
Important facts which are to be highlighted in the body text	Boldface	Transmission of freely configurable external **process data** (command values and actual values of the external control section)
Parameter names, diagnostic message names, function designations	Quotation marks	...the function "Set/shift coordinate system" for the MPx17 firmware...

Fig.4-1: Conventions of Notation

All important notes are highlighted. A symbol indicates what kind of note is used in the text. The symbols have the following meanings:

DANGER ...

In case of non-compliance with this safety instruction, death or serious injury will occur.

WARNING ...

In case of non-compliance with this safety instruction, death or serious injury could occur.

CAUTION ...

In case of non-compliance with this safety instruction, minor or moderate injury could occur.

NOTICE ...

In case of non-compliance with this safety instruction, property damage could occur.

Signal words in accordance with ANSI Z535.6-2006 draw the reader's attention to hazards (see "Explanation of Signal Words and the Safety Alert Symbol").

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

This symbol highlights useful tips and tricks.

Your Feedback

Your experience is important for our improvement processes of products and documentation.

If there are mistakes in this documentation or changes are recommended, send your feedback to the following e-mail address:

Dokusupport@boschrexroth.de

We need the following information to handle your feedback:

- The number indicated under "Internal File Reference".
- The page number.

How to Use This Documentation

Structure of the Version Notes

The functional descriptions of the IndraDrive firmware are divided into fixed sections. The individual subjects of the firmware description are assigned to these sections according to their content.

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

- Brief Description
- Functional Description
- Notes on Commissioning
- 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.

This **documentation for Rexroth IndraDrive, MPx-17, Version Notes** contains only the **"brief description"** sections.

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 examples of application.

The last section of the **Version Notes** contains the compatible and incompatible functional enhancements, as well as lists of new, modified and no longer existing 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" .

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 drive 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 the section "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 **family**, e.g. IndraDrive
- Firmware **design**, e.g. single-axis, double-axis or multi-axis
- Firmware **variant**, e.g. MP**B**, MP**E**
- Firmware **version**, e.g. MPM-**17**VRS
- Firmware **characteristic**, e.g. (open-loop/closed-loop)
- Firmware **performance**, e.g. Basic/Economy/Advanced
- Firmware **type** complete firmware type designation

Cross References

Many basic subfunctions of the firmware, as well as necessary settings and definitions, are of multiple use within the overall functionality or have an effect on neighboring areas of the drive functionality. Such subfunctions normally are described only once. Descriptions that are part of other IndraDrive documentation (Parameter Description, Troubleshooting Guide, 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 documentation, the following distinction is made:

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

Reference Documentations

Drive Systems, System Components

Drive Systems with Multi-Axis Drive Controllers

Title	Kind of documentation	Document typecode[1)]	Part number R911…
Rexroth IndraDrive Drive Controllers HCQ02, HCT02	Project Planning Manual	DOK-INDRV*-HCQ-T+HMQ-T-PRxx-EN-P	324185
Rexroth IndraDrive Additional Components and Accesso-ries	Project Planning Manual	DOK-INDRV*-ADDCOMP****-PRxx-EN-P	306140
Rexroth IndraControl VDP 80.1 Machine Operator Panel Operator Display	Project Planning Manual	DOK-SUPPL*-VDP*80.1***-PRxx-EN-P	329156

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

Fig.4-2: Documentations – Drive Systems, System Components

Drive Systems With Single-Axis Drive Controllers

Title Rexroth IndraDrive …	Kind of documentation	Document typecode[1)] DOK-INDRV*-…	Part number R911…
Cs Drive Systems With HCS01	Project Planning Manual	HCS01******-PRxx-EN-P	322210
Additional Components and Acces-sories	Project Planning Manual	ADDCOMP****-PRxx-EN-P	306140

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

Fig.4-3: Documentations – Drive Systems, System Components

Motors

Title Rexroth IndraDyn …	Kind of documentation	Document typecode[1)] DOK-MOTOR*-…	Part number R911…
A Asynchronous Motors MAD / MAF	Project Planning Manual	MAD/MAF****-PRxx-EN-P	295781
H Synchronous Kit Spindle Motors	Project Planning Manual	MBS-H******-PRxx-EN-P	297895
L Synchronous Linear Motors	Project Planning Manual	MLF********-PRxx-EN-P	293635
S MKE Synchronous Motors	Project Planning Manual	MKE*GEN2***-PRxx-EN-P	297663
S MSK Synchronous Motors	Project Planning Manual	MSK********-PRxx-EN-P	296289
S Synchronous Motors MSM	Data Sheet	MSM********-DAxx-EN-P	329338
S Synchronous Motors QSK	Project Planning Manual	QSK********-PRxx-EN-P	330321
T Synchronous Torque Motors	Project Planning Manual	MBT********-PRxx-EN-P	298798

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

Fig.4-4: Documentations – Motors

Cables

Title	Kind of documentation	Document typecode[1)] DOK-CONNEC-…	Part number R911…
Rexroth Connection Cables	Selection Data	CABLE*INDRV-CAxx-EN-P	322949

1) In the document typecodes, "xx" is a wild card for the current edition of the documentation (example: CA02 is the second edition of the documentation "Selection Data")

Fig.4-5: Documentations – Cables

Firmware

Title Rexroth IndraDrive ...	Kind of documentation	Document typecode[1)] DOK-INDRV*-…	Part number R911…
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
MPx-16 and MPx-17 Parameters	Reference Book	GEN1-PARA**-RExx-EN-P	328651
MPx-16 and MPx-17 Diagnostic Messages	Reference Book	GEN1-DIAG**-RExx-EN-P	326738
Integrated Safety Technology as of MPx-1x	Application Manual	SI3-OP-MAN*-APxx-EN-P	332634
Rexroth IndraMotion MLD Libraries as of MPx17	Reference Book	MLD-SYSLIB2-RExx-EN-P	332627
Rexroth IndraMotion MLD as of MPx-17	Application Manual	MLD2-**VRS*-APxx-EN-P	334351

1) In the document typecodes, "xx" is a wild card for the current edition of the documentation (example: RE02 is the second edition of a Reference Book)

Fig.4-6: Documentations – Firmware

Overview of Drive Firmware

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:

- **MPx**: Drives for general automation (including machine tool applications) with a MultiEthernet interface (SERCOS **III**, EtherCAT®, PROFINET®, EtherNet/IP™), field bus interface (e.g. Profibus DP) and analog interface (design version include **MPB**, **MPC**, **MPE** and **MPM**; see below)

Brief Functional Descriptions

☞ The **first two letters** of the firmware designation identify the application and profile of the firmware:

- **MP:** "Multi Purpose" → Drives for general automation (including machine tool applications) with a MultiEthernet interface (SERCOS III, EtherCAT®, PROFINET®, EtherNet/IP™), field bus interface (e.g. Profibus DP) and analog interface.

The **third letter** of the firmware designation identifies the hardware, as well as the performance and functionality of the firmware (**x** contains **B, C, E and M**):

- **B**: **Single-axis** firmware with **BASIC** performance and functionality
- **C**: **Single-axis** firmware with **ADVANCED** performance and functionality
- **E**: **Single-axis** firmware with **ECONOMY** performance and functionality
- **M**: **Double-axis/Multi-axis** firmware with **BASIC** performance and functionality

This documentation describes the functionality of the following firmware types:

- FWA-INDRV*-MPB-17VRS-D5
- FWA-INDRV*-MPC-17VRS-D5
- FWA-INDRV*-MPE-17VRS-D5
- FWA-INDRV*-MPM-17VRS-D5

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

Organization of the Firmware

For application-specific definition of drive functionality, the firmware functions are divided into different "functional packages". There are a **generally available base package** and various **additional functional packages** that can be optionally activated.

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

Terms, Basic Principles

Parameters

Communication between master and drive takes place, with a few exceptions, by means of parameters.

Parameters are used for:

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

All operating data is mapped to parameters!

The operating data stored in parameters can be identified by means of the IDN. It 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 drive firmware checks specific parameter values (operating data) for validity.

Data Storage and Parameter Handling

Data Memory

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

- In the controller
- In the motor encoder (depending on motor type)
- In the 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 control panel contains the firmware.
- 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 control panel. Due to the limited number of writing cycles of non-volatile storage media, application-specific parameter values can also be stored in the working memory (volatile memory) of the controller.

Storing 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 via:

- Commissioning tool "IndraWorks Ds/D/MLD"

  → Saving parameter values on external data carrier
- control master

  → Saving parameter values on master-side data carrier

Parameter IDN Lists

The drive 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

Loading parameter values is required in the following cases:

- Initial commissioning of the motor

  → Loading default values (factory settings) and the motor-specific parameter values
- Serial commissioning of machine axes on series machines

  → Loading the values saved after initial commissioning
- Reestablishing a defined initial status

  → Reloading the values saved after initial commissioning
- Replacing the controller for servicing

  → Loading the currently saved parameter values before servicing

Possibilities of 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

- Commissioning tool "IndraWorks Ds/D/MLD"

  → Loading parameter values on external data carrier

- control master

  → Loading parameter values on 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 correspond to the values saved on the master side.

Password

IndraDrive controllers provide the possibility to protect parameter values against accidental or unauthorized change by means of 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 memories, etc. ("administration parameters"). The values of these parameters ensure correct function and performance of the drive.
- 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 drive to the axis, after having determined them.
- All other writable parameters and are not contained in the above-mentioned groups. They are not write-protected.

Kinds of Passwords

The drive firmware allows activating and deactivating the write protection for parameter values by means of 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.

Commands

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

Each command is assigned to a parameter by means of which the execution of the command can be controlled. While the command is executed, 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 must be actively cleared again.

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

Kinds of Commands

There are 3 different kinds of commands:

- Drive control commands

  - can cause automatic drive motion,
  - can be started only when drive enable has been set,
  - deactivate the active operation mode while they are executed.
- **Monitor commands**
  - activate or deactivate monitoring or functions in the drive.
- **Administration commands**
  - carry out administration task,
  - cannot be interrupted.

See also section "Command Processing"

Operation Modes

The selection of operation modes defines which command values will be processed in which way, in order to lead to the desired drive motion. The operation mode does not determine how these command values are transmitted from the master to the slave.

One of the eight 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
- Drive follows command value
- "Drive Halt" function has not been activated
- No drive control command is active
- No error reaction is carried out

The display of the control panel reads "AF" when an operation mode was activated.

☞ All implemented operation modes are stored in parameter "S-0-0292, List of supported operation modes".

See also section "Operation Modes"

Warnings

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

☞ Warnings do not cause automatic shutdown (exception: fatal warnings).

Classes of Warnings

Warnings are classified in different warning classes which determine whether or not the drive carries out an automatic reaction when the warning is generated.

☞ The warning class can be recognized by the diagnostic message.

The following classes of warnings are distinguished:

- **Without** drive reaction → diagnostic message number **E2**xxx, **E3**xxx, **E4**xxx

- **With** drive reaction → diagnostic message number **E8**xxx

☞ Warnings cannot be cleared. They persist until the condition that activated the warning is no longer fulfilled.

Errors

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

Error Classes

Errors are assigned to various error classes that differ based on the different reactions of the drive to error.

☞ The error class can be recognized by the diagnostic message number.

Diagnostic message number	Error class
F2xxx	Non-fatal error
F3xxx	Non-fatal safety technology error
F4xxx	Interface error
F6xxx	Travel range error
F8xxx	Fatal error
F9xxx	Fatal system error

Fig.4-7: Overview of Error Classes

☞ Apart from the mentioned error classes that can occur during operation, errors can occur when the devices are booted 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. Boot and firmware download errors are described in a separate "Troubleshooting Guide" documentation (description of diagnostic messages).

Error Reactions of the Drive

If the drive controller is in control and an error status is detected, the execution of a drive error reaction is automatically started. The diagnostic message number "Fxxxx" flashes on the display of the control panel.

The drive reaction in case of F2xxx-, F3xxx-, F4xxx-, F6xxx errors is defined in parameter "P-0-0119, Best possible deceleration". At the end of each error reaction, the drive goes torque-free.

See also "Error Reactions"

Clearing an Error Message

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

If the error status persists the error message is immediately generated again.

Clearing Error Messages when Drive Enable Was Set

If a drive error occurs while operating with drive enable having been set, the drive carries out an error reaction. The drive automatically deactivates itself at the end of each error reaction; in other words, the output stage is switched off and the drive switches from an energized to a de-energized state.

To reactivate the drive:

- clear the error message and

- prescribe a positive 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 50 errors that occurred and the time when they occurred. Errors caused by a shutdown of the control voltage (e.g. "F8070 +24Volt DC error") 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 means of the control panel. The "IndraWorks Ds/D/MLD" commissioning tool allows displaying the diagnostic message numbers and the respective times at which the errors occurred.

Reconfigure Error as Warning

In some cases, the user can reconfigure an error as a warning. After an error has been reconfigured, it is not an error reaction that takes place when such an error occurs, but only a warning is output. The list of axis errors that can be reconfigured can be found in "P-0-0173, List of configurable axis-specific monitoring functions"; the reconfiguration occurs there as well.

☞ When an error has been reconfigured, only a warning is output instead of the error message; the warning shows the control master that there is a problem. It is the user's responsibility to react to the diagnostic warning messages in an appropriate way. If this is not the case, the machine or installation can be damaged.

The reconfiguration of errors as warnings can be used in applications in the following:

- Use of an external encoder as a redundant motor encoder, see the section "Redundant Motor Encoder"
- Use of a measuring encoder, see "Measuring Encoder"
- Position control with cyclic command value input, see the section of the same name, "Position Control With Cyclic Command Value Input" under "Operation Modes"

4.1.2 Drive Controllers

Overview

Standard Design of the IndraDrive Controllers

As a standard, IndraDrive controllers consist of two hardware components:

Brief Functional Descriptions

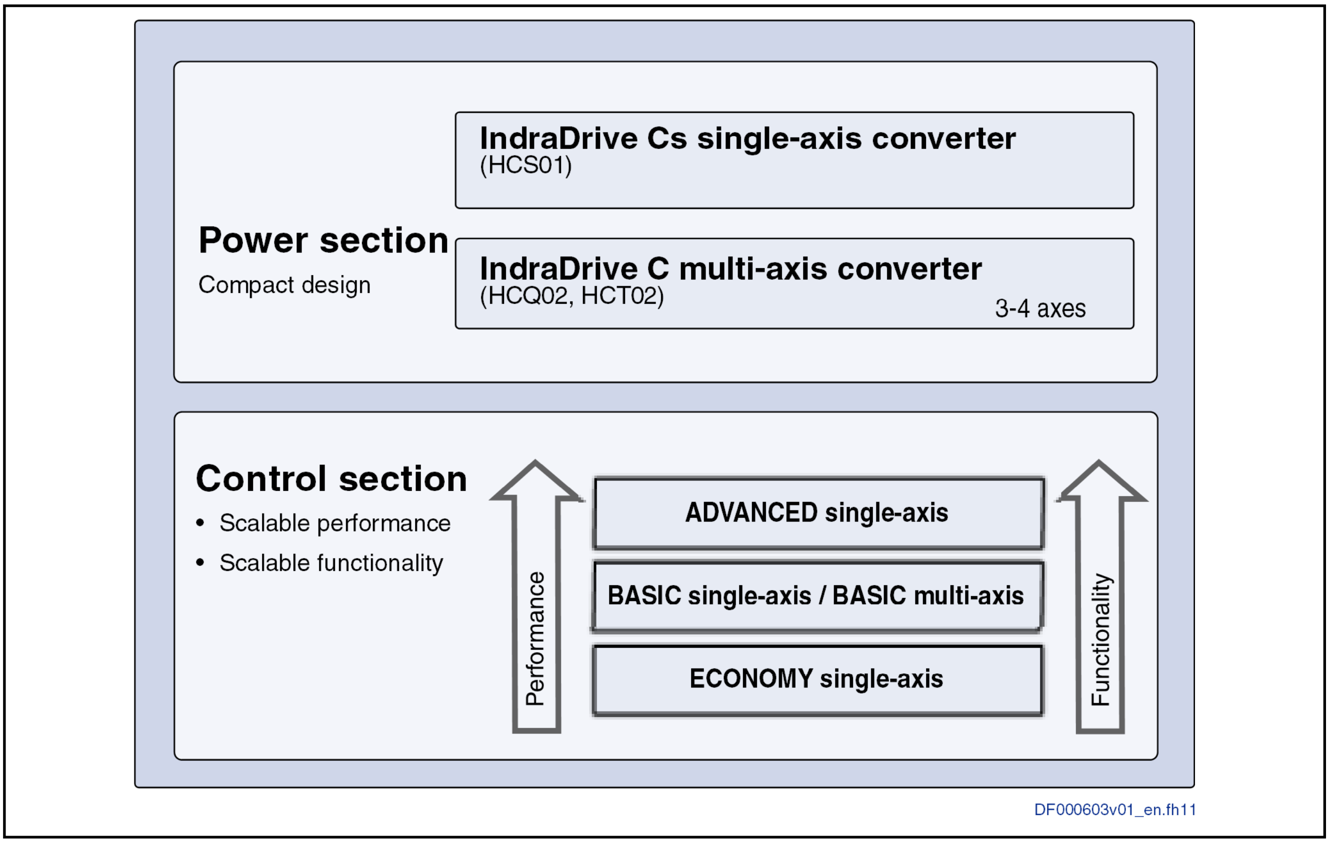


Fig.4-8: Design of the IndraDrive Controllers

Power Section

The following are connected to the power section:

- Power supply or DC bus voltage
- 24 V control voltage
- Motor

☞ The design versions of the power sections are described, respectively, in separate documentation (see "Other applicable documentation").

Power Section

The following power sections for the standard design of IndraDrive controllers can be operated with the firmware **MPx-17VRS**:

<table>
<tr><th>IndraDrive Cs
Single-axis converter</th><th>IndraDrive C
Multi-axis converter</th></tr>
<tr><td rowspan="3">HCS01</td><td>HCQ02
HCT02</td></tr>
<tr><td>IndraDrive M
Multi-axis inverter</td></tr>
<tr><td>HMQ02
HMT02</td></tr>
</table>

Fig.4-9: Power Section Platform for IndraDrive Firmware

Control Sections

Supported Control Section Cards

The following overview contains the **supported configurations** of control section cards as regards the support by the **MPx-17VRS** firmware.

☞ Our sales representative will help you with the current status of available control section card types.

Control section type →		HCS01 BASIC "Single-axis"	HCS01 ADVANCED "Single-axis"	HSC01 ECONOMY "Single-axis"	HCQ02, HCT02, HMQ02, HMT02 BASIC "Multi-axis"
Firmware variant →		MPB-17VRS	MPC-17VRS	MPE-17VRS	MPM-17VRS
Optional modules for master communication					
ET	MultiEthernet	■	■	-	-
PB	PROFIBUS-DP	■	■	-	-
CN	CANopen	■	■	-	-
Optional modules for encoder evaluation					
EC	Encoder interface for EnDat2.1, 1Vpp sine and TTL signals, HIPERFACE®	■	■	-	-
EM	Encoder emulation	■	■	-	-
Optional modules for safety technology					
L3	STO	■	■	■	-
L4	STO/SBC	■	■	■	-

Fig.4-10: Supported Control Section Configurations

4.1.3 Supported Motors and Measuring Systems

Supported Motors

The following table provides an overview of the Rexroth motors that are supported by this firmware:

Rexroth housing motors		Rexroth kit motors	
Synchronous	Asynchronous	Synchronous	Asynchronous
MSK (IndraDyn S) MSP MSM	MAD (IndraDyn A) MAF (IndraDyn A) MAL	MLF (IndraDyn L) MBS (Standard) MBSxx2 (IndraDyn H) MBT (IndraDyn T)	1MB

Fig.4-11: Appropriate Rexroth Motors for IndraDrive

Supported Measuring Systems

Supported Encoder Systems

Encoder systems with a supply voltage of **5 and 12 volt**

- MSM motor encoder
- MSK motor encoder
- Sin-cos encoder $1V_{pp}$; HIPERFACE®
- Sin-cos encoder $1V_{pp}$; EnDat2.1
- Sin-cos encoder $1V_{pp}$; with reference track
- 5V-TTL square-wave encoder; with reference track
- SSI (in preparation)
- Resolvers
- Hall-Sensor-Box SHL02.1
- Hall Sensor Box SHL03.1 (in preparation)

4.1.4 Overview of Master Communication

The firmware **MPx-17VRS** supports the following interfaces for master communication:

	Firmware Variant			
Master Communication	MPB	MPC	MPE	MPM
SERCOS III	■	■	■	■
PROFIBUS-DP	■	■	-	-
EtherNet/IP-Interface	■	■	-	-
PROFINET	■	■	-	-
Analog Interface	■	■	■	-
EtherCAT®	■	■	-	-
CANopen	■	■	-	-

Fig.4-12: Supported Interfaces for Master Communication

4.1.5 Overview of Functions/Functional Packages

Overview

General Information

The application-specific scope of usable functions of the **FWA-INDRV*-MP*-17VRS** 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 the Drive Functionality

Firmware Scaling by Control Section Configuration

IndraDrive drive controller have a maximum of 2 optional card slots. Depending on the available optional cards, it is possible to activate certain functions (incl. corresponding parameters), e.g.:

- **Master communication**
- **Safety technology** (STO, SBC)
- **Encoder emulation**

☞ The functions and parameters for the evaluation of the measuring systems as control encoders or measuring encoders do not depend on the device configuration, since their functions can be freely assigned to the various optional encoder modules.

See also the section "Drive Controllers"

Firmware Scaling by Functional Packages

The firmware functionality is divided into the following package groups:

- **Base packages** (open-loop or closed-loop)
- Optional **expansion packages**:
  - Alternative functional packages (expansion packages for servo function, main spindle function, synchronization)
  - Additive functional package "IndraMotion MLD"
    (drive-integrated PLC and technology functions)

Depending on the hardware configuration, the base packages are available without any access enable. Using the optional expansion packages, however, requires licensing.

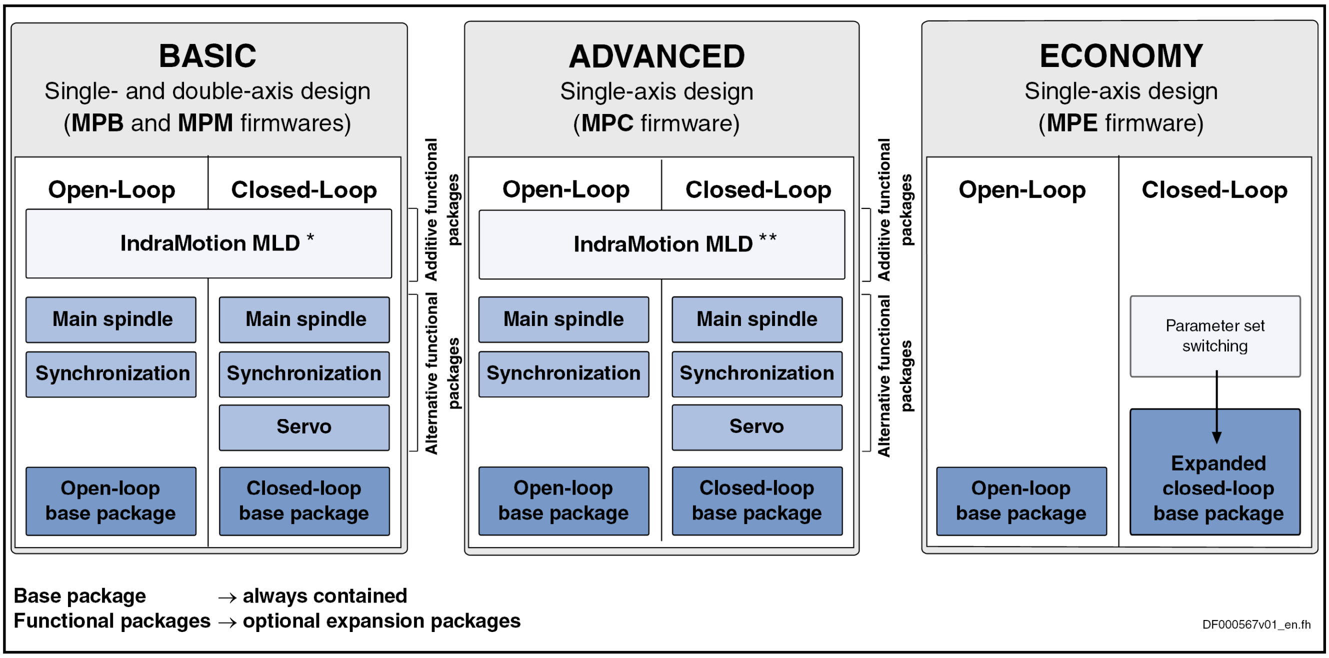
☞ The desired scope of firmware functions should preferably be defined when the firmware is ordered. This guarantees that the required functional packages have been enabled when the firmware is delivered. In individual cases, it is possible to provide access enable subsequently (additional licensing) or to reduce the activated scope of functions.

This procedure is described in the section "Enabling of Functional Packages" .

☞ The **drive-integrated safety technology** is a functionality only scalable by means of the hardware and does not require any additional enabling of functions!

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

Brief Functional Descriptions



* IndraMotion MLD, only MLD-S functionality, single-axis motion, not with MPM firmware

** IndraMotion MLD-M functionality, multi-axis motion

Fig.4-13: Functional Packages of IndraDrive Firmware MPx17 Depending on Control Performance

Brief Description of the Functional Packages

The overall functionality of an IndraDrive device is divided into groups of functions, the so-called "functional packages". The firmware FWA-INDRV*-MP*-17VRS supports the functional packages listed below.

☞ Each of the listed packages is available in Basic, Economy or Advanced design which differ with regard to their performance and functionality.

Base Packages

The following base packages are available:

- Base package "open-loop" (open-loop motor control)

  → No position evaluation and functions depending thereof and no position control modes are possible

- Base package "closed-loop" (closed-loop motor control)

  → Position evaluation and functions and operation modes that depending on it are possible

Alternative Functional Packages

The following alternative functional packages are available:

- Servo functions [1)]

  This package makes available all specific expansions for servo applications, such as compensations and correction functions (e.g. axis error correction, quadrant error correction).

- Synchronization[1)]

  With this package the possibilities of synchronization of the drive can be used (support of synchronization modes, measuring encoder function, probe function ...).

- Main spindle functions [1)]

This package contains the specific functions for the use of main spindles (e.g. spindle positioning, parameter set switching).

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

Additive Functional Packages

There is also an additional functional package available:

- **IndraMotion MLD**

For single-axis devices (ADVANCED and BASIC) the expansion package "IndraMotion MLD" can be activated in addition to a possibly available alternative package.

Overview of Dependencies

The overview below illustrates how the individual functional packages are depending on the respective hardware and the firmware type:

	Firmware variant →	MPB		MPC		MPE1)		MPM	
	Firmware characteristic →	OL	CL	OL	CL	OL	CL	OL	CL
Base package	Basic functions	■	■	■	■	■	■	■	■
	Base package "open-loop"	■	■	■	■	■	■	■	■
	Base package "closed-loop"	–	■	–	■	–	■	–	■
Alternative functional packages	Servo function	–	■	–	■	–	–	–	■
	Synchronization	■	■	■	■	–	–	■	■
	Main spindle	■	■	■	■	–	2)	■	■
Additive functional package	IndraMotion MLD	■	■	■	■	–	–	–	–

MPB Single-axis firmware with Basic performance
MPC Single-axis firmware with Advanced performance
MPE Single-axis firmware with Economy performance
MPM Multi-axis firmware with Basic performance
OL Open-loop characteristic
CL Closed-loop characteristic
1) For Economy firmware MPE, there is only one expanded base package available
2) The expanded base package contains the function "Parameter set switching".

Fig.4-14: Dependence of Functional Packages on Hardware and Firmware Variant

Firmware Types

Structure of the Firmware Type Designation

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

Brief Functional Descriptions

	IndraDrive firm-ware	Base package of variant (depend-ing on control section)	Version	Release	Language	OL/CL	Alternative expansion packages	Additive expansion packages
Basic single-axis	FWA-INDRV*	-MPB-	17	VRS-	D5-	x-	xxx-	xx
Advanced sin-gle-axis	FWA-INDRV*	-MPC-	17	VRS-	D5-	x-	xxx-	xx
Economy single-axis	FWA-INDRV*	-MPE-	17	VRS-	D5-	x-	xxx-	xx
Basic multi-axis	FWA-INDRV*	-MPM-	17	VRS-	D5-	x-	xxx-	xx

OL Open-loop characteristic
CL Closed-loop characteristic
Fig.4-15: Basic Structure of the Firmware Type Designation

Function-Specific Abbreviations in Type Designation of IndraDrive Firmware

Base package (application and performance):

- MPB → Single-axis firmware with Basic performance
- MPC → Single-axis firmware with Advanced performance
- MPE → Single-axis firmware with Economy performance
- MPM → Multi-axis firmware with Basic performance

Firmware characteristic:

- 0 → Open-loop
- 1 → Closed-loop

Alternative expansion packages:

- NNN → Without alternative expansion package
- SRV → Functional package "Servo function"
- SNC → Functional package "Synchronization"
- MSP → Functional package "Main spindle"
- ALL → All alternative expansion packages

Additive expansion packages:

- NN → Without additive expansion package
- TF → IndraMotion MLD for using the technology functions (for MPB firm-ware)
- ML → IndraMotion MLD for free programming; incl. use of technology functions (for MPB, MPC firmware)
- MA → IndraMotion MLD Advanced (only for MPB, MPC firmware)

☞ The sales representative in charge will help you with the current status of available firmware types.

Base Packages

General Information

In the base packages of the firmware, the minimum scope of functionalities is available depending on the respective firmware characteristic ("open-loop" or "closed-loop"). They contain the basic functions of a drive firmware and a number of other fundamental functions.

Basic Functions

The following basic functions are available for every drive and contain the fundamental basic functions of a digital drive (available in the firmware characteristics "open-loop" and "closed-loop"):

- Extensive diagnostic functions:
  - Drive-internal generation of diagnostic messages
  - Monitoring function
  - Patch function
  - Status displays, status classes
  - Oscilloscope function
  - Code of optional card
  - Parameter value check
  - Operating hours counter, logbook function, error memory
- Undervoltage monitor
- Output of control signals
- Limitations that can be parameterized

Scope of Functions of Base Packages

Apart from the basic functions, there are other functions available in the base package of the firmware. Their scope depends on the firmware variant and its design ("open-loop" or "closed-loop"). For example, in the base package is the function "Set/shift coordinate system" for the firmware MPx17 with "closed loop" characteristic

See "Supported Operation Modes" in the section "Operation Modes: General Information"

See "Availability of the Extended Axis Functions"

See "Availability of the Optional Device Functions"

Alternative Functional Packages

General Information

In addition to the base packages that are always available, the alternative function packages are offered as optional expansion packages. When these function packages are used, only one package can be activated (alternative activation).

The following expansion packages are available:

- Expanded servo function
- Synchronization
- Main Spindle Function

Servo Function

Depending on the firmware variant and characteristic, the "servo function" expansion package has the following scope of functions:

Firmware variant →	MPB		MPC		MPE		MPM	
Functions of the "Servo function" expansion package	OL	CL	OL	CL	OL	CL	OL	CL
Precision axis error correction	–	■	–	■	–	–	–	–
Temperature error correction	–	■	–	■	–	–	–	■
Quadrant Error Correction	–	■	–	■	–	–	–	■
Cogging torque compensation	–	■	–	■	–	–	–	■
Programmable position switch	–	■	–	■	–	–	–	–

OL Open-loop characteristic
CL Closed-loop characteristic
Fig.4-16: Overview of the "Servo Function" Expansion Package

Synchronization

Depending on the firmware variant and characteristic, the "Synchronization" expansion package has the following scope of functions:

Firmware variant →	MPB		MPC		MPE		MPM	
Functions of the expansion package "synchronization"	OL	CL	OL	CL	OL	CL	OL	CL
Velocity synchronization	■	■	■	■	–	–	■	■
Phase synchronization	–	■	–	■	–	–	–	■
Electronic cam	–	■	–	■	–	–	–	■
Electronic motion profile	–	■	–	■	–	–	–	■
Cogging Torque Compensation	–	■	–	■	–	–	–	■
Measuring wheel mode	–	■	–	■	–	–	–	■
Programmable position switch	–	■	–	■	–	–	–	–
Measuring Encoder	■	■	■	■	–	–	–	■

OL Open-loop characteristic
CL Closed-loop characteristic
Fig.4-17: Overview of the "Synchronization" Expansion Package

Main Spindle Function

Depending on the firmware variant and characteristic, the "Main spindle" expansion package has the following scope of functions:

Firmware variant →	MPB		MPC		MPE		MPM	
Functions of the expansion package "main spindle"	OL	CL	OL	CL	OL	CL	OL	CL
Spindle positioning	–	■	–	■	–	–	–	■
Parameter Set Switching	■	■	■	■	–	■ 1)	■	■
Drive-controlled oscillation	■	■	■	■	–	–	■	■

OL Open-loop characteristic
CL Closed-loop characteristic
1) Contained in the base package for the MPE
Fig.4-18: Overview of the "Main Spindle" Expansion Package

Additive Functional Packages

General Information

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

At present, there is the following additive functional package available (in different designs):

- **IndraMotion MLD** (drive-integrated PLC and technology functions)

IndraMotion MLD (Drive-Integrated PLC)

Depending on the structure (type designation), the extension package "IndraMotion MLD" offers the following scope of functions:

- **Integrated logic control** (type designation "ML")

  Standard PLC tasks
- **Integrated multi-axis motion control (MLD-M), MPC firmware only; integrated single-axis motion control (MLD-S), MPB and MPC firmware** (type designation "ML")

  Motion function block according to PLCopen for single-axis positioning on local and remote axes and synchronization mode (synchronous running, cam shaft) → "low-level motion functions"
- **Basis for technology functions** (type designation "TF" or "ML")

  Examples: Synchronous separator, pick&place, process controller (register controller, winding computation, etc.), preventive maintenance, free function block combination
- **IndraMotion MLD Advanced** (type designation "MA")

Integrated Safety Technology

> ☞ The **drive-integrated safety technology** is a functionality only scalable by means of the hardware and does not require any additional enabling of functions! The requirement for using this function is the use of the optional safety technology modules **L3** and **L4** depending on the control section configuration.

In connection with the safety technology option modules **L3** and **L4**, the safety function "Safe torque off" (STO) is supported.

When the safety function "Safe torque off" (STO) is selected, the safe brake control (SBC) is automatically activated at **L4**.

4.1.6 Performance Data

Overview

Levels of Control Performance

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

- **Advanced** performance

  High control performance due to shorter clock rates (cycle times) for the control loops and signal processing of inputs and outputs.
- **Basic** performance

→ Standard control performance due to average internal clock rates (cycle times) for the control loops and signal processing of inputs and outputs.

- **Economy** performance

  → Low control performance due to reduced clock rates (cycle times) for the control loops and signal processing of inputs and outputs.

Performance and Clock Rates

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

- Current loop clock $T_{A\_current}$
- Velocity loop clock $T_{A\_velocity}$
- Position loop clock $T_{A\_position}$
- Cycle time of master communication $T_{MastCom}$

The table below contains an overview of the clock rates depending on the respective control performance. The detailed assignment of clock rate to control section design, performance level and parameter setting is contained in the table "Performance depending on the control section design" in the section "Control Section Design and Performance" (see below).

	Performance	$T_{A\_current}$	$T_{A\_velocity}$	$T_{A\_position}$	$T_{MastCom}$
Single-axis	Economy	125	500	1000	1000 1) 2000
	Basic	125	250	500	500
	Advanced	62,5	125	250	250
Multi-axis	Basic	125	250	500	500

1) With half the quantity of cyclic data

Fig.4-19: Clock Rates (in µs)

☞ The control performance is not synonymous with the control section design because they are determined by several factors.

The available performance depends on the following requirements and parameter settings:

- **Device configuration** and the associated drive **firmware** (MPB, MPC, MPM and MPE)
- **Activation of functional packages** (cf. P-0-2004)
- Performance level in "P-0-0556, Config word of axis controller"
- Switching frequency in "P-0-0001, Switching frequency of the power output stage"

See also "Overview of Drive Control"

Control Section Design and Performance

The control section design differs with regard to the performance levels that can be reached (cycle times or switching frequencies).

The table below contains an overview of the performance levels and clock rates that can be reached depending on the control section design.

<table>
<tr><th>Control section/Firmware</th><th>Perform-ance level</th><th>f_{PWM} 1)</th><th>PWM change-over switch 2)</th><th>$T_{A\_current}$</th><th>$T_{A\_velocity}$</th><th>$T_{A\_position}$</th><th>$T_{MastCom}$</th></tr>
<tr><td rowspan="8">IndraDrive-Cs with
MPB and MPC</td><td>Basic</td><td>2 kHz</td><td>No</td><td>250 µs</td><td>250 µs</td><td>500 µs</td><td rowspan="8">As for
($T_{A\_position}$ 3)
1000 µs 4)
2000 µs 5)
500 µs 6)</td></tr>
<tr><td>Basic</td><td>4 kHz</td><td>Yes</td><td>125 µs</td><td>250 µs</td><td>500 µs</td></tr>
<tr><td>Basic</td><td>8 kHz</td><td>Yes</td><td>125 µs</td><td>250 µs</td><td>500 µs</td></tr>
<tr><td>Basic</td><td>12 kHz</td><td>Yes</td><td>83.3 µs</td><td>250 µs</td><td>500 µs</td></tr>
<tr><td>Basic</td><td>16 kHz</td><td>Yes</td><td>62.5 µs</td><td>250 µs</td><td>500 µs</td></tr>
<tr><td>Advanced</td><td>4 kHz</td><td>No</td><td>125 µs</td><td>125 µs</td><td>250 µs</td></tr>
<tr><td>Advanced</td><td>8 kHz</td><td>Yes</td><td>62.5 µs</td><td>125 µs</td><td>250 µs</td></tr>
<tr><td>Advanced</td><td>16 kHz</td><td>Yes</td><td>62.5 µs</td><td>125 µs</td><td>250 µs</td></tr>
<tr><td rowspan="2">IndraDrive-Cs with
MPE</td><td>Economy</td><td>4 kHz</td><td>No</td><td>125 µs</td><td>500 µs</td><td>1000 µs</td><td>2000 µs</td></tr>
<tr><td>Economy</td><td>8 kHz</td><td>No</td><td>125 µs</td><td>500 µs</td><td>1000 µs</td><td>2000 µs</td></tr>
<tr><td rowspan="2">IndraDrive C multi-axis (HCQ02) with
MPM</td><td>Basic</td><td>4 kHz</td><td>No</td><td>125 µs</td><td>250 µs</td><td>500 µs</td><td rowspan="2">As for
($T_{A\_position}$ 3)</td></tr>
<tr><td>Basic</td><td>8 kHz</td><td>No</td><td>125 µs</td><td>250 µs</td><td>500 µs</td></tr>
</table>

1) Switching frequency of the power output stage, device dependent (can be set via P--0-0001)
2) Reduction of the PWM frequency depending on velocity or load (can be set via P-0-0045)
3) For Sercos III
4) For PROFIBUS®
5) For PROFINET® and EtherNet/IP™
6) For EtherCAT®

Fig.4-20: Performance Depending on the Control Section Design

Performance When Switching Frequency is Reduced

At switching frequencies of 4 kHz, 8 kHz,12 kHz or 16 kHz and a corresponding setting in parameter "P-0-0045, Control word of current controller" this is reduced automatically by half in order to increase the ability of the controller to withstand thermal loads:

- Dependent on the thermal loading of the controller
- Dependent on velocity

When the reduction of the PWM frequency is used, the switching frequency of the power output stage is changed, but not the cycle times! There is no reduction in performance!

See "Current Limitation: Dynamic Current Limitation"

See "Automatic PWM adjustment: "

4.2 Master Communication

4.2.1 Safety Instructions

⚠ 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 safety fence, safety guard, protective covering, light barrier).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- In addition, observe the safety message "Protection Against Dangerous Movements" in the chapter "Safety Instructions for Electric Drives and Controls".

4.2.2 Basic Functions of Master Communication

Brief Description

General Information

The basic functions of the master communication with IndraDrive drives apply for the MultiEthernet interface (SERCOS III, EtherCAT®, PROFINET®, EtherNet/IP™), the field bus interface and the analog interface.

Features

All variants of master communication supported by IndraDrive have the following functional features in common:

- **Address assignment**

  Communications address that can be freely parameterized (via master communication, "Engineering over IP" and control panel) using parameter "S-0-1040, Drive address of master communication"
- **Command processing**

  Drive commands to be externally activated (via master communication, "Engineering over IP" and 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 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 III: "S-0-0135, Drive status word"; "S-0-1045, SERCOS III: 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". Operating mode (OM) and parameter mode (PM) are always differentiated.
- **Extended possibilities of control**
  – Signal control word (S-0-0145) and signal status word (S-0-0144)
  – Multiplex Channel

See the section "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 section of the respective master communication.

Pertinent Parameters

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

Parameters for State Machine and Phase Switch

- S-0-0011, Class 1 diagnostics
- S-0-0012, Class 2 diagnostics
- S-0-0013, Class 3 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-0-0032, Primary operation mode
- S-0-0033, Secondary operation mode 1
- S-0-0034, Secondary operation mode 2
- S-0-0035, Secondary operation mode 3
- S-0-0284, Secondary operation mode 4
- S-0-0285, Secondary operation mode 5
- S-0-0286, Secondary operation mode 6
- S-0-0287, Secondary operation mode 7

Control and Status Words Specific to SERCOS III

With the "SERCOS III" interface the following **additional** parameters are used:

- S-0-0134, Master control word
- S-0-0135, Drive status word
- S-0-1044, SERCOS III: Device Control (C-Dev)
- S-0-1045, SERCOS III: Device Status (S-Dev)

Field-Bus-Specific Parameters

With field buses, the following **additional** parameters are used:

- P-0-4068, Field bus: Control word IO
- P-0-4077, Field bus: Control word
- P-0-4078, Field bus: Status word

Specific Parameters for Parallel/Analog Interface

With the analog interface, the following **additional** parameters are used:

- P-0-4028, Device control word
- P-0-0115, Device control: Status word

Pertinent Diagnostic Messages

- 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

4.2.3 Control Options/Additional Functions

Configurable Signal Control Word

Brief Description

The signal control word allows writing individual control bits, that are available in different parameters, by a freely configurable collective parameter. The configurable signal control word is used to accept a maximum of 16 copies of bits from other drive parameters.

Examples of Use

This functionality can be used, for example,

- for freely configuring the digital inputs
- for setting-up mode via digital inputs
- for setting bits in drive parameters and for starting commands via the cyclic channel (master communication)

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

Pertinent Parameters

- 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

Configurable Signal Status Word

Brief Description

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

Pertinent Parameters

- 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

Multiplex Channel

Brief Description

The multiplex channel is an expansion of the cyclic data channel. By means of index assignment and switching, cyclic access to list elements is possible for the multiplex channel, too.

☞ The mechanism "multiplex channel" cannot be used with the analog interface.

Features

- 8 multiplex containers with 4 bytes each are available for cyclic command value data (MDT) and cyclic actual value data (AT)
- Multiplex data to be transmitted is addressed via parameter "S-0-0368, Data container A: Addressing" (L-byte for MDT; H-byte for AT)

- Individual elements from list parameters can be addressed via parameters S-0-0362 and S-0-0366
- Multiplex data are transmitted in communication cycle

Possible Applications

By means of the multiplex channel it is possible:

- To increase the number of transmittable bytes in the cyclic real-time channel (command and actual values) by multiplexing data,
- To transmit the multiplex data with a cycle time of "T_{scyc} x number of multiplex data" by incrementing the addressing index (S-0-0368)
- To achieve operation mode dependent configuration of the cyclic data by index switching in case the operation mode is changed.

☞ When IndraMotion MLC is used, the multiplex channel is used for communication between MLC and drive and can therefore no longer be used freely!

Pertinent Parameters

Parameters for command value channel:

- S-0-0362, Data container A: List index command values
- S-0-0368, Data container A: Addressing
- S-0-0360, Data container A: Command value 1
- S-0-0450, Data container A: Command value 2

  - to -

  S-0-0456, Data container A: Command value 8

Parameters for actual value channel:

- S-0-0366, Data container A: List index feedback values
- S-0-0364, Data container A: Feedback value 1
- S-0-0480, Data container A: Feedback value 2

  - to -

  S-0-0486, Data container A: Feedback value 8

Configuration lists of the command value data containers:

- S-0-0370, Data container A: Configuration list command value-1
- S-0-0490, Data container A: Configuration list command value 2

  - to -

  S-0-0496, Data container A: Configuration list command value 8

Configuration lists of the actual value data containers:

- S-0-0371, Data container A: Configuration list feedback value-1
- S-0-0500, Data container A: Configuration list feedback value 2

  - to -

  S-0-0506, Data container A: Configuration list feedback value 8

Pertinent Diagnostic Messages

- C0151 IDN for command value data container not allowed
- C0152 IDN for actual value data container not allowed
- C0238 Order of cyclic command value configuration incorrect
- E4008 Invalid addressing command value data container A
- E4009 Invalid addressing actual value data container A

4.2.4 Operating Modes of Master Communication

Introduction and Overview

Overview of Operating Modes and Possibilities of Command Triggering

Command triggering for the drive can take place by an external control master (remote mode) or internally using the inputs/outputs which are available (local mode).

The figure below contains an overview of the possibilities of drive command triggering.

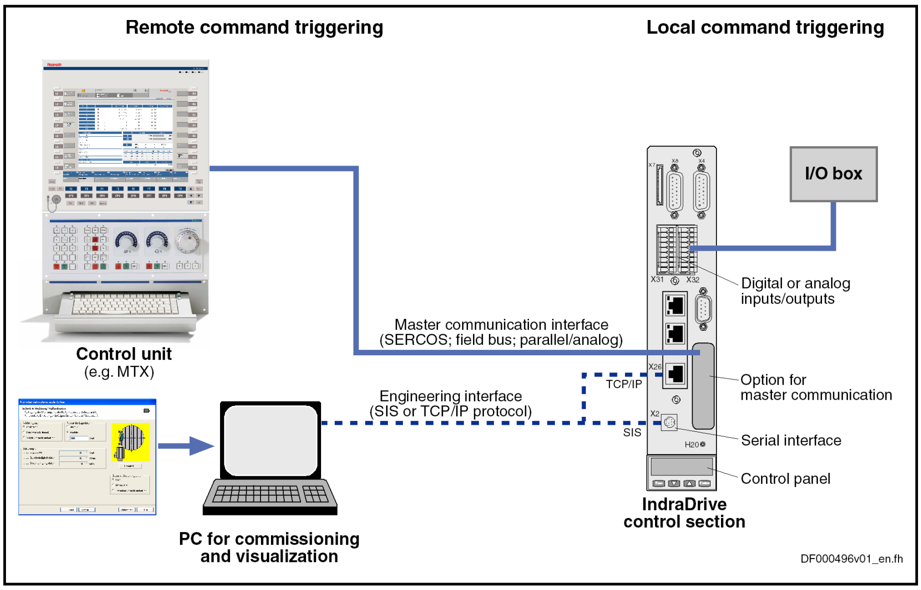


Fig.4-21: Overview of Possibilities of Command Triggering for an IndraDrive Device

Operating Modes and Changes of States

The overview below shows the basically possible operating states and the actions required for change/transition from one operating mode to the other.

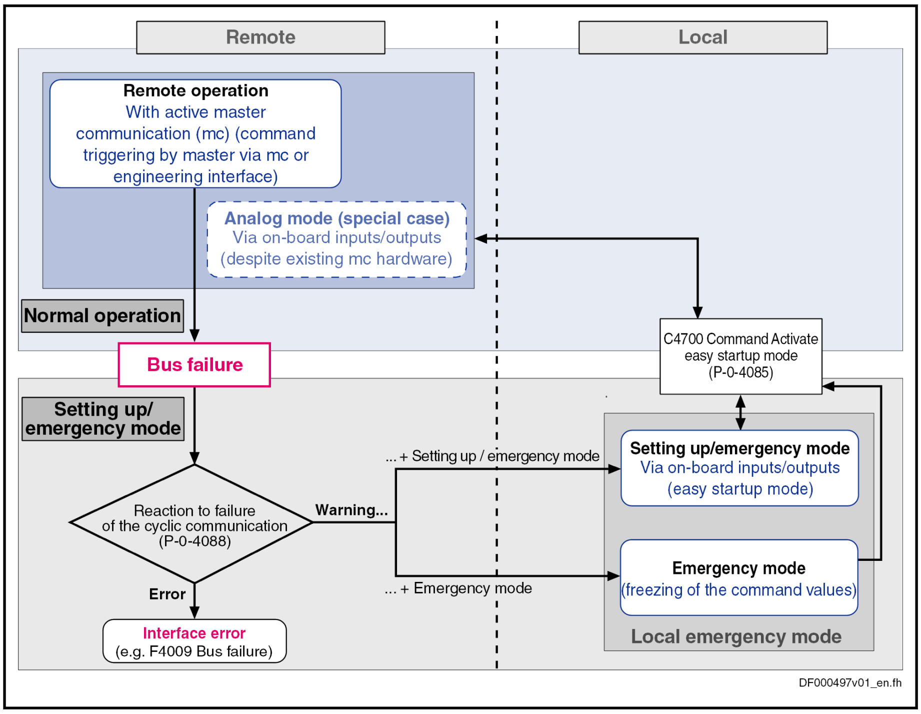


Fig.4-22: Operating States and Operating Modes of Master Communication

Device Control and State Machine

According to the kind of master communication or setting of the device control, different control words take effect. Internally, however, all relevant control bits are always displayed in parameter "P-0-0116, Device control: Control word".

☞ The actual state machines of master communication are described in the section "Device Control and State Machines"!

Normal Operation (via Internal or External Control Section)

In the so-called normal operation, the command triggering for the drive takes place via an external control section (e.g. IndraMotion MTX or MLC); the following cases are distinguished:

- **Remote mode** with active master communication (standard case)

  Command triggering for the axis takes place via the master communication (SERCOS III, field bus, analog/parallel).

  Special cases (respective configuration via "P-0-4088Master communication: Drive configuration"):

  - **Analog mode** for SERCOS or field bus devices (master communication has been deactivated and a device with SERCOS or field bus interface is permanently operated via the digital/analog inputs/outputs)
  - **EtherNet/IP^{TM} communication** via the engineering interface

Local Setting-Up Mode/Emergency Mode (Easy Startup Mode)

During operation, the drive can, **due to the situation**, change to a local mode for setting-up or to remedy an emergency (e.g. bus failure). The following operating modes are differentiated here:

- **Setting-up mode** (easy startup mode)

For commissioning or the setting-up procedure, the drive can temporarily be moved via the inputs/outputs (digital and analog), independently of the external master (e.g. field bus interfaced PLC or NC).

- **Emergency mode** in the case of bus failure (freezing the last command values)

  Even if the master communication fails, it is possible to continue operating the drive in an emergency mode via the (local) inputs/outputs at the device.

☞ Using the emergency mode requires the corresponding configuration in the parameter "P-0-4088, Master communication: Drive configuration"; the automatic activation of the easy startup mode can be set in this parameter, if necessary.

4.2.5 Profile Types (with Field Bus Interfaces)

Brief Description

Supported Profile Types, Overview

When a field bus interface is used for master communication, IndraDrive controllers support the following profile types (modes):

- "No profile"
- I/O mode positioning
- I/O mode preset velocity
- Freely configurable mode (IndraDrive profile type)

The tables below contain an overview of the most important properties and features of these 4 profile types:

Profile type: "No profile"			
Content of "P-0-4084, Field bus: Profile type"	Master Communication	Field bus or drive operation mode	Features
0x0000	PROFIBUS® CANopen PROFINET® EtherNet/IP™	- With the profile type "No profile", all settings relevant to the profile type are deactivated - The profile type "No profile" is mainly relevant to MLD applications with "permanent control" on the axis	- Profile type without field bus control word and field bus status word - Real-time data can be freely configured - Operation mode can be freely selected

Fig.4-23: Profile Type "No Profile"

I/O mode positioning			
Content of "P-0-4084, Field bus: Profile type"	Master Communication	Field bus or drive operation mode	Features
0xFF82	PROFIBUS® CANopen PROFINET® EtherNet/IP™	I/O mode positioning (positioning block mode, encoder 1, lagless)	- up to 64 positioning blocks can be controlled via field bus - apart from control and status word, other real-time data can be configured (in P-0-4080 and P-0-4081) - bits can be freely defined in signal status word via function "configurable signal status word"

Fig.4-24: Profile Type "I/O Mode Positioning"

I/O mode preset velocity			
Content of "P-0-4084, Field bus: Profile type"	Master Communication	Field bus or drive operation mode	Features
0xFF92	PROFIBUS® CANopen PROFINET® EtherNet/IP™	I/O mode preset velocity	- fixed velocity command values can be controlled and ramp-function generator can be operated via field bus - apart from control and status word, other real-time data can be configured (in P-0-4080 and P-0-4081) - bits can be freely defined in signal status word via function "configurable signal status word"

Fig.4-25: Profile Type "I/O Mode Preset Velocity"

Freely configurable mode			
Content of "P-0-4084, Field bus: Profile type"	Master Communication	Field bus or drive operation mode	Features
0xFFFE	PROFIBUS® CANopen PROFINET® EtherNet/IP™	Freely configurable mode (Default assignment is "drive-controlled positioning" with corresponding required cyclic data)	- possible use of complete drive functionality by free configuration of real-time data and operation mode selection - control word and status word have a Rexroth-specific structure - selection suited for operation with analog command values in commissioning phase
0xFFFD	As for profile 0xFFFE, but a reduced field bus control word		

Fig.4-26: Profile Type "Freely Configurable Mode"

Pertinent Parameters

- S-0-0026, Configuration list for signal status word
- S-0-0144, Signal status word
- S-0-0328, Assign list signal status word
- P-0-4068, Field bus: Control word IO

- P-0-4071, Field bus: Length of cyclic command value data channel
- P-0-4074, Field bus: Data format
- P-0-4077, Field bus: Control word
- P-0-4078, Field bus: Status word
- P-0-4080, Field bus: Config. list of cyclic actual value data ch.
- P-0-4081, Field bus: Config. list of cyclic command value data ch.
- P-0-4082, Field bus: length of cyclic actual value data channel
- P-0-4083, Parameter channel: Length
- P-0-4084, Field bus: Profile type

Supported Profile Types, Basic Principles and Terms

Drive Profile

The drive profile defines

- the structure of the field bus control word (P-0-4077) and of the field bus status word (P-0-4078),
- the structure and content of real-time channel (P-0-4080, P-0-4081),
- the active operation mode (S-0-0032, S-0-0033, S-0-0034, S-0-0035),
- the drive states and their transitions (state machine of IndraDrive profile type or I/O mode).

By selecting a profile type, the commissioning of field bus drives becomes very easy for the user. The advantage of the profile selection is that all important basic settings for the desired drive function are thereby made automatically in the drive. As the profile types are defined independently of the bus, the transfer of applications from one field bus to the other is also facilitated.

State Machine

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

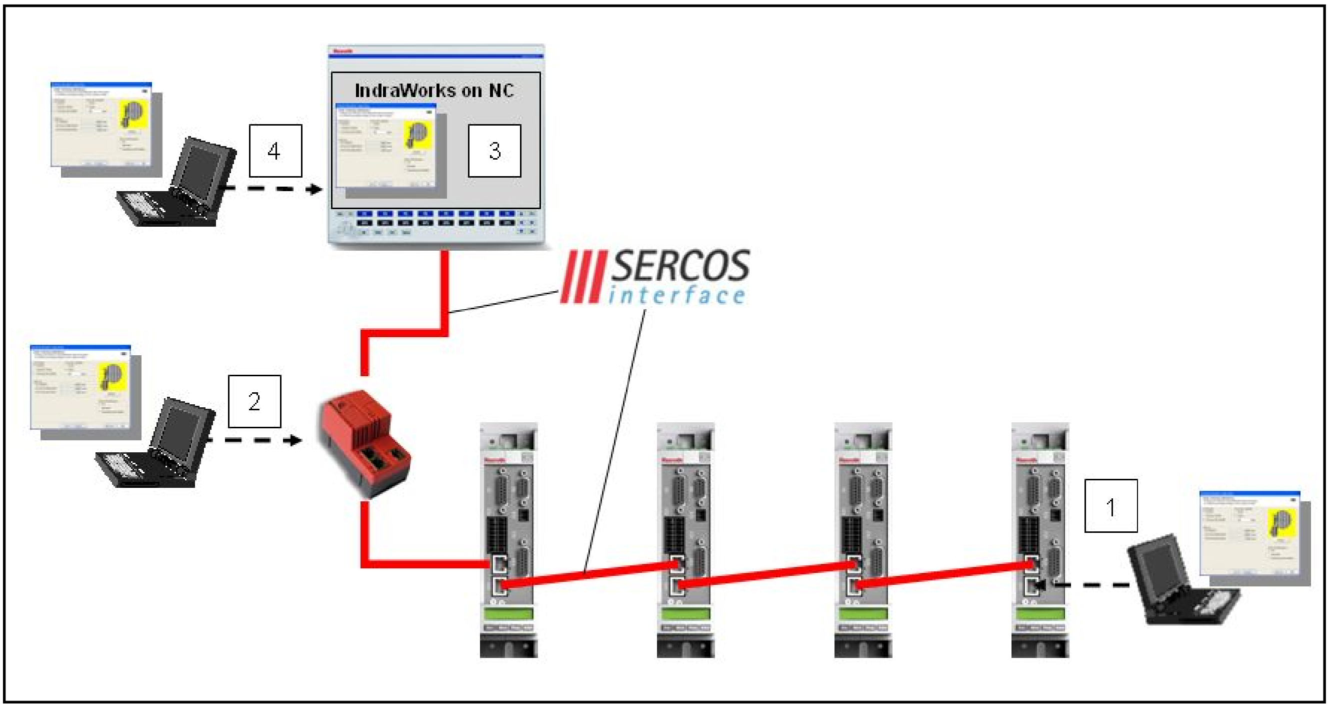
Abbreviations

- **i16**: 16-bit variable with sign (1 word) in Intel format
- **i32**: 32-bit variable with sign (2 words) in Intel format
- **u16**: 16-bit variable without sign (1 word) in Intel format
- **u32**: 32-bit variable without sign (2 words) in Intel format
- **ZKL1**: Class 1 diagnostics
- **ZKL2**: Class 2 diagnostics

4.2.6 SERCOS III

Brief Description

Topology



1	Engineering via free SERCOS III port of a participant on the bus
2	Engineering via optional SERCOS III-netSWITCH
3	Engineering via IndraWorks on SERCOS III control
4	Engineering via Routing using control (if Routing control is available)

Fig.4-27: Engineering Possibilities Using SERCOS III

It is possible to operate IndraDrive controllers with a MultiEthernet interface (ET) or an optional module "SERCOS III" (S3) as SERCOS III master communication. Via these modules, it is possible to exchange real-time data with a SERCOS III master.

The following communication channels are distinguished:

- **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

- Transmission rate 100 Mbit/s
- Cyclical data exchange of command and actual values in equal time intervals
- Data transmission via Ethernet cable (CAT5e-copper)
- Service channel for parameterization and diagnosis
- Free configuration of telegram contents
- Synchronization between time command value takes effect and measurement starting time of the actual values for all devices on a ring
- Overall synchronization of all connected devices

Brief Functional Descriptions

Firmware-Specific Features

<table>
<tr><th colspan="3"></th><th>BASIC
MPB-17VRS</th><th>ECONOMY
MPE-17VRS</th></tr>
<tr><td>Position loop cycle</td><td>$T_{position}$</td><td>µs</td><td>250/500</td><td>1000</td></tr>
<tr><td rowspan="2">MastCom cycle time</td><td>Min.</td><td>µs</td><td>250/500</td><td>2000</td></tr>
<tr><td>Max.</td><td>ms</td><td>65</td><td>65</td></tr>
<tr><td rowspan="4">Motion data
Respectively for MDT/ AT
[excluding 2 byte connection control word (C_Con)]</td><td rowspan="2">$T_{Sercos}=T_{position}$</td><td>Byte</td><td>26</td><td>---</td></tr>
<tr><td>IDN</td><td>12</td><td>---</td></tr>
<tr><td rowspan="2">$T_{Sercos}>T_{position}$</td><td>Byte</td><td>50</td><td>50</td></tr>
<tr><td>IDN</td><td>16</td><td>16</td></tr>
<tr><td colspan="2" rowspan="2">CC connections
[excluding 2 byte connection control word (C_Con)]</td><td>Byte</td><td>8</td><td>8</td></tr>
<tr><td>IDN</td><td>2</td><td>2</td></tr>
</table>

Fig.4-28: Key SERCOS III Data

- IndraDrive supports 4 connections, 2 between control and drive and 2 CC connections for direct communication with one or several other participants

> In this firmware version, CC connections are implemented according to the status of the SERCOS specification (SCP V1.1.2). Regarding use and configuration, see Technical Note "TN_332_CC-Verbindungen_SERCOS3_EIDN.pdf"

- Cycle time: Min. 250/500 µs, max. 65 ms (multiples of position clock 250 µs or 500 µs can be set)
- Max. number of configurable consumer data: 50 bytes / 16 identification numbers
- Max. number of configurable producer-consumer data: 50 bytes / 16 identification numbers

> The number of configurable bytes in consumer/producer connections depends on the relation of the position cycle time (P-0-0556, bit 2) to the SERCOS cycle time:
> - SERCOS cycle time = position cycle time → max. length 26 bytes / 12 identification numbers
> - SERCOS cycle time > position cycle time → max. length 50 bytes / 16 identification numbers
>
> The NRT channel is only possible, if a time slot of more than 125 µs is available.

Hardware Requirements

The optional module with SERCOS III interface is available for the following device:

- Single-axis Economy (HCS01.1-W00xx-X-0X-E-**S3**-EC-NN-NN-NN-NN-FW)

The optional module with MultiEthernet interface is available for the following device:

- Single-axis BASIC UNIVERSAL (HCS01.1-W00xx-X-0X-E-**S3**-EC-NN-NN-NN-NN-FW)

Axis Addresses

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

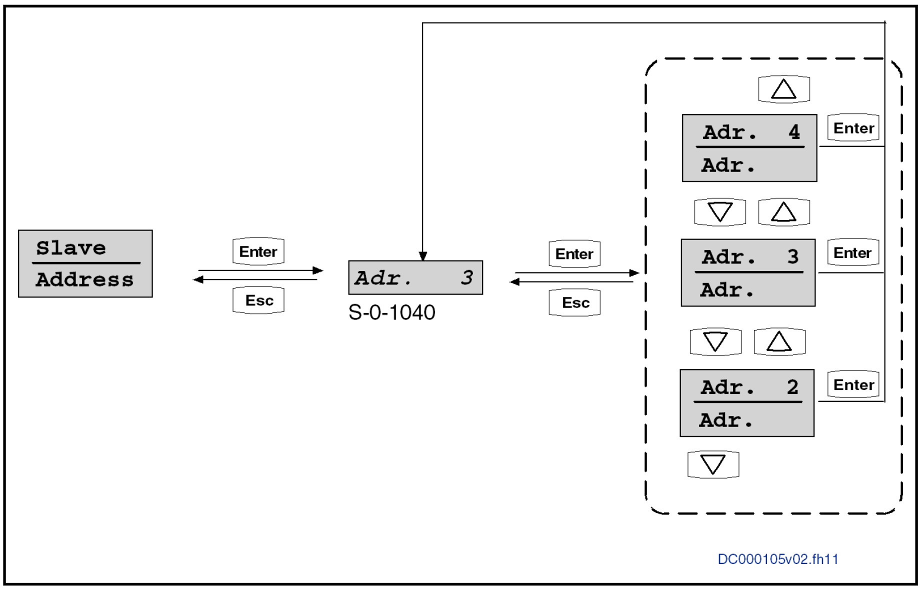


Fig.4-29: Submenu for "Slave___" "_Address"

Alternatively, the address can be changed or displayed using the parameter "S-0-1040, Drive address of master communication". With SERCOS IIII the address can be set remotely and automatically via the master using remote address assignment. This function must be supported by the master, e.g. the CCD master. In this regard, see the section "Cross Communication (CCD)" in the manual "Rexroth IndraDrive Firmware for Drive Controllers MPH, MPB, MPD, MPC-07".

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

Pertinent Parameters

Specific parameters for SERCOS III communication:

- S-0-1000, SERCOS III: SCP Type & Version
- S-0-1002, SERCOS III: Communication Cycle time (tScyc)
- S-0-1005, SERCOS III: Minimum feedback processing time (t5)
- S-0-1006, SERCOS III: AT0 transmission starting time (t1)
- S-0-1007, SERCOS III: Feedback acquisition capture point (t4)
- S-0-1008, SERCOS III: Command value valid time (t3)
- S-0-1009, SERCOS III: Device Control (C-Dev) offset in MDT
- S-0-1010, SERCOS III: Lengths of MDTs
- S-0-1011, SERCOS III: Device Status (S-Dev) offset in AT
- S-0-1012, SERCOS III: Length of ATs
- S-0-1013, SERCOS III: SVC offset in MDT
- S-0-1014, SERCOS III: SVC offset in AT
- S-0-1015, SERCOS III: Ring delay
- S-0-1016, SERCOS III: Slave delay (P/S)

Brief Functional Descriptions

- S-0-1017, SERCOS III: 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 III: SYNC jitter
- S-0-1024, C5300 SERCOS III: SYNC delay measuring procedure command
- S-0-1026, SERCOS III: Version of communication hardware
- S-0-1027.0.1, SERCOS III: Requested MTU
- S-0-1027.0.2, SERCOS III: Effective MTU
- S-0-1031, SERCOS III: Signal assignment TSx
- S-0-1035, SERCOS III: Error counter Port1 & Port2
- S-0-1041, SERCOS III: AT Command value valid time (t9)
- S-0-1044, SERCOS III: Device Control (C-Dev)
- S-0-1045, SERCOS III: Device Status (S-Dev)
- S-0-1046, List of slave addresses in device
- S-0-1047, SERCOS III: Maximum Consumer Activation Time
- S-0-1050.x.1, SIII-Connection: Connection setup
- S-0-1050.x.2, SIII-Connection: Connection number
- S-0-1050.x.3, SIII-Connection: Telegram assignment
- S-0-1050.x.4, SIII-Connection: Max. length of connection
- S-0-1050.x.5, SIII-Connection: Current length of connection
- S-0-1050.x.6, SIII-Connection: Configuration list
- S-0-1050.x.8, SIII-Connection: Connection control (C-Con)
- S-0-1050.x.10, SIII-Connection: Producer cycle time
- S-0-1050.x.11, SIII-Connection: Allowed data losses
- S-0-1050.x.12, SIII-Connection: Error counter data losses
- S-0-1050.x.20, SIII-Connection: IDN allocation of real-time bit
- S-0-1050.x.21, SIII-Connection: Bit allocation of real-time bit
- S-0-1051, SIII-Connection: Image of connection setups

Pertinent Diagnostic Messages

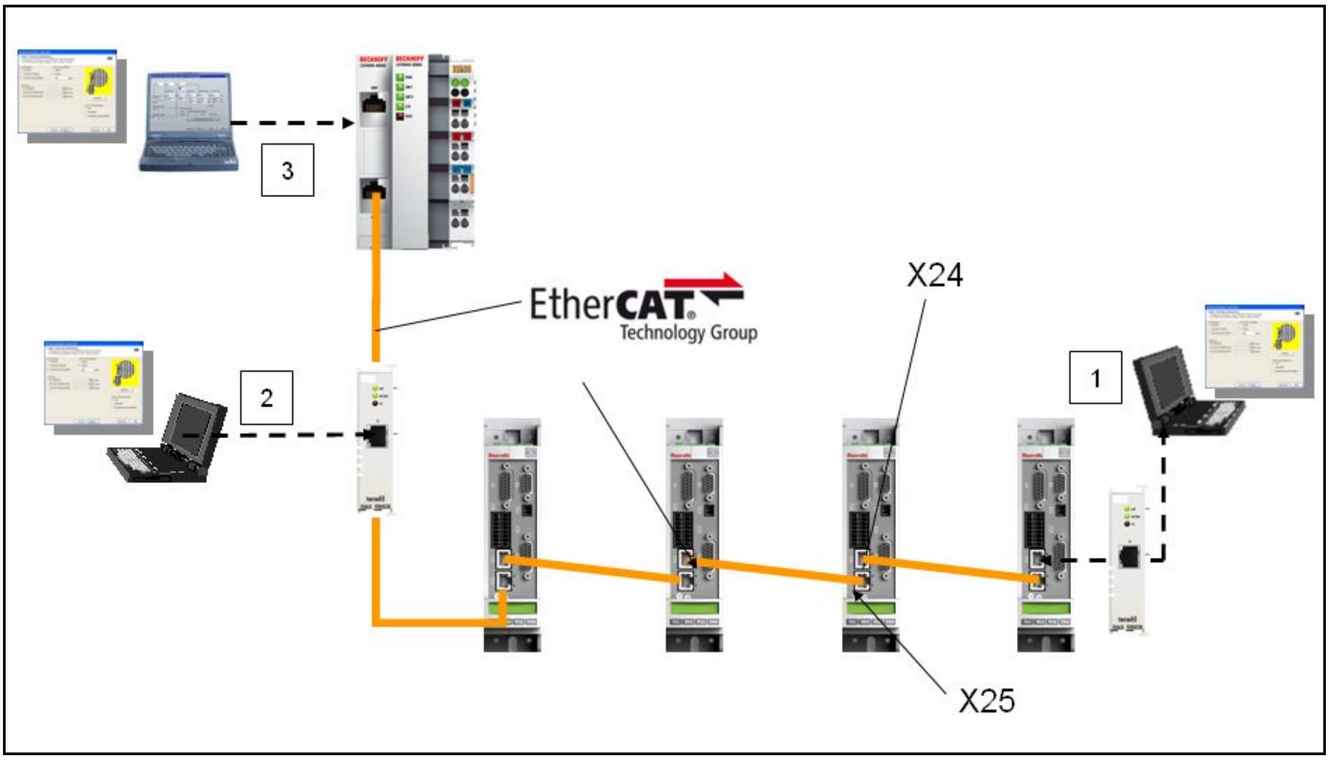
- C0108 Time slot parameter > Sercos cycle time
- C0109 Telegram offset unsuitable
- C0112 TNcyc (S-0-0001) or TScyc (S-0-0002) error
- C0113 Relation TNcyc (S-0-0001) to TScyc (S-0-0002) error
- C0170 Config. IDNs for connection not configurable
- C0171 Maximum length for connections exceeded
- C0172 Delay measurement (S-0-1024) not carried out
- C0173 Connections (number) not configurable
- C0174 Connection configuration not allowed
- C0175 Producer cycle time of a connection not correct
- C5301 SERCOS III: Delay measurement failed

- E4001 Sync telegram failure
- E4005 No command value input via master communication
- E4007 SERCOS III: Consumer connection failed
- E4010 Slave not scanned or address 0
- E4020 SIII: 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 S-III: Incorrect sequence during phase switch

4.2.7 EtherCAT®

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.4-30: Engineering Possibilities 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 a EtherCAT® master. The "Servo Drive Profile over EtherCAT®", which is based on the SERCOS II specification, is supported.

The following communication channels are distinguished:

- **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

- Transmission rate 100 Mbit/s
- Data transmission via Ethernet cable (CAT5e-copper)
- Topology: "Line"
- Access to 16 bit SERCOS parameters of the drive via "SoE" protocol ("Servo Drive Profile over EtherCAT®" protocol)
- EtherCAT® mailbox method for parameterization and diagnostic messages
- Cyclical data exchanged of command 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 divided by 2 to 24 bytes
- Cycle time: Min. 500 µs (multiples of the position clock can be set)
- "Distributed clock synchronization" (exact adjustment of distributed clocks)
- Synchronization between time command value takes effect and measurement starting time of the actual values for all drives on a ring
- Overall synchronization of all connected drives to the master
- "CAN over EtherCAT®" (CoE) is not supported
- Only released in connection with "Beckhoff-TwinCAT"

Hardware Requirements

Using the master communication "EtherCAT®" requires the following control section design:

- Single-axis BASIC UNIVERSAL (HCS01.1-W00xx-X-0X-E-**S3**-EC-NN-NN-NN-NN-FW)
- Single-axis ADVANCED (HCS01.1-W00xx-X-0X-A-CC-EC-**ET**-NN-NN-NN-FW)

The option ET must be present as a master communication module.

Axis Addresses

☞ There is no connection from the MastCom address (S-0-1040) shown in the display to the address given in the master (e.g. SystemManager by BECKHOFF). The drives are identified only based on the order in the bus (e.g. address = "1" in the master corresponds with "1st drive" in the line).

Pertinent Parameters

- S-0-0001, NC cycle time (TNcyc)
- 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-0-0134, Master control word
- S-0-0135, Drive 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

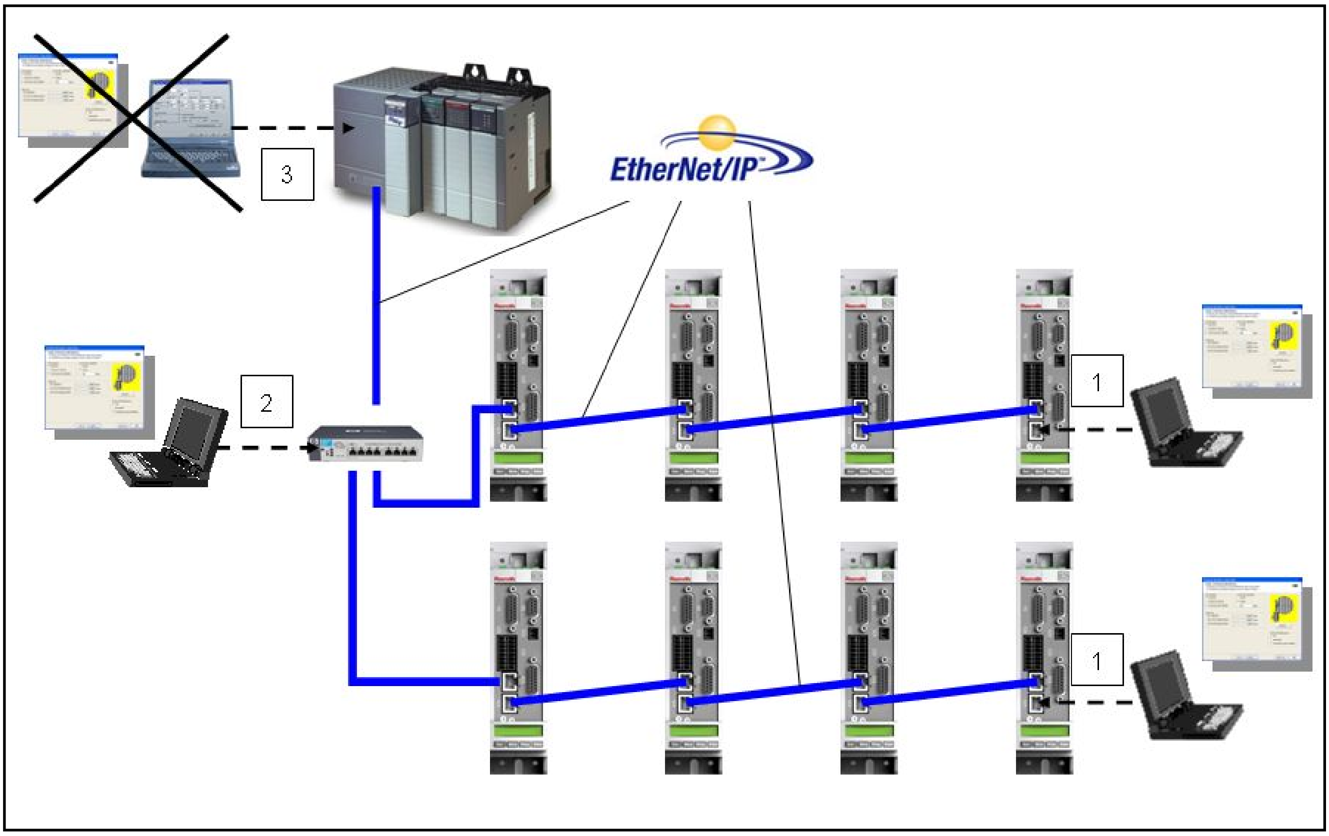
Pertinent Diagnostic Messages

- 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 TNcyc (S-0-0001) or TScyc (S-0-0002) error
- 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

4.2.8 EtherNet/IP(TM) Interface

Brief Description

Topology



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

Fig.4-31: EtherNet/IP(TM) Topology

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

- Transmission 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**evice-Net **V**endors **A**ssociation)
- EtherNet/IPTM Level 2 server
- Cyclic exchange via "Ethernet/IPTM I/O messaging" (class 1)
- Acyclic data exchange via "Ethernet/IPTM 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 2 router can be used to connect the industrial Ethernet network with a company network.)
- only switches with cut through be used for industrial Ethernet communication
- a star topology with cable type AWG22 or shielded cable be used, particularly for cables that exit the switching cabinet and for cable longer than 10 meters

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- Supported field bus profiles:
  - 0x0000: "No profile selected"
  - 0xFF82: I/O mode "positioning" with configurable real-time data
  - 0xFF92: I/O mode "preset velocity" with configurable real-time data
  - 0xFFFD: Freely configurable mode "Neutral operation modes"
  - 0xFFFE: Freely configurable mode

Hardware Requirements

Using the master communication "EtherNet/IP™" requires the following control section design:

- Single-axis BASIC UNIVERSAL (HCS01.1-W00xx-X-0X-E-**S3**-EC-NN-NN-NN-NN-FW)
- Single-axis ADVANCED (HCS01.1-W00xx-X-0X-A-CC-EC-**ET**-NN-NN-NN-FW)

Axis Addresses

With EtherNet/IP the master communication address is an IP address. It is set in P-0-4089.0.13. The address shown in the display on the drive is not significant with regard to EtherNet/IP.

Pertinent Parameters

- 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

In addition to simple communication parameters, parameters are used in conjunction with the profile types.

In this regard, see "Profile Types (with Field Bus Interfaces)"

Parameters for extended communication

Additional parameters are used for extended communication.

See following sections:

- "Configurable Signal Control Word"
- "Configurable Signal Status Word"
- "Multiplex Channel"

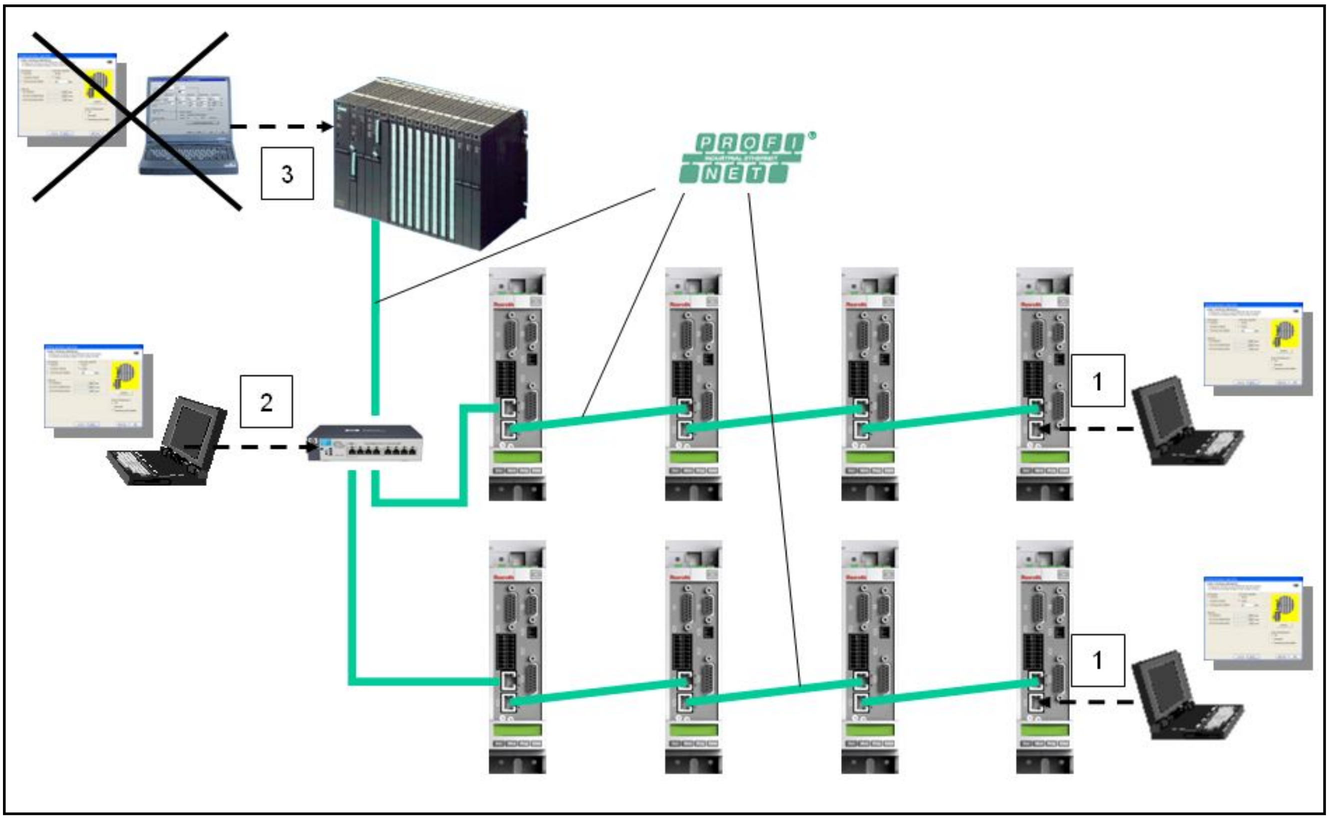
Pertinent Diagnostic Messages

- 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
- F4011Communication watchdog: Overload of cyclic communication

4.2.9 PROFINET®

Brief Description

Topology



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

Fig.4-32: Engineering Possibilities with PROFINET®

IndraDrive controllers with MultiEthernet interface (ET) can be operated as 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) **secure, axis-specific process data channel** (PROFIsafe).

> ☞ The **secure, axis-specific process data channel** is not available in the MPx17VRS. For configuration, however, the module "F-Module not used" must be integrated!

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

Brief Functional Descriptions

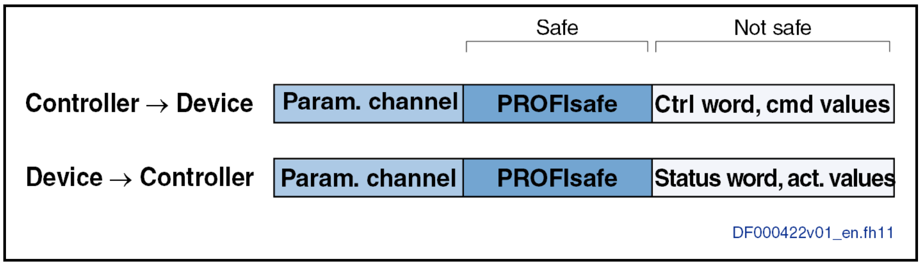


Fig.4-33: Overview of Cyclic Data Channel

To simplify field bus communication, PLC function blocks are available 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 PROFINET® controllers.

Features

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

- Ethernet in accordance with IEEE 802.3 and prioritization in accordance with IEEE 802.1Q
- Transmission 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 lowest supported cycle time (IO cycle update time) is 2 ms.

The IO cycle update time is described by the control and is the time cycle in which the process data from the PROFINET network are accepted onto 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 possibilities via "P-0-4076, Field bus: Process data - updating clock", min. 2 ms, max. 65 ms (can be set in 1 ms increments).

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 is accepted onto the drive 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 can be purchased from 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 2 router can be used to connect the industrial Ethernet network with a company network.)
- only switches with cut through be used for industrial Ethernet communication
- a star topology with cable type AWG22 or shielded cable be used, particularly for cables that exit the switching cabinet and for cable 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 link/activity status
- Support for CCA and RT_CLASS_1
- Diagnostic messages and alarms are not used due to reasons of compatibility with IndraDrive drive controllers with the PROFIBUS® master communication module.
- PROFINET® IRT is not supported.
- Operation in PROFINET® IRT networks is not possible.
- Supported field bus profiles:
  - 0x0000: "No profile" selected
  - 0xFF82: I/O mode "positioning" with configurable real-time data
  - 0xFF92: I/O mode "preset velocity" with configurable real-time data
  - 0xFFFD: Freely configurable mode "Neutral operation modes"
  - 0xFFFE: Freely configurable mode

Hardware Requirements

Using the master communication "PROFINET®" requires the following control section design:

- Single-axis BASIC UNIVERSAL (HCS01.1-W00xx-X-0X-E-**S3**-EC-NN-NN-NN-NN-FW)
- Single-axis ADVANCED (HCS01.1-W00xx-X-0X-A-CC-EC-**ET**-NN-NN-NN-FW)

The option ET must be present as a master communication module.

Axis Addresses

A participant 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 address shown in the display on the drive is not significant with regard to PROFINET.

Pertinent Parameters

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

In addition to simple communication parameters, parameters are used in conjunction with the profile types.

In this regard, see "Profile Types (with Field Bus Interfaces)"

In this regard, see "Engineering/diagnostic interfaces"

Parameters for extended communication

Additional parameters are used for extended communication.

See following sections:

- "Configurable Signal Control Word"
- "Configurable Signal Status Word"
- " Multiplex Channel"

Pertinent Diagnostic Messages

- 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
- F4009Bus failure
- F4011Communication watchdog: Overload of cyclic communication
- F4012Incorrect I/O length

4.2.10 PROFIBUS-DP

Brief Description

IndraDrive controller 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 divided 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 fulfill any "real-time properties"!

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

> ☞ The **secure, axis-specific process data channel** is not available in the MPx17VRS. For configuration, however, the module "F-Module not used" must be integrated!

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

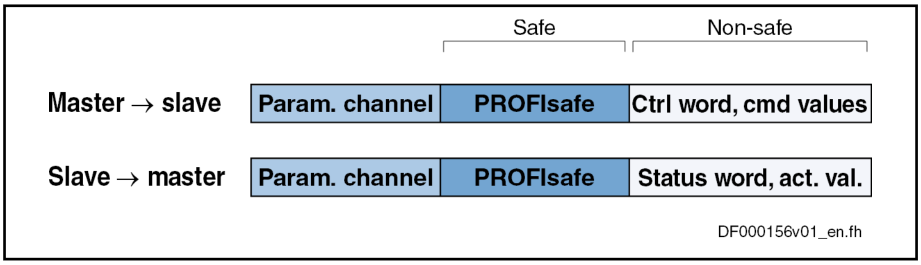


Fig.4-34: Overview of Cyclic Data Channel

> ☞ To simplify field bus communication, Rexroth PLC function blocks are available 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 circuit with master communication module PROFIBUS interface (PB) has the following functional features:

- Support of **RS485 interfaces according to IEC 61158-2**
- Support of all **data rates according to IEC 61158-2**, 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 possibilities for P-0-4076: min. 2 ms, max. 65 ms (can be set in 1 ms increments)

☞ 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 is accepted onto the drive and vice versa.

- Additional optional parameter channel in the cyclic channel with up to 16 bytes (8 words)
- Monitoring of the cyclical 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 (send 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 (abortion of connection)
  - DDLM_Idle (connection monitoring)
- Support of up to two DPV1 Class 2 connections
- TCI (Tool Calling Interface) support
- Supported field bus profiles:
  - 0x0000: "No profile selected"
  - 0xFF82: I/O mode "positioning" with configurable real-time data
  - 0xFF92: I/O mode "preset velocity" with configurable real-time data
  - 0xFFFD: Freely configurable mode "Neutral operation modes"
  - 0xFFFE: Freely configurable mode

Hardware Requirements

Using the master communication "PROFIBUS-DP" requires the following device design:

- Single-axis BASIC UNIVERSAL (HCS01.1-W00xx-X-0X-B-ET-EC-**PB**-NN-NN-NN-FW)
- Single-axis ADVANCED (HCS01.1-W00xx-X-0X-A-CC-EC-**PB**-NN-NN-NN-FW)

☞ When the Profibus card is inserted, a switch can only be made between inactive master communication and Profibus master communication. Switching into SERCOS III, EtherCAT, Ethernet/IP or PROFINET is not possible.

Axis Addresses

The axis address can be set directly using the control panel of the drive. This can be done using the so-called Easy menu.

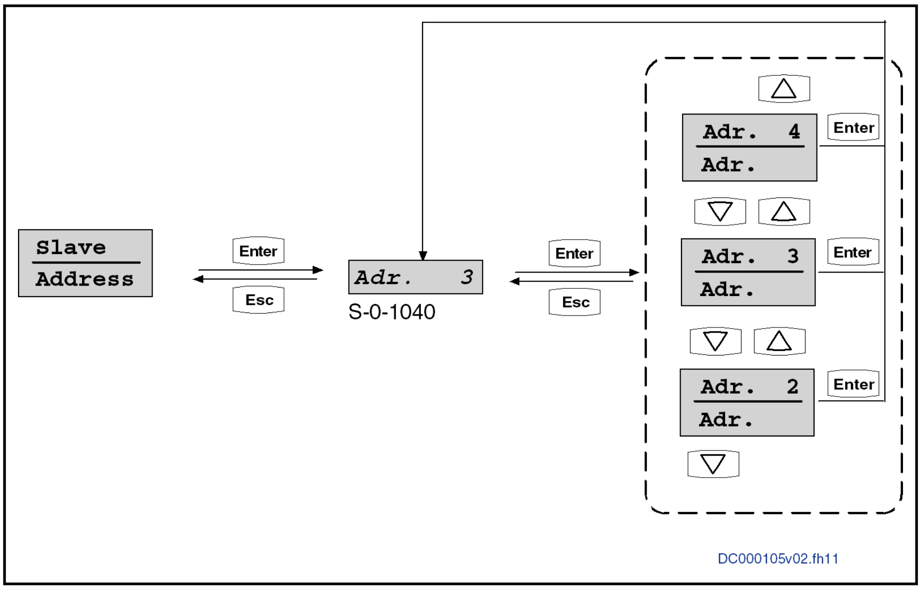


Fig.4-35: Submenu for "Slave___" "_Address"

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

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

Pertinent Parameters

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

In addition to simple communication parameters, parameters are used in conjunction with the profile types.

In this regard, see "Profile Types (with Field Bus Interfaces)"

Parameters for extended communication

Additional parameters are used for extended communication.

See following sections:

- "Configurable Signal Control Word"
- "Configurable Signal Status Word"
- " Multiplex Channel"

Pertinent Diagnostic Messages

- 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
- F4009Bus failure
- F4012Incorrect I/O length

4.2.11 CANopen Interface

Brief Description

It is possible to operate IndraDrive controllers with a CANopen interface as master communication module. This requires the control section with the optional module "CANopen" (CO). Via this optional module, it is possible to exchange real-time data with a CANopen master. The "CANopen" protocol (according to Draft Standard DS301, version 4.0.2) has been implemented in the drive controller.

Communication Channels

The following communication channels are differentiated:

- Cyclic data channel (process data objects → PDO)

  The field bus provides data containers in which useful data can be cyclically transmitted in real time (process data objects).
- Acyclic data channel (service data objects → SDO)

  The field bus provides data containers in which useful data (service data objects) can be acyclically transmitted.

☞ The process data are always transmitted via PDOs.

Features

- Simple configuration through use of "Predefined Connection Set" and "Minimal Boot-Up" according to DS301
- Baud rates of 20, 50, 125, 250, 500, 800 and 1000 kbit/s specified by CANopen according to DS301 are supported
- Configurable cyclic data up to 15 parameters (incl. field bus control word and field bus status word) in both data directions (max. 32 bytes or 16 words)
- Functional compatibility with EcoDrive functions through profile selection (I/O mode)
- Node monitoring (heartbeat function and node guard function)
- LED displays at the front panel of the master communication module for simple diagnosis of bus functions and most important communication relationships between drive and field bus (2 LEDs: "Run" status and "Error" status)
- All parameters of the drive can be directly read via SDO and, if permitted, can be written
- Upload/download function for all parameters of the drive possible with SDO services
- Event-controlled or synchronous transmission of process data

- CANopen Device profile DSP402 is not supported; field bus profiles according to DSP402 are partly supported (see "Profile Types (with Field Bus Interfaces)")

Hardware Requirements

The optional module with CANopen interface is available for the following configurable control sections:

- Single-axis BASIC UNIVERSAL (HCS01.1-W00xx-X-0X-B-ET-EC-**CN**-NN-NN-NN-FW)
- Single-axis ADVANCED (HCS01.1-W00xx-X-0X-A-CC-EC-**CN**-NN-NN-NN-FW)

Pertinent Parameters

Communication parameters

Specific parameters for CANopen communication:

- P-0-3610, CANopen: Heartbeat/NodeGuard Configuration
- P-0-3611, CANopen: COB-IDs
- P-0-3612, CANopen: Transmission Types
- P-0-3613, CANopen: List of the Event Parameters

Parameters for general field bus communication:

- P-0-4025, Drive address of master communication
- 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

Profile type parameters

In addition to simple communication parameters, parameters are used in conjunction with the profile types.

In this regard, see "Profile Types (with Field Bus Interfaces)"

Parameters for extended communication

Additional parameters are used for extended communication.

See following sections:

- "Configurable Signal Control Word"
- "Configurable Signal Status Word"

Pertinent Diagnostic Messages

- 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
- F4001Sync telegram failure
- F4002RTD telegram failure
- F4009Bus failure
- F4012Incorrect I/O length

4.2.12 Analog Interface

Brief Description

Overview

Apart from the digital master communication interfaces (SERCOS, PROFIBUS…), the drive controllers of the IndraDrive range provide an interface for analog master communication (analog interface). This allows assigning an analog command value to a drive parameter (e.g. "S-0-0036, Velocity command value").

The figures below illustrate the structure of drive solutions with analog interface and open-loop or closed-loop operation.

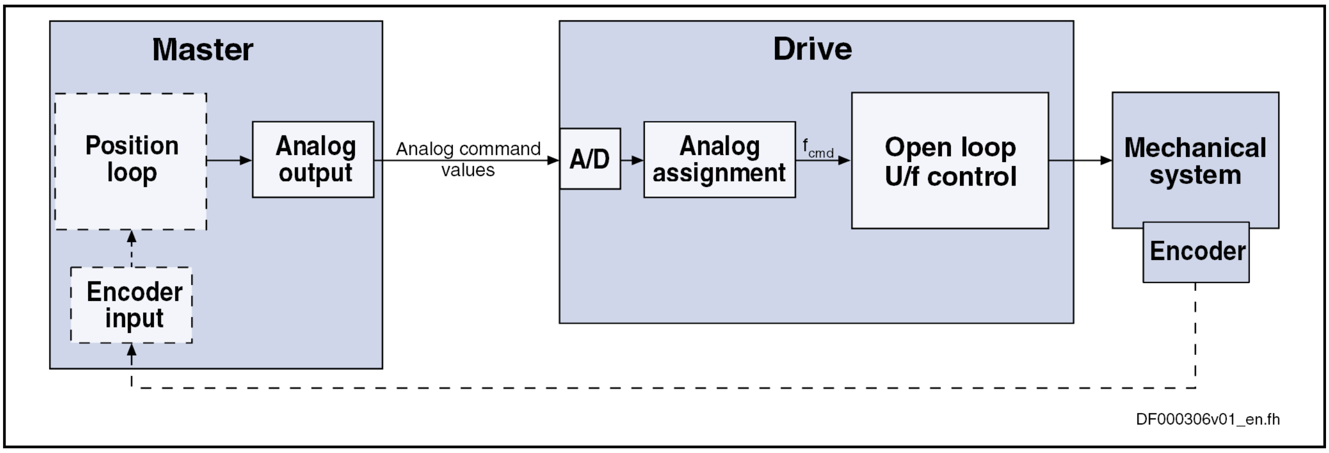


Fig.4-36: Open-Loop Operation With Analog Interface (with Optional Position Feedback to Open-Loop Control)

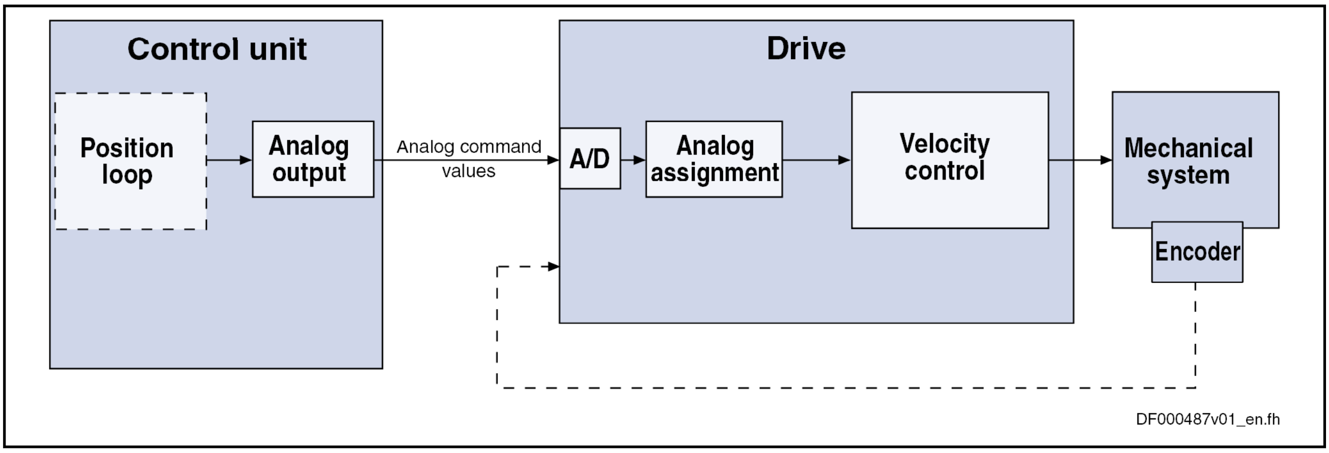


Fig.4-37: Closed-Loop Operation with Analog Interface (with Analog Command Value Input and SSI Emulation)

This section describes the basic functions of the analog interface and contains notes on commissioning and parameterization. The single function used, "Analog inputs", is described separately.

See also "Analog inputs"

Features

The analog interface is an interface for master communication with analog command values and digital I/Os (drive enable, Drive Halt...).

Features of the **analog inputs**:

- Analog inputs (14 bit) which can be assigned to parameters, with smoothing to be set (number of analog inputs depending on control section design)

- Sampling of the analog inputs in the position loop clock $T_{position}$ (see "Performance Data"

Features of the **analog assignment**:

- Two assignments to parameters are possible; offset and scaling of the analog input can be set for each assignment
- Sampling rates for analog input assignment:
  – Assignment channel A → assignment in position loop clock $T_{position}$
  – Assignment channel B → assignment in clock of 2 ms

Features of the **digital inputs/outputs**:

- Digital control and status information determined via configuration of the digital inputs of the control section:
  – **Digital control inputs** for analog master communication:
    – Signals "drive enable" and "Drive Halt"
    – Zero switch, limit switch (+/-); clearing errors and E-Stop
  – **Digital status outputs** for analog master communication:
    – Ready and warning output
    – Relay output for readiness for operation

Hardware Requirements

There are no hardware dependencies. However, for analog operation, the master communication must be deactivated.

The Multi-Ethernet interface can still be used for Engineering and diagnostic purposes.

Pertinent Parameters

Control and status parameters:

- P-0-0115, Device control: Status word
- P-0-0116, Device control: Control word
- P-0-4028, Device control word

Digital inputs/outputs:

- P-0-0300, Digital inputs, assignment list
- P-0-0301, Digital inputs, bit numbers
- P-0-0303, Digital inputs, input image of device
- P-0-0304, Digital outputs, output image of device
- P-0-0306, Digital inputs, assignment connector and pin
- P-0-0307, Digital inputs, input image sub-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

Analog inputs:

- P-0-0210, Analog input 1
- P-0-0212, Analog input, list of assignable parameters
- P-0-0213, Analog input, assignment A, target parameter
- P-0-0214, Analog input, assignment A, scaling per 10V full scale
- P-0-0215, Analog input, assignment A, signal value at 0V

- P-0-0216, Analog input, assignment A, dead zone
- P-0-0217, Analog input 1, time constant input filter
- P-0-0218, Analog input, control parameter
- P-0-0219, Analog input, maximum value for adjustment
- P-0-0220, C2800 Analog input adjustment command
- P-0-0236, Analog input, assignment B, target parameter
- P-0-0237, Analog input, assignment B, scaling per 10V full scale
- P-0-0238, Analog input, assignment B, signal value at 0V
- P-0-0239, Analog input, assignment B, dead zone
- P-0-3901, Adjustment values of control section

4.3 Motor, Mechanical Axis System, Measuring Systems

4.3.1 Safety Instructions

⚠ 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 safety fence, safety guard, protective covering, light barrier).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- In addition, observe the safety message "Protection Against Dangerous Movements" in the chapter "Safety Instructions for Electric Drives and Controls".

4.3.2 General Information on Operation of Motors With IndraDrive

Basics on the Motors to be Controlled

Brief Description

With the controllers of the IndraDrive range it is possible to control both synchronous motors and asynchronous motors.

Types of Construction

The following types of construction are possible:

- Rotary motors
- Linear motors

Both types can be used in housing design (motor with an output shaft that includes the bearing) or in kit design (stator and rotor as individual components).

Thermal Monitoring

When IndraDrive is used, the controlled motors are protected against thermal damage when they are provided with a temperature sensor connected to the controller. The controllers are equipped for evaluating the following temperature sensors:

- NTC thermistor K227 (manufacturer: Siemens)
- PTC thermistor KTY84 (manufacturer: Siemens)
- Thermal switch SNM150DK (manufacturer: Thermik)

In addition, it is possible to evaluate temperature sensors not listed above, but their specific resistance characteristics have to be entered manually!

Diagnostic Data of Motor Operation

The firmware provides the option to collect dynamic operating data of the motor and store it (operating hours counter, thermal and mechanical operating data, operational performance).

Adjusting Motor/Controller

The IndraDrive controllers are adjusted to the motor to be controlled by providing or inputting the motor-specific data.

- In the case of **Rexroth motors**, this can be done without any problem, because the manufacturer provides a specific data set for adjusting each motor type. The data are documented by the manufacturer as parameter values, stored and made available in motor-specific parameters.
- In the case of **third-party motors**, it is necessary to check, by means of the motor data and the data of the possibly available motor encoder, whether they are basically suited for operation with IndraDrive. The parameter values for adjusting the controller have to be specifically determined for each motor.

☞ Rexroth motors, by motor-specific parameter values made available and temperature evaluation adjusted in an optimum way, guarantee easy commissioning, full drive performance and a high degree of operational safety!

Motor Holding Brakes

IndraDrive allows controlling and monitoring holding brakes that are mechanically connected to the motor:

- Electrically releasing brakes (self-holding)
- Electrically holding brakes (self-releasing)

Hardware Data

For the electrical connection of the motors to the controller, see the Project Planning Manuals for the IndraDrive controllers. A complete connection diagram for the use of Rexroth motors is contained in the respective Project Planning Manual.

Pertinent Parameters

Motor parameters:

- S-0-0109, Motor peak current
- S-0-0111, Motor current at standstill
- S-0-0113, Maximum motor speed
- S-0-0141, Motor type
- P-0-0018, Number of pole pairs/pole pair distance
- P-0-0051, Torque/force constant
- P-0-0510, Rotor inertia
- P-0-0640, Cooling type
- P-0-4014, Type of construction of motor
- P-0-4048, Stator resistance

Synchronous motor parameters:

- P-0-4016, Direct-axis inductance of motor
- P-0-4002, Charact. of quadrature-axis induct. of motor, inductances
- P-0-4003, Charact. of quadrature-axis inductance of motor, currents
- P-0-4005, Flux-generating current, limit value
- P-0-4013, Current limit value of demagnetization

Asynchronous motor parameters:

- P-0-0532, Premagnetization factor
- P-0-4004, Magnetizing current
- P-0-0529, Scaling of stall current limit
- P-0-0530, Slip increase
- P-0-4039, Stator leakage inductance
- P-0-4040, Rotor leakage inductance
- P-0-4041, Motor magnetizing inductance
- P-0-4042, Characteristic of motor magnetizing inductance
- P-0-4043, Rotor time constant

Field-weakening range parameters:

- P-0-0533, Voltage loop proportional gain
- P-0-0534, Voltage loop integral action time
- P-0-0535, Motor voltage at no load
- P-0-0536, Maximum motor voltage

Other Motor-Relevant Parameters

In connection with the motor, there are other important parameters of the following parameter groups:

- Measuring system parameters
- Motor holding brake parameters
- Temperature sensor parameters
- Motor temperature model parameters
- Default control loop parameters

Motor Temperature Monitoring

Brief Description

See "Basics on the Motors to be Controlled"

Pertinent Parameters

- S-0-0201, Motor warning temperature
- S-0-0204, Motor shutdown temperature
- S-0-0383, Motor temperature
- P-0-0512, Temperature sensor
- P-0-0513, Temperature sensor characteristic

Pertinent Diagnostic Messages

- E2021 Motor temperature outside of measuring range
- E2051 Motor overtemp. prewarning
- F2019Motor overtemperature shutdown
- F2021Motor temperature monitor defective

4.3.3 Rexroth Motors

Basics on the Rexroth Motors

Brief Description

Classification

In the "Electric Drives and Controls" technology field, Rexroth offers a wide range of motors for equipping machines and installations with drives.

Due to their types of construction, Rexroth electric motors can be divided into:

- Housing motors with output shaft and flange or mounting supports
- Kit motors to be installed in machines and installations; consisting of individual components that are mounted to a moving and a static part of the mechanical system

Adjusting Motor/Controller

The controllers can be adjusted to Rexroth motors without any problem because the manufacturer provides the respective data set for each motor type. These data are available as parameter values.

- In the case of housing motors with data memory in the motor encoder, the parameter values are delivered as an integral part of the motor. At the initial commissioning they are automatically loaded to the controller.
- In the case of kit motors (individual components) and housing motors without data memory in the motor encoder, the respective motor parameters are not supplied with the motor. They can be easily loaded to the controller, however, from a database in the "IndraWorks Ds/D/MLD" commissioning tool.

The motor parameter values determined by the manufacturer guarantee that the motor can be loaded in accordance with its operating characteristic, if the required current and the corresponding power are provided by controller and supply unit.

The motor-specific parameter values of Rexroth motors can be loaded into the controller in different ways:

- Automatically for housing motors with encoder data memory
- Supported by a database for kit motors when using the commissioning tool "IndraWorks Ds/D/MLD"
- File-supported by loading a drive parameter set
- Manually by entering the parameter values based on a motor-specific data list

For automatic, database supported and file supported loading procedures, the motor-specific parameter values are written into a memory area of the controller that maintains the data unchanged, similar to a conventional "type plate". The data, which is converted depending on the scaling, is copied from this "type plate" memory area into the parameters active in the control. For manual input, the parameters of the "type plate" memory area should be described.

Thermal Motor Monitoring

Rexroth motors are thermally monitored by the controller and protected against overheating. To do this the current motor temperature is determined by thermo sensors installed in the motor winding. Depending on temperature thresholds that can be set, the controller generates a warning or switches the motor off.

☞ Due to the availability of motor parameters and perfectly adjusted temperature evaluation, Rexroth motors guarantee easy commissioning, full drive performance and a high degree of operational safety!

Measuring System

As a standard, Rexroth housing motors are equipped with a position measuring system. The individual motor series have different measuring systems which allows offering cost-efficient motors depending on the application.

The following measuring systems of Rexroth housing motors are supported by this firmware.

- Encoders with sine signals and HIPERFACE® interface (1 Vpp)
- Encoders with sine signals and EnDat2.1 interface (1 Vpp)

- Encoders with sine signals (1 Vpp)
- Encoders of MSM motors with digital interfaces

Various encoder systems can be used together with Rexroth kit motors:

- Encoders with sine signals and EnDat2.1 interface, 1Vpp, Heidenhain standard
- Encoders with sine signals and HIPERFACE® interface (1 Vpp) as long as the encoder is approved by Rexroth (seeFAQ_IndraDrive_HIPERFA-CEEncoder)
- Encoder with sine signals, 1Vpp, Heidenhain standard
- Encoder with square-wave signals, TTL, Heidenhain standard

Pertinent Parameters

The "type plate" contains the parameters listed below, among others. The parameters, which are converted depending on the scaling, are copied into the parameters active in the control (see "Pertinent Parameters" under "Basics on the Motors to be Controlled").

General motor parameters:

- P-0-2109, Motor peak current, type plate
- P-0-2111, Motor current at standstill, type plate
- P-0-2113, Maximum velocity of motor, type plate
- P-0-2141, Motor type, type plate
- P-0-3000, Module code of motor, type plate
- P-0-3002, Number of pole pairs/pole pair distance, type plate
- P-0-3003, Rotor inertia, type plate
- P-0-3005, Torque/force constant, type plate
- P-0-3007, Stator resistance, type plate
- P-0-3008, Commutation offset, type plate

Synchronous motor parameters

- P-0-3016, Direct-axis inductance of motor, type plate
- P-0-3017, Quadrature-axis inductance of motor, type plate
- P-0-3018, Charact. quadr.-axis induct. of motor, induct., type plate
- P-0-3019, Charact. quadr.-axis induct. of motor, currents, type plate
- P-0-3015, Flux-generating current, limit value, type plate
- P-0-3023, Current limit value of demagnetization, type plate
- P-0-3008, Commutation offset, type plate

Asynchronous motor parameters

- P-0-3032, Premagnetization factor, type plate
- P-0-3014, Magnetizing current, type plate
- P-0-3029, Scaling of stall current limit, type plate
- P-0-3039, Stator leakage inductance, type plate
- P-0-3040, Rotor leakage inductance, type plate
- P-0-3041, Motor magnetizing inductance, type plate
- P-0-3042, Characteristic of motor magnetizing inductance, type plate
- P-0-3043, Rotor time constant, type plate

Field-weakening range parameters

- P-0-3033, Voltage loop proportional gain, type plate

- P-0-3034, Voltage loop intergral action time, type plate
- P-0-3035, Motor voltage at no load, type plate
- P-0-3036, Maximum motor voltage, type plate

Parameters for measuring system:

- P-0-1000, Kind of encoder 1, encoder memory
- P-0-1001, Encoder 1 resolution, encoder memory

Only for absolute encoders (multi-turn):

- P-0-1002, Absolute encoder offset 1, encoder memory

Parameter for motor holding brake (if available):

- P-0-3010, Torque of motor holding brake, type plate

Default control loop parameters:

- P-0-2100, Velocity loop proportional gain, type plate
- P-0-2101, Velocity loop integral-action time, type plate
- P-0-2104, Position loop Kv-factor, type plate
- P-0-2106, Current loop proportional gain 1, type plate
- P-0-2107, Current loop integral-action time 1, type plate
- P-0-3004, Speed controller smoothing time constant, type plate

☞ At a command, default control loop parameters can be loaded to the controller. They are useful starting values for further control loop optimization.

Pertinent Diagnostic Messages

- C0700 Load defaults proced. command (motor-spec. controller val.)
- C0702 Default parameters not available
- C0703 Default parameters invalid
- C0704 Parameters not copyable
- C0706 Error when reading the controller parameters
- F2008RL The motor type has changed.
- F2104Commutation offset invalid

Rexroth Housing Motors

Rexroth Housing Motors With Encoder Data Memory

Motor Lines

The following Rexroth housing motors that are supported by this firmware are equipped with encoder data memory.

- MSK, MSP, MSM
- MAD, MAF

Brief Description

See the section "Basics on the Rexroth Motors"

Pertinent Parameters

See "Pertinent Parameters" in the section "Basics on the Rexroth Motors"

In addition to the parameters listed above there are other parameters for the data transfer from the encoder data memory into the parameter memory of the controller (administration parameters that users cannot interpret, the number of which depends on the number of encoder interfaces present):

- P-0-1031, Content of encoder memory optional slot 1

- P-0-1032, Content of encoder memory optional slot 2
- P-0-1033, Content of encoder memory optional slot 3
- P-0-1034, Content of encoder memory optional slot 4

Pertinent Diagnostic Messages

See "Pertinent Diagnostic Messages" in the section "Basics on the Rexroth Motors"

Notes on Commissioning

Initial Commissioning

In the case of Rexroth housing motors with encoder data memory, the values for the motor parameters stored in the encoder, the measuring system parameters and, where required, the motor holding brake parameters are automatically loaded to the "type plate" parameters of the controller when the drive is switched on.

When a drive is commissioned for the first time, first the error message "F2008 RL The motor type has changed." appears. This message only means that this motor has not yet been connected to the controller.

By clearing this error message (reset via control panel or command "S-0-0099, C0500 Reset class 1 diagnostics"), the command "S-0-0262, C07_x Load defaults procedure command" is automatically started. In this way, default control loop parameter values for this motor are loaded from the "type plate" parameters into the active parameters of the controller.

☞ With the command C07_x Load defaults procedure command (S-0-0262), depending on the setting in "P-0-4090, Configuration for loading default values", the following parameter values are loaded:

- default control loop parameter values (default setting)
- Default values of the firmware (factory settings)

In the case of motors with integrated holding brake, the type of motor holding brake and the activation of the brake control is automatically set in "P-0-0525, Holding brake control word".

In the case of motors with several cooling type variants (MSK), the load data can be referred to the cooling type realized by entering the corresponding value in "P-0-0640, Cooling type".

Recommissioning

During servicing the motor can be replaced by a motor of the same type without any problem. The adjustment to the controller does not need to be repeated. In the case of an absolute motor encoder, it is only necessary to make an adjustment to the machine axis by establishing the position data reference.

If the motor type connected to the controller has changed, the controller signals this with "F2008 RL The motor type has changed." and requests the default values of the control loop parameters and the motor type parameter to be loaded. In the case of a desired motor change, initial commissioning of the new axis motor is necessary. Otherwise, there is an assembly error that has to be corrected!

Diagnostic Messages

In connection with the loading and verifying of parameter values from the encoder data memory, the following messages might possibly be generated:

- When the default control loop parameter values and the motor-specific parameters are loaded

  → C07_0 Command for loading default values
- If the parameter values in the encoder data memory cannot be read

→ C0706 Error when reading the controller parameters

- If the motor type connected to the controller has changed

  → F2008 RL The motor type has changed.

- If an invalid value for the commutation offset is contained in the encoder memory

  → F2104 Commutation offset invalid

Rexroth Housing Motors Without Encoder Data Memory

Motor Lines

The following Rexroth housing motor supported by this firmware does not have encoder data memory:

- MAL

Brief Description

See the section "Basics on the Rexroth Motors"

Pertinent Parameters

See "Pertinent Parameters" in the section "Basics on the Rexroth Motors"

Pertinent Diagnostic Messages

See "Pertinent Diagnostic Messages" in the section "Basics on the Rexroth Motors"

For further information, see the section "Basics on the Rexroth Motors"

Rexroth Kit Motors

General Information

Kit motors consist of individual components that are mounted to a moving and as static part of the machine's mechanical system and functionally put together to form a motor.

A kit motor consists of the following components:

- Electrically active part with thermo sensor
- Electrically passive part
- Measuring System
- storage

The electrical parts of the kit motor are supplied by Rexroth, the measuring system and the bearing are provided on the machine side.

Rexroth kit motors are built according to the functional principles associated with "asynchronous motors" or "synchronous motors". With regard to control, the functional principles have different requirements:

- In the case of synchronous motors, the current in the windings of the stator must have a fixed allocation to the permanent magnetic field of the rotor so that the maximum torque or the maximum force is generated.
- In the case of asynchronous motors there is no fixed allocation between stator and rotor required in order to generate the maximum torque or the maximum force.

Rexroth Kit Motors, Synchronous

Brief Description

The following Rexroth kit motors are manufactured according to the functional principle "synchronous motor":

- Linear motor MLF
- Rotary motors MBS and MBT

As the motor is assembled in the machine, stator, rotor and measuring system can only be put together on site. The electric-magnetic-mechanical allocation of the synchronous motor is therefore only to be made on site. This is done by determining and setting the commutation offset.

The measuring system should be realized with high resolution and as a motor encoder to be evaluated in absolute form (see also "Absolute Measuring Systems"). If it is necessary to use an incremental measuring system, using encoders with square-wave signals should be avoided!

Determining the Commutation Offset

The commutation offset can be determined with different methods. The method is chosen in accordance with the axis geometry, the practicability and the chances of success of the respective method depending on the mechanical axis system:

- **Measuring method** for motor encoders that can be evaluated in absolute form

  → Distance measurement, currentless (only possible for Rexroth linear kit motors)
- **Saturation method** (axis needs to be blocked or at standstill)

  → With current (possible with all types of construction in combination with motor encoders that can be evaluated in absolute form or with relative motor encoders)
- **Sine method** (requires unrestricted movement of axis)

  → With current (possible with all types of construction in combination with motor encoders that can be evaluated in absolute form or with relative motor encoders)

In the case of absolute measuring systems, the commutation offset only has to be determined once (at initial commissioning), in the case of incremental measuring systems this has to be done each time the drive is switched on again!

Description of the method for commutation setting, see "Drive Control: Commutation setting"

Pertinent Parameters

See "Pertinent Parameters" in the section "Basics on the Rexroth Motors"

Pertinent Diagnostic Messages

See "Pertinent Diagnostic Messages" in the section "Basics on the Rexroth Motors"

For further information, see the section Basics on the Rexroth Motors

Rexroth Kit Motors, Asynchronous

Brief Description

The following Rexroth kit motors are manufactured according to the functional principle "asynchronous motor":

- Rotary motors 1 MB

As the motor is assembled in the machine, stator, rotor and measuring system can only be put together on site. After loading the specific parameter values for motor and measuring system the assembled motor can be put into operation independent of rotor position and allocation of the measuring system.

The measuring system should be realized with high resolution! Avoid using encoders with square-wave signals!

Pertinent Parameters

See "Pertinent Parameters" in the section "Basics on the Rexroth Motors"

Pertinent Diagnostic Messages

See "Pertinent Diagnostic Messages" in the section "Basics on the Rexroth Motors"

For further information, see the section Basics on the Rexroth Motors

4.3.4 Third-Party Motors at IndraDrive Controllers

General Information on Third-Party Motors

Today, machine axes are mainly moved with electric drives. Motors of standard design are used in most cases, as this is the most cost-efficient solution.

Special Requirements

Due to special requirements at machine axes, constructional or safety-related aspects, it may be necessary for the machine manufacturer to use a motor construction diverging from the standard.

Motor Design not Included in Product Range

For these cases there is the demand on the drive supplier to realize, apart from the deliverable standard drive consisting of (standard) motor, controller, cable and, if required, machine control section, drives with motors that are not included in his own product range due to the special design.

With Rexroth controllers of the IndraDrive range, it is also possible to control third-party motors.

Checking Whether Third-Party Motors Can be Controlled

For successfully and fail-safely controlling a third-party motor, it is necessary to check beforehand

- whether the third-party motor to be controlled meets the requirements of the controller,
- whether the third-party motor has the required minimum inductance,
- whether the mounted position measuring system can be evaluated by the controller or which position measuring system can be selected for kit motors,
- whether the motor can be protected against inadmissible temperature rise in the case of overload,
- which controller, including supply, is suitable due to the motor power to be delivered.

How to do Project Planning?

The requirements relevant in the system combination are documented in the Project Planning Manual of the drive system.

The filled out "forms for the required manufacturer's motor data" are to be made available for the motor suitability test!

See the documentation "Rexroth IndraDrive Drive System, Project Planning Manual" (DOK-INDRV*-SYSTEM*****-PR**-EN-P; part no.: R911309636)!

How to Commission?

First, the motor parameter values must be determined (see the section "Determining the Parameter Values for Motor and Motor Control"). The parameter values of motor control are calculated by command internally in the firmware.

The determined motor parameter values are to be documented in the forms included in the section "Forms for Parameter Values".

4.3.5 Motor Holding Brake

Monitoring the Brake Current

Brief Description

Fields of Application

Base package of all firmware variants in **open-loop and closed-loop** characteristic

Background

Particularly with vertical servo axes, the reliable function of a holding brake is fundamentally important to the operational safety of a machine. The "Function Check of Motor Holding Brake" can be used to check the holding brake for wear and corrosion; however, the use of this function check is left to the user.

Even with a cyclical function check, wire break that occurs in the meantime would lead to undesirable closing and possibly destruction of the brake before the functional fault could be recognized in the next function check. Between the function check intervals, the monitoring of the brake current, which is always active, recognizes faults with the holding brake control and draws attention to them immediately.

Overview of Functions

Operating Principle

The controller monitors the current that flows through the terminals on the controller side to operate the brake. The brake current monitoring recognizes these states:

- Wire break (brake current less than 100 mA)
- Brake current ok
- Short circuit

In case of "wire break" or "short circuit", the error message "F2068, Brake error" is generated. The monitoring is active as soon as an existing holding brake is entered in "P-0-0525, Holding brake control word".

☞ The wire break monitoring can be deactivated, e.g. in case of brake control via relays.

The status of the monitoring of the holding brake current is displayed in "P-0-0539, Holding brake status word"; for IndraDrive, the measured holding brake current is displayed in "P-0-0527, Actual holding brake current".

☞ For HCQ, holding break current output is not possible!

Hardware Requirements

No special hardware is required to use the function "brake current monitoring"!

For Rexroth motors with encoder data memory, the presence of a motor holding brake is automatically recognized; brake current monitoring is automatically activated. To activate the function for third-party motors and motors with external holding brakes, the presence of a holding brake must be entered in the holding brake control word.

Pertinent Parameters

- P-0-0525, Holding brake control word
- P-0-0539, Holding brake status word

- P-0-0527, Actual holding brake current

Pertinent Diagnostic Messages

- F2068, Brake error

Operating Behavior of the Motor Holding Brake

Brief Description

Motor holding brakes are used to hold axes with drive enable having been switched off. This is particularly important for non-equilibrated vertical axes. With IndraDrive controllers it is possible to control and monitor motor holding brakes in a wear-resistant way.

NOTICE	**Holding brakes at Rexroth motors normally aren't designed for decelerating when in operation. Increased wear caused by deceleration in operation can destroy the holding brake at an early stage!**

The following motor holding brake types are possible:

- Electrically releasing brakes (self-holding) for servo drives
- Electrically holding brakes (self-releasing) for main drives

The motor holding brake can be directly mounted on the motor shaft, e.g. in the case of Rexroth housing motors, or directly connected to the mechanical axis system, e.g. in the case of linear kit motors.

IndraDrive controllers include application-specific controls of the holding brake in order to minimize wear of the brake in the case of error. The following two functional principles of holding brake control are supported:

- Control of holding brake **for servo drives**
- Control of holding brake **for main drives**

Control of the holding brake is linked with drive enable, considering holding and releasing delays. In special cases it may be appropriate to avoid this programmed link and release or apply the holding brake independently. This, too, is possible with IndraDrive!

Hardware Requirements

The motor holding brake is controlled via a controller-internal relay contact. Power supply is realized by the controller via the 24V control voltage. The holding brake must be suited for the voltage that is output, the holding brake current is not permitted to exceed the allowed maximum value of the respective device (see documentation ""Supply Units and Power Sections; Project Planning Manual for Controllers"), or if necessary the holding brake has to be controlled separately.

☞ The optionally available holding brakes for Rexroth motors can be directly controlled via the controller!

Pertinent Parameters

- S-0-0206, Drive on delay time
- S-0-0207, Drive off delay time
- S-0-0273, Maximum drive off delay time
- P-0-0525, Holding brake control word
- P-0-0539, Holding brake status word
- P-0-0540, Torque of holding brake

- P-0-0542, C2000 Command Release holding brake
- P-0-0543, C3800 Command Apply holding brake

Pertinent Diagnostic Messages

- C2000Command Release motor holding brake
- C2001Command not enabled
- C3800Command Apply motor holding brake
- F6024Maximum braking time exceeded

Function Check of Motor Holding Brake, Drive-Controlled

Brief Description

If the braking torque of holding brakes is too low due to wear and corrosion, this can interrupt the service and endanger safety in machines and installations. IndraDrive controllers have the advantage of monitoring the effectiveness of the holding brake upon a command of the control master and recording the monitoring intervals.

This allows cyclic brake check according to EN-954-1, cat. 2 or dynamization/check of one of two redundant holding systems according to EN-954-1, cat. 3.

In the case of corrosion, the effectiveness of the holding brake can be reestablished by a drive-controlled "resurfacing procedure".

Pertinent Parameters

- P-0-0525, Holding brake control word
- P-0-0539, Holding brake status word
- P-0-0540, Torque of holding brake
- P-0-0541, C2100 Holding system check command
- P-0-0544, C3900 Command Holding brake resurfacing
- P-0-0545, Test torque for releasing holding system
- P-0-0546, Starting torque for releasing holding system
- P-0-0547, Nominal load of holding system
- P-0-0549, Oper. hours control sec. at last succ. holding system check
- P-0-0550, Time interval holding system check
- P-0-0554, Current torque value of the motor holding brake
- S-0-0084, Torque/force feedback value
- S-0-0135, Drive status word

Pertinent Diagnostic Messages

- C2100Command Holding system check
- C2101Holding system check only possible with drive enable
- C2103Holding brake: Torque too low
- C2104Command execution impossible
- C2105Load of holding system greater than test torque
- C2106Test torque of holding system not reached
- C3900Command Holding brake resurfacing
- C3901Resurfacing of holding brake only possible with drive enable
- C3902Error during resurfacing of holding brake
- C3903Command execution impossible
- E3115 Prewarning, end of brake check time interval
- F3115Brake check time interval exceeded

4.3.6 Measuring Systems

Basics on Measuring Systems, Resolution

Brief Description

Control Loops and Measuring Systems

Operating drives in the closed control loop requires measuring systems in order to metrologically acquire the current status of the physical value to be controlled, the so-called actual value.

The following drive control loops are distinguished:

- Torque/force control loop

  → Actual value by evaluating the current measuring system and converting the value
- Velocity control loop

  → Actual value by evaluating the position measuring system and time-derivation
- Position control loop

  → Actual value by evaluating the position measuring system

The actual value of the torque/force control loop is generated by means of the internal current measurement. The measuring system is inaccessible for the user and has a fixed configuration.

Possibilities of Position Measuring

For acquiring the actual values of the velocity and position control loop there are position measuring systems available that provide the user possibilities of configuration. Position measurement can be carried out:

- At the motor only (measurement via motor encoder)

- or -

- Both at the motor and at the mechanical axis system (measurement via motor encoder and "external" or "optional" encoder).

☞ Position measurement via motor encoder is always required, measurement at the mechanical axis system is optional, the encoder at the mechanical axis system is therefore called "optional encoder". It is also called "external encoder" because this encoder is not installed internally at the motor, but externally at the axis.

Types of Position Measuring Systems

Position measuring systems are available for the different kinds of motion in adapted types of construction:

- Rotary encoders
- Linear encoders

With the appropriate signal specification, encoders in both types of construction can be evaluated by IndraDrive controllers.

Evaluating Position Measurement

Depending on their design and the mechanical arrangement at the axis, the position encoders can be evaluated as

- relative encoders (incremental encoders)
- Absolute encoders (absolute value encoders).

The position information of the encoder can be embodied as

- two analog voltage signals with sinusoidal profile at constant speed and a 90° phase offset ("analog encoder")
- digital encoder signal with defined number of increments per encoder revolution ("digital encoder")

Brief Functional Descriptions

Relative Position Measurement

In the case of relative position measurement, only position differences can be evaluated by means of the measuring system. The actual position values signaled by the measuring system refer to the (mostly undefined) position at the time the drive is switched on. To operate the drive within a limited travel range a position reference must be established ("homing") after each time the drive is switched on again.

Absolute Position Measurement

In the case of absolute position measurement, the encoder signals actual position values with a fixed encoder-dependent reference point to the controller. After each time the drive is switched on the correct actual position value is immediately available with each axis position. Due to the mostly undefined mounting situation of the encoder to motor or mechanical axis system, it is necessary to determine the position offset ("setting the absolute value") once at the initial commissioning.

Precision, Resolution

The precision of the position measurement depends on:

- the resolution of the measuring system (division periods (DP) for analog encoders; increments/revolution for digital encoders)
- the absolute encoder precision
- the digitalization quality for analog encoder signals
- the dimension of the travel range of the axis

Monitoring Functions

Correct position information is of fundamental importance for reliable drive behavior and motion according to contour. The encoder signals are therefore monitored for validity and compliance with the allowed tolerances.

In addition, it is possible to monitor drives with an encoder that can be evaluated in absolute form for compliance with the position when switching on compared to the last time the drive was switched off.

It is also possible to monitor the difference between the actual position values of motor encoder and external encoder.

See also "Monitoring the Measuring Systems"

Hardware Requirements

For connecting the measuring systems to the controller there are two optional interfaces available. The parameters "P-0-0077, Assignment motor encoder->optional slot" and "P-0-0078, Assignment optional encoder->optional slot" define the interface to which the respective encoder is connected.

See also the documentation "Rexroth IndraDrive Cs, Drive Systems" and "Rexroth IndraDrive HCQ, Drive Systems"

The following points apply to the parameters P-0-0077 and P-0-0078:

- For motors with motor encoder data memory, the value for parameter P-0-0077 is automatically set correctly.
- For motors without motor encoder data memory (e.g. Rexroth kit motors), the value for parameter P-0-0077 must be set manually.
- In the case of optional encoders, the value for parameter P-0-0078 has to be set manually, too.

Pertinent Parameters

- S-0-0051, Position feedback value 1
- S-0-0053, Position feedback value 2
- S-0-0115, Position feedback 2 type
- S-0-0116, Resolution of feedback 1

- S-0-0117, Resolution of feedback 2
- S-0-0256, Multiplication 1 (motor encoder)
- S-0-0257, Multiplication 2 (optional encoder)
- S-0-0277, Position feedback 1 type
- S-0-0278, Maximum travel range
- P-0-0074, Encoder type 1 (motor encoder)
- P-0-0075, Encoder type 2 (optional encoder)
- P-0-0129, Internal position data format

Monitoring the Measuring Systems

Brief Description

Monitoring the Encoder Signals

Correct position information is the prerequisite for reliable drive behavior and motion according to contour. In order to guarantee best possible position evaluation the encoder signals are therefore monitored for validity and compliance with the allowed tolerances.

Monitoring the encoder signals allows detecting faulty states, such as:

- Encoder is dirty
- Noise injection in the case of inappropriate wire routing or wire design
- Exceeding the max. allowed encoder velocity (limit frequency of the encoder signals)
- Wire break or short circuit on wire

Monitoring the Axis Position when Switching On

In addition it is possible to monitor drives with an encoder that can be evaluated in absolute form for compliance with the position when switching on compared to the last time the drive was switched off. This allows detecting, for example, whether a vertical axis moved down after the machine was switched off or whether an axis was moved away from the position it had when the machine stopped.

Monitoring Mechanical Transfer Elements

It is also possible to monitor the difference between the actual position values of motor encoder and external encoder as well as percentage of slip. This allows, for example, detecting elasticity or slip due to wear in mechanical transfer elements between motor and axis at an early stage.

Monitoring the Position Data Reference

If the loss of the position data reference of absolute encoders (motor encoder or optional encoder) is detected due to changes in parameter values, e.g. of the mechanical drive system, the drive will signal this faulty status.

Pertinent Parameters

- S-0-0391, Monitoring window feedback 2
- P-0-0095, Absolute encoder monitoring window for motor encoder
- P-0-0096, Absolute encoder monitoring window for opt. encoder
- P-0-0177, Absolute encoder buffer 1 (motor encoder)
- P-0-0178, Absolute encoder buffer 2 (optional encoder)
- P-0-0185, Control word of encoder 2 (optional encoder)
- P-0-0391, Actual position value difference encoder1 - encoder2

Pertinent Diagnostic Messages

- E2074 Encoder 1: Encoder signals disturbed
- E2075 Encoder 2: Encoder signals disturbed
- F2036Excessive position feedback difference
- F2042Encoder 2: Encoder signals incorrect
- F2048Low battery voltage

- F2074Actual pos. value 1 outside absolute encoder window
- F2075Actual pos. value 2 outside absolute encoder window
- F2174Loss of motor encoder reference
- F2175Loss of optional encoder reference
- F8022Enc. 1: Enc. signals incorr. (can be cleared in ph. 2)

Absolute Measuring Systems

Brief Description

Evaluating Position Measurement

Depending on their design and the mechanical arrangement at the axis, position encoders can be evaluated by IndraDrive controllers as

- relative encoders (incremental encoders)

or as

- absolute encoders (absolute value encoders)

if they have the required signal specification.

Rexroth position encoders and motor encoders of Rexroth housing motors are available in one of the two designs:

- Single-turn encoders (absolute actual position values over one encoder shaft revolution)
- Multi-turn encoders (absolute actual position values over 4096 encoder shaft revolutions).

These encoders can be evaluated as absolute encoders if the travel range of the axis can be represented within the absolute actual position value range of the encoder:

- In the case of single-turn encoders within one encoder shaft revolution
- In the case of multi-turn encoders within 4096 encoder shaft revolutions

Encoders of Rexroth Housing Motors

As a standard, Rexroth housing motors are equipped with a position measuring system. The individual motor series have different measuring systems which allows offering cost-efficient motors depending on the application.

The following measuring systems are supported by this firmware:

- Motor encoder option S1 or M1: HIPERFACE® encoder, single- or multi-turn type
- Motor encoder option S2 or M2: EnDat2.1 encoder, single- or multi-turn type

Absolute Encoders for Kit Motors and External Encoders

For kit motors or directly at the mechanical axis system, the following measuring systems, that can be evaluated in absolute form, can be used:

- EnDat2.1 linear encoder (Heidenhain) or HIPERFACE® linear encoder (Stegmannn, only Rexroth authorized types or encoders with type ID "FF") for linear motors or linear axes
- Rotary EnDat2.1 encoder (Heidenhain) or rotary HIPERFACE® (Stegmannn, only Rexroth authorized types or encoders with type ID "FF") for rotary kit motors or rotary axes

Establishing Axis-Related Absolute Distance

Initially, the actual position values of an absolute encoder only relate to the encoder itself. Due to the mostly undefined mounting situation of the encoder to motor or mechanical axis system, at the initial commissioning it is necessary to determine the position offset between encoder and axis zero point once (see also "Position Data Reference: Establishing Position Data Reference for Absolute Measuring Systems").

Hardware Requirements

The signal specification of third-party encoders for position and homing signals with regard to amplitude and phase angle can be found in the documentation "Control Sections for Drive Controllers; Project Planning Manual".

☞ Rexroth encoders correspond to the required signal specification!

Pertinent Parameters

- S-0-0115, Position feedback 2 type
- S-0-0277, Position feedback 1 type
- S-0-0278, Maximum travel range
- S-0-0378, Absolute encoder range of motor encoder
- S-0-0379, Absolute encoder range of optional encoder
- P-0-0019, Initial position value

Relative Measuring Systems

Brief Description

Evaluating Position Measurement

IndraDrive controllers can evaluate the signals of both absolute and relative measuring systems, if the encoder signals correspond to the specification.

The **disadvantages** of relative encoders as opposed to encoders that can be evaluated in absolute form are as follows:

- Axes with relative position encoder must go through a homing procedure after switching on so that they can be operated in position control.
- Relative encoders are unsuitable as motor encoders for synchronous motors because each time the drive is restarted it has to go through a procedure for setting the commutation offset. Therefore, the immediate readiness for operation is not guaranteed for synchronous motors!

The **advantages** of relative encoders as opposed to encoders that can be evaluated in absolute form are as follows:

- Longer travel distances are possible for linear encoders.
- The costs of the encoder are mostly lower given equal absolute precision and number of lines or division period length.

Aspects of Use

Due to the above disadvantages, relative measuring systems are not used as motor encoders for synchronous Rexroth housing motors. For asynchronous motors there aren't any disadvantages when using relative motor encoders.

For kit motors it can be necessary, however, to use relative encoders as motor encoders if absolute encoders of the required design are not available:

- Great encoder lengths for long travel distances in the case of linear motors
- Hollow-shaft encoders with special drill diameters or encoders for high maximum speeds in the case of rotary kit motors

Establishing Axis-Related Absolute Distance

The actual position values of relative encoders first do not have any position reference. In any axis position the actual position value of the respective relative encoder, when switching the drive on, is written with the so-called initial position value, if no other encoder being in reference has been connected.

There are two ways to establish the axis-related absolute distance:

- Moving to a defined axis position with reproducible precision.

- or -

- Detecting a defined axis position by "passing" two distance-coded reference marks of the encoder.

At a defined position, the actual position value of the encoder to be homed is written with the corresponding absolute value of the axis (see "Position Data Reference: Establishing Position Data Reference for Relative Measuring Systems").

Hardware Requirements

The signal specification for position and homing signals with regard to amplitude and phase angle can be found in the documentation "Control Sections for Drive Controllers; Project Planning Manual".

Pertinent Parameters

- S-0-0115, Position feedback 2 type
- S-0-0116, Resolution of feedback 1
- S-0-0117, Resolution of feedback 2
- S-0-0165, Distance-coded reference offset A
- S-0-0166, Distance-coded reference offset B
- S-0-0277, Position feedback 1 type
- S-0-0440, Marker position feedback 1
- S-0-0441, Marker position feedback 2
- S-0-0442, Counter marker position feedback 1
- S-0-0443, Counter marker position feedback 2
- P-0-0019, Initial position value

Establishing the Position Data Reference

General Information on Establishing the Position Data Reference

Brief Description

During the initial commissioning of a drive the actual position values transmitted by the measuring systems do not yet have any reference to the machine axis. This applies to

- Relative measuring systems and
- Absolute measuring systems.

For more detailed information on relative and absolute evaluation of measuring systems, see "Absolute Measuring Systems"

Relative Measuring Systems

The position data reference of a relative measuring system to the axis has to be reestablished after each time the drive is switched on or after the position data reference is lost. For this it is necessary to move to a defined axis position and the actual position value is set to an axis-related value in a defined position (exception: For relative encoders with distance-coded reference marks movement is only required via two marks!)

Absolute Measuring Systems

The position data reference of an absolute measuring system to the axis has to be established once during initial commissioning after replacing the motor or encoder (motor encoder or external encoder) and changes in the mechanical axis system. The position data reference still is maintained and the actual position values are axis-related immediately after the drive is switched on.

Establishing the Position Data Reference, Drive-Controlled

For establishing the position data reference in a drive-controlled way, the position data reference is automatically established by the drive by master-side triggering of a command. The procedure depends on the kind of measuring system:

- In the case of a relative measuring system without distance-coded reference marks, the axis moves to the reference point or to a dedicated point and then automatically switches to axis-related actual position values.

- In the case of a relative measuring system with distance-coded reference marks, the axis moves between two reference marks and then automatically switches to axis-related actual position values.
- In the case of an absolute measuring system, the automatic switching to the axis-related actual position value is carried out with the axis in standstill.

The presettings for establishing the position data reference are made via assigned parameters.

Establishing the Position Data Reference, NC-Controlled

For establishing the position data reference in an NC-controlled way, the drive makes available three commands to the master. The master has to generate the travel motion for searching the mark:

- The master starts the command "NC-controlled homing" and for searching the reference point or dedicated point of the axis has to move the axis by inputting command values.
- To calculate the offset and switch to axis-related actual position values it is necessary to start further commands.

The presettings for establishing the position data reference are made via assigned parameters.

Displaying the Position Data Reference

A position status parameter shows whether the position data reference of a measuring system evaluated by the controller has been established.

Motor Encoder and External Encoders

In addition to the motor encoder an external (optional) encoder can be available. Both encoders, in any combination of relative and absolute measuring systems, can

- have position data reference to the axis independently of each other (both encoders have different actual position values)

- or -

- have position data reference to the axis depending on each other (both encoders have the same actual position values).

This is configured via parameters and realized with the commands for establishing the position data reference.

Actual Position Value Offset

The difference of the actual position value before and after establishing the position data reference is displayed, related to the motor encoder or external encoder, in one parameter respectively.

See also the following sections:

- "Establishing Position Data Reference for Absolute Measuring Systems"
- "Establishing Position Data Reference for Relative Measuring Systems"

Pertinent Parameters

- S-0-0115, Position feedback 2 type
- S-0-0175, Offset parameter 1
- S-0-0176, Offset parameter 2
- S-0-0277, Position feedback 1 type
- S-0-0403, Position feedback value status
- P-0-0074, Encoder type 1 (motor encoder)
- P-0-0075, Encoder type 2 (optional encoder)

Establishing Position Data Reference for Absolute Measuring Systems

Brief Description

Base package of all variants in **closed-loop** characteristic.

See also the section "General Information on Establishing the Position Data Reference"

The position data reference of an absolute measuring system to the axis has to be established once during initial commissioning, after replacing the motor or encoder (motor encoder or external encoder) and changes in the mechanical axis system.

Establishing Position Data Reference via Drive Commands

In the case of measuring systems to be evaluated in absolute form, the position data reference can be automatically established by the drive by starting the command

- "C0300 Set absolute position procedure command"

- or -

- "C0600 Drive-controlled homing procedure command".

The position data reference once established is maintained until one of the two commands is started again. The actual position values therefore are axis-related ("homed") immediately after the drive is switched on.

Motor Encoder and External Encoder

If two absolute measuring systems have been connected to the controller, the position data reference can be separately established for both measuring systems. If the position data reference was only set for one of the measuring systems, both actual position values are equal at the position at which the position data reference was established.

If the position data reference was only set for one encoder, the actual position values of both encoders remain equal as long as mechanical axis system and encoder systems are mechanically connected without slip (slip control is possible!).

"Set Absolute Measuring" Command

It is recommended to start the "Set absolute measuring" command when the axis is in standstill without drive enable. In the cases in which the axis, for establishing the position data reference, is to be brought to a defined position on the master side and be held in this position by the drive, "Set absolute measuring" can also be executed with active drive.

"Drive-Controlled Homing Procedure" Command

When the command "C0600 Drive-controlled homing procedure command" is started, without an existing reference the drive moves the axis independently as defined in parameter "S-0-0147, Homing parameter" and establishes the position data reference. If the drive position system already has a reference when the command "C0600 Drive-controlled homing procedure command" is started, the reference point already determined is approached and the commanded is acknowledged positively.

For absolute encoders, the command "Drive-controlled homing procedure" can be advantageously used after loss of position data reference after:

- encoder replacement in conjunction with a home switch or
- encoder error with peripheral causes in the case of modulo-scaled axes (e.g. encoder cable damage).

☞ "Active drive" means the drive that is in control. Drive enable (AF) has been set.

Assigning the Axis-Related Actual Position Value with "Set Absolute Measuring"

By starting the command "Set absolute measuring", the previous actual position value of an encoder at a dedicated position of the axis is set to a new value. This value is the current axis position related to the coordinate system of the machine.

The dedicated position is defined by:

- the current axis position

- or -

- the positioning of the axis at a "striking" axis position (e.g. value "0").

The required assignments and configurations for "Setting absolute measuring" are realized via parameter settings.

Assigning the Axis-Related Actual Position Value with "Drive-Controlled Homing Procedure"

By starting the command "Drive-Controlled Homing Procedure", the previous actual position value of an encoder at a dedicated position of the axis is set to a new value. This value is the current axis position related to the coordinate system of the machine.

The required assignments and configurations for the "Drive-Controlled Homing Procedure" are made using parameter settings (see the information regarding "Drive-Controlled Homing Procedure" in the section "Establishing Position Data Reference for Relative Measuring Systems").

Pertinent Parameters

- S-0-0052, Reference distance 1
- S-0-0054, Reference distance 2
- S-0-0148, C0600 Drive-controlled homing procedure command
- S-0-0447, C0300 Set absolute position procedure command
- S-0-0448, Set absolute position control
- P-0-0177, Absolute encoder buffer 1 (motor encoder)
- P-0-0178, Absolute encoder buffer 2 (optional encoder)
- P-0-1002, Absolute encoder offset 1, encoder memory
- P-0-1012, Absolute encoder offset 2, encoder memory

Pertinent Diagnostic Messages

- C0300 Set absolute position procedure command
- C0301 Measuring system unavailable
- C0302 Absolute evaluation of measuring system impossible
- C0303 Absolute encoder offset cannot be saved
- C0304 Command cannot be executed under drive enable
- C0600 Drive-controlled homing procedure command
- C0601 Homing only possible with drive enable
- C0602 Distance home switch - reference mark erroneous
- C0603 Homing impossible with optional encoder
- C0606 Reference mark not detected
- C0607 Reference cam input not assigned
- C0608 Pos. stop a. HW lim. switch not allowed f. modulo axes
- C0609 Different travel directions parameterized
- C0610 Absolute encoder offset could not be saved

Establishing Position Data Reference for Relative Measuring Systems (Homing)

Brief Description

Base package for all firmware variants in **closed loop** characteristic.

See also the section "General Information on Establishing the Position Data Reference"

Actual Position Value of Relative Measuring Systems when Switching On

After the drive is switched on the actual position values signaled by relative measuring systems do not yet have any reference to the machine axis. Measuring systems can be installed at the motor (motor encoder) and directly at the mechanical axis system (external or optional encoder).

For information on encoder arrangement and mechanical axis system see also "Mechanical Axis System and Arrangement of Measuring Systems"

The position data reference of relative measuring systems to the axis has to be established again each time after the drive was switched on or after all procedures that cause the position data reference to get lost (homing procedure).

Establishing the Position Data Reference, Drive-Controlled

After start of the respective command by the master, the drive can automatically establish the position data reference.

To do this, the drive moves the axis until the controller can detect a dedicated point. The actual position values then are automatically switched to axis reference. The presettings for the sequence for establishing the position data reference are made via assigned parameters.

Establishing the Position Data Reference, NC-Controlled

As an alternative to establishing the position data reference in a drive-controlled way, the NC ("master") can control the homing procedure.

In this case the master inputs the command values for moving the axis to the dedicated point and controls the homing procedure via commands and assigned parameters.

The NC-controlled homing procedure can be advantageous for drives with a rigid mechanical connection (e.g. for Gantry axes) because the master can input coordinated command values for the drives for the homing motion.

Dedicated Point for Establishing the Position Data Reference

The dedicated point for establishing the position data reference, in the case of linear axes, is at one end of the travel range. This allows finding the dedicated point from any axis position (situation when switched on) by moving in a defined direction. Rotary axes do not have an axis end position, the dedicated point is at a defined position within the travel range.

Reference Mark for Relative Measuring Systems

The precision with which this dedicated point is detected considerably influences the absolute precision of the axis. Apart from the signals for position detection, relative measuring systems therefore also provide a signal for exact determination of a dedicated point. This signal is called "reference mark". Depending on their type, relative measuring systems have one or several reference marks over the range of measurement.

Reference Mark and Home Switch

Especially in the case of rotary measuring systems (e.g. motor encoder) at axes moved in a linear way, the reference mark of the encoder can occur several times over the entire travel range. In this case it is required, by axis-side activation of a switch contact at the end of the travel range, to identify **one** reference mark signal. This defines an unequivocal dedicated point that can be found with reproducible precision. This switch contact is called "home switch". A possibly available travel range limit switch can be used like a home switch, too.

In addition, a reference mark signal can be identified by detecting axis blocking when positive stop at the end of the axis has been reached.

Independent of the number of reference marks over the travel range, an axis-side additional device (home switch or travel range limit switches or positive stop), is indispensable for linear axes for detecting the axis end position!

If only one reference mark occurs over the travel range in the case of rotary axes, the home switch in most cases is not required!

Dedicated Point and Reference Point of an Axis

The dedicated point identified by an encoder reference mark and, if necessary, by a home switch, in most cases is not identical to the reference point of the axis. The distance between reference point and zero point normally is determined on the machine side. Especially in the case of serial machines, this distance should be equal for axes of the same kind. The position of the dedicated point, however, is influenced by the kind of encoder arrangement and therefore differs from axis to axis.

Reference Offset

The position difference between dedicated point and reference point of the axis can be compensated by an offset value (reference offset).

See also the section "General Information on Establishing the Position Data Reference"

Pertinent Parameters

Parameters for relative measuring systems:

- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration
- S-0-0052, Reference distance 1
- S-0-0054, Reference distance 2
- S-0-0108, Feedrate override
- S-0-0147, Homing parameter
- S-0-0148, C0600 Drive-controlled homing procedure command
- S-0-0150, Reference offset 1
- S-0-0151, Reference offset 2
- S-0-0173, Marker position A
- S-0-0174, Marker position B
- S-0-0191, C1500 Cancel reference point procedure command
- S-0-0298, Reference cam shift
- S-0-0299, Home switch offset
- S-0-0349, Bipolar jerk limit
- S-0-0400, Home switch
- S-0-0403, Position feedback value status
- P-0-0153, Optimum distance home switch-reference mark

Parameters for NC-controlled homing:

- S-0-0146 C4300 NC-controlled homing procedure command
- S-0-0171, C4400 Calculate displacement procedure command
- S-0-0172, C4500 Displacement to referenced system procedure command
- S-0-0175, Offset parameter 1
- S-0-0176, Offset parameter 2
- S-0-0404, Position command value status

- S-0-0407, Homing enable
- S-0-0408, Reference marker pulse registered

Parameters for relative measuring systems, distance-coded:

- S-0-0165, Distance-coded reference offset A
- S-0-0166, Distance-coded reference offset B
- S-0-0177, Absolute offset 1
- S-0-0178, Absolute offset 2

Parameters for homing at travel range limit switches:

- P-0-0090, Travel range limit parameter
- P-0-0222, Travel range limit switch inputs

Parameters for homing at positive stop:

- S-0-0082, Torque/force limit value positive
- S-0-0083, Torque/force limit value negative
- S-0-0092, Bipolar torque/force limit value
- S-0-0124, Standstill window
- S-0-0331, Status "n_feedback = 0"
- S-0-0333, Status "T >= Tx"

Pertinent Diagnostic Messages

Diagnostic messages for drive-controlled homing:

- C0600 Drive-controlled homing procedure command
- C0601 Homing only possible with drive enable
- C0602 Distance home switch - reference mark erroneous
- C0606 Reference mark not detected
- C0607 Reference cam input not assigned

Diagnostic messages for NC-controlled homing:

- C4302Distance home switch - reference mark erroneous
- C4304Homing impossible with absolute encoder
- C4306Reference mark not detected
- C4307Reference cam input not assigned
- C4308Pos. stop a. HW lim. switch not allowed f. modulo axes
- C4400Calculate displacement procedure command

Establishing Position Data Reference for Relative Measuring Systems, Drive-controlled Homing Procedure

Brief Description

Basic Sequence of "Search for Dedicated Point"

After activation of "S-0-0148, C0600 Drive-controlled homing procedure command" the drive for searching the dedicated point moves the axis according to the reference travel direction set in "S-0-0147, Homing parameter". When the controller has detected the position of the dedicated point, e.g. by reference mark detection of the encoder selected in S-0-0147, the position data reference of the actual position values to the axis can be established.

Determining the homing appropriate procedure for the existing axis type (settings in S-0-0147) ensures that during the search for the dedicated point the axis only moves within the allowed travel range!

For information on the actual position value after establishing the position data reference for motor encoder and external encoder see the section "General Information on Establishing the Position Data Reference"

Establishing Position Data Reference for Relative Measuring Systems, NC-controlled Homing

Brief Description

Sequence of NC-Controlled Homing

For NC-controlled homing the master (NC control section) controls the homing motion for searching the dedicated point of the axis. To do this the master activates the parameter

- S-0-0146, C4300 NC-controlled homing procedure command

and presets the command value for axis motion, according to the active operation mode.

When the drive has detected the dedicated point, it informs the master of this fact and stores the position of the dedicated point. The master then completes the execution of command C4300 and afterwards activates the parameter

- S-0-0171, C4400 Calculate displacement procedure command.

The required displacement of the actual position values is now calculated in the drive controller, in order to establish the reference of the actual position value to the axis zero point.

When the displacement required for establishing the position data reference has been determined, the master completes the execution of command C4400 and then activates the parameter

- S-0-0172, C4500 Displacement to referenced system procedure command.

Drive-internally the actual position value now is changed by the calculated absolute displacement value and thereby the reference of the actual position value to the axis zero point is established. The master has to adjust its command value input to the changed actual position value, before it completes the NC-controlled homing procedure by deactivating command C4500.

Shifting the Position Data Reference for Absolute and Relative Measuring Systems (Shift Coordinate System Procedure)

Brief Description

Fields of Application

Base package of all firmware variants in **open-loop** and **closed-loop** characteristic

The existing position data reference of the measuring systems to the axis can be shifted if the respective command was activated by the master. It is possible to shift the data reference in standstill or while the axis is moving. This does not affect the position reference of the axis because it is only the actual position values output for the master that are displayed in "shifted" form. Internally the original ("non-shifted") position data reference is maintained.

Shifting the position data reference affects the motor encoder and, if available, the external encoder, independent of which encoder is the active encoder for position control. If different actual position values are valid for the encoders (both encoders possibly have position data reference independent of each other), the actual position values of both measuring systems are shifted by the same difference.

Pertinent Parameters

- S-0-0197, C3300 Set coordinate system procedure command
- S-0-0198, Initial coordinate value
- S-0-0199, C3400 Shift coordinate system procedure command
- S-0-0275, Coordinate offset value
- S-0-0283, Current coordinate offset

Pertinent Diagnostic Messages

- C3300Set coordinate system procedure command
- C3400Shift coordinate system procedure command
- C0600 Drive-controlled homing procedure command

Detecting the Marker Position

Brief Description

Base package for all firmware variants in **closed loop** characteristic.

The "get marker position" function, that is activated via the respective command, can be used for:

- Checking the correct detection of the reference mark of an incremental measuring system

- or -

- Determining the position of the reference mark in case the homing procedure is carried out by the control master. In this case, the coordinate system is switched in the master with the position information of the reference mark.

A possibly available home switch is not evaluated with this function!

Pertinent Parameters

- S-0-0173, Marker position A
- P-0-0014, C1400 Command Get marker position

Pertinent Diagnostic Messages

- C1400Command Get marker position

4.3.7 Mechanical Axis System and Arrangement of Measuring Systems

Brief Description

Motor Encoder

Controlled motor activation requires a position measuring system that measures the current rotor position or the position of the moving part as opposed to the static part of the motor.

This position measurement is required for the:

- Current control loop
- Velocity control loop
- if required, position control loop

The precision and resolution of the position measurement is decisive for the quality of the actual values, especially in the velocity and position control loop.

External Encoders

Depending on the mechanical properties of the mechanical system between driven motor shaft and machine axis it can be required to carry out the position control by means of an external position encoder (not integrated in the motor) directly at the moving part of the axis, e.g. in the case of

- mechanical system with slip,
- gear play or a low degree of stiffness of the mechanical system, etc.

The external (optional) encoder can also be used as a measuring wheel encoder (frictionally engaged on transported material).

See "Measuring wheel mode"

For information on encoder evaluation and encoder monitoring see also "Basics on Measuring Systems, Resolution" and "Monitoring the Measuring Systems"

Motor Encoders of Rexroth Housing Motors

Rexroth housing motors have integrated position measuring systems:

- EnDat2.1 encoder with 2048 increments for high precision requirements
- HIPERFACE® encoder with 128 increments for lower precision requirements

They are optionally available as

- Relative measuring system ("single-turn motor encoder")

or

- absolute measuring system ("multi-turn motor encoders", range of values ±4096 motor revolutions)

The measuring systems of Rexroth housing motors support the commissioning because the data for encoder type and resolution are stored in the encoder. They are loaded to the controller when the controller is switched on.

Motor Encoders for Rexroth Kit Motors and Third-Party Encoders

Rexroth kit motors are supplied as individual components and assembled in the machine to form the motor. It consists of a moving and a static part, the bearing and the motor encoder.

The following measuring systems can be used as a motor encoder:

- Incremental encoders with sine signals
(compatible with signal specification of Heidenhain)
- Encoders with EnDat2.1 interface from Heidenhain
- Encoder with HIPERFACE® interface from Stegmann, as long as approved by Rexroth (see automation portal (registration required): En_FAQ_IndraDrive_HIPERFACEEncoder).
- Incremental encoders with square-wave signals (compatible with signal specification of Heidenhain)

Do not use incremental encoders with square-wave signals as motor encoders. Bad drive characteristics are to be expected.

The mentioned measuring systems can be used as motor encoders for third-party kit motors and third-party housing motors.

For synchronous kit motors or synchronous third-party motors it is recommended that the measuring system used as a motor encoder can be evaluated in absolute form, so that the commutation offset of the motor must be determined only once (during initial commissioning) (see also "Absolute Measuring Systems").

Motor Encoder with Gear

Especially with rotary kit motors it is sometimes impossible to connect the motor encoder directly to the motor shaft. IndraDrive provides the possibility to evaluate a motor encoder connected via a gear.

☞ For synchronous motors in combination with a motor encoder which can be evaluated in absolute form, the advantage of setting the commutation offset only once (see above) can only be used with an encoder gear with i = "1" or when there is no encoder gear available.

Ab MPx16V04:

In two special cases, however, for synchronous motors with encoder gear and a motor that can be evaluated in absolute form (rotary encoders only) the commutation setting is performed only during initial commissioning. Then, when the drive is switched on again, it is immediately ready for operation; automatic commutation setting for initial drive enabling (AF) is not required, so it is not performed in the following cases:

Case 1, Single-turn (or multi-turn) encoder:

- if an n-fold motor revolution (n is an integer) yields exactly one encoder revolution

Case 2, Multi-turn encoder:

- if exactly one motor revolution yields an m-fold encoder revolution (m is an integer)

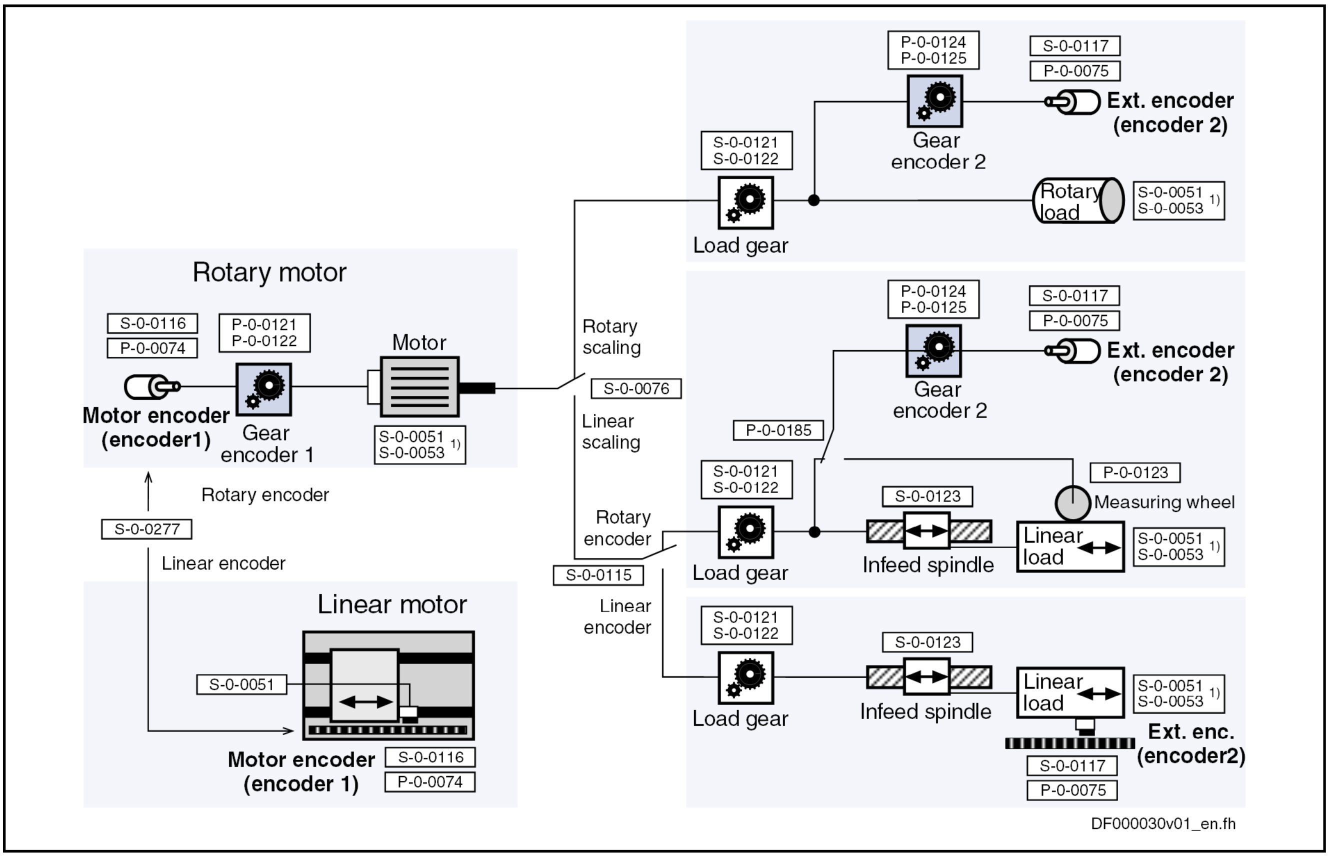
External Encoders at Machine Axes

IndraDrive controllers can evaluate the following measuring systems as external encoders:

- Incremental encoders with sine signals
  (compatible with signal specification of Heidenhain)
- Encoders with EnDat2.1 interface from Heidenhain
- Encoder with HIPERFACE® interface from Stegmann, as long as approved by Rexroth (see automation portal (registration required): En_FAQ_IndraDrive_HIPERFACEEncoder).
- Incremental encoders with square-wave signals (compatible with signal specification of Heidenhain)

Possibilities of Arranging Measuring Systems

The figure below shows an overview of arrangement possibilities of mechanical drive system and measuring systems.



1)	S-0-0051 or S-0-0053, depending on scaling (S-0-0076)
S-0-0051	Position feedback 1 value
S-0-0053	Position feedback 2 value
S-0-0076	Position data scaling type
S-0-0115	Position Feedback 2 Type
S-0-0116	Feedback 1 Resolution
S-0-0117	Feedback 2 Resolution
S-0-0121	Input revolutions of load gear
S-0-0122	Output revolutions of load gear
S-0-0123	Feed constant
S-0-0277	Position Feedback 1 Type
P-0-0074	Encoder type 1 (motor encoder)
P-0-0075	Encoder type 2 (optional encoder)
P-0-0121	Gear 1 motor-side (motor encoder)
P-0-0122	Gear 1 encoder-side (motor encoder)
P-0-0124	Gear 2 load-side (optional encoder)
P-0-0125	Gear 2 encoder-side (optional encoder)
P-0-0123	Feed constant 2 (optional encoder)
P-0-0185	Control word of encoder 2 (optional encoder)

Fig.4-38: Overview of Arrangement Possibilities of Mechanical Drive System and Measuring Systems

Hardware Requirements

For connecting the measuring systems to the controller there are 2 optional interfaces available. The parameters "P-0-0077, Assignment motor encoder->optional slot" and "P-0-0078, Assignment optional encoder->optional slot" define the interface to which the respective encoder is connected.

Pertinent Parameters

- S-0-0115, Position feedback 2 type
- S-0-0121, Input revolutions of load gear
- S-0-0122, Output revolutions of load gear

- S-0-0123, Feed constant
- S-0-0277, Position feedback 1 type
- P-0-0121, Gear 1 motor-side (motor encoder)
- P-0-0122, Gear 1 encoder-side (motor encoder)
- P-0-0123, Feed constant 2 (optional encoder)
- P-0-0124, Gear 2 load-side (optional encoder)
- P-0-0125, Gear 2 encoder-side (optional encoder)
- P-0-0185, Control word of encoder 2 (optional encoder)

4.3.8 Scaling of Physical Data

Brief Description

The controller via data maps the drive to an internal mathematical model. The status variables of the drive are determined on the basis of the following measurements:

- Position Measurement
- Current measurement
- Temperature measurement

The measured values collected in this way are converted into physical data:

- Position, velocity, acceleration and jerk data
- Current data, torque and force data
- Temperature data and load data

The master transmits command values to the drive that are used by the controller for transforming them at the motor output shaft or mechanical axis system. The drive in return registers and transmits actual values, signals operating and command states and, if necessary, generates error messages and warnings.

Communication between drive and master also takes place by exchanging data.

Scaling

An operating data (numeric value) can only be evaluated as a physical value, when the numeric value is connected to a physical unit and the position of the decimal point (decimal places). The data thereby is "scaled" in a qualitative and quantitative way.

Parameters

All data are stored in parameters and transmitted as parameter values (for explanations regarding parameters see "Parameters, Basics"). The scaling of the parameters containing data of the following physical values can be defined by the customer:

- Position
- Velocity
- Acceleration
- Torque/force
- Temperature

Preferred Scaling/Parameter Scaling

To simplify the scaling definition so-called "preferred scalings" were predefined. But physical data can also be exchanged in the control-internal format, i.e. without specific reference to physical units. To do this, the scaling for certain data can be freely set ("parameter scaling").

Linear and Rotary Data

Depending on the kind of motion of motor or load, the data can be displayed as follows:

- In linear form (linear axis or motor motion)

- or -

- In rotary form (rotary axis or motor motion)

Motor Reference/Load Reference

In the drive firmware there are mechanical transfer elements between motor and load mapped by means of mathematical models. The physical data can thereby be referred to

- the point where the load takes effect (load-side data reference)

- or -

- the point where the force is input (motor-side data reference).

Absolute/Modulo Evaluation

For technical reasons, the value range of the position data the controller can display is limited.

For axes with limited travel range (e.g. linear axes) the current axis position within the controller-side value range can be unambiguously displayed (see ""Basics on Measuring Systems, Resolution").

In the case of axes with unlimited travel range (e.g. rotary axes) it is useful to limit the infinite value range of the position data to a finite value. With continuous motion, the value range is recurrently run from minimum to maximum value ("modulo" evaluation of the actual position value).

Pertinent Parameters

- S-0-0043, Velocity polarity parameter
- S-0-0044, Velocity data scaling type
- S-0-0045, Velocity data scaling factor
- S-0-0046, Velocity data scaling exponent
- S-0-0055, Position polarities
- S-0-0076, Position data scaling type
- S-0-0077, Linear position data scaling factor
- S-0-0078, Linear position data scaling exponent
- S-0-0079, Rotational position resolution
- S-0-0085, Torque/force polarity parameter
- S-0-0086, Torque/force data scaling type
- S-0-0093, Torque/force data scaling factor
- S-0-0094, Torque/force data scaling exponent
- S-0-0103, Modulo value
- S-0-0121, Input revolutions of load gear
- S-0-0122, Output revolutions of load gear
- S-0-0123, Feed constant
- S-0-0160, Acceleration data scaling type
- S-0-0161, Acceleration data scaling factor
- S-0-0162, Acceleration data scaling exponent
- S-0-0208, Temperature data scaling type

4.4 Drive Control

4.4.1 Safety Instructions

⚠ 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 safety fence, safety guard, protective covering, light barrier).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- In addition, observe the safety message "Protection Against Dangerous Movements" in the chapter "Safety Instructions for Electric Drives and Controls".

4.4.2 Overview of Drive Control

Brief Description

Basic Principles and Terms

The IndraDrive firmware supports the following two basic principles of drive control:

- **Axis control** or **open-loop operation** (U/f control)

  → Open-loop-controlled operation without encoder information
- **Axis control** or **closed-loop axis control** (various methods of control)
  - **With** encoder feedback

    → Closed-loop-controlled operation (position, velocity and current)
  - **Without** encoder feedback

    → Closed-loop-controlled operation with motor model (velocity and current)

When selecting the functional packages, take the desired method of control into account because a choice must be made between open-loop and closed-loop base packages!

Operation mode / command value adjustment	Control mode	Functional principle of motor	Encoder available	Required base package	Method of control
U/f control with command value adjustment of the velocity control	Voltage-controlled operation	Asynchronous	Yes	Closed-loop	Not relevant
			No	Open-loop	U/f Control
Torque/Force Control	Field-oriented current control	Asynchronous	Yes	Closed-loop	FOC control
			No	--	No procedure available
		Synchronous	Yes	Closed-loop	FOC control
			No	--	No procedure available

Operation mode / command value adjustment	Control mode	Functional principle of motor	Encoder available	Required base package	Method of control
Velocity control / velocity synchronization	Velocity control	Asynchronous	Yes	Closed-loop	FOC control
			No	Open-loop	FXC control
		Synchronous	Yes	Closed-loop	FOC control
			No	Closed-loop	FOCsl control
Position control, drive-controlled positioning, positioning block mode, phase synchronization, electronic Cam	Position control	Asynchronous	Yes	Closed-loop	FOC control
			No	Closed-loop	FXC control 1)
		Synchronous	Yes	Closed-loop	FOC control
			No	Closed-loop	FOCsl control

1) Only with external encoder

Fig.4-39: Overview: Operation Modes and Available Control Methods

☞ For scaling the drive firmware, the functional base packages with "open-loop" and "closed-loop" characteristic are differentiated; in this case, however, the meaning is not identical to how the terms are used in conjunction with drive control!

See also the section "Overview of Functions/Functional Packages"

Principles of Drive Control

Overview of Open-Loop Axis Control

Axis control (or "open-loop operation") allows controlled operation of the drive without motor encoder (U/f control).

The primary operation mode "velocity control" is configured, but only the command value processing specific to this operation mode takes effect. Closed-loop control (position and velocity) and functions and operation modes depending on it are not possible.

See "Voltage-Controlled Open-Loop Operation (U/f Control)"

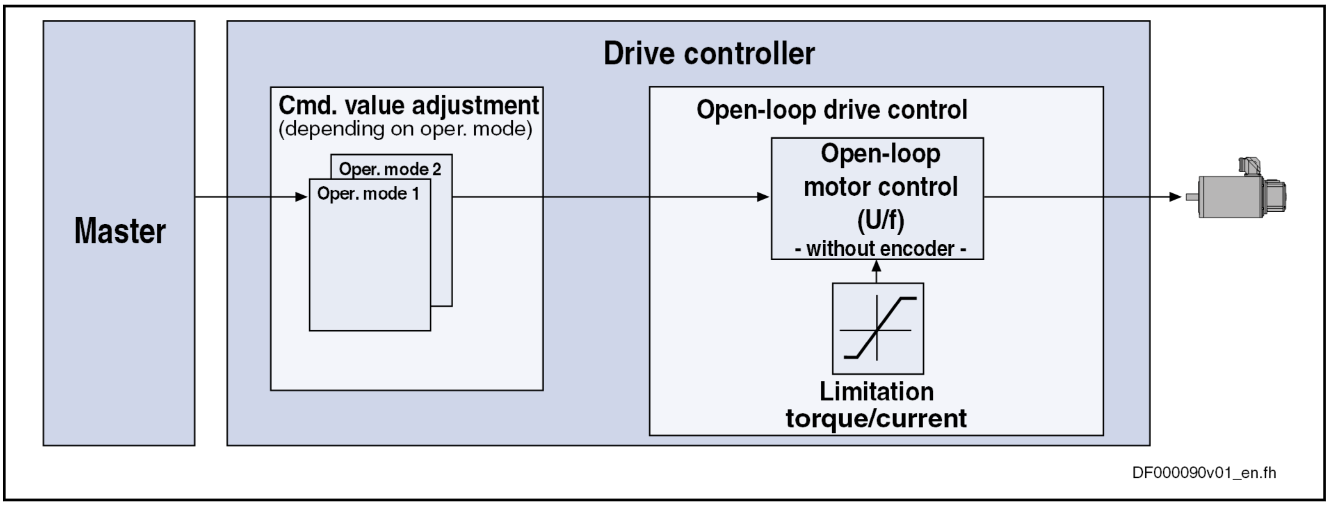


Fig.4-40: Principle of Drive Control (Open-Loop Operation)

See also the section "Closed-Loop Axis Control (Closed-Loop Operation)"

See also the section "Overview of Functions/Functional Packages"

Overview of Closed-Loop Axis Control

> The base package "Closed-Loop" also contains the functions of the base package "Open-Loop".

Axis control (or "closed-loop operation") allows closed-loop-controlled operation of the drive; two principles of drive control are differentiated:

- **Operation with encoder**

  The velocity control loop and the position control loop are closed by means of the encoder feedback so that the following operation modes are supported by field-oriented current control with encoder feedback:

  – Velocity control

  – Position Control With Cyclic Command Value Input

  – Positioning operation modes (drive-controlled positioning, positioning block mode)

  – Synchronization operation modes

- **Sensorless operation**

  The velocity control loop is closed by means of a motor model (monitor) so that field-oriented current control without encoder feedback supports velocity control without encoder.

See the section "Field-oriented Current Control"

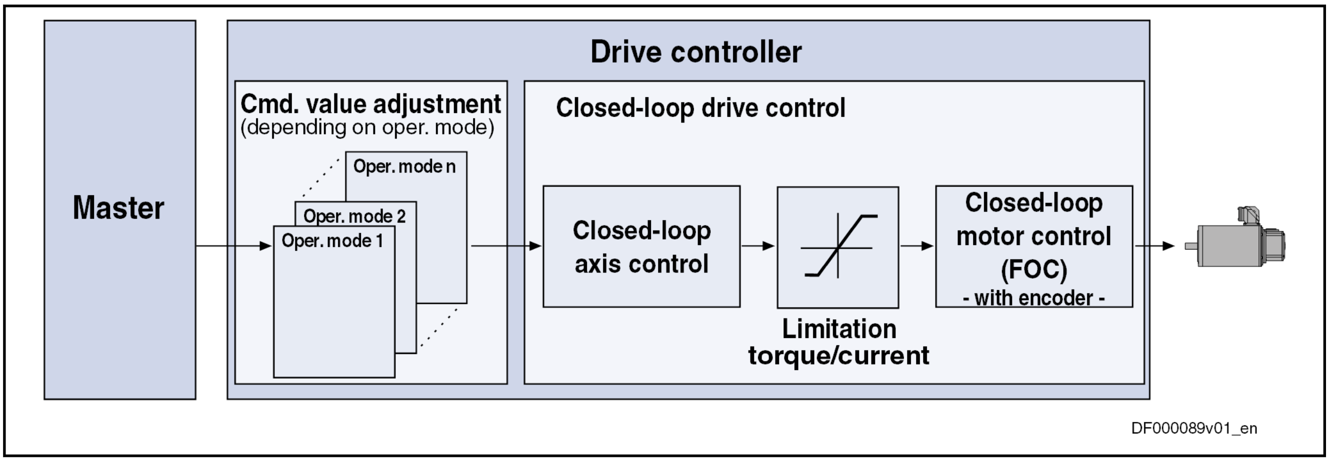


Fig.4-41: Principle of Drive Control (Closed-Loop Operation)

See also the section "Open-Loop Axis Control (Open-Loop Operation)"

See also the section "Overview of Functions/Functional Packages"

Control Loop Structure

General Information

The drive controller has a so-called cascade structure, i.e. the individual loops (position, velocity and current) are interconnected in cascaded form. Depending on the active operation mode, only the torque/force control loop, the torque/force control loop and the velocity control loop or, in addition to these two control loops, the position control loop are closed in the drive.

Torque/Force Control

The "torque/force control" mode actually isn't torque or force control but current control. Therefore, only the current control loop is closed in the drive.

See also "Torque/Force Control"

Velocity Control

In the "Velocity control" operation mode, the velocity control loop, apart form the current control loop, is closed in the drive, too.

See also "Velocity Control"

Position Control

For the following position control operation modes, the position control loop, apart from the current and velocity control loops, is closed internally (in the drive):

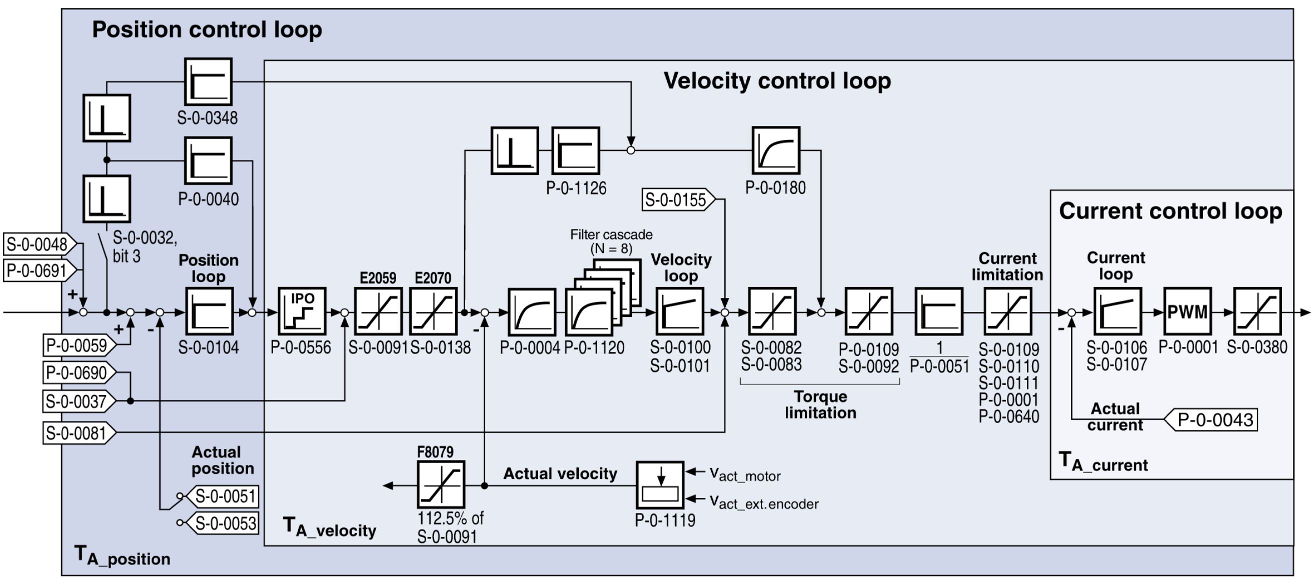
- Position Control With Cyclic Command Value Input
- Drive-internal interpolation
- Positioning operation modes (drive-controlled positioning, positioning block mode)

See also description of the respective operation mode

The figures in the following two paragraphs contain an overview of the structure and the interaction of the control loops (distinguished according to the illustration of the setting parameters and the display parameters).

Brief Functional Descriptions

Control Loop Structure with Setting Parameters

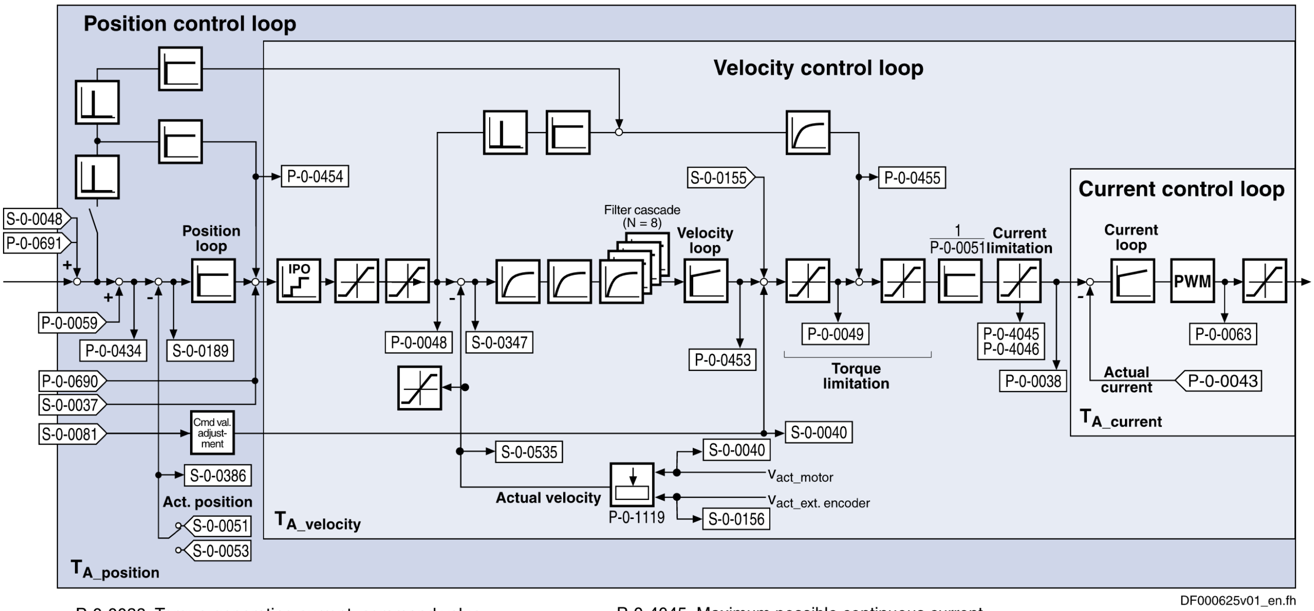


S-0-0032, Primary operation mode
S-0-0037, Additive velocity command value
S-0-0048, Additive position command value
S-0-0051, Position feedback value 1
S-0-0053, Position feedback value 2
S-0-0081, Additive torque/force command value
S-0-0082, Torque/force limit value positive
S-0-0083, Torque/force limit value negative
S-0-0091, Bipolar velocity limit value
S-0-0092, Bipolar torque/force limit value
S-0-0100, Velocity loop proportional gain
S-0-0101, Velocity loop integral action time
S-0-0104, Position loop Kv-factor
S-0-0106, Current loop proportional gain 1
S-0-0107, Current loop integral action time 1
S-0-0109, Motor peak current
S-0-0110, Amplifier peak current
S-0-0111, Motor current at standstill
S-0-0138, Bipolar acceleration limit value
S-0-0155, Friction compensation
S-0-0348, Acceleration feedforward gain
S-0-0380, DC bus voltage
P-0-0001, Switching frequency of the power output stage
P-0-0004, Velocity loop smoothing time constant
P-0-0040, Velocity feedforward evaluation
P-0-0043, Torque-generating current, actual value
P-0-0051, Torque/force constant
P-0-0059, Additive position command value, controller
P-0-0109, Torque/force peak limit
P-0-0180, Acceleration feedforward smoothing time constant
P-0-0556, Config word of axis controller
P-0-0640, Cooling type
P-0-0690, Additive velocity command value, process loop
P-0-0691, Additive position command value, process loop
P-0-1119, Velocity mix factor feedback 1 & 2
P-0-1120, Velocity control loop filter: Filter type
P-0-1126, Velocity control loop: Acceleration feedforward
E2059 Velocity command value limit active
E2070 Acceleration limit active
F8079 Velocity limit value exceeded

T_A Sampling times (see table in the section "Features of the Control Loops")

Fig.4-42: Overall Structure of the Control Loops with Points at which the Setting Parameters Take Effect (Example for Field-oriented Control with Encoder)

Control Loop Structure With Display Parameters



P-0-0038, Torque-generating current, command value
P-0-0043, Torque-generating current, actual value
P-0-0048, Effective velocity command value
P-0-0049, Effective torque/force command value
P-0-0051, Torque/force constant
P-0-0059, Additive position command value, controller
P-0-0063, Torque-generating voltage, actual value
P-0-0070, Effective additive torque/force command value
P-0-0434, Position command value of controller
P-0-0453, Integral-action component velocity loop
P-0-0454, Velocity feedforward actual value
P-0-0455, Acceleration feedforward actual value
P-0-0690, Additive velocity command value, process loop
P-0-0691, Additive position command value, process loop
P-0-1119, Velocity mix factor feedback 1 & 2
P-0-4045, Maximum possible continuous current
P-0-4046, Effective peak current

S-0-0037, Additive velocity command value
S-0-0040, Velocity feedback value
S-0-0048, Additive position command value
S-0-0051, Position feedback value 1
S-0-0053, Position feedback value 2
S-0-0081, Additive torque/force command value
S-0-0155, Friction compensation
S-0-0156, Velocity feedback value 2
S-0-0189, Following distance
S-0-0347, Velocity error
S-0-0386, Active position feedback value
S-0-0535, Active velocity feedback value

T_A Sampling times (see table in the section "Features of the Control Loops")

Fig.4-43: Overall Structure of the Control Loops With Display Parameters (Example)

Features of the Control Loops

Performance (Controller Cycle Times)

The internal controller cycle times (current, velocity and position) depend on the following conditions and parameters:

- Activation of the functional packages
- P-0-0001, Switching frequency of the power output stage
- P-0-0556, Config word of axis controller (bit 2)

Depending on these factors, the following cycle and switching times can be achieved:

	MPE	MPB	MPM
PWM switching frequency	Max. 8 kHz	Max. 16 kHz	Max. 8 kHz
Position loop clock ($T_{A\_position}$)	1000 µs	250 µs	500 µs

	MPE	MPB	MPM
Velocity loop clock ($T_{A\_velocity}$)	500 µs	125 µs	250 µs
Current loop clock ($T_{A\_current}$)	125 µs	62.5 µs	125 µs

Fig.4-44: Cycle and Switching Times to be Achieved With IndraDrive

All performance data are listed under "System Overview:Performance Data".

Current Loop

The current loop is characterized by the following features:

- PI loop for d-axis and q-axis of the field-oriented d-q coordinate system (S-0-0106, S-0-0107)
- Inductance feedforward for decoupling d-axis and q-axis (P-0-4017, P-0-4016) for synchronous motors
- Inductance characteristic for adjusting the current loop parameters in the case of saturation phenomena
- Precontrol of e.m.f.

Velocity Loop

The velocity loop is characterized by the following features:

- PI loop that can be set via the following parameters: "S-0-0100, Velocity loop proportional gain" S-0-0101, Velocity loop integral action time
- Standardization of the output value at the velocity loop to Newton (N) or Newton meter (Nm); therefore, depending on the motor type, the following unit results for the parameter "S-0-0100, Velocity loop proportional gain":
  - Rotary motor → Nm * s/rad
  - Linear motor → N * min/mm
- Has filter options for filtering encoder noise and resonance frequencies
  - a first order filter (first order low-pass), can be parameterized via P-0-0004
  - four second order filters (second order low-pass, band-stop filter, second order filter), can be activated via P-0-1120 with the setting parameters (P-0-1121), P-0-1122, P-0-1123, P-0-1140,P-0-1141, P-0-1143

In firmware variant MPE, only two second order filters are available.

- Acceleration feedforward can be set in parameter P-0-1126
- Option to mix the actual velocity value used for the control from the actual value of the motor-side and load-side encoder using a "mix factor" P-0-1119
- Limitation of command acceleration (velocity command value modification) in velocity control by setting in parameter "S-0-0138, Bipolar acceleration limit value"
- Limitation of the command velocity using parameters S-0-0113, S-0-0038, S-0-0039, S-0-0091 and P-0-0113

See also"Velocity Loop (Including the Respective Filters)"

Position loop

The position loop is characterized by the following features:

- P loop, can be set using "S-0-0104 Position loop Kv-factor"
- Velocity feedforward (degree of feedforward) can be set in parameter "P-0-0040, Velocity feedforward evaluation" (0 %…100 %)
- Acceleration feedforward can be set in parameter S-0-0348
- For the control, the actual value of the motor encoder or the optional encoder can be used al the actual position value. It is possible, however, to use both actual position values for position control ("hybrid actual position value").

See also "Position Loop (with Respective Feedforward Functions and Actual Value Adjustment)"

4.4.3 Motor Control

General Information on Motor Control

Overview of Motor Control Methods

Classification of Motor Control Methods

There are different methods available to control the motor; the main difference between these methods is the fact whether a motor encoder is required or not.

Motor Control With Motor Encoder

Motor control with position feedback via a motor encoder (field-oriented current control → FOC) is the highest-quality method of motor control providing the best control performance. It can be used for synchronous and asynchronous motors and, within the precision and performance of motor and controller determined by the hardware, allows unrestricted motor operation in the following operation modes:

- Position control operation modes
- Velocity control
- Torque/Force Control

Motor Control Without Motor Encoder

For sensorless motor control, there are different model-based methods available for synchronous and asynchronous motors.

- For asynchronous motors:
  - Voltage-Controlled Open-Loop Operation (U/f Control)
  - Flux-controlled operation (FXC)
- For synchronous motors
  - Flux-controlled operation (FXC)

Regarding the possible operation modes when using these methods, observe the following restrictions:

- Position control operation modes (positioning) are possible with sensorless synchronous and asynchronous motors in flux-controlled operation (FXC) in connection with an external encoder. In these cases, generally take the performance losses into account!
- Velocity control, too, can only be used with performance losses!

☞ Torque/force control cannot be used for motor control without motor encoder!

Motor Control Method and Functional Principle of Motor

Make sure that the requirements regarding functional principle of motor and motor encoder have been fulfilled for specified motor control mode. The table below contains an overview for selecting the method.

Motor encoder?	Functional principle of motor	Motor control method	Specific information for use	Possible operation modes
With Motor encoder	Synchronous motor Asynchronous motor	FOC	Parallel operation of linear motors MLF is possible!	Position control operation modes Velocity control Torque/Force Control
Without Motor encoder	Asynchronous motor	FXC	Only single-motor operation!	Position control operation modes Velocity control
		U/f Control	Parallel operation of motors is possible!	Velocity control
Without Motor encoder	Synchronous motor	FXC	Only single-motor operation!	Position control operation modes Velocity control

Fig.4-45: Overview of Motor Operation with and without Motor Encoder

See also "Overview of Drive Control"

Field-Oriented Current Control With Motor Encoder (FOC)

Features and Use

Field-oriented current control with position feedback via motor encoder (FOC) is characterized by the following features:

- Highest-quality method of motor control

  → To be used when there are high demands on the quality of control and the dynamic response!
- Can be used for synchronous and asynchronous motors

Operation Modes With FOC

Within the hardware-side precision and performance of motor and controller, field-oriented current control with position feedback via motor encoder allows unrestricted motor operation in the following operation modes:

- Position control operation modes
- Velocity control
- Torque/Force Control

See the main section "Field-Oriented Current Control (FOC Control)"

Model-Based Current Control Without Motor Encoder (FXC)

Features and Use

Model-based current control without motor encoder is characterized by the following features:

- Cost-saving motors, compared to the FOC method, can be used, as no motor encoder is required (however, performance losses)
- flux-controlled method (FXC) can be used without motor-specific restrictions

Operation Modes with FXC

Current control without motor encoder allows using the following operation modes:

- Velocity control (only suited for single motors, parallel operation of motors is not possible)
- Position control operation modes possible with external encoder

☞ Torque/force control cannot be used for sensorless (model-based) motor control!

See the main section "Sensorless Motor Operation, Flux-Controlled (FXC Control)"

Voltage-Controlled Open-Loop Operation (U/f Control)

Features and Use

Voltage-controlled motor operation without motor encoder is characterized by the following features:

- Cost-saving motors, compared to the FOC method, can be used, as no motor encoder is required (however, performance losses)
- Can only be used for asynchronous motors
- Linear or square U/f characteristic can be selected

Operation Mode With U/f Control

For voltage-controlled operation without motor encoder, only the "velocity control" operation mode with the following features can be used:

- Parallel operation of motors is possible
- Adjustment of motor control to velocity-proportional increase in load (e.g. with blowers) by adjusted ("square") U/f characteristic to reduce the motor losses
- Performance losses compared to velocity control with motor encoder

☞ Torque/force control and position control operation modes cannot be used for voltage-controlled operation without motor encoder!

See the main section "Voltage-Controlled Open-Loop Operation (U/f Control)"

Notes on Selection of Motor Control Method

Motor Control Performance

The performance of motor control significantly depends on the type of control section including the corresponding firmware, as well as on the PWM frequency of the power output stage which has been set.

☞ An overview of the performance to be achieved and the clock rates depending on control section design and parameter settings is contained in the section "Performance Data".

Selection Criteria

The following criteria have to be taken into account when selecting the appropriate motor control method:

Motor type	Motor encoder available?	Parallel connection of motors?	Motor control method	Notes on use
Synchronous motor	No	No	FOC	for standard applications with medium demands on quality of control and dynamic response
	Yes	Rotary: no Linear: Yes [1)]		for standard applications with high demands on quality of control and dynamic response

Brief Functional Descriptions

Motor type	Motor encoder available?	Parallel connection of motors?	Motor control method	Notes on use
Asynchronous motor	No	No	FXC	for standard applications with medium demands on quality of control and dynamic response
		Yes	U/f Control	for standard applications with low demands on quality of control and dynamic response
	Yes	No	FOC	for standard applications with high demands on quality of control and dynamic response

1) Observe Mechanical Setup According to Motor Data

Fig.4-46: Basic Selection Criteria for the Motor Control Method

See also "Overview of Drive Control"

Operating Properties for Control of Synchronous Motors

Observe the following differences for controlling synchronous motors in operation with and without motor encoder:

Motor characteristic		FOC	FXC
Speed working ranges	Basic speed range	Yes	Yes
	Field weakening range	Yes	Yes
Supported operation modes	Torque/force control	Yes	No
	Velocity control (incl. synchronization)	Yes	Yes (with limitations)
	Position control/positioning (incl. synchronization)	Yes	Yes (with limitations, external encoder required)
Torque limitation		Yes	Yes
Maximum torque		high	medium
Dynamic response		high	medium to high
Running smoothness/speed quality		high (depending on measuring system, motor type, mechanical system)	medium to high
Torque ripple		low (< ± 5%)	medium to high
Required precision of the motor parameters		low	medium to high
Robustness		high	medium
Sensitivity against disturbances		low	medium
Validity (availability) of the position information		Absolute encoder: in PM + OM	depending on load-side encoder type used
		Relative encoder: in OM	

PM Parameter mode
OM Operating mode

Fig.4-47: Comparison of Motor Control without Encoder and with Encoder for Synchronous Motors

Operating Properties for Control of Asynchronous Motors

Observe the following differences for controlling asynchronous motors as regards operation with and without encoder:

Motor characteristic		FOC	FXC	U/f Control
Speed working ranges	Basic speed range	Yes	Yes	Yes
	Field weakening range	Yes	Yes	Yes
Supported operation modes	Torque/force control	Yes	No	No
	Velocity control (incl. synchronization)	Yes	Yes (with restrictions)	Yes (with restrictions)
	Position control/positioning (incl. synchronization)	Yes	only with external position encoder	No
Torque limitation		Yes	Yes	No (only stall protection loop)
Maximum torque		high	medium	low
Dynamic response		high	medium	low
Running smoothness/speed quality		high (depending on measuring system, motor type, mechanical system)	medium	low
Torque ripple		low (< ± 5%)	high	high
required accuracy of the motor parameters		low	low	high, if high performance must be reached
Robustness		high	medium	low
Sensitivity against disturbances		low	high	high
Validity (availability) of the position information		Absolute encoder: in PM + OM	depending on load-side encoder type used	not available
		Relative encoder: only in OM		

PM Parameter mode
OM Operating mode
Fig.4-48: Comparison of Motor Control without Encoder and with Encoder for Asynchronous Motors

Motor Control Frequency

Brief Description

General Information

The speed of three-phase motors depends on the frequency of the voltage created at the motor. The maximum possible frequency of the motor voltage supplied from the controller depending on the PWM frequency with which the power output stage is controlled (cycled).

Value in P-0-0001 PWM frequency in Hz	max. motor control frequency in Hz[1)]
4000	400
8000	800

Brief Functional Descriptions

Value in P-0-0001 PWM frequency in Hz	max. motor control frequency in Hz[1)]
12000	1200
16000	1600

1) See the source "Supply Modules and Power Sections, Project Planning Manual"

Fig.4-49: Maximum Motor Control Frequency, Depending on PWM Setting

Note on Dimensioning

☞ The required PWM frequency must be observed when selecting the controller because the continuous current used with the controller is affected by the PWM frequency setting:

- Based on continuous current used with the controller, select the lowest possible PWM frequency
- Based on motor control frequency, select a PWM frequency that is only as high as necessary.

Advantageous Behavior

Due to the continuous current reduction with PWM frequencies greater than 4kHz, the controller can set the most advantageous PWM frequency automatically depending on the required motor control frequency.

Availability

Depending on the control section design, the follow PWM frequencies are available:

Device/control section	Firmware	Available PWM frequency / Hz
IndraDrive-Cs with Economy control section	Starting with MPE16VRS	4000 8000
IndraDrive-Cs with Basic control section	Starting with MPB16VRS	2000 4000 8000 12000 16000

Fig.4-50: Hardware and Firmware Dependencies of the PWM Frequency

Pertinent Parameters

- P-0-0001, Switching frequency of the power output stage
- P-0-0045, Control word of current controller

Pertinent Diagnostic Messages

The switching of the PWM frequency is displayed in the respective bit of "P-0-0046, Status word of current controller".

Voltage-Controlled Open-Loop Operation (U/f Control)

Brief Description

The drive function "voltage-controlled open-loop operation of asynchronous motors without encoder in U/f control" is made available in the base package "open-loop" in the "velocity control" operation mode. When the expansion package "synchronization" has been enabled, the operation mode "velocity synchronization with real/virtual master axis" is additionally available.

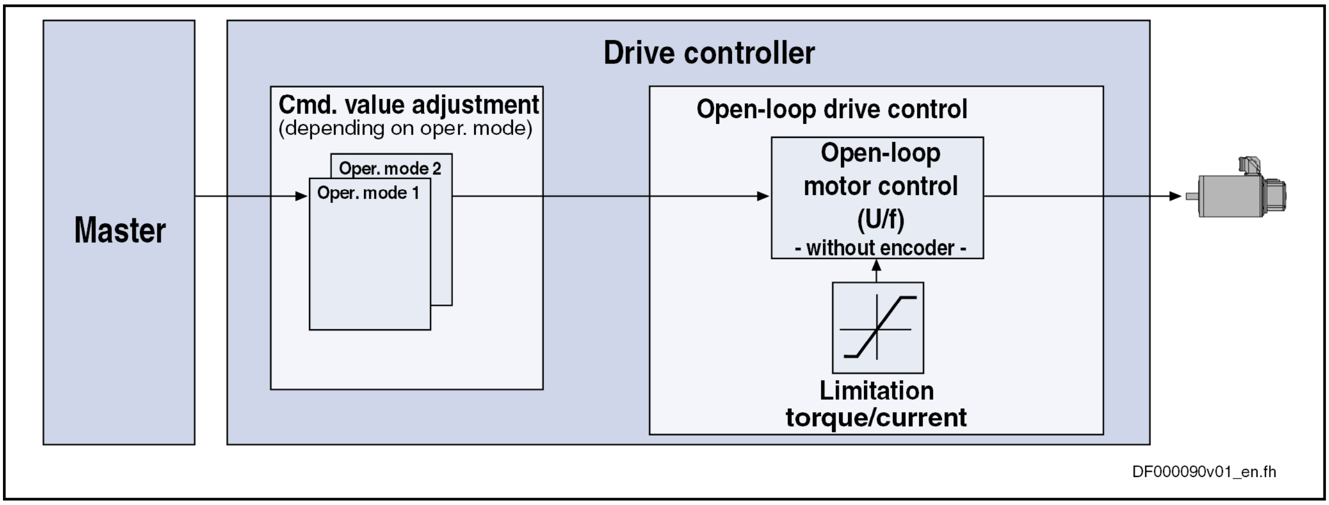


Fig.4-51: Principle of U/f Control

U/f motor control is characterized by the following features or core functions:

Features

- Monitoring and **limitation** of the maximum **stator frequency slope** that results from the command velocity change
- **Stall protection loop** (PI loop that can be optionally activated to prevent breakdown of the machine when the torque limits are attained)
- **Slip compensation** (feedforward of estimated slip of the machine by means of slip compensation factor)
- Calculation of output voltage by means of **U/f characteristic** based on motor model data
- Subsequent trimming of magnetization via premagnetization factor, as well as linear or square characteristic to be selected
- **IxR boost** (adjustable load-dependent feedforward of the output voltage due to the voltage drop on the motor winding resistance)
- **Oscillation damping** (adjustable load-dependent feedforward to prevent velocity oscillations in the partial load and idling ranges)
- **D.C. braking** to reach standstill more quickly
- User-side **torque/force limitation** via enabled stall protection loop
- **Velocity search mode** of a coasting machine after switching drive enable on (can be set for the preset rotational direction or both rotational directions)

Pertinent Parameters

- S-0-0040, Velocity feedback value
- S-0-0106, Current loop proportional gain 1
- S-0-0107, Current loop integral action time 1
- P-0-0043, Torque-generating current, actual value
- P-0-0044, Flux-generating current, actual value
- P-0-0045, Control word of current controller
- P-0-0046, Status word of current controller
- P-0-0048, Effective velocity command value
- P-0-0063, Torque-generating voltage, actual value
- P-0-0064, Flux-generating voltage, actual value
- P-0-0065, Absolute voltage value, actual value

- P-0-0440, Actual output current value (absolute value)
- P-0-0442, Actual value torque limit positive (stationary)
- P-0-0443, Actual value torque limit negative (stationary)
- P-0-0532, Premagnetization factor
- P-0-0556, Config word of axis controller
- P-0-0568, Voltage boost
- P-0-0569, Maximum stator frequency slope
- P-0-0570, Stall protection loop proportional gain
- P-0-0571, Stall protection loop integral action time
- P-0-0572, Slip compensation factor
- P-0-0573, IxR boost factor
- P-0-0574, Oscillation damping factor
- P-0-0575, Search mode: Search current factor
- P-0-0576, Search mode: Finding point slip factor
- P-0-0577, Square characteristic: Lowering factor
- P-0-0578, Current for deceleration, absolute value
- P-0-0579, Current for deceleration, time period
- P-0-4036, Rated motor speed
- P-0-4046, Effective peak current

Pertinent Diagnostic Messages

- E8040 Torque/force actual value limit active
- E8041 Current limit active
- E8260 Torque/force command value limit active

Field-Oriented Current Control (FOC Control)

Brief Description

Base package of all firmware variants in **closed loop** characteristic

The current loop was preset for all Rexroth motors and the parameter values have been stored in the motor encoder data memory or in the commissioning tool ("IndraWorks Ds/D/MLD", "DriveTop").

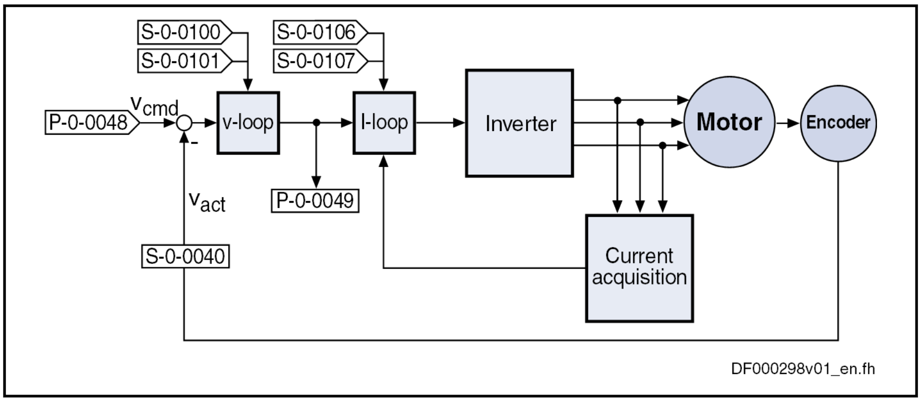
For information regarding commissioning the current loop for third-party motors, see "Third-Party Motors on IndraDrive Controllers"!

Principle of Field-Oriented Current Control

In the case of field-oriented current control, the internal control task consists in generating the transformed currents I_d and I_q in controlled form:

- I_d (flux-generating current) → PI loop for I_d
- I_q (torque-generating current) → PI loop for I_q

The figure below illustrates the principle of field-oriented current control for operation with motor encoder:



v-loop Velocity loop
I-loop Current loop
Fig.4-52: Simplified Schematic Diagram for Field-Oriented Current Control With Higher-Level Velocity Control

Working Ranges

Field-oriented current control of asynchronous and synchronous motors allows operation in the entire speed range.

The speed range is divided into the following working ranges:

- Basic speed range → **constant torque**
- Field weakening range 1 → **constant power**
- Field weakening range 2 → **power limit range**

General Features

Field-oriented current control has the following general features:

- Control of the motor current according to the principle of field orientation, i.e. separate control of the torque-generating current and the flux-generating current
- Compensation of the cross coupling of the d and q axes to increase dynamics
- Voltage loop for operation in the field weakening range
- Activation of the optimum current loop proportional gain value, depending on the current PWM frequency when loading the default values (motor-specific controller values)

Features of Synchronous Motor Control

In the case of **synchronous motors**, field-oriented current control additionally has the following features:

- Limitation of the I_q command value at the voltage limit for protection against too little control margin
- Utilization of the reluctance effect to increase the available torque in the basic speed range
- Support of synchronous motors with reluctance torque, i.e. motors with significantly different inductances in the d and q axes

Features of Asynchronous Motor Control

In the case of **asynchronous motors**, field-oriented current control has the following features in addition to the general features:

- Optimum torque linearity, even in the field weakening range, by:
  - Permanent correction of the torque constant and the slip factor by means of the currently calculated rotor flux
  - Rotor flux model taking temperature and saturation behavior of the magnetizing inductance into account
- Improved dynamic behavior by:

  - Voltage- and load-dependent flux feedforward
  - Voltage loop for correcting the flux feedforward
  - Flux loop for dynamically generating the rotor flux
- Possibility of reducing the magnetizing current for low-loss operation at no load or in partial load range

Pertinent Parameters

Current loop setting:

- S-0-0106, Current loop proportional gain 1
- S-0-0107, Current loop integral action time 1
- P-0-0001, Switching frequency of the power output stage
- P-0-0045, Control word of current controller
- P-0-4002, Charact. of quadrature-axis induct. of motor, inductances
- P-0-4003, Charact. of quadrature-axis inductance of motor, currents

Voltage loop setting:

- P-0-0533, Voltage loop proportional gain
- P-0-0534, Voltage loop integral action time
- P-0-0535, Motor voltage at no load
- P-0-0536, Maximum motor voltage

Rotor flux control for asynchronous motors:

- P-0-0528, Flux control loop proportional gain
- P-0-0529, Scaling of stall current limit
- P-0-0530, Slip increase
- P-0-0532, Premagnetization factor

Power monitoring:

- S-0-0158, Power threshold Px
- S-0-0337, Status "P >= Px"
- S-0-0382, DC bus power

Display parameters:

- S-0-0380, DC bus voltage
- P-0-0046, Status word of current controller
- P-0-0063, Torque-generating voltage, actual value
- P-0-0064, Flux-generating voltage, actual value
- P-0-0065, Absolute voltage value, actual value

Pertinent Diagnostic Messages

- C0132 Invalid settings for controller cycle times
- E8025 Overvoltage in power section
- E8028 Overcurrent in power section
- F2077Current measurement trim wrong
- F8060Overcurrent in power section

Sensorless Motor Operation, Flux-Controlled (FXC Control)

Brief Description

Base package of all firmware variants in **open-loop and closed-loop** characteristic

For asynchronous and synchronous motors, flux-controlled, sensorless motor operation is available in the base packages "open-loop" and "closed-loop" of all firmware variants and can be used in the "velocity control" operation mode and in position-controlled operation modes which use position encoder 2 (external encoder).

When using the firmware expansion package "synchronization", the operation mode "velocity synchronization with real/virtual master axis" can also be run.

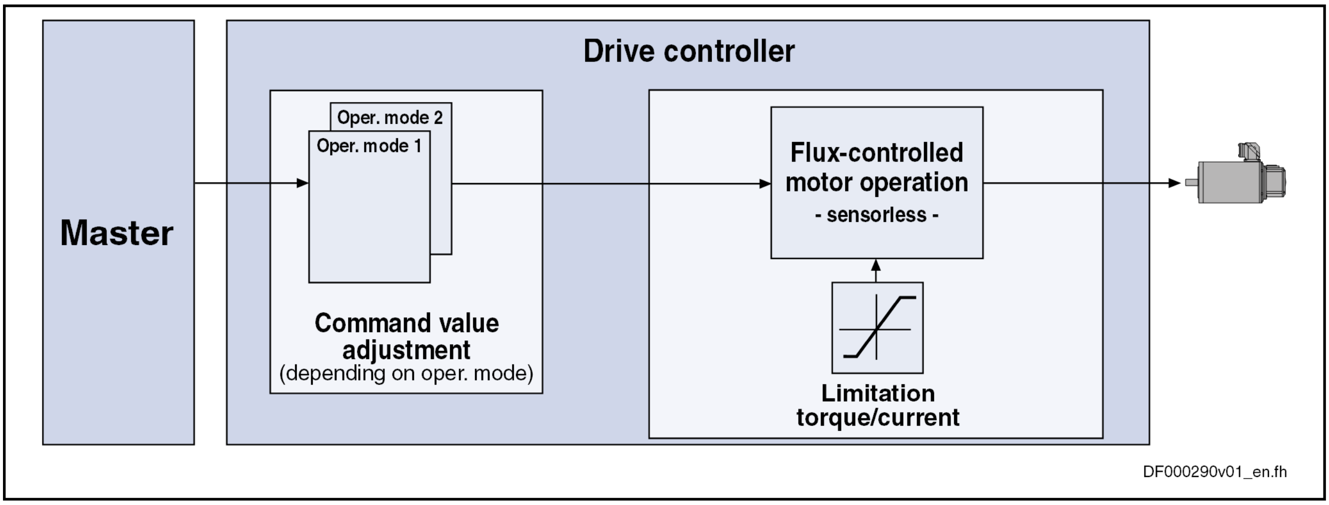


Fig.4-53: Principle of Sensorless, Flux-Controlled Motor Operation

Features

- Limitation of the maximum **stator frequency slope** that results from the command velocity change
- "Stable" motor operation

  → To maintain the maximum possible torque
- **Slip compensation** for asynchronous motors (estimated motor slip taken into account for calculating actual velocity value)

  → To minimize the stationary speed deviations, due to slip, from the command value when the asynchronous motor is loaded
- Motor speed does not tend to oscillation in operation at partial load and no-load operation
- **Velocity search mode** of a coasting asynchronous motor after switching drive enable on
- Possibility of taking user-side **torque/force limitation** into account

Pertinent Parameters

Motor control parameters of sensorless, flux-controlled motor operation:

- P-0-4033, C3200 Command Calculate motor data
- P-0-0532, Premagnetization factor
- P-0-0565, C3600 Command Motor data identification
- P-0-0578, Current for deceleration, absolute value
- P-0-0579, Current for deceleration, time period
- P-0-0580, Motor frequency
- P-0-0593, FXC: Total flux loop proportional gain
- P-0-0594, FXC: Total flux loop integral action time
- P-0-0595, Frequency loop proportional gain (FXC)
- P-0-0596, FXC: Frequency loop scaling factor of inertia
- P-0-0597, FXC: Current loop proportional gain

- P-0-0598, FXC: Current loop integral action time
- P-0-0599, FXC: Slip frequency filter time constant
- P-0-0600, FXC: Rated slip frequency
- P-0-0602, FXC: Minimum no-load current

Motor data parameters:

- P-0-0510, Rotor inertia
- P-0-4004, Magnetizing current
- P-0-4032, Motor type plate data

Axis data parameters:

- P-0-4010, Load inertia

Control parameters:

- P-0-0045, Control word of current controller
- P-0-0601, Configuration motor data identification

4.4.4 Automatic Setting of Motor Control

Brief Description

Base package of all firmware variants in **open-loop and closed-loop** characteristic

For operating motors, it is necessary to collect the values for motor parameters (resistance values, inductances, ...), in order to determine the motor control parameters (flux loop, voltage loop, current loop, ...) with these values.

Depending on the manufacturer and type of the motor to be controlled, the values for motor parameters and motor control parameters are made available to the controller in different ways.

Rexroth Motors

For Rexroth motors, the values for the motor and motor control parameters are optimized and made available by the manufacturer. The automatic setting of the motor control parameters by the drive firmware is not required and not allowed for Rexroth motors!

- For motors **with motor encoder data memory**:

  → Parameters loaded automatically when drive is switched on (see "Default Settings in the Motor Encoder Data Memory ("Loading Default Values")"
- For motors **without motor encoder data memory**:
  - Parameters loaded via the commissioning tool "IndraWorks Ds/D/MLD" from the motor data base (DriveBase)

    - or -
  - Individual parameters manually written via the serial interface or the master communication interface by means of a motor parameter list.

Third-party Motors

For third-party motors, the drive firmware possesses commands by means of which the values for the motor and motor control parameters are generated depending on the available output data and the functional principle of the motor.

The following commands are available for calculating values for the motor and motor control parameters:

- C3200Command Calculate motor data

1. Calculating the motor parameter values for asynchronous motors from the **data on the type plate**
2. Calculating the values to be set for the motor control parameters

- C3600Command Motor data identification
  1. Identifying (or optimizing) the motor parameter values for asynchronous motors

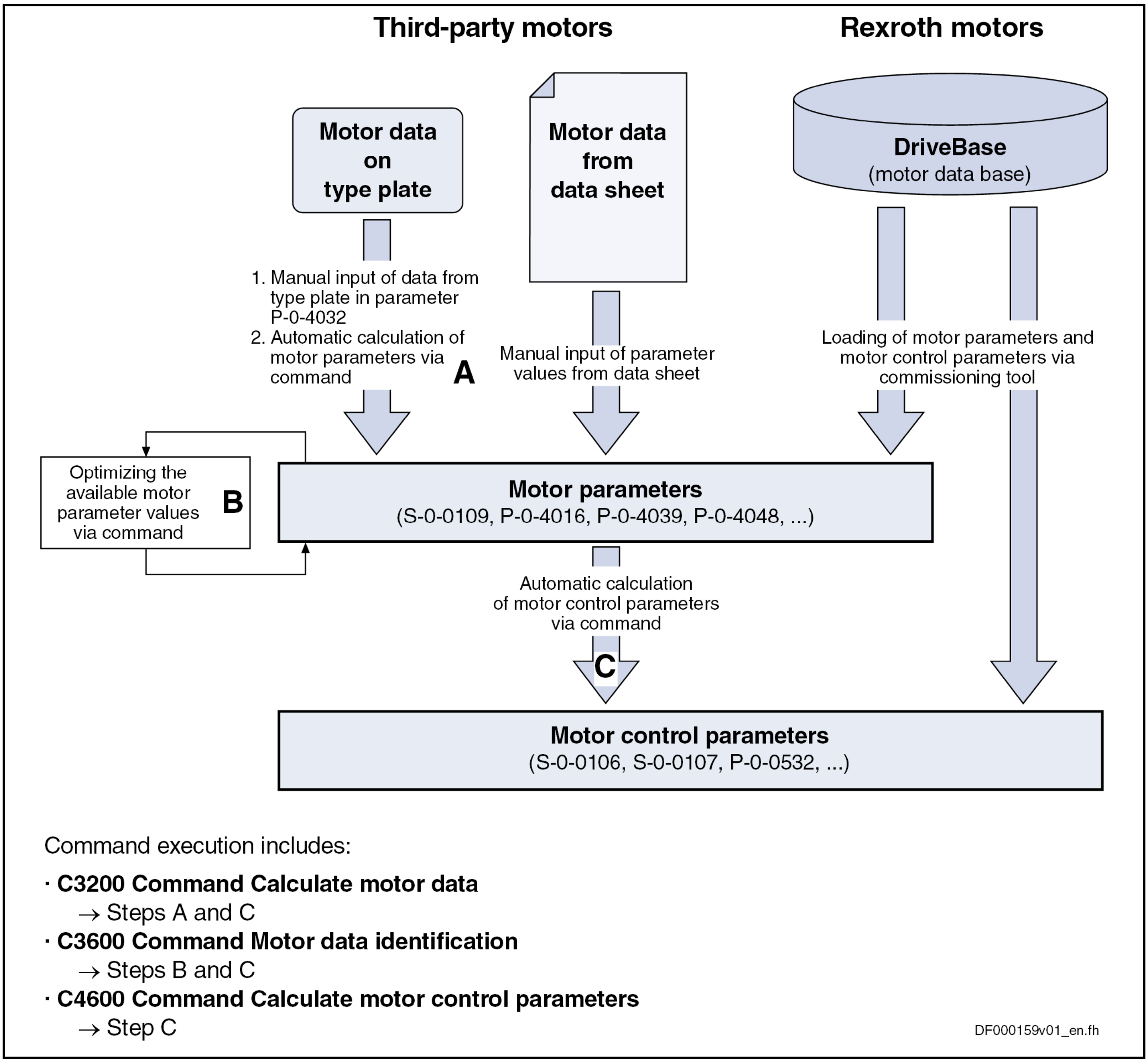
     Note: Appropriate start values already have to be available!
  2. Calculating the values of the motor control parameters
- C4600Command Calculate motor control parameters

  Calculating the values of the motor control parameters from the motor parameters for synchronous motors and, if necessary, for asynchronous motors (after manual input of motor data in motor parameters)

☞ The prerequisite is the form "Manufacturer-Side Data for Synchronous Motors" or " Manufacturer-Side Data of Asynchronous Motors" to be filled out by the motor manufacturer; it is located in the section "Third-Party Motors on IndraDrive Controllers"!

Overview

The figure below illustrates an overview of the possibilities of determining the motor and motor control parameters for motors without motor encoder data memory:



P-0-4032 Motor type plate data

Fig.4-54: Determining Motor and Motor Control Parameters for Motors Without Motor Encoder Data Memory

☞ In addition to collecting or determining the motor and motor control parameters, further data on measuring system, temperature sensor, motor temperature model, motor holding brake and, if necessary, position and velocity loop are required.

See "Closed-Loop Axis Control (Closed-Loop Operation)"

See the "Notes on Commissioning" in the section "Third-Party Motors on IndraDrive Controllers"

Pertinent Parameters

- P-0-0565, C3600 Command Motor data identification
- P-0-0566, C4600 Command Calculate motor control parameters
- P-0-4032, Motor type plate data

- P-0-4033, C3200 Command Calculate motor data

Pertinent Diagnostic Messages

- C3200Command Calculate motor data
- C3201Incorrect input for current
- C3202Incorrect input for voltage
- C3203Incorrect input for frequency
- C3204Incorrect input for speed
- C3205Incorrect input for power factor
- C3206Incorrect input for power
- C3207Type plate list incomplete
- C3208 Error when writing parameters (->S-0-0423)
- C3600 Command Motor data identification
- C3601 Motor not or not correctly connected
- C3602 Determined values invalid
- C3603 Device current limit too low
- C3604 Error when writing parameters (->S-0-0423)
- C3605 Motor turning
- C3606 Type of construction of motor not allowed
- C4600 Command Calculate motor control parameters
- C4601 Error when writing parameters (->S-0-0423)

4.4.5 Open-Loop Axis Control (Open-Loop Operation)

Brief Description

In sensorless operation (open-loop operation), the velocity control loop is not closed in the drive, but the drive is operated in a velocity-controlled way (without feedback) via open-loop U/f control.

☞ The method of open-loop/closed-loop motor control can be selected via bit 14 of "P-0-0045, Control word of current controller".

See also the section "Motor Control"

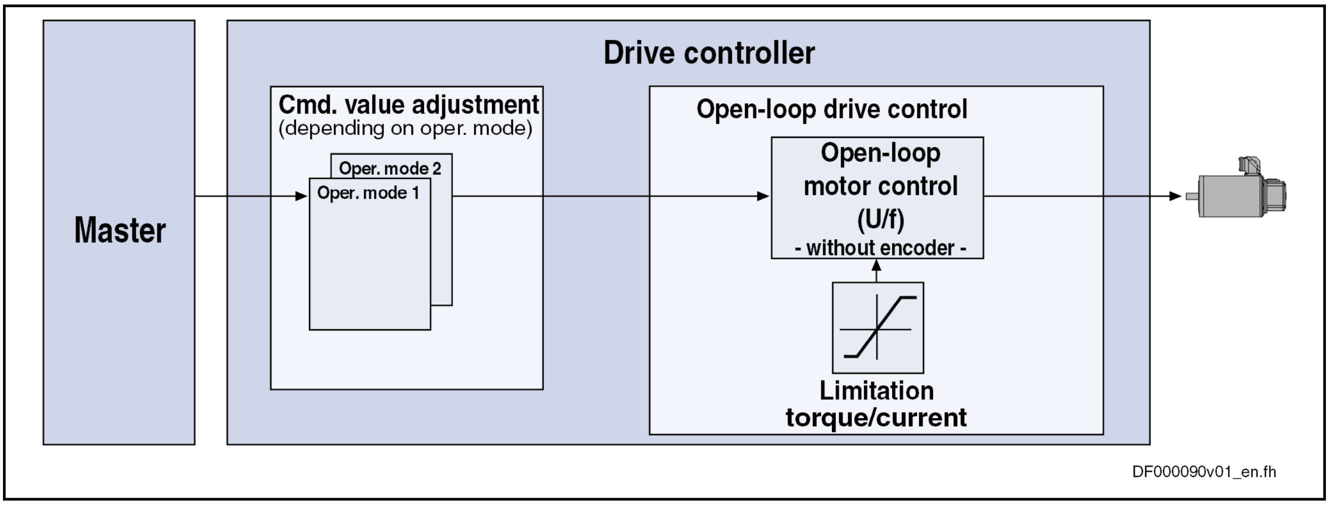


Fig.4-55: Principle of Drive Control in Open-Loop Operation

Features The velocity control has the following features:

- Fine interpolation of the velocity command value (can be switched off)
- Monitoring of the velocity control loop is possible (can be switched off via P-0-0556; bit 1)
- Parameterizable filtering of the actual velocity value
- Additive velocity command value (S-0-0037)
- Display of the resulting command value (in P-0-0048)
- Monitoring and **limitation** of the maximum stator frequency slope that results from the command velocity change
- **Stall protection loop** (PI loop that can be optionally activated to prevent breakdown of the machine when the torque limits are attained)
- **Slip compensation** (feedforward of estimated slip of the machine by means of rotor time constant and slip compensation factor)
- Calculation of output voltage by means of **U/f characteristic** based on motor model data
- Subsequent trimming of magnetization via premagnetization factor (linear or square characteristic to be selected)
- **IxR boost** (adjustable load-dependent feedforward of the output voltage due to the voltage drop on the motor winding resistance)
- **Oscillation damping** (adjustable load-dependent feedforward to prevent velocity oscillations in the partial load and idling ranges)
- **Current limitation loop** to protect the output stage
- **Velocity search mode** of a coasting machine after switching drive enable on (can be set for one or both rotational directions)

Pertinent Parameters

- S-0-0037, Additive velocity command value
- S-0-0040, Velocity feedback value
- S-0-0091, Bipolar velocity limit value
- P-0-0048, Effective velocity command value
- P-0-0049, Effective torque/force command value
- P-0-0555, axis controller messages
- P-0-0556, Config word of axis controller

Pertinent Diagnostic Messages, S-0-0091 Exceeded

- F8079 Velocity limit value exceeded (S-0-0091)

4.4.6 Closed-Loop Axis Control (Closed-Loop Operation)

General Information on Closed-Loop Axis Control

Control Loop Structure

The drive controller has a so-called cascade structure, i.e. the individual loops (position, velocity and current) are interconnected. Depending on the operation mode there are different control loop structures with different points of input and paths of the command values. Depending on the active operation mode, only the torque control loop, the torque control loop and the velocity control loop or, in addition to these two control loops the position control loop can be closed in the drive.

The structure and the interaction of the control loops are shown in two figures in the "Overview of Drive Control" (see "Control Loop Structure With Setting Parameters" or "Control Loop Structure With Display Parameters").

Features of the Control Loops

For the simplification of the parameterization of the control loops and for an increase in performance, a number of standardizations and structural changes have been carried out.

Current loop, velocity loop and position loop are described in the section "Performance (Controller Cycle Times)" (see "Overview of Drive Control, Features of the Control Loop").

Possibilities of Access to Included Control Loops

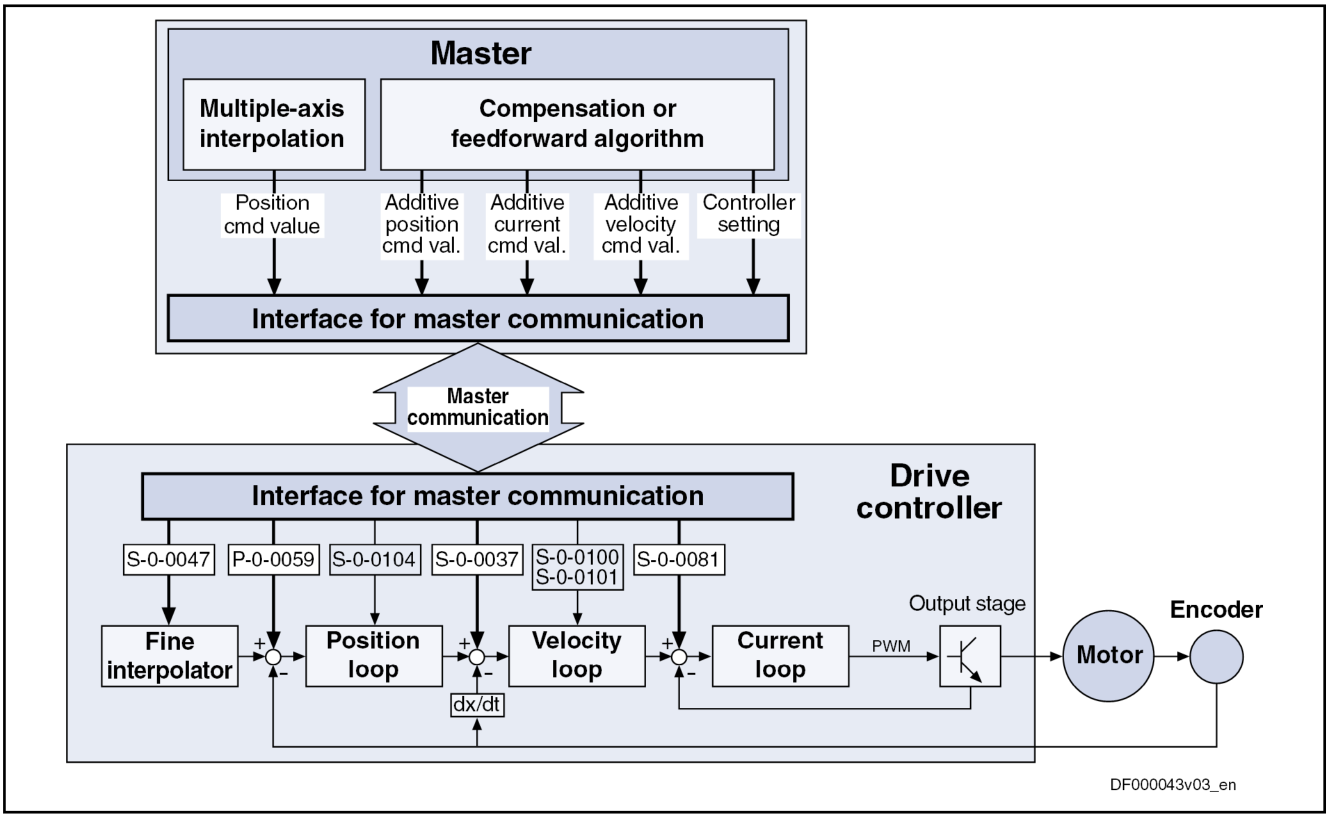
In closed-loop operation it is possible to add command values in addition to the command values available in the control loop. Depending on the active operation mode, the following parameters are available to do this:

Operation mode	S-0-0081	S-0-0037	P-0-0059	S-0-0048
U/f control (command value processing in velocity control)	--	--	--	--
Torque/Force Control	■	--	--	--
Velocity control / velocity synchronization	■	■	--	--
Position control	■	■	■	--
Drive-Controlled Positioning	■	■	■	--
Positioning Block Mode	■	■	■	--
Phase synchronization	■	■	--	■
Electronic cam	■	■	--	■

S-0-0081 Additive torque/force command value
S-0-0037 Additive velocity command value
P-0-0059 Additive position command value, controller
S-0-0048 Additive position command value
Fig.4-56: Overview of the Additive Command Values Depending on the Operation Mode

In closed-loop operation, it is possible to access the outer control loops from a higher-level operation mode. The access options to the individual control loops are illustrated in the following example:

Brief Functional Descriptions



S-0-0037	Additive velocity command value
S-0-0047	Position command value
S-0-0081	Additive torque/force command value
S-0-0100	Velocity loop proportional gain
S-0-0101	Velocity loop integral action time
S-0-0104	Position loop Kv-factor
P-0-0059	Additive position command value, controller

Fig.4-57: Structural overview with access options

Command Value Processing Depending on Operation Mode

Position control

For the following operation modes, the position control loop is closed internally (in the drive) in addition to the velocity and the current control loops:

- Position Control With Cyclic Command Value Input
- Drive-internal interpolation
- Positioning operation modes (drive-controlled positioning, positioning block mode)

See also description of the respective operation mode.

Velocity control

In the "Velocity control" operation mode, the velocity control loop, apart form the current control loop, is closed in the drive, too.

See also "Velocity Control"

Torque/Force Control

The "torque/force control" operation mode actually isn't torque or force control but current control. Therefore, only the current control loop is closed in the drive.

See also "Torque/Force Control"

Default Settings in the Motor Encoder Data Memory ("Load motor default values")

"Load Motor Default Values" Command

For all Rexroth motors of the lines with motor encoder data memory (e.g. MKE, MSK and possibly MAD and MAF), the basic settings for the controllers are stored and can be loaded to the drive by executing the command "Load default values" (S-0-0262).

The parameter "S-0-0262, C07_x Load defaults procedure command" can be activated in two ways:

- Automatically when running up the drive by recognizing that the motor type (cf. parameter S-0-0141) has changed. The display then reads "RL" and by pressing the "Esc" button on the control panel, the command "Load motor default values" is internally started unless this was deactivated in "P-0-0556, Config word of axis controller".
- Starting the command by writing "11b" to parameter S-0-0262.

See also "Loading, Storing and Saving Parameters"

> ☞ In order to start the command "Load motor default values", in parameter "P-0-4090, Configuration for loading default values" the value "0" (default setting) must have been set.

During the load motor default values procedure, the following control loop parameters are set to their default values optimized for the respective motor:

- S-0-0100, Velocity loop proportional gain
- S-0-0101, Velocity loop integral action time
- S-0-0104, Position loop Kv-factor
- S-0-0106, Current loop proportional gain 1
- S-0-0107, Current loop integral action time 1
- P-0-0004, Velocity loop smoothing time constant

> ☞ The default settings for the current loop (cf. S-0-0106 and S-0-0107) are automatically adjusted to the currently parameterized PWM frequency (cf. P-0-0001) and performance setting (cf. P-0-0556)!

In addition, when the motor default values are loaded, the following control loop parameters are set on the firmware-side default value even though there is no default value stored in the motor data memory for this.

- S-0-0348, Acceleration feedforward gain

> ☞ In the majority of cases, the controller settings stored in the motor encoder data memory provide a useful and reliable control loop setting. In exceptional cases, however, it may be necessary to make the settings with regard to the specific application.

Automatic Setting of Closed-Loop Axis Control

Brief Description

To facilitate drive parameterization, the IndraDrive firmware provides automatic control loop setting in closed-loop operation. The result of the control loop setting (obtained control loop dynamics) can be influenced via "P-0-0163, Damping factor for autom. controller setting" and "P-0-0164, Application for autom. controller setting".

☞ Depending on the settings in "P-0-0165, Drive optimization, control word" it is necessary to move the drive to carry out the automatic control loop setting. A motion is made when load inertia is determined and when the velocity and position control loops are optimized.

Features

- Definition of a travel range for movement control for the automatic control loop setting by
  – Absolute position limits for the travel range

  - or -

  – Entering a relative travel distance based on the current actual position
- Use of drive-internal interpolation and its parameters
- Via "P-0-0165, Drive optimization, control word" it is possible, by selecting the corresponding bit, to activate (bit = 1) or deactivate (bit = 0) the respective subfunction of the automatic control loop setting:
  – Calculation of velocity and/or position loop parameters (drive does not move)
  – Optimization of velocity and/or position loop parameters (drive moves)
  – Determination of acceleration feedforward (drive does not move)
  – Determination of load inertia (drive moves)
  – Determination of the maximum acceleration (drive does not move)
  – Oscillation movement / unipolar movement
  – Absolute travel limits / relative movement around start position

Pertinent Parameters

- P-0-0162, C1800 Command Drive optimization / command value box
- P-0-0163, Damping factor for autom. controller setting
- P-0-0164, Application for autom. controller setting
- P-0-0165, Drive optimization, control word
- P-0-0166, Drive optimization, end position negative
- P-0-0167, Drive optimization, end position positive
- P-0-0168, Maximum acceleration to be parameterized
- P-0-0169, Drive optimization, travel distance
- P-0-0170, Drive optimization, acceleration
- P-0-0171, Drive optimization, velocity

Pertinent Diagnostic Messages

- C1800 Command Drive optimization / command value box
- C1801 Start requires drive enable
- C1802 Motor feedback data not valid
- C1803 Inertia detection failed
- C1804 Automatic controller setting failed
- C1805 Travel range invalid
- C1806 Travel range exceeded
- C1807 Determining travel range only via travel distance
- E2049 Positioning velocity >= limit value (S-0-0091)
- E2055 Feedrate override S-0-0108 = 0

Velocity Loop (Including the Respective Filters)

Brief Description

In closed-loop operation, in addition to the field-oriented current controller, the velocity control loop is also closed in the drive by means of the drive software (PI cascade structure).

The controlled-loop operation (current and velocity) can be carried with encoder for all types of motors and for asynchronous motors also without encoders.

☞ The selection of the type of motor control is carried out via the parameter "P-0-0045, Control word of current controller" (Bit 14, 15).

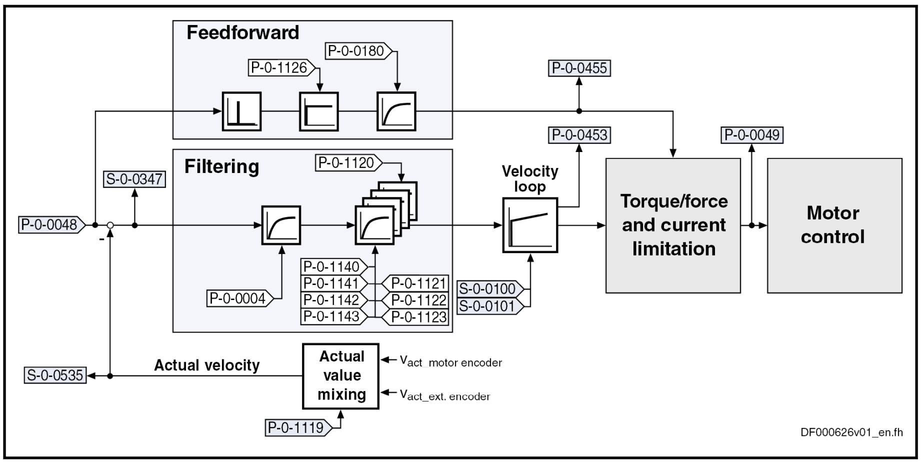


Fig.4-58: Structure of the Velocity Loop

☞ The following description is restricted to the velocity loop including the respective options of filtration and feedforward. The processing of the velocity command value is described within the operation mode "Velocity control".

Features

- Digital PI controller with anti-windup function, can be set by means of the following parameters:
  - S-0-0100, Velocity loop proportional gain
  - S-0-0101, Velocity loop integral action time
- Setting can be carried out by
  - One time execution of the function "Load default values (motor-specific controller values)"

    - or -
  - Manual optimization (see description below)

    - or -
  - Automatic parameteriztion of the axis controller (see "Automatic Setting of Closed-Loop Axis Control").
- Depending on the control performance which has been set, the cycle time $T_{A\_velocity}$ is used for velocity loop calculations (see "Performance Data").
- Possibility of mixing the velocities of motor encoder and optional encoder

- Four freely configurable filters of second order (e.g. band-stop filters) for filtering resonance frequencies

For firmware variant MPE, only two freely configurable filters are available.

- Low-pass filter to attenuate interference frequencies, to be set via P-0-0004 (VZ1)
- Fine interpolation of the command values of the position loop (can be switched on by P-0-0556, Bit 0)
- Monitoring of the velocity control loop (can be switched off by P-0-0556; Bit 1)
- Optional acceleration feedforward from the torque command value (with filtering option)

Pertinent Parameters

- S-0-0037, Additive velocity command value
- S-0-0040, Velocity feedback value
- S-0-0081, Additive torque/force command value
- S-0-0084, Torque/force feedback value
- S-0-0091, Bipolar velocity limit value
- S-0-0100, Velocity loop proportional gain
- S-0-0101, Velocity loop integral action time
- S-0-0149, C1300 Positive stop drive procedure command
- S-0-0155, Friction compensation
- S-0-0164, Acceleration feedback value 1
- S-0-0347, Velocity error
- P-0-0004, Velocity loop smoothing time constant
- P-0-0048, Effective velocity command value
- P-0-0049, Effective torque/force command value
- P-0-0180, Acceleration feedforward smoothing time constant
- P-0-0451, Actual acceleration torque/force value
- P-0-0452, Actual process torque/force value
- P-0-0555, axis controller messages
- P-0-0556, Config word of axis controller
- P-0-1119, Velocity mix factor feedback 1 & 2
- P-0-1120, Velocity control loop filter: Filter type
- P-0-1121, Velocity control loop filter: Limit frequency of low pass
- P-0-1122, Velocity control loop filter: Bandwidth of band-stop filter
- P-0-1123, Vel. cont. loop filter: Center frequency of band-stop filter
- P-0-1126, Velocity control loop: Acceleration feedforward
- P-0-1140, Velocity control loop filter: Numerator natural frequency
- P-0-1141, Velocity control loop filter: Denominator natural frequency
- P-0-1142, Velocity control loop filter: Numerator damping
- P-0-1143, Velocity control loop filter: Denominator damping
- P-0-2100, Velocity loop proportional gain, type plate

- P-0-2101, Velocity loop integral-action time, type plate
- P-0-3004, Speed controller smoothing time constant, type plate

Pertinent Diagnostic Messages

- E2059 Velocity command value limit active
- E8260 Torque/force command value limit active
- F8078 Speed loop error

Position Loop (with Respective Feedforward Functions and Actual Value Adjustment)

Brief Description

The following section only describes the position loop with the respective feedforward possibilities (velocity and acceleration feedforward).

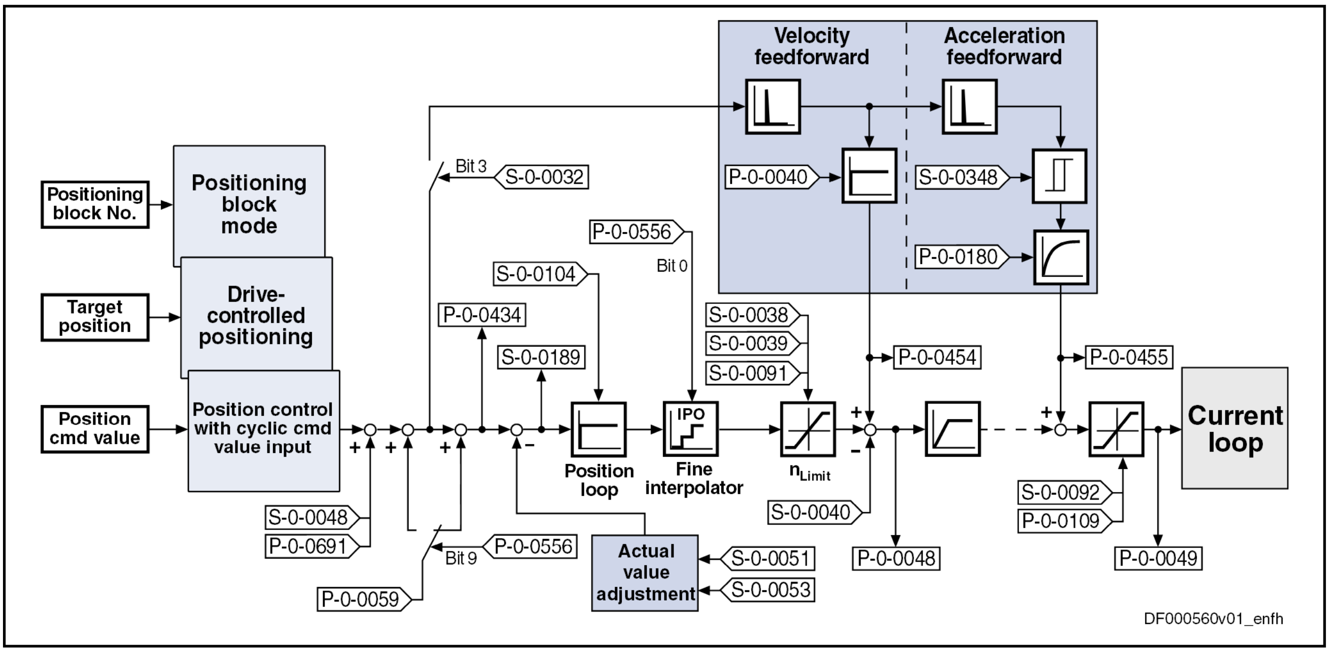


Fig.4-59: Structure of the Position Loop

☞ The preprocessing of the position command value (command value adjustment) is described in the corresponding section of the position control operation mode (e.g. position control with cyclic command value input, positioning block mode, ...).

Features

- Digital proportional loop, can be set via the following parameter:
  – S-0-0104, Position loop Kv-factor
- Lag error is minimized by:
  – Variable velocity feedforward (see P-0-0040)
  - and -
  – Variable acceleration feedforward (see S-0-0348), including smoothing filter
- Depending on the control performance which has been set, the cycle time $T_{A\_position}$ is used for position loop calculations (see "Performance Data").
- With lag error or lagless, i.e. with velocity feedforward
- Model monitor for the lag error (see also F2028)

- Possibility of evaluating a "hybrid actual position value" from motor encoder and external position control encoder (up to now only motor encoder and measuring wheel encoder)

Pertinent Parameters

- S-0-0032, Primary operation mode

  → Bit 3 = 1 → Activation of lagless operation
- S-0-0038, Positive velocity limit value
- S-0-0039, Negative velocity limit value
- S-0-0040, Velocity feedback value
- S-0-0048, Additive position command value
- S-0-0051, Position feedback value 1
- S-0-0053, Position feedback value 2
- S-0-0091, Bipolar velocity limit value
- S-0-0092, Bipolar torque/force limit value
- S-0-0104, Position loop Kv-factor
- S-0-0189, Following distance
- S-0-0348, Acceleration feedforward gain
- S-0-0386, Active position feedback value
- S-0-0520, Axis control word
- S-0-0521, Axis status word
- P-0-0040, Velocity feedforward evaluation
- P-0-0048, Effective velocity command value
- P-0-0049, Effective torque/force command value
- P-0-0059, Additive position command value, controller
- P-0-0109, Torque/force peak limit
- P-0-0180, Acceleration feedforward smoothing time constant
- P-0-0241, Actual pos. smoothing time constant for hybrid pos. control
- P-0-0434, Position command value of controller
- P-0-0454, Velocity feedforward actual value
- P-0-0455, Acceleration feedforward actual value
- P-0-0556, Config word of axis controller
- P-0-0691, Additive position command value, process loop

Pertinent Diagnostic Messages

- F2028 Excessive deviation
- F2036 Excessive position feedback difference
- F2037 Excessive position command difference

4.4.7 Commutation Setting

Basics on Commutation Setting

Brief Description

General Information

Significance of Commutation Offset

Three-phase synchronous motors are only operational if the current in the primary part to the magnetic field in the secondary part is correctly assigned. To do this, the position of the primary part (motor windings) with respect to the pole pair of the secondary part must always be known by the control. Depending on the primary part position reported by the motor encoder, the "commutation offset" is used to generate the current in the three-phase winding such that a force effect is produced in the motor.

A synchronous motor can only produce the maximum force with respect to the motor current if the value of the commutation offset is correct. Otherwise, the relation of torque/force to motor current (torque/force constant) would be lower and not optimum. A highly incorrect value implies the danger of the motor having a "runaway effect".

If the motor encoder is not installed in the defined orientation with respect to the primary and secondary part of the motor, an individual commutation offset value must be determined for each synchronous motor:

- With Rexroth synchronous motors with integrated motor encoders and encoder data memory (e.g. MSK motors), the commutation offset has already been determined at the factory and is delivered in the motor encoder data memory. The user no longer needs to set the commutation offset!
- Rexroth synchronous kit motors consists of motor components (primary part, secondary part). They are finally put together as an operational motor when they are installed in the machine axis and completed by the customer with a motor encoder. The commutation offset can only be determined by the user after the motor is complete.

  The following Rexroth kit motors are manufactured according to the functional principle "synchronous motor":

  – Linear motors LSF, MLF
  – Rotary motors MBS and MBT

Motor Encoders for Synchronous Motors

Ideally, absolute motor encoders should be used for synchronous Rexroth kit motors. The advantage in this case is the absolute position detection of the motor position which immediately ensures, when drive enable is set, the correct assignment of current in the primary part to the magnetic field in the secondary part if the commutation offset was determined in the initial commissioning of the motor and saved in the drive.

For some applications it is necessary to use relative motor encoders because the available length of absolute motor encoders is limited, for example. The disadvantage in this case is that absolute detection of the motor position is impossible. It is therefore necessary, after each time the drive is switched on again or after having changed the communication phase from "PM" to "OM" ("bb" or "Ab") to set the commutation offset again. For linear motors, this disadvantage can be removed by using the Hall sensor component or option because with regard to commutation setting the relative motor encoder then behaves like an absolute motor encoder.

☞ If a relative motor encoder is used with a Rexroth linear motor, the use of the Hall sensor component is absolutely recommended! This achieves the greatest safety with regard to correct motor function and compliance with the power data!

Concerning operationally reliable drives with synchronous third-party motors and IndraDrive controllers with regard to the selected motor encoder, the same principles apply as for Rexroth synchronous kit motors (see above); however, the Hall sensor box SHL02.1 cannot be used for linear third-party motors.

Brief Functional Descriptions

Overview of the Motor Encoders Usable with Synchronous Motors

Motor encoder	Rexroth synchronous kit motor (rotary, linear)	Rexroth synchronous kit motor (linear) with SHL02 or Hall unit	Synchronous third-party motor
Absolute	+	--	+
Relative	o	+	o

+ Advantageous combination
o Combination possible, initial commissioning might possibly require especially trained staff
-- Combination not useful

Fig.4-60: Possible Combinations of Motor Encoders and Synchronous Motors for Which Commutation Setting is Required

☞ The motor encoder should be implemented with a high resolution and as a **motor encoder to be evaluated in absolute form.** If it is necessary to use a relative motor encoder, using encoders with square-wave signals should be avoided!

With synchronous motors with a gear between motor and motor encoder (**encoder gear**), in general an absolute motor encoder **cannot be evaluated as an absolute commutation encoder** (for special cases, see below)!

For synchronous motors with relative motor encoders in combination with an additional **external encoder that can be evaluated in absolute form** installed on the axis, with a slip-free mechanical axis system the external encoder can be used as an **absolute commutation encoder** for the motor (for special cases, see below).

Pertinent Parameters

Except for the motor parameters (see overview of parameters in "Basics on the Motors to be Controlled") the other for the commutation setting are available:

- P-0-0506, Amplitude for angle acquisition
- P-0-0507, Test frequency for angle acquisition
- P-0-0508, Commutation offset
- P-0-0509, Commutation offset coarse
- P-0-0517, Commutation: Required harmonics component
- P-0-0518, C5600 Command subsequent optimization of commutation offset
- P-0-0519, Commutation status word
- P-0-0521, Effective commutation offset
- P-0-0522, Control word for commutation setting
- P-0-0523, Commutation setting measured value
- P-0-0524, C1200 Commutation offset setting command
- P-0-3008, Commutation offset, type plate

Pertinent Diagnostic Messages

- C1200 Commutation offset setting command
- C1204 Error in offset calculation
- C1208 No adjustment with asynchronous motor
- C1209 Proceed to phase 4
- C1211 Commutation offset could not be determined.

- C1212 Motion range exceeded during commutation
- C1214 Command only possible with linear synchronous motor
- C1215 Command only possible in 'bb'
- C1216 Commutation determination not selected
- C1217 Setting only possible in 'Ab'
- C1218 Automatic commutation: Current too low
- C1219 Automatic commutation: Overcurrent
- C1220 Automatic commutation: Timeout
- C1221 Automatic commutation: Iteration without result
- C1222 Error when writing offset parameters
- C1223 Command execution impossible
- C5600 Command subsequent optimization of commutation offset
- C5601 Command requires drive enable
- C5602 Axis blocked
- C5603 Timeout: Axis in motion
- F2032 Validation error during commutation fine adjustment
- F8010 Autom. commutation: Max. motion range when moving back
- F8011 Commutation offset could not be determined
- F8012 Autom. commutation: Max. motion range
- F8013 Automatic commutation: Current too low
- F8014 Automatic commutation: Overcurrent
- F8015 Automatic commutation: Timeout
- F8016 Automatic commutation: Iteration without result
- F8017 Automatic commutation: Incorrect commutation adjustment

Overview of Methods for Determining the Commutation Offset

Methods for Determining the Commutation Offset

The commutation offset can be determined with different methods. The method is chosen in accordance with the axis geometry, the practicability and the chances of success of the respective method depending on motor and mechanical axis system.

The following methods are possible:

- **Calculation method**

  → For relative motor encoder when using the Hall sensor component SHL02 (distance measurement, currentless → only possible with Rexroth linear kit motors, see documentation "Hall Sensor Box SHL02.1")

- **Measuring method**

  → For motor encoder that can be evaluated in absolute form (distance measurement, currentless → only possible with Rexroth linear kit motors)

- **Saturation method** (axis needs to be blocked or at standstill, with current)

  → Possible with all types of motors in combination with motor encoders that can be evaluated in absolute form and with relative motor encoders; but see "Restrictions for saturation method" in table below

- **Sine method** (requires unrestricted movement of axis, with current)

→ Possible with all types of motors in combination with motor encoders that can be evaluated in absolute form and with relative motor encoders; but see "Restrictions for sine method" in table below

Recommendations for selecting the determination method:

Motor type	Determination method (and motor encoders that can be used)			
	Calculation method (relative linear encoder with Hall sensor component)	Measuring method (absolute linear encoders only)	Saturation method* (absolute or relative motor encoder)	Sine method* (absolute or relative motor encoder)
MBSxx0	--	--	+	o
MBSxx2 (high speed)	--	--	o	+
MBT	--	--	+	o
LSF	+ (with SHL02)	+	+	o
MLF	+ (with SHL02)	+	+	o
MCL	(not required for "Hall unit..." option)	+	--	o
MSP	--	--	+	o
Sy third-party motors (rotary and linear)	--	--	+	o

+ Recommended method
o Method not recommended
-- Method not possible
* See application-related limitations

Fig.4-61: Recommendations for Selecting Determination Method for Commutation Offset Depending on Motor Type (for Rexroth Motors)

☞ The sine method (generally requires unrestricted movement of axis) should only be used if the saturation method cannot be used!

Restrictions for Saturation Method

Applications of synchronous motors	Restrictions for saturation method
Third-party motors that have no saturation effects or where they are low (e.g. ironless motors or motors with high magnetic leakage flux)	Saturation method cannot be used for determining commutation offset!
Applications with relative measuring system (without using the optimum commutation offset value with regard to the reference point)	Max. torque/force can be reduced by approx. 20% compared to the optimum value (autom. determination of the commutation offset with "AF" - drive enable)!
Applications with relative measuring system that are using the optimum commutation offset value with regard to the reference point	Max. torque/force until reference mark is passed can be reduced by approx. 20%!

Applications of synchronous motors	Restrictions for saturation method
Drives that can be in motion during the determination of the commutation offset, e.g. coasting spindles, printing roller drives etc.	Saturation method is only possible for motors in standstill!
Drives with a low degree of overload capacity	Saturation method only possible if amplifier current is sufficiently high (2...4-fold continuous motor current required)!
Drives that are not permitted to move during determination of the commutation offset (low-friction axes with low inertia)	Saturation method (with current) can cause a motor "runaway effect"!

Fig.4-62: Typical Applications and Restrictions for Saturation Method

Restrictions for Sine-wave Method

Applications of synchronous motors	Restrictions for sine-wave method
Linear axis with single motor or parallel motor	Only balanced (e.g. horizontal) axes with low friction!
Linear axes in Gantry arrangement	Only balanced (e.g. horizontal) axes with low friction! In addition, both drives have to carry out sequential commutation settings; in this case "AF" may not be allowed to be active at the other drive!
Axis with holding brake (e.g. vertical axis)	Holding brake must be opened to determine the commutation offset successfully. Only balance axes!
Rotary axes with single drive	Only balanced axes with little friction; high inertia can cause problems!
Rotary axes, mechanically connected	See above "Linear axes in gantry arrangement"!

Fig.4-63: Typical Applications and Restrictions for Sine-Wave Method

Limitations for Motors with Relative Motor Encoders and Digital Hall Sensors

The respective limitations are explained in the sub-section.

Identification of the Motor Encoder

Brief Functional Descriptions

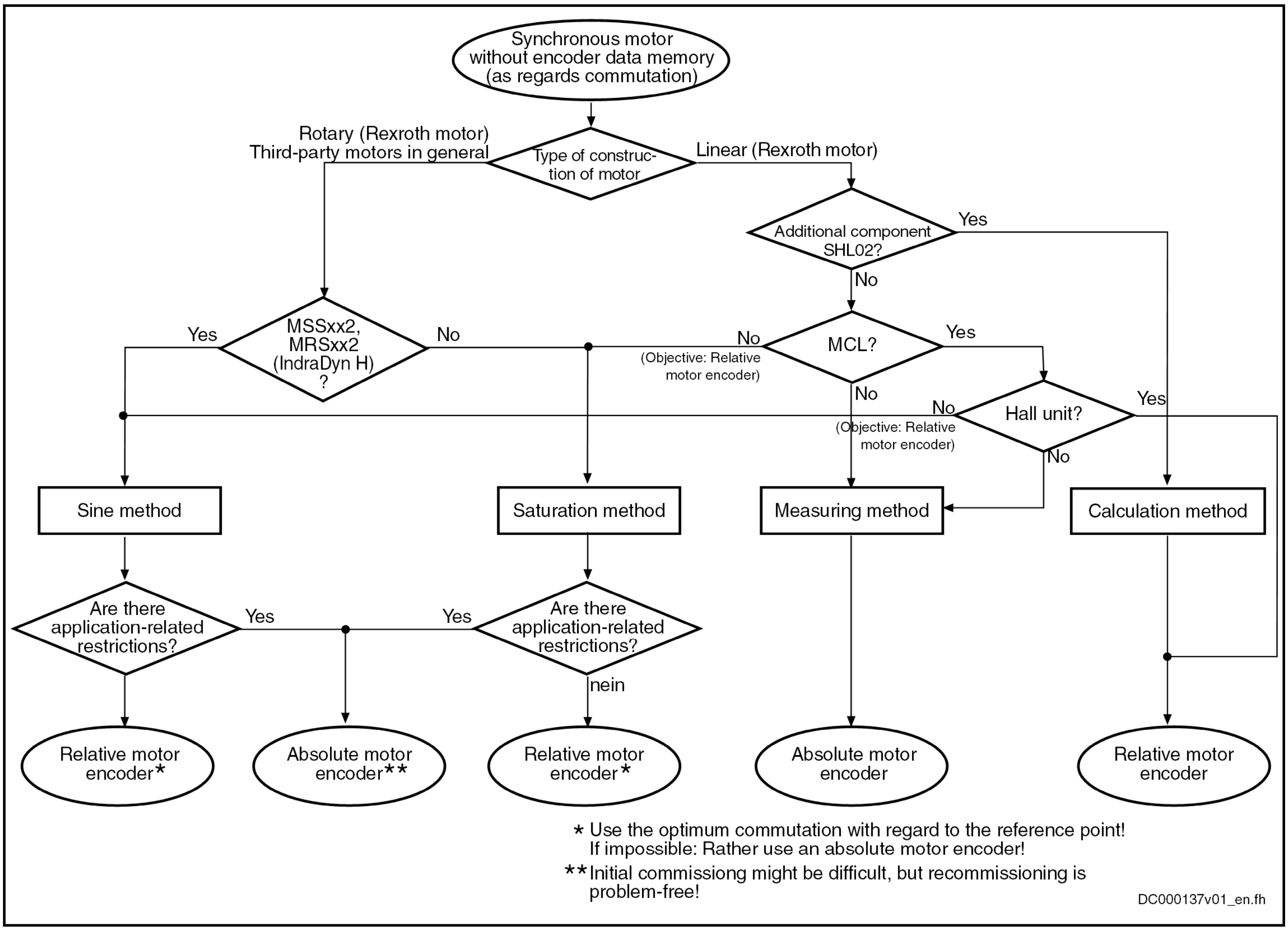


Fig.4-64: Identification of Absolute or Relative Motor Encoders Depending on the Motor and Application-related Limitations

Effect of an Encoder Gear

If a motor encoder to be evaluated in absolute form is connected with an encoder gear in the case of a synchronous motor, in general there is no unambiguous assignment of electrical angle and absolute actual position value. For this reason, the motor encoder to be evaluated in absolute form now behaves as a relative motor encoder with respect to the commutation.

In two special cases, however, absolute commutation encoder evaluation is possible for synchronous motors with encoder gear (rotary encoders only):

Case 1, Single-turn (or multi-turn) encoder:

- if an n-fold motor revolution (n is an integer) yields exactly one encoder revolution

Case 2, Multi-turn encoder:

- if exactly one motor revolution yields an m-fold encoder revolution (m is an integer)

Effect of an External Absolute Encoder

For synchronous motors with relative motor encoders in combination with an additional external encoder that can be evaluated in absolute form installed on the axis, with a slip-free mechanical axis system the external encoder can be used as an absolute commutation encoder for the motor. If this is the case, in "P-0-0185, Control word of encoder 2 (optional encoder)" the external encoder can be assigned as commutation encoder. Then the specifications as for a synchronous motor with a motor encoder that can be evaluated in absolute form apply.

Determining the Commutation Offset

The active commutation offset value is located in parameter "P-0-0521, Effective commutation offset". Due to it significance for the torque/force development of the motor and operational safety, P-0-0521 is always write-protected.

Depending on the motor encoder used, the commutation offset must be determined for the following situations:

- With absolute motor encoder only during **initial commissioning** of the drive
- With relative motor encoder both during **initial commissioning** of the motor and each time the drive has been switched on again (**recommissioning**)

☞ With Rexroth synchronous motors with integrated motor encoders (e.g. MSK motors), the initial commissioning has already been performed at the factory and the correct commutation offset has been determined and is delivered in the motor encoder data memory. The user no longer needs to set the commutation offset!

Initial Commissioning and Recommissioning

In the initial commissioning of Rexroth kit and third-party synchronous motors, the commutation offset is determined in the initial commissioning of the motor with a suitable, available method from the drive. The quality of this commutation offset determination is subject to variations that can be caused by the current conditions of the mechanical axis and electromagnetic systems. Because the torque or force development of the motor depends on the quality of the commutation offset value, however, this value should be carefully optimized during the initial commissioning of the motor.

However, to do this it is necessary to allow the description of parameter "P-0-0521, Effective commutation offset", which is normally write-protected, so that the value can also be optimized manually if necessary. To do this, the drive has "initial commissioning mode" (activation in "P-0-0522, Control word for commutation setting").

The optimum value of the commutation offset identified in initial commissioning is displayed in "P-0-0521, Effective commutation offset" and should also be effective when the drive is switched on again (recommissioned). To do this, this value must be save in the "initial commissioning mode" in an appropriate manner such that it is available during recommissioning:

- **For motors with absolute motor encoders as well as for relative motor encoders and analog Hall sensors (SHL02 for MLF, analog Hall unit for MCL):**

  The value of the effective commutation offset (P-0-0521) is automatically saved in "P-0-0508, Commutation offset" as well. When the drive is recommissioned, this saved value becomes effective again. If the motor encoder has data memory, the value of P-0-0521 is also saved in "P-0-3008, Commutation offset, type plate".

- **For motors with relative motor encoders and motors with additional digital Hall sensors (digital Hall unit for MCL, third-party motors):**

  The value of the effective commutation offset (P-0-0521) is saved in reference to a fixed, reproducible motor or axis position in "P-0-0508, Commutation offset". To do this, the user must execute appropriate drive actions. When recommissioning, after the drive is initially enabled (AF), first the automatic commutation setting of the motor is carried out or, in the case of digital Hall sensors, the acceptance of "P-0-0509, Commutation offset coarse" in P-0-0521. In turn, based on the appropriate drive actions taken by the user, the value saved in P-0-0508 becomes effective in a manner that is optimized for the automatically determined commutation offset (P-0-0521) in that a correction value is determined and added.

☞ By adding a correction value, after the motor is recommissioned, the effective commutation offset (P-0-0521) achieves the quality of the value effective in the initial commissioning of the drive. This yields reproducible drive behavior with respect to torque/force development. The determination of the suitable correction value is supported by the reference mark of the motor encoder or the homing reference position of the axis; for this reason, the method is designated as "reference point optimized commutation offset".

Commutation Setting for Rexroth motors MLF, LSF

Brief Description

Rexroth kit linear motors of the MLF and MCL lines are manufactured according to the functional principle "synchronous motor". For kit motors, the motor components primary part, secondary part and motor encoder are finally assembled on the customer side in the machine.

Motors with Absolute Motor Encoders

The operational capability of the synchronous motor can only be established on site by determining and setting the commutation offset. For motors with a motor encoder that can be evaluated in absolute form, this is done once during initial commissioning.

Motors with Relative Motor Encoders

For synchronous motors with a relative motor encoder, it is necessary to redetermine the commutation offset each time the drive is switched on again. Deviating commutation offset values are possible due to redetermination and this can cause lower force development at the same motor current.

To prevent this, it is recommended that Hall sensor components, developed especially for Rexroth linear motors be used in addition to the relative motor encoder.

Analog Hall Sensors

Via analog signals from Hall sensors, the controller detects the position of the motor windings with respect to the magnetic field of the motor and in this way also completes the commutation setting during initial commissioning. When the drive is recommissioned, the correct commutation offset is immediately available at drive enable ("AF").

- Hall sensor-Box SHL02.1 for MLF motors
- Analog Hall unit (motor option) for MCL motors

☞ A second encoder input is required on the controller for evaluating the analog Hall sensor signals. This requires a controller with a Basic control section; an Economy control section cannot be used for this purpose!

Digital Hall Sensors

There is also a Hall unit with digital signals available as a motor option for the ironless motor MCL in Economy applications. Via three digital signals that are offset by 120° with respect to a pole pair, the controller detects the position of the motor windings with respect to the magnetic field of the motor with a precision of +/-30° (with respect to the pole pair). This enables the motor, immediately after it is switched on, to operate at at least 50% of the possible motor force.

The following homing procedures of the relative measuring system allows full motor force to be achieved again if this was prepared accordingly in the initial commissioning. The current status of the performance of the motor is diagnosed and can be queried from the control master side.

☞ To evaluate the digital Hall sensor signals, the additional component "SHL03" is required (conflating motor encoder and Hall sensor signals). One control section with just one encoder input is sufficient for the controller. For this reason, Economy control sections can be used!

In principle, MLF or MCL motors in combination with a relative motor encoder can also be commutated without using a Hall unit or SHL02 additional components by using the available current supply method.

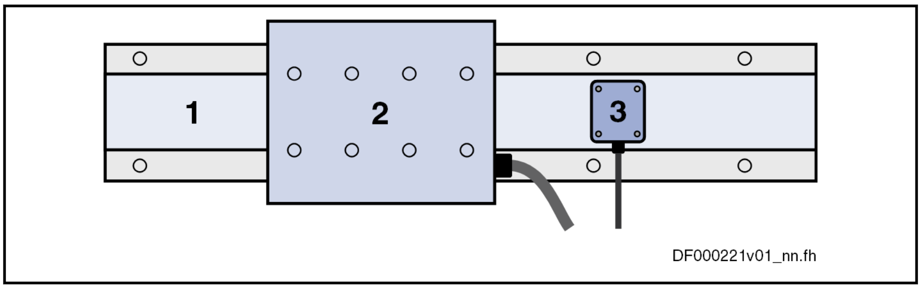
- Saturation method for MLF motors
- Sine method for MCL motors

Each time the drive is switched on again, the commutation setting is performed again in connection with the disadvantages listed above. These disadvantages can be compensated for by using the "reference point optimized commutation offset".

☞ Application-related limitations are to be noted for the saturation and sine methods! Using the "reference point optimized commutation offset" is urgently recommended! !See above!)

Hall Sensor Box SHL02.1 for MLF

The Hall sensor box SHL02.1 is an absolute measuring system, outside of the motor, within one pole pair distance of Rexroth linear MLF motors.



1	Secondary part
2	Primary part
3	Hall sensor box SHL02 (connected with the primary part)

Fig.4-65: Rexroth Linear Motor with Hall Sensor Box SHL02

For information on mounting and connection see the documentation on Hall sensor box SHL02.1.

Hall Unit, Motor Option with MCL

The Hall unit is an absolute measuring system, integrated into the motor, within one pole pair distance of Rexroth linear MCL motors. The Hall unit is optional; it can be ordered directly or retrofitted.

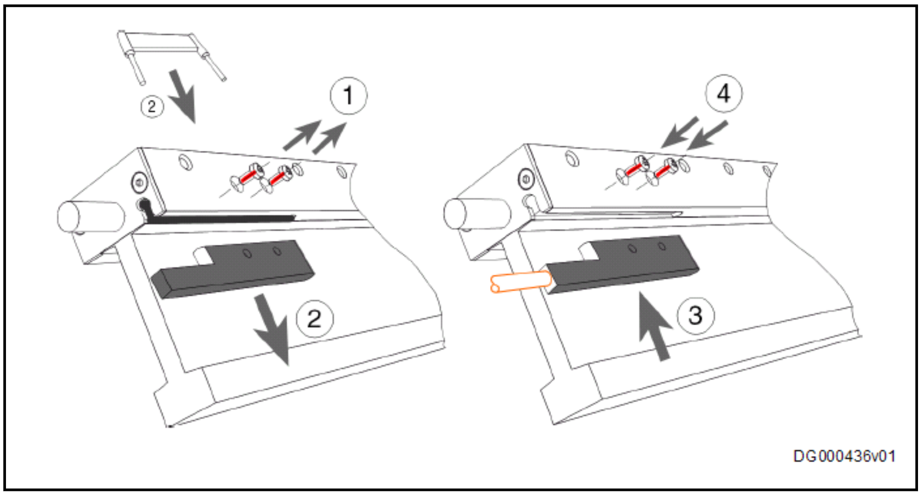


Fig.4-66: "Hall Unit" Option for MCL Motors; Dismounting the Dummy Unit, Retrofitting the Hall Unit

Information regarding dismounting/assembly and connection is contained in the "Ironless Linear MCL Motors" documentation.

Saturation Method

Brief Description

For rotary synchronous Rexroth kit motors and synchronous third-party motors, IndraDrive controllers only provide methods with current to determine the commutation offset. The saturation method, which requires that the motor does not move, is among these methods. A possibly available holding brake should remain applied!

☞ For Rexroth synchronous motors with integrated motor encoder (MSK, MHD, MKD, MKE motors), it is not necessary to set the commutation offset! The correct value is provided in the motor encoder data memory and is automatically activated.

The saturation method is also relevant for linear synchronous Rexroth kit motors if they are equipped only with a relative motor encoder or for motors with a motor encoder that can be evaluated in absolute form if distance measurement at the axis is not possible due to installation issues.

As a prerequisite for successful application of the saturation method, the iron material of the motor must be magnetically saturated when current is supplied, i.e. the controller must be able to provide sufficiently high current to the motor. For synchronous motors which are not magnetically saturated at maximum allowed current, this method is unsuited for determining the commutation offset!

☞ If the saturation method cannot be used, the controller provides the sine-wave method (works with current, too) for determining the commutation offset.

The saturation method is suitable for both the initial commissioning and the recommissioning, although the limitations must be observed.

☞ The limitations to be observed when using the saturation method are described in the section "Basics on Commutation Setting". This section outlines the different methods which can be used for determining the commutation offset.

Sine-Wave Method

Brief Description

For synchronous motors, in addition to the saturation method, IndraDrive controllers provide the sine-wave method, also with current, to determine the commutation offset.

Application-Related Aspect

The sine-wave method for determining the commutation offset can be used for all types of synchronous motors.

The disadvantage of the sine-wave method is that the motor has to be put into motion by supplying current. Limitations of the motivity (e.g. friction or blocking) can reduce the quality of offset determination or even cause offset determination to fail! See the section "Basics on Commutation Setting"

Before using the sine-wave method, carefully check whether it is possible to use the saturation method, because unrestricted movement of the axis generally causes problems. For the saturation method movement of axis is not necessary, it should be blocked, if possible.

The sine method is suitable for both the initial commissioning and the recommissioning, although the limitations must be observed.

☞ The limitations to be observed when using the sine method are described in the section "Basics on Commutation Setting". This section outlines the different methods which can be used for determining the commutation offset.

Commutation Setting via Digital Hall Sensors

Brief Description

General Information

Digital Hall Sensors for Three-Phase Synchronous Motors

In addition to the typical absolute measuring systems on the market, for three-phrase synchronous motors the position of the motor windings with respect to the magnetic field of the motor can also be identified using three digital signals that are offset by 120° with respect to a pole pair. The precision of +/-30° with respect to a pole pair is low; however, with respect to the commutation offset it is still sufficient for use.

In combination with a relative motor encoder, for synchronous motors an absolute motor measuring system can be realized with respect to the commutation offset; this system can be evaluated by IndraDrive controllers. To do this, the additional component "SHL03" is required, which brings both measuring systems together and enables the connection to just one encoder input of the controller.

Rexroth MCL Motors, "Digital Hall Unit" Option

Digital Hall sensors are available for the ironless Rexroth MCL linear motors. They can be ordered as motor option "Hall sensor, digital" and integrated into the primary part of the motor. An additional relative motor encoder and the SHL03 component are required!

☞
- For information regarding the commutation setting of MCL motors, see the section "Commutation Setting for Rexroth Linear Motors MLF, MCL"
- See also the documentation "Rexroth IndraDyn L, Ironless Linear MCL Motors; Project Planning Manual"

Third-party Motors with Digital Hall Sensors

General Conditions

- Three-phase synchronous motors with a fixed interconnection (star or delta switching)
- Three Hall sensor signals offset by 120° (with respect to a pole pair) for motor commutation
- Relative motor encoder for motor operation

Hardware-side features and requirements

- Supply voltage for the motor encoder: DC5V
- Supply voltage for the Hall sensors: DC12V
- Voltage level of the Hall sensor signals: 5VTTL
- SHL03 component for bringing together the motor encoder and Hall sensor signals for connection to an encoder input of the controller.

☞ For more information regarding the technical data, see the documentation "IndraDrive Cs Drive Systems. Project Planning Manual"

4.4.8 Limitations

Overview of Limitations

To protect the mechanical axis system, the controllers and the motors against overload, IndraDrive devices have different possibilities of limitation:

- Torque/Force limitation
  - Axis-side torque/force limit values, depending on the preceding sign
  - Axis-side torque/force limit values, related to the absolute value (independent of the preceding sign)
- Current limitation
  - Absolute current limit values, depending on controller or motor
  - Dynamic current limitation, depending on the thermal load of controller or motor
- Velocity limitation
  - Motor-side velocity limit values
  - Axis-side velocity limit values
- Position limitation
  - Evaluation of axis-side travel range limit switches
  - Firmware-side travel range limit values

The existing limiting facilities are active depending on the method of motor control.

Voltage-Controlled Open-Loop Operation (U/f Control)

With voltage-controlled, sensorless operation, the following limitations are available to protect the device or motor:

- Torque/force limitation via stall protection loop
- Current limitation via current limitation loop
- Position limitation by
  - Travel range limit switches
  - Software limit switches

Closed-Loop Operation of Motors (FXC, FOC, FOCsl)

In closed-loop operation (flux-controlled or current-controlled), there are the following parameterizable limitations to protect the device or motor:

- Torque/Force Limitation
- Current limitation
- Velocity Limitation
- Position limitation by
  – Travel range limit switches
  – Software limit switches

Current and Torque/Force Limitation

Brief Description

Current limitation and torque/force limitation avoid mechanical overload of the axis and thermal overload of motor and controller.

Torque/force limit values due to axis conditions and processing take effect statically as positive and negative limits of the torque/force command value. The thermal overload protection might possibly reduce these limits dynamically, depending on the current thermal load of motor and controller.

Features

- User-side limit values for torque/force (drive-internally converted to current limit values):
  – Bipolar limit values (S-0-0092, P-0-0109)
  – Unipolar limit values (S-0-0082, S-0-0083)
- Display of the current torque/force command value in "P-0-0049, Effective torque/force command value"
- Display of the process torque or process force in "S-0-0084, Torque/force feedback value"
- Drive side, absolute current limit values in "S-0-0110, Amplifier peak current" and "S-0-0109, Motor peak current"
- Dynamic current limitation depending on work load reduces maximum current to the thermally allowed continuous current on the basis of motor and amplifier temperature model (depending on motor type and possibly selected cooling type, as well as on PWM frequency and amplifier type); currently available maximum current and thermally possible continuous current displayed in the parameters:
  – P-0-4045, Maximum possible continuous current
  – P-0-4046, Effective peak current
- Resulting torque/force limit values from the user-side torque/force limitations and the (dynamic) current limitation depending on work load are displayed in the parameters:
  – P-0-0442, Actual value torque limit positive (stationary)
  – P-0-0443, Actual value torque limit negative (stationary)
  – P-0-0444, Actual value peak torque limit
- Status word for analysis of the currently active torque/current limitation (P-0-0445)
- Display of effective torque-generating current command value ("limited" current command value) in parameter
  – P-0-0038, Torque-generating current, command value
- Display of actual current values in the parameters
  – P-0-0440, Actual output current value (absolute value)
  – P-0-0043, Torque-generating current, actual value

  – P-0-0044, Flux-generating current, actual value

Pertinent Parameters

- S-0-0082, Torque/force limit value positive
- S-0-0083, Torque/force limit value negative
- S-0-0092, Bipolar torque/force limit value
- S-0-0109, Motor peak current
- S-0-0110, Amplifier peak current
- S-0-0111, Motor current at standstill
- S-0-0112, Amplifier nominal current
- S-0-0384, Amplifier temperature
- P-0-0001, Switching frequency of the power output stage
- P-0-0038, Torque-generating current, command value
- P-0-0049, Effective torque/force command value
- P-0-0051, Torque/force constant
- P-0-0109, Torque/force peak limit
- P-0-0141, Thermal drive load
- P-0-0440, Actual output current value (absolute value)
- P-0-0441, Thermal drive load warning threshold
- P-0-0442, Actual value torque limit positive (stationary)
- P-0-0443, Actual value torque limit negative (stationary)
- P-0-0444, Actual value peak torque limit
- P-0-0445, Status word torque/current limit
- P-0-0045, Control word of current controller
- P-0-0640, Cooling type
- P-0-4034, Thermal time constant of winding
- P-0-4035, Thermal time constant of motor
- P-0-4037, Thermal short-time overload of winding
- P-0-4045, Maximum possible continuous current
- P-0-4046, Effective peak current
- P-0-4058, Amplifier type data
- P-0-4059, Electric type data of power section

Pertinent Diagnostic Messages

- E2050 Device overtemp. prewarning
- E2051 Motor overtemp. prewarning
- E2056 Torque limit = 0
- E2061 Device overload prewarning
- E8055 Motor overload, current limit active
- E8057 Device overload, current limit active
- F2018 Device overtemperature shutdown
- F2019 Motor overtemperature shutdown
- F2021 Motor temperature monitor defective
- F2022 Device temperature monitor defective

Velocity Limitation

Brief Description

Velocity limitations are implemented in the drive that allow the velocity command value to be limited to a freely definable value or to various positive and negative values.

Features

- Unipolar velocity limit values (S-0-0038, S-0-0039), scaled, referenced to load if necessary
- Cyclically configurable, bipolar velocity limit value (S-0-0091), scaled, reference to load if necessary
- Bipolar velocity limit value (P-0-0113) of the motor, unscaled, referenced only to the motor

Pertinent Parameters

- S-0-0036, Velocity command value
- S-0-0037, Additive velocity command value
- S-0-0038, Positive velocity limit value
- S-0-0039, Negative velocity limit value
- S-0-0091, Bipolar velocity limit value
- P-0-0113, Bipolar velocity limit value of motor

Pertinent Diagnostic Messages

- E2059 Velocity command value limit active
- E2063 Velocity command value > limit value
- F8079 Velocity limit value exceeded

Position Limitation/Travel Range Limit Switches

Brief Description

To avoid accidents and damages to the machine, comprehensive preventive safety precautions are provided. Part of these safety precautions is the limitation of the allowed working range (travel range) by the drive. For this purpose, position monitoring functions and position limitations have been implemented in the drive.

⚠ CAUTION	**The travel range monitoring function (travel range limit switches or software limit switches) only fulfills the requirements for protecting machinery, but is not sufficient for personal protection!**

Realizing Travel Range Monitoring

The drive provides two possibilities of determining and monitoring a limitation of the working range (travel range):

- Monitoring of **position limit values (software limit switches)**

  Monitoring of the motor position for exceeding one of the two position limit values (positive/negative → S-0-0049/S-0-0050) by the homed actual position value (S-0-0403), i.e. value related to the machine zero point.
- Monitoring of **travel range limit switches**

  Monitoring for activation of one of the two travel range limit switches (Limit+, Limit-) that are connected to the digital inputs of the drive.

> ☞ The functionality of the travel range limit switches is only guaranteed, if the corresponding digital inputs have been configured for this purpose!
>
> See "Digital Inputs/Outputs"

Features of Travel Range Limit Switches

- Two travel range limit switches (Limit+, Limit-) can be monitored at the drive
- Signal behavior of travel range limit switches (N/C and N/O) can be set
- Travel range limit switches activated via parameter
- Reaction (error/warning) when exceeding travel range can be set
- Status display of travel range limit switches
- Command values monitored for validity when limit switch activated
- Travel range limit switches evaluated and position limit value monitor activated in 2 ms clock

Features of Position Limit Values

- Two position limit values ("software limit switches") can be parameterized; only operational when axis has been homed
- Reaction (error/warning) when exceeding position limit values can be set
- Position limit values activated via parameter
- Automatic reference to measuring system that has been homed
- Command values monitored for validity when position limit values exceeded

Pertinent Parameters

- S-0-0012, Class 2 diagnostics
- S-0-0049, Positive position limit value
- S-0-0050, Negative position limit value
- S-0-0055, Position polarities
- S-0-0147, Homing parameter
- S-0-0403, Position feedback value status
- P-0-0090, Travel range limit parameter
- P-0-0222, Travel range limit switch inputs

Pertinent Diagnostic Messages

- E2053 Target position out of travel range
- E8029 Positive position limit exceeded
- E8030 Negative position limit exceeded
- E8042 Both travel range limit switches activated
- E8043 Positive travel range limit switch activated
- E8044 Negative travel range limit switch activated
- F6029 Positive position limit exceeded
- F6030 Negative position limit exceeded
- F6042 Both travel range limit switches activated
- F6043 Positive travel range limit switch activated
- F6044 Negative travel range limit switch activated

4.4.9 Power Supply

Brief Description

Possibilities of Power Supply

The following IndraDrive devices are supported by this firmware:

- Single-axis converters in the IndraDrive Cs range (controllers HCS01.1)
- Multi-axis converters (controllers HCQ, HCT)

Converters include a supply unit and an inverter unit. They are suitable for direct power supply connection, but can only be used in a single-axis design (HCS01.1) and a bus linked, modular drive system.

Pertinent Parameters

- S-0-0380, DC bus voltage
- P-0-0114, Undervoltage threshold
- P-0-0118, Power supply, configuration
- P-0-0119, Best possible deceleration
- P-0-0460, Module group, control word
- P-0-0461, Module group, status word
- P-0-0806, Current mains voltage crest value
- P-0-0809, Properties of charging circuit
- P-0-0810, Minimum mains crest value
- P-0-0815, Nominal mains voltage crest value
- P-0-0816, Amplifier temperature 2
- P-0-0819, Energy counter
- P-0-0833, Braking resistor threshold
- P-0-0844, thermal load of Braking resistor
- P-0-0858, Data of external braking resistor
- P-0-0859, Data of internal braking resistor
- P-0-0860, Converter configuration
- P-0-0861, Power supply status word

Pertinent Diagnostic Messages

- E2026 Undervoltage in power section
- E2040 Device overtemperature 2 prewarning
- E2050 Device overtemp. prewarning
- E2061 Device overload prewarning
- E2086 Prewarning supply module overload
- E2810 Drive system not ready for operation
- E2814 Undervoltage in mains
- E2816 Undervoltage in power section
- E2819 Mains failure
- E2820 Braking resistor overload prewarning
- E2829 Not ready for power on
- E8025 Overvoltage in power section
- E8028 Overcurrent in power section
- E8057 Device overload, current limit active
- E8058 Drive system not ready for operation

- F2026 Undervoltage in power section
- F2086 Error supply module
- F2087 Module group communication error
- F2816 Softstart fault power supply unit
- F2818 Phase failure
- F2819 Mains failure
- F2820 Braking resistor overload
- F2821 Error in control of braking resistor
- F2825 Switch-on threshold braking resistor too low
- F2836 DC bus balancing monitor error
- F8838 Overcurrent external braking resistor

Possible Device Combinations and Mains Connection

☞ The possible device combinations are only described in principle for the purpose of explanation. The device types that can actually be combined and what in particular must be noted is described in the separate documentation "Rexroth IndraDrive Cs – Drive System, Project Planning Manual" (DOK-INDRV*-HCS01******-PR01;part no.:

Central Supply

The figure below illustrates the principle of central supply:

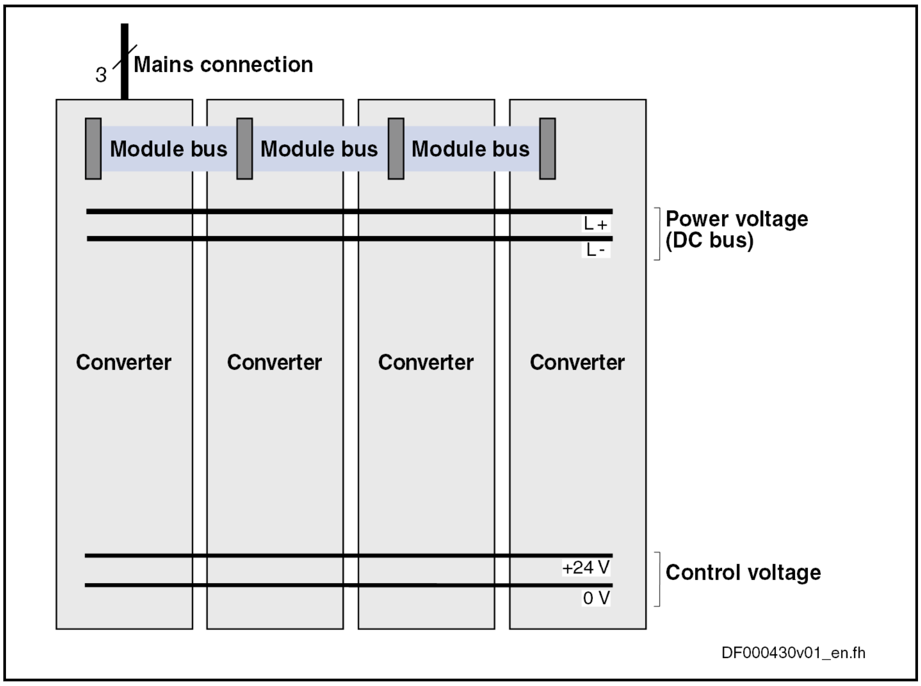


Fig.4-67: Mains Supply via Converter

Group Supply

The figure below illustrates the principle of group supply:

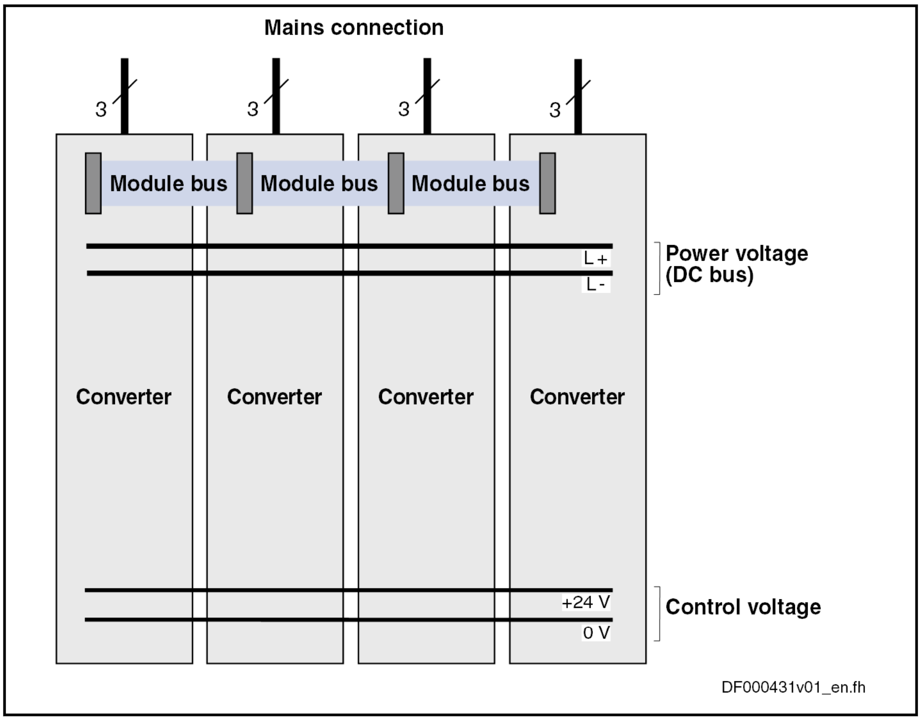


Fig.4-68: Mains supply via all devices

Communication in Drive Group

Depending on the task of a drive system or of several drives cooperating in a process, it can be appropriate to rapidly carry out a common reaction to certain events. This requires the exchange of signals (communication) between the cooperating devices.

- Multi-axis converters have internal communication between the supply unit and the axis axis inverters
- Single-axis converters (IndraDrive Cs) are interconnected via the module bus.

Note Regarding Single-axis Converters, IndraDriveCs

A single-axis converter joins the supply unit and inverter in one device. In a "drive system" (several drives the DC buses and module buses of which are interconnected), a converter can fulfill the following functions:

- Supply of an integrated inverter and other inverters or converters operated as such

- or -

- Operation only as an inverter in a DC bus

Note Regarding Multi-axis Converters

A multi-axis converter joins the supply unit and several inverters in one device. It always functions as a "drive system" (several drives that have their DC bus and module bus connected with each other). Supply of other external inverters or converters or external module bus connection is not possible!

Regenerated Energy

In the case of regenerative operation (e.g. deceleration mode) of the motors connected to a single-axis or multi-axis converter, the regenerated energy is first absorbed by the DC bus. If the ability to absorb energy is exhausted, the energy absorbed is transformed into heat via the braking resistor.

Braking Resistor

The braking resistor is connected on the DC bus side. Depending on the device line, an internal braking resistor is available or an external braking resistor can be connected.

Module Bus

As regards hardware, connections and signals, the module bus is described in the documentation of the devices (Project Planning Manuals).

4.5 Operation Modes

4.5.1 Safety Instructions

⚠ 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 safety fence, safety guard, protective covering, light barrier).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- In addition, observe the safety message "Protection Against Dangerous Movements" in the chapter "Safety Instructions for Electric Drives and Controls".

4.5.2 General Information on the Operation Modes

Supported Operation Modes

☞ The operation modes supported by the firmware depend on the hardware and firmware and are contained in parameter "S-0-0292, List of supported operation modes".

The following overview illustrates with which base or functional package the respective operation mode is supported and it applies for the two firmware variants MPB and MPM. The firmware variant MPE is only supported by an expanded base package.

Operation mode	In base package (characteristic)	In functional package ... (on the basis of a base package with the following characteristics)		
		Servo function	Synchronization	Main spindle
Standard operation modes:				
- torque/force control	CL	–	–	–
- velocity control	OL/CL	–	–	–
- position control	CL	–	–	–
- drive-internal interpolation	CL	–	–	–
- drive-controlled positioning	CL	–	–	–
- positioning block mode	CL	–	–	–
Synchronization operation modes:				
- velocity synchronization	–	–	OL/CL	–
- phase synchronization	–	–	CL	–

Operation mode	In base package (characteristic)	In functional package ... (on the basis of a base package with the following characteristics)		
		Servo function	Synchronization	Main spindle
- electronic cam	–	–	CL	–
- electronic motion profile	–	–	CL	–

OL Open-loop characteristic
CL Closed-loop characteristic
Fig.4-69: Supported Operation Modes

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

See also "Enabling of Functional Packages"

Operation Mode Handling

Selecting the Operation Mode

It is possible to configure up to 8 different operation modes in the drive (depending on "S-0-0292, List of supported operation modes"). Assignment and configuration are made via the following parameters:

- S-0-0032, Primary operation mode
- S-0-0033, Secondary operation mode 1
- S-0-0034, Secondary operation mode 2
- S-0-0035, Secondary operation mode 3
- S-0-0284, Secondary operation mode 4
- S-0-0285, Secondary operation mode 5
- S-0-0286, Secondary operation mode 6
- S-0-0287, Secondary operation mode 7

☞ If the value "0" was entered in one of these parameters, the error message "F2007 Switching to non-initialized operation mode" is generated when this operation mode is activated.

Activating the Operation Mode

The operation mode is activated and controlled via bits 8, 9 and 11 in parameter "P-0-0116,Device control: Control word".

The following applies to parameter P-0-0116:

- Bits 8 and 9 → Selecting primary mode of operation and secondary oper. modes 1 to 3
- Bit 11 → Selecting secondary operation modes 4 to 7 (only SERCOS)

☞ The secondary operation modes 4 to 7 can only be used via SERCOS interface. Bit 11 therefore only takes effect in the control word of the device control (P-0-0116) in conjunction with parameter S-0-0134 (master control word for SERCOS)!

The figure below illustrates the interrelation of the control word of the respective master communication and the device control word/device status word with regard to the operation mode selection.

Brief Functional Descriptions

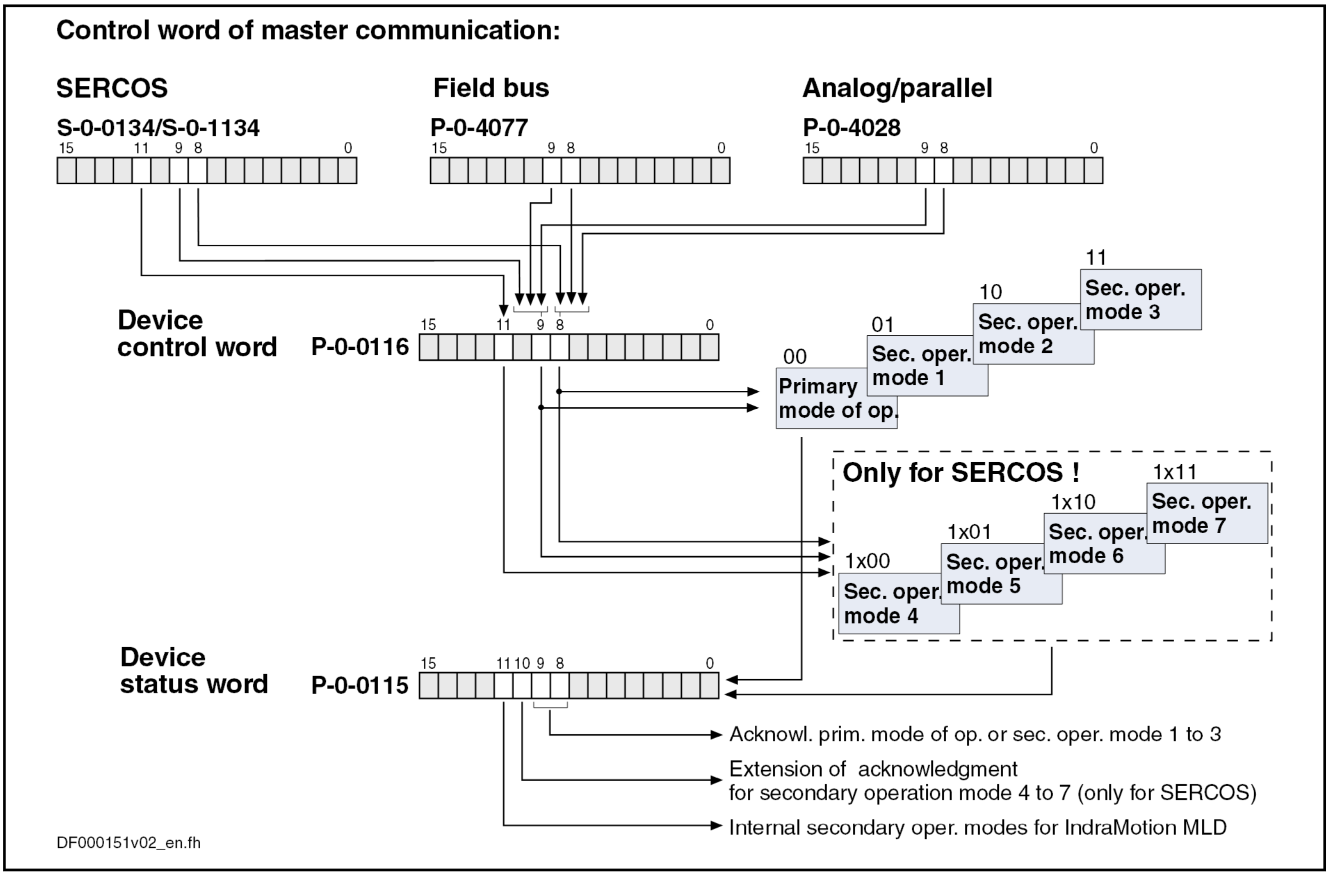


Fig.4-70: Operation Mode Selection via Control Word

☞ The control bits (8 and 9) contained in parameter P-0-0116 are also contained in the control words depending on the master communication (cf. S-0-0134, P-0-4077, P-0-4068 and P-0-4028) and can therefore be written via the control words.

An operation mode defined via the operation mode selection is active when:

- The drive (control section and power section) is ready for operation

- and -

- The drive enable signal sees a positive edge.

Acknowledging the Active Operation Mode

As regards the activation of an operation mode, there are the following kinds of feedback:

- With active operation mode, the display of the control panel reads "AF".
- In parameter "S-0-0390, Diagnostic message number", the respective diagnostic message number of the active operation mode is displayed (e.g. "A0101" in "velocity control" mode).
- In parameter "S-0-0095, Diagnostic message", the active operation mode is displayed in text form (e.g. "A0101 Velocity control").
- In parameter "P-0-0115, Device control: Status word", bit 3 ("Drive follows external command values") is used to acknowledge whether the drive is running in the preset operation mode or not.
- In parameter "P-0-0115, Device control: Status word", bits 8, 9 and 10 ("Acknowledgment of operation mode") are used to signal the operation mode presently active.

☞ The status bits contained in parameter P-0-0115 (3, 8, 9 and 10) are also contained in the status words depending on the master communication (S-0-0135, P-0-4078) and can therefore be read in the status words. Bit 10, however, is only activated with SERCOS interface!

See also "Device Control and State Machines"

Changing the Operation Mode

When drive enable is activated, the drive, after having gone through the initialization routines, changes to the operation mode that was selected via bits 8 and 9 of the specific control word of the respective master communication (S-0-0134, P-0-4077, P-0-4068 4028 or P-0-0116).

☞ The change of operation modes is carried out within one position loop clock (Advanced: 250 µs; Basic: 500 µs). Another position loop clock passes until the command values of the activated operation mode become effective, because the initialization of the operation mode is carried out first.

Special Cases

With the following **exceptional circumstances**, the desired operation mode is not carried out in spite of the operation mode having been correctly selected:

- **Drive error** is present

  → The corresponding error reaction is carried out.
- **Fatal warning** was triggered

  → The corresponding reaction is carried out.
- A "**drive command**" (e.g. homing procedure, set absolute measuring, ...) is executed

  → The command started is carried out.
- **Drive Halt**

  → This drive function is carried out.

See also "Device Control and State Machines"

Drive-Controlled Change of Operation Mode

In order to achieve a quick and smooth change of operation mode in running operation, it is possible to make a "drive-controlled change of operation mode". Drive-internally this procedure ensures that, when the operation mode is changed, the transition is carried out in a synchronized way, even if the command value changes abruptly.

See also "Command Value Adjustment with Position Control"

Command Value Acceptance and Acknowledgment

Immediate Command Value Acceptance

Each preset command value is accepted immediately, when the respective command value parameter (e.g. S-0-0036, S-0-0080, S-0-0258, …) is written in the case of the operation modes:

- Torque/Force Control
- Velocity control
- Position Control With Cyclic Command Value Input
- Drive-internal interpolation
- synchronization operation modes:
  - Velocity Synchronization With Real/Virtual Master Axis

– Phase Synchronization With Real/Virtual Master Axis
– Electronic Cam With Real/Virtual Master Axis
– Electronic motion profile with real/virtual master axis

Command Value Acceptance After Master Request

In the **positioning modes** (drive-controlled positioning, positioning block mode), however, the command value (target position, velocity, positioning block, ...) is only accepted, when the master explicitly requests this by a "command value acceptance".

The command value acceptance is carried out in a different way, according to the positioning mode or profile type:

- Operation mode "Drive-controlled positioning"

  Acceptance of preset command value (position, velocity) by toggling bit 0 of parameter "S-0-0346, Positioning control word"

  → **Toggle mechanism**
- Operation mode "Positioning block mode":

  Acceptance of the positioning block selected via "P-0-4026, Positioning block selection" by a 0-1 edge of bit 0 of parameter "P-0-4060, Positioning block control word", when the parallel interface or, in the case of field buses, the I/O mode is used as master communication

  → **Edge control**

☞ When the positioning block mode is used for field buses in the freely configurable operating mode (P-0-4084 = 0xFFFE) or with SERCOS interface, the toggle mechanism is used **in spite of the above rule**.

Command Value Acknowledgment

The explicit acknowledgment of the command value acceptance only takes place for the positioning modes (drive-controlled positioning, positioning block mode).

It is possible to check in the master whether and when the preset command value was accepted in the drive (command value acceptance handshake).

The command value acknowledgment is carried out in a different way, according to the positioning mode:

- Operation mode "Drive-controlled positioning"

  The drive acknowledges the command value acceptance by toggling bit 0 of parameter "S-0-0419, Positioning command acknowledge".
- Operation mode "Positioning block mode":

  The drive acknowledges the command value acceptance by displaying the effective positioning block in parameter "P-0-4051, Positioning block acknowledgment".

☞ In the positioning block mode, too, the acceptance of a new positioning block causes bit 0 of parameter S-0-0419 to be toggled, because in this case the internal processing of the positioning command values is identical to the "drive-controlled positioning" mode.

4.5.3 Torque/Force Control

Brief Description

Assignment to functional firmware package, see chapter "Supported Operation Modes".

In the "torque/force control" mode, a torque/force command value is preset for the drive. If required, this command value can be filtered. When the operation mode has been activated, the diagnostic message is "A0100 Torque control".

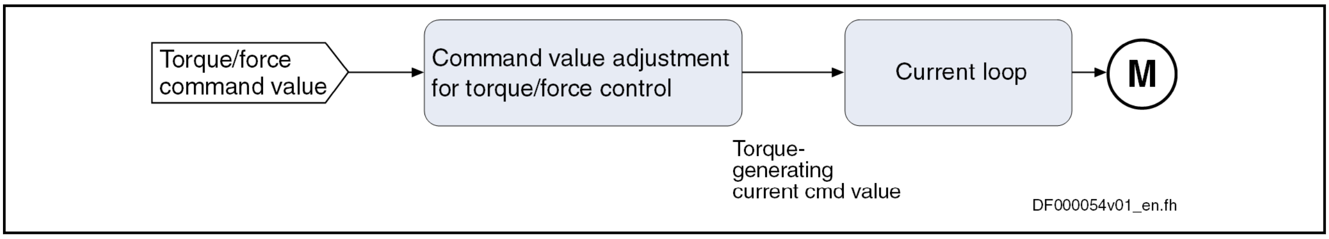


Fig.4-71: Block Diagram, "Torque/Force Control"

Features

- Torque/force control with regard to the sum of the command values preset in parameters "S-0-0080, Torque/force command value" and "S-0-0081, Additive torque/force command value"
- Torque/force command value is generated internally by the velocity loop; value of S-0-0081 can be added as additive component
- Limitation of the preset command value to limit value that can be parameterized
- Command value filtered via "S-0-0822, Torque/force ramp" and "S-0-0823, Torque/force ramp time"

Pertinent Parameters

- S-0-0080, Torque/force command value
- S-0-0081, Additive torque/force command value
- S-0-0082, Torque/force limit value positive
- S-0-0083, Torque/force limit value negative
- S-0-0092, Bipolar torque/force limit value
- S-0-0109, Motor peak current
- S-0-0110, Amplifier peak current
- S-0-0111, Motor current at standstill
- S-0-0822, Torque/force ramp
- S-0-0823, Torque/force ramp time
- S-0-0824, Status "Torque/force command value attained"
- P-0-0001, Switching frequency of the power output stage
- P-0-0038, Torque-generating current, command value
- P-0-0049, Effective torque/force command value
- P-0-0051, Torque/force constant
- P-0-0109, Torque/force peak limit
- P-0-4046, Effective peak current

Pertinent Diagnostic Messages

- A0100 Torque control
- E8057 Device overload, current limit active

- E8260 Torque/force command value limit active
- F8079 Velocity limit value exceeded

4.5.4 Velocity Control

Brief Description

Assignment to functional firmware package, see chapter "Supported Operation Modes".

In the "velocity control" operation mode, a velocity command value is preset for the drive. The velocity command value is limited by ramps and filters.

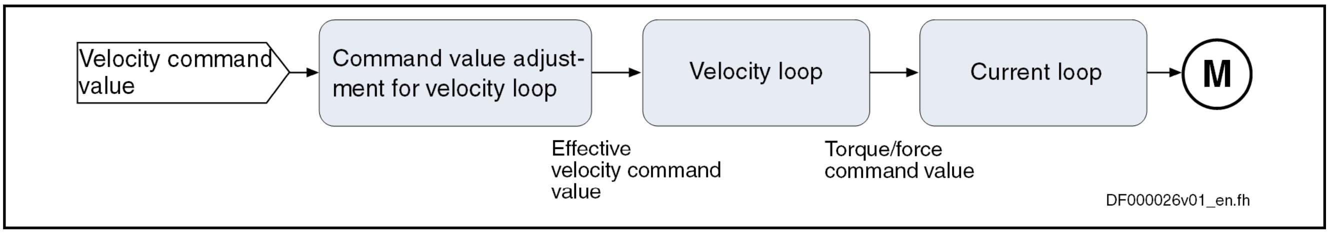


Fig.4-72: Block Diagram, "Velocity Control"

Features

- Specification of an external velocity command value (sum of "S-0-0036, Velocity command value" and "S-0-0037, Additive velocity command value") via analog inputs or master communication interface (SERCOS, field bus, ...)
- Selection of predefined and internally stored velocity command values (31 fixed values) is possible via binarily coded digital inputs (e.g. for jogging forward/backward, feeding, setting up, ...) with separately definable acceleration and deceleration ramps (31 different ramps), as well as jerk filter to be set (31 different time constants)
- Use of a drive-internal command value generator for generating command value ramps ("motor potentiometer")
- Inversion of the provided velocity command value before it is processed in the ramp-function generator
- Window comparator for masking critical velocity ranges in the command value channel (e.g. machine resonances) with corresponding acceleration adjustment (see P-0-1209)
- Ramp-function generator with separately adjustable, two-stage acceleration and deceleration limits of the preset velocity command value; switching from ramp 1 to ramp 2 is done with selectable velocity and run-up stop that can be parameterized
- Velocity control via a digital PI loop with extensive filter measures
- Monitoring the command velocity and actual velocity for exceeding parameter "S-0-0091, Bipolar velocity limit value"
- Smoothing of velocity control loop difference via filter that can be parameterized
- Smoothing of preset command value by means of average filter (jerk limitation by means of moving average filter)
- Fine interpolation of the velocity command values; transmission of these command values in the position loop clock; fine interpolator can be switched on or off (P-0-0556, bit 0)

- Velocity control loop monitoring (cannot be parameterized) to prevent the drive from running away; monitor can be switched on or off (P-0-0556, bit 1)
- Velocity loop internally generates the torque/force command value to which the value of parameter "S-0-0081, Additive torque/force command value" can be added as an additive component
- Control word and status word especially for "velocity control" operation mode (P-0-1200 and P-0-1210)

Pertinent Parameters

- S-0-0036, Velocity command value
- S-0-0037, Additive velocity command value
- S-0-0091, Bipolar velocity limit value
- S-0-0100, Velocity loop proportional gain
- S-0-0101, Velocity loop integral action time
- P-0-0004, Velocity loop smoothing time constant
- P-0-0048, Effective velocity command value
- P-0-0556, Config word of axis controller
- P-0-1119, Velocity mix factor feedback 1 & 2(applies only for single-axis firmware MPB16 and multi-axis firmware MPM16)
- P-0-1120, Velocity control loop filter: Filter type
- P-0-1126, Velocity control loop: Acceleration feedforward
- P-0-1200, Control word 1 velocity control
- P-0-1201, Ramp 1 pitch
- P-0-1202, Final speed ramp 1
- P-0-1203, Ramp 2 pitch
- P-0-1206, Memory of velocity command values
- P-0-1207, Lower limit of velocity masking window
- P-0-1208, Upper limit of velocity masking window
- P-0-1209, Acceleration factors for velocity masking window
- P-0-1210, Status word of velocity control mode
- P-0-1211, Deceleration ramp 1
- P-0-1213, Deceleration ramp 2
- P-0-1214, Control word 2 velocity control
- P-0-1215, Motor potentiometer, acceleration
- P-0-1216, Motor potentiometer, deceleration
- P-0-1217, Motor potentiometer, step size
- P-0-1218, Motor potentiometer, command value
- P-0-1222, Velocity command filter
- P-0-1223, List of acceleration ramps
- P-0-1224, List of deceleration ramps
- P-0-1225, List of smoothing time constants

Pertinent Diagnostic Messages

- A0101 Velocity control
- E2059 Velocity command value limit active
- E2063 Velocity command value > limit value

- E8260 Torque/force command value limit active
- F8078 Speed loop error
- F8079 Velocity limit value exceeded

4.5.5 Position Control With Cyclic Command Value Input

Brief Description

Assignment to functional firmware package, see chapter "Supported Operation Modes".

In the "position control" mode, a cyclic position command value is preset for the drive in NC cycle time. This command value is fine interpolated in the drive and jerk-limited via filters, if necessary, before being transmitted to the position loop.

To minimize the lag error, variable acceleration feedforward is available in addition to variable velocity feedforward.

There are different forms of the "position control" mode which result in the corresponding diagnostic messages when the operating mode was activated (see below "Pertinent Diagnostic Messages").

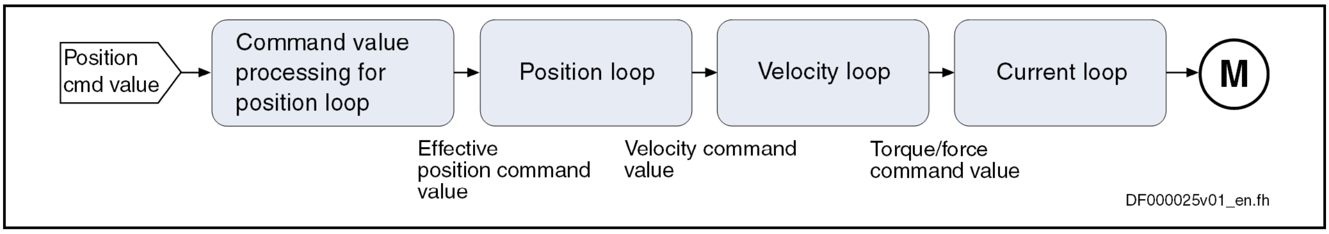


Fig.4-73: Block Diagram, "Position Control With Cyclic Command Value Input"

Features

- Position control with regard to the command value preset in parameter "S-0-0047, Position command value"
- NC-controlled or drive-controlled position control with internal, dynamic synchronization when changing operation modes
- Timebase for cyclic command value input defined by "S-0-0001, NC cycle time (TNcyc)"
- Monitoring of the position command value difference for exceeding parameter "S-0-0091, Bipolar velocity limit value"
- Position command values of the control section smoothed by means of adjustable average value filter; calculation from acceleration and jerk limit values; display in parameter "P-0-0042, Current position command average value filter order"
- Fine interpolation of position command value of the control section to position loop clock; can be switched via "P-0-0187, Position command processing mode"
- Adjustable position command value delay in position cycle times (P-0-0456, Position command value delay), maximum of 32 cycles.
- Position control with regard to actual position value encoder 1 (motor encoder) or actual position value encoder 2 [external (load-side) encoder], can be dynamically switched
- Velocity feedforward through adjustable factor of 0 to 150 % (default = 100 %)

- Cyclic acceptance of an additive torque/force command value of the control section (external determination of acceleration feedfoward)

☞ The condition for this operating mode is synchronous communication between the control section and the drive, as is the case with SERCOS interface, for example.

Pertinent Parameters

- S-0-0047, Position command value
- S-0-0081, Additive torque/force command value
- S-0-0091, Bipolar velocity limit value
- S-0-0138, Bipolar acceleration limit value
- S-0-0520, Axis control word
- P-0-0010, Excessive position command value
- P-0-0011, Last valid position command value
- P-0-0041, Position command average value filter time constant
- P-0-0042, Current position command average value filter order
- P-0-0047, Position command value control
- P-0-0059, Additive position command value, controller
- P-0-0070, Effective additive torque/force command value
- P-0-0099, Position command smoothing time constant
- P-0-0142, Synchronization acceleration
- P-0-0143, Synchronization velocity
- P-0-0187, Position command processing mode
- P-0-0434, Position command value of controller
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0458, Delay of add. command values
- P-0-0556, Config word of axis controller

Pertinent Diagnostic Messages

- A0102 Position mode, encoder 1
- A0103 Position mode, encoder 2
- A0104 Position mode lagless, encoder 1
- A0105 Position mode lagless, encoder 2
- A0154 Position mode drive controlled, encoder 1
- A0155 Position mode drive controlled, encoder 2
- A0156 Position mode lagless, encoder 1 drive controlled
- A0157 Position mode lagless, encoder 2 drive controlled
- F2036 Excessive position feedback difference
- F2037 Excessive position command difference

☞ The error message F2037 can also be configured as a warning. In this case, there is no error reaction on the drive side. The user is then responsible for initiating an appropriate reaction via the control master

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4.5.6 Drive-Internal Interpolation

Brief Description

Assignment to functional firmware package, see chapter "Supported Operation Modes".

The two operation modes "drive-internal interpolation" and "drive-controlled positioning" allow time-optimized positioning of a single axis. The "drive-internal interpolation" mode is the basis for the more comprehensive functionality of the "drive-controlled positioning" mode.

In the "drive-internal interpolation" mode, a target position is directly preset for the drive. In the internal positioning generator, a position command value characteristic is generated (interpolated), from the preset value for the target position considering preset positioning data (velocity, acceleration and jerk), as the input value for the position loop.

There are different forms of the "drive-internal interpolation" mode which result in the corresponding diagnostic messages when the operating mode was activated (see below "Pertinent Diagnostic Messages").

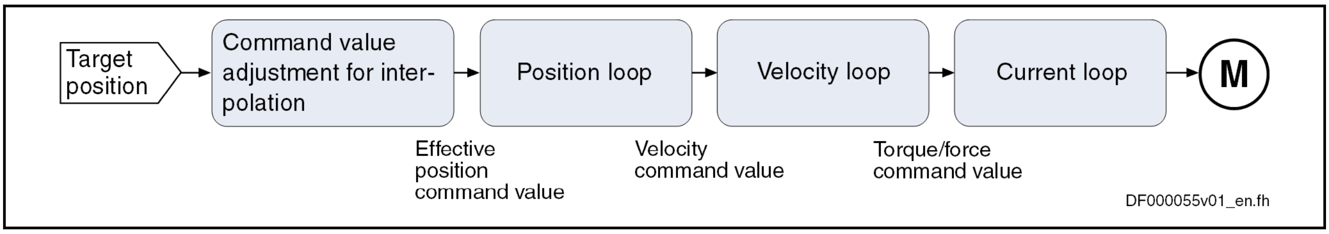


Fig.4-74: Block Diagram, "Drive-internal Interpolation"

Features

- Drive-internal generation of a position command value profile to travel to a preset target position (S-0-0258) while maintaining the positioning velocity (S-0-0259) and positioning acceleration (S-0-0260) or positioning deceleration (S-0-0359) that can be set; can be set separately
- Command value generation runs in the NC cycle "S-0-0001, NC cycle time (TNcyc)". The transition into the position loop cycle is made by cubic fine interpolation.
- Jerk limitation of the generated position command value via "S-0-0193, Positioning jerk"
- Setting of the average value filter (jerk limitation) to a fixed filter time with interpolation command value average value filter time constant (P-0-0641)
- Adjustable position command value delay in position cycle times (P-0-0456), maximum of 32 cycles.
- Evaluation of the positioning velocity with "S-0-0108, Feedrate override"
- Monitoring of the positioning velocity for exceeding "S-0-0091, Bipolar velocity limit value"
- Monitoring of the target position for compliance with the position limit values
- Command value mode can be set (S-0-0393) in modulo format (shortest distance, only positive or only negative direction)
- Position control with regard to "S-0-0051, Position feedback value 1" (motor encoder) or "S-0-0053, Position feedback value 2" [external (load-side) encoder]

- Acceleration and deceleration ramps, can be set separately
- No change in direction of motion when

  "command value mode in modulo format" equals "shortest distance", if v_{act} > S-0-0417
- "Shortest distance" mode when "command value mode in modulo format" equals "only positive/negative direction of motion" and target position within "S-0-0418, Target position window in modulo mode"

☞ In this operating mode, it is possible to separately parameterize the acceleration and deceleration processes. This allows optimum adjustment to the respective application-specific requirements.

Pertinent Parameters

- S-0-0108, Feedrate override
- S-0-0138, Bipolar acceleration limit value
- S-0-0193, Positioning jerk
- S-0-0258, Target position
- S-0-0259, Positioning velocity
- S-0-0260, Positioning acceleration
- S-0-0342, Status "Target position attained"
- S-0-0343, Status "Interpolator halted"
- S-0-0359, Positioning deceleration
- S-0-0393, Command value mode
- S-0-0417, Positioning velocity threshold in modulo mode
- S-0-0418, Target position window in modulo mode
- S-0-0430, Effective target position
- S-0-0437, Positioning status
- P-0-0059, Additive position command value, controller
- P-0-0434, Position command value of controller
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0556, Config word of axis controller
- P-0-0641, Interpolation cmd value average value filter time constant

Pertinent Diagnostic Messages

- A0106 Drive-internal interpolation, encoder 1
- A0107 Drive-internal interpolation, encoder 2
- A0108 Drive controlled interpolation, lagless, encoder 1
- A0109 Drive controlled interpolation, lagless, encoder 2
- E2049 Positioning velocity >= limit value
- E2053 Target position out of travel range
- E2055 Feedrate override S-0-0108 = 0
- F2057 Target position out of travel range

4.5.7 Drive-Controlled Positioning

Brief Description

Assignment to functional firmware package, see chapter "Supported Operation Modes".

The operation modes "drive-internal interpolation" and "drive-controlled positioning" allow time-optimized positioning of a single axis. The "drive-internal interpolation" mode is the basis for the more comprehensive functionality of the "drive-controlled positioning" mode.

In the "drive-controlled positioning" mode, a positioning command value is preset for the drive. The drive can continue processing this value internally in absolute (position target) or relative (travel distance) form. In the internal interpolator, a position command value characteristic is generated as the input value for the position loop from the preset positioning data (effective target position, velocity, acceleration and jerk).

There are different forms of the "drive-controlled positioning" mode which result in the corresponding diagnostic messages when the operation mode was activated (see below "Pertinent Diagnostic Messages").

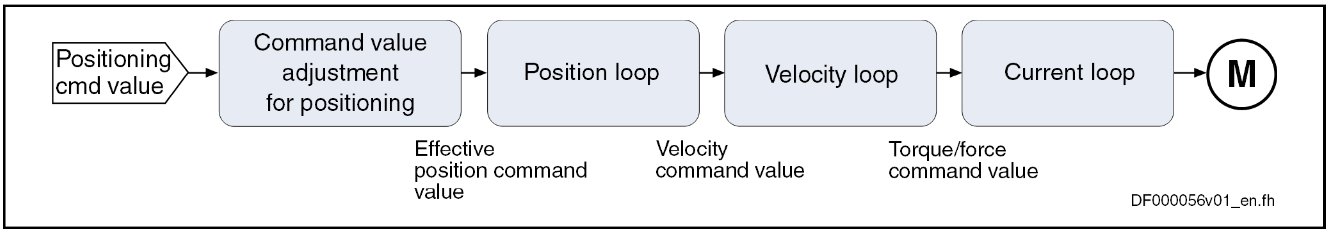


Fig.4-75: Block Diagram, Drive-Controlled Positioning

Features

- Processing of an absolute target position or a relative travel distance
- Drive-internal generation of a position command value profile to travel to the positioning command value (S-0-0282) while maintaining the positioning velocity (S-0-0259) and positioning acceleration (S-0-0260) or positioning deceleration (S-0-0359) that can be set; can be set separately
- Command value generation runs in the NC cycle "S-0-0001, NC cycle time (TNcyc)". The transition into the position loop cycle is made by cubic fine interpolation.
- Acceptance of the positioning command value via toggle bit (S-0-0346, bit 0)
- Jerk limitation of the generated position command value with parameter "S-0-0193, Positioning jerk"
- Setting of the average value filter (jerk limitation) to a fixed filter time with interpolation command value average value filter time constant (P-0-0641)
- Adjustable position command value delay in position cycle times (P-0-0456), maximum of 32 cycles.
- Evaluation of the positioning velocity with parameter "S-0-0108, Feedrate override"
- Monitoring of the positioning velocity for exceeding the value in parameter "S-0-0091, Bipolar velocity limit value"

- Monitoring of the target position for compliance with the position limit values (see "S-0-0049, Positive position limit value", "S-0-0050, Negative position limit value")
- Command value mode can be set in modulo format in parameter "S-0-0393, Command value mode" (shortest distance, positive only or negative only direction, no reversal of direction of rotation)
- Position control with regard to "S-0-0051, Position feedback value 1" (motor encoder) or "S-0-0053, Position feedback value 2" [external (load-side) encoder]
- Acceleration and deceleration ramps can be set separately ("S-0-0260, Positioning acceleration" or "S-0-0359, Positioning deceleration")
- Position limit values taken into account when accepting target position, positioning velocity and positioning acceleration
- Jog mode ("infinite travel" positive/negative; S-0-0346, bits 1 and 2)
- Residual path processing can be activated
- "On-the-fly acceptance" of the new target position or intermediate stop

☞ In this operation mode, it is possible to separately parameterize the acceleration and deceleration processes in order to achieve optimum adjustment to the respective application-specific requirements.

Pertinent Parameters

- S-0-0057, Position window
- S-0-0108, Feedrate override
- S-0-0138, Bipolar acceleration limit value
- S-0-0193, Positioning jerk
- S-0-0259, Positioning velocity
- S-0-0260, Positioning acceleration
- S-0-0282, Positioning command value
- S-0-0342, Status "Target position attained"
- S-0-0343, Status "Interpolator halted"
- S-0-0346, Positioning control word
- S-0-0359, Positioning deceleration
- S-0-0393, Command value mode
- S-0-0417, Positioning velocity threshold in modulo mode
- S-0-0418, Target position window in modulo mode
- S-0-0419, Positioning command acknowledge
- S-0-0430, Effective target position
- S-0-0437, Positioning status
- P-0-0059, Additive position command value, controller
- P-0-0434, Position command value of controller
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0556, Config word of axis controller
- P-0-0641, Interpolation cmd value average value filter time constant

Pertinent Diagnostic Messages

- A0150 Drive-controlled positioning, encoder 1

- A0151 Drive-controlled positioning, encoder 1, lagless
- A0152 Drive-controlled positioning, encoder 2
- A0153 Drive-controlled positioning, encoder 2, lagless
- E2049 Positioning velocity >= limit value
- E2053 Target position out of travel range
- E2055 Feedrate override S-0-0108 = 0
- F2050 Overflow of target position preset memory
- F2057 Target position out of travel range

4.5.8 Positioning Block Mode

Brief Description

Assignment to functional firmware package, see chapter "Supported Operation Modes".

In the operation mode, it is possible to run up to 64 programmed positioning blocks. The drive moves to the target position in position control, while maintaining velocity, acceleration, deceleration and jerk limits as defined in the respective positioning block.

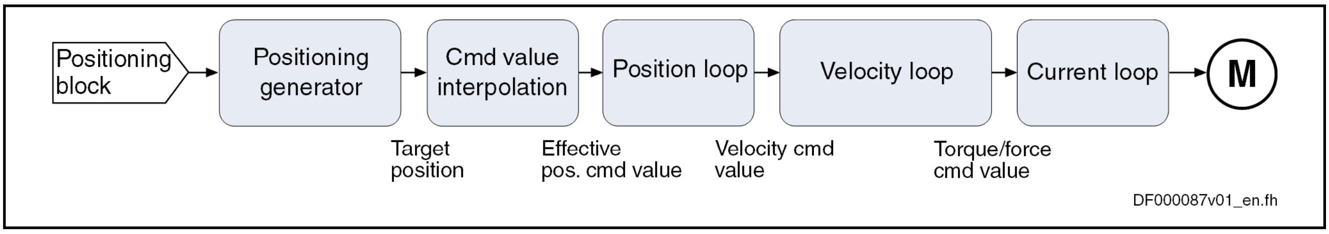


Fig.4-76: Block Diagram, "Positioning Block Mode":

Features

- Parameterization of up to 64 positioning blocks; each with target position/travel distance, velocity, acceleration, deceleration and jerk
- Command value generation runs in the NC cycle "S-0-0001, NC cycle time (TNcyc)". The transition into the position loop cycle is made by cubic fine interpolation.
- Jerk limitation of the generated position command value via "P-0-4009, Positioning block jerk"
- Setting of the average value filter (jerk limitation) to a fixed filter time with interpolation command value average value filter time constant (P-0-0641)
- Adjustable position command value delay in position cycle times (P-0-0456), maximum of 32 cycles.
- Defined block acceptance by toggling bit 0 in S-0-0346 with reaction time $t_{R\_strobe} = t_{position}$

  Note: For field bus drives, the I/O mode is an exception. In these cases, acceptance takes place by a 0-1 edge of bit 0 in P-0-4060.

  → Block selection and acknowledgment via separate parameters (handshake principle)
- Positioning modes to be freely parameterized:
  - Relative positioning
  - Absolute positioning

  - Infinite travel (positive or negative)
- Single-block or sequential block mode with different conditions for advance:
  - Block advance with switch cams
  - Block advance at defined position value
  - Block transition with "old" or "new" positioning velocity
- Positioning block transition with freely definable delay time (P-0-4018)
- Positioning while taking command value mode into account (shortest distance, positive direction, ...)
- Residual path processing can be activated (→ no loss of incremental dimension)
- "Slow travel" mode can be activated
- Velocity override to be set

Fields of Application

Sequential block processing allows executing several positioning blocks in direct sequence without having to give a new start signal each time. Typical fields of application are:

- There is none or only a very simple higher-level control section available and control is realized via digital I/Os only or a field bus control word (I/O mode with field bus interface).
- There are quick reaction times or block advances required. The required motion profiles can be represented in the drive by the maximum possible 64 positioning blocks.
- There are positioning processes required which cover long distances at high speeds (rapid traverse) and then position at the end position at low speed without any intermediate stops; for example:
  - Taking up or putting down transport goods in handling robots
  - Execution of joining processes in assembly facilities

Pertinent Parameters

- S-0-0138, Bipolar acceleration limit value
- S-0-0259, Positioning velocity
- S-0-0346, Positioning control word
- S-0-0393, Command value mode
- S-0-0419, Positioning command acknowledge
- S-0-0430, Effective target position
- S-0-0437, Positioning status
- P-0-0059, Additive position command value, controller
- P-0-0434, Position command value of controller
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0556, Config word of axis controller
- P-0-0641, Interpolation cmd value average value filter time constant
- P-0-4006, Positioning block target position
- P-0-4007, Positioning block velocity
- P-0-4008, Positioning block acceleration
- P-0-4009, Positioning block jerk
- P-0-4018, Positioning block delay time

- P-0-4019, Positioning block mode
- P-0-4026, Positioning block selection
- P-0-4051, Positioning block acknowledgment
- P-0-4052, Positioning block, last accepted
- P-0-4053, Positioning block, last active
- P-0-4057, Positioning block, input linked blocks
- P-0-4060, Positioning block control word
- P-0-4061, Positioning block status word
- P-0-4063, Positioning block deceleration

☞ Parameter S-0-0259 is used in positioning block mode to reduce positioning velocity (see also "P-0-4060, Positioning block control word").

Pertinent Diagnostic Messages

- A0162 Positioning block mode
- A0206 Positioning block mode, encoder 1
- A0207 Positioning block mode lagless, encoder 1
- A0210 Positioning block mode, encoder 2
- A0211 Positioning block mode lagless, encoder 2
- E2049 Positioning velocity >= limit value
- E2053 Target position out of travel range
- E2054 Not homed
- E2055 Feedrate override S-0-0108 = 0
- E2058 Selected positioning block has not been programmed
- F2028 Excessive deviation

4.5.9 Synchronization Modes

Basic Functions of the Synchronization Modes

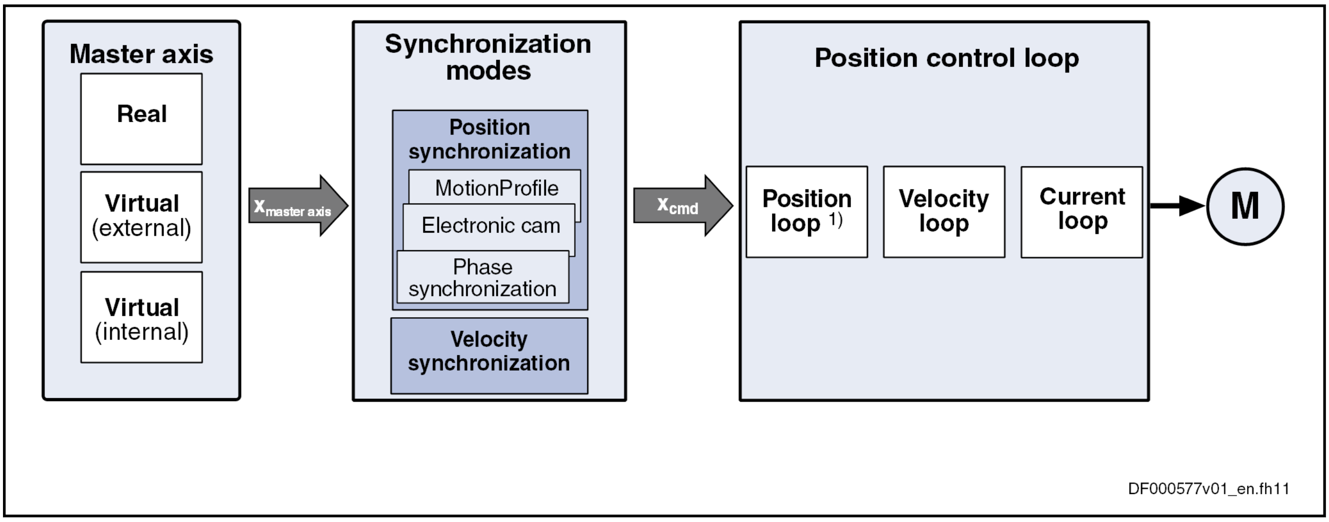
Overview

General Information on Synchronization Modes

The synchronization modes allow the drive to run synchronously with regard to a real or virtual master axis. The synchronization modes are basically divided into the following groups:

- **Velocity synchronization**
- **Position synchronization with the operation modes**
  - Phase synchronization
  - Electronic cam
  - MotionProfile

The figure below illustrates how the synchronization modes are integrated in the control loop structure.



1) No position loop with "velocity synchronization" operation mode

Fig.4-77: General Block Diagram of the Synchronization Modes

All synchronization modes have the following identical or similar basic functions which are comprehensively described in this section:

- Adjustment of master axis, consisting of
  - Generation of master axis
  - Master axis offset and modulo limitation
  - Electronic gear with fine adjustment
- Drive-controlled dynamic synchronization

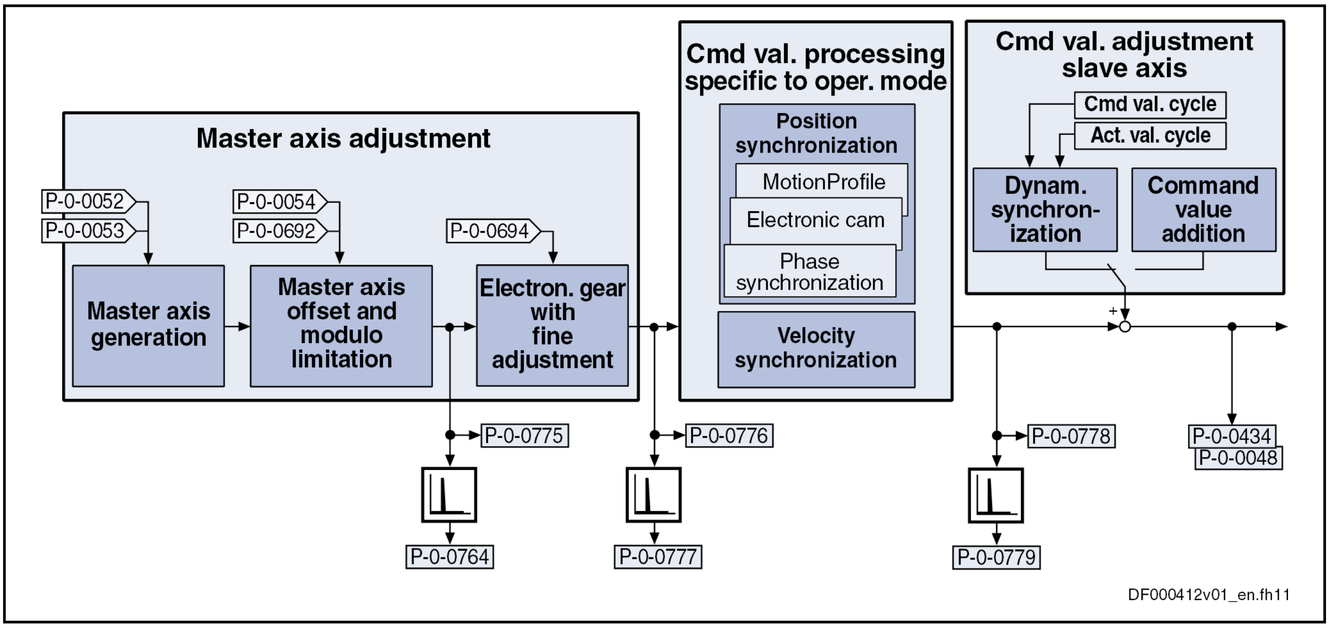
☞ The individual synchronization modes basically differ in the following function blocks:

- Command value processing specific to operation mode

- Command value addition for slave axis

These function blocks are described specific to operation mode in the individual sections on the respective synchronization modes.

The figure below illustrates the interaction of the individual basic functions (function blocks) of the synchronization modes.



P-0-0048	Effective velocity command value
P-0-0052	Actual position value of measuring encoder
P-0-0053	Master axis position
P-0-0054	Additive master axis position
P-0-0434	Position command value of controller
P-0-0692	Additive position command value, process loop
P-0-0694	Gear ratio fine adjustment, process loop
P-0-0761	Master axis position for slave axes
P-0-0764	Master Axis Speed
P-0-0775	Resulting Master Axis Position
P-0-0776	Effective master axis position
P-0-0777	Effective master axis velocity
P-0-0778	Synchronous position command value
P-0-0779	Synchronous velocity
P-0-0787	Group axis position

Fig.4-78: Function Blocks of the Synchronization Modes

Explanation of Terms

Master axis:

The virtual or real axis that provides the master axis position for generating the synchronous position command value for the slave axis is called master axis.

Master axis cycle

The master axis cycle specifies the range in which the master axis values move. It corresponds to one master axis revolution or a multiple of that. So that the master axis positions can be processed correctly (e.g. in the case of modulo overflow), the size of the master axis cycle must be known in the drive. The control communicates the size of the master axis cycle to the drive in the configuration of parameter **"P-0-0750, Master axis revolutions per master axis cycle"**.

Slave axis:

The drive that follows the command values derived from the master axis is called the slave axis.

Command value cycle:

In processes with different machining cycles, the slave axis must be able to synchronize over several master axis revolutions or divisions of a master axis revolution. The so-called command value cycle provides this option. The modulo value of the command value cycle is calculated internally depending on the electronic gear (P-0-0156, Master drive gear input revolutions; P-0-0157, Master drive gear output revolutions) and the sizes "P-0-0750, Master axis revolutions per master axis cycle" and "S-0-0103, Modulo value".

See also parameter description "P-0-0754, Command value cycle".

Actual value cycle (actual position value in the actual value cycle)

The actual value cycle ("P-0-0786, Modulo value actual value cycle") is the modulo range within which the actual position values of the slave axis are to be found when the position synchronization operation mode is active (P-0-0753, Position actual value in actual value cycle). The user can specify the modulo value of the actual value cycle.

☞ **The operation modes of the position synchronization (phase synchronization, cam and MotionProfile) use the "actual position value in the actual value cycle" (P-0-0753) to close their control loop.**

The travel distance for synchronization is determined using the "actual position value in the actual value cycle" and the set synchronization range (see parameter description "P-0-0155, Synchronization mode") when one of the operation modes of the position synchronization is activated. The travel distance is limited by the synchronization range, i.e. the command value cycle, division of the command value cycle or modulo range (S-0-0103, Probe value 1 positive edge).

See parameter description "P-0-0753, Position actual value in actual value cycle".

See parameter description "P-0-0786, Modulo value actual value cycle"

The modulo value of the actual value cycle must be specified such that it corresponds with a whole number multiple of the command value cycle or the modulo range (S-0-0103, Probe value 1 positive edge).

Configuring and Controlling the Synchronization Modes

The synchronization modes velocity synchronization and position synchronization are configured and controlled by means of the following synchronization parameters:

Pertinent Parameters (Synchronization Parameters)

- S-0-0520, Axis control word
- S-0-0521, Axis status word
- P-0-0086, Configuration word synchronous operation modes
- P-0-0088, Control word synchronization modes
- P-0-0089, Status word synchronization modes

The following specifications can be made for the position-controlled operation modes using parameter S-0-0520:

- Position control with lag error or lagless
- Use of encoder 1 or encoder 2

See also "Operation Mode-Handling"

Command Value Addition

This section contains an overview of the basic possibilities of adding command values. The characteristics and details specific to operation mode are described in the section of the respective synchronization mode.

Pertinent Parameters

- S-0-0037, Additive velocity command value
- S-0-0048, Additive position command value
- P-0-0048, Effective velocity command value
- P-0-0054, Additive master axis position
- P-0-0060, Filter time constant additive position cmd value
- P-0-0434, Position command value of controller
- P-0-0686, Additive position command value, positioning velocity
- P-0-0687, Additive position command value, positioning acceleration
- P-0-0688, Additive master axis position, positioning velocity
- P-0-0689, Additive master axis position, positioning acceleration
- P-0-0690, Additive velocity command value, process loop
- P-0-0691, Additive position command value, process loop
- P-0-0692, Additive master axis position, process loop
- P-0-0693, Filter time constant, add. master axis pos., process loop

The figure below contains a rough overview of the command values which can act on the master and slave axis and of how they can be influenced.

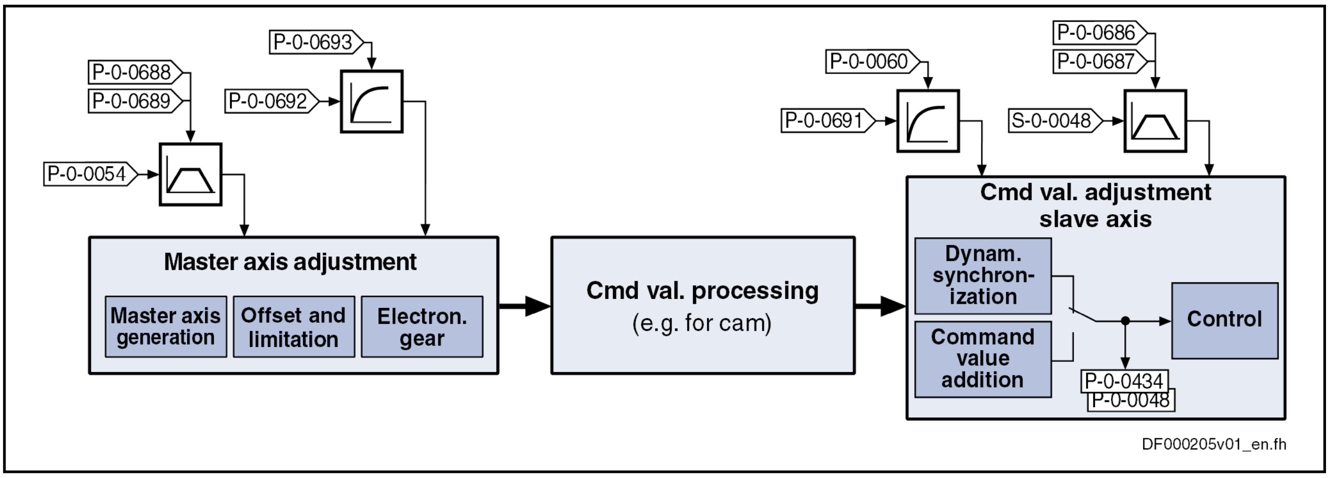


Fig.4-79: Possibilities of Command Value Addition for Master and Slave Axis

Velocity Synchronization With Real/Virtual Master Axis

Brief Description

Assignment to functional firmware package, see chapter "Supported Operation Modes".

In the operating mode "velocity synchronization with real/virtual master axis", the drive follows a preset master axis velocity at a synchronous velocity.

The real master axis velocity is generated by a measuring encoder; in contrast, the virtual master axis velocity is preset by the master.

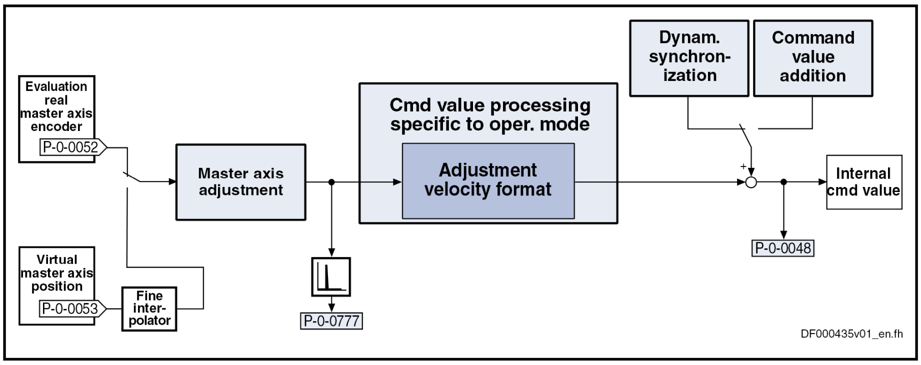
See also "Dynamic Synchronization of the Slave Axis" in the section "Basic Functions of the Synchronization Modes"

Features

- Determination of the effective velocity command value (P-0-0048) from the differentiated and fine interpolated sum of master axis position (P-0-0053) or measuring encoder position (P-0-0052) and additive components of "P-0-0054, Additive master axis position" and "P-0-0692, Additive master axis position, process loop", multiplied by master axis gear and fine adjustment

- Adjustable master axis polarity
- Synchronization takes place in single-step form
- Synchronization mode to be selected
  - Velocity adjustment always uses synchronization acceleration (P-0-0142)
  - Velocity adjustment using synchronization acceleration (P-0-0142) only in the first synchronization

The figure below illustrates the interaction of the individual subfunctions (function blocks) of the "velocity synchronization" mode:



P-0-0048	Effective velocity command value
P-0-0052	Actual position value of measuring encoder
P-0-0053	Master axis position
P-0-0777	Effective master axis velocity

Fig.4-80: Function Blocks of the Operation Mode "Velocity Synchronization With Real/Virtual Master Axis"

Variants of the Operation Mode

The following variants can be configured:

- Velocity synchronization with real master axis
- Velocity synchronization with virtual master axis

Application of the Operating Mode

Velocity synchronization is used, for example, for simple transport rolls of printing machines. The drive runs with a velocity synchronous to the master axis. The track speed at the circumference of the transport roll or the winder is preset by the electric gear. A defined tension can be set by the fine adjustment of the gear.

Pertinent Parameters

In addition to the general parameters of all synchronization modes, there are other parameters involved in velocity synchronization:

- S-0-0037, Additive velocity command value
- S-0-0183, Velocity synchronization window
- P-0-0159, Slave drive feed travel
- P-0-0690, Additive velocity command value, process loop
- P-0-0777, Effective master axis velocity

See also "Pertinent Parameters" in the subsections of "Basic Functions of the Synchronization Modes"

Pertinent Diagnostic Messages

In addition to the general diagnostic messages of all synchronization modes, there are other diagnostic messages involved in velocity synchronization:

- A0110 Velocity synchronization, virtual master axis
- A0111 Velocity synchronization, real master axis

- A0164 Velocity synchronization
- E2063 Velocity command value > limit value

See also "Pertinent Diagnostic Messages" in the subsections of "Basic Functions of the Synchronization Modes"

Position Synchronization: Phase Synchronization

Brief Description

Assignment to functional firmware package, see chapter "Supported Operation Modes".

In the operating mode "phase synchronization with real/virtual master axis", the drive follows a preset master axis position in an absolute or relative phase synchronous way.

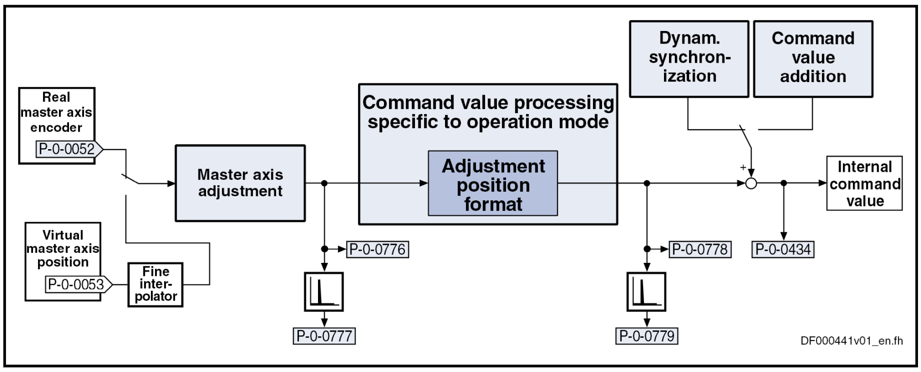
The real master axis velocity is generated by a measuring encoder; in contrast, the virtual master axis velocity is preset by the master.

See also "Dynamic Synchronization of the Slave Axis" in the section "Basic Functions of the Synchronization Modes"

Features

- Determination of the position command value from the master axis position using the electronic gear with fine adjustment, adjustable master axis polarity
- Synchronization mode to be selected
- Single-step, double-step or optimized double-step synchronization
- Absolute or relative phase synchronization
- Synchronization range to be selected

The figure below illustrates the interaction of the individual subfunctions (function blocks) of the "phase synchronization" mode:



P-0-0052	Actual position value of measuring encoder
P-0-0053	Master axis position
P-0-0434	Position command value of controller
P-0-0776	Effective master axis position
P-0-0777	Effective master axis velocity
P-0-0778	Synchronous position command value
P-0-0779	Synchronous velocity

Fig.4-81: Function Blocks of the Operation Mode "Phase Synchronization With Real/Virtual Master Axis"

Variants of the Operation Mode

The following variants can be configured:

- Position synchronization: Phase synchronization
  - Phase synchronization with real master axis, encoder 1

- Phase synchronization with real master axis, encoder 2
- Phase synchronization with real master axis, encoder 1, lagless
- Phase synchronization with real master axis, encoder 2, lagless
- Phase synchronization with virtual master axis, encoder 1
- Phase synchronization with virtual master axis, encoder 2
- Phase synchronization with virtual master axis, encoder 1, lagless
- Phase synchronization with virtual master axis, encoder 2, lagless

The position synchronization operation mode "phase synchronization", "cam" or "MotionProfile" and the active master axis are selected in parameter "P-0-0088, Control word synchronization modes". Encoder selection and specification of lagless position control or position control with lag error are made in parameter "S-0-0520, Axis control word".

Application "Absolute Phase Synchronization"

In machining processes that require absolute phase synchronization, e.g. printing, punching or perforating in printing machines, the absolute position reference to the master axis is established in the operating mode "phase synchronization". The drive synchronizes with a position command value that is generated from master axis position and additive position command value.

Application "Relative Phase Synchronization"

For machining processes that only require relative phase synchronization, e.g. synchronization of belts or feed rollers without defined starting point, a relative position reference to the master axis is established. During the first synchronization, there is only an adjustment to the synchronous velocity but no position adjustment carried out.

Pertinent Parameters

In addition to the general parameters of all synchronization modes, there are other parameters involved in phase synchronization:

- S-0-0103, Modulo value
- S-0-0520, Axis control word
- S-0-0521, Axis status word
- P-0-0086, Configuration word synchronous operation modes
- P-0-0088, Control word synchronization modes
- P-0-0089, Status word synchronization modes
- P-0-0159, Slave drive feed travel
- P-0-0776, Effective master axis position
- P-0-0777, Effective master axis velocity
- P-0-0778, Synchronous position command value
- P-0-0779, Synchronous velocity

See also "Pertinent Parameters" in the subsections of "Basic Functions of the Synchronization Modes"

Position Synchronization: Electronic Cam

Brief Description

Assignment to functional firmware package, see chapter "Supported Operation Modes".

In the operation mode "electronic cam with real/virtual master axis", there is a fixed relationship between the master axis position and the slave axis.

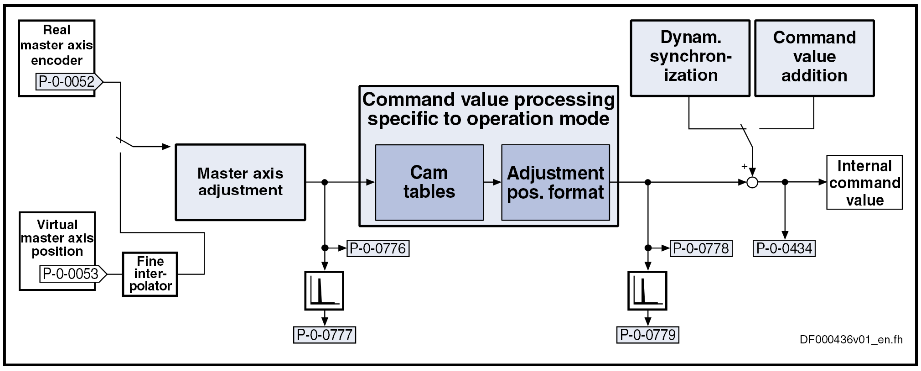
The real master axis velocity is generated by a measuring encoder; in contrast, the virtual master axis velocity is preset by the master.

See also "Dynamic Synchronization of the Slave Axis" in the section "Basic Functions of the Synchronization Modes"

Features

- 4 cam shaft profiles with a max. of 1024 data points (P-0-0072, P-0-0092, P-0-0780, P-0-0781)
- 4 cam shaft profiles with a max. of 128 data points (P-0-0783, P-0-0784, P-0-0785, P-0-0786)
- Cubic spline interpolation of the cam data points
- Dynamic angle offset and angle offset at begin of profile
- Freely definable switch angle for cam and cam distance
- Synchronization mode to be selected
- Single-step, double-step or optimized double-step synchronization
- Absolute or relative phase synchronization
- Synchronization range to be selected
- Change of format "on the fly"
- Cross cutter function
- Clocked Pull Roll

The figure below illustrates the interaction of the individual subfunctions (function blocks) of the "electronic cam" mode:



P-0-0052	Actual position value of measuring encoder
P-0-0053	Master axis position
P-0-0434	Position command value of controller
P-0-0776	Effective master axis position
P-0-0777	Effective master axis velocity
P-0-0778	Synchronous position command value
P-0-0779	Synchronous velocity

Fig.4-82: Function Blocks of the Operation Mode "Electronic Cam"

Variants of the Operation Mode

The following variants can be configured:

- Position synchronization: Cam with real master axis, encoder 1
- Position synchronization: Cam with real master axis, encoder 2
- Position synchronization: Cam with real master axis, encoder 1, lagless
- Position synchronization: Cam with real master axis, encoder 2, lagless
- Position synchronization: Cam with virtual master axis, encoder 1
- Position synchronization: Cam with virtual master axis, encoder 2
- Position synchronization: Cam with virtual master axis, encoder 1, lagless

- Position synchronization: Cam with virtual master axis, encoder 2, lag-less

☞ The position synchronization operation mode "phase synchronization", "cam" or "MotionProfile" and the active master axis are selected in parameter "P-0-0088, Control word synchronization modes". Encoder selection and specification of lagless position control or position control with lag error are made in parameter "S-0-0520, Axis control word".

Pertinent Parameters

In addition to the general parameters of all synchronization modes, there are other parameters involved in this operating mode:

- S-0-0103, Modulo value
- S-0-0520, Axis control word
- S-0-0521, Axis status word
- P-0-0061, Angle offset begin of table
- P-0-0072, Cam table 1
- P-0-0073, Cam distance 2
- P-0-0085, Dynamic angle offset
- P-0-0086, Configuration word synchronous operation modes
- P-0-0088, Control word synchronization modes
- P-0-0089, Status word synchronization modes
- P-0-0092, Cam table 2
- P-0-0093, Cam distance
- P-0-0094, Cam switch angle
- P-0-0144, Cam distance switch angle
- P-0-0158, Angle offset change rate
- P-0-0159, Slave drive feed travel
- P-0-0227, Cam table, access angle
- P-0-0695, Angle offset begin of profile, process loop
- P-0-0696, Filter time constant, angle offset profile, process loop
- P-0-0776, Effective master axis position
- P-0-0777, Effective master axis velocity
- P-0-0778, Synchronous position command value
- P-0-0779, Synchronous velocity
- P-0-0780, Cam table 3
- P-0-0781, Cam table 4
- P-0-0782, Cam table 5
- P-0-0783, Cam table 6
- P-0-0784, Cam table 7
- P-0-0785, Cam table 8

See also "Pertinent Parameters" in the subsections of "Basic Functions of the Synchronization Modes"

Pertinent Diagnostic Messages

In addition to the general diagnostic messages of all synchronization modes, there are other diagnostic messages involved in this operating mode:

- A0128 Cam, encoder 1, virtual master axis
- A0129 Cam, encoder 2, virtual master axis
- A0130 Cam, encoder 1, real master axis
- A0131 Cam, encoder 2, real master axis
- A0132 Cam, lagless, encoder 1, virt. master axis
- A0133 Cam, lagless, encoder 2, virt. master axis
- A0134 Cam, lagless, encoder 1, real master axis
- A0135 Cam, lagless, encoder 2, real master axis
- A0163 Position synchronization
- F2002 Assignment of encoder for synchronization is not allowed
- F2005 Cam table invalid

See also "Pertinent Diagnostic Messages" in the subsections of "Basic Functions of the Synchronization Modes"

Position Synchronization: MotionProfile

Brief Description

Expansion package **Synchronization** (order code **SNC**) for the variants **MPB and MPD** in **closed-loop** characteristic

In the operation mode "MotionProfile with real/virtual master axis", there is a fixed relationship between the master axis position and the slave axis.

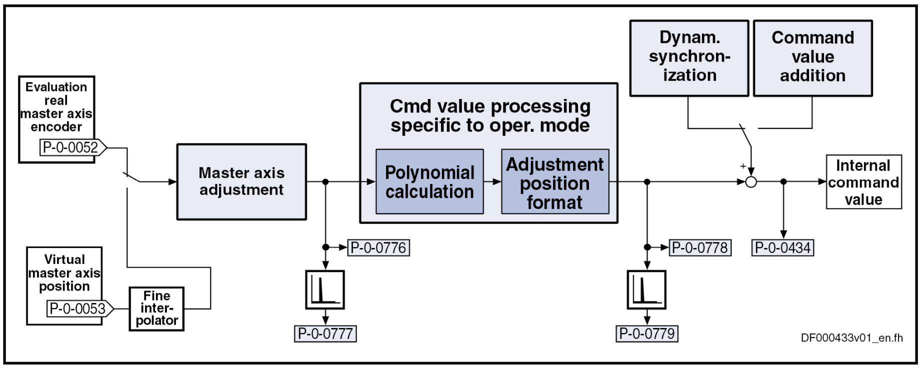
The real master axis velocity is generated by a measuring encoder; in contrast, the virtual master axis velocity is preset by the master.

See also "Dynamic Synchronization of the Slave Axis" in the section "Basic Functions of the Synchronization Modes"

Features

- 2 sequences of motion with up to 8 motion steps per master axis revolution
- Definition of a motion step by standardized profile or cam table
- Motion laws can be selected (rest in rest, rest in velocity, velocity in rest, velocity in velocity, constant velocity)
- Motion laws realized by 5th order polynomial or, in the case of rest in rest, alternatively by inclined sine curve
- Individual distance for each motion step
- Dynamic angle offset and angle offset at begin of profile
- Absolute synchronization can be switched off
- Synchronization mode to be selected
- Absolute or relative processing of the motion steps to be selected
- Synchronization range to be selected
- Cross cutter function

The figure below illustrates the interaction of the individual subfunctions (function blocks) of the "MotionProfile" mode:



P-0-0052	Actual position value of measuring encoder
P-0-0053	Master axis position
P-0-0434	Position command value of controller
P-0-0776	Effective master axis position
P-0-0777	Effective master axis velocity
P-0-0778	Synchronous position command value
P-0-0779	Synchronous velocity

Fig.4-83: Function Blocks of the "MotionProfile" Operation Mode

Variants of the Operation Mode

The following variants can be configured:

- Position synchronization: MotionProfile
  - MotionProfile with real master axis, encoder 1
  - MotionProfile with real master axis, encoder 2
  - MotionProfile with real master axis, encoder 1, lagless
  - MotionProfile with real master axis, encoder 2, lagless
  - MotionProfile with virtual master axis, encoder 1
  - MotionProfile with virtual master axis, encoder 2
  - MotionProfile with virtual master axis, encoder 1, lagless
  - MotionProfile with virtual master axis, encoder 2, lagless

---

☞ The position synchronization operation mode "phase synchronization", "cam" or "MotionProfile" and the active master axis are selected in parameter "P-0-0088, Control word synchronization modes". Encoder selection and specification of lagless position control or position control with lag error are made in parameter "S-0-0520, Axis control word".

Pertinent Parameters

In addition to the general parameters of all synchronization modes, there are other parameters involved in this operating mode:

- S-0-0103, Modulo value
- S-0-0520, Axis control word
- S-0-0521, Axis status word
- P-0-0061, Angle offset begin of table
- P-0-0085, Dynamic angle offset
- P-0-0086, Configuration word synchronous operation modes
- P-0-0088, Control word synchronization modes
- P-0-0089, Status word synchronization modes
- P-0-0158, Angle offset change rate

- P-0-0159, Slave drive feed travel
- P-0-0227, Cam table, access angle
- P-0-0695, Angle offset begin of profile, process loop
- P-0-0696, Filter time constant, angle offset profile, process loop
- P-0-0700, MotionProfile, master axis switching position
- P-0-0701, Motion step 1, slave axis initial position
- P-0-0702, MotionProfile, diagnosis, set 0
- P-0-0703, Number of motion steps, set 0
- P-0-0704, Master axis velocity, set 0
- P-0-0705, List of master axis initial positions, set 0
- P-0-0706, List of motion laws, set 0
- P-0-0707, List of distances, set 0
- P-0-0708, List of slave axis velocities, set 0
- P-0-0709, MotionProfile, diagnosis, set 1
- P-0-0710, Number of motion steps, set 1
- P-0-0711, Master axis velocity, set 1
- P-0-0712, List of master axis initial positions, set 1
- P-0-0713, List of motion laws, set 1
- P-0-0714, List of distances, set 1
- P-0-0715, List of slave axis velocities, set 1
- P-0-0755, Gear reduction
- P-0-0776, Effective master axis position
- P-0-0777, Effective master axis velocity
- P-0-0778, Synchronous position command value
- P-0-0779, Synchronous velocity

See also "Pertinent Parameters" in the subsections of "Basic Functions of the Synchronization Modes"

Pertinent Diagnostic Messages

In addition to the general diagnostic messages of all synchronization modes, there are other diagnostic messages involved in this operating mode:

- A0136 MotionProfile, encoder 1, virtual master axis
- A0137 MotionProfile, encoder 2, virtual master axis
- A0138 MotionProfile, encoder 2, real master axis
- A0139 MotionProfile, encoder 1, real master axis
- A0140 MotionProfile lagless, encoder 1, virtual master axis
- A0141 MotionProfile lagless, encoder 2, virtual master axis
- A0142 MotionProfile lagless, encoder 1, real master axis
- A0143 MotionProfile lagless, encoder 2, real master axis
- A0163 Position synchronization
- F2002 Assignment of encoder for synchronization is not allowed
- F2003 Motion step skipped
- F2004 Error in MotionProfile

See also "Pertinent Diagnostic Messages" in the subsections of "Basic Functions of the Synchronization Modes"

4.6 Extended Axis Functions

4.6.1 Safety Instructions

⚠ 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 safety fence, safety guard, protective covering, light barrier).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- In addition, observe the safety message "Protection Against Dangerous Movements" in the chapter "Safety Instructions for Electric Drives and Controls".

4.6.2 Availability of the Extended Axis Functions

The following overview illustrates by which base or functional packages the respective extended axis function is supported (if not stated otherwise, this applies to all three firmware versions, MPB, MPM and MPE).

Extended axis function	In base package (characteristic)	In functional package ... (on the basis of a base package with the following characteristics)		
		Servo function	Synchronization	Main spindle
Drive Halt	OL/CL	–	–	–
v_{cmd} reset ("emergency halt")	OL/CL	–	–	–
v_{cmd} reset with ramp ("quick stop")	OL/CL	–	–	–
$_{cmd}$ reset while maintaining a_{max}	CL	–	–	–
Torque enable	OL/CL	–	–	–
Package reaction on error	OL/CL	–	–	–
NC reaction on error	OL/CL	–	–	–
E-Stop function	OL/CL	–	–	–
Friction torque compensation	CL	–	–	–
Backlash on reversal correction	CL [1)]	–	–	–
Precision axis error correction	–	CL [1)]	–	–
Control-side axis error correction	–	CL [1)]	–	–
Temperature error correction	–	CL [1)]	–	–
Quadrant error correction	–	CL [1)]	–	–
Cogging torque compensation	–	CL [1)]	CL [1)]	–
Measuring wheel mode	–	–	CL [1)]	–

Extended axis function	In base package (characteristic)	In functional package ... (on the basis of a base package with the following characteristics)		
		Servo function	Synchronization	Main spindle
Positive stop drive procedure	OL/CL	–	–	–
Redundant motor encoder	CL [1)]	–	–	–
Spindle positioning	–	–	–	CL [1)]
Parameter set switching	–	–	–	OL/CL [1)]
Drive-controlled oscillation	–	–	–	OL/CL [1)]
Parking axis	OL/CL	–	–	–
Programmable position switch	–	CL [1)2)]	CL [1)2)]	–
Set/shift coordinate system	–	CL [1)]	CL [1)]	CL [1)]

OL Open-loop characteristic
CL Closed-loop characteristic
1) Not for the firmware version MPE
2) Not for the firmware version MPM

Fig.4-84: Availability of the Extended Axis Functions

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

See also "Enabling of Functional Packages"

4.6.3 Drive Halt

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

The "Drive Halt" function is used to shut down an axis with defined acceleration and defined jerk.

In the default case, Drive Halt is executed as a quick stop in position control or velocity control. Position control is activated when one of the operation modes (S-0-0032 ...) with position control is defined (including internal PLC operation modes). Otherwise, velocity control is active.

With the Drive Halt configuration (P-0-0558, Bit 1,2), the type of control can also be freely selected.

- Bit 1,2 = 1,1 position control
- Bit 1,2 = 1,0 velocity control

With the configuration "Drive Halt" (P-0-0558, Bit 0 = 1), a switch can be made to the function "operational halt". Then the operation modes "velocity control", "drive-internal interpolation", "drive-controlled positioning" and "positioning block" are stopped internally with V cmd = 0. After "Drive Halt" has been removed, motion is active again.

The adjustable position command value delay in position cycle times (P-0-0456) is a maximum of 32 cycles.

☞ In addition to the "Drive Halt" function, there is an operational stop for the operation modes "drive-controlled positioning" and "drive-internal interpolation". This function, however, has its own control signal.

Features

- Activation using the "halt bit" of the master communication (see "Device Control and State Machines")
- Active operating mode interrupted; drive remains in control (after setting the "halt bit" the interrupted operating mode is continued)
- Quick stop in position control

  → Shutdown with acceleration (S-0-0372) and jerk limit values (S-0-0349) in position control
- Quick stop in velocity control

  → Shutdown with acceleration (S-0-0372) and jerk limit values (S-0-0349) in velocity control
- If the Drive Halt acceleration bipolar (S-0-0372) is set to "0", " S-0-0138, Bipolar acceleration limit value" is effective at shutdown.
- Acknowledgement of "Drive Halt" in P-0-0115

Pertinent Parameters

- S-0-0124, Standstill window
- S-0-0349, Bipolar jerk limit
- S-0-0372, Drive Halt acceleration bipolar
- S-0-0138, Bipolar acceleration limit value
- P-0-0115, Device control: Status word
- P-0-0434, Position command value of controller
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0558, Drive Halt configuration

4.6.4 Error Reactions

Overview of Error Reactions

Depending on the operation mode that is used and some parameter settings, the drive controller carries out monitoring functions. An error message is generated by the drive controller, if a status is detected that no longer allows correct operation.

Errors are classified in error classes. The error class is represented by the first two digits of the diagnostic message number.

See also "Terms, Basic Principles"

See also "Diagnostic System"

If the drive controller is in control (drive enable was set) and an error occurs, the drive controller automatically starts a drive error reaction.

This drive error reaction depends on:

- The error class of the error occurred and
- The settings of the following parameters:
  - P-0-0117, Activation of control unit reaction on error
  - P-0-0118, Power supply, configuration
  - P-0-0119, Best possible deceleration

At the end of each error reaction, the drive goes torque-free. Power off depends on the setting in P-0-0118!

Error Classes

There are 8 error classes with different priority:

Diagnostic message number	Error class	Error Reaction
F2xxx	Non-fatal error	According to setting in parameters "P-0-0119, Best possible deceleration" and "P-0-0117, Activation of control unit reaction on error"
F3xxx	Non-fatal safety technology error	According to setting in "P-0-0119, Best possible deceleration" and "P-0-0117, Activation of control unit reaction on error"
F4xxx	Interface error	According to setting in "P-0-0119, Best possible deceleration"
F6xxx	Travel range error	Velocity command value reset ("emergency halt")
F8xxx	Fatal error	Immediate torque enable if this is also the error reaction for non-fatal errors; otherwise, deceleration of the motor by short circuiting the motor windings
F9xxx	Fatal system error	immediate torque enable
E-xxxx	Fatal system error "processor exception"	immediate torque enable

Fig.4-85: Error Classes and Drive Reaction

The error class can be recognized by the diagnostic message number and defines the drive behavior in the case of error.

Best Possible Deceleration

Short Description

The error reaction "best possible deceleration" (can be set in parameter "P-0-0119, Best possible deceleration") is carried out automatically in the case of the following states:

- Non-Fatal Errors (F2xxx)
- Non-Fatal Safety Technology Errors (F3xxx)
- Interface Errors (F4xxx)
- Communication phase is reset
- Drive enable is removed (see S-0-0134 resp. P-0-4077 or P-0-0115, bit 15)
- Travel range error (F6xxx)
- Fatal warnings which require the reaction "velocity command value reset" (e.g. E8034, E6044)

One of the following reactions for "best possible deceleration" can be set in P-0-0119:

- Velocity command value reset (emergency halt)

- Velocity command value reset with ramp and filter
- Velocity command value reset while maintaining the maximum acceleration
- Torque enable

See also parameter description "P-0-0119, Best possible deceleration"

NOTICE

If the error reaction "torque enable" was set in P-0-0119, the drive also reacts to F8 errors with a torque enable; otherwise, for most F8 errors, the motor is decelerated by short circuiting the motor windings!

Due to the system, decelerating by short circuiting the motor windings is not possible with:

- **F8000 Fatal hardware error**
- **F8060 Overcurrent in power section**

In the case of fatal system errors (F9xxx) the setting in P-0-0119 is ignored; the drive is shut down with an immediate torque enable.

Package Reaction on Error

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

"Package reaction" is the simultaneous error reaction of all axis drives supplied by a common power bus (DC bus). Drive errors of a drive can be signaled to all other axis drives via the module bus (signal bus) which allows the simultaneous error reaction (according to setting in parameter "P-0-0119, Best possible deceleration") of all axis drives.

The settings for signaling drive errors and package reaction are made individually for each drive in "P-0-0118, Power supply, configuration". This allows activating the package reaction only for individual axes. The behavior of the axes for which the package reaction has not been activated has to be taken into account for the case of error and must be controlled on the master side, if necessary!

The supply unit switches off power supply only in the case of its own errors and in the case of fatal drive errors (F8xxx), if the drive signaling errors signals F8 errors to the supply.

Fields of Application

Examples of applications with interactive (interpolating, synchronized) use of drives that are supplied by a common power bus ("drive package"):

- Machine tools (e.g. milling, turning, grinding machines)
- Gear cutting machines (gear wheel machining)
- Printing mechanisms of printing machines, etc.

By setting the error reaction of the drive system devices according to the application, the following damages can be minimized:

- Machine damages
- Tool/workpiece/material damages

⚠ WARNING **The package reaction is not suitable for avoiding personal injury!**

Reaction to drive errors	Priority of appropriate error reactions for typical drive applications	Setting in P-0-0117	Setting in P-0-0118	General Conditions
NC master-side reaction	NC master-side priority of shutdown and power off	NC reaction active	no package reaction, no signaling of drive errors	Drive with F8 error does not decelerate!
Drive reaction	Shutdown spindle drive (asynchronous motors) Shutdown servo drives (synchronous motors) Power off	NC reaction not active	Package reaction, signaling of drive errors	Drive with F8 error does not decelerate! , No DC bus short circuit Power off via NC master
	Shutdown servo drives (synchronous motors) Power off Shutdown spindle drive (asynchronous motors) irrelevant	NC reaction not active	Package reaction, signaling of drive errors, signaling of F8 errors to supply	Power off only with F8 error, otherwise via NC master with DC bus short circuit
	Power off Shutdown spindle drive (asynchronous motors) Shutdown servo drives (synchronous motors)	NC reaction not active	Package reaction, signaling of drive errors, signaling of F8 errors to supply	Power off only with F8 error, otherwise via NC master; no DC bus short circuit, drive with F8 error does not decelerate!
	Power off Shutdown servo drives (synchronous motors) Shutdown spindle drive (asynchronous motors)	NC reaction not active	Package reaction, signaling of drive errors, signaling of F8 errors to supply	Power off only with F8 error, otherwise via NC master with DC bus short circuit

Fig.4-86: Examples of Settings in P-0-0117 and P-0-0118, Depending on the Priority of Appropriate Error Reactions (with General Conditions)

☞ The above examples are not binding and provide basic information on the settings that have to be made according to the axis-specific and application-dependent requirements.

Pertinent Parameters

- P-0-0118, Power supply, configuration
- P-0-0119, Best possible deceleration

Axis-specific Monitoring

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

Control Reaction on Error

NC Reaction on Error

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

To avoid damage to the machine, some applications require that the master (e.g. NC) retains control of the travel profile of the axes even in case of error and shuts down the machine axes in a coordinated way. For this case, the "NC reaction on error" option was implemented; it can be activated via parameter P-0-0117.

The master is informed of an error in the drive controller via the drive status word (see S-0-0135) so that the master can shut down the machine axes in a coordinated way and therefore avoid possible damage.

NC reaction on error is only possible with non-fatal errors (diagnostic message F2xxx), otherwise the drive always reacts with an immediate drive-side error reaction.

Pertinent Parameters

- S-0-0135, Drive status word
- P-0-0117, Activation of control unit reaction on error
- P-0-0119, Best possible deceleration

MLD Reaction on Error

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

As an alternative to the NC reaction, the IndraMotion MLD reaction on error can also be realized for the (local) axis. Here the MLD reaction and the NC reaction are differentiated functionally in that by means of IndraMotion MLD, even for an interface error (F4xxx), an error reaction to be defined by the operator can be executed for the (local) axis.

Prerequisite for using the MLD error reaction is an enable for the PLC function in the drive (see "Enabling of Functional Packages").

Pertinent Parameters

- S-0-0135, Drive status word
- P-0-0117, Activation of control unit reaction on error
- P-0-0119, Best possible deceleration

- P-0-2003, Selection of functional packages

4.6.5 E-Stop Function

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

The E-Stop function is used to shut down the drive with selectable drive reaction (see Parameter Description "P-0-0008, Activation E-Stop function") via a digital input of the drive controller.

The following options are available for using the E-Stop function:

- E-Stop with reaction to interface error (F4034 Emergency-Stop activated)

  → **Reaction:** Best possible deceleration (as set in P-0-0119)
- E-Stop with reaction to travel range error (F6034 Emergency-Stop activated)

  → **Reaction:** Velocity command value reset
- E-Stop as fatal warning "E8034 Emergency-Stop activated"

  → **Reaction:** Best possible deceleration (as set in P-0-0119)

If "E-Stop" was parameterized as a warning, the diagnostic message does not have to be cleared!

Pertinent Parameters

- P-0-0008, Activation E-Stop function
- P-0-0119, Best possible deceleration
- P-0-0223, E-Stop input

Pertinent Diagnostic Messages

- E8034 Emergency-Stop activated
- F4034 Emergency-Stop activated
- F6034 Emergency-Stop activated

4.6.6 Compensation Functions / Corrections

Friction Torque Compensation

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

The behavior of a machine axis is negatively affected by static friction when starting or when reversing the direction. The drive-internal friction torque compensation allows compensating the static friction by adding, depending on the direction of movement, a torque/force command value.

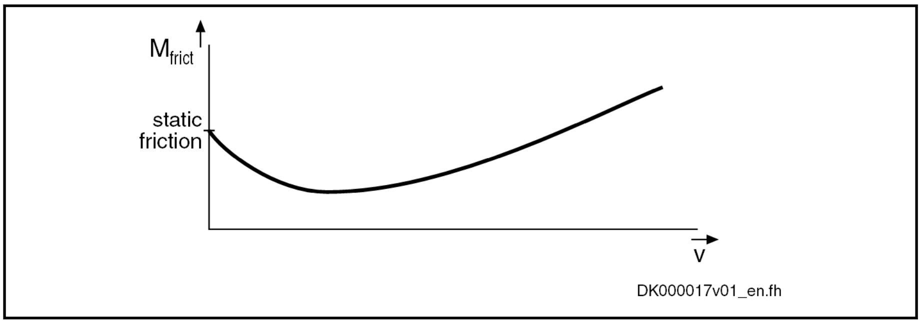


Fig.4-87: Friction Torque Curve With Static Friction

☞ Friction torque compensation is mainly intended to be used in precision machine tools and to reduce the path errors caused by static friction. This applies particularly to circular errors at the quadrant transitions.

Pertinent Parameters

- S-0-0092, Bipolar torque/force limit value
- S-0-0124, Standstill window
- S-0-0155, Friction compensation

Axis Error Correction

Brief Description

The actual position value provided by the measuring system can differ from the real actual position value at the axis, e.g. at the point of chip removal in the case of metal-cutting machining, due to

- inaccuracy of the measuring system,
- transmission inaccuracy in mechanical transmission elements such as gear, clutch, feed spindle etc.,
- thermal expansion of machine parts of the drive system.

For compensating the mechanically determined position error sources, IndraDrive controllers provide the following correction functions:

- Backlash on reversal correction
- Precision axis error correction
- Control-side axis error correction

The control-side axis error correction is always active. The correction value can be transmitted in the cyclic telegram or in the service channel. In addition, precision axis error correction or reversal clearance can be activated, precision axis error correction having higher priority.

Moreover, it is possible to activate the temperature error correction. IndraDrive controllers provide two possibilities of correcting temperature errors:

- Independent of axis position
- Depending on axis position

Pertinent Parameters

- S-0-0058, Reversal clearance
- S-0-0124, Standstill window
- P-0-0400, Axis correction external correction value
- P-0-0401, Axis correction active correction value
- P-0-0402, Axis correction reference temperature

- P-0-0403, Axis correction reference position for temp. corr.
- P-0-0404, Axis correction actual temperature pos.-dependent
- P-0-0405, Axis correction actual temperature pos.-independent
- P-0-0406, Axis correction temperature factor pos.-dependent
- P-0-0407, Axis correction temperature factor pos.-independent
- P-0-0408, Axis correction start position
- P-0-0409, Axis correction end position
- P-0-0410, Axis correction support point distance
- P-0-0411, Axis correction, correction table positive
- P-0-0412, Axis correction, correction table negative
- P-0-0413, Axis correction control word

Quadrant Error Correction

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

In the case of axis drives that are controlled, for example, in circular interpolation, static friction at the reversal points of the direction of motion can cause distortion of the circular contour.

In order to compensate this contour error at the so-called "quadrant transitions" (velocity reversal), IndraDrive controllers provide the "quadrant error correction" function.

This correction function is useful for such cases when drives are operated in cyclic position control and in circular interpolation by the control master.

Pertinent Parameters

- P-0-0100, Position command value extension
- P-0-0435, Control word of position controller
- P-0-0436, Reference radius for quadrant error correction
- P-0-0437, Velocity time range for quadrant error correction
- P-0-0438, Table of path velocities for quadrant error correction
- P-0-0439, Table of velocity pulse for quadrant error correction

Cogging Torque Compensation

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

Motors for which the magnetic excitation is realized with permanent magnets (e.g. synchronous motors) in many cases show cogging torques or cogging forces. Cogging torques/cogging forces already act on the moving component of the motor in the de-energized state and aim at moving it to a stable position.

When the motor is put into motion by control, the cogging torques/cogging forces act on the motor in a decelerating or accelerating way, according to the position. For applications in which minimum lag error or very constant velocity is important, the position-dependent cogging torques/cogging forces can have a negative effect.

To improve the synchronous operation and lag error behavior of synchronous motors, IndraDrive controllers provide cogging torque and cogging force compensation for drives with high demands on lag error and synchronous operation quality. For this purpose, the position dependent, additive torque command values that take effect in the drive control require an unambiguous position reference from the motor measuring system to the motor.

The position reference is automatically established using a search of the reference marks. If this is not possible, a switch can be made into the function "Position reference by homing" (P-0-1131, Control word of cogging torque compensation). The position reference is then established only with the command "Homing"; in this way, even encoders without a mark or with several marks can be used.

Hardware Requirements

The motor must be equipped with a motor encoder. Cogging torque compensation is not possible with sensorless motor operation!

Pertinent Parameters

- P-0-0162, C1800 Command Drive optimization / command value box
- P-0-0165, Drive optimization, control word
- P-0-0170, Drive optimization, acceleration
- P-0-0171, Drive optimization, velocity
- P-0-1129, Cogging torque compensation value
- P-0-1130, Table of cogging torque compensation values pos. direction
- P-0-1131, Control word of cogging torque compensation
- P-0-1132, Table of cogging torque compensation values neg. direction
- P-0-1133, Status word of cogging torque compensation
- P-0-1134, Velocity threshold for attenuation of cogging torque compens
- P-0-1135, Velocity threshold for switching off cogging torque compens.
- P-0-1136, Lead time cogging torque compensation
- P-0-1138, C4800 Command Determine cogging torque compensation table
- P-0-1139, Cogging torque compensation adaption factor

Pertinent Diagnostic Messages

- C1808 Drive not homed
- C4800 Command Determine cogging torque compensation table
- C4801 Cogging torque compensation: Measuring vel. too high
- C4802 Cogging torque compensation: Measuring vel. too low
- C4803 Cogging torque compensation: Inadmissible acceleration
- C4804 Cogging torque comp.: Err. when storing corr. val table
- C4805 Cogging torque comp.: Motor measuring system not homed

Correction of Torque/Force Constant

Brief Description

Fields of Application

Base package of all firmware variants in **closed loop** characteristic

Display of Motor Load, Load Limit Values

For IndraDrive devices, the current load of the motor is determined and displayed on the drive side. The load can be limited by means of the controller.

The unit of the load display and load limit value input can be selected:

- Percentage-based, with relation to the continuous motor current or nominal motor current
- Physically, values in "Nm" (rotary) or "N" (linear)

The load of the motor is determined by means of the measured motor current; with physical scaling, the controller determines the motor torque or force by using the currently flowing current for calculating the motor-type-specific torque or force constant.

If torque/force precision up to approx. +/- 5% is required (e.g., for load limitation) due to the mechanical axis system or process technology, the controller provides the "correction of torque/force constant". In this case, the motor-type-specific value is corrected depending on the current motor current, the motor temperature and the average speed.

☞ Due to the downward compatibility of the firmware and possibly unavailable parameter values (e.g., for third-party motors), this correction must be separately activated!

Pertinent Parameters

- P-0-0448, Temperature-dependent torque/force coefficient
- P-0-0449, Speed-dependent torque/force coefficient
- P-0-0450, Current torque/force constant
- P-0-0556, Config word of axis controller
- P-0-3055, Maximum motor torque/force, encoder memory
- P-0-3056, Nominal motor torque/force, encoder memory
- P-0-3057, Speed-dependent torque/force coefficient, encoder memory
- P-0-3058, Temperature-dependent torque/force coefficient, enc. memory
- S-0-0533, Nominal torque/force of motor
- S-0-0534, Maximum torque/force of motor

Pertinent Diagnostic Messages

- None -

4.6.7 Measuring Wheel Mode

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

The measuring wheel mode is used for material feed axes, e.g. in sheet-metal machining. For direct measurement of the infeed of moved material, a rotary encoder that is detecting the infeed length is driven via a measuring wheel with frictionally engaged contact to the material surface.

The position control loop is closed via motor encoder and measuring wheel encoder, possible slip between motor and material does not cause incorrect measured values of material length.

The measuring wheel mode may only be activated when contact has been established between measuring wheel and material surface.

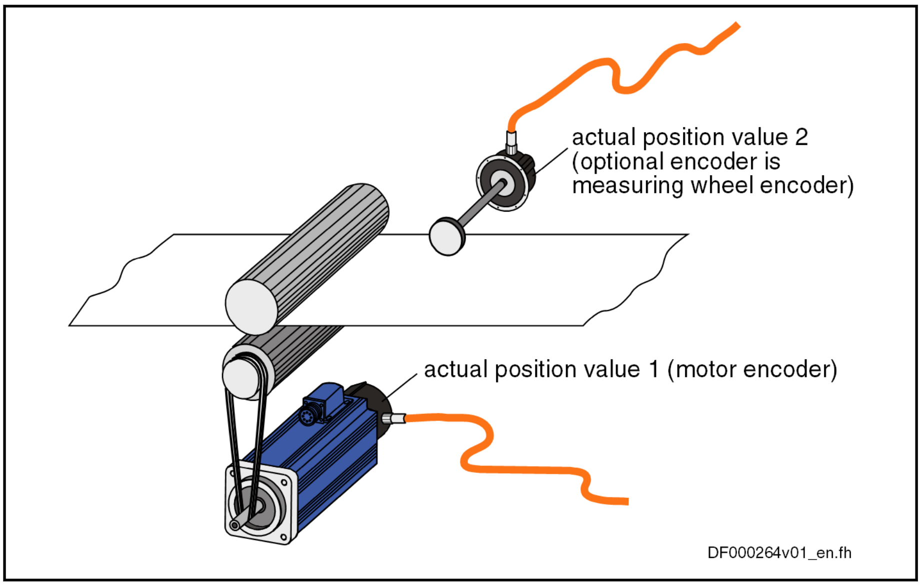


Fig.4-88: Typical arrangement of drive for material infeed with measuring wheel encoder

Hardware Requirements

The measuring wheel encoder is an optional (external) encoder that is connected according to the connection diagram contained in the separate documentation (see "Other applicable documentation").

See also Measuring Systems

Pertinent Parameters

The following parameters are used to parameterize this function:

- S-0-0520, Axis control word
- S-0-0521, Axis status word
- P-0-0241, Actual pos. smoothing time constant for hybrid pos. control
- P-0-0242, Current actual slip value
- P-0-0243, Maximum occurred actual slip value
- P-0-0244, Monitoring window of slip

The following parameters are used to parameterize the measuring wheel encoder:

- S-0-0115, Position feedback 2 type
- S-0-0117, Resolution of feedback 2
- P-0-0123, Feed constant 2 (optional encoder)
- P-0-0124, Gear 2 load-side (optional encoder)
- P-0-0125, Gear 2 encoder-side (optional encoder)
- P-0-0185, Control word of encoder 2 (optional encoder)

Pertinent Diagnostic Messages

- F2036 Excessive position feedback difference

4.6.8 Positive Stop Drive Procedure

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

For special applications, it is required to move machine axes operated in position or velocity control up to a limit stop in order to generate forces of pressure.

When an axis in the standard situation has moved up to a limit stop, the drive should signal a drive error by the monitoring facilities of the position or velocity control loop and react with shutdown.

But if the drive can detect the special case of operation "positive stop drive procedure", it can ignore the messages of the position and motions monitors and generate the required force of pressure, if necessary.

The control master signals this special case to the controller of IndraDrive devices via a command. Upon this command, the drive switches off the respective monitors and acknowledges axis standstill to have been detected and a parameterizable force or torque threshold to have been exceeded.

Pertinent Parameters

- S-0-0082, Torque/force limit value positive
- S-0-0083, Torque/force limit value negative
- S-0-0092, Bipolar torque/force limit value
- S-0-0124, Standstill window
- S-0-0149, C1300 Positive stop drive procedure command

Pertinent Diagnostic Messages

- C1300 Positive stop drive procedure command
- C1301 Class 1 diagnostics error at command start

4.6.9 Redundant Motor Encoder

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

Motor control of synchronous motors requires a position measuring system that measures the position of the moving part of the motor as opposed to the static part. If there is malfunction or defect in the position measuring system (motor encoder), a synchronous motor can no longer be decelerated in a controlled way.

Depending on the requirements, position control can require an external measuring system at the axis which detects the position at the load with the required precision.

For axis control, the entire mechanical drive system between motor encoder and load position of the external encoder is mapped via parameters. This allows calculating the position of the motor encoder from the position of the external encoder or determining the load position from the motor encoder position, if the mechanical drive system is without slip.

If there is a defect in the motor encoder, the motor position, when an external encoder is used, can be determined via the position of the external encoder and the synchronous motor can be decelerated in a controlled way.

For asynchronous motors with motor encoder, it is also possible to use an external measuring system for controlled deceleration, if there is a defect in the motor encoder. But if the asynchronous motor, depending on the drive task, is operated without encoder, controlled deceleration via external encoder in the case of error is not possible!

Only measuring systems with U_{pp} = 1V or resolvers can be used as redundant motor encoders!

Pertinent Parameters

- P-0-0185, Control word of encoder 2 (optional encoder)

Pertinent Diagnostic Messages

- F2031 Encoder 1 error: signal amplitude incorrect
- F2042 Encoder 2: Encoder signals incorrect
- F8022 Enc. 1: Enc. signals incorr. (can be cleared in ph. 2)
- F8042 Encoder 2 error: Signal amplitude incorrect

4.6.10 Spindle Positioning

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

With the drive function "spindle positioning", the drive, at a command of the master, aligns the spindle independently with regard to the spindle zero position. The command position is transmitted to the drive controller via parameter and can be preset as absolute or relative position.

By means of the "position spindle" command, the spindle can be positioned in a position-controlled way (e.g. within the "velocity control" mode) without having to switch the operation mode from velocity to position control.

How to use the drive function "spindle positioning":

- For **milling and drilling spindles**
  - To prepare tool change → spindle remains at a defined position to allow changing the tool
- For **turning machine main spindles**
  - To change the workpiece (if required)
  - To place balancing drillings for workpieces to be balanced
  - To index the workpiece for further machining
- For **revolving transfer machines**
  - To advance the turntable in order to bring workpieces to a defined machining position at the different stations

Hardware Requirements

The use of a home switch may be required.

See "Establishing Position Data Reference for Relative Measuring Systems"

Pertinent Parameters

- S-0-0152, C0900 Position spindle procedure command
- S-0-0153, Spindle angle position
- S-0-0154, Spindle positioning parameter
- S-0-0180, Spindle relative offset
- S-0-0222, Spindle positioning speed

- S-0-0372, Drive Halt acceleration bipolar
- S-0-0417, Positioning velocity threshold in modulo mode
- S-0-0418, Target position window in modulo mode
- S-0-0437, Positioning status
- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration
- P-0-1201, Ramp 1 pitch
- P-0-1202, Final speed ramp 1
- P-0-1203, Ramp 2 pitch
- P-0-1211, Deceleration ramp 1
- P-0-1213, Deceleration ramp 2

Pertinent Diagnostic Messages

- C0900 Position spindle command
- C0902 Spindle positioning requires drive enable
- C0903 Error during initialization
- C0906 Error during search for zero pulse

4.6.11 Parameter Set Switching

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

IndraDrive drives are equipped with eight parameter sets (MPB-17VRS, MPC-17VRS, MPE-17VRS) or four parameter sets (MPM-17VRS) and switches can be made among them during operation. One of the switchable parameter sets is always active. Switching takes place upon command of the control master.

Notes on Applications

By switching parameter sets during operation, the values of specific parameters can be adjusted to the different operating phases or machining processes. This supports the work flow in flexible production facilities.

Examples of application:

- Changing from C-axis to roughing or finishing operation in the case of spindles
- Positioning mode for tool change with different gear ratios
- Changing motor spindles for different machining phases
- Adjusting the control loop gains to different load inertia or load masses (e.g. with very different workpieces)
- Star-delta switching of motors with switchable winding to increase the torque in short-time operation

Classification of Switchable Parameters

Under the application-related point of view, the parameters to be switched are divided into the following groups:

- Application Parameters
- Control Loop Parameters
- Load gear parameters (for MPB-17VRS, MPC-17VRS, MPM-17VRS only in the alternative functional package Main spindle function)

- Winding parameters (for MPB-17VRS, MPC-17VRS, MPM-7VRS only in the alternative functional package Main spindle function)
- Motor control and motor encoder parameters (for MPB-17VRS, MPC-17VRS, MPM-17VRS only in the alternative functional package Main spindle function)

Pertinent Parameters

- S-0-0216, C4100 Switch parameter set command
- S-0-0217, Preselect parameter set command
- S-0-0219, IDN-list of parameter set

☞ List parameters S-**0**-0219 to S-**7**-0219 contain parameter sets no. 0 to no. 7

- S-0-0254, Current parameter set
- P-0-2216, Parameter set switching, configuration
- P-0-2217, Parameter set switching, preselection range
- P-0-2218, Parameter set switching, delay time

Pertinent Diagnostic Messages

- C0273 Modulo value for motor encoder cannot be displayed
- C0278 Modulo value for optional encoder cannot be displayed
- C0280 Maximum travel range cannot be displayed internally
- C4100 Switch parameter set command
- C4101 Switching only possible without AF
- C4103 Preselect parameter set forbidden value
- C4104 Error during parameter set switching (->S-0-0423)

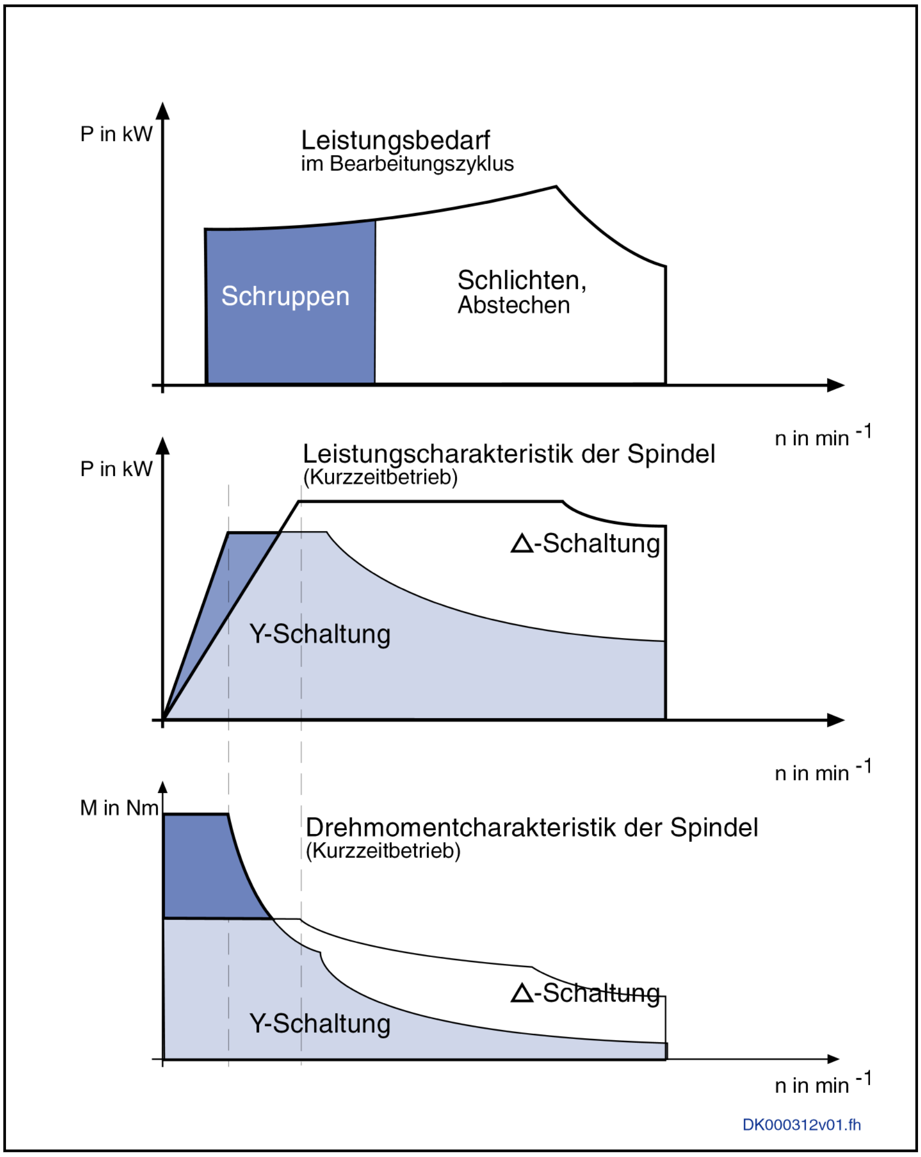
4.6.12 Star-Delta Switching

Brief Description

Fields of Application

With star(Y)-delta(D) switching, the torque power characteristic of a spindle for short-time operation without mechanical transmission elements can be adapted to various processing requirements:

- Removing material (roughing): high torque, low speed
- Fine machining (finishing): high speed, low torque



Y	Star connection
D	Delta connection

Fig.4-89: *Schematic Operating Characteristic of a Spindle Drive with a Star-Delta-Switchable Motor*

The spindle output capacity with star connection is just 2/3 of the capacity with delta connection, i.e. the star-delta-switching is not a complete replacement for gear switching because for each gear level the same output capacity is available! The increased torque in short-time operation with star connection in comparison with delta connection is not associated with an increase in the continuous torque of the spindle!

☞ The increase in the short-time operation torque can also be achieved with an increased type current of the controller with a nested motor instead of with star-delta-switching. This eliminates the protective circuit that is not maintenance free over the long term with which additional wiring effort and braking problems in case of mains power failure are associated!

For milling spindles, due to long run-up times for star connection, star-delta switching is usually not suitable!

Features

Motor design

Star-delta switching can only be used with Rexroth motors specially designed for this purpose or with third-party motors. With these motors, all six winding ends of the three-phase motor are run into the motor terminal box. Standard motors are interconnected internally in a fixed manner; only three power connections are accessible!

Procedure for Star-Delta Switching

IndraDrive controllers support star-delta switching of synchronous and asynchronous three-phase motors in the following way:

- Using switchable parameters, a parameter set with all of the relevant motor parameters is assigned to every type of motor connection in the controller. To do this, the functional package "Main spindle" is required, which offers "parameter set switching".
- Star-delta switching can be performed during operation, i.e. with an active drive. The controller converts the motor control voltage to the new type of connection and, in so doing, implements a connection type transition without it being noticed. However, the controller does not control the contactors for switching the motor windings; this is carried out externally by the control master.
- Each connection type must be taken into operation respectively and each is independently effective and functional. There is no conversion of winding-specific parameter values based on the respective connection type.

Triggering Star-Delta Switching

The change into the other connection type is triggered by switching parameters ("parameter set switching").

Pertinent Parameters

- P-0-2216, Parameter set switching, configuration
- S-0-0217, Preselect parameter set command
- S-0-0216, C4100 Switch parameter set command
- S-0-0219, IDN-list of parameter set

Pertinent Diagnostic Messages

- C4100 Switch parameter set command

4.6.13 Drive-Controlled Oscillation

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

Upon a command of the control master, the drive ignores the cyclic command value input and independently turns alternately in positive and negative direction (speed oscillation). The cyclic speed characteristic can be set via parameters and can be realized symmetrically or asymmetrically.

Notes on Applications

With speed oscillation the main drive supports the following applications, for example:

- Meshing the toothed wheels when switching a gear train
- Engaging positive clutches (e.g. connecting IC engine equipment under test to test stands)

Pertinent Parameters

- S-0-0213, Oscillation speed

- S-0-0214, Oscillation offset speed
- S-0-0215, Oscillation cycle time

Pertinent Diagnostic Messages

- C4200 Drive-controlled oscillation command
- C4201 Oscillation requires drive enable
- C4202 Oscillation command speed cannot be reached

4.6.14 Parking Axis

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

If individual axes within a master communication group (e.g. SERCOS ring, PROFIBUS) are to be temporarily deactivated, without taking them out of the axis group on the hardware and communication side, the function "parking axis" can be activated via command.

When a drive has been put into the status "parking axis", it behaves "neutrally" with regard to hardware and master communication. Errors possibly detected by the drive are suppressed and have no effect on the axes in operation. This allows, for example, uncoupling the motor and the motor encoder in the status "parking axis" without errors being signaled.

The axis that has been "parked" behaves as if it would not exist!

Pertinent Parameters

- S-0-0139, C1600 Parking axis procedure command

Pertinent Diagnostic Messages

- C1600 Parking axis command

4.6.15 Integrated Safety Technology

General Information

The integrated safety functions "Safe torque off" and "Safe brake control" (L4) can be used as of the firmware version MPx16V14.

☞ The following section provides an overview of the integrated safety functions. Details concerning function, notes on commissioning and examples of application are described in the separate documentation "Rexroth IndraDrive, Integrated Safety Technology as of MPx-1x" (DOK-INDRV*-SI3-OP-MAN*-OPxx-DE-P; part no. R911332836).

Product Presentation

What is "Integrated Safety Technology"?

The control sections of the IndraDrive Cs range can be equipped with the optional modules "L3" [STO (Safe Torque Off)] or "L4" [STO (Safe Torque Off) and SBC (Safe Brake Control)].

By the mentioned optional modules, IndraDrive Cs is equipped with integrated safety technology which provides the user with safe torque off, as well as, when using the optional module "L4", with safe control of a brake.

Definition

- "Safe Torque Off" means application-related safety functions which are applicable for personal protection at machines according to EN ISO 13849-1 Category 4 PL e and IEC EN 62061 SIL 3.

- "Safe Brake Control" means application-related safety functions which are applicable for personal protection at machines according to EN ISO 13849-1 Category 4 PL e and IEC EN 62061 SIL 3.

Selecting the Function The safety functions can be selected via 24 V inputs at the drive controller.

Certification The safety technology was certified by TÜV Rheinland ®; the NRTL listing by TÜV Rheinland of North America is in preparation.

Certificates are available on the Internet/Extranet.

Requirements That Can Be Realized The integrated safety technology is independent of the type of master communication, the higher-level control units and the supply modules. It is available as a functional characteristic of the standard drive system. The requirements below can be realized in the machine or in the installation:

- Measures according to EN ISO 12100-2, if accessing the danger zone is required, for example, for equipping, teaching or material withdrawal.
- Requirements for safety-related parts of control units according to EN ISO 13849-1 Category 4 PL e and IEC EN 62061 SIL 3, as required in EN 1010-1 (printing and paper converting machines), EN 12415 (turning machines) and EN 12417 (machining centres).
- Control functions in the case of error according to EN 60204-1 (see "Using diversity" in EN 60204-1).

Integrated Safety Technology as IndraDrive Platform Solution

The type code below shows the different characteristics of IndraDrive Cs.

Abbrev. column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Example:	H	C	S	0	1	.	1	E	-	W	0	0	1	3	-	A	-	0	2	-	E	-	S	3	-	E	C	-	N	N	-	N	N	-	N	N	-	F	W	

Product
HCS . . . . = HCS

Line
1 . . . .= 01

Design
1 . . . . = 1

Power supply unit
Infeeding . . . . = E

Cooling mode
Air, internal. . . . .= W

Maximum current
At mains connection voltage "02"
3 A . . . . = 0003
6 A . . . . = 0006
9 A . . . . = 0009
13 A . . . . = 0013
18 A . . . . = 0018
At mains connection voltage "03"
5 A . . . . = 0005
8 A . . . . = 0008
18 A . . . . = 0018
28 A . . . . = 0028
54 A . . . . = 0054

Degree of protection
IP 20 . . . . = A

Mains connection voltage
3 x AC 110...230 V ±10% . . . . = 02
3 x AC 200...500 V ±10% . . . . = 03

Control section design | Communication
ADVANCED | SERCOS III master (cross communication). . . . .= A-CC
BASIC | MultiEthernet. . . . .= B-ET
ECONOMY | SERCOS III. . . . .= E-S3

Interface 1
Encoder IndraDyn / Hiperface® / 1Vpp / TTL / EnDat 2.1/2.2. . . . . = EC

Interface 2
CANopen . . . . = CN ①
Encoder IndraDyn / Hiperface® / 1Vpp / TTL / EnDat 2.1/2.2. . . . . = EC ①
Encoder emulation. . . . .= EM ①
MultiEthernet . . . . = ET ②
Not equipped . . . . = NN
PROFIBUS . . . . = PB ①

Interface 3
STO (Safe Torque Off) . . . . = L3 ③
STO (Safe Torque Off) and SBC (Safe Brake Control). . . . . = L4 ③
Not equipped . . . . = NN

Other design
None . . . . = NN

Firmware
Denotes that firmware must be ordered as separate subposition . . . . = FW

Note
① Not available with Control section design | Communication "E-S3"
② Not available with Control section design | Communication "A-CC"
③ The "L3" and "L4" interfaces guarantee the function, as well as its certification

Standard reference

Standard	Edition	Title
DIN EN 60529	2000-09	Degrees of protection provided by enclosures (IP code)

DT000063v04_en.fh11

Fig.4-90: Type Code HCS01

To employ the integrated safety technology according to IEC EN 61800-5-2, you must at least use the following firmware version or higher in the drive.

- Optional module "L3": MP*17V06
- Optional module "L4": MP*16V14

Safe Torque Off (STO)

Brief Description

Using the function "Safe torque off" requires the optional safety technology module "L3" or "L4".

The energy supply to the motor is safely interrupted with the safety function "Safe torque off". The drive cannot generate any torque/force and, as a consequence, it cannot generate any dangerous motions, either.

Before activating the safety function "Safe torque off", the drive system must be decelerated via the command value input; there is no drive-controlled deceleration!

⚠ WARNING **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ If external force influences are to be expected with the safety function "Safe torque off", e.g. in the case of a vertical axis, this motion has to be safely prevented by additional measures, e.g. a mechanical brake or a weight compensation; for such axes, Bosch Rexroth recommends that you use the safe braking and holding system.

⚠ WARNING **High electrical voltage! Danger to life, risk of injury by electric shock or serious injury!**

During the time a safety function is active, power is not removed from the motor; de-energize the motor's drive before working on it.

Features

The safety function "Safe torque off" (STO) has the following features:

- When the optional safety technology module "L4" is used and the safety function "Safe torque off" (STO) is selected, the "Safe brake control" (SBC) is automatically activated.
- Corresponds to stop category 0 according to EN 60204-1
- Is suited for safety-relevant applications up to Category 4 PL e according to EN ISO 13849-1 or SIL 3 according to IEC EN 62061.
- The energy supply to the motor is safely interrupted via two channels.
- The **selection can take place via two channels**, alternatively by means of
  - a passive safety unit with dual-channel, isolated conventional (non-solid-state) normally closed contacts (e.g., safety switching device for emergency stop, safety door monitor, etc.) or
  - an active safety unit with plus-plus-switching or plus-minus-switching OSSD outputs (e.g., safety control units, laser scanners, etc.).
- The **selection can take place via one channel**, alternatively by means of

  - a passive safety unit with an isolated conventional (non-solid-state) normally closed contact (designed in compliance with SIL3), e.g., safety switching device for emergency stop, safety door monitor, etc.

    In addition, the elimination of errors in the wiring (considering EN 61800-5-2: 2007, table D.1 or EN ISO 13849-2: 2008, table D.4) is required, or
  - by means of an active safety unit with plus-switching OSSD output (e.g., safety control units, laser scanners, etc.). In addition, the elimination of errors in the wiring (considering EN 61800-5-2: 2007, table D.1 or EN ISO 13849-2: 2008, table D.4) is required.
- The dynamization of the safety function selection takes place alternatively by means of
  - the OSSD dynamization of the active safety unit or
  - the dynamization outputs at the X49 terminal connector of the optional safety technology module "L3" or "L4" in the case of control by passive safety units.
- It is possible to set up a zone by connecting up to 25 drives in parallel.
- Online dynamization of the outputs and interrupting circuits
- Quick reaction time (18 ms)
- The status of the safety function "Safe torque off" is displayed via the parameter "P-0-0106, Operating status STO/SBC".

Pertinent Parameters

The following parameters are used in conjunction with the safety function "Safe torque off":

- P-0-0106, Operating status STO/SBC

Pertinent Diagnostic Messages

The following diagnostic messages can be generated in conjunction with the safety function "Safe torque off":

- A0011 STO/SBC active
- E8027 STO/SBC while drive enabled
- F3134 Dynamization time interval incorrect
- F8027 STO/SBC while drive enabled
- F8300 Dynamization pulse width incorrect
- F8301 Error when checking selection signals
- F8302 Error when checking switch-off channels STO/SBC
- F8303 System error STO/SBC

With the safety function "Safe torque off" activated, the display of the IndraDrive control panel shows "STO".

Safe Brake Control (SBC)

Brief Description

☞ Using the function "Safe brake control (SBC)" requires the optional safety technology module "L4".

With the safety function "Safe brake control (SBC)", the motor holding brake is switched off safely (via two channels).

☞ Before activating the safety function "Safe brake control (SBC)", the drive system must be decelerated via the command value input; there is no drive-controlled deceleration!

Features

The safety function "Safe brake control" (SBC) has the following features:

- The safety function "Safe brake control" (SBC) is automatically activated when the safety function "Safe torque off" (STO) is selected
- Is suited for safety-relevant applications up to Category 4 PL e according to EN ISO 13849-1 or SIL 3 according to IEC EN 62061.
- The energy supply to the motor holding brake is safely interrupted via two channels.
- The **selection can take place via two channels**, alternatively by means of
  – a passive safety unit with dual-channel, isolated conventional (non-solid-state) normally closed contacts (e.g., safety switching device for emergency stop, safety door monitor, etc.) or
  – by an active safety unit with plus-plus-switching or plus-minus-switching OSSD outputs (e.g., safety control units, laser scanners, etc.).
- The **selection can take place via one channel**, alternatively by means of
  – a passive safety unit with an isolated conventional (non-solid-state) normally closed contact (designed in compliance with SIL3), e.g., safety switching device for emergency stop, safety door monitor, etc.

    In addition, the elimination of errors in the wiring (considering EN 61800-5-2: 2007, table D.1 or EN ISO 13849-2: 2008, table D.4) is required, or
  – by means of an active safety unit with plus-switching OSSD output (e.g., safety control units, laser scanners, etc.). In addition, the elimination of errors in the wiring (considering EN 61800-5-2: 2007, table D.1 or EN ISO 13849-2: 2008, table D.4) is required.
- The dynamization of the safety function selection takes place alternatively by means of
  – the OSSD dynamization of the active safety unit or
  – the dynamization outputs at the X49 terminal connector of the optional safety technology module "L4" in the case of control by passive safety units.
- It is possible to set up a zone by connecting up to 25 drives in parallel
- Only self-holding (electrically releasing) brakes are supported
- Online dynamization of the outputs and interrupting circuits
- Quick reaction time (18 ms plus brake delay time)
- The status of the safety function "Safe brake control" is displayed via the parameter "P-0-0106, Operating status STO/SBC".

Pertinent Parameters

The following parameter is used in conjunction with the safety function "Safe brake control":

- P-0-0106, Operating status STO/SBC

Pertinent Diagnostic Messages

The following diagnostic messages can be generated in conjunction with the safety function "Safe brake control" (SBC):

- A0011 STO/SBC active
- C0256 Safety technology configuration error
- E8027 STO/SBC while drive enabled
- F3134 Dynamization time interval incorrect
- F8027 STO/SBC while drive enabled

- F8300 Dynamization pulse width incorrect
- F8301 Error when checking selection signals
- F8302 Error when checking switch-off channels STO/SBC
- F8303 System error STO/SBC

With the safety function "Safe brake control" activated, the display of the IndraDrive control panel shows "STO", because the safe brake control can only be activated in conjunction with the safe torque off (STO) function.

4.7 Optional Device Functions

4.7.1 Safety Instructions

⚠ 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 safety fence, safety guard, protective covering, light barrier).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- In addition, observe the safety message "Protection Against Dangerous Movements" in the chapter "Safety Instructions for Electric Drives and Controls".

4.7.2 Availability of the Optional Device Functions

The following overview illustrates by which base or functional packages the respective optional device function is supported (if not stated otherwise, this applies to all firmware versions, MPB, MPE and MPC).

Optional device function	In base package (characteristic)	In functional package ... (on the basis of a base package with the following characteristics)		
		Servo function	Synchronization	Main spindle
Digital inputs/outputs 1)	OL/CL	–	–	–
Analog inputs 1)	OL/CL	–	–	–
Command value generator	OL/CL	–	–	–
command value box	CL	–	–	–
Programmable position switch	–	CL 2)3)	CL 2)3)	–
Probe	CL	–	–	–
Measuring encoder 1)	–	OL/CL 2)	OL/CL 2)	–

OL Open-loop characteristic
CL Closed-loop characteristic
1) Depending on hardware configuration
2) Not for the firmware version MPE
3) Not for the firmware version MPM

Fig.4-91: Availability of the Optional Device Functions

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

See also "Enabling of Functional Packages"

4.7.3 Cross Communication (CCD)

Brief Description

Overview The IndraDrive "cross communication" device function (Cross Communication Drives → CCD) allows electronic (digital) coupling of axes and the connection of I/O modules for IndraMotion MLD.

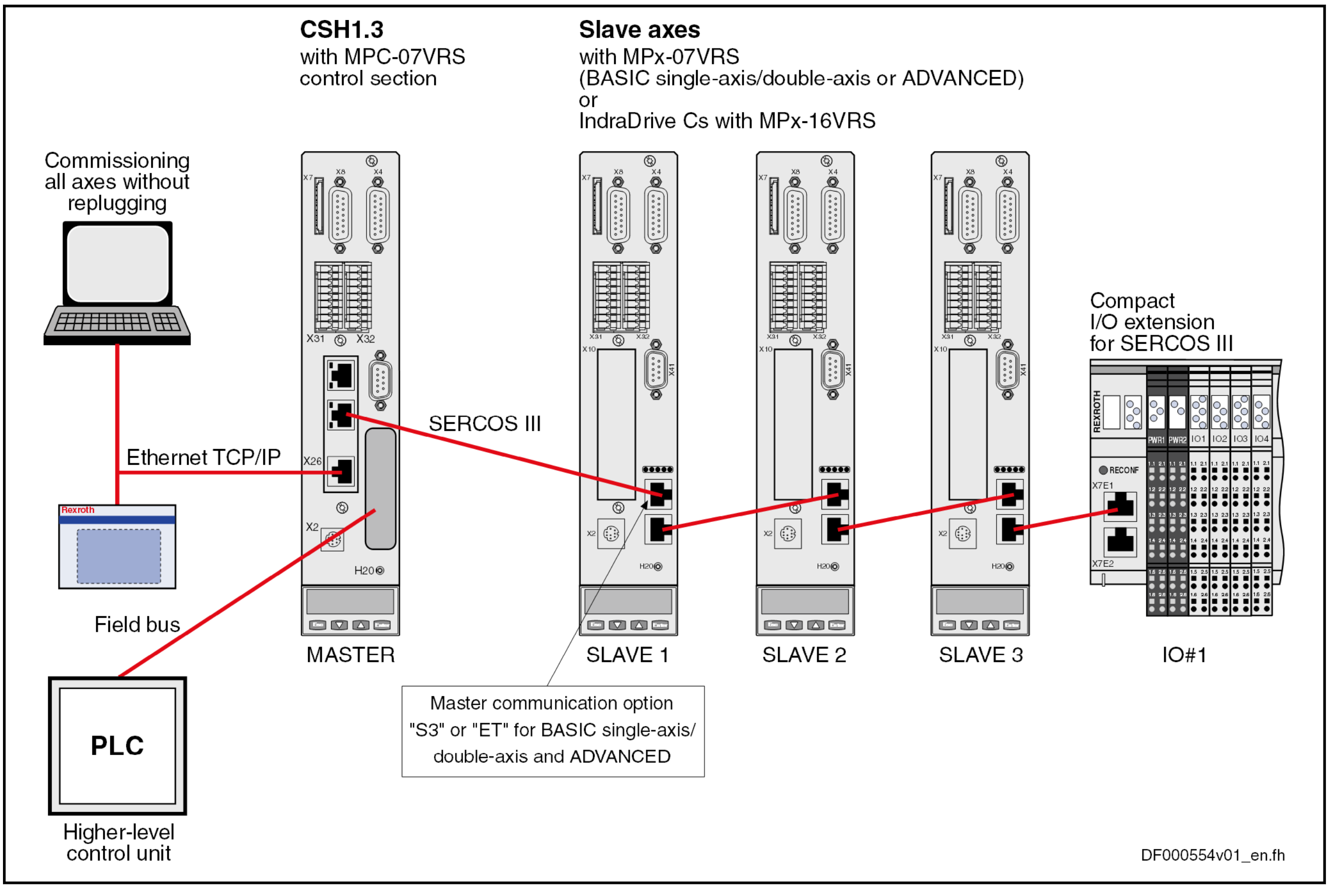


Fig.4-92: Hardware Topology of Drive Cross Communication (CCD)

Bus Topology Configuration of the CCD slaves and communication with the external control section always takes place via the CCD master drive, as the individual CCD slaves are connected to the master via a SERCOS III interface. Therefore, external access always takes place via the drive acting as the CCD master, which requires a master communication interface (e.g. PROFIBUS) in addition to the CCD optional module ("SERCOS III master connection").

CCD Modes (Kinds of Coupling) When cross communication (CCD) is used between the drives, the following variants (CCD modes) are differentiated:

- **CCD system mode**

  The CCD slaves have a direct logic connection to the field bus master. The command triggering and input of process data are carried out via an external control.

- **CCD basic mode**

The same functions as for the CCD system mode are available. However, the user has to program them. It is not possible to use the MLD-M functionality in the master axis.

- MLD-M system mode

  The CCD slaves have no direct logic connection to the external control section, but only to the MLD-M in the CCD master. Command triggering and input of process data take place by the MLD-M in the CCD master.

Features

The device function "cross communication (CCD)" is characterized by the following features:

- Synchronization of CCD slaves to CCD master
- Transmission of freely configurable external process data (command values and actual values of the external control section)
- Command value linking by transmission of freely configurable process data of the CCD axes (e.g. master/slave, Gantry axis)
- Connection of I/O extensions for SERCOS III via CCD (a maximum of 4 modules per CCD master)
- CCD (SERCOS III) cycle time can be parameterized (0.25 ms to 4 ms; depends on CCD mode, controller performance and number of axes)
- Max. baud rate: 100 MBaud
- CCD communication protocol: SERCOS III (see "SERCOS III")
- Data channels:
  - Cyclic data channel (MDT, AT): Max. 48 bytes and 16 IDN
  - Parameter or service channel: 4 bytes
- Parameterization of all axes in the CCD group via the CCD master interfaces (RS232, Engineering Port, field bus, …)
- Command triggering of the CCD slaves depending on selected CCD mode via external control section or internally via MLD in CCD master
- Max. number of CCD slaves: 7 or 9 (depends on CCD mode; see below "Performance Features")

Fields of Application

Typical fields of application for cross communication:

- Control tasks for multi-axis applications
  - Anti backlash
  - Synchronous operation control
  - Load control of several axes
- Simple command value linking
  - Position command value linking (Gantry axes)
  - Torque/force linking
- Simple motion controls with decentralized command value adjustment for single-axis positioning and master axis linking
- I/O extension by connection of I/O modules for SERCOS III via CCD

Restrictions

When using cross communication, observe the following restrictions:

- With the cross communication function, "Coordinated Motion" is not possible!
- In the MLD-M system mode, the multiplex channel for external controls in the CCD is not available

- The higher-level master is usually a PLC with a field bus which does **not** have real-time and synchronization ability (PROFIBUS®, DeviceNet™, EtherNet/IP™).

Hardware Requirements

Using the drive function "cross communication" requires the following control section design:

- **CCD master**

  Control section/device in ADVANCED form with CCD option

  → CSH-01.3C-xx-xxx-xxx-CCD-xx-x-..

  → HCS01.1E-W00xx-A-0x-A-xx-xx-xx-xx-xx-FW

- **CCD slaves**

  Control section with master communication interface "SERCOS III" (S3) or "Multiethernet" (ET); possible with the following designs:

  – BASIC UNIVERSAL single-axis → CSB-01.xC-S3-xxx-xx-x, CSB-01.xC-ET-xxx-xx-x

  – BASIC UNIVERSAL double-axis → CDB-01.xC-S3-xxx-xx-x, CDB-01.xC-ET-xxx-xx-x

  – ADVANCED single-axis → CSH-01.xC-S3-xxx-xx-x, CSH-01.xC-ET-xxx-xx-x

  – IndraDrive Cs-single-axis → HCS01.1E-W00xx-A-0x-x-xx-xx-xx-xx-xx-FW

See documentation "Control Sections for Drive Controllers; Project Planning Manual"

Firmware Requirements

When using the drive function "cross communication", observe the following aspects regarding the firmware:

- This drive function is supported as of the firmware version MPx04.
- For firmware versions MPx04 and MPx05 all drives of a CCD group (CCD master and CCD slaves) have to be operated with the same firmware version (e.g. all MPx05VRS).
- The CCD master has to be operated with MPC0xVRS (CSH1.3), pr MPC17 (HCS01.1E-W00xx-A-0x-A-xx-xx-xx-xx-xx-FW). In this case, CCD slaves with MPx04 or MPx05 cannot be operated.
- As for integrated safety technology, this firmware function does not require separate enabling of functional packages; the function of drive cross communication is available with the corresponding hardware design.

Pertinent Parameters

The parameters listed below only exist for the CCD master:

- P-0-0197, System time
- P-0-1600, CCD: configuration
- P-0-1601, CCD: addresses of projected drives
- P-0-1602, CCD: timing settings
- P-0-1603, CCD: Actual topology addresses
- P-0-1604, CCD: addresses of projected I/Os
- P-0-1605, CCD: command communication phase
- P-0-1606, CCD: actual communication phase
- P-0-1607, CCD: axis error
- P-0-1609, CCD: status word

- P-0-1610, CCD: cycle time
- P-0-1610.0.3, CCD: Actual topology
- P-0-1610.0.21, CCD: Slave addresses at end of line
- P-0-1610.0.30, CCD: Diagnostic message text
- P-0-1611, CCD: configuration list signal status word
- P-0-1612, CCD: configuration list signal control word
- P-0-1613, CCD: assignment list signal status word
- P-0-1614, CCD: assignment list signal control word
- P-0-1615, CCD: extrapolated cmd value IDN list signal selection
- P-0-1616, CCD: extrapolated cmd value signal selection
- P-0-1617, CCD: number of extrapolation steps
- P-0-1618, CCD: extrapolated command value
- P-0-1619, CCD: Slave information at topology location
- P-0-1620.0.3, CCD: Command topology
- P-0-1620.0.4, CCD: Slave identification
- P-0-1620.0.5, C7400 CCD: Switching to phase 2
- P-0-1620.0.6, C7500 CCD: Switching to phase 4
- P-0-1620.0.21, C7100 CCD: Command Close ring
- P-0-1620.0.30, CCD: I/O selection for commando C72
- P-0-1620.0.31, C7200 CCD: Commando Apply I/O configuration
- P-0-1621, CCD: configuration list master communication cmd values
- P-0-1621.x.1, CCD: Slave address in high level network
- P-0-1621.x.9, CCD: Master comm. C0100 Comm. phase 3 transition check
- P-0-1621.x.10, CCD: Master comm. C5200 Comm. phase 4 transition check
- P-0-1621.x.24, CCD: Master communication gateway parameter pool 1
- P-0-1621.x.25, CCD: Master communication gateway parameter pool 2
- P-0-1621.x.35, g C5300 CCD: SIII SYNC delay measuring procedure command
- P-0-1622, CCD: configuration list master communication actual values
- P-0-1623, CCD: configuration list master cmd values
- P-0-1624, CCD: configuration list actual master values
- P-0-1625, CCD: configuration list slave cmd values
- P-0-1626, CCD: configuration list actual slave values
- P-0-1627, CCD: configuration list master cmd values I/Os
- P-0-1628, CCD: configuration list act. master values I/Os
- P-0-1629, CCD: configuration compact I/Os
- P-0-1630, CCD: diagnosis
- P-0-1630.x.1, CCD: Slave IP address
- P-0-1630.x.2, CCD: Device Status (S-Dev)
- P-0-1630.x.3, CCD: Connection-Control #0 (C-Con)
- P-0-1630.x.20, CCD: Resource-Status (S-Res)

- P-0-1631, CCD: AT error counter
- P-0-1632, CCD: system data 2 bytes
- P-0-1633, CCD: system data 4 bytes
- P-0-1634.x.1, CCD: Module type codes of the modular I/Os
- P-0-1635, C7000 CCD: command adjust slave addresses
- P-0-1636, CCD: Command topology addresses
- P-0-1637, CCD: error counter Port-1
- P-0-1638, CCD: error counter Port-2
- P-0-1639, CCD: allowed telegram failures
- 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-0-1645.x.1, CCD connection: Configuration
- P-0-1645.x.2, CCD connection: Connection number
- P-0-1645.x.3, CCD connection: Telegram assignment
- P-0-1645.x.4, CCD connection: Max. length of connection
- P-0-1645.x.5, CCD connection: Current connection length
- P-0-1645.x.6, CCD connection: Configuration list
- P-0-1645.x.8, CCD connection: Connection control (C-Con)
- P-0-1645.x.10, CCD connection: Producer cycle time
- P-0-1645.x.11, CCD connection: Allowed losses of producer data
- P-0-1645.x.12, CCD connection: Error counter data losses
- P-0-1645.x.20, CCD connection: IDN allocation of real-time bits
- P-0-1645.x.21, CCD connection: Bit number allocation of real-time bits
- P-0-1651, CCD: master control word, slave 1
  (up to P-0-1659)
- P-0-1660.x.2, CCD: Device Control (C-Res)
- P-0-1660.x.3, CCD: Connection-Control #1 (C-Con)
- P-0-1660.x.20, CDD: Resource-Control (C-Res)
- P-0-1661, CCD: drive status word, slave 1
  (up to P-0-1669)
- P-0-1670, CCD: active actual position value, master
- P-0-1671, CCD: active actual position value, slave 1
  (up to P-0-1679)
- P-0-1680, CCD: actual velocity value, master
- P-0-1681, CCD: actual velocity value, slave 1
  (up to P-0-1689)
- P-0-1690, CCD: actual torque/force value, master
- P-0-1691, CCD: actual torque/force value, slave 1
  (up to P-0-1699)

- P-0-1701, CCD: Diagnostic message number, slave 1
  (up to P-0-1709)
- P-0-1710, CCD: signal status word, master
- P-0-1711, CCD: signal status word, slave 1
  (up to P-0-1719)
- P-0-1720, CCD: signal control word, master
- P-0-1721, CCD: signal control word, slave 1
  (up to P-0-1729)
- P-0-1730, CCD: Command value data container 1, Master 4Byte
- P-0-1731, CCD: Command value data container 1, Slave 1 4Byte
  (up to P-0-1739)
- P-0-1740, CCD: Command value data container 2, Master 4Byte
- P-0-1741, CCD: Command value data container 2, Slave 1 4Byte
  (up to P-0-1749)
- P-0-1750, CCD: Command value data container 3, Master 4Byte
- P-0-1751, CCD: Command value data container 3, Slave 1 4Byte
  (up to P-0-1759)
- P-0-1760, CCD: Command value data container 4, Master 4Byte
- P-0-1761, CCD: Command value data container 4, Slave 1 4Byte
  (up to P-0-1769)
- P-0-1770, CCD: Actual value data container 1, Master 4Byte
- P-0-1771, CCD: Actual value data container 1, Slave 1 4Byte
  (up to P-0-1779)
- P-0-1780, CCD: Actual value data container 2, Master 4Byte
- P-0-1781, CCD: Actual value data container 2, Slave 1 4Byte
  (up to P-0-1789)
- P-0-1790, CCD: Actual value data container 3, Master 4Byte
- P-0-1791, CCD: Actual value data container 3, Slave 1 4Byte
  (up to P-0-1799)
- P-0-1800, CCD: Actual value data container 4, Master 4Byte
- P-0-1801, CCD: Actual value data container 4, Slave 1 4Byte
  (up to P-0-1809)
- P-0-1810, CCD: Status word synchronous operation modes, master
- P-0-1811, CCD: Status word synchronous operation modes, slave 1
  (up to P-0-1819)
- P-0-1820, CCD: Command value data container 1, Master 2Byte
- P-0-1821, CCD: Command value data container 1, Slave 1 2Byte
  (up to P-0-1829)
- P-0-1830, CCD: Command value data container 2, Master 2Byte
- P-0-1831, CCD: Command value data container 2, Slave 1 2Byte
  (up to P-0-1839)
- P-0-1840, CCD: Command value data container 3, Master 2Byte

- P-0-1841, CCD: Command value data container 3, Slave 1 2Byte (up to P-0-1849)
- P-0-1850, CCD: Command value data container 4, Master 2Byte
- P-0-1851, CCD: Command value data container 4, Slave 1 2Byte (up to P-0-1859)
- P-0-1860, CCD: Actual value data container 1, Master 2Byte
- P-0-1861, CCD: Actual value data container 1, Slave 1 2Byte (up to P-0-1869)
- P-0-1870, CCD: Actual value data container 2, Master 2Byte
- P-0-1871, CCD: Actual value data container 2, Slave 1 2Byte (up to P-0-1879)
- P-0-1880, CCD: Actual value data container 3, Master 2Byte
- P-0-1881, CCD: Actual value data container 3, Slave 1 2Byte (up to P-0-1889)
- P-0-1890, CCD: Actual value data container 3, Master 2Byte
- P-0-1891, CCD: Actual value data container 3, Slave 1 2Byte (up to P-0-1899)

☞ For configuring the SERCOS III communication in the slaves, the standard SERCOS III parameters are used (e.g. "S-0-1002, SERCOS III: Communication Cycle time (tScyc)" etc.).

Pertinent Diagnostic Messages

- C0265 Incorrect CCD address configuration
- C0266 Incorrect CCD phase switch
- C0267 CCD timeout phase switch
- C0403 Switching to CCD phase 2 impossible
- C7000 CCD: Command Close ring
- C7001 CCD: Impossible to close ring
- C7100 CCD: Command Close ring
- C7101 CCD: Impossible to close ring
- C7200 CCD: Command Apply I/O configuration
- C7201 CCD: Impossible to apply I/O configuration
- C7400 CCD: Switching to phase 2
- C7401 CCD: Impossible to switch to phase 2
- C7500 CCD: Switching to phase 4
- C7501 CCD: Impossible to switch to phase 4
- E4012 Maximum number of CCD slaves exceeded
- E4013 Incorrect CCD addressing
- E4014 Incorrect phase switch of CCD slaves
- E4016 CCD: Topology error
- E4017 CCD: Unknown I/O configuration
- F2140 CCD slave error
- F4012 Incorrect I/O length
- F4140 CCD communication error

- F6140 CCD slave error (emergency halt)
- F8140 Fatal CCD error

4.7.4 Digital Inputs/Outputs

Brief Description

General Information

The basic variants of the IndraDrive Cs controllers with their ECONOMY and BASIC control section versions and the IndraDrive C multi-axis controllers with BASIC control section version already have configurable digital inputs/outputs.

Hardware Requirements

The number, assignment and function of the digital inputs/outputs depend on the type of the drive controller and are contained in the respective hardware description (Project Planning Manual).

Digital Inputs/Outputs on Control Section

Features

- Sampling of digital inputs and outputs or transmitting data to them is done in the position loop clock $T_{A\_position}$ (see "Performance Data")
- Configurable digital inputs/outputs with effective direction that can be freely set to some extent (input or output):
  - IndraDrive Cs with firmware MPB or MPE:
    - 1 switchable digital input/output
    - 7 digital inputs [2 of which are quick inputs as probe inputs (µs increments)]
  - IndraDrive C multi-axis controllers with firmware MPM:
    - 16 digital outputs
    - 32 digital inputs [4 of which are quick inputs as probe inputs (µs increments)]
- All inputs/outputs refer to the level of 0 V (LOW) or 24 V (HIGH)
- Assignment of the inputs/outputs on several axes within one device possible

  An IndraDrive Cs drive controller includes an axis (subdevice)

  An IndraDrive C four-axis controller includes four axes (subdevices)
- Several axes within one device can be addressed by one digital input
- Within a device, each axis can access each input/output present on the hardware side
- Multiple assignments for an input possible with multiple parameters
- An axis output can be used simultaneously as in input on the same parameter.
- Signal states of digital inputs/outputs of a device are mapped to their respective individual parameters.
- In addition, the signal states of digital inputs/outputs of an axis are mapped to their respective individual parameters.
- Digital outputs can be directly controlled by the control master, if not used on drive-side
- Galvanic isolation of the inputs/outputs from the internal control voltage supply

☞ Assignment of each individual input or output to drive parameters possible. The IDN of the permitted 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 an axis (subdevice)

  For an entry, the bit configured in the parameter "P-0-0301, Digital inputs, bit numbers" of an identification number defined in P-0-0300 is written with the logic value (0 or 1) provided at the input.

- Output of an axis (subdevice)

  In the case of an output, the content of the bit configured in "P-0-0311, Digital outputs, bit numbers" is taken from the identification number (source parameter) determined in P-0-0300 and transmitted to the output of the subdevice (P-0-0313).

☞ When 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-0-0301 is not significant!

- Access to the axis on a hardware input

  The parameter P-0-0306 is used to assign any hardware input to the input map of an axis (P-0-0307).

- Description of a hardware output

  The output map of an axis (P-0-0313) is linked to any hardware output using P-0-0312 and P-0-0316.

State map of the assigned parameters of an axis

☞ The following parameters can be used as a state map 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

The following table shows a standard configuration with firmware MPB as an example:

PLUG_PIN	Function	P-0-0300[i]	P-0-0301[i]
X31_1	Probe 1	S-0-0401	0
X31_2	Probe 2	S-0-0402	0
X31_3	E-Stop input	P-0-0223	0
X31_4	Travel range limit inputs	P-0-0222	0
X31_5	Travel range limit inputs	P-0-0222	1
X31_6	Not assigned	S-0-0000	0

PLUG_PIN	Function	P-0-0300[i]	P-0-0301[i]
X31_7	Not assigned	S-0-0000	0
X31_8	Not assigned	S-0-0000	0

i = index List element

Fig.4-93: Standard Configurations for Digital Inputs/Outputs (Examples)

Deactivation

To deactivate an input, in parameter P-0-0300 in the respective list element, the IDN "S-0-0000" must be entered; alternatively, in P-0-0306 the corresponding list element can be written with "0".

When deactivating an output, in parameter P-0-0310 the corresponding list element can be written with the IDN "S-0-0000" or in parameter P-0-0312 or P-0-0316 the corresponding list element can be written with "0".

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.

Pertinent Parameters

- S-0-0398, IDN-list of configurable data in signal status word
- S-0-0399, IDN-list of configurable data in signal control word
- P-0-0300, Digital inputs, assignment list
- P-0-0301, Digital inputs, bit numbers
- P-0-0303, Digital inputs, input image of device
- P-0-0304, Digital outputs, output image of device
- P-0-0306, Digital inputs, assignment connector and pin
- P-0-0307, Digital inputs, input image sub-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

Pertinent Diagnostic Messages

- F2010 Error when initializing digital I/O (-> S-0-0423)

Digital Inputs/Outputs on Optional Modules OM1 and OM2

For the multi-axis controllers, it is possible to individually configure, apart from the standard digital inputs/outputs, an extension of these inputs/outputs.

The option modules OM1 and OM2 can be used for the following purposes:

- Making available digital inputs/outputs to external control section
- Enabling input/output of drive parameters

☞ Using the digital I/O extension by using the optional module OM1 or OM2 is **only possible for multi-axis controllers with MPM firmware**!

Features

- All inputs/outputs refer to the level of 0 V (LOW) or 24 V (HIGH)
- External 24 V supply of the digital outputs required
- Galvanic isolation of the inputs/outputs from the control voltage supply

- Assignment of inputs/outputs to internal parameters or bits
- 32 digital inputs per option module OM1 or OM2
- 16 digital outputs per option module OM1 or OM2

Pertinent Parameters

- S-0-0398, IDN-list of configurable data in signal status word
- S-0-0399, IDN-list of configurable data in signal control word
- P-0-0300, Digital inputs, assignment list
- P-0-0301, Digital inputs, bit numbers
- P-0-0303, Digital inputs, input image of device
- P-0-0304, Digital outputs, output image of device
- P-0-0306, Digital inputs, assignment connector and pin
- P-0-0307, Digital inputs, input image sub-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

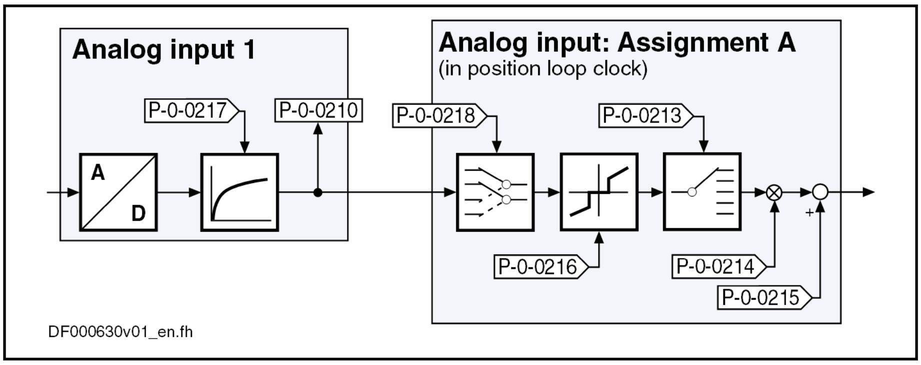
4.7.5 Analog Inputs

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

Overview

According to type, IndraDrive controllers already have an analog input in their basic configuration (without optional modules).



P-0-0210	Analog input 1
P-0-0213	Analog input, assignment A, target parameter
P-0-0214	Analog input, assignment A, scaling per 10V full scale
P-0-0215	Analog input, assignment A, signal value at 0V
P-0-0216	Analog input, assignment A, dead zone
P-0-0217	Analog input 1, time constant input filter
P-0-0218	Analog input, control parameter

Fig.4-94: Overview: Analog Input and Assignment (Example for Control Section CSH01.1C)

Features

General features:

- Two assignment mechanisms for analog input (assignment A)
- Different sampling rate for assignment A

   – Assignment channel A works in position loop clock (see "Performance Data")
- Assignment to command value/limit value/control parameters of the drive by means of adjustable scaling
- Assignment of max. 1 analog inputs to internal drive parameters possible
- Variable scaling for 1 analog channel
- Dead zone to be entered for suppressing the zero drift for the analog input
- Offset and amplification adjust for the analog input via command

Features of the analog input on the control section:
- Low-pass filtering for the analogchannel can be activated
- Analog input designed as differential input
- Input voltage range of ± 10 V

Pertinent Parameters

Configuration of the analog input:
- P-0-0212, Analog input, list of assignable parameters
- P-0-0218, Analog input, control parameter
- P-0-0219, Analog input, maximum value for adjustment
- P-0-0220, C2800 Analog input adjustment command
- P-0-3901, Adjustment values of control section
- P-0-3904, Adjustment values analog I/O interface 3-4
- P-0-3905, Adjustment values analog I/O interface 5-6

Analog input values:
- P-0-0210, Analog input 1
- P-0-0217, Analog input 1, time constant input filter
- P-0-0232, Analog input 3, time constant input filter
- P-0-0233, Analog input 4, time constant input filter
- P-0-0234, Analog input 5, time constant input filter
- P-0-0235, Analog input 6, time constant input filter

Assignment A:
- P-0-0213, Analog input, assignment A, target parameter
- P-0-0214, Analog input, assignment A, scaling per 10V full scale
- P-0-0215, Analog input, assignment A, signal value at 0V
- P-0-0216, Analog input, assignment A, dead zone

Pertinent Diagnostic Messages
- C2800 Analog input adjustment command
- C2801 Analog input not configured
- C2802 Oscillations of input signal outside tolerance range
- C2803 Measured values at zero point and max. value identical
- C2804 Automatic adjustment failed

4.7.6 Virtual Master Axis Generator

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

The master axis generator serves for generating a master axis position, which is used as input variable for the position synchronization operation modes and the operation mode "velocity synchronization".

There are three ways of generating the master axis position:

- Format conversion of an actual position value or a command position value of the local axis or of an axis connected via CCD **[1]**
- Generating a virtual actual position value via a positioning motion and subsequent format conversion **[2]**
- Phase-synchronous motion of the master axis position to a primary master (secondary master mode) **[3]**

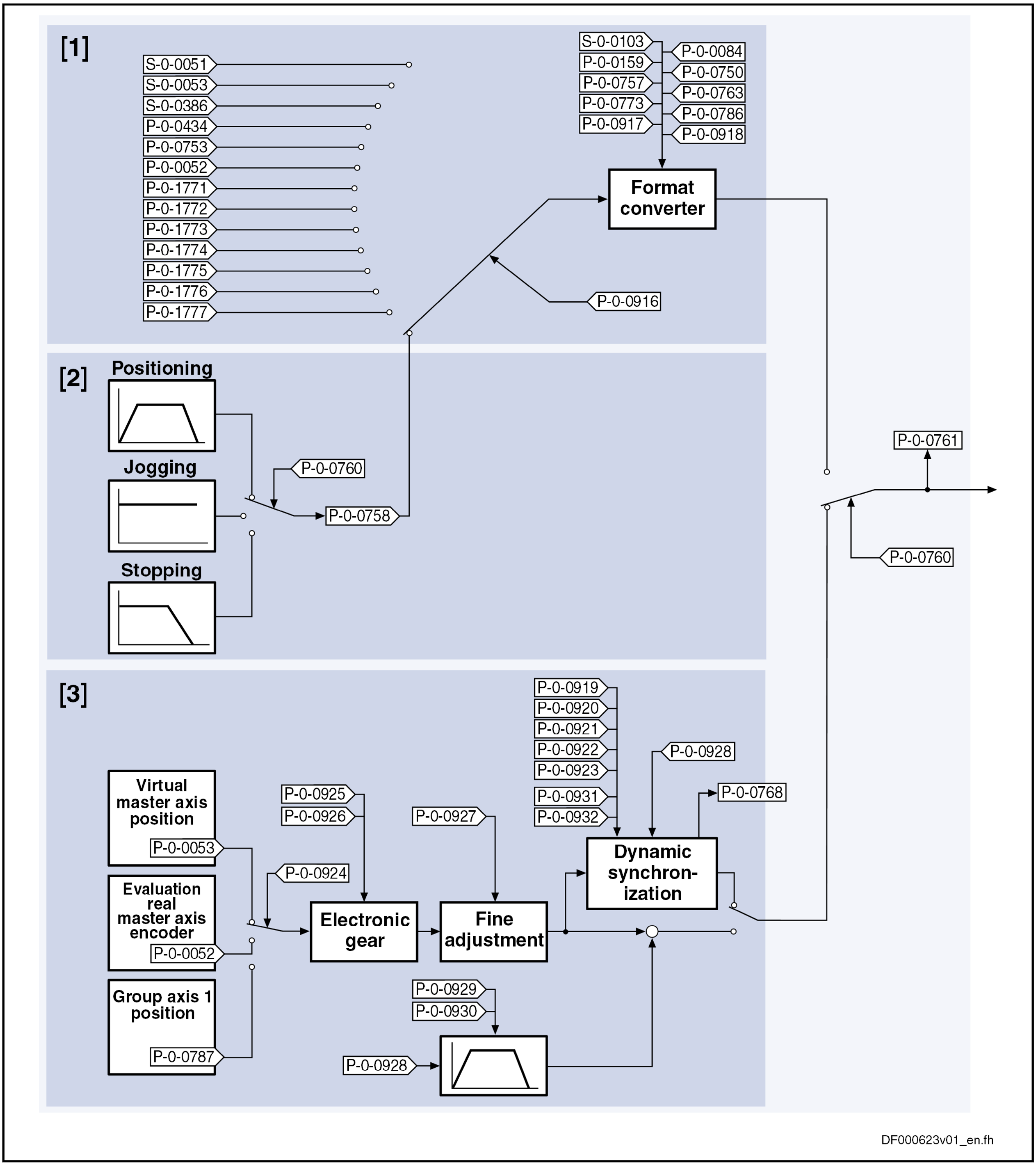


Fig.4-95: Possibilities of Generating the Master Axis Position for the Slave Axis

Features Features of generating the virtual actual position value with the master axis generator:

- 3rd order command value interpolator
- Absolute, relative and additive positioning capability
- "Infinite travel" (jogging) is possible

- Position data format to be set:
  - Linear → 0.0001 mm / 0.0001 inch
  - Rotary → 0.0001 degrees
- Modulo value to be set
- "Absolute" or "modulo" master axis
- Format conversion from position format "Virtual master axis" to master axis format (modulo value "virtual master axis" → $2^{\text{P-0-0084}}$ × P-0-0750 or $2^{\text{P-0-0773}}$ × P-0-0763)
- Virtual master axis generator realized as virtual axis in IndraMotion MLD with individual scaling system
- Setting of virtual master axis generator, either directly via parameters or via the following function blocks:
  - MC_MoveVelocity / MX_MoveVelocity
  - MC_MoveAbsolut / MX_MoveAbsolut
  - MC_MoveAdditiv / MX_MoveAdditiv
  - MC_MoveRelativ / MX_MoveRelativ
  - MC_Stop
  - MB_Stop

  Note:

  The function blocks for the virtual axis behave exactly like those for a real axis. The diagnostic and error messages, however, are different.

Features of the secondary master mode:

- Real and virtual primary master can be selected
- Electronic gear with fine adjustment
- Dynamic synchronization to the primary master
- Master axis position is added as an offset with parameterization of the acceleration and velocity that can be changed
- Activating by means of the functional block "MB_GearInPos"; deactivating by means of the functional block "MB_GearOut"

Pertinent Parameters

- P-0-0084, Number of bits per master axis revolution
- P-0-0750, Master axis revolutions per master axis cycle
- P-0-0756, Virtual master axis, scaling type
- P-0-0757, Virtual master axis, modulo value
- P-0-0758, Virtual master axis, actual position value
- P-0-0759, Virtual master axis, actual velocity value
- P-0-0760, Virtual master axis, positioning control word
- P-0-0761, Master axis position for slave axis
- P-0-0762, Virtual master axis, velocity limit value
- P-0-0763, Modulo factor, master axis format converter
- P-0-0766, Virtual master axis, positioning command value
- P-0-0767, Virtual master axis, effective target position
- P-0-0768, Virtual master axis, positioning status
- P-0-0769, Virtual master axis, command value mode
- P-0-0770, Virtual master axis, positioning velocity

- P-0-0771, Virtual master axis, positioning acceleration
- P-0-0772, Virtual master axis, positioning deceleration
- P-0-0773, Number of bits per master axis revolution, format converter
- P-0-0774, Virtual master axis, positioning window shortest distance
- P-0-0911, Virtual master axis, positioning window
- P-0-0912, Virtual master axis, standstill window
- P-0-0913, Virtual master axis, positioning jerk
- P-0-0914, Virtual master axis, velocity threshold positioning
- P-0-0915, Master axis format converter IDN list signal selection
- P-0-0916, Master axis format converter signal selection
- P-0-0917, Control word of master axis generator
- P-0-0918, Feed travel internal virtual master axis
- P-0-0919, Synchronization mode, secondary master
- P-0-0920, Synchronization acceleration, secondary master
- P-0-0921, Synchronization velocity, secondary master
- P-0-0922, Preferred synchronization direction, secondary master
- P-0-0923, Synchroniz. window for shortest distance, secondary master
- P-0-0924, Selection primary master
- P-0-0925, Master drive gear input revolutions, secondary master
- P-0-0926, Master drive gear output revolutions, secondary master
- P-0-0927, Master drive gear fine adjustment, secondary master
- P-0-0928, Additive master axis position, secondary master
- P-0-0929, Change velocity of add. master axis posit., secondary master
- P-0-0930, Change accel. of add. master axis posit., secondary master
- P-0-0931, Synchronous position, secondary master
- P-0-0932, Synchronization range, secondary master

Pertinent Diagnostic Messages

- E2100 Positioning velocity of master axis generator too high
- F2063 Internal overflow master axis generator
- F2064 Incorrect cmd value direction master axis generator

4.7.7 Drive-Integrated Command Value Generator

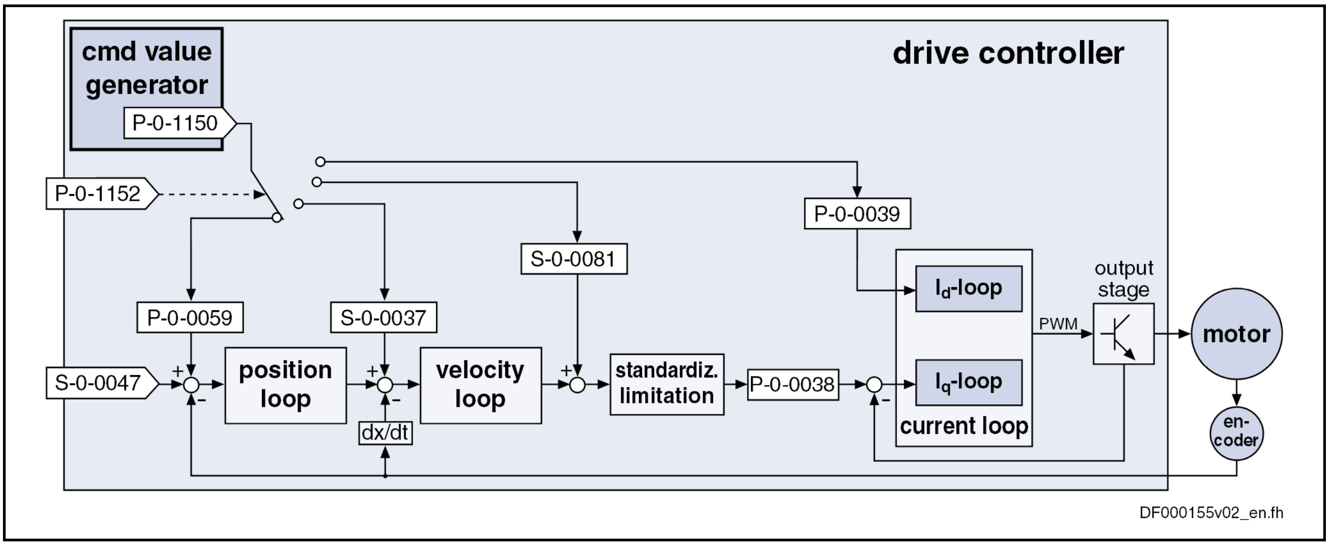
Brief Description

Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

The drive-integrated command value generator can be used for commissioning and controller optimization of drives. The command value generator is used to generate various signal forms (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 drive-integrated command value generator also provides the possibility of measuring the frequency response.

The figure below illustrates the points at which the drive-integrated command value generator can take effect:



S-0-0037	Additive velocity command value
S-0-0047	Position command value
S-0-0081	Additive torque/force command value
P-0-0038	Torque-generating current, command value
P-0-0039	Flux-generating current, command value
P-0-0059	Additive position command value, controller
P-0-1150	Command value generator output
P-0-1152	Command value generator, target parameter assignment

Fig.4-96: Points at which function "command value generator" can take effect

Features

- Possibility of generating different signal shapes that are added as command values to the respective control loop command value (position, velocity or current)

  The following signal shapes are possible:

  – Square-wave signals
  – Sine signals
  – Noise signals
  – Modified sine signals
  – Sine sweep
- Generating **velocity and position command values** in the position loop clock; **current command values** in the velocity loop clock
- With regard to **amplitude and frequency**, generated command values can be freely defined

Pertinent Parameters

- 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

4.7.8 Drive-internal "Command Value Box"

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

With IndraDrive controllers, a so-called "command value box" is internally available for manual drive optimization. It offers the possibility to internally (independent of the master) generate a command value characteristic that can be defined by the user. By this, an axis drive can be moved in the same way as with an external command value box, without an external command value being effective (→drive-internal "command value box"). Drive enable must merely be set for the drive.

The command value characteristic that can be defined by the user, allows for an axis to be moved within determinable position limits in continuous sequence in the velocity control loop or position control loop. This can be made use of, in order to manually optimize the control loop parameters of the drive, by e.g. moving the drive with a low velocity command value and by evaluating the status variables "actual current value" and "actual velocity value".

More details on the manual control loop setting are described in the "Overview of Drive Control: Notes on Commissioning for Control Loop Setting".

By the internal command value box, an axis can be continuously moved in an "oscillating movement" (oscillating between two position limit values) or in "stepper mode" (unidirectional moving over a defined path or a travel range).

The internal command value box is configured via a command word, the command value characteristic is defined via the respective parameters. Activating the internal command value box is carried out via a command.

Pertinent Parameters

- P-0-0162, C1800 Command Drive optimization / command value box
- P-0-0165, Drive optimization, control word
- P-0-0166, Drive optimization, end position negative
- P-0-0167, Drive optimization, end position positive
- P-0-0169, Drive optimization, travel distance
- P-0-0170, Drive optimization, acceleration
- P-0-0171, Drive optimization, velocity
- P-0-0172, Drive optimization, dwell time

Pertinent Diagnostic Messages

- C1800 Command Drive optimization / command value box
- C1801 Start requires drive enable
- C1806 Travel range exceeded

4.7.9 Programmable Position Switch

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

The firmware function "programmable position switch" can be used instead of a mechanical position switch that has to be externally mounted.

Features

- Realization of a maximum of **8 dynamic position switch points** (switch cams) in the position loop clock
- Freely **selectable reference signals** (P-0-0130) for generating the switch cams, all 8 cams are referring to the same signal (P-0-0131)
- **Switch-on and switch-off position can be separately parameterized** via list parameters (P-0-0132, P-0-0133); corresponding position switch bit can be inverted by selecting the switch-on and switch-off threshold
- **Lead time that can be separately parameterized** via list parameter (P-0-0134) for compensating internal processing times (dead time compensation)
- **8 position switch bits displayed** in the position switch status word (P-0-0135) which can be assigned to digital outputs or cyclically transmitted via master communication interface
- Permanently defined **switch hysteresis** to avoid position switch bit flicker when the switch-on or switch-off threshold is reached

Pertinent Parameters

- P-0-0130, Position switch signal selection list
- P-0-0131, Position switch signal selection
- P-0-0132, Position switch switch-on threshold
- P-0-0133, Position switch switch-off thresholds
- P-0-0134, Position switch lead times
- P-0-0135, Position switch status word

Pertinent Diagnostic Messages

- C0242 Multiple configuration of a parameter (->S-0-0423)

4.7.10 Probe Function

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

Features

- Two probes (S-0-0401 / S-0-0402) can be evaluated per axis.
- Each probe (S-0-0401 / S-0-0402) can be assigned to any digital input that can handle probes. Several probes can use the same digital input. Depending on the control section, these include digital inputs E1, E2, E3 and E4 (see Control Sections for Drive Controllers; Project Planning Manual).
- Measuring signals can be actual position values of motor encoder, external encoder or measuring encoder, in addition master axis position values
- Measurement of absolute signal values, of signal value differences, detection of time intervals between measuring signals

- Measurement triggered by positive and/or negative probe signal edges
- Single measurement or continuous measurement to be selected, measurement events are counted in the case of continuous measurement
- Position value range ("expectation window") per probe can be defined within which measurement can take place (activation of a "failure counter" when expectation window is passed through without measuring event)
- Quick stop triggered via probe input
- Adjustable dead time compensation for each probe, separated for each edge (positive / negative) up to 50000μs
- Measuring accuracy depends on the hardware version (see the section "Probes" in the documentation "Control Sections for Drive Controllers; Project Planning Manual")

Pertinent Parameters

- S-0-0130, Probe value 1 positive edge
- S-0-0131, Probe value 1 negative edge
- S-0-0132, Probe value 2 positive edge
- S-0-0133, Probe value 2 negative edge
- S-0-0169, Probe control parameter
- S-0-0170, Probing cycle procedure command
- S-0-0179, Probe status
- S-0-0401, Probe 1
- S-0-0402, Probe 2
- S-0-0405, Probe 1 enable
- S-0-0406, Probe 2 enable
- S-0-0409, Probe 1 positive latched
- S-0-0410, Probe 1 negative latched
- S-0-0411, Probe 2 positive latched
- S-0-0412, Probe 2 negative latched
- S-0-0426, Signal selection probe 1
- S-0-0427, Signal selection probe 2
- S-0-0428, Probe, IDN-list signal selection
- S-0-0524, Dead time compensation, positive edge, probe 1
- S-0-0525, Dead time compensation, negative edge, probe 1
- S-0-0526, Dead time compensation, positive edge, probe 2
- S-0-0527, Dead time compensation, negative edge, probe 2
- P-0-0200, Start position probe function 2 active
- P-0-0201, End position probe function 2 active
- P-0-0202, Difference probe values 1
- P-0-0203, Difference probe values 2
- P-0-0204, Start position probe function 1 active
- P-0-0205, End position probe function 1 active
- P-0-0206, Probe 1, max. number of marker failures
- P-0-0207, Probe 2, max. number of marker failures
- P-0-0224, Probe 1, number of marker failures

- P-0-0225, Probe 2, number of marker failures
- P-0-0226, Probe, extended control word
- P-0-0300, Digital inputs, assignment list
- P-0-0306, Digital inputs, assignment connector and pin

Pertinent Diagnostic Messages

- A0403 Quick stop with probe detection is active
- C0250 Probe inputs incorrectly configured

4.7.11 Measuring Encoder

Brief Description

Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

Position Measurement

Measuring encoders are used for position evaluation of a rotary motion that takes effect as a command variable for drive control. The actual position value of the measuring encoder therefore is of command value nature for drive control, the measuring encoder acts as a master axis encoder, for example.

Evaluating Position Measurement

Depending on its design and the mechanical arrangement at the axis, the measuring encoder can be evaluated as

- Relative encoder (incremental encoder)

- or -

- Absolute encoder (absolute value encoder).

Relative Position Measurement

In the case of relative position measurement, only position differences can be evaluated by means of the measuring system. The actual position values signaled by the measuring system refer to the (mostly undefined) position at the time the drive is switched on. If the actual position value is to refer to an axis or shaft, it is necessary to establish position data reference ("homing").

Absolute Position Measurement

In the case of absolute position measurement, the encoder signals actual position values with a fixed encoder-dependent reference point to the controller. After the drive is switched on, the correct actual position value is immediately available for each axis or shaft position. Due to the mostly undefined mounting situation of the encoder, it is necessary during initial commissioning to once adjust the actual position value to the axis or shaft ("set absolute measuring").

Precision, Resolution

The precision of the position measurement depends on

- the resolution of the measuring system (division periods = DP),
- the absolute encoder precision,
- the digitalization quality of the analog encoder signals,
- the size of the selected modulo range of the encoder.

Monitoring Functions

The correct position information of the measuring encoder is required for correct recording of a command variable. The encoder signals are therefore monitored for validity and compliance with the allowed tolerances.

In addition, it is possible to monitor drives with an encoder that can be evaluated in absolute form for compliance with the position when switching on compared to the last time the drive was switched off.

See "Monitoring the Measuring Systems"

Hardware Requirements

For connecting the measuring systems to the controller, the control section has to be equipped with the corresponding interfaces. Parameter "P-0-0079, Assignment measuring encoder->optional slot" is used to determine the interface to which the respective encoder is connected.

Pertinent Parameters

- P-0-0052, Actual position value of measuring encoder
- P-0-0076, Encoder type 3 (measuring encoder)
- P-0-0079, Assignment measuring encoder->optional slot
- P-0-0084, Number of bits per master axis revolution
- P-0-0087, Actual position value offset of measuring encoder
- P-0-0097, Absolute encoder monitoring window for measuring encoder
- P-0-0127, Input revolutions of measuring gear
- P-0-0128, Output revolutions of measuring gear
- P-0-0179, Absolute encoder buffer 3 (measuring encoder)
- P-0-0326, Multiplication of measuring encoder
- P-0-0327, Encoder resolution of measuring encoder
- P-0-0328, Type of position encoder for measuring encoder
- P-0-0329, Smoothing of actual position value 3 of measuring encoder
- P-0-0330, Control word of measuring encoder
- P-0-0331, Status of measuring encoder
- P-0-0332, Actual velocity value of measuring encoder
- P-0-0334, Absolute encoder range of measuring encoder
- P-0-0347, Encoder 3, cosine signal
- P-0-0348, Encoder 3, sine signal
- P-0-0765, Modulo factor measuring encoder
- P-0-1020, Kind of encoder 3, encoder memory
- P-0-1021, Encoder 3 resolution, encoder memory
- P-0-1022, Absolute encoder offset 3, encoder memory

Pertinent Diagnostic Messages

- C0227 Error when initializing position of measuring encoder
- C0228 Initialization velocity measuring encoder too high
- E2076 Measuring encoder: Encoder signals disturbed
- F2043 Measuring encoder: Encoder signals incorrect

☞ The error message F2043 can also be configured as a warning. In this case, there is no error reaction on the drive side. The user is then responsible for initiating an appropriate reaction via the control master

- F2076 Actual pos. value 3 outside absolute encoder window
- F2176 Loss of measuring encoder reference
- F2179 Modulo limitation error of measuring encoder

4.8 Handling, Diagnostic and Service Functions

4.8.1 Safety Instructions

⚠ 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 safety fence, safety guard, protective covering, light barrier).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- In addition, observe the safety message "Protection Against Dangerous Movements" in the chapter "Safety Instructions for Electric Drives and Controls".

4.8.2 Parameters, Basics

Properties/Features of Parameters

Brief Description

The controller firmware via data maps the drive to an internal mathematical model. All operating data relevant therefor are mapped to parameters. An identification number (IDN) is assigned to each parameter. The IDN allows accessing operating data via

- the serial interface

- or -

- a master communication interface suited for data transfer.

The operating data stored in parameters can be identified by means of the IDN. It 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. Specific parameter values (operating data) are checked for validity by the drive firmware.

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 device:

- 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 drive 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.

Brief Functional Descriptions

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 via:

- "IndraWorks Ds/D/MLD" commissioning tool → saving the parameter values to an external data carrier
- Control master → saving parameter values on master-side data carrier

Parameter IDN Lists

The drive 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

Loading parameter values is required in the following cases:

- Initial commissioning of the motor (loading default values and motor-specific parameter values)
- Serial commissioning of machine axes at series machines (loading the values saved after initial commissioning)
- Reestablishing a defined initial status (repeated loading of the values saved after initial commissioning)
- Replacing the controller for servicing (loading the current parameter values saved before servicing)

Possibilities of 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 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 correspond to the values saved on the master side.

Pertinent Parameters

- 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-0-4023, C0400 Communication phase 2 transition
- P-0-4065, Active non-volatile memory
- P-0-4090, Configuration for loading default values

Pertinent Diagnostic Messages

Load default values (factory settings):

- C07_0 Load defaults proced. command (motor-spec. controller val.)
- C0702 Default parameters not available
- C0703 Default parameters invalid
- C0704 Parameters not copyable
- C0706 Error when reading the controller parameters

Load default values:

- C07_1 Load defaults procedure command (factory settings)
- C0751 Parameter default value incorrect (-> S-0-0423)
- C0752 Locked with password

Backup working memory procedure:

- C2202 Error when writing data to non-volatile memory
- C2200 Backup working memory procedure command

Loading 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
- F2103 It was impossible to address EnDat memory

IDN Lists of Parameters

General Information

Some of the parameters stored in the drive contain, as their operating data (parameter value), a list of IDNs of drive parameters corresponding to a specific, given criterion. These so-called IDN lists enable the master or a commissioning software to handle drive parameters in a specific way.

Using a Password

Brief Description

IndraDrive controllers provide the possibility to protect parameter values against accidental or unauthorized change by means of 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 memories, etc. ("administration parameters"). The values of these parameters ensure correct function and performance of the drive.

- 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 drive to the axis, after having determined them.
- All other writable parameters and are not contained in the above-mentioned groups. They are not write-protected.

The drive firmware allows activating and deactivating the write protection for parameter values by means of 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!

Pertinent Parameters

- 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

4.8.3 Device Configuration

Controller Design

The drive controllers of the IndraDrive range consist of several modules. In principle, the control section is differentiated from the power section:

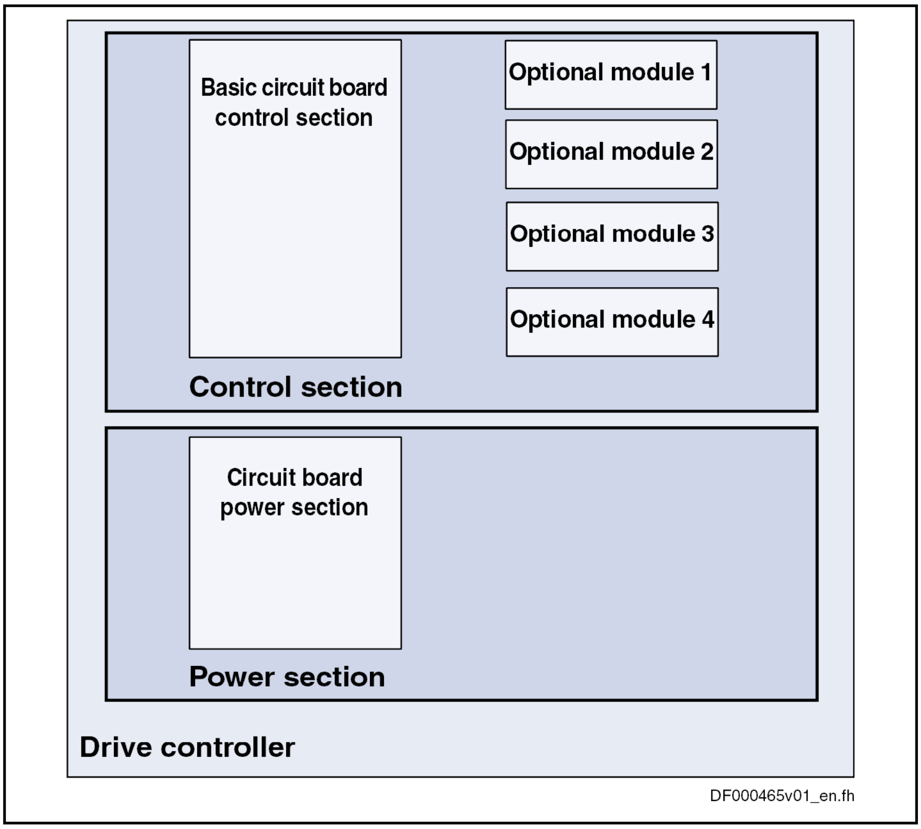


Fig.4-97: Example of design including device, modules and circuit boards for IndraDrive controllers

Cooperation between firmware version and single-axis converter:

Brief Functional Descriptions

Product Line		Performance class			Design	Required firmware version
HCS01.1E	-	W0003	-	A-02-	E-S3-EC-xx-xx-xx-xx	as of MPE-16VRS
					B-ET-EC-xx-xx-xx-xx	as of MPB-16VRS
					A-CD-EC-xx-xx-xx-xx	as of MPC-17VRS
	-	W0006	-	A-02-	E-S3-EC-xx-xx-xx-xx	as of MPE-16VRS
					B-ET-EC-xx-xx-xx-xx	as of MPB-16VRS
					A-CD-EC-xx-xx-xx-xx	as of MPC-17VRS
	-	W0009	-	A-02-	E-S3-EC-xx-xx-xx-xx	as of MPE-16VRS
					B-ET-EC-xx-xx-xx-xx	as of MPB-16VRS
					A-CD-EC-xx-xx-xx-xx	as of MPC-17VRS
	-	W0013	-	A-02-	E-S3-EC-xx-xx-xx-xx	as of MPE-16VRS
					B-ET-EC-xx-xx-xx-xx	as of MPB-16VRS
					A-CD-EC-xx-xx-xx-xx	as of MPC-17VRS
	-	W0018	-	A-02-	E-S3-EC-xx-xx-xx-xx	as of MPE-16VRS
					B-ET-EC-xx-xx-xx-xx	as of MPB-16VRS
					A-CD-EC-xx-xx-xx-xx	as of MPC-17VRS
	-	W0005	-	A-03-	E-S3-EC-xx-xx-xx-xx	as of MPE-16VRS
					B-ET-EC-xx-xx-xx-xx	as of MPB-16VRS
					A-CD-EC-xx-xx-xx-xx	as of MPC-17VRS
	-	W0008	-	A-03-	E-S3-EC-xx-xx-xx-xx	as of MPE-16VRS
					B-ET-EC-xx-xx-xx-xx	as of MPB-16VRS
					A-CD-EC-xx-xx-xx-xx	as of MPC-17VRS
	-	W0018	-	A-03-	E-S3-EC-xx-xx-xx-xx	as of MPE-16VRS
					B-ET-EC-xx-xx-xx-xx	as of MPB-16VRS
					A-CD-EC-xx-xx-xx-xx	as of MPC-17VRS
	-	W0028	-	A-03-	E-S3-EC-xx-xx-xx-xx	as of MPE-16VRS
					B-ET-EC-xx-xx-xx-xx	as of MPB-16VRS
					A-CD-EC-xx-xx-xx-xx	as of MPC-17VRS
	-	W0054	-	A-03-	E-S3-EC-xx-xx-xx-xx	as of MPE-17VRS
					B-ET-EC-xx-xx-xx-xx	as of MPB-17VRS
					A-CD-EC-xx-xx-xx-xx	as of MPC-17VRS

Fig.4-98: Required Firmware Versions for Converters

Cooperation between firmware version and multi-axis converter:

Product Line		Type performance			Control section design	Master communication	Supported as of firmware version
HCQ02.1E	-	W0025	-	A-03-	-B-	ET	MPM-16VRS
HCT02.1E	-	W0020	-	A-03-	-B-	ET	MPM-16VRS

Fig.4-99: Required Firmware Versions for Converters (Multi-Axis)

☞ The devices are configured at the factory and can be read via parameters, if required.

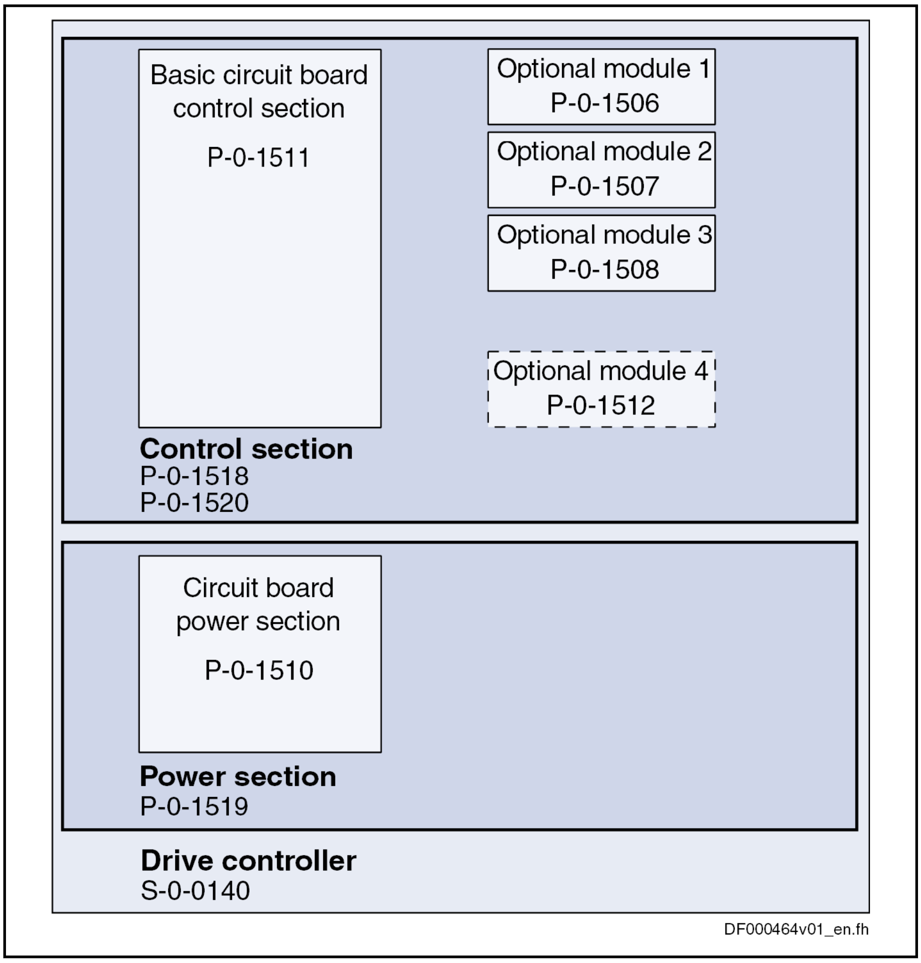
Circuit Board Code

Brief Description

The configurable control section of a drive controller consists of the basic control section circuit board and one or several optional modules (see type code in the documentation "Control Sections for Drive Controllers; Project Planning Manual").

An individual parameter is assigned to each slot for circuit board or optional module (cf. P-0-1506 to P-0-1514). The specific data (circuit board code) of the circuit board that has been plugged are stored in these parameters.

☞ The circuit board codes are stored directly on the circuit board or the respective optional module.



S-0-0140	Controller type
P-0-1506	Circuit board code optional module 1
P-0-1507	Circuit board code optional module 2
P-0-1508	Circuit board code optional module 3
P-0-1510	Circuit board code power section
P-0-1511	Circuit board code control section
P-0-1512	Circuit board code optional module 4
P-0-1518	Module code of control section
P-0-1519	Module code of power section
P-0-1520	Control section type

Fig.4-100: Device Configuration and Circuit Board Code for IndraDrive

In the initialization phase (when booting), the drive firmware automatically checks the arrangement (configuration) of the control section by means of the individual circuit board codes, and on this basis generates the content of parameter "P-0-1520, Control section type". The configuration of the control section used can be read via this parameter.

☞ The control section is configured at the factory and the configuration is displayed in parameter P-0-1520 for diagnostic purposes (type designation in plain text)!

Pertinent Parameters

- S-0-0140, Controller type
- P-0-1506, Circuit board code optional module 1
- P-0-1507, Circuit board code optional module 2

- P-0-1508, Circuit board code optional module 3
- P-0-1510, Circuit board code power section
- P-0-1511, Circuit board code control section
- P-0-1512, Circuit board code of optional module 4
- P-0-1518, Module code of control section
- P-0-1519, Module code of power section
- P-0-1520, Control section type

Pertinent Diagnostic Messages

During the initialization phase the drive, apart from checking the existing configuration, carries out some additional checks. Errors detected during the checks are classified according to their cause.

General malfunction of a circuit board with specific error messages:

- F8091 Power section defective
- F8122 Control section defective

Configuration of control section not allowed, i.e. an optional card was plugged into a slot that does not support this card (observe allowed combinations of the individual optional modules; see documentation "Control Sections for Drive Controllers; Project Planning Manual"):

- F8118 Invalid power section/firmware combination
- F8120 Invalid control section/firmware combination

Operating Hours Counter

Brief Description

There are operating hours counters available in the drive that separately record the operating time 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.

Pertinent Parameters

- P-0-0190, Operating hours control section
- P-0-0191, Operating hours power section

Parameter "P-0-0190, Operating hours control section" displays the operating time of the control section of the drive. The unit is seconds.

The time the drive has been switched on is considered to be the operating time of the control section.

Parameter "P-0-0191, Operating hours power section" displays the operating time of the power section of the drive 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.

> ☞ Before delivery, the operating hours counters are set to a defined value at the factory. They can therefore indicate the total runtime of a component in field duty.

In addition, there is an operating hours counter for motors with which the dynamic operating data of the motor are collected and stored.

See the section "Diagnostic Data of Motor Operation"

Error Memory (Power Section and Control Section)

Brief Description

In the drive, 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 separating the power section and control section.

☞ When an error occurs, the diagnostic message number and the current count of the operating hours counter are automatically stored.

Pertinent Parameters

- 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

☞ 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.

4.8.4 Diagnostic System

Coded Diagnostic Messages of the Drive

Brief Description

The drive provides a diagnostic system including different options that are basically divided into two groups:

- Recognizing and displaying the current drive status by means of drive-internal, priority-dependent generation of diagnostic messages
- Collective messages for various status messages

Additionally, there are parameters for all important operating data the values of which 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").

Pertinent Parameters

- S-0-0030, Manufacturer version
- S-0-0095, Diagnostic message
- S-0-0140, Controller type
- S-0-0142, Application type
- S-0-0375, Diagnostic numbers list
- S-0-0390, Diagnostic message number
- P-0-0007, Display text of diagnostic message
- P-0-0009, Error number
- P-0-0478, Logbook event
- P-0-0479, Logbook time stamp

Status Classes, Status Displays, Control Parameters

General Information

In the drive 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"

The drive differentiates the error, warning and message states (state classes).

In the drive there are parameters

- with direct relation to the status of the sequence of different drive functions (fixed status displays)
- for controlling the drive functions (control parameters)

Diagnostic Data of Motor Operation

Brief Description

For preventive maintenance and service purposes, the firmware provides the option to collect dynamic operating data of the motor and store them in the controller.

The operating hours counter for motors allows planning maintenance intervals, minimize machine downtimes and reduce maintenance costs.

Features

- Recording the total time during which:
  – Operating state "AF" present
  – Velocity is unequal zero
  – Motor temperature is greater than 10 K below shutdown threshold (parameter "S-0-0204, Motor shutdown temperature")
- Recording the maximum velocity of the motor in operation
- Determining the average value of the motor velocity in operation
- Recording the maximum temperature of the motor winding in motor operation
- Determining the average value of the motor winding temperature, referring to the duration of the operating status "AF"
- Determining the operational performance of the motor by multiplying average speed and duration with velocity unequal zero

Pertinent Parameters

- P-0-2051, Operating hours counter, motor
- P-0-2052, Thermal operating data, motor
- P-0-2053, Mechanical operating data, motor
- P-0-2054, Operational performance, motor
- P-0-2055, Serial number, motor

Load Preview

Brief Description

When operating electrical drives when power or torque/force is delivered by the motor, there is also power dissipation. For electrical equipment or electrical components, due to the materials used, there is a maximum permissible operating temperature up to which continuous operation is safe. This temperature determines the permissible continuous load for the electrical components.

Overload Capability

The heating of electrical components based on current supply runs in parallel with their thermal time constants. As long as the maximum permissible operating temperature has not be reached, an electrical component may be overloaded, i.e. short-time operation with more than the permissible continuous load. This causes heating to occur more quickly but does not pose a problem as long as the permissible operating temperature is not exceeded.

If the permissible operating temperature is reached, the overload must be reduced to the permissible continuous load so that the electrical components are not damaged. Functions for limiting overload are present on Bosch Rexroth drives for various drive component that are relevant to performance:

- Motor
- Controller inverter
- Braking resistor of the supply unit or converter

Protective Functions

The functions that supply protection from loads that are not permitted are realized in the hardware or firmware side:

- Hardware-side temperature measurement in the motor windings and on the controller heat sink
- Firmware-side temperature model calculation for temperatures at temperature-sensitive components that cannot be measured on the hardware-side.

With hardware-side temperature measurement, only the heating processes that take place in the seconds range can be recorded; heating that takes place more quickly can only be monitored using firmware-side model calculation anyway.

Overload Limit

The high overload capability of the electrical drives can only be realized such that operational safety is ensured by using temperature model calculation and automatic overload limits:

- Current limitation with controller temperature model (inverter)
- Current limitation with motor temperature model
- Output limitation with braking resistor temperature model

Load Preview

Limits that intervene automatically do protect the electrical components from damage, but also affects drive torque or power delivery and can lead to shutdown due to resulting errors or rejects during processing. Early detection and reporting of threatening limitations is possible with the function "Load preview" for the three temperature model calculations listed above:

- Processing the machining cycle with the highest load
- Determining the stroke of the load sequence (difference between maximum and start value)
- Determination of a threshold value fo the load at which the expected load stroke is still just possible without reaching the limit
- Message when the thermal load has reached the specified threshold value.

Pertinent Parameters

- P-0-0141, Thermal drive load
- P-0-0441, Thermal drive load warning threshold
- P-0-0446, Thermal motor load
- P-0-0465, Maximum value thermal drive load
- P-0-0466, Maximum value thermal motor load

- P-0-0467, Maximum value thermal load of Braking resistor
- P-0-0468, Prewarning threshold of therm. motor load
- P-0-0469, Prewarning threshold of therm. load of braking resistor
- P-0-0844, thermal load of Braking resistor

Pertinent Diagnostic Messages

- E2051 Motor overtemp. prewarning
- E2061 Device overload prewarning
- E2820 Braking resistor overload prewarning

4.8.5 Control Panel of the IndraDrive Controller

Control Panel

Brief Description

IndraDrive controllers are equipped with an operating unit whose front, i.e., the "control panel", consists of a display and four keys located below it. The display shows operating states, command and error diagnoses, as well as present warnings.

Fig.4-101: Control Panel of the IndraDrive Cs with Optional Memory Card

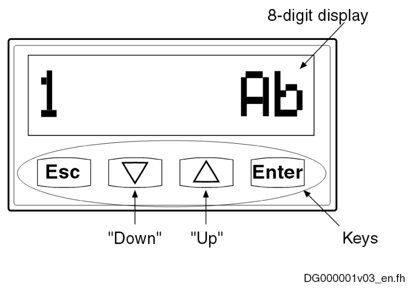


Fig.4-102: Schematic Illustration of the IndraDrive Cs Operating Panel

The four keys can be used to display further diagnostic messages and initiate simple commands (additional for 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.

Display Options for the Operating Panel

The display of the IndraDrive controller automatically shows

- status of the master communication
- the operating status,
- commands and diagnostic command messages,
- warnings and diagnostic error messages,

- extended displays such as contents of error memories, diagnostic message memory, operating hours counter of control section, operating hours counter of power section, type designation of firmware active in the device, safety technology code (if safety technology option available)

Control Panel Variants

There are two control panel variants as follows

1. Standard control panel
2. Advanced control panel

In addition to the functions of the Standard control panel, the Advanced control panel has another slot on the left side for a micro SD card. Using the Advanced control panel requires an IndraDrive Cs Advanced.

Setting Options Using the Control Panel

The following settings can be made using the control panel:

- Setting the drive address (drive number in the bus system of the master communication)
- Activating the Easy startup mode for initial commissioning
- Setting the master communication protocol
- Setting IP addresses for Engineering

Command Activation Using the Control Panel

The following commands can be activated using the control panel:

- Activating "S-0-0262, C07_x Load defaults procedure command" (load controller parameters or basic parameters)
- Activating other commands, such as:
  – C0200 Exit parameterization level procedure command
  – C0300 Set absolute position procedure command
  – C0400 Activate parameterization level 1 procedure command
  – C2000 Command Release motor holding brake
  – C2200 Backup working memory procedure command
  – C2300 Load working memory procedure command
  – C2800 Analog input adjustment command

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; accessing all of the parameters of the drive and variables of the MLD is possible.

4.8.6 Firmware Replacement

Brief Description

Basic Principles

Explanation of Terms

The following cases are distinguished for firmware replacement:

- **Release update**

  An old firmware release (e.g. MPB-17**V02**) contained in the device is replaced by a new firmware release (e.g. MPB-17**V04**).
- **Version upgrade**

  The old firmware version contained in the device is replaced by a new firmware version (example: MPB**17**V06 is replaced by MPB**18**V02).

☞ With the firmware MPx17, it is currently impossible to make a version upgrade!

Firmware for IndraDrive can be replaced using the following hardware and software:

- Computer with software "IndraWorks" or
- Computer with TFTP client or
- Change of the programming module (only IndraDrive Cs)

☞ 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.

Preparations and Conditions for Firmware Replacement

Preparing the Firmware Replacement

The following preparations are necessary for firmware replacement:

1. Drive controller must be on (24V-V supply).
2. Drive controller is **not** permitted to be in operating mode (communication phase 4) (cf. P-0-0115).
3. It is recommended to save the parameter values before replacing the firmware (see Functional Description "Loading, Storing and Saving Parameters").

General Notes on How to Carry Out Firmware Replacement

Observe the following points when carrying out the firmware replacement:

- Do not switch off the 24V control voltage while replacing the firmware.
- The firmware replacement always must be carried out completely.

Firmware Release Update

IndraDrive Cs

General Information

☞ During a firmware release update, the following must be observed:

- If the master communication protocol is changed to EtherCAT® (P-0-4089.000.001) after the firmware release update, during phase progression with TwinCAT (BECKHOFF) the drive will generate the switching error C0101 once. In this case, the parameters listed in S-0-0021 must be set to "valid" using IndraWorks.
- Before the firmware release update, saving the backup parameters of the drive is recommended!

Communication Types

For engineering, the two Ethernet ports (X24/X25) are available. In general, users must know which master communication is used:

- PROFIBUS®

  For a PROFIBUS® device, both Ethernet ports (X24/X25) are available exclusively as Engineering ports (see also the functional description "TCP/IP Communication"). This is used to carry out the firmware download as well.

- EtherNet/IP™, PROFINET®

  With EtherNet/IP™ and PROFINET®, a firmware download can be carried out using "Engineering over IP".

> After the master communication has been changed, the device must be restarted for activating the settings.

- EtherCAT®

  With EtherCAT® the firmware update can be carried out using the profile "Ethernet over EtherCAT".

- SERCOS III

  When SERCOS III has been activated as master communication, "Engineering over IP" is available. The computer can, for example, be directly connected to the last device in the bus and thus, a firmware update can be started.

> If there are several devices in the bus, make sure that an unambiguous IP address is assigned for each node.

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 must be restarted for activating the settings.

IP Configuration in the "EasyMenue" See Functional Description "Standard Control Panel"

IP Settings at the Computer See Microsoft help, keyword "LAN connection"

Changing the Master Communication See Functional Description "MultiEthernet"

Switching to "PM"

1. Via IndraWorks - e.g. Menu **Project** ▸ **Switch Devices Online...** or in the context menu of the axis, the drive can be switched online.
2. Switch to parameter mode (PM):
   - Via IndraWorks e.g. Menu **Device Status** ▸ **Activate Parameterization Level** or
   - the button **PM**.
   - Or via the extended menu of the programming module (see Functional Description "Standard Control Panel").

Firmware Release Update With Computer

1. Connect drive to computer (recommended: Cat-5e EtherNet cable)
2. Load firmware

   There are two possibilities of performing a firmware release update using a computer:
   - By means of IndraWorks or
   - with a TFTP client

   1. *Firmware Release Update by Means of IndraWorks*

      1.1 Call "IndraWorks".

      1.2 Load project for corresponding axis or create new project; to do this, address axis 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 drive is displayed.

1.5 Highlight new firmware (*.ibf file) in upper part of dialog and start firmware download via "Download" button.

Firmware download runs automatically and all required firmware components are loaded to drive.

1.6 After firmware download has been completed, close "Firmware Management" window.

1.7 Reboot the drive controller or execute the command "Reboot".

2. *Firmware Release Update Using a TFTP Client*

2.1 Firmware update service is made available via a TFTP server. Command for sending the firmware is "put" command.

☞ It is possible with any TFTP client supporting this command (e.g. Windows command line program "tftp.exe") to carry out a firmware release update **without IndraWorks**.

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 system. For the host, the IP address of the device is to be specified (standard is 192.168.0.1): `tftp -i 192.168.0.1 put FWA-INDRV_-MPB-16V04-D5.ibf`

See also Functional Description "Firmware Download via TFTP Server"

3. Put machine into ready-for-operation status again according to machine manufacturer's instructions.
4. Check functions of drive.

Firmware Release Update With Programming Module

On the programming module, the firmware and the user data used in the device are stored.

☞ Before replacing the programming module, a programming module with the desired firmware must be ordered from Rexroth.

To replace the programming module, proceed as follows:

1. Switch drive off.
2. Remove old programming module.
3. Plug in new programming module.
4. Switch drive on.
5. Put machine into ready-for-operation status again according to machine manufacturer's instructions.
6. Check functions of drive.

IndraDrive HCQ / IndraDrive HCT

The firmware replacement for "IndraDrive HCQ" / "IndraDrive HCT" is described in the documentation "Rexroth IndraMotion, MTX micro 10VRS, System Description" (DOK-MTXMIC-SYS*DES*V10-PR01-EN-P, part number R911330178).

☞ For the firmware release update from MPM16V02 to MPM16V04, more device parameters are required that can only be entered by a Rexroth service technician!

Firmware Version Upgrade

☞ With the firmware MPx-17, it is currently impossible to make a firmware version upgrade!

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:

- 24V supply of control section is switched off
- Connection to drive is interrupted (e.g., defective interface cable)
- Crash of update software / of computer

If there isn't any valid firmware available in the control section, the loader is started. The text "LOADER IP address; 192.168.0.1" runs through the display. 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 menu under **Tools Drive ▸ Firmware Management** call firmware management.

   A new window opens and firmware available in current firmware directory is displayed on its left side.
3. Select "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 drive.
7. After firmware download has been completed, close "Firmware Management" window.
8. Restart drive.

4.8.7 Notes on How to Replace the Devices

Replacing the Supply Unit

General Information

The concept of Rexroth supply units includes safe, quick and uncomplicated replacement of devices. This allows reducing production downtimes, caused by failures of these devices, to a minimum.

Failures in the supply unit are displayed by means of diagnostic messages. According to the diagnostic error message, the measure "replacing the supply unit" can be indicated.

See documentation "Troubleshooting Guide" (Description of Diagnostic Messages)

Immediately after having replaced the device, the drive is operational again, because it is not required to repeat the adjustment of the drive to the machine.

How to Replace the Supply Unit

Procure Replacement Device

Identify device to be replaced by means of type plate; procure supply unit of same type from Rexroth!

See also documentation of the respective supply unit

Fill Out Fault Report

In the documentation of the respective supply unit is a fault report form to be copied. Please copy this fault report, fill it out carefully and completely and enclose it with the defective device! The fault report filled out completely supports quick handling of repair and helps recognizing application-related failure causes.

Replace Supply Unit

De-energize drive system; wait for DC bus to discharge; then replace defective supply unit!

⚠ WARNING

Live conductor bars (higher than 50 V), even if mains voltage switched off!

Electric shock when touching!

⇒ Wait for the DC bus (L+/L-) to discharge; before touching the conductor bar, check whether below 50 V!

Notes on how to mount and dismount the supply unit, see documentation of the respective supply unit

Put Drive System Into Operation Again

Put machine into operation again according to machine manufacturer's instructions!

4.8.8 Replacing the Controller

Overview

A controller of the IndraDrive range consists of the components power section and control section (incl. firmware). The control section can be configured with additional components (encoder interface). The control section and power section are firmly connected; only Rexroth service engineers or especially trained users are allowed to replace individual components. The paragraphs below describe how to replace the complete controller as regards the parameter backup. The mounting and dismounting of the entire drive controller is described in the Project Planning Manual for the power section.

The controller must be replaced by a device of the identical type. Only in this way is it ensured that the originally configured functions can be used in unchanged form.

If you use devices with integrated safety technology, you should replace several devices one after the other to avoid interchanging the device types.

A device which is intended for replacement and has already been in operation (thus is not in the factory-new condition as supplied), must be brought to the condition as supplied again ("load defaults procedure (factory settings)") before it is used.

The figure below illustrates the basically required individual steps.

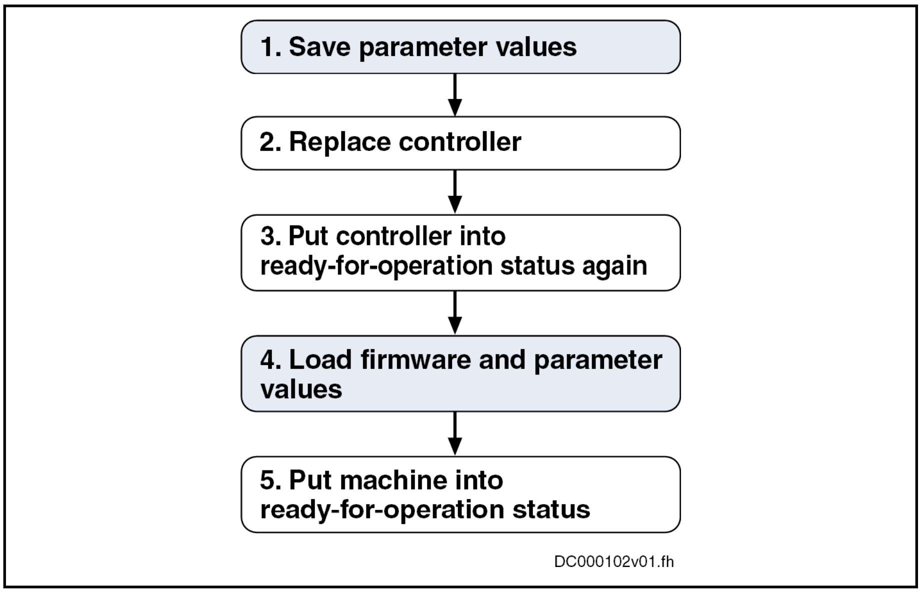


Fig.4-103: General Sequence of Controller Replacement

How to Proceed when Replacing Controllers

1. Save parameter values

   Before dismounting the defective device, save the drive parameter values, if possible.

If saving the parameter values before replacing the device should be impossible due to a total breakdown of the device, only the parameter values backed up after initial commissioning can be loaded when the parameter values are loaded later on (see "Load Parameter Values in Case of Total Breakdown of Device")!

1. Switch to the parameter mode (PM or P2)

2. Saving the parameter values of the defective device can take place via the "IndraWorks Ds/D/MLD" commissioning tool or the control master:

- "IndraWorks" commissioning tool:

The backup operation data can be stored by means of the following procedure.

1. In IndraWorks, open the context menu of the device

2. In the context menu, select the menu item "Saving..." under "Parameters"

3. The following window opens

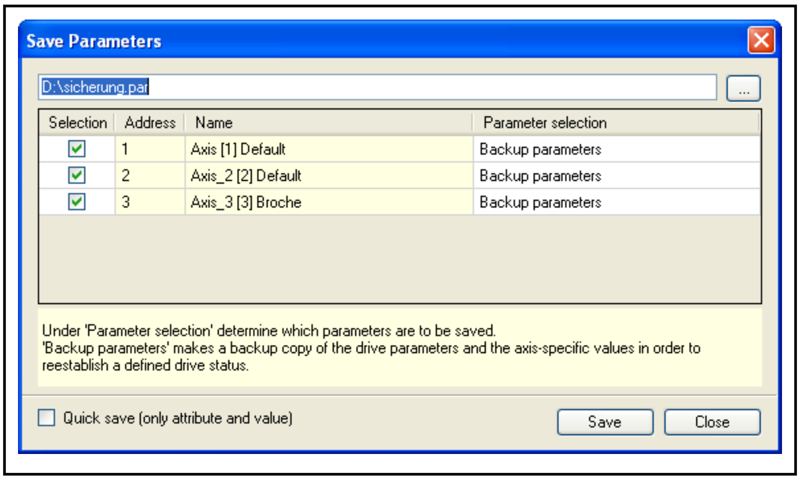


Fig.4-104: Save Parameters

At the top of the window, specify a data path; below, select the axis to be replaced and click the "Save" button.

- Control master:

  By the control master, store the parameter values according to the list parameters S-0-0192 and P-0-0195 on a master-side data carrier.

2. **Replace controller**

   1. Open main switch

   2. Make sure main switch cannot be switched on again

   3. Make sure the drive controller is completely de-energized

⚠ WARNING **Lethal electric shock by live parts with more than 50 V!**

Before working on live parts: De-energize installation and secure power switch against unintentional or unauthorized re-energization.

Wait at least **30 minutes** after switching off the supply voltages to allow **discharging.**

Check whether voltage has fallen below 50 V before touching live parts!

4. Separate connection lines from controller and dismount drive controller from the control cabinet

5. Mount new controller and connect it according to the machine circuit diagram

☞ The controller must be replaced by a device of the identical type. Only in this way is it ensured that the originally configured functions can be used in unchanged form.

3. **Plug display of the defective device in new controller**

4. **Load firmware and parameter values (if item 3. impossible, e.g. display defective)**

   When firmware and drive parameters are to be transmitted to the replaced controller, the required firmware and a parameter backup of the respective axis must be available.

☞ To be noticed with EtherCAT®: After the master communication protocol has been changed for the first time, some additional parameters can be activated. Initially, they are invalid and must be set valid manually. This can be done by means of "load basic parameters". "Load basic parameters" can be executed via the display

1. Press ESC+Enter keys until "1. Er. Anz." appears on the display
2. Go to the menu "2. Command" and press Enter
3. In the command menu, go to "2.5 C07" and press Enter
4. Select "P4090=1"

By pressing the Enter key, "load basic parameters" is executed and the EtherCAT®-specific parameters are valid.

---

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 the parameter file to the controller:

- "IndraWorks" commissioning tool

  Load the operating data saved under item 2 to the controller.

- Control master

  Load the axis-specific parameter values (according to list parameters S-0-0192 and P-0-0195) saved before the replacement of the device.

5. **Put machine into ready-for-operation status**

   1. Put machine into ready-for-operation status again according to the machine manufacturer's instructions.

   2. Check functions of the drive.

Possible Problems During Controller Replacement

The paragraphs below give a brief description of critical problems and their recommended handling.

Loading Parameter Values in Case of Total Breakdown of Device

If it should have been impossible to save the parameter values according to the list parameters S-0-0192 and P-0-0195 immediately before replacing the device (total breakdown of device), the parameter values saved after initial commissioning have to be loaded.

☞ In the case of drives with absolute value encoder and modulo format, the position data reference must be established again after having loaded the parameter values saved after initial commissioning, even if the actual position values are signaled to be valid via the parameter "S-0-0403, Position feedback value status"!

NOTICE	The parameter values saved after initial commissioning are not generally suited for reestablishing the operatability of the drive after replacement of devices!

Check actual position values and active target position before setting drive enable!

4.8.9 Enabling of Functional Packages

Brief Description

The scope of functionality of the IndraDrive firmware can be scaled by the user. This allows adjusting the scope of firmware functions to the respective requirements and, if necessary, reducing its complexity.

The drive 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 at last change of access enable is stored

Pertinent Parameters

- S-0-0030, Manufacturer version
- 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

Pertinent Diagnostic Messages

- C0202 Parameter limit error (->S-0-0423)
- C0299 Configuration changed. Restart

4.8.10 Extended Diagnostic Possibilities

Monitoring Function

Brief Description

☞ The so-called "monitor function" implemented in the drive is **for internal use only**, or can be used as an extended possibility of diagnosis in the case of error.

The monitoring function provides the following options:

- Displaying memory ranges
- Changing storage locations
- Writing/reading EEPROM memory cells (controller and encoder)
- Adjusting analog measured values
- Displaying internal system states
- Executing several test routines for software and hardware

☞ Using the monitor function requires a VT100 terminal, an ANSI terminal or a corresponding emulation. It is recommended to have a 132-column display.

Pertinent Parameters

- P-0-4021, Baud rate RS-232/485
- P-0-4025, Drive address of master communication
- P-0-4095, RS-232/485 Parity

Logbook Function

Brief Description

A logbook function is realized in the drive firmware in order to obtain a detailed diagnostic error message in the case of error. The information provided by the logbook function allows reproducing the internal firmware sequence, if required.

Pertinent Parameters

- P-0-0478, Logbook event
- P-0-0479, Logbook time stamp

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 serves for diagnosis of internal signal states and internal data of the PLC by developers and instructed users.

☞ When using the patch display in the oscilloscope take into account that first the patch address and then the oscilloscope signal is assigned. This must be repeated after every change in the patch address.

☞ As 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 stored in the flash**, but are lost when the drive is switched off.

Pertinent Parameters

General patch functions:

- 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

4.8.11 Oscilloscope Function

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:

- Recording measured values

  It is possible to record 4 channels at the same time, the signals being selected by configuration of signal selection lists (IDN lists).
- Configuration (basic settings)

  The control/status block determines the basic functions (start/stop, time resolution, size of memory, operating mode). The current status (status 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:

- Recording measured values
  - 4 channels, each with a maximum of 8192 measured values
  - Time resolution to be freely selected in steps of the position loop clock (see "Performance Data")
  - Signal selection by indicating the IDN of the respective parameter
- Configuration (basic settings)
  - 4-channel display in "IndraWorks Ds/D/MLD"
  - More than 100 different measuring and trigger signals (cf. P-0-0149)
  - Expanded oscilloscope function using patch function
- 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

Pertinent Parameters

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

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

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

4.9 Engineering/Diagnostic Interfaces

4.9.1 Safety Instructions

⚠ 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 safety fence, safety guard, protective covering, light barrier).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- In addition, observe the safety message "Protection Against Dangerous Movements" in the chapter "Safety Instructions for Electric Drives and Controls".

4.9.2 S/IP Protocol

Brief Description

Fields of Application

S/IP enables easy access to all drive parameters.

Typical areas of application are:

- Communication with the drive for Engineering via the company's own tool

- Replacement for cyclic bus communication for controlling simple axis applications without real-time requirements, e.g. in positioning block mode or for drive-controlled positioning

Overview of Functions

Features

- TCP/IP-based protocol
- The protocol is focused on exchanging data; very little management is required.
- User-defined Busy-Timeout (time until drive sends a defined answer)
- User-defined Lease-Timeout (time after which the connection is released again if no new queries are made)
- Its own service for reading out all information of a parameter in a query
- Up to two connections possible simultaneously

Pertinent Diagnostic Messages

The following error messages are defined and are sent directly back into the drive's own service:

Name	Value in telegram	Significance
CONNECTION_ERROR	1	Error in establishing the connection
ABORTED	2	Procedure aborted
UNKNOWN_MESSAGE_TYPE	3	Message type in header is unknown
SERVICE_SPECIFIC	4	Service -specific error, e.g. "Data is write-protected"

Fig.4-105: S/IP Error Classes

4.9.3 TCP/IP Communication

Brief Description

☞ In the section "TCP/IP Communication" all necessary information for standard Ethernet communication is given. In addition to TCP/IP, communication via UDP/IP is also possible.

To prevent confusion with the master communication "EtherNet/IP™ interface", the designation "Ethernet communication" was not used here; instead, the term "IP communication" is used.

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 over which TCP/IP communication is possible provide connection options. This can be a free port of the master communication card (e.g. SERCOS III or EtherNet/IP™) or a separate Engineering port (if present).

Example, SERCOS III Master Communication

For SERCOS III, in addition to the time-controlled transmission of SERCOS-type Ethernet telegrams (MDT and AT), an NRT channel (NonRealTime or IP channel) exists, for which telegrams are sent in a specially reserved time slot.

Therefore, for SERCOS III, another option for asynchronous data transmission is available in addition to the existing service channel, that is very well suitable for large data volumes due to the maximum lengths of useful data of approx. 1500 bytes.

Possible Applications

With the utilization of the TCP/IP communication in the drive, different application options are available, which are summarized in the following table.

Connection	Server application	Possible client applications
SIS Protocol	Parameterization via SIS-based parameter services, integrated in TCP	Addressed on the client-side via SCP in IndraWorks
TFTP	Firmware update service	Implementing a firmware update

Fig.4-106: Overview of the Possible Applications

Pertinent 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-0-1534, C6100 Command Activate IP settings
- P-0-1544, Engineering: Status IP communication

Pertinent Diagnostic Messages

- C6101 Incorrect IP settings
- F2190 Incorrect Ethernet configuration

4.9.4 Firmware Download via TFTP Server

Brief Description

Fields of Application

If a firmware download is to be carried out, a TFTP server is available. 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 existing in the device. To do this, in the "ReadRequest" the string "Firmware" is transmitted.

The response telegram contains a data packet, the first four bytes of which are the control section circuit board code and the following content is the manufacturer's version (cf. S-0-0030.0.0).

Firmware Download

The download procedure is started using a WriteRequest. To do this, the drive must be in PM. Here the "WriteRequest" also initiates the connect to the TFTP server.

Then "DataRequests" is used to download the firmware onto the device. The device takes over various testing:

- Can the new firmware file be used with this device (compatibility test)?

- Was the correct amount of data transmitted (data integrity test)?
- Was the firmware file transferred correctly and properly (validity test)?

Error Diagnostics

Any possible error that occurs during this procedure is sent back via the ErrorFrame in the TFTP. The error text is included as plain text.

Features

The TFTP server of an IndraDrive device has the following features:

- A TFTP connection does not recognize authentication
- The following five packet types are present in a TFTP connection:
  - "ReadRequest" (reading of files from server/drive starts)
  - "WriteRequest" (writing of files from server/drive starts)
  - "Data" (data is transmitted)
  - "Acknowledge" (data packets are confirmed)
  - "Error" (any type of error message)
- Each data packet must be confirmed with "Acknowledge" before the next data packet is sent.

Pertinent Diagnostic Messages

Errors that occur are transmitted as plain text via "TFTP ErrorFrame" (see the description of diagnostic message: "Firmware Download")

5 Notes on Application

5.1 Safety Instructions

⚠ 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 safety fence, safety guard, protective covering, light barrier).
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- In addition, observe the safety message "Protection Against Dangerous Movements" in the chapter "Safety Instructions for Electric Drives and Controls".

5.2 Definitions of Terms

Incompatible and compatible functions and functional enhancements are differentiated.

Incompatible Functions

Incompatible new functions or incompatible functional enhancements produce an axis behavior which does not correspond to the previous version.

The causes can be, for example:

- Changes in the error behavior
- Change of default values (e.g. inertia)
- Change of filter types and filter degree
- Additional monitoring functions (e.g. in the safety technology) take effect

☞ Before commissioning, check whether the new firmware in the application results in a different behavior at the axis, which might possibly cause problems.

The behavior of the previous version can partly be reestablished by parameter adjustment.

Compatible Functions

Compatibility of a new function or functional enhancement means that, for example, a parameter file from a previous version (MPx16VRS in this case) can be used in the new firmware (MPx17V06 in this case).

With the standard settings of the new firmware and/or the parameter settings from the previous version, the drive shows the same behavior as before the upgrade; the reaction to a command value input, for example, does not differ in either firmware. It is not necessary to adjust parameters.

5.3 Incompatible New Functions and Functional Changes

5.3.1 System Overview

IndraDrive Cs W54 Device

The IndraDrive Cs W54 device is supported as of firmware MPx-17VRS.

5.3.2 Master Communication

PROFINET®

With PROFINET® master communication, make sure that X25 corresponds to the logic Port 1 and X24 corresponds to the logic Port 2 in the Engineering. When the process data length configured in the device deviates from the process data length configured in the control section, the error "F4012 Incorrect I/O length" is generated in the device when PROFINET® is used. With PROFINET®, the device name and the network settings are reset to the default value when the device is reset to the factory setting; i.e. the device name and the IP address are cleared. With PROFINET® and, for example, via the "HW Config" configuration tool by Siemens, "Reset to factory settings" can be carried out for any device. The "Edit Ethernet Node" dialog is used for this purpose.

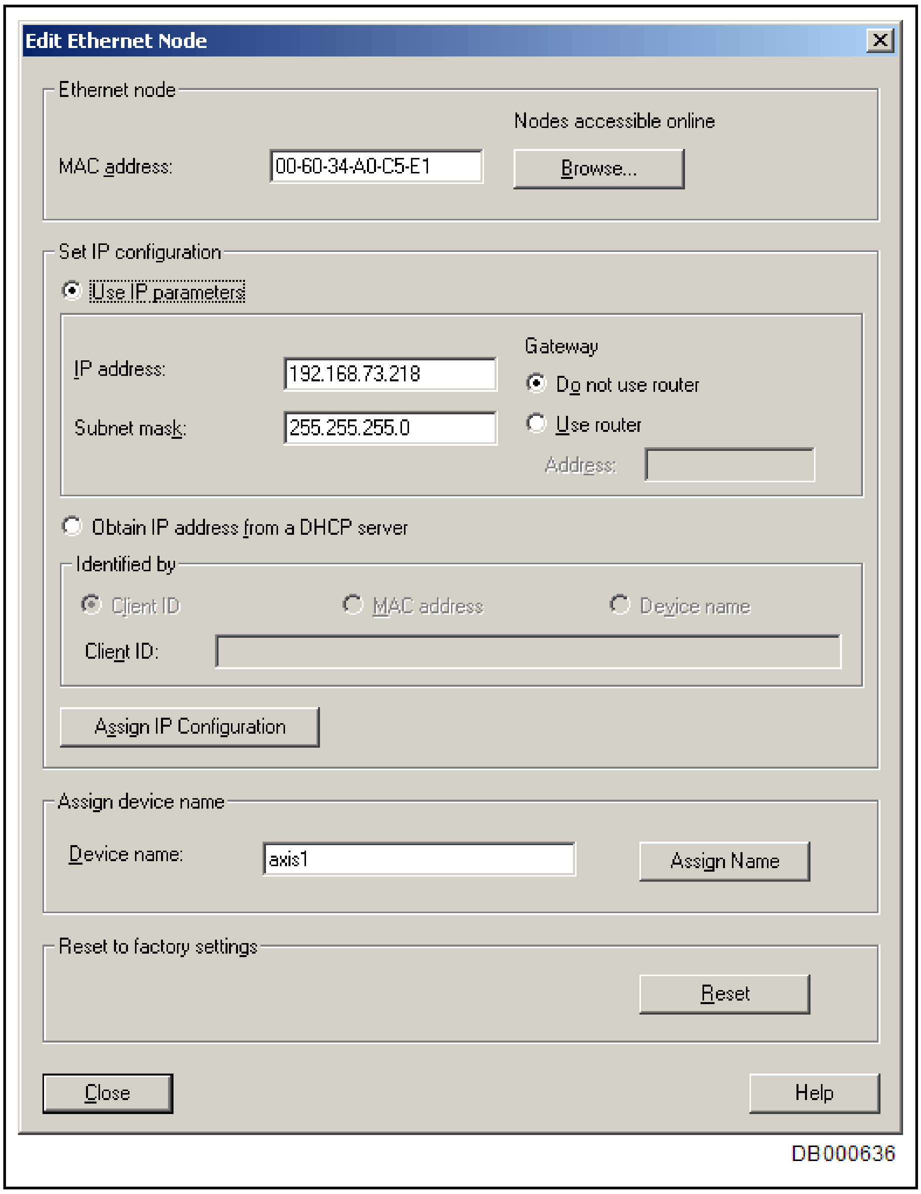


Fig.5-1: Reset to Factory Settings

Maximum Activation Time

In IndraDrive, the process data are processed in a synchronous way. The characteristic of synchronous processing is that a master, via timing parameter, can exactly define the time of actual value determination (and command value acceptance). For the calculation, each slave via parameter makes available its time conditions (processing times, protection times etc.).

The maximum activation time of the consumer is implemented in IndraDrive in the new parameter "S-0-1047, SERCOS III: Maximum Consumer Activation Time" and made available to the user.

Resource Optimization SERCOS III Slave

As of MPx17, a diagnostic LED in accordance with the SERCOS III specification is implemented in IndraDrive.

Blinking code												Function	Display priority (1 = highest)
												No SERCOS III Telegrams (NRT mode)	6
Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	CP0	6
Orange	Green	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	CP1	6
Orange	Green	Orange	Green	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	CP2	6
Orange	Green	Orange	Green	Orange	Green	Orange	Orange	Orange	Orange	Orange	Orange	CP3	6
Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	CP4	6
Green		Green		Green		Green		Green		Green		CPx →Loopback	5
Red	Orange	Red	Orange	Red	Orange	Red	Orange	Red	Orange	Red	Orange	Application-related 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
Orange		Orange		Orange		Orange		Orange		Orange		C-Dev.Bit15 (Identification)	1
Red		Red		Red		Red		Red		Red		Internal watchdog has triggered	0

Black LED is off

Fig.5-2: Supported Blinking Codes and Their Significance of the Diagnostic LED According to SERCOS III Specification

Heterogeneous Connections

As of the firmware MPx-17, IndraDrive with SERCOS III interface supports connections with different properties. To describe the connection properties, the "S-0-1060.x.y, SIII-Connection type ..." parameters are implemented. These properties can be assigned to the connections. In the structure element 7, the corresponding instance of "S-0-1050.x.y, SIII-Connection ..." points to the connection class contained in "S-0-1060.x.y, SIII-Connection type ...". Thus, the connection inherits the properties of the referenced class.

5.3.3 Drive Control

Magnetization Time of Asynchronous Motors

After "AF", the asynchronous motor must be magnetized before it can deliver torque. For this purpose, the magnetizing current command value in previous firmware was set to the 2-fold nominal magnetizing current and the reaction to master-side command values took place in a fixed interval of 300 ms after "set AF".

To reduce the reaction time to master-side command values, a maximum of 70% of the allowed maximum motor current is now internally preset as magnetizing current command value (if possible on controller side) and external command values are enabled when the magnetic flux in the motor has reached 75% of the command value of the magnetic flux.

Due to the increased magnetizing current, the field is built up faster than before. The drive releases the holding brake and enables the external command value at 75% of the flux command value. The flux command value is influenced by the premagnetization factor.

The flux command value for the flux loop is calculated as follows:

Flux command value = nominal flux * premagnetization factor

A premagnetization factor smaller than 100% reduces the reaction time from AF to the enabling of the external command value; the immediate torque development of the asynchronous motor, however, is reduced to the percentage value that is entered. This effect is transient, i.e. the reduction does not take effect in the case of stationary load.

Effective Actual Velocity Value

For MPx17 the actual value for the velocity control is "S-0-0535, Active velocity feedback value". If an external encoder is used, the value of S-0-0535 can be generated by mixing; the mixing ratio is specified in "P-0-1119, Velocity mix factor feedback 1 & 2":

$$\text{S-0-0535} = \text{S-0-0040} * (1 - \text{P-0-1119}/100\%) + \text{S-0-0156} * (\text{P-0-1119}/100\%)$$

S-0-0535	Active velocity feedback value
S-0-0040	Velocity feedback value
S-0-0156	Velocity feedback value 2
P-0-1119	Velocity mix factor encoder 1 and encoder 2

Fig.5-3: Calculation of "S-0-0535, Velocity feedback value"

☞ In previous firmware versions, the value of S-0-0040 was the actual value for the velocity control (result of the velocity mix factor feedback)!

The values of S-0-0040 and S-0-0156 are scaled (e.g. load-referenced, etc.). The actual velocity of the motor is displayed in "P-0-0112, Actual velocity value of motor".

5.3.4 Operation Modes

Group Master Axis for Real Axes

The "P-0-0787, Group axis 1 position" is no longer used only as group axis between IndraMotion MLD-M and a higher-level control section, but also as virtual master axis for the real synchronous operation modes. For this purpose, the parameters "P-0-0787, Group axis 1 position" and "P-0-0788, Group axis 1 position, fine-interpolated" are displayed for all derivates (MPx), when the functional package "Synchronization" has been activated. In addition, the selection of the master axis in parameter "P-0-0088, Control word synchronization modes" is extended by the group axis 1 position.

5.3.5 Optional Device Functions

Rexroth IndraMotion MLD (Drive-Integrated PLC)

MLD 1G Solution for IndraDrive Cs

With the following changes, the existing MLD 1G solution is ported to IndraDrive Cs with Basic Universal signal processing.

- Big-endian

  The data filing is converted from little-endian to big-endian. The data interpretation of binary data is no longer compatible. This affects the MLD user programs in the case of the corresponding data access.

- Storage concept

  The "BOOT.SDB" and "persist.dat" files are stored in two new list parameters in the drive. (For IndraDrive C and IndraDrive M, these files are stored on the MMC.) It is impossible to access user files with the PLC program or create user files via existing libraries.

- Characteristics of the PLC
  - The maximum size of the compressed boot project in 192 kB, the uncompressed size is approx. 400 kB (distributed to a maximum of 6 parameters)
  - The maximum size of the uncompressed "BOOT.SDB" of 32 kB is ensured, with 600 symbols, stored in a parameter
  - Retain memory of 512 Byte has been integrated in the programming module
  - MLD performance is below the one of a CSH01.1 control section
  - MLD-S function is ported, i.e. there aren't any remote axes and no decentralized I/Os

CCD State Machine Separated from Sub-Device State Machine

As of MPC-08VRS and with "P-0-1600, CCD: configuration", bit 5, the behavior or the linking of the state machine/phase progression of the CCD slaves can be configured. It is possible to separate the phase input for the CCD slaves from the state machine of the CCD master (for the default setting as of MPC-08VRS, the following setting applies: P-0-1600, bit 5 = "0"). The previous behavior of the firmware versions up to MPC-07VRS can be set, i.e. fixed linking of state machine of the CCD master and phase input of the CCD slaves: P-0-1600, bit 5 = "1".

The separation of the parameter mode (PM) ↔ operating mode (OM) switching (sub-device state machine) of the CCD master and the SERCOS phase switch of the CCD slaves results in the following behavior: After the devices have been switched on, the SERCOS communication of the CCD group in most cases is in phase 4 or, as far as possible, remains in phase 4, independent of the PM/OM status of the CCD master.

The SERCOS(II+III)-CCD system mode is an exception: In this mode, the SERCOS phase input for the CCD group is directly linked to the SERCOS phase switch of the CCD master (this does not affect the PM ↔ OM switching). When the control section switches the CCD master to phase 2/4, the CCD slaves (in the CCD system mode) are automatically switched to phase 2/4, too.

In the CCD group, the sub-device state machine of the CCD master is linked to the sub-device state machines of the CCD slaves (only drives). When PM→OM switching takes place in the CCD master (automatically during run-up or later, depending on "P-0-4088, Master communication: Drive configuration", bit 0, in the CCD master), the CCD master carries out the PM→OM switching for the CCD slaves (only drives), too, as soon as the CCD group is in phase 4. OM→PM switching in the CCD master does not have an effect on the SERCOS phase, but switches the CCD slaves (only drives) to PM, too.

Synchronization of the System Time

In each CCD mode, the CCD master in the phase progression, i.e. directly after CCD phase 2 has been reached and once again shortly before switching to phase 4, automatically sets the parameter "P-0-0197, System time" in the CCD slaves to the value of P-0-0197 in the CCD master. The system time in the CCD slaves (P-0-0197) is also set to the value of P-0-0197 in the CCD master, when P-0-0197 is written in the CCD master. This allows nearly synchronous error diagnosis of the CCD group.

The delay for the setting or transmission of the system time in the CCD slaves is taken into account and compensated by the CCD master. Via bit 6 in "P-0-1600, CCD: configuration", this function of the automatic writing of the system time (P-0-0197) in the CCD slaves by the CCD master can be deactivated. In the CCD master, the system time is stored in P-0-0197 and it is maintained after the drive has been switched off. When a different value is written to the parameter P-0-0197, counting continues with this value as of this point of time. If no value was entered in P-0-0197, counting starts automatically with 2000-01-01.

The parameter P-0-0197 is not contained in "P-0-0192, Error memory of diagnostic numbers" and is not overwritten with "load basic parameters".

5.3.6 Handling, Diagnostic and Service Functions

Safe PL Detection and Restoring

Due to "safe PL detection and restoring", the error condition changes in the case of update to the new version (MPx-16VRS to MPx-17VRS). Instead of "F2009 PL Load parameter default values", the user must now load the parameters manually.

The following procedure must be observed:

1. Save the backup operating data of the drive.
2. Firmware upgrade (MPx-16VRS to MPx-17VRS)
3. Restart drive (24 V)
4. F8100 Error when initializing the parameter handling
5. Default IP address is already active "192.168.0. <drive address>".

   The drive address can be seen on the display and is also stored in "S-0-1040, ". Go online with IndraWorks and set "P-0-2003, Selection of functional packages" and "P-0-4089.0.1, Master communication: Protocol" manually valid. This can be done via the IndraWorks dialogs:

Functional Packages "P-0-2003, Selection of functional packages"

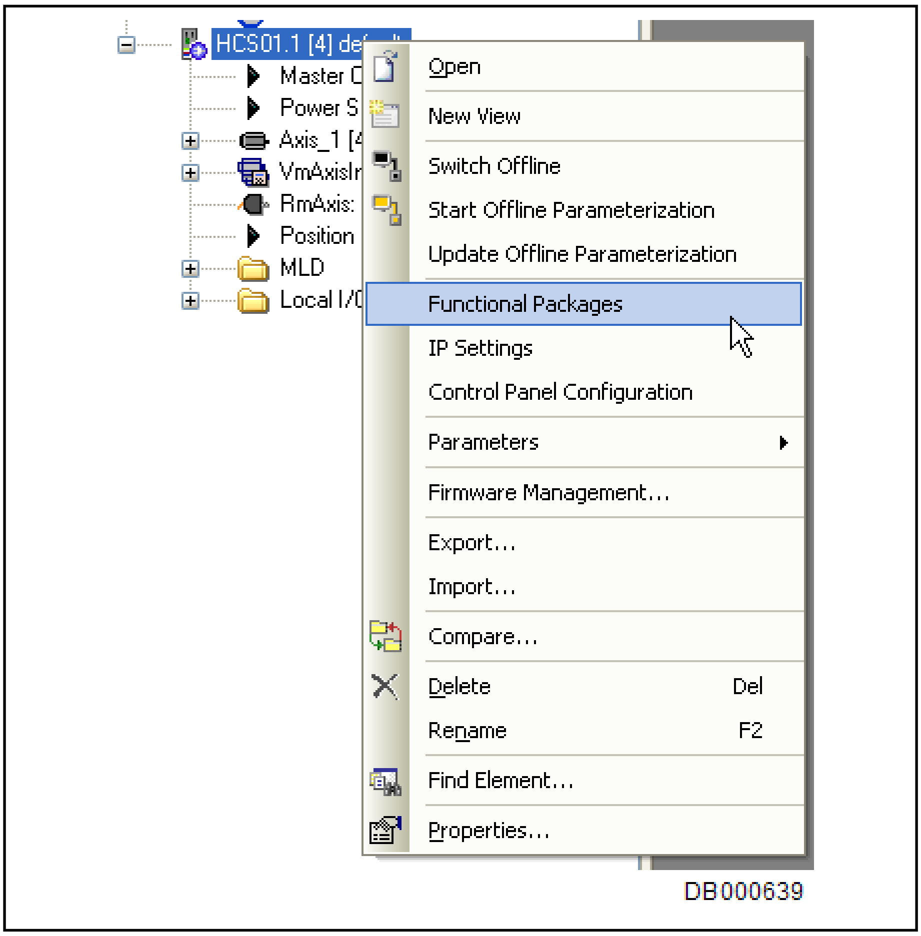


Fig.5-4: Menu Item Functional Packages

Notes on Application

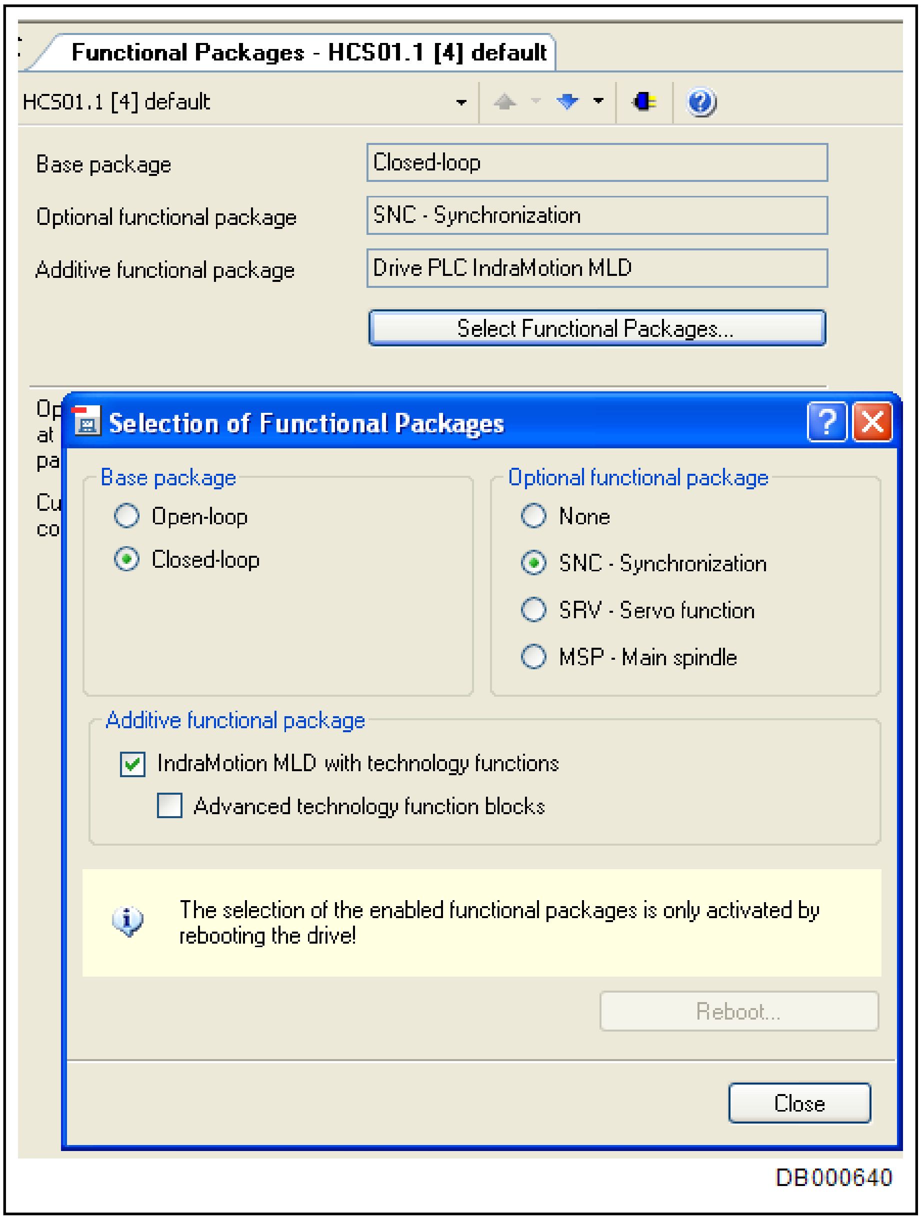


Fig.5-5: Selection of Functional Packages

☞ Even if only the closed-loop base package is used, the functional package must once be explicitly selected so that the value is detected as being valid and selected by the user.

Master Communication "P-0-4089.0.1, Master communication: Protocol"

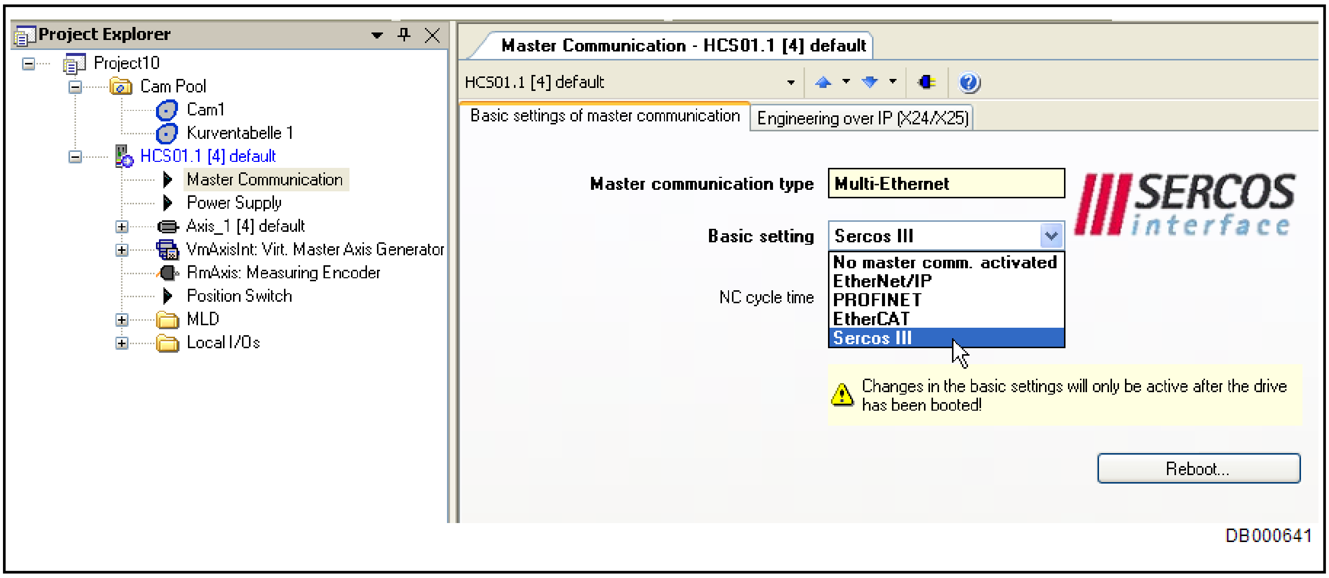


Fig.5-6: Selected Master Communication

- Even if the setting is already correct, the correct protocol must be selected once again so that the value is applied.
- For PROFIBUS® devices, too, the protocol must be explicitly selected again.

6. Load Basic Parameters

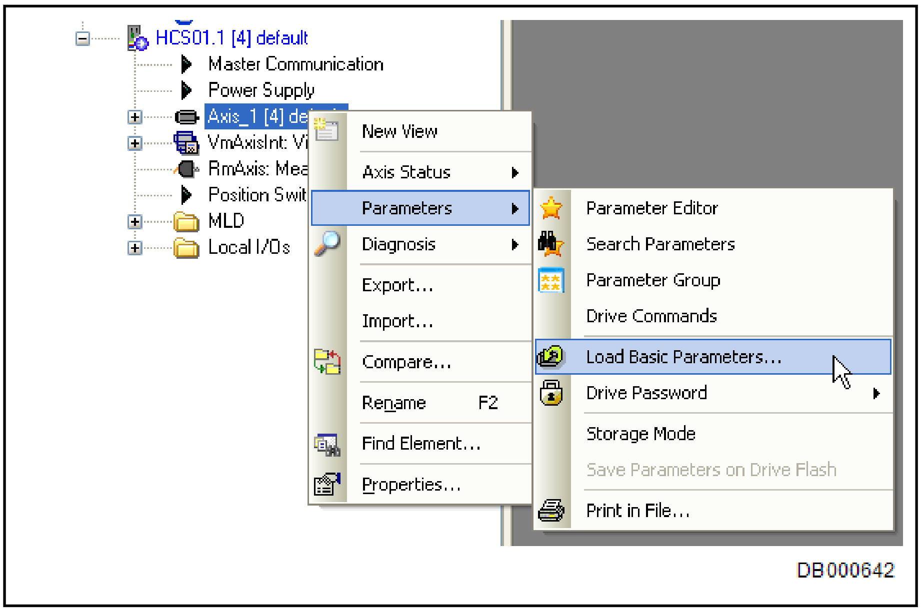


Fig.5-7: Load Basic Parameters

Notes on Application

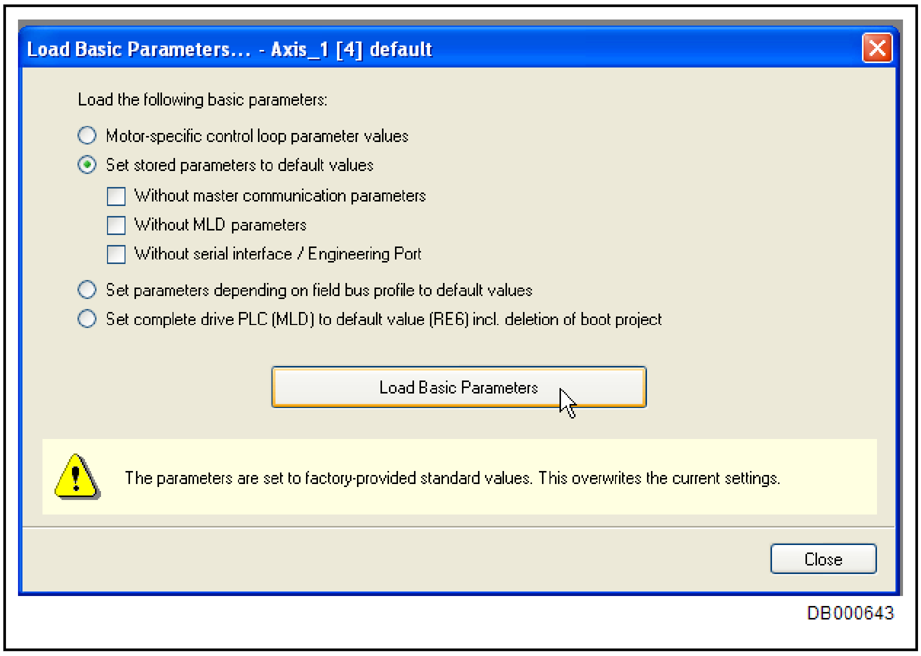


Fig.5-8: "Load Basic Parameters" Dialog

7. Load the saved parameters to the drive.
8. Restart drive

   or

   as of IndraWorks 11V06 via the "Reboot..." button in the master communication dialog

   or

   switch 24 V control voltage supply off and on.

When EtherCAT® is selected as master communication, engineering communication is impossible after the restart. To continue the commissioning, it is absolutely necessary to have an EtherCAT® control section. If supported by the control section, it is possible to continue working with IndraWorks with the active EtherCAT® control section via EoE (Ethernet over EtherCAT).

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9. If there are invalid parameters, they are entered in the parameter "S-0-0423, IDN-list of invalid data for parameterization levels" when phase switch to phase 4 takes place again and a transition command error is generated. Via IndraWorks, these parameters can be collectively set valid.

With MPB17-V04 and activated MLD, the following parameters become additionally invalid when phase progression takes place for the first time. They must be set valid once during the first phase progression.

- P-0-1611.0.0, CCD: configuration list signal status word
- P-0-1612.0.0, CCD: configuration list signal control word
- P-0-1613.0.0, CCD: assignment list signal status word
- P-0-1614.0.0, CCD: assignment list signal control word
- P-0-1623.0.0, CCD: configuration list master cmd values
- P-0-1624.0.0, CCD: configuration list actual master values
- P-0-1625.0.0, CCD: configuration list slave cmd values
- P-0-1626.0.0, CCD: configuration list actual slave values

10. Put drive into operation again according to the machine manufacturer's directives and check the correct function.

Explicit Acknowledgment During Transition Command

When the run-up process of the controller, with automatic run-up to the operating mode after the booting process, is aborted during run-up with a C02xx command error, the command is not automatically cleared. The drive continues displaying the error. The configuration error must be resolved before the drive boots up.

5.3.7 Engineering/Diagnostic Interfaces

S/IP Server in the Drive

In the SERCOS III specification for the NRT channel, the S/IP service has been defined.

It is based on the TCP/IP stack and is available not only via the SERCOS III NRT channel, but is made available on all the available TCP/IP networks, such as Ethernet engineering, PROFINET-RT, EtherNet/IP™ and EtherCAT® (EoE).

Service[1]		Server
Connection	63: Connect	Yes
	65: Ping	Yes
	66: Busy	Yes
	67: Exception	Yes
Parameters	69: Read Everything	Yes
	71: Read Only Data	Yes
	73: Read Description	Yes
	74: Read Data Status	Yes
	83: Write Data	Yes
	85: Write Data Bits	Yes

Service[1]		Server
Nameplate	89: Nameplate	Yes
Watchdog	101: Watchdog	No

1 The server informs the client of the available services in the "Connect Response".

Fig.5-9: Realized Services

☞ With the firmware variant MPC, there is a maximum of three communication interfaces:

- MultiEthernet master communication
- Cross communication (CCD)
- Engineering Port

With the other firmware variants (MPE, MPB, MPM), only MultiEthernet master communication is possible.

- It is possible to have several connections (Connection Sockets) at the same time.
- For reasons of simplification and to save resources, incoming requests for each connection are processed in sequential form (synchronously).

5.4 Compatible new Functions and Functional Changes

5.4.1 System Overview

Adjustment of Hardware Requirements

IndraDrive MI V2 is based on the control section platform of the IndraDrive Cs device range with STO/SBC functionality. All the necessary adjustments were made to support IndraDrive MI V2 with the MPx-17VRS firmware in compatible form.

5.4.2 Master Communication

Field Bus Profile, Deactivating the Profile Preselection

In the parameter "P-0-4084, Field bus: Profile type", the profile preselection can be deactivated by the selection "0x0000". In this way, the real-time data can be configured without field bus control word and status word.

The tables below contain an overview of the most important properties and features of the profile type "No profile":

Profile type: "No profile"			
Content of "P-0-4084, Field bus: Profile type"	Master Communication	Field bus or drive operation mode	Features
0x0000	PROFIBUS® CANopen PROFINET® EtherNet/IP™	- With the profile type "No profile", all settings relevant to the profile type are deactivated - The profile type "No profile" is mainly relevant to MLD applications with "permanent control" on the axis	- Profile type without field bus control word and field bus status word - Real-time data can be freely configured - Operation mode can be freely selected

Fig.5-10: Profile Type "No Profile"

CANopen

CAN Controller for IndraDrive

CANopen is available as another master communication.

It is possible to operate IndraDrive controllers with a CANopen interface as master communication module. This requires the control section with the optional module "CANopen" (CO). Via this optional module, it is possible to exchange real-time data with a CANopen master. The "CANopen" protocol (according to Draft Standard DS301, version 4.0.2) has been implemented in the drive controller.

Communication Channels

The following communication channels are differentiated:

- Cyclic data channel (process data objects → PDO)

  The field bus provides data containers in which useful data can be cyclically transmitted in real time (process data objects).
- Acyclic data channel (service data objects → SDO)

  The field bus provides data containers in which useful data (service data objects) can be acyclically transmitted.

☞ The process data are always transmitted via PDOs.

Features

- Simple configuration through use of "Predefined Connection Set" and "Minimal Boot-Up" according to DS301
- Baud rates of 20, 50, 125, 250, 500, 800 and 1000 kbit/s specified by CANopen according to DS301 are supported
  - Configurable cyclic data up to 12 parameters (incl. field bus control word and field bus status word) in both data directions (max. 32 bytes or 16 words)
- Functional compatibility with EcoDrive functions through profile selection (I/O mode)
- Node monitoring (heartbeat function and node guard function)
- LED displays at the front panel of the master communication module for simple diagnosis of bus functions and most important communication relationships between drive and field bus (2 LEDs: "Run" status and "Error" status)
- IDN parameters of the drive can be directly read via SDO and, if permitted, can be written
- Upload/download function for IDN parameters of the drive possible with SDO services
- Event-controlled or synchronous transmission of process data
- CANopen Device profile DSP402 is not supported; field bus profiles according to DSP402 are partly supported (see "Profile Types (with Field Bus Interfaces)")

Transmission Type 1 with CANopen, "No PLL Synchronization" Variant

The PLL synchronization can be switched off via bit 9 of "P-0-4088, Master communication: Drive configuration":

- Bit 9 = "0" → PLL synchronization active
- Bit 9 = "1" → PLL synchronization not active

In the next position loop clock after the Sync telegram has been received and with PLL synchronization switched off,

- the command values are applied from the last RxPDO and
- the actual values are registered and transmitted as TxPDO.

Enabling of 4th PDO with CANopen

Extension of the cycl. data from 3 PDOs (24 bytes) to 4 PDOs (32 bytes).

Another PDO is created on the basis of the existing PDOs. This extends the real-time data width from 24 bytes to 32 bytes. The corresponding configuration parameters were extended.

Up to MPx05, the 4th PDO had been reserved for the CANopen multiplex channel, since MPx05 it is no longer supported.

Transmission Type 254 with Cyclic Event

With bit 11 of "P-0-4088, Master communication: Drive configuration", it is possible to switch between the event types "ChangeOfState" and "cyclic".

- Bit 11 = 0: Event type "ChangeOfState"
- Bit 11 = 1: Event type "cyclic"

With the cyclic event, PDO telegrams with the transmission type "254" are transmitted cyclically in the clock of the parameter "P-0-4076, Field bus: Process data - updating clock", i.e. the PDO telegrams have one common cyclic clock.

EIDN Extension Parameter Channel for PROFIBUS® and PROFINET®

The parameter channel configuration is extended by the EIDN access configuration and harmonized between PROFIBUS® and PROFINET®.

When 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 IDN" 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 EIDN" module and configure it accordingly in the parameter "P-0-4083.0.1, Parameter channel: Configuration".

Configuring the parameter channel

The new general configuration parameter "P-0-4083.0.1, Parameter channel: Configuration" provides the following configuration options:

- 0: Deactivated

  The parameter channel has been deactivated.

- 1: IDN access

  Access to IDN parameters of the drive takes place via the parameter channel.

- 2: EIDN access

  Via the "EIDN parameter channel access", IDN and EIDN parameters of the drive can be accessed.

For IndraLogic and Siemens S7, there are functions blocks available which use the parameter channel protocol. The user does not need to deal with the parameter channel details. The parameter channel is described in the Technical Note "TN_40_Bosch_Rexroth PROFIBUS_PROFINET_Parameterkanal_V1.x".

5.4.3 Motor, Mechanical Axis System, Measuring Systems

Third-Party Motor with Motor-Specifically Adapted HIPERFACE® Encoder

For reasons of commutation, some motor manufacturers (e.g. SEW) shift, for HIPERFACE® encoders, the digital absolute track as compared to the incremental analog signals. This can cause an initialization error with IndraDrive. This initialization error can be avoided by position initialization without incremental track, to be activated in the position feedback type parameter (S-0-0277, Position feedback 1 type).

The diagnostic messages

- C0220 Error when initializing position of encoder 1
- C0224 Error when initializing position of encoder 2
- C0227 Error when initializing position of measuring encoder

were extended by the error cause "absolute position shifted as compared to the incremental track".

The position can also be initialized without incremental track. This can be configured in:

- S-0-0277, Position feedback 1 type
- S-0-0115, Position feedback 2 type
- P-0-0328, Type of position encoder for measuring encoder

Motor Identification

Identification of the motor data from third-party motors with added test voltage is now also available of synchronous motors. The procedure is started with "P-0-0565, C3600 Command Motor data identification"; ideally it should be performed with a rotating motor because more precise results can be expected then. The sequence for motor identification is in P-0-0601, Configuration motor data identification.

Input values for synchronous motors are:

- P-0-0018, Number of pole pairs/pole pair distance
- P-0-4036, Rated motor speed
- S-0-0111, Motor current at standstill

The following data is determined for synchronous motors via C3600:

- P-0-4048, Stator resistance
- P-0-0051, Torque/force constant
- P-0-4016, Direct-axis inductance of motor
- P-0-4017, Quadrature-axis inductance of motor
- P-0-0510, Rotor inertia

In addition, for synchronous and asynchronous motors

- Plausibility testing of the motor data and
- Sense of rotation testing from motor encoder to motor windings

can be carried out if there are difficulties during the commissioning of third-party motors that could be caused by faulty motor data. The corresponding error is reported in case of negative results.

Notes on Application

Parameter Scaling for Torque/Force Data

Parameter scaling is now possible for the torque/force scaling. For this purpose, the bit 3 is used in the scaling type for torque/force data (S-0-0086, Torque/force data scaling type).

The scaling **factor** for torque/force data (S-0-0093, Torque/force data scaling factor) can be set to a value unequal "1".

The scaling **exponent** for torque/force data (S-0-0094, Torque/force data scaling exponent) can be set to the maximum value "6".

- When an exponent from 1 to 3 is set, the unit of the torque/force data is set to kN or kNm, kilo pound force or inch kilo pound force.
- When an exponent from 4 to 6 is set, the unit of the torque/force data is set to MN or MNm, American units (pound force, inch pound force) are not possible.

The unit "mega pound force" does not exist.

Force values up to a maximum of 32768 MN and torque values up to a maximum of 32768 MNm are possible.

Actual Value Monitoring for Encoders with Endat2.1- and with a HIPERFACE® interface

Encoders with Endat2.1- or with HIPERFACE® interfaces provide analog and digital position information. When the encoder is initialized, the digital absolute position value is transmitted serially to the controller. The motor control is executed via the analog relative sine signal of the encoder because to a great extent it can be read without delay in comparison with the serial transmission of the absolute actual position values.

The absolute actual position value is generated from the absolute initial position value and an added relative actual position value. The absolute value determined in this way is compared cyclically with the digital serial absolute value to detect and report any measuring errors using redundant position testing (warning E2074).

HIPERFACE Encoder with Integrated Encoder Data

Up to now it had only been possible to evaluate HIPERFACE encoders, when encoder-specific data for their "type ID", such as

- Checksum
- Structure
- Encoder resolution
- Absolute encoder range
- Name

had been stored in a firmware-internal database. Up to now it had only been possible to evaluate new encoder types, when the data of their type ID had been included in the firmware-internal database. Depending on the firmware release, it might therefore be possible to evaluate different HIPERFACE encoders. This situation caused uncertainty with regard to the correct use of a HIPERFACE encoder.

HIPERFACE encoders of the type ID "0xFF" now include their encoder-specific data in an encoder-integrated memory. The drive firmware reads the encoder-specific data directly from the connected Hiperface encoder. It is no longer necessary to enter the data in the firmware-internal database; the possibility of encoder type evaluation no longer depends on the firmware release status!

SSI Encoder Evaluation

Encoders in accordance with the SSI standard already provide merely digital position information for the encoder input of the controller. Encoders in accordance with the SSI standard (rotary and linear ones) can be evaluated by the MPx-17 firmware. A supply voltage of 5 VDC or 12 VDC is possible. Gray code and binary evaluation are supported, the baud rate can be set in steps of 100 kHz from 100 kHz to 400 kHz. With rotary SSI encoders, single-turn evaluation (up to 31 bits) and multi-turn evaluation (also theoretically up to 31 bits) are possible; with linear encoders, the data width can be freely set between 0 to 31 bits.

For high quality motor controls the SSI encoders that function serially are only suitable in certain cases because the position information must be provided must be as current as possible, i.e. provided as quickly as possible. The preferred slot for motor encoders is X4, the encoder evaluation at this slot takes place in the velocity loop clock; at all other slots it takes place in the position loop clock. Measuring encoders with SSI format cannot be evaluated.

The SSI encoder evaluation takes place in the two-level SERCOS III encoder profile and contains a so-called "Basic" and a so-called "Extended" evaluation. The "Basic" evaluation makes available standardized encoder raw data, the "Extended" evaluation is independent of the encoder type and processes the standardized encoder raw data with the selected scaling and the influences of mechanical transmission elements, as well as position data reference or absolute position. The parameterization is supported via the corresponding dialogs in IndraWorks.

☞ The two-level SERCOS III encoder evaluation allows multiple evaluation of SSI encoders at different controllers. Several "Extended" evaluations can access the standardized raw data of a "Basic" evaluation.

SSI Combined Encoder

An SSI combined encoder consists of two components:

- SSI encoder (absolute measuring system)
- Sine-cosine encoder with 1Vss output signals (relative measuring system)

The SSI combined encoder is suitable for use as a motor encoder because it unites the advantage of absolute position detection with the precision and quick supply of the actual position value of a 1Vss encoder. The disadvantage of the time delay of the actual position value caused by serial SSI data transmission is insignificant because the absolute actual position value is only read out when the encoder is initialized and for cyclic actual position value testing.

As a motor encoder for synchronous motors, the SSI combined encoder offers the advantage that the commutation angle only has to be determined for initial commissioning and the motor is immediately operational when it is switched on again.

For the evaluation of the SSI combined encoder, the items listed under "SSI encoder evaluation" apply.

The two components of an SSI combined encoder are connected to an encoder interface.

Time Interval Monitoring without Error

Bit 12 was implemented in "P-0-0525, Holding brake control word" to suppress the error when the "holding brake check" time interval is active.

The time interval monitoring is activated with P-0-0525, bit 6 = "1". When bit 12 has been additionally set in parameter P-0-0525 (bit 12 = "1"), only the status of the motor holding brake is set to invalid (P-0-0539, Holding brake status word, bit 1, 2, 3 = "0") when the time interval is exceeded (P-0-0551, Current load torque), but there isn't any warning or error diagnosed.

The status of the holding brake will only be set to valid upon a successful brake check.

5.4.4 Drive Control

Automatic Control Loop Optimization

The sequence of the automatic control loop setting has a new structure. The following functions can now be individually selected:

- Determination of inertia
- Calculation of control loop parameters (speed loop and/or position loop)
- Optimization of control loop parameters (speed loop and/or position loop)
- Determination of acceleration feedforward (S-0-0348, Acceleration feedforward gain)
- Calculation of the max. acceleration

For this purpose, the drive optimization control word (P-0-0165, Drive optimization, control word) was partly redefined.

Acceleration Feedforward for ECONOMY Performance

With MPE-17VRS (single-axis firmware with ECONOMY performance) it is now possible to use the acceleration feedforward (S-0-0348, Acceleration feedforward gain).

Fine Interpolation of the Velocity Command Values

In the case of a position-controlled operation mode or velocity control in the drive, the velocity command value generated in the position loop clock can be fine interpolated to the velocity loop clock.

The fine interpolation of the position loop clock, which is half as fast as the velocity loop clock, to the velocity loop clock has been implemented as a linear interpolation. This interpolation causes less noise in the effective torque command value (output of speed loop). However, the interpolation causes a delay in a position-controlled operation mode. The velocity command values are interpolated to the velocity loop clock, when bit 0 has been set to "0".

☞ The fine interpolation takes effect like an additional delay in the position control loop, reduce the control loop gain in this case.

The function does not take effect automatically, but can be activated as an additional function via "P-0-0556, Config word of axis controller", bit 0.

Second Order Filter

The existing velocity control loop filter is extended by the filter type "2nd order filter".

In the drive, up to 4 different filters can be activated with the parameter "P-0-1120, Velocity control loop filter: Filter type".

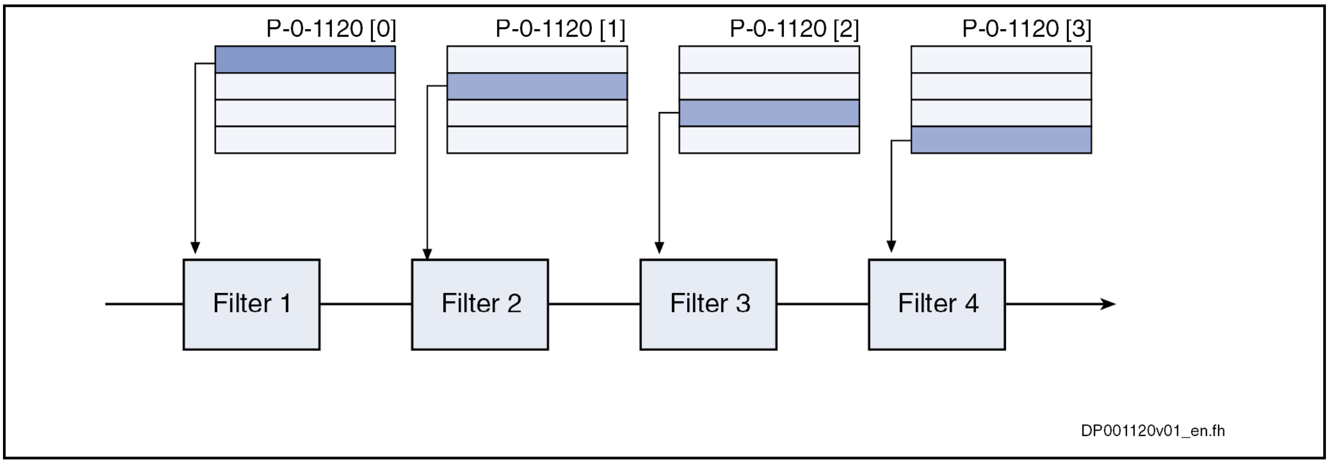

Fig.5-11: Activating the Filters with "P-0-1120, Velocity control loop filter: Filter type"

The parameter "P-0-1120, Velocity control loop filter: Filter type" is extended by the filter type "2nd order filter", value 3.

Four new parameters are implemented for the 2nd order filter:

- P-0-1140, Velocity control loop filter: Numerator natural frequency
- P-0-1141, Velocity control loop filter: Denominator natural frequency
- P-0-1142, Velocity control loop filter: Numerator damping
- P-0-1143, Velocity control loop filter: Denominator damping

The "natural frequency" parameters have the unit [Hz]. The "damping" parameters do not have any unit.

Phase Failure Handling

The mains phase monitoring of the IndraDrive Cs devices can be deactivated to suppress the error message F2818 in the case of single-phase mains voltage supply. It is necessary, however, to distinguish between HCS01.1E-W00xx-A-02 devices and HCS01.1E-W00xx-A-03 devices. In the case of devices with the voltage index 02, the complete power of the drive controller is still available, even after a mains phase has failed. In the case of devices with the voltage index 03, deactivating the mains phase monitoring limits the controller output current to 25% of the nominal device current in order not to overload the device.

Converter Mode at Energy Store

With an energy store connected, it is possible to continue operating HCS01/HCQ/HCT devices without mains or in the case of mains failure, as long as the DC bus is sufficiently backed up from the energy store.

This functionality is parameterized via the parameters P-0-0860 and P-0-0114.

Evaluation of Digital Hall Sensors

The evaluation of digital Hall sensors helps to determine the commutation angle without current and without motion when commissioning a synchronous motor equipped with a relative motor measuring system. During the initialization of the motor, the commutation angle is determined by evaluating the Hall sensor signals with a precision of +/-30° electrical (1 pole pair = 360° electrical). With this "rough" commutation angle, the synchronous motor develops at least 50% of its maximum possible torque or its force. With this reduced value, the motor must be able to move in such a way that the position data reference can be established or that a reference mark of the encoder can be read in.

The full torque or full motor force can be achieved by activating an optimum value for the commutation angle, as soon as the motor or the axis has been homed or has detected an unequivocal reference mark of the motor encoder related to the travel distance (drive- or NC-controlled homing, spindle positioning, cyclic mark detection).

☞ During the initial commissioning, a commutation angle must be identified which causes the maximum force effect of the motor at minimum current. By means of a homing procedure or a motor motion for reading in a reference mark of the motor encoder, this optimum commutation angle is converted to an unequivocal dedicated point (actual position value) of the travel distance and stored in the drive, when the so-called "initial commissioning mode" had been activated.

During recommissioning of the motor ("initial commissioning mode" deactivated!), the initially active commutation angle, when the position data reference is established or the reference mark is passed, is automatically corrected to take a value corresponding to the optimum value (this correction can be switched off via a configuration bit). The status of the active commutation angle is displayed in a parameter.

☞ When a motor encoder that can be evaluated in absolute form is used, digital Hall sensors are not required! Using only digital Hall sensors (without incremental motor encoder) is impossible!

Hardware details:

- The digital Hall sensors must be shifted by 120° electrical with regard to a motor pole pair and must be in correct phase relation to the motor windings. Integration in the motor winding space is not required. The position of the Hall sensors with regard to the motor windings is adjusted by means of a parameter.
- It is only possible to connect the digital Hall sensors via the additional component SHL03.1. The supply voltage for the Hall sensors is DC12V. 1Vpp encoders can be used as motor encoders. It is obligatory to use a motor encoder.
- The additional component SHL03.1 combines the motor encoder signals (1Vpp) and the signals of the digital Hall sensors. SHL03.1 is connected to the encoder input of the controller with only one cable.

Quick Stop Torque Limit

When drive enable is switched off, switching to the machine limitation takes place.

Some torque limitations are available in IndraDrive Cs. The limit values can be divided into process limitations and machine limitations. The parameters to be used for torque limitation in the production process can be cyclically configured and are adjusted by the control section in accordance with the process. These are the torque limit values:

- S-0-0082, Torque/force limit value positive
- S-0-0083, Torque/force limit value negative
- S-0-0092, Bipolar torque/force limit value

The parameter "P-0-0109, Torque/force peak limit" should be set to the limit value of the machine. This value cannot be cyclically configured and it should not be possible for the NC to write it (configuration parameter). The setting of "P-0-0119, Best possible deceleration", bit 0-3, takes effect in these cases:

- Drive enable switched off
- Drive-controlled stopping process by the E-Stop function
- Drive-controlled stopping process in the case of errors of error classes F2 and F4

During the drive-controlled stopping process, it is always the parameter "P-0-0109, Torque/force peak limit" which takes effect.

☞ In the case of NC reaction to drive errors, the process values remain effective.

Interpolation Delay, S-0-0081

In the "cyclic position control" modes, the parameter "S-0-0081, Additive torque/force command value" takes effect synchronously to the position command value.

The "cyclic position control" mode is extended as follows:

- The cyclic additive torque command value is applied in the NC clock, synchronously to the position command value.
- The torque command value (internal) is smoothed in an average value filter (filter order as "P-0-0041, Position command average value filter time constant").
- With a linear fine interpolator, the torque command value (filtered) is taken from the NC clock to the position clock.
- By means of a delay element (max. 64 clocks), the torque command value (position) is delayed by n position clocks. (Compensation of delay of cubic fine interpolation and "P-0-0456, Position command value delay")

The acceptance and processing of the additive torque command value is integrated in the "cyclic position control" mode. The torque command value is processed and transmitted to the controllers synchronously to the position command value.

Average value filter

The position command value in the operation mode can be smoothed via an average value filter (max. 64 values). The filter runs in the NC clock and is set via the parameter "P-0-0041, Position command average value filter time constant".

If necessary, "additive torque command value" is smoothed via a parallel average value filter. The filter setting is taken from the position filter, i.e. the same time constant and filter order.

Fine interpolation

For the transition to the position clock, a fine interpolator is required for the torque, too. A linear fine interpolator (2nd derivative) is sufficient. The additional delay of the "cubic fine interpolation of position" is taken into account in a delay element.

With a "linear fine interpolator of position", a subsequent VZ1 filter (P-0-0099, Position command smoothing time constant) can be used. This is not taken into account for the processing of the torque. For linear fine interpolation, the cyclic acceptance "S-0-0081, Additive torque/force command value" is not recommended.

Delay element

To compensate the delay in the position clock, a delay element according to the position command value delay is implemented for the torque value. This compensates the delays described below.

The cubic fine interpolation, approximation delays the position command value additionally as compared to linear fine interpolation.

Example:

Cubic approximation (P-0-0187 = "1", "P-0-0187, Position command processing mode") is additionally delayed by 1 NC clock + n position clocks.

The position command value delay (P-0-0456, Position command value delay) can be up to 32 position clocks.

To generate the command velocity, the position command value is delayed by 1 clock.

It is sufficient to delay the torque command value by a maximum of 64 cycles. For this purpose, the parameter "P-0-0458, " is implemented; this parameter activates the function (input value > 0).

The parameter "P-0-0070, Effective additive torque/force command value" instead of "S-0-0081, Additive torque/force command value" is added in the velocity loop, when the function has been activated. The torque command value is generated in the position loop clock and not fine interpolated to the velocity loop, the value can be smoothed via a filter (P-0-0180, Acceleration feedforward smoothing time constant).

The "additive torque command value" takes effect before the anti-windup limitation.

The fine interpolation is derived from the "fine interpolation of position", the delay must be set separately, but it can be calculated from the position delay.

	Linear fine interpolation	Delay
Linear fine interpolation of position command value	Linear fine interpolation of S-0-0081 in position loop clock VZ1 filter (P-0-0099) is not taken into account	Delay by one NC clock + position command value delay from P-0-0456
Cubic approximation of position command value	Linear fine interpolation of S-0-0081 in position loop clock	Delay by two NC clocks + n position clocks + position command value delay from P-0-0456
Cubic fine interpolation of position command value (acc. to contour)	Linear fine interpolation of S-0-0081 in position loop clock	Delay by two NC clocks + position command value delay from P-0-0456

Fig.5-12: Internal Delay of the Position Command Value

- Linear fine interpolation

  P-0-0458 = P-0-0456 + 1

  1 clock due to delay X-cmd by velocity feedforward
- Cubic approximation

  P-0-0485 = P-0-0456 + (NC clock / position clock – 1) + 1
- Cubic fine interpolation (according to contour)

P-0-0485 = P-0-0456 + NC clock / position clock + 1

With a clock ratio 1/1, the clock ratio term is not required

☞ No fine interpolation of "S-0-0037, Additive velocity command value"!

The "additive torque command value" is not reduced by a limitation. The additive torque takes effect in unchanged form before the anti-windup limitation. According to the feedforward mode ("P-0-0556, Config word of axis controller", bit 14), it is still possible to shift the point at which the torque takes effect.

Motor-Related Actual Speed Value and Limitation for Linear Load-Related Scaling

For the limitation of the motor velocity with regard to the application, the parameter "P-0-0113, " is implemented; for display, the parameter "P-0-0112, " in implemented. The new parameters are independent of the scaling.

For these parameters, the fixed scaling is defined as in "S-0-0113, Maximum motor speed" (rpm with 4 decimal places or mm/min with 2 decimal places).

For reasons of compatibility, the same procedure as for "S-0-0038, Positive velocity limit value" and "S-0-0039, Negative velocity limit value" is used for "P-0-0113, ". That is to say the default value for the parameters is "0" (switched off).

The parameter P-0-0113 can only be written in the parameter mode and it takes effect like the parameter S-0-0113; that is to say, if the value of P-0-0113 differs from "0", the smallest value of the following parameters takes effect:

- S-0-0038, Positive velocity limit value
- S-0-0039, Negative velocity limit value
- S-0-0091, Bipolar velocity limit value
- P-0-0113,
- S-0-0113, Maximum motor speed

The parameter "P-0-0112, " can be recorded with the oscilloscope of the drive.

Monitoring Mechanical Transfer Elements for Slip

For axis drives that are equipped with an external encoder, the controller provides the possibility of using the encoder in addition to the existing motor encoder to monitor any mechanical axis slip with regard to a maximum value that can be set. Previously slip monitoring was only possible with "measuring wheel mode", but this limitation has now been removed. In principle, monitoring can be activated if the drive is equipped with a motor encoder and an external encoder.

If the slip that occurs exceeds a set threshold value, an error is reported and the drive reacts with the set error reaction.

PWM Switching Depending on Velocity

The maximum motor control frequency that a controller can output is proportional to the active PWM control frequency of the inverter. For high speed motors or motors with a large number of pole pairs, appropriately increasing the PWM frequency may be required to achieve the required motor speed. However, the current carrying capacity of the controllers is reduced with increasing PWM frequency.

The experience that at high speeds the working power is mainly generated by the speed and the required torque (along with the motor current) is low and that at low speeds high processing torque is required indicates that the PWM frequency should be switched depending on the motor speed. For this reason, above a motor control frequency threshold the preselected PWM frequency is effective; below this threshold value, provided with a hysteresis, only half of the PWM frequency is effective. For this reason, the current carrying capacity at low speeds is greater than at high speeds, which corresponds to the torque required by spindles, which depends on speed. The current data for the respective, active PWM frequency apply.

The velocity dependent PWM switching must be activated itself (Control word of current controller). The desired maximum PWM frequency must be set on the parameter side.

Value of P-0-0001 in Hz	Velocity dependent active PWM frequency in kHz	Motor control frequency thresholds in Hz for accelerating/braking
4000	4 / 2	200 /160
8000	8 / 4	400 / 360
12000	12 / 6	600 / 560
16000	16 / 8	800 / 760

Fig.5-13: PWM Frequencies and Associated Motor Control Frequency Thresholds for PWM Switching

☞ "Speed dependent PWM switching" and "load dependent PWM switching" cannot be activated simultaneously!

5.4.5 Operation Modes

Single-Step Relative Set in Operation Mode "MotionProfile"

In the "MotionProfile" mode, it is possible to describe a relative rest in rest motion by the motion law of **one step**. Previously, a set with at least 2 segments was always required for relative processing.

5.4.6 Extended Axis Functions

Star-Delta Switching for Synchronous Motors

With IndraDrive, star-delta switching is generally handled as winding switching. That is to say, the motor data are not automatically calculated from star to delta and vice versa, but the corresponding data for inductance, resistance, current loop gain etc. must be entered separately for each parameter set. The input is supported by the IndraWorks dialog "Parameter Set Switching".

The paragraphs below describe the commissioning and determination of the commutation setting. The starting point of the described procedure is an already parameterized motor for star and delta switching in the respective parameter sets.

The motor encoder used determines the commissioning steps. Three encoder types are differentiated:

- Rexroth motors with absolute encoder and data memory
- Absolute motor encoder with data memory
- Incremental encoder

Rexroth motors with absolute encoder and data memory

For Rexroth motors, the motor data and the commutation offset have been stored in the feedback memory. With star-delta-switchable motors, the commutation offset (P-0-3008, Commutation offset, type plate) and the motor data have only been stored for star switching. The data for delta switching are not contained and must be subsequently loaded with IndraWorks. Rexroth motors with motor data in the data memory are not suited for star-delta switching.

Absolute motor encoder with data memory

For third-party motors or Rexroth kit motors, there aren't any motor data stored in the encoder memory.

Even if the encoder has a data memory, the commutation offset is not allowed to be stored there because only one memory cell has been reserved. To avoid the storing of the commutation offset, set bit 9 = "1" in the parameter "P-0-0522, Control word for commutation setting".

It is therefore necessary to carry out the initial commissioning of the commutation for the parameter sets used.

During the initial commissioning, the values for "P-**0**-0508, Commutation offset" to P-**7**-0508 must be determined by the automatic commutation setting which has to be carried out in the corresponding parameter set. Thus, the values of P-**0**-0508 to P-**7**-0508 are only stored in the drive and not in the feedback. When the parameter sets are switched, the parameter "P-0-0521, Effective commutation offset" is initialized from the parameters P-**0**-0508 to P-**7**-0508.

☞ After a motor was replaced, the commutation angles are wrong; the initial commissioning must be repeated.

Incremental encoder

After the control voltage has been switched on or by switching to the parameter mode, the commutation angle of the motor is unknown. With incremental measuring systems, the actual position value is set to zero as switching to the operating mode takes place. The commutation offset, the angle between the actual position value and the correct commutation angle, must be determined first.

This is done automatically when switching drive enable on or by the "commutation setting" command. Due to the type of construction of the motor and the external load depending on the application, the commutation setting is not always ideal. To always ensure the optimum commutation offset for incremental measuring systems, the commutation offset should be related to the reference mark of the encoder.

For this purpose, initial commissioning must be carried out:

Initial commissioning

For encoders with one reference mark per revolution, the optimum correction with regard to the reference mark can be used (an encoder gear is not allowed). For this purpose, the initial commissioning must be carried out in each parameter set. (Initial commissioning of the commutation "P-0-0522, Control word for commutation setting", bit 15 = "1")

It is first necessary to determine the optimum commutation angle by the command for "commutation offset determination" and subsequent optimization. Afterwards, the commutation angle must be related to the zero mark of the encoder and stored in the parameter "P-x-0508, Commutation offset".

Optimized commutation by homing procedure

If the reference has not been established, the reference mark evaluation is activated in the case of the commands "drive-controlled homing procedure" or "spindle positioning". When the axis passes the reference mark of the encoder, the offset between the commutation angle and the reference mark is stored in the parameter "P-x-0508, Commutation offset" of the current parameter set.

The optimization and homing procedure must be carried out in each parameter set so that the respective optimum commutation offset with regard to the reference mark is stored in each P-x-0508.

☞ When the "spindle positioning" command is used, the reference must be cleared before, e.g. with the "clear reference" command.

Optimized commutation by means of cyclic reference mark evaluation

When the cyclic reference mark evaluation ("S-0-0277, Position feedback 1 type", bit 9 = "1") and the acceptance in the case of cyclic reference mark evaluation have been activated ("P-0-0522, Control word for commutation setting", bit 10), the commutation offset with regard to the reference mark is stored at the next reference mark of the encoder.

Upon successful initial commissioning, the bit 15 must be cleared in the parameter P-0-0522 (bit 15 = "0").

Acceptance of optimized commutation offset during homing procedure

If the optimum commutation angle with regard to the reference mark is to be accepted, bit 11 must be set in the parameter "P-0-0522, Control word for commutation setting" (bit 11 = "1"). That is to say, the reference mark evaluation is activated during the execution of the "drive-controlled homing procedure" command or the "spindle positioning" command (if the reference has not been established). When the reference mark is passed, the optimized commutation angle becomes active.

Acceptance of optimized commutation offset by means of cyclic reference mark evaluation

The cyclic reference mark evaluation must be active.

If bit 10 = "1" and bit 11 = "1" in the parameter "P-0-0522, Control word for commutation setting", acceptance takes place automatically when the first reference mark of the encoder is passed.

In the case of winding switching, the acceptance of the optimum commutation angle with regard to the reference point is restarted after each parameter set switching. Thus, for each winding switching the optimized commutation angle becomes active after the parameter set switching, when the first reference mark of the encoder is passed.

Cogging Torque Compensation for Encoders without Reference Mark

The determination of the position reference for cogging torque compensation by homing is activated in the control word of cogging torque compensation (P-0-1131, Control word of cogging torque compensation, bit 14).

The automatic marker search for determining the position reference is switched off. In the case of encoders with a zero mark, for example, the position reference up to now had been established when the zero mark was detected for the first time.

The position reference is determined during the homing procedure. Thus, the position reference for cogging torque compensation can also be established for special cases:

- Selection of mark via reference cam

- Reference value is positive stop
- Reference value is travel range limit switch

In the functions "drive-controlled" and "NC-controlled homing", the position value is stored as the position reference value for cogging torque compensation when the reference (cam, positive stop, etc.) is detected.

External Cogging Torque Compensation

Position dependent torque/force command values become effective in the motor control to compensate for the cogging behavior of a synchronous motor. These position dependent compensation values are saved internally in the drive tables of list parameters. The currently effective compensation command value is displayed in the new parameter "P-0-1129, Control word for commutation settingCogging torque compensation value".

The following limitations are in effect for compensation values:

- S-0-0092, Bipolar torque/force limit value
- P-0-0109, Torque/force peak limit

The following limitations are **not** in effect for compensation values:

- S-0-0082, Torque/force limit value positive
- S-0-0083, Torque/force limit value negative

The parameter "P-0-1129, Cogging torque compensation value" is set to the value "0" if the (drive-internal) cogging torque compensation is deactivated. P-0-1129 can then be described cyclically by a control master; the processing in the controller takes place in the velocity loop clock. The value is entered in the motor control as an added torque/force command value. In this way, cogging torque compensation values can take effect in the motor control from an external location (e.g. via MLD, etc.). If the drive-internal cogging torque compensation is activated, values written to P-0-1129 from an external location are ignored.

☞ The drive-internal cogging torque compensation is only available in the functional packages "Servo" and "Sync"! Cogging torque compensation values can already be specified from an external location in the base package via P-0-1129!

5.4.7 Optional Device Functions

MLD 1G with SERCOS III Modular I/Os

The following types of up to 4 SERCOS modular I/O devices with a maximum of 16 modules each are supported:

- Digital outputs (S-0-1502)
- Digital inputs (S-0-1503)
- Analog outputs (S-0-1504)
- Analog inputs (S-0-1505)
- Possibly selected I/O nodes (modules) of the inline I/Os with complex protocol (S-0-1507)

In IndraWorks-MLD, the actual configuration and command configuration are displayed for diagnostic purposes. The current diagnosis and the properties (electric type plate) of the I/O device are displayed, too. For each I/O slave, MLD makes available a container parameter which can include the maximum supported input/output image of a modular I/O (200 bytes). The container parameter is a list parameter P-0-14xy of a maximum length of 200 bytes. If this parameter is configured in "P-0-1627, CCD: configuration list master cmd values I/Os", there is no length check and as many bytes as configured in the connection to the I/O are taken from the container parameter and transmitted to the I/O slave.

Container parameters for SERCOS III E/A

Inputs:

- P-0-1470.0.1, PLC inputs area AT %IB1000 - %IB1199
- P-0-1470.0.2, PLC inputs area AT %IB1200 - %IB1399
- P-0-1470.0.3, PLC inputs area AT %IB1400 - %IB1599
- P-0-1470.0.4, PLC inputs area AT %IB1600 - %IB1799

Outputs:

- P-0-1471.0.1, PLC outputs area AT %QB1000 - %QB1199
- P-0-1471.0.2, PLC outputs area AT %QB1200 - %QB1399
- P-0-1471.0.3, PLC outputs area AT %QB1400 - %QB1599
- P-0-1471.0.4, PLC outputs area AT %QB1600 - %QB1799

The configuration of the modular I/Os in IndraWorks has not been provided for.

Therefore, operation is limited to

- I/O devices which are directly configured via a separate tool
- modules which do not need to be configured
- modules with a complex protocol (S-0-1507) which can be configured at runtime by means of a function block

The I/O image of the maximum of four I/O devices has been permanently mapped to the process image.

Identification for CCD Slaves

When the CCD group is in phase 2, it is possible with P-0-1619 to recognize which slave type is at which position in the CCD group. This allows, for example, checking the topology and the wiring order to ensure correct remote address assignment. The parameter P-0-1619 provides different pieces of information on the recognized slaves at their topology locations.

From the CCD master, it is possible to specifically control the diagnostic LED of a SERCOS III slave in the CCD group. With "P-0-1620.0.4, CCD: Slave identification" for a SERCOS III slave in phase 2 it is possible to control the diagnostic LED from the CCD master by entering a topology location (cf. "P-0-1603, CCD: Actual topology addresses"). This allows identifying a specific SERCOS III slave at a topology location.

SERCOS III CCD System Mode

With the corresponding master communication of the CCD master, the SERCOS III or EtherCAT® CCD system mode can be set for the CCD group. In this way, the communication channels of the superimposed SERCOS III/ EtherCAT® network are available to the CCD slaves of the subordinate SERCOS III network (CCD group).

The CCD slaves (in the subordinate network) can be directly addressed by the master of the superimposed network and behave as if they had been directly included in the superimposed network. With regard to the higher-level master communication master, the CCD group (CCD master + CCD slaves) behaves like a device with up to 8 axes/slaves. The SERCOS III I/Os and SERCOS III encoders, however, cannot be addressed by the higher-level master communication master and they are invisible to the master.

Backup-Restore Function

This function allows managing the device data of a complete CCD group by means of a central machine archive. The machine archive is stored on the SD card of the CCD master. It is possible to store the active parameterization of all drives in the CCD group in centralized form and to restore it, if required, or to load an existing machine archive to another installation.

The machine archive contains all the application-relevant data (parameters according to the list of backup operation data, MLD program, retain variables, firmware).

The following actions are possible:

- Save, restore or update an MLD project with and without MLD retain data
- Save, restore or update the operating data of one or several axes
- Carry out a firmware update
- After a device has been replaced, put the new device into operation with the configuration of the old device
- Duplicate an existing installation

> ☞ The backup-restore function requires an IndraDrive Cs Advanced device with SD card.

Rotary Preferred Scaling of the Measuring Encoder

Up to now, only incremental scaling had been possible for measuring encoders. Rotary preferred scaling is now possible with the fixed setting of modulo 360° per measuring encoder revolution and four decimal places. The setting is made in parameter "P-0-0330, Control word of measuring encoder". The measuring encoder can still be used as a master axis encoder (incremental scaling) for the axis, and alternatively as an actual position value encoder (rotary scaling) for the control master. The position data reference of the measuring encoder is established as before, the encoders that can be used are unchanged.

> ☞ When rotary scaling has been set, the measuring encoder can no longer be used as a master axis encoder for the axis!

5.4.8 Handling, Diagnostic and Service Functions

Percentage-Based Scaling of the Message n_feedback == n_command

In addition to the absolute velocity window (S-0-0157, Velocity window), a percentage-based velocity window (S-0-0272, Velocity window as percentage) is implemented. The message n_feedback = n_command is output when the absolute velocity window (S-0-0157) or the percentage-based velocity window (S-0-0272) has been reached. The effective velocity window is calculated as follows:

Effective V-window = (percentage-based V-window) * V-command value + (absolute V-window)

Effective V-window = S-0-0272 * (S-0-0036 + S-0-0037 + P-0-0690) + S-0-0157

When the percentage-based window is set to "0", only the absolute window takes effect, the message behaves as it did before "S-0-0272, Velocity window as percentage" had been implemented.

The default value of parameter S-0-0272 = "0". When the absolute window is set to "0", only the percentage-based window takes effect.

Status messages:

- S-0-0330, n_feedback = n_command
- n_command = S-0-0036 + S-0-0037 + P-0-0690
- n_command = velocity command value + (additive velocity command value) + (additive velocity command value, process loop)
- n_feedback = "S-0-0040, Velocity feedback value"
- S-0-0330 = "1", when

  | (n_cmd - n_feedback) | <= | (n_cmd) * S-0-0272 + S-0-0157 |

Configurable Error Class

In MPx17, the user can reclassify some error cases as warning. After an error has been reclassified, it is not an error reaction that takes place when such an error occurs, but only a warning is output. The parameter "P-0-0173, List of configurable axis-specific monitoring functions" is used for reclassification.

☞ When an error has been reclassified, only a warning is output instead of the error message; the warning shows the control master that there is a problem. It is the user's responsibility to react to the diagnostic warning messages in an appropriate way. If this is not the case, the machine or installation can be damaged.

List of the currently planned reclassifiable axis errors for MPx17: "P-0-0173, List of configurable axis-specific monitoring functions"

List element	Default value	Diagnostic text	Alternative diagnostic messages	Diagnostic text
0	0x000F2031	Encoder 1 error: Signal amplitude incorrect	0x000E2031	Encoder 1 warning: Signal amplitude incorrect
1	0x000F2037	Excessive position command difference	0x000E2037	Excessive position command difference warning
2	0x000F2042	Encoder 2: Encoder signals incorrect	0x000E2042	Encoder 2 warning: Encoder signals incorrect
3	0x000F2043	Measuring encoder: Encoder signals incorrect	0x000E2043	Measuring encoder warning: Encoder signals incorrect

Fig.5-14: P-0-0173, List of Configurable Axis-specific Monitoring Functions

The reclassification of errors as warnings has consequences, particularly when an external encoder is used as a redundant motor encoder:

If the error case "signal amplitude/encoder signals incorrect" of the motor encoder (F2031 Encoder 1 error: signal amplitude incorrect) has been classified as a warning:

- When the motor encoder is defective and the external encoder is intact, there is no error reaction. The control of the motor continues with the external encoder acting as a redundant motor control encoder. The drive outputs the warning "E2031 Encoder 1 warning: Signal amplitude incorrect".

- When the motor encoder is defective and the external encoder has already been defective, the drive signals the fatal error "F8022 Enc. 1: Enc. signals incorr. (can be cleared in ph. 2)", the motor goes torque-free and coasts to stop.

If the error case "signal amplitude/encoder signals incorrect" of the ext. encoder (F2042 Encoder 2: Encoder signals incorrect) has been classified as a warning:

- When the external encoder is defective, there is no error reaction, if the motor encoder is intact. The control of the motor is maintained, because normal operation is not disturbed. The drive outputs the warning "E2042 Encoder 2 warning: Encoder signals incorrect".
- When the external encoder is defective and the motor encoder has already been defective, the drive signals the fatal error "F8042 Encoder 2 error: Signal amplitude incorrect", the motor goes torque-free and coasts to stop.

If the error case "signal amplitude/encoder signals incorrect", neither for the motor encoder (F2031) nor for the ext. encoder (F2042) has been classified as a warning:

- When one of the two encoders is defective, the configured error reaction takes place, because one encoder can still be used for motor control. The drive outputs the corresponding error message "F2031 Encoder 1 error: signal amplitude incorrect" or "F2042 Encoder 2: Encoder signals incorrect".

Resetting the described errors and clearing the warnings is only possible by changing to the parameter mode (PM, P2).

"Reboot" Command

By means of the "C6400 Reboot command", the drive can be directly restarted via the higher-level control section or via an engineering tool, without switching the 24 V control voltage supply off and on. The drive goes through the booting process as usual and changes are applied which require the reboot of the device, such as a change in the master communication in parameter "P-0-4089.0.1, Master communication: Protocol" or a change of the functional packages (P-0-2003, Selection of functional packages). The command is started with a delay of 2 seconds so that the master can restart all drives without interruption in the case of multi-axis systems.

The delay cannot be parameterized.

The command is started via the parameter "S-0-1350, C6400 reboot command". The command can only be executed in the parameter mode.

Outlook for Load

By presetting the load of the thermal monitoring models to 90%, for example, for the amplifier, motor and braking resistor, it is possible to recognize, when a machining cycle is processed, whether the load basically falls or keeps rising. It is thereby possible to judge whether the average load is smaller than the maximum load.

If high peak load values occur during a machining cycle, the thermal models limit the output current. This is not allowed in many processes.

In order to decide whether a machining cycle is thermally possible, the maximum load must be determined with a small load during a cycle.

The following procedure is necessary (example of amplifier load):

- Before starting a machining cycle, reset the parameter "P-0-0465, Maximum value thermal drive load" (P-0-0465 = "0").

- Before starting a machining cycle, read the current load "P-0-0141, Thermal drive load".
- After the first machining cycle, read the parameter "P-0-0465, Maximum value thermal drive load".
- Calculate the load resource for a machining cycle from: (P-0-0465, Maximum value thermal drive load) - (P-0-0141, Thermal drive load)
- Set the parameter for the load "P-0-0141, Thermal drive load" to the value: 100% - ([P-0-0465] - [P-0-0141])
- If the load continued to rise after another machining cycle, the machining cycle cannot be processed. If the load falls, continuous processing is possible.

Carry out this procedure for the motor load and braking resistor load, too.

Using the prewarning thresholds:

To avoid transmitting the load data always in the cyclic channel for monitoring, there are prewarning thresholds.

When the prewarning thresholds are set to the value: 100% - ([P-0-0465] - [P-0-0141]), the load can be monitored with bit 2 of "S-0-0012, Class 2 diagnostics" as a prewarning bit. The prewarning bits can be configured for a real-time status bit or signal status word.

Pertinent Parameters:

- P-0-0141, Thermal drive load
- P-0-0441, Thermal drive load warning threshold
- P-0-0465, Maximum value thermal drive load
- P-0-0466, Maximum value thermal motor load
- P-0-0467, Maximum value thermal load of Braking resistor
- P-0-0468, Prewarning threshold of therm. motor load
- P-0-0469, Prewarning threshold of therm. load of braking resistor
- P-0-0844, thermal load of Braking resistor

The long-term trend of the load can only be recognized by writing the value = 100% - ([P-0-0465] - [P-0-0141]) to the load.

Configurable Standard Control Panel Application

The configurable standard control panel application is made available to the user in the form of two new menu items within the easy menu. For each menu item, there is a configuration parameter. One configuration parameter is made available for the menu item "Quick Setup" (changeable parameters), another configuration parameter for the menu item "Actual Values" (parameters to be displayed, actual values): "P-0-0680.0.1, Control panel: Config. list of changeable app. parameters" and "P-0-0680.0.2., Ctrl panel: Config. list of app. parameters to be displayed".

5.4.9 Engineering/Diagnostic Interfaces

Deactivation of Diagnostic Message as Running Text

Via the parameter "P-0-0680, Control panel: Configuration", bit 15, the running text of the diagnostic messages on the display (e.g. in the case of command errors) can be switched off and on. In the default state, the diagnostic message is output as a running text. When the running text of the diagnostic message has been switched off, the display only shows the diagnostic message number.

ComServer

With MPx-17, Rexroth IndraWorks HMI with the VCP device group is supported. VCP can access all S and P parameters in reading form and, if necessary, in writing form. Accessing MLD variables requires the Advanced control panel with plugged SD card.

Default IP Address for Engineering Port

The default IP address for the Engineering Port of the Advanced device is "192.168.1.<S-0-01040>".

5.5 New, Modified or no Longer Existing Parameters

5.5.1 New Parameters

- P-0-0070, Effective additive torque/force command value
- P-0-0101, Configuration STO/SBC
- P-0-0112, Actual velocity value of motor
- P-0-0113, Bipolar velocity limit value of motor
- P-0-0173, List of configurable axis-specific monitoring functions
- P-0-0174, Enabling of device-specific error reaction
- P-0-0175, List of configurable device-specific monitoring functions
- P-0-0249, E-Stop and safety zones
- P-0-0250, System identification
- P-0-0250.0.1, System data
- P-0-0446, Thermal motor load
- P-0-0447, Motor shaft power
- P-0-0458, Delay of add. command values
- P-0-0465, Maximum value thermal drive load
- P-0-0466, Maximum value thermal motor load
- P-0-0467, Maximum value thermal load of Braking resistor
- P-0-0468, Prewarning threshold of therm. motor load
- P-0-0469, Prewarning threshold of therm. load of braking resistor
- P-0-0509, Commutation offset coarse
- P-0-0519, Commutation status word
- P-0-0526, Displacement during brake check
- P-0-0553, Voltage loop proportional gain
- P-0-0610, Control word of current rms value generator
- P-0-0611, Current rms value
- P-0-0660.0.0, configurable factory default values
- P-0-0664, C6800 Control command device data archiving
- P-0-0665, C6500 Command Archive device data
- P-0-0666, C6600 Command Restore device data
- P-0-0667, C6700 Command update of device data
- P-0-0668, Device data archiving, configuration
- P-0-0669, Device data archiving, status
- P-0-0680, Control panel: Configuration

- P-0-0680.0.1, Control panel: Config. list of changeable app. parameters
- P-0-0680.0.2, Ctrl panel: Config. list of app. parameters to be displayed
- P-0-0710, Number of motion steps, set 1
- P-0-0756, Virtual master axis, scaling type
- P-0-0757, Virtual master axis, modulo value
- P-0-0758, Virtual master axis, actual position value
- P-0-0759, Virtual master axis, actual velocity value
- P-0-0760, Virtual master axis, positioning control word
- P-0-0761, Master axis position for slave axis
- P-0-0762, Virtual master axis, velocity limit value
- P-0-0763, Modulo factor, master axis format converter
- P-0-0766, Virtual master axis, positioning command value
- P-0-0767, Virtual master axis, effective target position
- P-0-0768, Virtual master axis, positioning status
- P-0-0769, Virtual master axis, command value mode
- P-0-0770, Virtual master axis, positioning velocity
- P-0-0771, Virtual master axis, positioning acceleration
- P-0-0772, Virtual master axis, positioning deceleration
- P-0-0773, Number of bits per master axis revolution, format converter
- P-0-0774, Virtual master axis, positioning window shortest distance
- P-0-0787, Group axis 1 position
- P-0-0788, Group axis 1 position, fine-interpolated
- P-0-0900, Encoder emulation signal selection list
- P-0-0901.0.1, Encoder emulation signal selection
- P-0-0901.0.2, Encoder emulation control parameter
- P-0-0901.0.3, Encoder emulation resolution
- P-0-0901.0.4, Encoder emulation zero pulse offset
- P-0-0901.0.5, Encoder emulation zero pulse distance
- P-0-0901.0.6, Encoder emulation assignment
- P-0-0901.0.7, Encoder emulation, external signal
- P-0-0901.0.8, Encoder emulation, modulo value of external signal
- P-0-0911, Virtual master axis, positioning window
- P-0-0912, Virtual master axis, standstill window
- P-0-0913, Virtual master axis, positioning jerk
- P-0-0914, Virtual master axis, velocity threshold positioning
- P-0-0915, Master axis format converter IDN list signal selection
- P-0-0916, Master axis format converter signal selection
- P-0-0917, Control word of master axis generator
- P-0-0918, Feed travel internal virtual master axis
- P-0-0919, Synchronization mode, secondary master
- P-0-0920, Synchronization acceleration, secondary master
- P-0-0921, Synchronization velocity, secondary master
- P-0-0922, Preferred synchronization direction, secondary master

- P-0-0923, Synchroniz. window for shortest distance, secondary master
- P-0-0924, Selection primary master
- P-0-0925, Master drive gear input revolutions, secondary master
- P-0-0926, Master drive gear output revolutions, secondary master
- P-0-0927, Master drive gear fine adjustment, secondary master
- P-0-0928, Additive master axis position, secondary master
- P-0-0929, Change velocity of add. master axis posit., secondary master
- P-0-0930, Change accel. of add. master axis posit., secondary master
- P-0-0931, Synchronous position, secondary master
- P-0-0932, Synchronization range, secondary master
- P-0-1129, Cogging torque compensation value
- P-0-1140, Velocity control loop filter: Numerator natural frequency
- P-0-1141, Velocity control loop filter: Denominator natural frequency
- P-0-1142, Velocity control loop filter: Numerator damping
- P-0-1143, Velocity control loop filter: Denominator damping
- P-0-1159, Command value generator, sine sweep start frequency
- P-0-1160, Command value generator, sine sweep end frequency
- P-0-1270, PLC Global Register A0
- P-0-1271, PLC Global Register A1
- P-0-1272, PLC Global Register A2
- P-0-1273, PLC Global Register A3
- P-0-1274, PLC Global Register A4
- P-0-1275, PLC Global Register A5
- P-0-1276, PLC Global Register A6
- P-0-1277, PLC Global Register A7
- P-0-1278, PLC Global Register A8
- P-0-1279, PLC Global Register A9
- P-0-1280, PLC Global Register A10
- P-0-1281, PLC Global Register A11
- P-0-1282, PLC Global Register A12
- P-0-1283, PLC Global Register A13
- P-0-1284, PLC Global Register A14
- P-0-1285, PLC Global Register A15
- P-0-1286, PLC Global Register A16
- P-0-1287, PLC Global Register A17
- P-0-1288, PLC Global Register A18
- P-0-1289, PLC Global Register A19
- P-0-1290, PLC Global Register A20
- P-0-1291, PLC Global Register A21
- P-0-1292, PLC Global Register A22
- P-0-1293, PLC Global Register A23
- P-0-1294, PLC Global Register A24
- P-0-1295, PLC Global Register A25

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- P-0-1296, PLC Global Register A26
- P-0-1297, PLC Global Register A27
- P-0-1298, PLC Global Register A28
- P-0-1299, PLC Global Register A29
- P-0-1300, PLC Global Register A30
- P-0-1301, PLC Global Register A31
- P-0-1311, PLC Global Register GL1
- P-0-1312, PLC Global Register GL2
- P-0-1316, PLC Global Register G16
- P-0-1317, PLC Global Register G17
- P-0-1318, PLC Global Register G18
- P-0-1319, PLC Global Register G19
- P-0-1320, PLC Global Register G20
- P-0-1321, PLC Global Register G21
- P-0-1322, PLC Global Register G22
- P-0-1323, PLC Global Register G23
- P-0-1324, PLC Global Register G24
- P-0-1325, PLC Global Register G25
- P-0-1326, PLC Global Register G26
- P-0-1327, PLC Global Register G27
- P-0-1328, PLC Global Register G28
- P-0-1329, PLC Global Register G29
- P-0-1330, PLC Global Register G30
- P-0-1331, PLC Global Register G31
- P-0-1350, PLC control word
- P-0-1351, PLC status word
- P-0-1352, PLC user program administration data
- 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
- P-0-1359, PLC retain data
- P-0-1360, PLC program identifier
- P-0-1361, PLC program name
- P-0-1363, PLC project info
- P-0-1364, PLC idle time
- P-0-1365, PLC error message
- P-0-1367, PLC configuration
- P-0-1368, PLC Global Register AL0
- P-0-1370, PLC Global Register G0
- P-0-1371, PLC Global Register G1

- P-0-1372, PLC Global Register G2
- P-0-1373, PLC Global Register G3
- P-0-1374, PLC Global Register G4
- P-0-1375, PLC Global Register G5
- P-0-1376, PLC Global Register G6
- P-0-1377, PLC Global Register G7
- P-0-1378, PLC Global Register G8
- P-0-1379, PLC Global Register G9
- P-0-1380, PLC Global Register G10
- P-0-1381, PLC Global Register G11
- P-0-1382, PLC Global Register G12
- P-0-1383, PLC Global Register G13
- P-0-1384, PLC Global Register G14
- P-0-1385, PLC Global Register G15
- P-0-1386, PLC display format Global Register
- P-0-1387, PLC Global Register AT0
- P-0-1388, PLC Global Register AT1
- P-0-1389, PLC Global Register GL0
- P-0-1390, PLC input WORD0 AT %IB0
- P-0-1391, PLC input WORD1 AT %IB2
- P-0-1392, PLC input WORD2 AT %IB4
- P-0-1393, PLC input WORD3 AT %IB6
- P-0-1394, PLC input WORD4 AT %IB8
- P-0-1395, PLC input WORD5 AT %IB10
- P-0-1396, PLC input WORD6 AT %IB12
- P-0-1397, PLC input WORD7 AT %IB14
- P-0-1398, PLC input WORD8 AT %IB16
- P-0-1399, PLC input WORD9 AT %IB18
- P-0-1400, PLC input WORD10 AT %IB20
- P-0-1401, PLC input WORD11 AT %IB22
- P-0-1402, PLC input WORD12 AT %IB24
- P-0-1403, PLC input WORD13 AT %IB26
- P-0-1404, PLC input WORD14 AT %IB28
- P-0-1405, PLC input WORD15 AT %IB30
- P-0-1406, PLC input WORD16 AT %IB32
- P-0-1407, PLC input WORD17 AT %IB34
- P-0-1408, PLC input WORD18 AT %IB36
- P-0-1409, PLC input WORD19 AT %IB38
- P-0-1410, PLC output WORD0 AT %QB0
- P-0-1411, PLC output WORD1 AT %QB2
- P-0-1412, PLC output WORD2 AT %QB4
- P-0-1413, PLC output WORD3 AT %QB6
- P-0-1414, PLC output WORD4 AT %QB8

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- P-0-1415, PLC output WORD5 AT %QB10
- P-0-1416, PLC output WORD6 AT %QB12
- P-0-1417, PLC output WORD7 AT %QB14
- P-0-1418, PLC output WORD8 AT %QB16
- P-0-1419, PLC output WORD9 AT %QB18
- P-0-1420, PLC output WORD10 AT %QB20
- P-0-1421, PLC output WORD11 AT %QB22
- P-0-1422, PLC output WORD12 AT %QB24
- P-0-1423, PLC output WORD13 AT %QB26
- P-0-1424, PLC output WORD14 AT %QB28
- P-0-1425, PLC output WORD15 AT %QB30
- P-0-1426, PLC output WORD16 AT %QB32
- P-0-1427, PLC output WORD17 AT %QB34
- P-0-1428, PLC output WORD18 AT %QB36
- P-0-1429, PLC output WORD19 AT %QB38
- P-0-1440, PLC input DWORD25 AT %IB100
- P-0-1441, PLC input DWORD26 AT %IB104
- P-0-1442, PLC input DWORD27 AT %IB108
- P-0-1443, PLC input DWORD28 AT %IB112
- P-0-1444, PLC input DWORD29 AT %IB116
- P-0-1445, PLC input DWORD30 AT %IB120
- P-0-1446, PLC input DWORD31 AT %IB124
- P-0-1447, PLC input DWORD32 AT %IB128
- P-0-1449, C4900 PLC command
- P-0-1470.0.1, PLC inputs area AT %IB1000 - %IB1199
- P-0-1470.0.2, PLC inputs area AT %IB1200 - %IB1399
- P-0-1470.0.3, PLC inputs area AT %IB1400 - %IB1599
- P-0-1470.0.4, PLC inputs area AT %IB1600 - %IB1799
- P-0-1471.0.1, PLC outputs area AT %QB1000 - %QB1199
- P-0-1471.0.2, PLC outputs area AT %QB1200 - %QB1399
- P-0-1471.0.3, PLC outputs area AT %QB1400 - %QB1599
- P-0-1471.0.4, PLC outputs area AT %QB1600 - %QB1799
- P-0-1516, Circuit board code optional module 5
- P-0-1517, Circuit board code optional module 6
- P-0-1521, Programming module identifier
- P-0-1522, Type data of module 3
- P-0-1600, CCD: configuration
- P-0-1601, CCD: addresses of projected drives
- P-0-1602, CCD: timing settings
- P-0-1603, CCD: Actual topology addresses
- P-0-1604, CCD: addresses of projected I/Os
- P-0-1605, CCD: command communication phase
- P-0-1606, CCD: actual communication phase

- P-0-1607, CCD: axis error
- P-0-1608, CCD: control word
- P-0-1609, CCD: status word
- P-0-1610, CCD: cycle time
- P-0-1610.0.3, CCD: Actual topology
- P-0-1610.0.21, CCD: Slave addresses at end of line
- P-0-1610.0.30, CCD: Diagnostic message text
- P-0-1610.0.31, CCD: Diagnosis code
- P-0-1611, CCD: configuration list signal status word
- P-0-1612, CCD: configuration list signal control word
- P-0-1613, CCD: assignment list signal status word
- P-0-1614, CCD: assignment list signal control word
- P-0-1615, CCD: extrapolated cmd value IDN list signal selection
- P-0-1616, CCD: extrapolated cmd value signal selection
- P-0-1617, CCD: number of extrapolation steps
- P-0-1618, CCD: extrapolated command value
- P-0-1619, CCD: Slave information at topology location
- P-0-1620.0.3, CCD: Command topology
- P-0-1620.0.4, CCD: Slave identification
- P-0-1620.0.5, C7400 CCD: Switching to phase 2
- P-0-1620.0.6, C7500 CCD: Switching to phase 4
- P-0-1620.0.21, C7100 CCD: Command Close ring
- P-0-1620.0.30, CCD: I/O selection for commando C72
- P-0-1620.0.31, C7200 CCD: Commando Apply I/O configuration
- P-0-1621, CCD: configuration list master communication cmd values
- P-0-1621.0.1, CCD: Slave address in high level network
- P-0-1621.0.9, CCD: Master comm. C0100 Comm. phase 3 transition check
- P-0-1621.0.10, CCD: Master comm. C5200 Comm. phase 4 transition check
- P-0-1621.0.24, CCD: Master communication gateway parameter pool 1
- P-0-1621.0.25, CCD: Master communication gateway parameter pool 2
- P-0-1621.0.35, C5300 CCD: SIII SYNC delay measuring procedure command
- P-0-1622, CCD: configuration list master communication actual values
- P-0-1623, CCD: configuration list master cmd values
- P-0-1624, CCD: configuration list actual master values
- P-0-1625, CCD: configuration list slave cmd values
- P-0-1626, CCD: configuration list actual slave values
- P-0-1627, CCD: configuration list master cmd values I/Os
- P-0-1628, CCD: configuration list act. master values I/Os
- P-0-1629, CCD: configuration compact I/Os
- P-0-1630, CCD: diagnosis
- P-0-1630.000.001, CCD: Slave IP address

Notes on Application

- P-0-1630.000.002, CCD: Device Status (S-Dev)
- P-0-1630.000.003, CCD: Connection-Control #0 (C-Con)
- P-0-1630.000.020, CCD: Resource-Status (S-Res)
- P-0-1631, CCD: AT error counter
- P-0-1632, CCD: system data 2 bytes
- P-0-1633, CCD: system data 4 bytes
- P-0-1634.0.1, CCD: Module type codes of the modular I/Os
- P-0-1635, C7000 CCD: command adjust slave addresses
- P-0-1636, CCD: Command topology addresses
- P-0-1637, CCD: error counter Port-1
- P-0-1638, CCD: error counter Port-2
- P-0-1639, CCD: allowed telegram failures
- 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-0-1645.001, CCD connection: Configuration
- P-0-1645.002, CCD connection: Connection number
- P-0-1645.003, CCD connection: Telegram assignment
- P-0-1645.004, CCD connection: Max. length of connection
- P-0-1645.005, CCD connection: Current connection length
- P-0-1645.006, CCD connection: Configuration list
- P-0-1645.007, CCD connection: Assigned connection capability
- P-0-1645.008, CCD connection: Connection control (C-Con)
- P-0-1645.009, CCD connection: State
- P-0-1645.010, CCD connection: Producer cycle time
- P-0-1645.011, CCD connection: Allowed losses of producer data
- P-0-1645.012, CCD connection: Error counter data losses
- P-0-1645.020, CCD connection: IDN allocation of real-time bits
- P-0-1645.021, CCD connection: Bit number allocation of real-time bits
- P-0-1651, CCD: master control word, slave 1
- P-0-1652, CCD: master control word, slave 2
- P-0-1653, CCD: master control word, slave 3
- P-0-1654, CCD: master control word, slave 4
- P-0-1655, CCD: master control word, slave 5
- P-0-1656, CCD: master control word, slave 6
- P-0-1657, CCD: master control word, slave 7
- P-0-1658, CCD: master control word, slave 8
- P-0-1659, CCD: master control word, slave 9
- P-0-1660.002, CCD: Device Control (C-Res)
- P-0-1660.003, CCD: Connection-Control #1 (C-Con)
- P-0-1660.020, CDD: Resource-Control (C-Res)
- P-0-1661, CCD: drive status word, slave 1

- P-0-1662, CCD: drive status word, slave 2
- P-0-1663, CCD: drive status word, slave 3
- P-0-1664, CCD: drive status word, slave 4
- P-0-1666, CCD: drive status word, slave 6
- P-0-1667, CCD: drive status word, slave 7
- P-0-1668, CCD: drive status word, slave 8
- P-0-1669, CCD: drive status word, slave 9
- P-0-1670, CCD: active actual position value, master
- P-0-1671, CCD: active actual position value, slave 1
- P-0-1672, CCD: active actual position value, slave 2
- P-0-1673, CCD: active actual position value, slave 3
- P-0-1674, CCD: active actual position value, slave 4
- P-0-1675, CCD: active actual position value, slave 5
- P-0-1676, CCD: active actual position value, slave 6
- P-0-1677, CCD: active actual position value, slave 7
- P-0-1678, CCD: active actual position value, slave 8
- P-0-1679, CCD: active actual position value, slave 9
- P-0-1680, CCD: actual velocity value, master
- P-0-1681, CCD: actual velocity value, slave 1
- P-0-1682, CCD: actual velocity value, slave 2
- P-0-1683, CCD: actual velocity value, slave 3
- P-0-1684, CCD: actual velocity value, slave 4
- P-0-1685, CCD: actual velocity value, slave 5
- P-0-1686, CCD: actual velocity value, slave 6
- P-0-1687, CCD: actual velocity value, slave 7
- P-0-1688, CCD: actual velocity value, slave 8
- P-0-1689, CCD: actual velocity value, slave 9
- P-0-1690, CCD: actual torque/force value, master
- P-0-1691, CCD: actual torque/force value, slave 1
- P-0-1692, CCD: actual torque/force value, slave 2
- P-0-1693, CCD: actual torque/force value, slave 3
- P-0-1694, CCD: actual torque/force value, slave 4
- P-0-1695, CCD: actual torque/force value, slave 5
- P-0-1696, CCD: actual torque/force value, slave 6
- P-0-1697, CCD: actual torque/force value, slave 7
- P-0-1698, CCD: actual torque/force value, slave 8
- P-0-1699, CCD: actual torque/force value, slave 9
- P-0-1701, CCD: Diagnostic message number, slave 1
- P-0-1702, CCD: Diagnostic message number, slave 2
- P-0-1703, CCD: Diagnostic message number, slave 3
- P-0-1704, CCD: Diagnostic message number, slave 4
- P-0-1705, CCD: Diagnostic message number, slave 5
- P-0-1706, CCD: Diagnostic message number, slave 6

- P-0-1707, CCD: Diagnostic message number, slave 7
- P-0-1708, CCD: Diagnostic message number, slave 8
- P-0-1709, CCD: Diagnostic message number, slave 9
- P-0-1710, CCD: signal status word, master
- P-0-1711, CCD: signal status word, slave 1
- P-0-1712, CCD: signal status word, slave 2
- P-0-1713, CCD: signal status word, slave 3
- P-0-1714, CCD: signal status word, slave 4
- P-0-1715, CCD: signal status word, slave 5
- P-0-1716, CCD: signal status word, slave 6
- P-0-1717, CCD: signal status word, slave 7
- P-0-1718, CCD: signal status word, slave 8
- P-0-1719, CCD: signal status word, slave 9
- P-0-1720, CCD: signal control word, master
- P-0-1721, CCD: signal control word, slave 1
- P-0-1722, CCD: signal control word, slave 2
- P-0-1723, CCD: signal control word, slave 3
- P-0-1724, CCD: signal control word, slave 4
- P-0-1725, CCD: signal control word, slave 5
- P-0-1726, CCD: signal control word, slave 6
- P-0-1727, CCD: signal control word, slave 7
- P-0-1728, CCD: signal control word, slave 8
- P-0-1729, CCD: signal control word, slave 9
- P-0-1730, CCD: Command value data container 1, Master 4Byte
- P-0-1731, CCD: Command value data container 1, Slave 1 4Byte
- P-0-1732, CCD: Command value data container 1, Slave 2 4Byte
- P-0-1733, CCD: Command value data container 1, Slave 3 4Byte
- P-0-1734. CCD: Command value data container 1, Slave 4 4Byte
- P-0-1735, CCD: Command value data container 1, Slave 5 4Byte
- P-0-1736, CCD: Command value data container 1, Slave 6 4Byte
- P-0-1737, CCD: Command value data container 1, Slave 7 4Byte
- P-0-1738, CCD: Command value data container 1, Slave 8 4Byte
- P-0-1739, CCD: Command value data container 1, Slave 9 4Byte
- P-0-1740, CCD: Command value data container 2, Master 4Byte
- P-0-1741, CCD: Command value data container 2, Slave 1 4Byte
- P-0-1742, CCD: Command value data container 2, Slave 2 4Byte
- P-0-1743, CCD: Command value data container 2, Slave 3 4Byte
- P-0-1744, CCD: Command value data container 2, Slave 4 4Byte
- P-0-1745, CCD: Command value data container 2, Slave 5 4Byte
- P-0-1746, CCD: Command value data container 2, Slave 6 4Byte
- P-0-1747, CCD: Command value data container 2, Slave 7 4Byte
- P-0-1748, CCD: Command value data container 2, Slave 8 4Byte
- P-0-1749, CCD: Command value data container 2, Slave 9 4Byte

- P-0-1750, CCD: Command value data container 3, Master 4Byte
- P-0-1751, CCD: Command value data container 3, Slave 1 4Byte
- P-0-1752, CCD: Command value data container 3, Slave 2 4Byte
- P-0-1753, CCD: Command value data container 3, Slave 3 4Byte
- P-0-1754, CCD: Command value data container 3, Slave 4 4Byte
- P-0-1755, CCD: Command value data container 3, Slave 5 4Byte
- P-0-1756, CCD: Command value data container 3, Slave 6 4Byte
- P-0-1757, CCD: Command value data container 3, Slave 7 4Byte
- P-0-1758, CCD: Command value data container 3, Slave 8 4Byte
- P-0-1759, CCD: Command value data container 3, Slave 9 4Byte
- P-0-1760, CCD: Command value data container 4, Master 4Byte
- P-0-1761, CCD: Command value data container 4, Slave 1 4Byte
- P-0-1762, CCD: Command value data container 4, Slave 2 4Byte
- P-0-1763, CCD: Command value data container 4, Slave 3 4Byte
- P-0-1764, CCD: Command value data container 4, Slave 4 4Byte
- P-0-1765, CCD: Command value data container 4, Slave 5 4Byte
- P-0-1766, CCD: Command value data container 4, Slave 6 4Byte
- P-0-1767, CCD: Command value data container 4, Slave 7 4Byte
- P-0-1768, CCD: Command value data container 4, Slave 8 4Byte
- P-0-1769, CCD: Command value data container 4, Slave 9 4Byte
- P-0-1770, CCD: Actual value data container 1, Master 4Byte
- P-0-1771, CCD: Actual value data container 1, Slave 1 4Byte
- P-0-1772, CCD: Actual value data container 1, Slave 2 4Byte
- P-0-1773, CCD: Actual value data container 1, Slave 3 4Byte
- P-0-1774, CCD: Actual value data container 1, Slave 4 4Byte
- P-0-1775, CCD: Actual value data container 1, Slave 5 4Byte
- P-0-1776, CCD: Actual value data container 1, Slave 6 4Byte
- P-0-1777, CCD: Actual value data container 1, Slave 7 4Byte
- P-0-1778, CCD: Actual value data container 1, Slave 8 4Byte
- P-0-1779, CCD: Actual value data container 1, Slave 9 4Byte
- P-0-1780, CCD: Actual value data container 2, Master 4Byte
- P-0-1781, CCD: Actual value data container 2, Slave 1 4Byte
- P-0-1782, CCD: Actual value data container 2, Slave 2 4Byte
- P-0-1783, CCD: Actual value data container 2, Slave 3 4Byte
- P-0-1784, CCD: Actual value data container 2, Slave 4 4Byte
- P-0-1785, CCD: Actual value data container 2, Slave 5 4Byte
- P-0-1786, CCD: Actual value data container 2, Slave 6 4Byte
- P-0-1787, CCD: Actual value data container 2, Slave 7 4Byte
- P-0-1788, CCD: Actual value data container 2, Slave 8 4Byte
- P-0-1789, CCD: Actual value data container 2, Slave 9 4Byte
- P-0-1790, CCD: Actual value data container 3, Master 4Byte
- P-0-1791, CCD: Actual value data container 3, Slave 1 4Byte
- P-0-1792, CCD: Actual value data container 3, Slave 2 4Byte

- P-0-1793, CCD: Actual value data container 3, Slave 3 4Byte
- P-0-1794, CCD: Actual value data container 3, Slave 4 4Byte
- P-0-1795, CCD: Actual value data container 3, Slave 5 4Byte
- P-0-1796, CCD: Actual value data container 3, Slave 6 4Byte
- P-0-1797, CCD: Actual value data container 3, Slave 7 4Byte
- P-0-1798, CCD: Actual value data container 3, Slave 8 4Byte
- P-0-1799, CCD: Actual value data container 3, Slave 9 4Byte
- P-0-1800, CCD: Actual value data container 4, Master 4Byte
- P-0-1801, CCD: Actual value data container 4, Slave 1 4Byte
- P-0-1802, CCD: Actual value data container 4, Slave 2 4Byte
- P-0-1803, CCD: Actual value data container 4, Slave 3 4Byte
- P-0-1804, CCD: Actual value data container 4, Slave 4 4Byte
- P-0-1805, CCD: Actual value data container 4, Slave 5 4Byte
- P-0-1806, CCD: Actual value data container 4, Slave 6 4Byte
- P-0-1807, CCD: Actual value data container 4, Slave 7 4Byte
- P-0-1808, CCD: Actual value data container 4, Slave 8 4Byte
- P-0-1809, CCD: Actual value data container 4, Slave 9 4Byte
- P-0-1810, CCD: Status word synchronous operation modes, master
- P-0-1811, CCD: Status word synchronous operation modes, slave 1
- P-0-1812, CCD: Status word synchronous operation modes, slave 2
- P-0-1813, CCD: Status word synchronous operation modes, slave 3
- P-0-1814, CCD: Status word synchronous operation modes, slave 4
- P-0-1815, CCD: Status word synchronous operation modes, slave 5
- P-0-1816, CCD: Status word synchronous operation modes, slave 6
- P-0-1817, CCD: Status word synchronous operation modes, slave 7
- P-0-1818, CCD: Status word synchronous operation modes, slave 8
- P-0-1819, CCD: Status word synchronous operation modes, slave 9
- P-0-1820, CCD: Command value data container 1, Master 2Byte
- P-0-1821, CCD: Command value data container 1, Slave 1 2Byte
- P-0-1822, CCD: Command value data container 1, Slave 2 2Byte
- P-0-1823, CCD: Command value data container 1, Slave 3 2Byte
- P-0-1824, CCD: Command value data container 1, Slave 4 2Byte
- P-0-1825, CCD: Command value data container 1, Slave 5 2Byte
- P-0-1826, CCD: Command value data container 1, Slave 6 2Byte
- P-0-1827, CCD: Command value data container 1, Slave 7 2Byte
- P-0-1828, CCD: Command value data container 1, Slave 8 2Byte
- P-0-1829, CCD: Command value data container 1, Slave 9 2Byte
- P-0-1830, CCD: Command value data container 2, Master 2Byte
- P-0-1831, CCD: Command value data container 2, Slave 1 2Byte
- P-0-1832, CCD: Command value data container 2, Slave 2 2Byte
- P-0-1833, CCD: Command value data container 2, Slave 3 2Byte
- P-0-1834, CCD: Command value data container 2, Slave 4 2Byte
- P-0-1835, CCD: Command value data container 2, Slave 5 2Byte

- P-0-1836, CCD: Command value data container 2, Slave 6 2Byte
- P-0-1837, CCD: Command value data container 2, Slave 7 2Byte
- P-0-1838, CCD: Command value data container 2, Slave 8 2Byte
- P-0-1839, CCD: Command value data container 2, Slave 9 2Byte
- P-0-1840, CCD: Command value data container 3, Master 2Byte
- P-0-1841, CCD: Command value data container 3, Slave 1 2Byte
- P-0-1842, CCD: Command value data container 3, Slave 2 2Byte
- P-0-1843, CCD: Command value data container 3, Slave 3 2Byte
- P-0-1844, CCD: Command value data container 3, Slave 4 2Byte
- P-0-1845, CCD: Command value data container 3, Slave 5 2Byte
- P-0-1846, CCD: Command value data container 3, Slave 6 2Byte
- P-0-1847, CCD: Command value data container 3, Slave 7 2Byte
- P-0-1848, CCD: Command value data container 3, Slave 8 2Byte
- P-0-1849, CCD: Command value data container 3, Slave 9 2Byte
- P-0-1850, CCD: Command value data container 4, Master 2Byte
- P-0-1851, CCD: Command value data container 4, Slave 1 2Byte
- P-0-1852, CCD: Command value data container 4, Slave 2 2Byte
- P-0-1853, CCD: Command value data container 4, Slave 3 2Byte
- P-0-1854, CCD: Command value data container 4, Slave 4 2Byte
- P-0-1855, CCD: Command value data container 4, Slave 5 2Byte
- P-0-1856, CCD: Command value data container 4, Slave 6 2Byte
- P-0-1857, CCD: Command value data container 4, Slave 7 2Byte
- P-0-1858, CCD: Command value data container 4, Slave 8 2Byte
- P-0-1859, CCD: Command value data container 4, Slave 9 2Byte
- P-0-1860, CCD: Actual value data container 1, Master 2Byte
- P-0-1861, CCD: Actual value data container 1, Slave 1 2Byte
- P-0-1862, CCD: Actual value data container 1, Slave 2 2Byte
- P-0-1863, CCD: Actual value data container 1, Slave 3 2Byte
- P-0-1864, CCD: Actual value data container 1, Slave 4 2Byte
- P-0-1865, CCD: Actual value data container 1, Slave 5 2Byte
- P-0-1866, CCD: Actual value data container 1, Slave 6 2Byte
- P-0-1867, CCD: Actual value data container 1, Slave 7 2Byte
- P-0-1868, CCD: Actual value data container 1, Slave 8 2Byte
- P-0-1869, CCD: Actual value data container 1, Slave 9 2Byte
- P-0-1870, CCD: Actual value data container 2, Master 2Byte
- P-0-1871, CCD: Actual value data container 2, Slave 1 2Byte
- P-0-1872, CCD: Actual value data container 2, Slave 2 2Byte
- P-0-1873, CCD: Actual value data container 2, Slave 3 2Byte
- P-0-1874, CCD: Actual value data container 2, Slave 4 2Byte
- P-0-1875, CCD: Actual value data container 2, Slave 5 2Byte
- P-0-1876, CCD: Actual value data container 2, Slave 6 2Byte
- P-0-1877, CCD: Actual value data container 2, Slave 7 2Byte
- P-0-1878, CCD: Actual value data container 2, Slave 8 2Byte

- P-0-1879, CCD: Actual value data container 2, Slave 9 2Byte
- P-0-1880, CCD: Actual value data container 3, Master 2Byte
- P-0-1881, CCD: Actual value data container 3, Slave 1 2Byte
- P-0-1882, CCD: Actual value data container 3, Slave 2 2Byte
- P-0-1883, CCD: Actual value data container 3, Slave 3 2Byte
- P-0-1884, CCD: Actual value data container 3, Slave 4 2Byte
- P-0-1885, CCD: Actual value data container 3, Slave 5 2Byte
- P-0-1886, CCD: Actual value data container 3, Slave 6 2Byte
- P-0-1887, CCD: Actual value data container 3, Slave 7 2Byte
- P-0-1888, CCD: Actual value data container 3, Slave 8 2Byte
- P-0-1889, CCD: Actual value data container 3, Slave 9 2Byte
- P-0-1890, CCD: Actual value data container 4, Master 2Byte
- P-0-1891, CCD: Actual value data container 4, Slave 1 2Byte
- P-0-1892, CCD: Actual value data container 4, Slave 2 2Byte
- P-0-1893, CCD: Actual value data container 4, Slave 3 2Byte
- P-0-1894, CCD: Actual value data container 4, Slave 4 2Byte
- P-0-1895, CCD: Actual value data container 4, Slave 5 2Byte
- P-0-1896, CCD: Actual value data container 4, Slave 6 2Byte
- P-0-1897, CCD: Actual value data container 4, Slave 7 2Byte
- P-0-1898, CCD: Actual value data container 4, Slave 8 2Byte
- P-0-1899, CCD: Actual value data container 4, Slave 9 2Byte
- P-0-3610, CANopen: Heartbeat/NodeGuard Configuration
- P-0-3611, CANopen: COB-IDs
- P-0-3612, CANopen: Transmission Types
- P-0-3613, CANopen: List of the Event Parameters
- P-0-3912, Command values for adjustment of PI interface extension
- P-0-3913, Adjustment values of PI interface extension
- P-0-3914, Type data of PI interface extension
- P-0-3930, C7600 Command Create parameter image
- P-0-3931, Config. Of create parameter image
- P-0-3933, Service password
- P-0-4066, Card Identification Data
- P-0-4083.0.1, Parameter channel: Configuration
- P-0-4089.0.3, Device Address
- P-0-4089.0.4, Active Device Address
- P-0-4089.0.5, Master communication: Configuration

- S-0-0272, Velocity window as percentage
- S-0-0381, DC bus current
- S-0-0535, Active velocity feedback value
- S-0-0600.0.20, Encoder data out container
- S-0-0601.0.1, Encoder data out configuration
- S-0-0601.0.2, Resolution position

- S-0-0601.0.6, Absolute position range
- S-0-0601.0.10, Overflow threshold position
- S-0-0601.0.11, Encoder available data out
- S-0-0601.0.12, Encoder refresh time data out
- S-0-0602.0.1, Phy. Encoder type
- S-0-0602.0.2, Phy. Encoder properties
- S-0-0602.0.3, Phy. Encoder resolution (incremental)
- S-0-0602.0.4, Phy. Encoder resolution (absolute)
- S-0-0602.0.7, Phy. Encoder protocol configuration
- S-0-0610.0.1, Encoder status (input)
- S-0-0610.0.2, Position not scaled (input)
- S-0-0610.0.20, Encoder data out container (input)
- S-0-0611.0.1, Encoder data out configuration (input)
- S-0-0611.0.2, Resolution position (input)
- S-0-0611.0.6, Absolute position range (input)
- S-0-0611.0.10, Overflow threshold position (input)
- S-0-0611.0.11, Encoder available data out (input)
- S-0-0611.0.12, Encoder refresh time data out (input)
- S-0-1036, SERCOS III: Inter Frame Gap
- S-0-1037, SERCOS III: Slave Jitter
- S-0-1039, Hostname
- S-0-1047, SERCOS III: Maximum Consumer Activation Time
- S-0-1050.0.7, SIII-Connection: Assigned connection capability
- S-0-1050.0.9, SIII-Connection: State
- S-0-1060.0.1, SIII-Connectiontype: Default configuration
- S-0-1060.0.2, SIII-Connectiontype: Configuration mask
- S-0-1060.0.3, SIII-Connectiontype: Max. quantity of this conn. capability
- S-0-1060.0.4, SIII-Connectiontype: Max. Length of Connection
- S-0-1060.0.6, SIII-Connectiontype: Configurable EIDNs
- S-0-1060.0.7, SIII-Connectiontype: Min. processing time
- S-0-1060.0.10, SIII-Connectiontype: Minimum producer cycle time
- S-0-1061, SERCOS III: Maximum ScycCnt
- S-0-1099.0.1, SERCOS III: Test-IDN for Conformity purpose - configuration
- S-0-1099.0.2, SERCOS III: Test-IDN for Conformity purpose
- S-0-1100.0.1, Diagnostic counter sent SMP fragments
- S-0-1100.0.2, Diagnostic counter received SMP fragments
- S-0-1100.0.3, Diagnostic counter dropped SMP fragments
- S-0-1101.0.1, SMP Container Data
- S-0-1101.0.2, List of session identifiers
- S-0-1101.0.3, List of session priorities
- S-0-1300.0.1, Component Name
- S-0-1300.0.4, Device Name

- S-0-1300.0.8, Hardware Revision
- S-0-1300.0.9, Software Revision
- S-0-1300.0.11, Order Number
- S-0-1300.0.12, Serial Number
- S-0-1300.0.20, Operational Hours
- S-0-1305.0.2, SERCOS III: SERCOS current fine time
- S-0-1350, C6400 reboot command

5.5.2 Modified Parameters

- P-0-0045, Control word of current controller
- P-0-0052, Actual position value of measuring encoder
- P-0-0054, Additive master axis position
- P-0-0074, Encoder type 1 (motor encoder)
- P-0-0078, Assignment optional encoder->optional slot
- P-0-0079, Assignment measuring encoder->optional slot
- P-0-0087, Actual position value offset of measuring encoder
- P-0-0088, Control word synchronization modes
- P-0-0097, Absolute encoder monitoring window for measuring encoder
- P-0-0114, Undervoltage threshold
- P-0-0119, Best possible deceleration
- P-0-0155, Synchronization mode
- P-0-0165, Drive optimization, control word
- P-0-0197, System time
- P-0-0223, E-Stop input
- P-0-0241, Actual pos. smoothing time constant for hybrid pos. control
- P-0-0242, Current actual slip value
- P-0-0243, Maximum occurred actual slip value
- P-0-0244, Monitoring window of slip
- P-0-0328, Type of position encoder for measuring encoder
- P-0-0330, Control word of measuring encoder
- P-0-0441, Thermal drive load warning threshold
- P-0-0508, Commutation offset
- P-0-0522, Control word for commutation setting
- P-0-0533, Voltage loop proportional gain
- P-0-0555, axis controller messages
- P-0-0556, Config word of axis controller
- P-0-0601, Configuration motor data identification
- P-0-0703, Number of motion steps, set 0
- P-0-0710, Number of motion steps, set 1
- P-0-0775, Resulting master axis position
- P-0-0844, thermal load of Braking resistor
- P-0-0860, Converter configuration
- P-0-0861, Power supply status word

- P-0-1120, Velocity control loop filter: Filter type
- P-0-1131, Control word of cogging torque compensation
- P-0-4025.0.0, Drive address of master communication
- P-0-4031, Overview of device addresses
- P-0-4075, Field bus: Watchdog
- P-0-4076, Field bus: Process data - updating clock
- P-0-4083, Parameter channel: Length
- P-0-4084, Field bus: Profile type
- P-0-4088, Master communication: Drive configuration
- P-0-4089.0.10, Master communication: MAC address device
- P-0-4089.0.11, Master communication: MAC address Port1
- P-0-4089.0.12, Master communication: MAC address Port2
- 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
- P-0-4089.0.127, Master communication: Master debugging
- S-0-0002, SERCOS cycle time (TScyc)
- S-0-0006, AT Transmission starting time (T1)
- S-0-0013, Class 3 diagnostics
- S-0-0086, Torque/force data scaling type
- S-0-0089, MDT Transmit starting time (T2)
- S-0-0093, Torque/force data scaling factor
- S-0-0094, Torque/force data scaling exponent
  S-0-0096, Slave arrangement (SLKN)
- S-0-0115, Position feedback 2 type
- S-0-0157, Velocity window
- S-0-0222, Spindle positioning speed
- S-0-0277, Position feedback 1 type
- S-0-0292, List of supported operation modes
- S-0-0330, Status "n_feedback = n_command"
- S-0-0446, Ramp reference velocity for acceleration data
- S-0-0521, Axis status word
- S-0-1012, SERCOS III: Length of ATs
- 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-0-1040, Drive address of master communication

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- P-0-4022, Drive address of serial interface
- P-0-4027, Transmission length SERCOS interface
- P-0-4067, Project identification

- P-0-4087, Baud rate SERCOS interface
- S-0-0003, Minimum AT transmit starting time (T1min)
- S-0-0004, Transmit/receive transition time (TATMT)
- S-0-0006, AT Transmission starting time (T1)
- S-0-0008, Command value valid time (T3)
- S-0-0009, Position of data record in MDT
- S-0-0010, Length of master data telegram
- S-0-0028, MST error counter
- S-0-0087, Transmit to transmit recovery time (TATAT)
- S-0-0088, Receive to receive recovery time (TMTSY)
- S-0-0090, Command value proceeding time (TMTSG)
- S-0-0143, SERCOS interface version
- S-0-0601.0.8, Status word, encoder
- S-0-0601.0.13, Overflow threshold, encoder

5.6 New, Modified or no Longer Existing Diagnostic Messages

5.6.1 New Diagnostic Messages

The following new diagnostic messages were implemented in firmware version MPx17:

- A0008 SERCOS III: NRT Mode
- A0165 Position control with control word of axis controller
- A0166 Drive-internal interpolat. with ctrl word of axis controller
- A4002 Drive in automatic mode
- C0241 Incorrect parameterization of motion task
- C0252 Incorrect MLD initialization (write access->S-0-0423)
- C0259 MLD configuration error (->S-0-0423)
- C0260 Incremental enc. emulator resol. cannot be displayed
- C0265 Incorrect CCD address configuration
- C0266 Incorrect CCD phase switch
- C0267 CCD timeout phase switch
- C0296 Error in initialization of absolute encoder monitoring
- C0403 Switching to CCD phase 2 impossible
- C0730 Load defaults procedure command (MLD)
- C0761 Factory default values incorrect (->S-0-0423)
- C3607 Motor revolution/motion impeded
- C3608 Incorrect motor phases or rotational direction of encoder
- C3609 Incorrect number of pole pairs or number of encoder lines
- C3610 No encoder: Validation check impossible
- C3611 Test velocity not reached
- C3612 Command execution impossible
- C4900 PLC command
- C4901 PLC command error no. 1
- C4902 PLC command error no. 2

- C4903 PLC command error no. 3
- C4904 PLC command error no. 4
- C4910 PLC command timeout
- C6400 Reboot command
- C6401 reboot command impossible
- C6500 Archive device data
- C6501 Error when creating machine archive
- C6502 Error when reading device data
- C6503 Inconsistent backup of machine archive
- C6600 Restore device data
- C6601 Error when accessing machine archive
- C6602 Error when writing device data
- C6604 Error when reading device data
- C6605 Device data incompletely restored
- C6606 PLC user program is active
- C6700 Update of device data
- C6701 Error when accessing update archive
- C6702 Error when writing device data
- C6703 Warning - Incomplete update of device data
- C6706 PLC user program is active
- C6800 Control command device data archiving
- C6704 Machine archive is not up-to-date
- C7000 CCD: command adjust slave addresses
- C7001 CCD: impossible to adjust slave addresses
- C7100 CCD: Command Close ring
- C7101 CCD: Impossible to close ring
- C7200 CCD: Command Apply I/O configuration
- C7201 CCD: Impossible to apply I/O configuration
- C7400 CCD: Switching to phase 2
- C7401 CCD: Impossible to switch to phase 2
- C7500 CCD: Switching to phase 4
- C7501 CCD: Impossible to switch to phase 4
- C7600 Command Create parameter image
- C7601 Memory access impossible
- C7602 Slave access impossible
- E2011 PLC - Warning no. 1
- E2012 PLC - Warning no. 2
- E2013 PLC - Warning no. 3
- E2014 PLC - Warning no. 4
- E2015 PLC - Warning no. 5
- E2016 PLC - Warning no. 6
- E2017 PLC - Warning no. 7
- E2031 Encoder 1 warning: Signal amplitude incorrect

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- E2037 Excessive position command difference warning
- E2042 Encoder 2 warning: Encoder signals incorrect
- E2043 Measuring encoder warning: Encoder signals incorrect
- E2077 Absolute encoder monitoring, motor encoder (encoder alarm)
- E2078 Absolute encoder monitoring, opt. encoder (encoder alarm)
- E2079 Absolute enc. monitoring, measuring encoder (encoder alarm)
- E2100 Positioning velocity of master axis generator too high
- E2140 CCD error at node
- E2667 Machine archive is not up-to-date
- E4006 Communication module overload
- E4012 Maximum number of CCD slaves exceeded
- E4013 Incorrect CCD addressing
- E4014 Incorrect phase switch of CCD slaves
- E4016 CCD: Topology error
- E4017 CCD: Unknown I/O configuration
- E4020 SIII: Ring interruption (FF to LF)
- F2011 PLC - Error no. 1
- F2012 PLC - Error no. 2
- F2013 PLC - Error no. 3
- F2014 PLC - Error no. 4
- F2015 PLC - Error no. 5
- F2016 PLC - Error no. 6
- F2017 PLC - Error no. 7
- F2053 Incr. encoder emulator: Pulse frequency too high
- F2054 Incr. encoder emulator: Hardware error
- F2063 Internal overflow master axis generator
- F2064 Incorrect cmd value direction master axis generator
- F2072 Error in power supply of brake
- F2101 File system structure error on the memory card
- F2120 Memory card could not be initialized
- F2140 CCD slave error
- F2150 MLD motion function block error
- F2860 Overcurrent in mains-side power section
- F4016 PLC double real-time channel failure
- F4020 SIII: Cable break (L+F to NRT)
- F4140 CCD communication error
- F6002 Assignment of encoder for synchronization is not allowed
- F6003 Motion step skipped
- F6004 Error in MotionProfile
- F6005 Cam table invalid
- F6006 Incorrect initialization of effective master axis position
- F6007 Switching to non-initialized operation mode
- F6010 PLC runtime error

- F6058 Internal overflow by positioning input
- F6059 Incorrect command value direction when positioning
- F6140 CCD slave error (emergency halt)
- F8027 STO/SBC while drive enabled
- F8140 Fatal CCD error

5.6.2 Modified Diagnostic Messages

The following diagnostic messages were extended or modified in firmware version MPx17:

- A0160 Pos. ctrl drive-controlled with ctrl word of axis controller
- A0161 Drive-controlled posit. with ctrl word of axis controller
- C0174 Connection configuration not allowed
- C0220 Error when initializing position of encoder 1
- C0221 Initialization velocity encoder 1 too high
- C0224 Error when initializing position of encoder 2
- C0225 Initialization velocity encoder 2 too high
- C0227 Error when initializing position of measuring encoder
- C0228 Initialization velocity measuring encoder too high
- C0230 Field bus: Max. length for cycl. command val. exceeded
- C0232 Field bus: Length for cycl. actual values exceeded
- C0233 Field bus: Tcyc (P-0-4076) incorrect
- C6100 Command Activate IP settings
- E2021 Motor temperature outside of measuring range
- E2051 Motor overtemp. prewarning
- E2061 Device overload prewarning
- E2074 Encoder 1: Encoder signals disturbed
- E2075 Encoder 2: Encoder signals disturbed
- E2076 Measuring encoder: Encoder signals disturbed
- E2820 Braking resistor overload prewarning
- F2007 Switching to non-initialized operation mode
- F2022 Device temperature monitor defective
- F2031 Encoder 1 error: signal amplitude incorrect
- F2037 Excessive position command difference
- F2042 Encoder 2: Encoder signals incorrect
- F2043 Measuring encoder: Encoder signals incorrect
- F2190 Incorrect Ethernet configuration
- F8070 Control voltage failure
- F8071 Overvoltage of control voltage

5.6.3 No Longer Existing Diagnostic Messages

Compared to the firmware version MPx16, all diagnostic messages still exist and none of them were replaced by other diagnostic messages.

6 Service and Support

The Bosch Rexroth service helpdesk at out headquarters in Lohr, Germany, and our worldwide service provide 24/7 support and assistance.

	Helpdesk	Worldwide service hotline
Phone	+49 (0) 9352 40 50 60	Outside Germany, please contact your sales/service office first.
Fax	+49 (0) 9352 40 49 41	
E-mail	service.svc@boschrexroth.de	For hotline numbers, refer to the sales office addresses on the internet.
Internet	For additional information on service, maintenance (e.g. delivery addresses) and training, please go to http://www.boschrexroth.com	

Required information

Please provide the following information:

- Detailed description of malfunction and circumstances leading to the malfunction
- Type plate name of the affected products, in particular type codes and serial numbers
- Phone and fax numbers as well as your e-mail address

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