The Drive & Control Company

Rexroth
Bosch Group

Rexroth IndraDrive

MPx-20
Version Notes

Release Notes
R911345606

Edition 03

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1 How to use this documentation

1.1 Structure of the Version Notes

Purpose of this documentation

These Version Notes contain

- the changes compared with the previous firmware version MPx-18VRS "Rexroth IndraDrive, MPx-18 Functions" (DOK-INDRV*-MP*-18VRS**-APxx-EN-P, mat. no.: R911338673) with the following contents:
  - the compatible new functions and functional enhancements
  - the incompatible new functions and functional enhancements
  - the new, modified and no longer existing parameters
  - the new, modified and no longer existing diagnostic messages
- an overview of the firmware function with the relevant parameters and diagnostic messages in chapter 5 "Overview of the functional scope" on page 69.

The description of a firmware function in the documentation is basically divided into fixed chapters:

- Brief description
- Functional description
- Notes on commissioning
- Diagnostic and status messages, monitoring functions

This documentation "Rexroth IndraDrive, MPx-20, Version Notes" only contains the "Brief description" sections of the firmware function. They provide an overview of the firmware function or the subject of the section. The brief description can contain, for example, general basics, the most important features of the function, overviews and application examples.

The detailed description of the firmware function is contained in the Application Manual "Rexroth IndraDrive, MPx-20, Functions" (DOK-INDRV*-MP*-20VRS**-APxx-EN-P, mat. no. R911345608).

The detailed description of the parameters, their function and structure is contained in the separate documentation "Rexroth IndraDrive, MPx-16 to MPx-20 and PSB, Parameters" (DOK-INDRV*-GEN1-PARA**-RExx-EN-P, mat. no. R911328651) .

The detailed description of the diagnostic messages, their causes and measures for remedy is contained in the separate documentation "Rexroth IndraDrive, MPx-16 to MPx-20 and PSB, Diagnostic Messages" (DOK-INDRV*-GEN1-DIAG**-RE xx-EN-P, mat. no. R911326738) .

Your feedback

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

If you discover mistakes in this documentation or suggest changes, please send your feedback to the following e-mail address:

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In order that we can handle your feedback, please send us the number indicated under "Internal File Reference" and the page number.

1.2 Markers and terms

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

The descriptions of the 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.

Terms

The following terms are used in the Version Notes and in the Functional Description:

- Firmware **range**, e.g. IndraDrive
- Firmware **design**, e.g. single-axis, double-axis
- Firmware **variant** e.g. MPB, MPE
- Firmware **version** e.g. MPB-20VRS
- Firmware **characteristic**, e.g. open-loop/closed-loop
- Firmware **performance** e.g. Basic/Economy/Advanced
- Firmware **type**, complete firmware type designation

Means of representation in this documentation

Bold type is used for important facts which are to be highlighted in the body text. "Quotation marks" are used for parameter names, diagnostic message names, function designations.

All important information (e.g. Warning, Caution) are highlighted by a symbol. 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"). In addition, there are the following tips:

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

This symbol highlights useful tips and tricks.

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

1.4 Documentations

For a list of the reference documentations, see chapter 5.1 "System overview" on page 69

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 their 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 install damaged or faulty products or put them into 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 electric motors and monitor their operation.

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

☞ 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 to ensure that the motor executes the specific functions of an application.

Drive controllers of the Rexroth IndraDrive series 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
- 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 may 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 may 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 Rexroth IndraDrive system are **products of Category C3** (with restricted distribution) in accordance with IEC 61800-3. This Category comprises EMC limit values for line-based and radiated noise emission. Compliance with this Category (limit values) requires the appropriate measures of interference suppression to be used in the drive system (e.g., mains filters, shielding measures).

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 interference suppression.

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: Operating Instructions, Commissioning Manual, Instruction Manual, Project Planning Manual, Application Description, 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,

- to be trained, instructed or authorized to switch electric circuits and devices safely on and off, to ground them and to mark them.
- to be trained or instructed to maintain and use adequate safety equipment.
- 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 Technology". 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 has to comply with

- 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 any 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 (16 AWG)	10 mm^2 (8 AWG)	2 × 1.5 mm^2 (16 AWG)
2.5 mm^2 (14 AWG)		2 × 2.5 mm^2 (14 AWG)
4 mm^2 (12 AWG)		2 × 4 mm^2 (12 AWG)
6 mm^2 (10 AWG)		2 × 6 mm^2 (10 AWG)
10 mm^2 (8 AWG)		-
16 mm^2 (6 AWG)	16 mm^2 (6 AWG)	-
25 mm^2 (4 AWG)		-
35 mm^2 (2 AWG)		-
50 mm^2 (1/0 AWG)	25 mm^2 (4 AWG)	-
70 mm^2 (2/0 AWG)	35 mm^2 (2 AWG)	-
...	...	...

Tab. 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 up to 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 equip-

ment 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 electromagnetic and magnetic fields during operation and mounting

Electromagnetic and magnetic fields!

Health hazard for persons with active implantable medical devices (AIMD) such as pacemakers or passive metallic implants.

- Hazards for the above-mentioned groups of persons by electromagnetic and magnetic fields in the immediate vicinity of drive controllers and the associated current-carrying conductors.
- Entering these areas can pose an increased risk to the above-mentioned groups of persons. They should seek advice from their physician.
- If overcome by possible effects on above-mentioned persons during operation of drive controllers and accessories, remove the exposed persons from the vicinity of conductors and devices.

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 Z535.6-2011).

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 Changes and enhancements compared to the previous version

4.1 Definitions of terms

Regarding the changes and enhancements compared to the previous version MPx-18VRS, we distinguish between the incompatible and compatible functions and functional enhancements.

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 in default values (e.g., inertia)
- Change in filter types and filter degree
- Additional monitoring functions (e.g., in the safety technology) take effect

☞ Before commissioning, it is necessary to check whether the new firmware in the application results in a different behavior at the axis, which might possibly cause problems.

If a new function or functional enhancement is incompatible, this means that, for example, a parameter file from a previous version (MPx16VRS, MPx17VRS, MPx18 in this case) **cannot** be used in the new firmware (MPx20 in this case).

Maybe 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, MPx17VRS, MPx18 in this case) can be used in the new firmware (MPx20 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 both firmwares. It is not necessary to adjust parameters.

4.2 Incompatible functions and functional changes

4.2.1 System overview

CSx02 control sections - CSB02, Basic plug-in unit

New control sections (CSx02.5) are supported for IndraDrive ML, see also separate documentation "Rexroth IndraDrive ML, Drive Systems with HMU05" (DOK-INDRV*-HXX05******-PR**-EN-P; mat. no.: R911344279)

CSx02 control sections - Advanced plug-in unit

New control sections (CSx02.5) are supported for IndraDrive ML, see also separate documentation "Rexroth IndraDrive ML, Drive Systems with HMU05" (DOK-INDRV*-HXX05******-PR**-EN-P; mat. no.: R911344279).

Motors that can be operated, general

Motors that can be operated expanded by MS2N

New parameter "P-0-4044, Phase inductance of preconnected choke" implemented for motors that have to be operated with a preconnected choke due to reduced dielectric strength.

Decimal places to be entered in "P-0-0018, Number of pole pairs/pole pair distance" expanded from one to two decimal places (due to PASIM motors).

Redundant motor encoder not yet available

If there is a motor encoder defect, the motor position, when an additional position control encoder is used with MPx18, can be determined via the position of the additional encoder and the synchronous motor can be decelerated in a controlled way. This function is not yet available in this MPx20 release!

Spindle encoder not yet available

If a spindle is equipped with a high-resolution load-side position encoder, "tolerant" signal evaluation is possible for high-speed spindle operation with MPx18. With MPx18, the load-side encoder can be configured as a "spindle encoder" and then has advantageous properties for spindle operation. This configuration option is not yet available in this MPx20 release!

Encoder 2 not yet available as a commutation encoder

If a synchronous motor only has a relative motor encoder, a position control encoder mounted on the load side that can be evaluated in absolute form can be used as a commutation encoder with MPx18. This function is not yet available in this MPx20 release!

Distance-coded reference marks cannot yet be used

With MPx18, distance-coded reference marks of relative measuring systems can be advantageously used to establish the position data reference (minimizing the travel distance of the homing procedure). The evaluation of distance-coded reference marks cannot yet be used in this MPx20 release!

Additional Hall sensor components cannot yet be used

In combination with a relative measuring system, additional Hall sensor components (analog or digital Hall sensors) can be evaluated as commutation encoders with MPx18. This is not yet possible with this MPx20 release!

Absolute encoder emulation not yet available

With MPx18, the controller can output position information of connected position encoders as incremental or absolute encoder signals. In this MPx20 release, only the output of incremental encoder signals is possible, the output of absolute encoder signals is not yet available!

4.2.2 Master communication

Master communication, general

The device-dependent configuration of the master communication interfaces (example: PLL configuration) is now performed in parameter "P-0-4089.0.5, Master communication: Configuration".

Sub-device state machine

- Implementing Sercos-compatible coupling and decoupling of master communication state machine and sub-device state machine
- Error display can be cleared via "S-0-0390, Diagnostic message number"

EtherCAT, general

Supporting FSoE with EtherCAT.

New addressing using "Device Identification Value" ("P-0-4089.0.3, Device Address") and "SII Configured State Alias" ("P-0-4089.0.7, ECAT: SII Configured Station Alias").

Communication profile based on CANopen

CANopen communication objects and their mapping to the Sercos parameter system were implemented.

The following communication objects are distinguished:

- Communication objects compatible with the original CiA 301 specification, they are used by all bus systems.
- Communication objects that are used in accordance with CiA 301 and only in conjunction with CAN bus communication.
- Communication objects that are used in EtherCAT, differing from the CiA 301 specification.
- Communication objects that are used in POWERLINK, differing from the CiA 301 specification.

See also "CANopen-based communication", chapter "General information" on page 138.

4.2.3 Motor, drive mechanics, measuring systems

Diagnostic LED

The display of the diagnostic LED was simplified, it is available in the following devices:

- IndraDrive HCQ / HCT
- IndraControl FM
- IndraDrive Mi, distributed servo drive KSM02.1
- IndraDrive Mi, distributed drive controller KMS02.1
- IndraDrive, KMV supply module

LED Color / flashing pattern [1)]		Significance *Measures*
○	Off --	Supply unit not switched on *Check 24V supply and switch it on, if not yet done*
		Cable interrupted *Check cable and connector*
		Hardware defective *Replace hardware*

Changes and enhancements compared to the previous version

LED Color / flashing pattern [1)]	Significance *Measures*
Flashing green GN --	Firmware update active
GN -- -- -- -- -- --	• Transition command active • PM (parameter mode)
GN -- GN -- -- -- -- -- --	• bb (control section ready for oper., mains voltage not available) • ZKS (DC bus short circuit)
GN -- GN -- GN -- -- -- -- -- --	• Ab (drive ready for operation, power on) • Bb (control section and power section ready for operation, mains voltage available) • charg (DC bus charging active)
Green GN	• AH (Drive Halt) • AF (Drive in control) • Lb (supply unit in rectifier mode) • LB (supply unit in voltage control) • I LB (supply unit in current control)
Flashing red-green GN -- RD -- -- -- -- -- --	Bus state (e.g., not active, pre-operational, …)
GN RD	Loader active
GN GN -- -- GN GN -- -- RD RD -- -- RD RD -- --	Identification
Flashing red RD --	Firmware update error *Repeat firmware update*
RD -- -- -- -- -- --	• All warnings • Command errors *Read detailed state via "S-0-0095, Diagnostic message"*
RD -- RD -- -- -- -- -- --	All errors (except F4xxx) *Read detailed state via "S-0-0095, Diagnostic message" and carry out service function*
RD -- RD -- RD -- -- -- -- -- --	Communication error (F4xxx) *If necessary, read detailed state via "S-0-0095, Diagnostic message"*

LED Color / flashing pattern [1]		Significance *Measures*
	Red RD	Booting phase *Wait until booting phase is over (approx. 2 minutes)*
		System error (F9xxx) • *Switch off and on; replace hardware, if necessary* • *Check whether programming module has been plugged*

1) Flashing pattern: One square corresponds to a duration of 250 ms; the arrow marks the end of a cycle; abbreviations on the squares: GN = LED permanently lit green, RD = LED permanently lit red, -- = LED is off

Tab. 4-1: LED displays

Thermal motor monitoring

See chapter "Motor temperature monitoring" on page 146 .

Establishing the position data reference

When the position data reference is established using "positive stop drive procedure" and the next reference mark is identified as the dedicated point, the specifically configurable threshold value "S-0-0530, Clamping torque" takes effect for detecting the axis end (triggering the reversal of motion).

Diagnostic motor data

Operational performance

The value in "P-0-2054, Operational performance, motor" can now be utilized by the user for service intervals. It can be manually reset, e.g., when a new service interval begins.

Motors with restricted use of the encoder data memory

For motors whose serial number can be read from the data memory, but whose encoder data memory cannot be written (e.g., MSM motor range), the values in the parameters P-0-2051...P-0-2054 are set appropriately:

- If the parameter "P-0-2055, Serial number, motor" does not contain any data, the serial number that was read is written to P-0-2055 and the values of P-0-2051...P-0-2054 are set to zero.
- If P-0-2055 contains a value corresponding to the value that was read, the values in P-0-2051...P-0-2054 are retained in unchanged form.
- If P-0-2055 contains a value not corresponding to the value that was read, the error diagnostics "C0263 Serial number of motor has changed" is generated when progressing from PM to OM and the values in P-0-2051...P-0-2054 are not affected.
- If "P-0-2055, Serial number, motor" already contains a value, this value, when switching from PM to OM, is compared to the serial number of the connected motor and overwritten if it deviates. The values in P-0-2051...P-0-2054, however, are retained!

Measuring systems, general

See chapter "Basics on measuring systems, resolution" on page 159

Encoder interfaces

The following encoders with the corresponding interface were modified:

- Encoders with HIPERFACE interface, modified for SIII encoder profile
- Encoders with 1Vpp interface, modified for SIII encoder profile
- Encoders with EnDat 2.1 interface, modified for SIII encoder profile
- Encoders with TTL interface (square-wave encoders), modified for SIII encoder profile
- Extended evaluation as encoder 1 / motor encoder, modified for ENCE input data
- Extended evaluation as encoder 2, modified for ENCE input data
- Extended encoder evaluation (measuring encoder), modified for ENCE input data
- Extended evaluation as motor encoder (complex actuator), modified for ENCE input data
- Number of encoder evaluations depending on firmware (ENCB):
  - MPE: 1
  - MPB: 2
  - MPC: 3 (MPx20V08: 2)
  - MPM (double-axis): 4
  - MPM (HCQ, HCT): 5 (MPx20V08: 4)

4.2.4 Mains connection

Module group

New module group support implemented for IndraDrive ML:

- The so-called IndraBus is used instead of the module bus to communicate in the module group with IndraDrive ML. The IndraBus differs from the module bus with the following characteristics:
  - It is safe from cable breaks.
  - There are four pieces of status information:
    - Supply error
    - Inverter error
    - DC bus voltage error, mains failure
    - DC bus short circuit blocked
- Power off is parameterized for all errors in the supply unit. If the function is activated, the supply unit reads the status information "Inverter error" and switches the power off in the case of an error.

Internal and external braking resistor

Load-dependent increase in the switch-on threshold

With loads over 100%, the threshold is increased until the max. DC bus voltage (e.g., 900 V) is reached. (A load of up to 166% can be reached in this process.) At 110%, however, "F2820 Braking resistor overload", or "F8820 Braking resistor overload" for supply units, is generated.

Mains power display and energy counter

Sercos parameters for mains-side power and energy display (S-0-1700.0.13 to S-0-1700.0.15) and display for cosPhi (S-0-1700.0.16) implemented:

S-0-1700.0.13, Mains power

S-0-1700.0.14, Short-time mains energy counter

S-0-1700.0.15, Mains energy counter

S-0-1700.0.16, Power factor

4.2.5 Drive control

Motor control overview

Motor control functions that so far could be activated by bits of "P-0-0045, Control word of current controller" or "P-0-0556, Config word of axis controller" are now contained in "P-0-3945, Motor control configuration" and can be activated by the corresponding bits.

Position controller

The lag error monitoring can be deactivated by entering the value "0" in "S-0-0159, ".

Motor control, setting

By executing "P-0-0565, C3600 Command Motor data identification" with a turning motor, the motor inertia is now determined. With the appropriate configuration, the total inertia of the axis can be determined using "P-0-0162, C1800 Command Drive optimization/command value box". Taking the total inertia of the axis into account, it is now possible to automatcally calculate suitable velocity controller parameters.

4.2.6 Extended axis functions

Measuring wheel mode

Measuring wheel mode is only possible in operation modes in which the encoder active in position control is selected using "S-0-0520, Axis control word". In operation modes with a permanently assigned position encoder (encoder 1 or encoder 2), the measuring wheel mode is no longer possible.

4.2.7 Optional device functions

CCD system mode

The parameters relevant to master communication have changed.

There is a new timing variant for dead time compensation in the Sercos CCD system mode (CCD cycle time < master communication cycle time in CCD master).

Analog inputs

Three remote analog inputs are supported in addition to the physical analog inputs. The following parameters were implmented:

- P-0-0251, Remote analog input 1
- P-0-0252, Remote analog input 2
- P-0-0253, Remote analog input 3

The analog command value processes for the remote analog inputs are carried out via master communication or field bus only.

The remote analog inputs 1…3 have a fixed assignment to the assignments A…C; using "P-0-0218, Analog input, control parameter" it is possible to parameterize which inputs are to be assigned or deselected.

Analog outputs at the control section

The default setting of all analog outputs was changed so that they now are by default active in the "limitation" mode. The configuration can be changed to the "overflow" mode using "P-0-0427, Control parameter of analog output".

4.2.8 Handling, diagnostic and service functions

Firmware replacement, release update

When updating from MPx20V02 to MPx20V04, any connected absolute measuring system has to be homed again. "F2174 Loss of encoder 1 reference" is signaled during phase switch.

Error and diagnostic memory

The manufacturer-specific diagnostic memory is replaced by the standard Sercos Diagnostic Trace.

The following parameters no longer exist:

- "S-0-0375 Diagnostic numbers list"
- "P-0-0105 Time stamp for list of diagnostic message numbers"
- "P-0-0198, System time error memory"
- "P-0-0199, System time error code"

Oscilloscope function

The device oscilloscope was expanded to 8 channels. The system time latching was changed from "P-0-0197, System time" to "S-0-1305.0.1 System time".

4.2.9 Engineering/diagnostic interfaces

IP communication/addressing

With active CCD communication, the IP configuration of CCD master and CCD slaves is automatically carried out via the CCD master.

4.2.10 Commissioning

Simulation mode

In the simulation mode, the encoders assigned to interfaces using P-0-0077 and/or P-0-0078 are simulated. The corresponding position feedback values are generated, the position data reference can be established.

4.3 Compatible new functions and functional changes

4.3.1 System overview

Supported devices, general

The following additional devices are supported:

- IndraDrive ML (Hxx05)
- IndraDrive Mi (KMS03.1)
- IndraDrive C (HCS03.1E-W0350)

CSB02 control sections - Basic plug-in unit

Changes to CSB02.x control section

- A new optional Engineering module "EP" is available. This Engineering port module allows IP communication with devices for which IP communication via the master communication interface is impossible (e.g., EtherCAT® protocol and control unit without an implemented EoE profile).

Type code: CSB02.xA-ET-EC-**EP**-xx

- New optional safety technology modules "SB" and "S5" are available. In conjunction with the functional firmware package "SIL3 Motion" they support the safety level SIL3 also for encoder-based safety functions
  - SB: Safe Motion Bus option: To be selected via Safety bus communication only [CIPsafety over Sercos (CSoS) and FailSafe over EtherCAT® (FSoE)].
  - S5: Safe Motion option

  Type code: CSB02.xB-ET-EC-EC-xx-**SB/S5**-xx
- New optional safety technology module "L3" available, this option supports the Safe Torque Off function

  Type code: CSB02.xA-ET-EC-xx-**L3**-xx

  Type code: CSB02.xB-ET-EC-xx-**L3**-xx
- HAP01.1A control panel additionally supported (with FRAM, with µSD slot)

CSH02 control sections - Advanced plug-in unit

Changes to Advanced control section CSH02.x

- A new master communication module ET MultiEthernet is available. This module provides a slave interface functionality for these protocols: sercos, EtherCAT, ProfiNet and Ethernet IP.

  Type code: CSH02.xB-**ET**-EC-xx
- New optional safety technology modules SB and S5 are available. In conjunction with the functional firmware package "SIL3 Motion" they support the safety level SIL3 also for encoder-based safety functions.
  - SB: Safe Motion Bus option: To be selected via Safety bus communication only [CIPsafety over Sercos (CSoS) and FailSafe over EtherCAT® (FSoE)].
  - S5: Safe Motion option

  Type code: CSH02.xB-xx-EC-xx-**SB/S5**-xx

IndraDrive Cs

Changes to HCS01.1 drive controller

- IndraDrive Cs Economy: HCS01.1E-W00xx-E-S3-xx
  - Master communication module S3 provides a slave interface functionality for the sercos and EtherCAT protocols.
  - A new optional Engineering module EP is available. This Engineering port module allows IP communication with devices for which IP communication via the master communication interface is impossible (e.g., EtherCAT® protocol and control unit without an implemented EoE profile).

    Type code: HCS01.1E-W00xx-E-S3-EC-**EP**-xx
  - Display HAP01.1A (with FRAM and µSD slot) is supported
- IndraDrive Cs Basic: HCS01.1E-W00xx-B-ET-xx
  - A new optional Engineering module EP is available. This Engineering port module allows IP communication with devices for which IP communication via the master communication interface is impossi-

ble (e.g., EtherCAT® protocol and control unit without an implemented EoE profile).

Type code: HCS01.1E-W00xx-B-ET-EC-**EP**-xx

- Display HAP01.1A (with FRAM and µSDslot) is supported
- New optional safety technology modules SB and S5 are available. In conjunction with the functional firmware package "SIL3 Motion" they support the safety level SIL3 also for encoder-based safety functions
  - SB: Safe Motion Bus option: To be selected via Safety bus communication only [CIPsafety over Sercos (CSoS) and Fail-Safe over EtherCAT® (FSoE)].
  - S5: Safe Motion option

  Type code: HCS01.1E-W00xx-B-ET-EC-xx-**SB/S5**-xx

- IndraDrive Cs Advanced: HCS01.1E-W00xx-A-CC-xx and HCS01.1E-W00xx-A-ET
  - Master communication module ET provides a slave interface functionality with Sercos protocol

    Type code: HCS01.1E-W00xx-A-**ET**-EC-xx
  - New optional safety technology modules SB and S5 are available. In conjunction with the functional package "SIL3 Motion" they support the safety level SIL3 also for encoder-based safety functions.
    - SB: Safe Motion Bus option: To be selected via Safety bus communication only [CIPsafety over Sercos (CSoS) and Fail-Safe over EtherCAT® (FSoE)].
    - S5: Safe Motion option

    Type code: HCS01.1E-W00xx-A-xx-EC-xx-**SB/S5**-xx

IndraDrive Mi: KMS02.1, KMS03.1 distributed drive controller

- A new optional safety technology module "SD" is available. It supports the safety function "Safe brake control" (SBC), and in conjunction with the functional package "SIL3 Motion" the safety level SIL3 also for encoder-based safety functions.

  The supported encoder-based SIL3 functions can be identified as follows in the type codes:

  KMS02.1B-A018-x-D7-ET-xxx-**SD**-xx

  KMS03.1B-B036-P-D7-ET-END-**SD**-xx

CSE02.1 control sections - Economy plug-in unit

- A new optional Engineering module "EP" is available. This Engineering port module allows IP communication to be carried out with devices for which IP communication via the master communication interface is impossible (e.g., EtherCAT® protocol and control unit without an implemented EoE profile), see also separate documentation "IndraDrive Control Sections, CSB02, CSE02, CSH02, CDB02; Project Planning Manual" (DOK-INDRV*-CXX02******-PRxx-EN-P, mat. no. R911338962)

  Type code: CSE02.1A-S3-EC-**EP**-xx
- New optional safety technology module L3 available, this option supports the Safe Torque Off function

  Type code CSE02.1A-S3-EC-xx-**L3**-xx
- HAP01.1A control panel additionally supported (µSD slot)

Functional packages overview

The functional packages "SYX", "ML", "TF", "MA" are only available for Basic devices with standard performance.

New base package "E" implemented for devices with restricted export.

New additive functional package "ME" (Ethernet IP scanner) implemented for MPC20VRS.

Enabling functional packages

Implemented functional package SYTRONIX "SYX", for which either the additive functional package "TF" or "ML" has to be additionally selected.

Performance data

Performance

For high-performance controllers, the PWM frequency can be reduced to 1 kHz to reduce inverter losses.

<table>
<tr><th>Drive System and/or Control section / Firmware</th><th>Performance Level</th><th>f_{PWM} 1)</th><th>PWM Switch. 2)</th><th>$T_{A\_current}$</th><th>$T_{A\_velocity}$</th><th>$T_{A\_position}$</th><th>T_{MLD}</th><th>$T_{MastCom}$</th></tr>
<tr><td rowspan="8">HCS01.1 / MPB
CSB02.1 / MPB
KSM02.1 / MPB
KMS02.1 / MPB
CDB02.1 / MPM</td><td rowspan="5">Basic</td><td>2 kHz</td><td>No</td><td>250 µs</td><td rowspan="5">250 µs</td><td rowspan="5">500 µs</td><td rowspan="8">1000 µs
(not available with MPM)</td><td rowspan="5">≥$T_{A\_position}$ 3) 6)
≥1000 µs 4) 5)</td></tr>
<tr><td>4 kHz</td><td>Yes</td><td>125 µs</td></tr>
<tr><td>8 kHz</td><td>Yes</td><td>125 µs</td></tr>
<tr><td>12 kHz</td><td>Yes</td><td>83.3 µs</td></tr>
<tr><td>16 kHz</td><td>Yes</td><td>62.5 µs</td></tr>
<tr><td rowspan="3">Advanced</td><td>4 kHz</td><td>No</td><td>125 µs</td><td rowspan="3">125 µs</td><td rowspan="3">250 µs</td><td rowspan="3">≥$T_{A\_position}$ 3) 6)
≥1000 µs 4) 5)</td></tr>
<tr><td>8 kHz</td><td>Yes</td><td>62.5 µs</td></tr>
<tr><td>16 kHz</td><td>Yes</td><td>62.5 µs</td></tr>
<tr><td rowspan="8">HCS01.1 / MPC
CSH02.1 / MPC</td><td rowspan="5">Basic</td><td>2 kHz</td><td>No</td><td>250 µs</td><td rowspan="5">250 µs</td><td rowspan="5">500 µs</td><td rowspan="8">1000 µs</td><td rowspan="5">≥$T_{A\_position}$ 3) 4) 5) 6)</td></tr>
<tr><td>4 kHz</td><td>Yes</td><td>125 µs</td></tr>
<tr><td>8 kHz</td><td>Yes</td><td>125 µs</td></tr>
<tr><td>12 kHz</td><td>Yes</td><td>83.3 µs</td></tr>
<tr><td>16 kHz</td><td>Yes</td><td>62.5 µs</td></tr>
<tr><td rowspan="3">Advanced</td><td>4 kHz</td><td>No</td><td>125 µs</td><td rowspan="3">125 µs</td><td rowspan="3">250 µs</td><td rowspan="3">≥$T_{A\_position}$ 3) 6)
≥500 µs 4) 5)</td></tr>
<tr><td>8 kHz</td><td>Yes</td><td>62.5 µs</td></tr>
<tr><td>16 kHz</td><td>Yes</td><td>62.5 µs</td></tr>
<tr><td rowspan="2">HCS01.1 / MPE</td><td rowspan="2">Economy</td><td>4 kHz</td><td>No</td><td>125 µs</td><td rowspan="2">500 µs</td><td rowspan="2">1000 µs</td><td rowspan="2">Not available</td><td rowspan="2">≥$T_{A\_position}$ 3) 6)
≥2000 µs 4) 5)</td></tr>
<tr><td>8 kHz</td><td>No</td><td>125 µs</td></tr>
</table>

Changes and enhancements compared to the previous version

Drive System and/or Control section / Firmware	Performance Level	f_{PWM} [1]	PWM Switch. [2]	$T_{A\_current}$	$T_{A\_velocity}$	$T_{A\_position}$	T_{MLD}	$T_{MastCom}$
HCQ02.1 / MPM HCT02.1 / MPM	Basic	4 kHz	No	125 µs	250 µs	500 µs	Not available	500 µs
		8 kHz	No	125 µs				

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) With sercos
4) With PROFIBUS®
5) With PROFINET® and EtherNet/IP™
6) With EtherCAT®

Tab. 4-2: Performance depending on the control section design

Drive System and/or Control section / Firmware	Performance Level	f_{PWM} [1]	PWM Switch. [2]	$T_{A\_current}$	$T_{A\_velocity}$	$T_{A\_position}$	T_{MLD}	$T_{MastCom}$
HMU05 with CSB02.5 / MPB	Basic	1 kHz	No	500 µs	500 µs	500 µs	1000 µs	As for $T_{A\_position}$ [3] 1000 µs[4] 2000 µs[5] 500 µs[6]
		2 kHz	Yes[7]	250 µs	250 µs			
		4 kHz	Yes	125 µs				
		8 kHz	Yes	125 µs				
	Advanced	4 kHz	No	125 µs	125 µs	250 µs		
		8 kHz	Yes	62.5 µs				
HMU05 with CSH02.5 / MPC	Basic	1 kHz	No	500 µs	500 µs	500 µs	1000 µs	As for $T_{A\_position}$ [3] 1000 µs[4] 2000 µs[5] 500 µs[6]
		2 kHz	Yes[7]	250 µs	250 µs (500µs) [7]			
		4 kHz	Yes	125 µs				
		8 kHz	Yes	125 µs				
	Advanced	4 kHz	No	125 µs	125 µs	250 µs		
		8 kHz	Yes	62.5 µs				

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) With sercos
4) With PROFIBUS®
5) With PROFINET® and EtherNet/IP™
6) With EtherCAT®
7) With PWM switching from 2 → 1 kHz, only 500 µs is possible for $T_{A\_velocity}$

Tab. 4-3: Performance depending on the control section design

Static type data, modules

Implemented electronic type plate S-0-1300 per module.

4.3.2 Master communication

Master communication state machine

Ethernet POWERLINK was added, see also chapter "Brief description" on page 131.

Ethernet POWERLINK, general

ETHERNET POWERLINK Ethernet POWERLINK, general; see auch chapter "Brief description" on page 131.

Ethernet POWERLINK diagnostic and status messages

Diagnostic and status messages for the master communication via Ethernet POWERLINK, see also chapter "Brief description" on page 131.

Ethernet POWERLINK, synchronization and timing

Mechanisms for synchronization and timing with Ethernet POWERLINK master communication, see also chapter "Brief description" on page 131.

Analog master communication

Analog mode is supported for IndraDrive and HydraulikDrive.

The analog mode is set with the parameter "P-0-2945, Configuration of analog mode" and the control word "P-0-4028, Device control word" .

Field bus profile types, general

Implemented new profiles CiA402, analog, Servodrive, FSP Drive

sercos / field bus addressing, address assignment, identification

Configured Station Address supported with EtherCAT.

sercos, general information

Hotplug for sercos implemented

SoE, general information

Supporting FSoE with EtherCAT.

sercos, connections

Operation of non-synchronous operation modes via asynchronous connections (configured with "S-0-1050.x.1, ")

Profile type: FSP Drive (sercos profile)

With sercos, "S-0-0134, Master control word" is mapped to "P-0-0116, Device control: Control word".

The evaluation of bit 14 depends on the profile type (only with 0x0102 and 0x0002). No evaluation with profile types 0x0F102 and 0xF002.

4.3.3 Motor, drive mechanics, measuring systems

Third-party motors

Extended command "calculate type plate data" (phase inductance of preconnected choke added), encoder data memory can now be used for third-party motors if an appropriate encoder is used as the motor encoder.

With the "motor data identification" command, it is possible to check the direction of rotation before starting the command to determine the motor data with motion. This is particularly advantageous for sensorless motors, if with mounted pumps, for example, an inadmissible direction of rotation would cause damage.

Rexroth motors with motor data memory

Rexroth motors with encoder data memory provide the highest convenience for commissioning, because all data for motor control come "on board" in the motor encoder and are automatically activated. Thanks to the continuing development of the motor properties and firmware functions, the current motor ranges have different encoder data memory structure versions that support extended functions, where applicable:

Motor	Encoder memory version	P-0-3100	Comment
MSK, MAD, MAF, KSM	4.1	0x0401	Standard
	4.2	0x0402	IndraDrive Mi
	4.3	0x0403	4.1 + Diagnostic data of motor operation
	4.4	0x0404	4.3 + Field weakening
	4.5	0x0405	4.4 + Torque constant correction
	4.6	0x0406	4.5 + MSK133 reluctance utilization
MSM	5.1	0x0501	Standard
SBC (Parker)	6.1	0x0601	Standard
MS2N with encoder performance A	4.6 and 7.1	0x0406 0x0701	4.5 + MSK133 Standard reluctance utilization
MS2N with encoder performance C	7.1	0x0701	Standard

Tab. 4-4: Versions and properties of encoder memory integrated in motors

The improved encoder memory version 7 is used for the new MS2N motor range with MPx20 and above. Its data structure is more transparent for the user and compared to the previous encoder memory versions it can be used with a higher flexibility for future motor functions:

Depending on the upload to the device, the encoder memory parameters are divided into…

...parameters loaded during boot-up or during the run-up to OM:

- P-0-3071, Identification data, type plate (motor, compact parameter)
- P-0-3072, Motor: Static type data, type plate (motor, compact parameter)
- Diagnostic motor data (P-0-3051, P-0-3052, P-0-3053) with the operating hours, therm. and mech. operating hours
- P-0-3075, Application-specific data, type plate(compact parameter)

...parameters only loaded when "loading the control loop default values (RL)":

- P-0-3073, Motor: Control loop default values, type plate (compact parameter), it additionally contains P-0-3945, Motor control configuration (new parameter), as well as bit 0 and bit 2 of P-0-3009, Holding brake control word, type plate

The so-called "compact parameters" are also new. In contrast to the fixed data structure of older encoder memory versions, they can be flexibly configured with data.

MPx20 allows data to be written to the motor encoder data memory with the master password having been set.

See also chapter "Rexroth housing motors with encoder data memory" on page 150.

Encoders with ACURO®Link interface

The support of the ACURO®Link interface was implemented. For MS2N motors, this encoder is optionally available as a motor encoder (encoder performance = C). Currently supported encoders: Hengstler AD37S

An ACURO®Link encoder transmits absolute position information serially in digital format and safe communication:

- Evaluating a maximum of 31 position bits
- Automatically recognizing the encoder properties
- Memory range for user data
- Monitoring functions, such as error bit, warning bit, CRC (Cyclic Redundancy Check), signaling of encoder errors
- Transmitting the motor temperature if KTY84-130 or PT1000 (installed in the motor windings) connected to the encoder sensor
- Can be used as a safety technology encoder

Basic level and extended evaluation parameters are used to parameterize the ACURO®Link encoder. On the user side, it is basically necessary to write the characteristic number for the ACURO®Link encoder to S-0-0602.x.01, Phys. encoder type and to write the intended maximum travel range. The encoder-specific data are automatically copied from the encoder memory to the assigned parameters.

The ACURO®Link encoder can be used for motor control, because the time offset between the recording of actual position values and their availability is sufficiently small due to the serial transmission.

Stationarily offsetting the encoder position

The current position feedback value of an ACURO®Link encoder can be permanently offset using a command. This allows the commutation angle of synchronous motors to be adjusted to the value "zero":

- An encoder arbitrarily mounted to the motor shaft can hereby be brought into alignment with the direction of the magnetic field of the rotor without being mechanically offset.
- The encoder position is offset by reinitializing the encoder and the offset remains permanently effective.

☞ The following aspects apply to ACURO®Link encoders with this MPx20 release:

- The maximum cable length is 50 m (otherwise usually 75 m)!
- The drive-controlled homing procedure is not yet possible if it requires the reference mark of the encoder!
- The safety-related evaluation is not yet possible!

Encoders with EnDat 2.2 interface

With EnDat2.2, a range of the encoder data memory can be used for user data (the Heidenhain order code is "EnDat22").

EnDat2.2 encoders with multi-turn function via battery backup are not supported!

Stationarily offsetting the encoder position

The current position feedback value of an encoder can be permanently offset using an EnDat command. This allows the commutation angle of synchronous motors to be adjusted to the value "zero":

- An encoder arbitrarily mounted to the motor shaft can hereby be brought into alignment with the direction of the magnetic field of the rotor without being mechanically offset.
- The encoder position is offset by reinitializing the encoder and the offset remains permanently effective.

4.3.4 Mains connection

Converter power supply, mains failure and phase failure

Control word and status word S-0-1720 implemented.

4.3.5 Drive control

Motor control frequency

1 kHz PWM implemented for HMS05, see also chapter "Performance" on page 29.

- Firmware requires export licenses, if motor control frequency > 600Hz is necessary (FWA type designation with "control mode" = E for "restricted export")
- "Inverse" PWM to reduce ground leakage currents in the case of multiple axes in the modular drive system with HMS05 devices
- Configuration option for the minimum pulse duration to reduce periodic overvoltages at the motor terminals (with MPC firmware only)

Velocity controller

Speed control loop filters increased from 4 to 8 filters with MPC.

Automatic control loop setting

Autom. control loop setting started via display.

In FXC motor control without an optional encoder, the automatic control loop setting can only be used to determine the load inertia and to calculate the velocity controller parameters.

Thermal controller monitoring

New power section parameters for Hxx05 and parallel connection of power sections implemented.

Protection against overcurrent and overvoltage

- The overcurrent monitoring has been expanded and now has multiple stages.
  - Firmware monitoring for peak current,

    if the total current exceeds a specific threshold.
  - Overcurrent detection in the power section,

    if the current in the power section rises above a specific percentage of the peak current.
  - Desaturation monitoring,

if the current exceeds 5-10 times the type current of the IGBT modules.

  – Power supply immediately switched off,

    if the current in the power section does not subside, despite the output stage being switched off.

- Expansion of the ground fault monitoring

Sensorless motor operation, flux-controlled (FXC control)

When drive enable is set for a sensorless synchronous motor in FXC operation, a jerky initial motion of up to 90° electrically can occur. Alternatively, it is now possible to determine the rotor position when drive enable is set; this considerably reduces the initial motion.

The frequency threshold for current-controlled FXC operation was modified from a motor control frequency of previously 3 Hz as follows:

- Frequency threshold of synchronous motors is the motor control frequency that generates an induced voltage of 5 V at the motor,
- Frequency threshold of asynchronous motors is nominal frequency/50.

Thereby, torque output is already possible above this frequency threshold. Below this value only frequency-controlled operation with a low torque output ability is possible!

Using an adjustment factor, the slip compensation can be adjusted so that errors caused by non-linearity can be compensated.

Preconnected choke taken into account in the motor model "P-0-4044, Phase inductance of preconnected choke";

Command and actual parameters for the model currents:

P-0-0603, FXC: Torque-generating current command value, model

P-0-0604, FXC: Flux-generating current command value, model

P-0-0605, FXC: Torque-generating actual current value, model

P-0-0606, FXC: Flux-generating actual current value, model

P-0-0607, FXC, current command value

P-0-0608, Controlled decel.: Velocity controller P-gain

P-0-0609, Controlled decel.: Velocity controller integral action time

Commutation setting using measuring method

For a specific, non-equilibrated drive mechanics, the measuring method for determining the commutation offset can also be used with relative measuring systems if the axis is always in the same, defined initial position (axis limit stop) when switching on. The monitoring of the defined initial position requires a switch.

Torque/force scaling

Reference value of percentage-based scaling is "S-0-0533, Nominal torque/force of motor" and no longer "S-0-0111, Motor current at standstill".

Current and torque/force limitation, overview, application-related

"S-0-0530, Clamping torque" is taken into account for the current limitation for "positive stop drive procedure or homing at positive stop".

Acceleration limitation

The acceleration limitation was expanded by parameter "P-0-0564, Beschleunigungs-Grenzwert Motor".

Changes and enhancements compared to the previous version

Holding brakes, brake check

The brake check configuration options were expanded for different mechanical arrangement options of holding brake, motor and measuring system. The test procedure can thereby be adjusted to the properties of elasticity, gear backlash, clearance, etc.

These are the possible settings for checking the released holding brake:

- Maximum allowed displacement during holding system check
- Maximum velocity during holding system check
- Maximum test duration during "releasing the holding system" test

These are the possible settings for the holding system check:

- Maximum test duration "holding torque check", holding system
- Duration for applying torque, "holding torque check", holding system
- Effective direction of test torque

The following data are determined for detection of wear:

- Change in position when checking the applied holding brake
- Starting torque with holding system released
- Current holding torque of brake

Positive stop drive procedure

A specific torque/force limit value (S-0-0530, Clamping torque) is now available for the "positive stop drive procedure" command. This parameter limits the force that is used to move the axis or to push it toward the positive stop when the command is active, if this value is lower than all other torque/force limit values.

☞ If there is a drive-controlled error reaction while the "positive stop drive procedure" command is active, the torque/force limitation through S-0-0530 etc. does not take effect!

4.3.6 Operation modes

Operation modes, general

The following operation mode restrictions were implemented:

Applying to

- Economy variant with a sercos master communication cycle time of 1 ms

and

- Basic variant with a master communication cycle time less than 1 ms

For performance reasons, only the following torque control, velocity control and cyclic position control modes are possible:

- 0x0000 No operation mode
- 0x0001 Torque control
- 0x0002 Velocity control
- 0x0003 Position control, motor encoder, with lag error
- 0x000B Position control, motor encoder, without lag error
- 0x0103 Position control, motor encoder, with lag error, drive-controlled
- 0x010B Position control, motor encoder, without lag error, drive-controlled

- 0x0205 "A0165 Position control with control word of axis controller"
- 0x0305 "A0160 Pos. ctrl drive-controlled with ctrl word of axis controller"

The error message "C0245 Operation mode configuration (->S-0-0423) not allowed" is displayed in case the configuration is incorrect

Operation mode cycl. position control

An input shaper was integrated in the position command value path (P-0-0642 to P-0-0644).

Drive-internal interpolation mode

An input shaper was integrated in the position command value path (P-0-0642 to P-0-0644).

Drive-controlled positioning mode

An input shaper was integrated in the position command value path (P-0-0642 to P-0-0644).

Positioning block mode

An input shaper was integrated in the position command value path (P-0-0642 to P-0-0644).

4.3.7 Extended axis functions

Integrated safety technology

Safety technology in distributed drives

Only the optional safety technology module "S3" had previously been available for the distributed drives (IndraDrive Mi: KMS02 and KSM02).

The "Safe brake control (SBC)" is also available in the distributed drives (IndraDrive Mi) with the optional safety technology module "SD" for the near motor servo drive KMS02 and KMS03. In addition, encoder-dependent safety functions up to SIL3 can be executed (see "Optional expansion packages for safety technology").

Optional safety technology modules

Only the optional safety technology modules "L3", "L4" and "S4" had previously been available for the drive systems IndraDrive Cs, IndraDrive M / IndraDrive C (Cxx02 control section) and IndraDrive ML.

Encoder-dependent safety functions up to SIL3 can be executed with the optional safety technology modules "S5" and "SB" for the drive systems IndraDrive Cs, IndraDrive M / IndraDrive C (Cxx02 control section) and IndraDrive ML (see "Optional expansion packages for safety technology").

The differences between the optional safety technology modules "S5" and "SB" consist, among other things, in the selection and feedback options for the safety functions:

With the optional safety technology module "S5", the safety zone module, safe local outputs or Safety bus communication can be used for the selection and feedback of the safety functions. With the optional safety technology module "SB", only Safety bus communication can be used for the selection and feedback of the safety functions.

Changes and enhancements compared to the previous version

Safety functions

In addition, the following safety functions are available for position monitoring:

Safety technology function	Available with optional safety technology module					SIL	Notes
	IndraDrive Mi		IndraDrive Cs, IndraDrive M / IndraDrive C (Cxx02 control section) and IndraDrive ML				
	S3 (KMS02 and KSM02)	SD (KMS02 and KMS03)	S4	S5	SB		
Safely Monitored Position (SMP) The safety function "Safely monitored position" monitors whether or not the parameterized position range is exceeded in positive or negative direction.	✓	✓	✓	✓	✓	2 / 3*	Available in MPx-20 and above with firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS" * SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safely Limited Position (SLP) The safety function "Safely limited position " monitors via two channels that the drive can be decelerated within the parameterized **position limits** with the current velocity and the parameterized minimum delay.	✓	✓	✓	✓	✓	2 / 3*	Available in MPx-20 and above with firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS" * SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safely Limited End Position (SLE) The safety function "Safely limited end position" monitors via two channels that the drive can be decelerated within the parameterized **end position limit value** with the current velocity and the parameterized minimum delay.	✓	✓	✓	✓	✓	2 / 3*	Available in MPx-20 and above with firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS" * SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safe CAM (SCA) The safety function "Safe CAM" monitors via two channels whether or not the axis is within a position range defined by the switch-on und switch-off thresholds (cam range) and makes available the result via the status words.	✓	✓	✓	✓	✓	2 / 3*	Available in MPx-20 and above with firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS" * SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safe Homing Procedure With the auxiliary function "Safe homing procedure", another homing event is expected at a separate position after the functional homing procedure. The second homing event is used to verify the functional homing procedure.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"

"Safe Brake Control (SBC)" with "HAT02" control module

The safety function "Safe brake control (SBC)" previously could only be used with the IndraDrive Cs drive system.

With the introduction of the "HAT02" control module, the safety function "Safe brake control (SBC)" can also be used with the drive systems IndraDrive M / IndraDrive C (Cxx02 control section) and IndraDrive ML.

IO mapper inputs

The "IO mapper inputs" function was enhanced by the "Safe CAM" input signals. This allows safety functions to be selected via Safe CAM.

Up to MPx-19, the start input for restart protection of the IO mapper block "Safe AND with protection against restart" (type 6) was a safe input, in MPx-20 and above it is a functional input.

Other IO mapper blocks are available in the firmware MPx-20 and above:

- The IO mapper block "Safe AND" is used to map additional activation signals [mode selection signal (MS), enabling control signal (EC), SMMx signal (A_SSMx)] to other, also functional, signals from the machine/ installation.
- The IO mapper block "functional connector" is used to map a reference signal at a functional input to the control word of the safety technology function "Safe homing procedure"
- The IO mapper block "Safe AND with ES bypass and protection against restart" is used for parallel processing of multiple emergency stop signals (ES) and the protection against automatic restart. The individual emergency stop signals (ES) can be dynamically masked using bypass signals.

Safety bus communication via "FailSafe over EtherCat (FSoE)"

In the firmware version MPx20VRS, "FailSafe over EtherCat (FSoE)" is available in addition to "CIP Safety on sercos" for Safety bus communication. Via "P-0-3345, SMO: Safety bus configuration" select the Safety bus communication which is to be active.

Two new predefined configurations for the consumer connections were defined [types 5 (786) and 6 (787)] to assign the following new target signals:

- Reference signal for Safe homing procedure
- Assigning a signal of a safety-relevant control unit to the safe output at the local interface
- Releasing the holding brake

Three new predefined configurations for the producer connections were defined [type 5 (788), type 6 (789) and 7 (790)] to assign the following new source signals:

- Functional signals
- Safe CAM status
- Acknowledgment of holding brake control
- Encoder standstill signal

☞ In the firmware version MPx20VRS, the new predefined configurations cannot be used for FSoE; the consumer and producer connection are combined in a fixed profile for FSoE. The profile selection is restricted to these two possible profiles: "2-byte SMO control word / status word [bit-coded SMM (780/784)]" and "2-byte SMO control word / status word (binary-coded SMM (781/785)]".

Safe encoder evaluation

The safe absolute position of an encoder can be detected using the Safe encoder evaluation. The safe absolute position is established using the auxiliary function "Safe homing procedure" and is the basis for the following position-based safety functions:

- Safely Monitored Position (SMP)
- Safely Limited Position (SLP)
- Safely Limited End Position (SLE)
- Safe CAM (SCA)

The "safe encoder evaluation" in the safety options "S5" and "SB" supports resolvers. SIL3 can therefore be attained with the encoder detection.

For encoder-dependent safety functions, the synchronous servo motors of the MS2N series are supported with the encoder options "CS"/"CM" (Safety4Wire single-turn / Safety4Wire multi-turn).

Firmware options for safety technology

In the firmware version MPx20VRS, three new firmware options (FWS) are available:

- "SAFETY-PLUS"
- "SIL3-MOTION"
- "SIL3-PLUS"

The firmware can be enhanced by the following safety functions using the "SAFETY-PLUS" firmware option:

- Safely Monitored Position (SMP)
- Safely Limited Position (SLP)
- Safely Limited End Position (SLE)
- Safe CAM (SCA)

Using the firmware option "SIL3-MOTION", SIL3 is also attained with the encoder-dependent safety functions. As a prerequisite, a SIL3-capable encoder (e.g., resolver) has to be used.

The firmware option "SIL3-PLUS" combines the functionalities of the firmware options "SAFETY-PLUS" and "SIL3-MOTION" in one firmware option.

Correction of the torque/force constant

The correction of the torque/force constant can be used for synchronous motors. The current torque/force constant value depends on the motor temperature, the average speed and the current torque-generating motor current (due to saturation effects).

For the following motors with encoder data memory, the required motor data are automatically loaded to the drive:

- MSK with encoder memory version 4.5 and above
- MS2N with encoder memory version 4.6, and generally with encoder memory version 7

With MS2N (encoder memory vers. 7), the correction is automatically activated via the parameter "P-0-3945, Motor control configuration". The saturation current threshold is now preset via "P-0-0472, Motor saturation current".

With MSK (with encoder memory vers. 4.5 and above) and MS2N (encoder memory vers. 4.6), the required motor data are loaded to the drive, but the correction function has to be manually activated at commissioning (in the case of MSK for compatibility reasons). For MSK, the saturation current threshold is displayed in "P-0-0472, Motor saturation current".

Overview of warning and error classes and reactions

Controlled braking in the case of motor encoder (P-0-0119).

Decelerating by short circuiting the motor windings

Permanent motor phase short circuit, even if drive enable has been switched off, instead of a motor holding brake (can be configured in P-0-0119).

Error reaction in the case of fatal errors: Deceleration by motor phase short circuit.

Operation mode handling, drive state machine

Controlled deceleration, motor phase short circuit in NoRF. New diagnostic messages implemented: A4004 to A4009.

4.3.8 Optional device functions

Time formats and time functions

The IndraLogic programming system and the MLD system libraries make available functions and function blocks for processing time data types. Furthermore, there are functions that can be used to make time measurements.

The drive system time can be read or set using these functions and function blocks. In addition, the units of the time data can be converted.

The following time data types are available:

Function	Time data type	Unit
SYSTIME	ULINT, 64bit	ms (since 1970-01-01 UTC)

Tab. 4-5: Time data type

The following functions are available in the new "SysTimeRtc" library:

Function	Time data type	Unit
SysTimeRtcGet	DWORD	Provides the current drive system time (s since 1970-01-01 UTC)
SysTimeRtcSet	DWORD	Sets current drive system time (s since 1970-01-01 UTC)
SysTimeRtcHighResGet	SYSTIME	Provides the drive system time
SysTimeRtcHighResSet	SYSTIME	Sets the drive system time

Tab. 4-6: Time data type

Device/libraries and version assignment

Libraries with the „xxxx23.library" extension are converted libraries primarily intended to port MLD1G projects. There are no placeholders for these libraries. For new PLC projects and if multiple libraries are available, the libraries without the „xxxx23.library" extension should be used (e.g., SysSem.library instead of SysSem23.library).

Motion

The same library is provided for all variants. This allows all provided function blocks to be called. Function blocks that are not operable on a configuration signal „RESOURCE_ERROR“.

Changes and enhancements compared to the previous version

MLD file system

The PLC system files are managed by IndraLogic. There are files available in the form of parameters, independent of the external memory card. All other files are contained on the memory card. In MPx20/PSB20 and above, the file system is available with all variants with MLD, if a µSD card has been plugged. When the memory card is initialized, the folder structure required for the application is created, unless it already exists. This folder structure consists of:

- Backup
- Documentation
- PLC
- Temp
- Tools
- User

This is how the directories are used:

- In the "Documentation" directory, the user can store their own files to keep records of their installation/machine.
- In the "Tools" directory, the user can store tools.
- The "PLC" directory contains files that are managed by IndraLogic.
- The "User" directory is reserved for user files that can be accessed from the PLC, via FTP or using the IndraWorks File Explorer.
- The "Backup" directory is used to store a backup of the retain data and the parameters.
- The "Temp" directory contains temporary files.

External memory card as a storage medium

When MLD is used, the external memory card is particularly important. The drive-integrated PLC can also be used without the memory card, but in this case some options are missing, such as the loading of source code. If an external memory card is used for the MLD options, it has to have been plugged before the drive is started.

The external memory card provides the following options for MLD:

- Storing the source code of a PLC application
- Optional: Filing of the PLC boot application (with corresponding "MLD configuration" in IndraWorks or corresponding parameter setting of P-0-1367)
- Restoring a PLC project from the loaded source code
- PLC retain data and parameter backup

Drives at Sercos peripherals

It is possible to connect up to 4 drives to the Sercos peripherals. This increases the number of drives in the CCD group by the max. number of configurable I/Os.

☞ The number of configurable peripheral Sercos devices remains the same. It is possible to configure uo to 4 devices. These are counted among the peripheral Sercos devices:

- Block IO modules
- IO bus couplers (modular IO, S20 bus couplers, S67 bus couplers, etc.)
- Drives

CCD: IP communication

Automatic IP address assignment for CCD slaves can be activated via P-0-1800.0.1.

IP address: 172.31.<master comm. address CCD master><device part automatically set>

Depending on the master communication protocol that was set, the "master comm. address CCD master" results from:

"S-0-1040, Drive address of master communication" with sercos master communication set or without master communication set

"P-0-4089.0.3, Device Address" for all other master communications

The following values are assigned to the device part of the automatically set IP address:

CCD master: 254

CCD slave: "S-0-1040, Drive address of master communication"

CCD: Overview, features, modes

Optional CCD slaves (hotplug capability) are possible, and acyclic access to CCD slave parameters is possible via S/IP. The max. number of slaves is higher at CCD cycle times of 250 µs or 500 µs.

CCD: Addressing

Hotplug is supported.

It is possible to mark CCD slaves when addressing. These devices can be missing in the CCD group without causing offsets in the CCD slave addressing/assignment. Thus, the CCD group can also be operated without configuration adjustments after the optional CCD slaves have been added/removed.

Probe

The probe function was enhanced by absolute time measurement; previously, only relative time measurement had been possible. The absolute time measurement is supported by "S-0-1305.0.2, System fine time", i.e. the possible measuring signals were expanded by parameter S-0-1305.0.2.

4.3.9 Handling, diagnostic and service functions

Diagnostics: Structure and priority-based generation

If the device status changes after a diagnostic message was signaled and the diagnostic message is no longer present, this change is now recorded.

The new parameter "S-0-0390.0.136, Detailed diagnostic message" was implemented (replaces logbook, is basis for Diagnostic Trace).

The bit 20 was implemented in "S-0-0390, Diagnostic message number", it displays the diagnostic message status:

- Bit 20="0":

Changes and enhancements compared to the previous version

- Diagnostic message is "Fxxxx" (error) type:

  The error cannot be cleared, because its cause has not yet been removed.
- Diagnostic message is "Cxxxx" (command) type:

  The command is in process.

- Bit 20="1":
  - Diagnostic message is "Fxxxx" (error) type:

    The error can be cleared.
  - Diagnostic message is "Cxxxx" (command) type:

    The command was terminated with error or completed without error.

Patch function

Symbol-based patch function and displaying internal storage locations for Hxx05 power section

The patch function allows the IndraWorks Engineering software to access internal data and variables that are not mapped by S- and P-parameters. The following functions are available for this purpose:

- Standard patch function: Accessing internal data and variables via the memory address
- Symbol-based patch function: Accessing internal variables via a symbol assigned to the variable
- Block patch function: Easily accessing entire internal data ranges.

4 to 8 symbol-based patch functions can be activated. Four of them are active in the electric variants, all eight in the hydraulic variants.

P-0-0492, Symbol-based patch function 1, data source

P-0-0493, Symbol-based patch function 1, display

P-0-0494, Symbol-based patch function 2, data source

P-0-0495, Symbol-based patch function 2, display

P-0-0496, Symbol-based patch function 3, data source

P-0-0497, Symbol-based patch function 3, display

P-0-0498, Symbol-based patch function 4, data source

P-0-0499, Symbol-based patch function 4, display

P-0-0792, Symbol-based patch function 5, data source

P-0-0793, Symbol-based patch function 5, display

P-0-0794, Symbol-based patch function 6, data source

P-0-0795, Symbol-based patch function 6, display

P-0-0796, Symbol-based patch function 7, data source

P-0-0797, Symbol-based patch function 7, display

P-0-0798, Symbol-based patch function 8, data source

P-0-0799, Symbol-based patch function 8, display

Operating hours and error memory

HMU05 error memory

The power section error memory is used to analyze the error history for servicing. This is also possible if power sections come back without the control sections, e.g. for repair.

The information from "P-0-0194, Error memory power section" is additionally displayed in the parameters "P-0-2602.0.1, Power section logbook event", "P-0-2602.0.2, Time stamp of power section logbook event" to obtain a consistent interface for the power section error memory. The operating hours counter of the power section is displayed in addition to "P-0-0191, Operating hours power section".

Each HMU has its individual operating hours counter (P-0-2602.SI.20, Operating hours counter of power section). The master HMU synchronizes to the system time. Each power section (HMU) has its own logbook for the errors, diagnostics and events occurred on the respective module. (P-0-2602.SI.1 and P-0-2602.SI.2) In addition, each slave (ILC system) persistently records the 16-bit error code of its subsystems, available on its error status, in its local logbook with the time stamp "individual operating hours counter". The power section master also records its own errors persistently in its logbook. The entries are persistently stored in the power section so to enable diagnostics for servicing.

Diagnostic LED

For devices without a display, the bus-specific state and the state of the subdevice state machine is displayed on a diagnostic LED.

Besides IndraDrive HCQ / HCT, KSM02.1, KMS02.1, the diagnostic LED is also available for the KMV supply unit, see also Project Planning Manual "Rexroth IndraDrive Mi, Drive Systems with KCU02, KSM02, KMS02" (DOK-INDRV*-KCU02+KSM02-PRxx-EN-P, mat. no. R911335703).

Application-specific control panel function

Predefined default value for supply units

The "Actual"-"Values" (P-0-0680.0.2) menu item of the supply units is initialized with a predefined menu structure (default value P-0-0680.0.2). The following parameters are displayed:

- Mains voltage peak value (S-0-1702.0.1)
- Mains current (S-0-1702.0.2)
- Mains power (S-0-1702.0.13)
- DC bus voltage (S-0-1707.0.1)
- Thermal device load (S-0-1710.0.2)

Application-specific control panel function

Device info extended for Hxx05, menu for supply units adjusted

Resetting to default values

Loading application-specific parameters from the motor type plate, i.e. writing the factory default values via the "create type plate data" command, is possible with MPx20 and above, see also "P-0-4090, Configuration for loading default values".

sercos function groups

New supply unit parameter "S-0-1700.0.1, List of FSP Power Supply classes" and new instances of "S-0-1302.x.1, FSP Type".

Identification parameter of the implemented function and sercos profiles of the firmware/hardware combination.

Saving system information

Parameter was created for saving the view (e.g., configurable axis view with IndraWorks Ds) to the drive (P-0-0250.x.x).

Optional memory card, file system

Availabilityof the optional memory card also extended to Basic and Economy devices.

Operating hours counter and system time

New parameters for the system time implemented:

- S-0-1305.0.1, System time
- S-0-1305.0.2, System fine time
- S-0-1305.0.3, System coarse time

This allows the system time to be set and tracked with high precision via the sercos and EtherCAT master communication protocols.

"P-0-0197, System time" is maintained for compatibility reasons.

4.3.10 Engineering/diagnostic interfaces

Internet protocol services (S/IP)

It is possible to access PLC variables via S/IP. Implementing S/IP routing and SVC routing depending on the SCP class.

FTP server

With the implementation of a new display type with memory card, the FTP server is available in all firmware derivatives.

Webserver

Open source licenses can be displayed via <IP.IP.IP.IP>/licenses.htm (<IP.IP.IP.IP> coresponds to the English IP address of the drive).

Open source licenses displayed via "licenses.htm"

Engineering over IP

Ethernet POWERLINK was added, see also chapter "Brief description" on page 131.

4.4 New, modified and no longer existing parameters

4.4.1 New, modified and no longer existing parameters

New parameters

- P-0-0564, Motor acceleration limit value
- P-0-3061, Status of motor fan control
- P-0-3235.0.6, SMO: Proposed axis identifier, auto commissioning
- P-0-3235.0.7, SSO Proposed TUNID, auto commissioning
- P-0-3242.0.4, SMO: Phys. encoder resolution (digital)
- P-0-3263.0.8, SMO: Jerk
- P-0-3271.0.1, SMO: Safe CAM 1
- P-0-3271.0.2, SMO: Safe CAM 2
- P-0-3271.0.3, SMO: Safe CAM 3

- P-0-3271.0.4, SMO: Safe CAM 4
- P-0-3271.0.5, SMO: Safe CAM 5
- P-0-3271.0.6, SMO: Safe CAM 6
- P-0-3271.0.7, SMO: Safe CAM 7
- P-0-3271.0.8, SMO: Safe CAM 8
- P-0-3271.0.130, SMO: Safe CAM, compact
- P-0-3353, Proposed FSoE slave address, auto commissioning
- P-0-3360.0.1, PROFIsafe: F-Device Address
- P-0-3360.0.2, PROFIsafe: Proposed F-Device address
- P-0-3360.0.3, PROFIsafe: Current F-Device state
- P-0-3360.0.4, PROFIsafe: F-parameters
- P-0-3360.0.5, PROFIsafe: Application parameters
- P-0-3360.0.6, PROFIsafe: Proposed F-Device address, auto commissioning
- P-0-3915.0.1, Module/firmware history, time stamp
- P-0-3915.0.2, Module/firmware history, component designation
- P-0-3915.0.3, Module/firmware history, cause of error
- P-0-3915.0.130, Module/firmware history, compact
- P-0-4084.0.2, Default profile

- S-0-0550, Torque/force command value, positive 2
- S-0-0551, Torque/force command value, negative 2
- S-0-0552, Torque/force feedback value 2
- S-0-0553, Torque/force command value 2 ramp
- S-0-0602.0.8, Phys. max. initialization speed

New alias parameters

- P-0-2760, Supply unit control loop data, compact
- P-0-2767, Multi-encoder interface configuration
- P-0-3589, Holding system check configuration data, compact
- P-0-3591, Module/firmware history, compact
- P-0-3720, Default profile
- P-0-3721, SMO: Safe CAM, compact
- P-0-3898, SSO Proposed TUNID, auto commissioning
- P-0-3899, SMO: Proposed axis identifier, auto commissioning

Definitions:

An alias parameter is a replacement parameter for communication interfaces which do not support 32 bit IDNs (EIDN).

Example:

Alias parameter:

P-0-2599 -> "S-0-1702.0.16"

A legacy alias parameter is a replacement parameter for compatible access and for communication interfaces which do not support 32 bit IDNs (EIDN).

Example:

Legacy alias parameter:

e.g., P-0-1701 -> "P-0-1808.2.1"

Modified parameters

- P-0-0001, Switching frequency of the power output stage
- P-0-0214, Analog input, assignment A, scaling
- P-0-0215, Analog input, assignment A, signal value at 0
- P-0-0216, Analog input, assignment A, dead zone
- P-0-0217, Analog input 1, time constant input filter
- P-0-0231, Analog input 2, time constant input filter
- P-0-0232, Analog input 3, time constant input filter
- P-0-0233, DA: Analog input 1, time constant input filter
- P-0-0234, DA: Analog input 2, time constant input filter
- P-0-0237, Analog input, assignment B, scaling
- P-0-0238, Analog input, assignment B, signal value at 0
- P-0-0239, Analog input, assignment B, dead zone
- P-0-0246, Analog input, assignment C, scaling
- P-0-0247, Analog input, assignment C, signal value at 0
- P-0-0248, Analog input, assignment C, dead zone
- P-0-0701, Motion step 1, slave axis initial position
- P-0-0853, Max. DC bus voltage, motor
- P-0-1120, Velocity control loop filter: Filter type
- P-0-3242.0.1, SMO: Phys. Encoder type
- P-0-3242.0.2, SMO: Phys. Encoder properties
- P-0-3242.0.3, SMO: Phys. Encoder resolution (analog)
- P-0-4014, Type of construction of motor

- S-0-0127, C0100 Communication phase 3 transition check
- S-0-0600.0.1, Encoder status

Modified alias parameters

No alias parameter was modified.

No longer existing parameters

- P-0-0074, Encoder type 1 (motor encoder)
- P-0-0075, Encoder type 2 (optional encoder)
- P-0-0076, Encoder type 3 (measuring encoder)

- P-0-0105, Time stamp for list of diagnostic message numbers
- P-0-0198, System time error memory
- P-0-0199, System time error code
- P-0-0326, Multiplication of measuring encoder
- P-0-0327, Encoder resolution of measuring encoder
- P-0-0343, Encoder 1, cosine signal
- P-0-0344, Encoder 1, sine signal
- P-0-0345, Encoder 2, cosine signal
- P-0-0346, Encoder 2, sine signal
- P-0-0347, Encoder 3, cosine signal
- P-0-0348, Encoder 3, sine signal
- P-0-0476, Logbook configuration word
- P-0-0477, Logbook axis number
- P-0-0478, Logbook event
- P-0-0479, Logbook time stamp
- P-0-1000, Kind of encoder 1, encoder memory
- P-0-1001, Encoder 1 resolution, encoder memory
- P-0-1010, Kind of encoder 2, encoder memory
- P-0-1011, Encoder 2 resolution, encoder memory
- P-0-1020, Kind of encoder 3, encoder memory
- P-0-1021, Encoder 3 resolution, encoder memory
- P-0-3354, FSoE: Connection ID
- 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-0-3908.0.1, Circuit board designation
- P-0-3908.0.4, Circuit board name
- P-0-3908.0.8, Circuit board hardware version
- P-0-3908.0.11, Circuit board order code
- P-0-3908.0.12, Circuit board serial number
- P-0-3908.0.150, Circuit board firmware identifier
- P-0-4089.0.9, ECAT: XInt Shift
- S-0-0059, Position switch flag parameter
- S-0-0060, Position switch point 1 "On"
- S-0-0116, Feedback 1 resolution
- S-0-0117, Feedback 2 resolution
- S-0-0256, Multiplication 1 (motor encoder)
- S-0-0257, Multiplication 2 (optional encoder)
- S-0-0375, List of diagnostic numbers
- S-0-0441, Marker position feedback 2
- S-0-0443, Counter marker position feedback 2
- S-0-0460, Position switch point 1 "Off"

- S-0-0600.0.20, Encoder data out container
- S-0-0602.x.137, Phys. max. initialization speed
- S-0-0603.0.3, Phys. encoder input signal A
- S-0-0603.0.4, Phys. encoder input signal B
- S-0-0610.0.20, Encoder data out container (input)
- S-0-0900, Torque/force command value, positive 2
- S-0-0901, Torque/force command value, negative 2
- S-0-0902, Torque/force feedback value 2
- S-0-0903, Torque/force command value 2 ramp

Alias parameters

- P-0-2719
- P-0-3580

4.4.2 Changes in comparison to MPx20V06

New, modified and no longer existing parameters

New parameters

- P-0-3242.0.4, SMO: Phys. Encoder resolution (digital)
- P-0-3263.0.8, SMO: Jerk
- P-0-3915.0.1, Module/firmware history, time stamp
- P-0-3915.0.2, Module/firmware history, component designation
- P-0-3915.0.3, Module/firmware history, cause of error
- P-0-3915.0.130, Module/firmware history, compact
- P-0-4089.0.9, ECAT: XInt Shift

New alias parameters

- P-0-3580, ECAT: XInt Shift
- P-0-3591, Module/firmware history, compact

Definitions:

An alias parameter is a replacement parameter for communication interfaces which do not support 32 bit IDNs (EIDN).

Example:

Alias parameter:

P-0-2599 -> "S-0-1702.0.16"

A legacy alias parameter is a replacement parameter for compatible access and for communication interfaces which do not support 32 bit IDNs (EIDN).

Example:

Legacy alias parameter:

e.g., P-0-1701 -> "P-0-1808.2.1"

Modified parameters

- P-0-0214, Analog input, assignment A, scaling
- P-0-0215, Analog input, assignment A, signal value at 0
- P-0-0216, Analog input, assignment A, dead zone
- P-0-0217, Analog input 1, time constant input filter
- P-0-0231, Analog input 2, time constant input filter
- P-0-0232, Analog input 3, time constant input filter
- P-0-0233, DA: Analog input 1, time constant input filter
- P-0-0234, DA: Analog input 2, time constant input filter
- P-0-0237, Analog input, assignment B, scaling
- P-0-0238, Analog input, assignment B, signal value at 0
- P-0-0239, Analog input, assignment B, dead zone
- P-0-0246, Analog input, assignment C, scaling
- P-0-0247, Analog input, assignment C, signal value at 0
- P-0-0248, Analog input, assignment C, dead zone
- P-0-0853, Max. DC bus voltage, motor
- S-0-0127, C0100 Communication phase 3 transition check

Modified alias parameters

No alias parameter was modified.

No longer existing parameters

- P-0-3625.000.001, EPL: ERR History
- P-0-3625.000.002, EPL: Error Entry
- P-0-3626.000.004, EPL: ConfId
- P-0-3626.000.005, EPL: VerifyConfInvalid

4.4.3 Changes in comparison to MPx20V04

New parameters

- P-0-0015, Minimum pulse duration
- P-0-0016, Current controller control word 2
- P-0-0035.0.1, Oscilloscope: Trigger time
- P-0-0110, Device control: Status word 2
- P-0-0183, Drive optimization, checksum
- P-0-0250.0.10, IndraWorks view manager
- P-0-0251, Remote analog input 1
- P-0-0252, Remote analog input 2
- P-0-0253, Remote analog input 3
- P-0-0269, Oscilloscope: Channel number setting
- P-0-0270, Oscilloscope: Signal selection 5
- P-0-0271, Oscilloscope: Signal selection 6
- P-0-0272, Oscilloscope: Signal selection 7
- P-0-0273, Oscilloscope: Signal selection 8
- P-0-0274, Oscilloscope: List of measured values 5

Changes and enhancements compared to the previous version

- P-0-0275, Oscilloscope: List of measured values 6
- P-0-0276, Oscilloscope: List of measured values 7
- P-0-0277, Oscilloscope: List of measured values 8
- P-0-0322.0.2, Performance load prewarning threshold exceeded
- P-0-0472, Motor saturation current
- P-0-0501, Dynamic alias mapping, mapping EIDN
- P-0-0502, Dynamic alias mapping, mapping EIDN content
- P-0-0560, Configuration of actuator
- P-0-0561, Effective velocity controller command value
- P-0-0562, Active infeed/gear factor
- P-0-0563, Velocity command value input for adjustment
- P-0-0603, FXC: Torque-generating current command value, model
- P-0-0604, FXC: Flux-generating current command value, model
- P-0-0605, FXC: Torque-generating actual current value, model
- P-0-0606, FXC: Flux-generating actual current value, model
- P-0-0607, FXC, current command value
- P-0-0608, Controlled decel.: Velocity controller P-gain
- P-0-0609, Controlled decel.: Velocity controller integral action time
- P-0-0642, Anti-vibration filter frequency
- P-0-0643, Anti-vibration filter damping
- P-0-0644, Anti-vibration filter delay clocks
- P-0-0650.0.1, Internal IndraDrive parameter
- P-0-0650.0.2, Internal IndraDrive parameter
- P-0-0650.0.3, Internal IndraDrive parameter
- P-0-0660, C6300 Generate type plate command
- P-0-0660.0.2, Generate type plate, IDN list of type plates
- P-0-0660.0.3, Generate type plate, configuration list
- P-0-0661, C9100 Confirm power section configuration command
- P-0-1000.0.130, Phys. encoder type plate
- P-0-1550, Container FSoE MasterMessage
- P-0-1551, Container FSoE SlaveMessage
- P-0-1901.0.1, CiA402: Controlword
- P-0-1901.0.2, CiA402: Statusword
- P-0-1901.0.3, CiA402: Abort connection option code
- P-0-1901.0.4, CiA402: Quick stop option code
- P-0-1901.0.5, CiA402: Shutdown option code
- P-0-1901.0.6, CiA402: Disable operation option code
- P-0-1901.0.7, CiA402: Halt option code
- P-0-1901.0.8, CiA402: Fault reaction option code
- P-0-1901.0.9, CiA402: Modes of operation
- P-0-1901.0.10, CiA402: Modes of operation display
- P-0-1901.0.11, CiA402: Supported drive modes
- P-0-1901.0.12, CiA402: Error Code

- P-0-1901.0.21, CiA402: Position encoder resolution
- P-0-1901.0.22, CiA402: Position encoder resolution, Encoder icrements
- P-0-1901.0.23, CiA402: Position encoder resolution, Motor revelutions
- P-0-1901.0.24, CiA402: Gear ratio
- P-0-1901.0.25, CiA402: Feed constant
- P-0-1901.0.26, CiA402: Feed constant, feed
- P-0-1901.0.27, CiA402: Feed constant, shaft revolutions
- P-0-1901.0.28, CiA402: Velocity factor
- P-0-1901.0.29, CiA402: Velocity factor, numerator
- P-0-1901.0.30, CiA402: Velocity factor, divisor
- P-0-1901.0.31, CiA402: Acceleration factor
- P-0-1901.0.32, CiA402: Acceleration factor, numerator
- P-0-1901.0.33, CiA402: Acceleration factor, divisor
- P-0-1901.0.34, CiA402: Polarity
- P-0-1901.0.35, CiA402: SI unit position
- P-0-1901.0.36, CiA402: SI unit velocity
- P-0-1901.0.37, CiA402:SI unit acceleration
- P-0-1901.0.41, CiA402: Target Position
- P-0-1901.0.42, CiA402: Interpolation time period
- P-0-1901.0.43, CiA402: Interpolation time period value
- P-0-1901.0.44, CiA402: Interpolation time index
- P-0-1901.0.45, CiA402: Position Range Limit
- P-0-1901.0.46, CiA402: Min position range limit
- P-0-1901.0.47, CiA402: Max position range limit
- P-0-1901.0.48, CiA402: Software Position Limit
- P-0-1901.0.49, CiA402: Min position limit
- P-0-1901.0.50, CiA402: Max position limit
- P-0-1901.0.51, CiA402:Position actual internal value
- P-0-1901.0.52, CiA402:Position demand internal value
- P-0-1901.0.53, CiA402:Homing method
- P-0-1901.0.54, CiA402: Homing speeds
- P-0-2602.0.3, Error memory: Diagnostic code
- P-0-2603.0.4, Error memory: Time stamp (system time)
- P-0-2603.0.50, Power section XML identification data
- P-0-2875.0.3, Maximum flow
- P-0-2875.0.4, Maximum pressure
- P-0-2943, Pump displacement volume
- P-0-2944, Motor nominal speed
- P-0-2945, Configuration of analog mode
- P-0-3060.0.1, Motor fan switch-on temperature
- P-0-3060.0.3, Speed-dependent motor shutdown temperature reduction
- P-0-3060.0.4, Motor mounting situation
- P-0-3060.0.5, Motor shutdown temperature reduction / 1000rpm

Changes and enhancements compared to the previous version

- P-0-3060.0.10, Thermal parameters, motor
- P-0-3060.0.130, Thermal parameters, motor, compact
- P-0-3071, Identification data, type plate
- P-0-3072, Motor: Static type data, type plate
- P-0-3073, Motor: Control loop default values, type plate
- P-0-3075, Application-specific data, type plate
- P-0-3203, SMO: Optional firmware packages
- P-0-3215, SMO: Velocity command value for SOS check function
- P-0-3238.0.1, SMO: Active position limit value, positive
- P-0-3238.0.2, SMO: Active position limit value, negative
- P-0-3253, SMO: Safe homing procedure control word
- P-0-3253.0.1, SMO: Safe homing procedure configuration
- P-0-3253.0.2, SMO: C4000 Safe homing procedure command
- P-0-3253.0.3, SMO: Reference position
- P-0-3253.0.4, SMO: Safe homing procedure tolerance window
- P-0-3253.0.5, SMO: Maximum homing velocity
- P-0-3253.0.6, SMO: Reference check time interval
- P-0-3257.0.1, SMO: Actual position value, coded
- P-0-3264.0.2, SMO: Safety function diagnostics
- P-0-3270.0.4, SMO: Safe end position limit value, positive
- P-0-3270.0.5, SMO: Safe end position limit value, negative
- P-0-3290.0.4, SMO: Safe position limit value, positive
- P-0-3290.0.5, SMO: Safe position limit value, negative
- P-0-3332.0.2, SMO: IO mapper inputs, IO mapper block status
- P-0-3350, FSoE: Slave address
- P-0-3351, FSoE: Expected slave address
- P-0-3352, FSoE: Slave state
- P-0-3355, FSoE: Safe communication parameters
- P-0-3356, FSoE: Safe application parameters
- P-0-3600.0.1, CANopen: Device type
- P-0-3601.0.1, CANopen: Error register
- P-0-3603.0.1, CANopen: Communication cycle period
- P-0-3604.0.1, CANopen: Manufacturer device name
- P-0-3604.0.2, CANopen: Manufacturer hardware version
- P-0-3604.0.3, CANopen: Manufacturer software version
- P-0-3606.0.1, Identity Object: Highest sub-index supported
- P-0-3606.0.2, CANopen: Vendor ID
- P-0-3606.0.3, CANopen: Product Code
- P-0-3606.0.4, CANopen: Revision Number
- P-0-3606.0.5, CANopen: Serial Number
- P-0-3616.0.1, ECAT: EtherCAT Address
- P-0-3616.0.2, ECAT: Virtual MAC Address
- P-0-3617.0.1, ECAT: IP Address Info

- P-0-3617.0.2, ECAT: IP Address
- P-0-3617.0.3, ECAT: Subnet Mask
- P-0-3617.0.4, ECAT: Default Gateway
- P-0-3618.0.1, ECAT: Receive PDO Mapping
- P-0-3619.0.1, ECAT: RPDO: application object
- P-0-3620.0.1, ECAT: Transmit PDO Mapping
- P-0-3621.0.1, ECAT: TPDO: application object
- P-0-3622.0.1, ECAT: Sync Manager Communication Type
- P-0-3622.0.2, ECAT: Sync Manager 1
- P-0-3622.0.3, ECAT: Sync Manager 2
- P-0-3622.0.4, ECAT: Sync Manager 3
- P-0-3622.0.5, ECAT: Sync Manager 4
- P-0-3623.0.1, ECAT: PDO Assignment RX (Outputs)
- P-0-3623.0.2, ECAT: PDO Assign Outputs 1
- P-0-3624.0.1, ECAT: PDO Assignment TX (Inputs)
- P-0-3624.0.2, ECAT: PDO Assign Inputs 1
- P-0-3625.0.1, EPL: ERR History
- P-0-3625.0.2, EPL: Error Entry
- P-0-3626.0.1, EPL: Verify Configuration
- P-0-3626.0.2, EPL: ConfDate
- P-0-3626.0.3, EPL: ConfTime
- P-0-3626.0.4, EPL: ConfId
- P-0-3626.0.5, EPL: VerifyConfInvalid
- P-0-3627.0.1, EPL: Interface Group
- P-0-3627.0.2, EPL: Interface Index
- P-0-3627.0.3, EPL: Interface Description
- P-0-3627.0.4, EPL: Interface Type
- P-0-3627.0.5, EPL: Interface Mtu
- P-0-3627.0.6, EPL: Interface Phys Address
- P-0-3627.0.7, EPL: Interface Name
- P-0-3627.0.8, EPL: Interface Oper Status
- P-0-3627.0.9, EPL: Interface Admin State
- P-0-3627.0.10, EPL: Valid
- P-0-3628.0.1, EPL: Sequ Layer Timeout
- P-0-3629.0.1, EPL: Cmd Layer Timeout
- P-0-3630.0.1, EPL: Rx Comm Param
- P-0-3630.0.2, EPL: Node ID
- P-0-3630.0.3, EPL: Mapping Version
- P-0-3631.0.1, EPL: Rx Mapp Param
- P-0-3631.0.2, EPL: Rx Object Mapping
- P-0-3632.0.1, EPL: Tx Comm Param
- P-0-3632.0.2, EPL: Node ID
- P-0-3632.0.3, EPL: Mapping Version

Changes and enhancements compared to the previous version

- P-0-3633.0.1, EPL: Tx Mapp Param
- P-0-3633.0.2, EPL: Tx Object Mapping
- P-0-3634.0.1, EPL: CN Loss SoC
- P-0-3634.0.2, EPL: Loss SoC: Cumulative Cnt
- P-0-3634.0.3, EPL: Loss SoC: Threshold Cnt
- P-0-3634.0.4, EPL: Loss SoC: Threshold
- P-0-3635.0.1, EPL: CN CRC Error
- P-0-3635.0.2, EPL: CRC Error: Cumulative Cnt
- P-0-3635.0.3, EPL: CRC Error: Threshold Cnt
- P-0-3635.0.4, EPL: CRC Error: Threshold
- P-0-3636.0.1, EPL: CN Loss Of SoC Tolerance
- P-0-3637.0.1, EPL: IP Addr Table
- P-0-3637.0.2, EPL: If Index
- P-0-3637.0.3, EPL: Addr IPAD
- P-0-3637.0.4, EPL: Net Mask IPAD
- P-0-3637.0.5, EPL: Reasm Max Size
- P-0-3637.0.6, EPL: Default Gateway IPAD
- P-0-3638.0.1, EPL: Ip Group
- P-0-3638.0.2, EPL: Forwarding
- P-0-3638.0.3, EPL: Default TTL
- P-0-3638.0.4, EPL: Forward Datagrams
- P-0-3639.0.1, EPL: Feature Flags
- P-0-3640.0.1, EPL: EPL Version
- P-0-3641.0.1, EPL: Curr NMT State
- P-0-3642.0.1, EPL: EPL Node ID
- P-0-3642.0.2, EPL: Node ID
- P-0-3642.0.3, EPL: Node ID By HW
- P-0-3642.0.4, EPL: SW Node ID
- P-0-3643.0.1, EPL: Cycle Timing
- P-0-3643.0.2, EPL: Isochr Tx Max Payload
- P-0-3643.0.3, EPL: Isochr Rx Max Payload
- P-0-3643.0.4, EPL: Pres Max Latency
- P-0-3643.0.5, EPL: Preq Act Payload Limit
- P-0-3643.0.6, EPL: Pres Act Payload Limit
- P-0-3643.0.7, EPL: Asnd Max Latency
- P-0-3643.0.8, EPL: Multiple Cycle Cnt
- P-0-3643.0.9, EPL: Async MTU
- P-0-3643.0.10, EPL: Prescaler
- P-0-3644.0.1, EPL: CN Basic Ethernet Timeout
- P-0-3645.0.1, EPL: Host Name
- P-0-3646.0.1, EPL: Reset Cmd
- P-0-3647.0.1, ECAT: Synchronization Type (Outputs) number of entries
- P-0-3647.0.2, ECAT: Synchronization Type (Outputs)

- P-0-3647.0.5, ECAT: Synchronization Types Supported (Outputs)
- P-0-3647.0.7, ECAT: Calc and Copy Time (Outputs)
- P-0-3647.0.10, ECAT: Delay Time (Outputs)
- P-0-3648.0.1, ECAT: Synchronization Type (Inputs) number of entries
- P-0-3648.0.2, ECAT: Synchronization Type (Inputs)
- P-0-3648.0.5, ECAT: Synchronization Types Supported (Inputs)
- P-0-3648.0.7, ECAT: Calc and Copy Time (Inputs)
- P-0-3648.0.10, ECAT: Delay Time (Inputs)
- P-0-3945, Motor control configuration
- P-0-4044, Phase inductance of preconnected choke
- P-0-4083.0.2, Application: Allocation of object ID to sercos EIDN
- P-0-4083.0.3, Master communication: Allocation of object ID to sercos EIDN
- P-0-4084.0.1, List of available profile types
- P-0-4089.0.7, ECAT: SII Configured Station Alias
- P-0-4089.0.8, ECAT: Register Configured Station Alias
- S-0-0105, Position controller integral action time
- S-0-0390.0.136, Detailed diagnostic message
- S-0-0530, Clamping torque
- S-0-0600.0.10, Marker position
- S-0-0601.0.136, Multi-encoder interface configuration
- S-0-0602.0.5, Phys. distance-coded reference offset A
- S-0-0602.0.6, Phys. distance-coded reference offset B
- S-0-0602.0.136, Phys. encoder evaluation configuration
- S-0-0602.0.137, Phys. max. initialization speed
- S-0-0603.0.3, Phys. encoder input signal A
- S-0-0603.0.4, Phys. encoder input signal B
- S-0-0610.0.10, Marker position not scaled (input)
- S-0-0611.0.130, sercos III encoder profile "extended", compact
- S-0-0611.0.136, Serial number of encoder
- S-0-0800, Pressure command value
- S-0-0801, Pressure command value additive
- S-0-0802, Bipolar pressure limit value
- S-0-0803, Pressure feedback value A
- S-0-0804, Pressure feedback value B
- S-0-0805, Pressure polarity parameter
- S-0-0806, Pressure data scaling type
- S-0-0807, Pressure data scaling factor
- S-0-0808, Pressure data scaling exponent
- S-0-0809, Pressure feedback value
- S-0-0810, Pressure ramp time
- S-0-0811, Pressure ramp reference
- S-0-0813, System pressure

Changes and enhancements compared to the previous version

- S-0-0814, Tank pressure
- S-0-0819, Cylinder stroke
- S-0-0820, Piston area A
- S-0-0821, Piston area B
- S-0-0827, Pressure control deviation
- S-0-0828, Positive pressure limit value
- S-0-0829, Negative pressure limit value
- S-0-0830, Pressure status word
- S-0-0831, Depressurized window
- S-0-0832, Pressure window
- S-0-0840, Flow command value
- S-0-0841, Flow command value additive
- S-0-0842, Flow feedback value
- S-0-0843, Flow control deviation
- S-0-0844, Flow zero window
- S-0-0845, Flow data scaling type
- S-0-0846, Flow data scaling factor
- S-0-0847, Flow data scaling exponent
- S-0-0848, Flow polarities
- S-0-0849, Flow status word
- S-0-0850, Bipolar flow limit value
- S-0-0851, Positive flow limit value
- S-0-0852, Negative flow limit value
- S-0-0853, Flow window absolute
- S-0-0854, Flow window percentage
- S-0-0855, Flow ramp reference
- S-0-0856, Flow ramp time
- S-0-0857, Flow threshold
- S-0-0900, Torque/force command value, positive 2
- S-0-0901, Torque/force command value, negative 2
- S-0-0902, Torque/force feedback value 2
- S-0-0903, Torque/force command value 2 ramp
- S-0-1048, C6100 Command Activate IP settings
- S-0-1300.0.151, Adjustment values
- S-0-1300.0.153, Type data 1
- S-0-1303.0.1, Diagnostic trace configuration
- S-0-1303.0.2, Diagnostic trace control
- S-0-1303.0.3, Diagnostic trace state
- S-0-1303.0.10, Diagnostic trace main diagnostics
- S-0-1303.0.11, Diagnostic trace system time
- S-0-1303.0.12, Diagnostic trace detailed diagnostics
- S-0-1303.0.13, Diagnostic trace system time fine
- S-0-1303.0.14, Diagnostic trace system time coarse

- S-0-1305.0.1, System time
- S-0-1320, List of available energy modes
- S-0-1321.0.1, Energy Mode Name
- S-0-1321.0.6, Power Consumption
- S-0-1323.0.1, Current Energy Mode
- S-0-1323.0.7, Consumed Energy Odometer
- S-0-1323.0.8, Supplied Energy Odometer
- S-0-1708.0.130, Supply unit control loop data, compact

New alias parameters

- P-0-2592, Power section logbook data, compact
- P-0-2704, Actual DC bus voltage

Definitions:

An alias parameter is a replacement parameter for communication interfaces which do not support 32 bit IDNs (EIDN).

Example:

Alias parameter:

P-0-2599 -> "S-0-1702.0.16"

A legacy alias parameter is a replacement parameter for compatible access and for communication interfaces which do not support 32 bit IDNs (EIDN).

Example:

Legacy alias parameter:

e.g., P-0-1701 -> "P-0-1808.2.1"

- P-0-0804, Effective active-current generating component, command value
- P-0-0805, Effective reactive-current generating component, cmd value
- P-0-0807, Active-current generating component, actual value
- P-0-0808, Reactive-current generating component, actual value
- P-0-0822, DC bus voltage command value
- P-0-0836, Phase-to-phase mains voltage L1-L2
- P-0-0837, Phase-to-phase mains voltage L2-L3
- P-0-0838, Phase current L1
- P-0-0839, Phase current L2
- P-0-0842, Output voltage, active component
- P-0-0843, Output voltage, reactive component
- P-0-0863, Mains current controller, status word
- P-0-0867, Mains angle
- P-0-0873, Active-current generating component, command value
- P-0-0874, Reactive-current generating component, command value

- P-0-0886, Mains frequency
- P-0-0887, Mains integral
- P-0-2302, SMO: Status word, bit-coded SCA
- P-0-2588, Diagnostic trace configuration
- P-0-2589, Diagnostic trace control
- P-0-2590, Diagnostic trace state
- P-0-2591, Diagnostic trace main diagnostics
- P-0-2593, Diagnostic trace detailed diagnostics
- P-0-2594, Diagnostic trace system time fine
- P-0-2595, Diagnostic trace system time coarse
- P-0-2729, Detailed diagnostics
- P-0-2730, Generate type plate, IDN list of type plates
- P-0-2738, Generate type plate, configuration list
- P-0-2742, Type plate, compact
- P-0-2743, Type plate, compact
- P-0-2744, Type plate, compact
- P-0-2745, Type plate, compact
- P-0-2746, Type plate, compact
- P-0-2747, Type plate, compact
- P-0-2748, Type plate, compact
- P-0-2749, Type plate, compact
- P-0-2750, Type plate, compact
- P-0-2751, SMO: IO mapper block type, compact
- P-0-2752, SMO: IO mapper block type, compact
- P-0-2753, SMO: IO mapper block type, compact
- P-0-2754, SMO: IO mapper inputs, IO mapper block status
- P-0-2755, System time (fine)
- P-0-2756, System time (coarse)
- P-0-2757, ECAT: SII Configured Station Alias
- P-0-2758, ECAT: Register Configured Station Alias
- P-0-2759, IndraWorks view manager
- P-0-2761, Thermal parameters, motor, compact
- P-0-2762, Power section XML identification data
- P-0-2763, sercos III encoder profile "extended", compact
- P-0-2764, sercos III encoder profile "extended", compact
- P-0-2765, Encoder status (input)
- P-0-2766, Position (input)
- P-0-2768, Encoder status
- P-0-2769, Marker position
- P-0-2770, Position
- P-0-2771, Encoder status
- P-0-2772, Marker position
- P-0-2773, Position

- P-0-2774, Encoder status
- P-0-2775, Marker position
- P-0-2776, Position
- P-0-2777, Encoder status
- P-0-2778, Marker position
- P-0-2779, Position
- P-0-2780, Encoder status
- P-0-2781, Marker position
- P-0-2782, Position
- P-0-2783, Encoder status
- P-0-2784, Marker position
- P-0-2785, Position
- P-0-2786, Encoder status (input)
- P-0-2787, Marker position not scaled (input)
- P-0-2788, Position (input)
- P-0-2789, sercos III encoder profile "extended", compact
- P-0-2790, Performance load prewarning threshold exceeded
- P-0-2791, SMO: Active position limit value, positive
- P-0-2792, SMO: Active position limit value, negative
- P-0-2793, SMO: Safe homing procedure configuration
- P-0-2794, SMO: C4000 Safe homing procedure command
- P-0-2795, SMO: Reference position
- P-0-2796, SMO: Safe homing procedure tolerance window
- P-0-2797, SMO: Maximum homing velocity
- P-0-2798, SMO: Reference check time interval
- P-0-2799, SMO: Actual position value, coded
- P-0-3473, Maximum flow
- P-0-3474, Maximum pressure
- P-0-3581, List of available profile types
- P-0-3582, Encoder status (input)
- P-0-3583, Marker position not scaled (input)
- P-0-3584, Position (input)
- P-0-3585, Encoder status (input)
- P-0-3586, Marker position not scaled (input)
- P-0-3587, Position (input)
- P-0-3590, SMO: Safety function diagnostics

Modified parameters

- P-0-0018, Number of pole pairs/pole pair distance
- P-0-0045, Control word of current controller
- P-0-0049, Effective torque/force command value
- P-0-0077, Assignment of encoder 1->interface
- P-0-0078, Assignment of encoder 2->interface

Changes and enhancements compared to the previous version

- P-0-0079, Assignment measuring encoder->interface
- P-0-0098, Max. model deviation
- P-0-0113, Bipolar velocity limit value of motor
- P-0-0118, Power supply, configuration
- P-0-0119, Best possible deceleration
- P-0-0121, Encoder 1, gear turns, mechanical system side
- P-0-0122, Encoder 1, gear turns, encoder side
- P-0-0124, Encoder 2, gear turns, mechanical system side
- P-0-0125, Encoder 2, gear turns, encoder side
- P-0-0127, Measuring encoder gearbox revolutions, encoder side
- P-0-0128, Measuring encoder gearbox revolutions, mechanical side
- P-0-0130, Position switch signal selection list
- P-0-0131, Position switch signal selection
- P-0-0177, Encoder 1, absoute encoder buffer
- P-0-0178, Encoder 2, absoute encoder buffer
- P-0-0179, Absolute encoder buffer, measuring encoder
- P-0-0185, Encoder 2 control word
- P-0-0194, Error memory power section
- P-0-0197, System time
- P-0-0218, Analog input, control parameter
- P-0-0241, Actual pos. smoothing time constant for hybrid pos. control
- P-0-0328, Measuring encoder properties
- P-0-0329, Actual pos. smoothing time constant for measuring encoder
- P-0-0330, Control word of measuring encoder
- P-0-0427, Control parameter of analog output
- P-0-0460, Module group, control word
- P-0-0461, Module group, status word
- P-0-0467, Maximum value thermal load of braking resistor
- P-0-0469, Prewarning threshold of therm. load of braking resistor
- P-0-0512, Temperature sensor
- P-0-0522, Control word for commutation setting
- P-0-0540, Torque of holding brake
- P-0-0556, Config word of axis controller
- P-0-0558, Drive Halt configuration
- P-0-0668, Device data archiving, configuration
- P-0-0833, Braking resistor threshold
- P-0-0844, Thermal load of braking resistor
- P-0-0858, Data of external braking resistor
- P-0-0860, Converter configuration
- P-0-1800.0.1, CCD: Configuration
- P-0-1801.0.10, CCD: Addresses of configured drives
- P-0-1801.0.11, CCD: Addresses of configured I/Os
- P-0-2003, Selection of functional packages

- P-0-2054, Operational performance, motor
- P-0-2055, Serial number, motor
- P-0-3001, Encoder type, encoder memory
- P-0-3002, Number of pole pairs/pole pair distance, type plate
- P-0-3051, Encoder memory, operating hours counter, motor
- P-0-3052, Encoder memory, thermal operating data, motor
- P-0-3053, Encoder memory, mechanical operating data, motor
- P-0-3222.0.2, SMO: Linear position data scaling exponent
- P-0-3224.0.2, SMO: Acceleration data scaling exponent
- P-0-3255, SMO: Velocity threshold for Safe standstill
- P-0-3256, SMO: Encoder evaluation status
- P-0-3264, SMO: Safety function selection
- P-0-3264.0.1, SMO: Safety function status
- P-0-3270.0.1, SMO: Configuration of global safety functions
- P-0-3270.0.3, SMO: Standstill window for safe direction
- P-0-3277.0.1, SMO: Configuration of normal operation
- P-0-3290.0.1, SMO: Configuration of safe motion
- P-0-3330.0.1, SMO: IO mapper inputs, type
- P-0-3330.0.2, SMO: IO mapper inputs, IDN source
- P-0-3330.0.3, SMO: IO mapper inputs, bit source
- P-0-3332.0.1, SMO: IO mapper inputs, minimum pulse duration
- P-0-3345, SMO: Safety bus configuration
- P-0-4084, Application: Profile type
- P-0-4088, Master communication: Drive configuration
- P-0-4089.0.1, Master communication: Protocol
- P-0-4089.0.3, Device Address
- P-0-4089.0.5, Master communication: Configuration
- P-0-4090, Configuration for loading default values
- S-0-0012, Class 2 diagnostics
- S-0-0040, Velocity feedback value of encoder 1
- S-0-0051, Position feedback value of encoder 1
- S-0-0052, Reference distance of encoder 1
- S-0-0053, Position feedback value of encoder 2
- S-0-0054, Reference distance of encoder 2
- S-0-0082, Torque/force limit value positive
- S-0-0083, Torque/force limit value negative
- S-0-0084, Torque/force feedback value
- S-0-0115, Encoder 2, type of position encoder
- S-0-0147, Homing paramete
- S-0-0150, Reference offset of encoder 1
- S-0-0151, Reference offset of encoder 2
- S-0-0156, Velocity feedback value of encoder 2
- S-0-0159, Monitoring window of following distance

- S-0-0164, Acceleration feedback value encoder 1
- S-0-0175, Offset of position feedback value of encoder 1
- S-0-0176, Offset of position feedback value of encoder 2
- S-0-0177, Absolute offset encoder 1
- S-0-0178, Absolute offset encoder 2
- S-0-0195, Acceleration feedback value encoder 2
- S-0-0277, Encoder 1, type of position encoder
- S-0-0378, Absolute encoder range, encoder 1
- S-0-0379, Absolute encoder range, encoder 2
- S-0-0390, Diagnostic message number
- S-0-0428, Probe, IDN list signal selection
- S-0-0600.0.1, Encoder status
- S-0-0600.0.2, Position
- S-0-0601.0.1, Encoder data out configuration
- S-0-0601.0.2, Resolution of position
- S-0-0602.0.1, Phys. Encoder type
- S-0-0602.0.3, Phys. Encoder resolution (analog)
- S-0-0602.0.4, Phys. Encoder resolution (digital)
- S-0-0602.0.7, Phys. Encoder protocol configuration
- S-0-0610.0.1, Encoder status (input)
- S-0-0610.0.2, Position (input)
- S-0-1050.0.1, sercos Connection: Connection setup
- S-0-1305.0.2, System time (fine)
- S-0-1305.0.3, System time (coarse)

Modified alias parameters

- P-0-1534, C6100 Command Activate IP settings

No longer existing parameters

No parameter was removed.

4.5 New, modified or no longer existing diagnostic messages

4.5.1 New Diagnostic Messages

The following diagnostic messages were **subsequently** implemented in the firmware version **MPx-18**:

- C0611 Travel range greater than absolute range (distance-coded)
- E2004 Performance load prewarning threshold exceeded
- E2048 Low battery voltage (encoder)

The following diagnostic messages were **subsequently** implemented in the firmware version **MPx-19**:

- C9100 Confirm power section configuration command
- C9101 Confirm power section configuration command error
- E2822 Mains connection temperature monitoring defective
- E2834 Switching off via OFF input

- E2841 Prewarning: Mains connection overtemperature
- F2020 Low device temperature error
- F2813 Mains connection function error
- F2822 Mains connection temperature monitoring defective
- F2841 Shutdown: Mains connection overtemperature
- F8033 Ground fault in motor line

The following new diagnostic messages were implemented in firmware version MPx-20:

- A0007 Operational
- A0025 Basic ethernet mode
- A0026 Ready to operate
- A0030 Hot-plug phase 0
- A0031 Hot-plug phase 1
- A0032 Hot-plug phase 2
- A0040 Communication phase 4
- A0324 SMO: Normal operation
- A0325 SMO parameter mode active
- A0326 SMO parking axis active
- A4004 Drive without controller enable
- A4005 Drive decelerated by motor phase short circuit
- A4006 Drive decelerated in a controlled way
- A4007 "Drive on" delay time
- A4008 "Drive off" delay time
- A4009 Motor phase short circuit with drive enable switched off
- C0133 FKM: Address conflict
- C0211 Invalid encoder configuration (3 active encoders)
- C0760 Load defaults procedure command (application data)
- C0762 Locked with password
- C1809 Command start only possible with active position limits
- C1810 Drive optimization incorrectly configured
- C0763 Load defaults procedure (application data), invalid param.
- C4000 SMO: Safe homing procedure command
- C4001 Encoder evaluation error during Safe homing procedure
- C4002 Incorrect SMO position feedback value
- C4003 Home switch distance below minimum value
- C4004 Faulty SMO reference signal
- C6300 Generate type plate command
- C6301 Command is password-protected
- C6302 IDN not permissible (->S-0-0423)
- C6303 Insufficient memory
- C6304 Type plate unknown
- C6305 General type plate generation error
- C6310 Command not possible with this encoder type

- C6311 Error when accessing encoder memory
- E2009 Synchronous velocity command value > limit value
- E3112 Safe reference missing
- E3113 Prewarning: End of reference position check time interval
- E3460 PROFIsafe: Wrong F-module selected
- E4040 sercos: Hot-plug error
- E4041 sercos: HP0 Cycle Time invalid
- E4042 sercos: HP0 MDT length invalid
- E4043 sercos: HP0 AT length invalid
- E4044 sercos: HP0 MTU size invalid
- E4045 sercos: HP0 NRT window invalid
- E4046 sercos: HP supported removed
- E4047 sercos: HP enabled removed
- F2056 Overload at dig. I/Os
- F2107 Incorrect commutation angle
- F2191 No automatic CCD slaves IP configuration
- F3112 Safe reference missing
- F3135 Zone bus error
- F3165 Faulty SMO reference signal
- F3166 Reference position check failed
- F3167 Encoder evaluation warning
- F3451 FSoE stack error
- F3452 FSoE stack connection error
- F3460 PROFIsafe error
- F3461 PROFIsafe connection error
- F4019 sercos: Incorrect sequence upon phase start
- F6008 Internal overflow when calculating positioning profile
- F7009 Homing velocity exceeded
- F7011 SMP, SLP: Safe position limit value, positive exceeded
- F7012 SMP, SLP: Safe position limit value, negative exceeded
- F7015 SMO: Cross data comparison error
- F7023 SLE: Safe position limit value, positive exceeded
- F7024 SLE: Safe position limit value, negative exceeded
- F8033 Ground fault in motor line
- F8055 Incorrect processing of diagnostic message

The following new diagnostic messages were implemented in firmware version MPx-20V06:

- A4010 Drive control command active
- C0263 Serial number of motor has changed
- C1224 Zero point shifting only possible in parameter mode
- C1225 Zero point shifting only possible with master password
- E4021 CCD: Not all slaves support SWC
- E2001 Diagnostic trace S-0-1303.0.10 overflow warning

- F6001 Non-fatal system error

4.5.2 Modified diagnostic messages

The following diagnostic messages were **subsequently** extended or modified in the firmware version **MPx-18**:

- C0256 Safety technology configuration error
- F2048 Low battery voltage

The following diagnostic messages were **subsequently** extended or modified in the firmware version **MPx-19**:

- E2810 Drive system not ready for operation
- F8028 Overcurrent in power section

The following diagnostic messages were extended or modified in the firmware version **MPx-20**:

- A0004 Initialization
- A0005 Pre-Operational
- C0214 SMO: Incorrect configuration
- C0290 Error when reading encoder data => measuring encoder
- C0291 Incorr. parameterization of measuring enc. (hardware)
- C6100 Command Activate IP settings
- C6101 Incorrect IP settings
- C8214 SMO: Incorrect configuration
- C8215 SMO: Incorrect encoder/scaling configuration
- 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
- E2059 Velocity command value limit active
- E2063 Velocity command value > limit value
- E2075 Encoder 2: Encoder signals disturbed
- E2076 Measuring encoder: Encoder signals disturbed
- E2077 Absolute encoder monitoring, encoder 1 (encoder alarm)
- 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
- F2105 Cannot address OEM encoder memory
- F2174 Loss of encoder 1 reference
- F2175 Loss of encoder 2 reference

- F2177 Encoder 1 modulo limitation error
- F2178 Encoder 2 modulo limitation error
- F4002 RTD telegram failure
- F4009 Bus failure
- F8079 Velocity limit value exceeded
- F8314 SMO: Incorrect configuration
- F8324 SMO: Error in activation

4.5.3 No longer existing diagnostic messages

Compared to the firmware version MPx-19, the following diagnostic messages no longer exist or were replaced by other diagnostic messages:

- C0296 Error in initialization of absolute encoder monitoring
- E2031 Encoder 1 warning: Signal amplitude incorrect
- E2042 Encoder 2 warning: Encoder signals incorrect
- E2075 Encoder 2: Encoder signals disturbed
- E2078 Absolute encoder monitoring, opt. encoder (encoder alarm)

5 Overview of the functional scope

5.1 System overview

5.1.1 General information

About this documentation

Editions of this documentation

Edition	Release date	Notes
DOK-INDRV*-MP*-20VRS**-AP01-EN-P	2015-09-01	First edition
DOK-INDRV*-MP*-20VRS**-AP02-EN-P	2015-12-22	Corrections
DOK-INDRV*-MP*-20VRS**-AP03-EN-P	2016-05-01	Corrections

Tab. 5-1: Record of revisions

Means of representation in this documentation

This section contains an overview of the means of representation and notations of recurring terms.

Bold type is used for important facts which are to be highlighted in the body text.

"Quotation marks" are used for parameter names, diagnostic message names, function designations.

All important information (e.g. Warning, Caution) are highlighted by a symbol. 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 documentations.

If you discover mistakes in this documentation or suggest changes, please send your feedback to the following e-mail address:

Dokusupport@boschrexroth.de

In order that we can handle your feedback, please send us the number indicated under "Internal File Reference" and the page number.

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 are mapped to parameters!

The operating data stored in parameters can be identified by means of the IDN. They can be read and transferred, if required. The user write access to parameters depends on the properties of the respective parameter and the current communication phase. The 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 programming module / control panel

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

Condition as supplied

Condition as supplied of the Rexroth drive components:

- The controller memory contains controller-specific parameter values.
- The programming module / control panel contains the firmware.
- 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 programming module / control panel. Due to the limited number of writing cycles of non-volatile storage media, application-specific parameter values can be stored in the working memory (volatile memory) of the controller, too.
- With the "IMST" or "IDST" service tool (as of MPx18V10), parameter values can be saved on an external data carrier.

Saving parameter values

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

- After initial commissioning of 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 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 at series machines

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

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

  → Loading the parameter values currently saved before servicing

Options for loading parameter values to the controller:

- Motor encoder data memory

  → Loading the parameter values by command or via the control panel during initial motor commissioning
- "IndraWorks Ds/D/MLD" commissioning tool

  → Loading the parameter values from an external data carrier
- "IMST" or "IDST" service tool as of MPx18V10

  → Loading the parameter values from an external data carrier
- Control master

  → Loading the parameter values from a master-side data carrier

Checksum of parameter values

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

Password

By means of a password, IndraDrive controllers provide the possibility to protect parameter values against accidental or unauthorized change. 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 guarantee the 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.

Types 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 and clear commands.

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

☞ Each command that was started must be actively cleared again.

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

Types of commands

There are 3 different types of commands:

- **Drive control commands**
  - Can cause automatic drive motion
  - Can only be started when drive enable has been set
  - Deactivate the active operation mode during its execution
- **Administration commands**
  - Carry out administration tasks
  - Cannot be interrupted

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 input
- "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 chapter "Operation modes"

Warnings

Depending on the active operation mode and the parameter settings, many monitoring functions are carried out. If a state is detected that permits correct operation, but if continued 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 warning).

Warning classes

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.

We distinguish the following warning classes:

- **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 triggered 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 state 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 error reactions of the drive.

☞ 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
F28xx	Non-fatal error
F4xxx	Interface error (master communication error)
F6xxx	Travel range error
F7xxx	Safety technology error
F8xxx	Fatal error
F83xx	Fatal safety technology error
F9xxx	Fatal system error

Tab. 5-2: Overview of error classes

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

Error reactions of the drive

If the drive controller is in control and an error state 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 the case of F2xxx, F3xxx, F4xxx, F6xxx, F7xxx and F8xxx errors is defined in parameter "P-0-0119, Best possible deceleration". At the end of each error reaction, the drive goes torque-free. The motor phase short circuit error reaction for F8xxx is an exception. Here it is possible to set that a motor phase short circuit is maintained after the error reaction was completed.

See also "Error reactions"

Clearing an error message

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

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

Clearing error messages when drive enable was set

If a drive error occurs during operation 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
- set 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 Control voltage failure"), are not stored in the error memory.

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

Reconfiguring an error as a warning

The user can reconfigure some error cases 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 reconfigurable axis errors is contained in "P-0-0173, List of configurable axis-specific monitoring functions", reconfiguration also takes place in this parameter.

☞ 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 then 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 application-related form in the following cases:

- Using an external encoder as a redundant motor encoder, see chapter "Redundant motor encoder"
- Using a measuring encoder, see "Measuring encoder"
- Position control with cyclic command value input, see chapter of the same name, "Position control with cyclic command value input" under "Operation modes"

5.1.2 IndraDrive product range

The figure below shows the relations between control sections and power sections, firmware derivatives and possible technology modules.

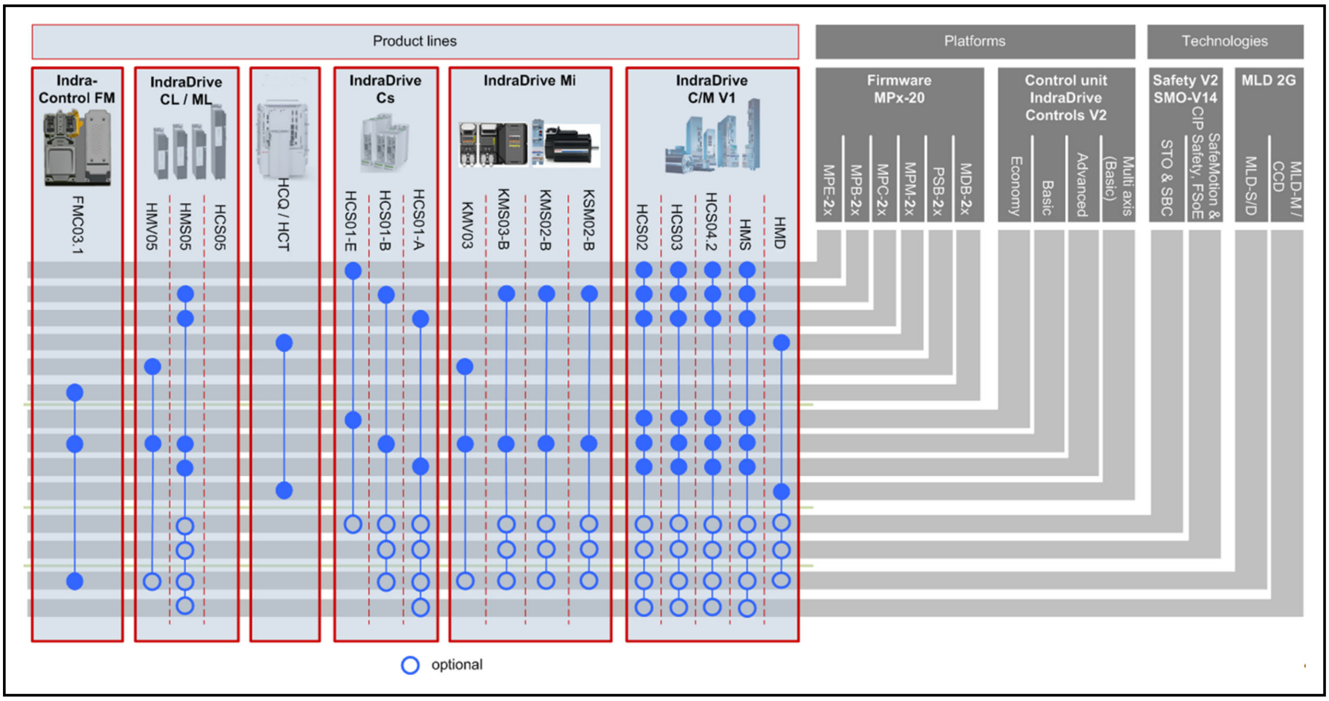


Fig. 5-1: IndraDrive - version 20 product range

5.1.3 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, EtherCAT®, PROFINET®, EtherNet/IP™), field bus interface (PROFIBUS-DP) and analog interface
- PSx: Supply units for IndraDrive devices.

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

- **MP:** "Multi Purpose" → Drives for general automation
- **PS:** "Power Supply" → Supply units for modular drives

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

---

This documentation describes the functionality of the following firmware types:

- FWA-INDRV*-MPB-20VRS-D5
- FWA-INDRV*-MPC-20VRS-D5
- FWA-INDRV*-MPE-20VRS-D5
- FWA-INDRV*-MPM-20VRS-D5
- FWA-INDRV*-PSB-20VRS

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

Organizing the firmware

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

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

5.1.4 Master communication overview

The **MPx-20VRS** firmware supports the following interfaces for master communication:

	Firmware variant				
Master communication	MPB	MPC	MPE	MPM	PSB
sercos	■	■	■	■	■
PROFIBUS-DP	■	■	-	■	■
EtherNet/IP interface	■	■	-	■	-
PROFINET	■	■	-	■	-
Analog interface	■	■	■	■	■
Servodrive over EtherCAT	■	■	■	■	■
CANopen	■	■	-	-	-
CoE (CAN application protocol over EtherCAT)	■	■	■	-	■
Ethernet POWERLINK	■	■	-	-	■

Tab. 5-3: Supported master communication interfaces

5.1.5 Overview of functions/functional packages

Overview

General information

The application-specific scope of usable functions of the **FWA-INDRV*-MP*-20VRS** 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.

Drive functionality scaling

Firmware scaling by control section configuration

IndraDrive controllers have slots for optional cards. Depending on the available optional cards, it is possible to activate certain functions (incl. corresponding parameters), e.g.:

- Master communication
- Safety technology
- Encoder emulation
- Optional encoders
- I/O extension

☞ The functions and parameters for the evaluation of the measuring systems as control 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, Sytronix)
  - Additive functional package (technology functions, IndraMotion MLD, IndraMotion MLD Advanced, IndraMotion MLD Ethernet IP scanner)

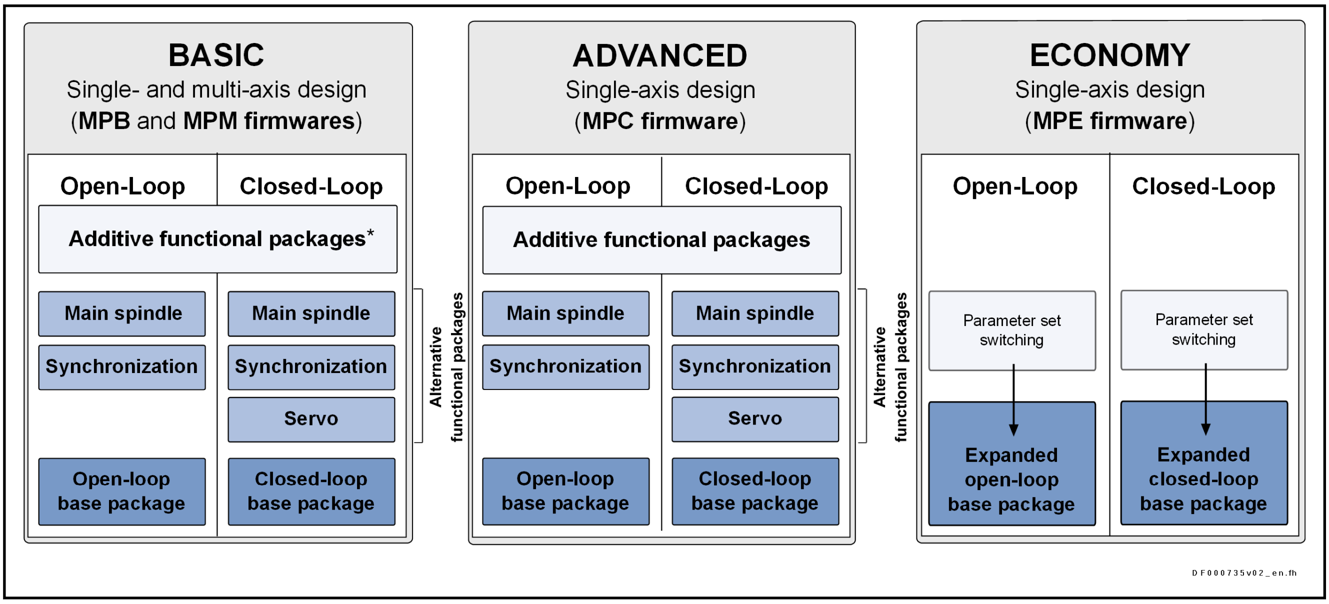
Depending on the hardware configuration, the base packages are available without any access enable. Using the optional expansion packages, however, requires licensing.

☞ 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 functional packages" .

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

Overview of the functional scope



*	not with MPM firmware
Base package	is always contained, functional packages are optional expansion packages
Functional packages	are optional expansion packages

Fig. 5-2: Functional packages of IndraDrive firmware MPx20 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 FWA-INDRV*-MP*-20VRS firmware supports the functional packages listed below.

☞ Each of the listed packages is available in Basic, Economy or Advanced characteristic 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 depending thereof 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, parameter set switching to a limited extent).

- Synchronization[1)]

  With this package, the synchronization options of the drive can be used (support of synchronization modes, measuring encoder function, probe function, parameter set switching to a limited extent…).

- Main spindle functions[1)]

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

- **Sytronix**[1)]

  This package provides extended functions for hydraulics applications.

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

Additive functional packages

In addition, additive functional packages are available:

- **Technology functions**
- **IndraMotion MLD**
- **IndraMotion MLD Advanced**
- **IndraMotion MLD Ethernet/IP scanner**

One design of the additive functional packages can be activated with each single-axis device (ADVANCED and BASIC) in addition to any available alternative package. IndraMotion MLD Ethernet/IP scanner can only be activated on ADVANCED devices.

Firmware types

Structure of the firmware type designation

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

	IndraDrive firmware	Base package of variant (depending on control section)	Version	Release	Language	OL/CL	Alternative functional packages	Additive functional packages
Basic single-axis	FWA-INDRV*	-MPB-	20	VRS-	D5-	x-	xxx-	xx
Advanced single-axis	FWA-INDRV*	-MPC-	20	VRS-	D5-	x-	xxx-	xx
Economy single-axis	FWA-INDRV*	-MPE-	20	VRS-	D5-	x-	xxx-	-
Basic multi-axis	FWA-INDRV*	-MPM-	20	VRS-	D5-	x-	xxx-	-

OL Open-loop characteristic
CL Closed-loop characteristic

Tab. 5-4: 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 functional packages:

- NNN → No alternative functional package
- SRV → Functional package "Servo function"
- SNC → Functional package "Synchronization"
- MSP → Functional package "Main spindle"
- SYX → Functional package "Sytronix"
- ALL → All alternative functional packages (except SYX), i.e. it is possible to select any alternative functional package

Additive functional packages (only with MPB and MPC firmware)

- NN → No additive expansion package
- TF → Technology functions
- ML → IndraMotion MLD
- MA → IndraMotion MLD Advanced
- ME → IndraMotion MLD Ethernet/IP scanner (only with MPC firmware and if "ALL" has been selected as the alternative functional package)

☞ The sales representative in charge will help you with the currently 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
  - 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

Motor control modes

	MPB	MPC	MPE	MPM
V/Hz (U/f)	CL/OL	CL/OL	CL/OL	CL/OL
FXC	CL/OL	CL/OL	-	CL/OL
FOC	CL	CL	CL	CL
FOCsl	CL	CL	CL	CL

V/Hz (U/f) Frequency-controlled operation of sensorless asynchronous three-phase a.c. motors
FXC Flux-controlled, sensorless operation of three-phase a.c. motors
FOC Current-controlled operation of three-phase a.c. motors (with motor encoder)
FOCsl Current-controlled operation of sensorless three-phase a.c. motors
OL Open-loop characteristic
CL Closed-loop characteristic

Tab. 5-5: Motor control mode depending on firmware variant

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 to all firmware variants.

Operation mode	In base package (characteristic)	In functional package ... (on the basis of a base package with the following characteristic)		
		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 modes:				
- Velocity synchronization	-	-	OL/CL	-
- Phase synchronization	-	-	CL	-

Overview of the functional scope

Operation mode	In base package (characteristic)	In functional package ... (on the basis of a base package with the following characteristic)		
		Servo function	Synchronization	Main spindle
- Electronic cam	-	-	CL	-
- Electronic motion profile	-	-	CL	-

+ Operation mode already contained in base package (for characteristic see base package)
- Operation mode not possible
OL Open-loop characteristic
CL Closed-loop characteristic

Tab. 5-6: Supported operation modes

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

See also "Enabling functional packages"

Availability of the extended axis functions

The following overview illustrates in which base or functional packages the respective extended axis function is available (if not stated otherwise, this applies to all firmware versions MPB, MPC, MPE and MPM).

Extended axis function	In base package (characteristic)	In functional package … (on the basis of a base package with the following characteristic)		
		Servo function	Synchronization	Main spindle
Drive Halt	OL/CL	+	+	+
v_{cmd} reset (emergency stop)	OL/CL	+	+	+
v_{cmd} reset with ramp and filter (quick stop)	OL/CL	+	+	+
v_{cmd} reset with ramp and filter (emergency stop)	OL/CL	+	+	+
Torque disable	OL/CL	+	+	+
Return motion	-	CL	-	-
Package reaction on error	OL/CL	+	+	+
NC reaction on error	OL/CL	+	+	+
MLD reaction on error	OL/CL[1) 2)]	+[1) 2)]	+[1) 2)]	+[1) 2)]
E-Stop function	OL/CL	+	+	+
Friction torque compensation	CL	+	+	+
Encoder error correction	CL	+	+	+
Backlash on reversal correction	CL[1)]	+[1)]	+[1)]	+[1)]
Precision axis error correction	-	CL[1)]	-	-
Control-side axis error correction	-	CL[1)]	-	-

Extended axis function	In base package (characteristic)	In functional package … (on the basis of a base package with the following characteristic)		
		Servo function	Synchronization	Main spindle
Temperature error correction	-	CL 1)	-	-
Quadrant error correction	-	CL 1)	-	-
Cogging torque compensation	-	CL 1)	CL 1)	-
Measuring wheel mode	-	-	CL 1)	-
Positive stop drive procedure	OL/CL	+	+	+
Redundant motor encoder	CL 1)	+ 1)	+ 1)	+ 1)
Spindle positioning	-	-	-	CL 1)
Parameter set switching	OL/CL	CL 3) 4)	OL/CL 4)	OL/CL
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)
Integrated safety technology	Only available via the corresponding hardware configuration			

+	Extended axis function already contained in base package (for characteristic see base package)
-	Extended axis function not possible
OL	Open-loop characteristic
CL	Closed-loop characteristic
1)	Not for the MPE firmware variant
2)	Not for the MPM firmware variant
3)	For the MPE firmware variant only (8 switchable parameter sets, all parameter groups)
4)	In the functional packages "Servo function" and "Synchronization", only the "Application" and "Control loop" parameter groups can be switched. MPB/MPC features 8 switchable parameter sets, MPM only features 4 switchable parameter sets.

Tab. 5-7: Availability of the extended axis functions

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

See also "Enabling functional packages"

Availability of the optional device functions

The following overview illustrates in which base or functional packages the respective optional device function is available (if not stated otherwise, this applies to all firmware versions MPB, MPE, MPC and MPM).

Optional device function	In base package (characteristic)	In functional package …		
		Servo function	Synchronization	Main spindle
Cross communication (CCD) 4)	OL/CL	+	+	+
IndraMotion MLD	Additive functional packages (TF, ML, MA or ME) 1) 2) 3)			

Overview of the functional scope

Optional device function	In base package (characteristic)	In functional package …		
		Servo function	Synchronization	Main spindle
Digital inputs/outputs[1)]	OL/CL	+	+	+
Analog inputs[1)]	OL/CL	+	+	+
Virtual master axis generator[3)]	OL/CL	-	+	-
Command value generator	OL/CL	+	+	+
Command value box	CL	+	+	+
Encoder emulation	OL/CL	+	+	+
Programmable position switch	-	CL[2)]	CL[2)]	-
Probe	CL	+	+	+
Position control encoder	CL	+	+	+
Measuring encoder[1)]	-	OL/CL[2)]	OL/CL[2)]	-

+ Optional device function already contained in base package (for characteristic see base package)
- Optional device function not possible
OL Can be used in open-loop operation
CL Can be used in closed-loop operation
TF IndraMotion MLD, technology functions
ML IndraMotion MLD, Motion Logic Standard
MA IndraMotion MLD, Motion Logic Advanced
ME IndraMotion MLD, Dual Master Ethernet/IP sercos III
1) Depending on hardware configuration
2) Not for the MPE firmware variant
3) Not for the MPM firmware variant
4) Only with MPC firmware variant

Tab. 5-8: Availability of the optional device functions

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

See also "Enabling functional packages"

Alternative functional packages

General information

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

The following expansion packages are available:

- (Expanded) servo function
- Synchronization
- Main spindle function
- Sytronix

Servo function

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

	MPB	MPC	MPE	MPM
Relative return motion	CL	CL	-	-
Precision axis error correction	CL	CL	-	-
Temperature error correction	CL	CL	-	CL
Quadrant error correction	CL	CL	-	CL
Cogging torque compensation	CL	CL	-	CL
Programmable position switch	CL	CL	-	-
Set/shift coordinate system	CL	CL	-	-
Parameter set switching (only the "Application" and "Control loop" parameter groups)	CL	CL	Contained in base package	-

CL Closed-loop characteristic

Tab. 5-9: Overview of the "Servo function" expansion package

Synchronization

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

	MPB	MPC	MPE	MPM
Velocity synchronization	OL, CL	OL, CL	-	OL, CL
Phase synchronization	CL	CL	-	CL
Electronic cam	CL	CL	-	CL
Electronic motion profile	CL	CL	-	CL
Cogging torque compensation	CL	CL	-	CL
Measuring wheel mode	CL	CL	-	CL
Programmable position switch	CL	CL	-	-
Measuring encoder	OL, CL	OL, CL	-	CL
Parameter set switching	OL,CL 1)	OL,CL 1)	-	OL,CL 2)

OL Open-loop characteristic
CL Closed-loop characteristic
1) 8 switchable parameter sets, only "Application" and "Control" parameter groups
2) 4 switchable parameter sets, only "Application" and "Control" parameter groups

Tab. 5-10: Overview of the "Synchronization" expansion package

Main spindle function

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

Overview of the functional scope

	MPB	MPC	MPE	MPM
Spindle positioning	CL	CL	-	CL
Parameter set switching	OL, CL	OL, CL	OL, CL[1)]	OL, CL
Drive-controlled oscillation	OL, CL	OL, CL	-	OL, CL

OL Open-loop characteristic
CL Closed-loop characteristic
1) The functional package "Main spindle" is not available for MPE; parameter set switching, however, is already available to the full extent in both base packages (OL, CL)!

Tab. 5-11: Overview of the "Main spindle" expansion package

Sytronix

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

	MPB	MPC	MPE	MPM
Pressure and flow rate scaling	OL, CL	OL, CL	-	-
Command values/actual values of pressure and flow rate	OL, CL	OL, CL	-	-
Complex actuators (separate evaluation for motor encoder and encoder 1)	CL	CL	-	-
Controller output adaptation, parameterizable	OL, CL	OL, CL	-	-
Return motion error reaction	CL	CL	-	-
Parameter set switching (limited functionality)	OL, CL[2)]	OL, CL[2)]	-	-

OL Open-loop characteristic
CL Closed-loop characteristic
1) Contained in the expanded base package for MPE
2) 8 switchable parameter sets, only "Application" and "Control" parameter groups

Tab. 5-12: Overview of the "Sytronix" expansion package

Additive functional packages

General information

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

IndraMotion MLD (drive-integrated PLC)

☞ Employing the "Advanced performance" level (P-0-0556, bit 2) is not possible with the firmware MPB-18V08 and above, if an additive functional package is used.

Additive functional package

The following designs of the additive functional package are available:

- The **"TF"** design allows self-contained PLC programs (technology functions) by Rexroth to be loaded and used (see "Technology functions").
- The **"ML"** design allows Rexroth IndraMotion MLD-S / MLD-M to be freely programmed.
- The **"MA"** design adds the use of self-contained technology function blocks (library) to the "ML" design.

- The **"ME"** design adds an Ethernet/IP scanner functionality to the "MA" design that is provided in the form of an MLD library.

A technology function is a complete (compiled) PLC project that can consist of multiple function blocks (conforming to IEC). A project is created by combining IEC or firmware function blocks and mostly provides a complex and comprehensive functionality to solve a specific technological application.

The technology functions can be loaded via IndraWorks (see also MLD Application Manual: "Using technology functions").

Examples of technology functions: Following-on cutting devices, pick&place, process controller (register controller, winding computation,…), preventive maintenance, Sytronix…

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

Integrated safety technology

Introduction

The **integrated safety technology** in the drive can only be used if the device is equipped with an optional safety technology module "Lx" or "Sx".

Optional safety technology modules "Lx" provide functions of the "Safe standstill" group. Optional safety technology modules "Sx" provide functions for safe motion monitoring and safe standstill monitoring.

Optional packages

The integrated safety technology can be expanded and supplemented by the optional firmware supplements "Extended Safety Functions" and "SafeMotion SIL3":

- Using the safety functions of safe absolute position monitoring (SLP, SMP, SLE, SCA) requires the firmware supplement "Extended Safety Functions" in addition to an optional safety technology module "Sx".
- By purchasing the firmware supplement "SafeMotion SIL3", all safety functions comply with SIL 3.

"Extended Safety Functions" and "SafeMotion SIL3" can be ordered individually or combined as "FWS" in addition to a firmware (FWA), either preconfigured when a device is ordered or subsequently to expand the functionality.

Safety technology function descriptions

The chapter "Integrated safety technology "Safe Torque Off" and "Safe Brake Control"" lists the safety technology functions depending on the optional modules "Lx". For the descriptions of the safety functions, please see the documentation "Rexroth IndraDrive Integrated Safety Technology "Safe Torque Off" (as of MPx-16), Application Manual" (DOK-INDRV*-SI3-**VRS**-AP; mat. no.: R911332634).

The chapter "Integrated safety technology "Safe Motion"" lists the safety technology functions depending on the optional modules "Sx". For the descriptions of the safety functions, please see the documentation "Rexroth IndraDrive Integrated Safety Technology "Safe Motion" (as of MPx-18), Application Manual" (DOK-INDRV*-SI3*SMO-VRS**-AP; mat. no.: R911338920).

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

- **Basic** performance

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

- **Economy** performance

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

☞ Basic control section and "Advanced performance" setting are not possible when functional package "MLD" is active.

Performance and clock rates

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

- Current controller clock $T_{A\_current}$
- Velocity controller clock $T_{A\_velocity}$
- Position controller clock $T_{A\_position}$
- Cycle time of PLC (IndraMotion MLD) T_{MLD}
- 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 section "Control section design and performance" (see below).

☞ The control performance is not synonymous with the control section design, because it is 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.

Drive system and/or Control section / firmware	Functional packages	Perform. level	f_{PWM} 1)	PWM switching 2)	$T_{A\_current}$	$T_{A\_velocity}$	$T_{A\_position}$	T_{MLD}
HCS01.1 / MPB CSB02.1 / MPB CSB02.5 / MPB KSM02.1 / MPB KMS02.1 / MPB KMS03.1 / MPB CDB02.1 / MPM	All3)	Basic	2 kHz	No	250 µs	250 µs	500 µs	1000 µs (not available with MPM)
			4 kHz	Yes	125 µs			
			8 kHz	Yes	125 µs			
			12 kHz	Yes	83.3 µs			
			16 kHz	Yes	62.5 µs			
	All3), except MLD	Advanced	4 kHz	No	125 µs	125 µs	250 µs	Not available
			8 kHz	Yes	62.5 µs			
			16 kHz	Yes	62.5 µs			
HCS01.1 / MPC CSH02.1 / MPC CSH02.5 / MPC	All3)	Basic	2 kHz	No	250 µs	250 µs	500 µs	1000 µs
			4 kHz	Yes	125 µs			
			8 kHz	Yes	125 µs			
			12 kHz	Yes	83.3 µs			
			16 kHz	Yes	62.5 µs			
		Advanced	4 kHz	No	125 µs	125 µs	250 µs	
			8 kHz	Yes	62.5 µs			
			16 kHz	Yes	62.5 µs			
HCS01.1 / MPE CSE02.1 / MPE	All3)	Economy	4 kHz	No	125 µs	500 µs	1000 µs	Not available
			8 kHz	No	125 µs			
HCQ02.1 / MPM HCT02.1 / MPM	All3)	Basic	4 kHz	No	125 µs	250 µs	500 µs	Not available
			8 kHz	No	125 µs			

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) The selection of functional packages depends on the drive system and on the control section/firmware

Tab. 5-13: Performance depending on the control section design

Overview of the functional scope

Control section performance with sercos and EtherCAT

Performance level	Position clock $T_{A\_position}$/µs	Bus clock $T_{MastCom}$/µs	MPE	MPB / MPM	MPC
Advanced	250	250	Not possible	No MLD No 2nd encoder No synchronization modes Reduced cyclic data 1)	ok
	250	500	Not possible	No MLD No synchronization modes	ok
	250	≥1000	Not possible	No MLD	ok
Basic	500	250	Not possible	Not possible	Not possible
	500	500	Not possible	No synchronization modes	ok
	500	≥1000	Not possible	ok	ok
Economy	1000	1000	Reduced cyclic data 1)	Not relevant	Not relevant
	1000	≥1000	ok	Not relevant	Not relevant

1) With sercos MDT/AT: 22 bytes
CC connection: 12 bytes
Safety connection: 10 bytes
1) With EtherCAT SoE MDT/AT: 26 bytes
CoE MDT/AT: 24 bytes

Tab. 5-14: Control section performance with sercos and EtherCAT

Control section performance with Ethernet/IP, PROFINET and PROFIBUS

Performance level	Position clock $T_{A\_position}$/µs	Bus clock $T_{MastCom}$/µs	MPE	MPB / MPM	MPC
Advanced	250	250	Not possible	Not possible	Not possible
	250	500	Not possible	Not possible	Reduced cyclic data (24 bytes)
	250	1000	Not possible	No MLD No 2nd encoder Reduced cyclic data (32 bytes)	Reduced cyclic data (32 bytes)
	250	≥2000	Not possible	No MLD	ok
Basic	500	250	Not possible	Not possible	Not possible
	500	500	Not possible	Not possible	Reduced cyclic data (24 bytes)
	500	1000	Not possible	Reduced cyclic data (32 bytes)	Reduced cyclic data (32 bytes)
	500	≥2000	Not possible	ok	ok

Performance level	Position clock $T_{A\_position}$/µs	Bus clock $T_{MastCom}$/µs	MPE	MPB / MPM	MPC
Economy	1000	1000	Not possible	Not relevant	Not relevant
	1000	≥2000	ok	Not relevant	Not relevant

Tab. 5-15: Control section performance with Ethernet/IP, PROFINET and PROFIBUS

Performance at reduced switching frequency

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

- Depending on the thermal load of the controller
- Depending on the 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! The performance is not reduced!

See "Current limitation: Principles of current limitation"

Automatic PWM adjustment see chapter "Dynamic current limitation", section "Continuous current of controller depending on work load at PWM of 12 kHz or 16 kHz"

5.1.7 Drive controllers

Standard design of the IndraDrive controllers

Design of the IndraDrive controllers

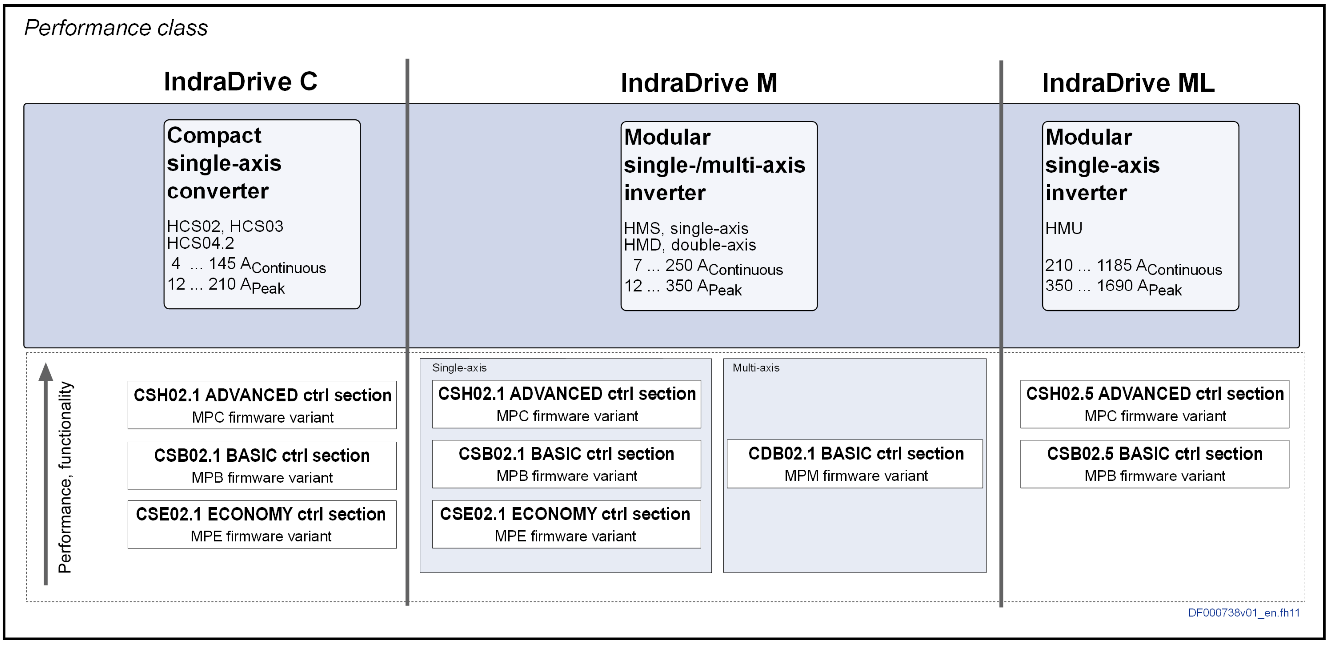


Fig. 5-3: Standard design of the IndraDrive controllers

Power section The following are connected to the power section:

- Mains or DC bus voltage

- 24 V control voltage
- Motor

> The design versions of the power sections are described, respectively, in separate documentations (see "Reference documentations").

Control section

The control section additionally makes available connections for:

- Encoder
- Master communication
- Digital / analog inputs / outputs
- Optional Ethernet engineering
- Optional safety technology
- Optional memories for user data
- Optional encoder emulation
- Optional Engineering port

The control section is a separate part of the IndraDrive controller and is plugged in the power section. The drive controller is supplied ex works complete with the control section. The control section may only be replaced by a qualified service engineer.

> The available control sections are described in the separate documentation "IndraDrive Control Sections CSB02, CSE02, CSH02, CDB02" (DOK-INDRV*-CSx02-CDB02-PRxx-EN-P; mat. no.: R911338962).

Special design of the IndraDrive controllers

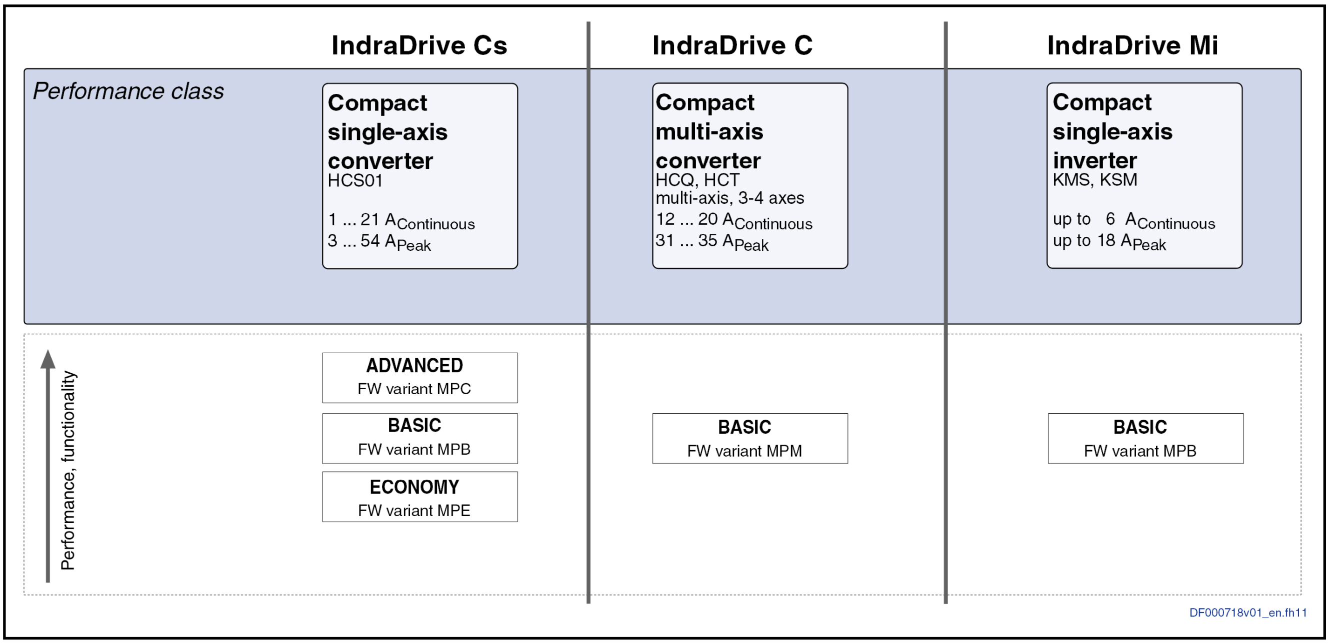


Fig. 5-4: Special design of the IndraDrive controllers

Compact converters, special design

- IndraDrive Cs (HCS01), compact single-axis converter

In contrast to the usual device design with power sections and control sections that can be explicitly ordered, the control section and power section of the HCS01 controller (IndraDrive Cs) are inseparably integrated in one device.

For information on the functional and performance features of HCS01 controllers, see "Rexroth IndraDrive Cs, Drive Systems with HCS01", Project Planning Manual, mat. no. R911322210, DOK-INDRV*-HCS01******-PR**-EN-P.

- IndraDrive C (HCQ, HCT), compact multi-axis converter

  Also in contrast to the usual device design, each of the compact HCT and HCQ controllers can operate 3 - 4 axes. The control section and power section are inseparably integrated in one device.

  For information on the functional and performance features, see "Rexroth IndraDrive, Drive Controllers HCQ02, HCT02", Project Planning Manual, mat. no. R911324185, DOK-INDRV*-HCQ-T+HMQ-TPRxx-EN-P.

Inverters for cabinet free drive technology

- IndraDrive Mi (KSM02.1, distributed servo drive)

  ⇒ Synchronous servo motors with integrated inverter

  In KSM (distributed servo drive), the control section and the power section are integrated in the motor (synchronous servo motor), safety technology and MultiEthernet options are optionally available.

  See also separate documentations:

  – "Rexroth IndraDrive Mi, Drive Systems with KCU02 KSM02, KMS02/03, KMV03, KNK03" (DOK-INDRV*-KCU02+KSM02-PR**-EN-P; mat. no.: R911335703)

- Rexroth IndraDrive Mi (KMS02.1, distributed drive controller)

  ⇒ Compact inverter with control section for near motor mounting

  In KMS (distributed drive controller), the control section and the power section are integrated and remote from the motor. Due to the high degree of protection, KMS can be mounted as near as possible to the motor. Safety technology and MultiEthernet options are optionally available. This variant of IndraDrive Mi does not have a HIPERFACE® encoder interface.

  See also separate documentations:

  – "Rexroth IndraDrive Mi Distributed Drive Controller KMS02" (DOK-INDRV*-KMS02******-IT**-EN-P; mat. no.: R911339112).

  – "Rexroth IndraDrive Mi Distributed Servo Drive KSM02" (DOK-INDRV*-KSM02******-IT**-EN-P; mat. no.: R911339106)

Power sections, drive systems

All HMS01, HMD01, HCS02, HCS03 and HCS04.2 power sections from the table below with the production date **FD: 07W01** and above are supported (07W01 means production year 2007, week 01).

Plus the HMU05 controllers.

Power sections

Overview of the functional scope

Power sections
HMS01.1N-W0020-A-07-NNNN HMS01.1N-W0036-A-07-NNNN HMS01.1N-W0054-A-07-NNNN HMS01.1N-W0070-A-07-NNNN HMS01.1N-W0110-A-07-NNNN HMS01.1N-W0150-A-07-NNNN HMS01.1N-W0210-A-07-NNNN HMS01.1N-W0350-A-07-NNNN
HMD01.1N-W0012-A-07-NNNN HMD01.1N-W0020-A-07-NNNN HMD01.1N-W0036-A-07-NNNN
HMS02.1N-W0028-A-07-NNNN HMS02.1N-W0054-A-07-NNNN
HCS02.1E-W0012-A-03-xNNx HCS02.1E-W0028-A-03-xNNx HCS02.1E-W0054-A-03-xNNx[1)] HCS02.1E-W0070-A-03-xNNx[1)]
HCS03.1E-W0070-A-05-xNxx HCS03.1E-W0100-A-05-xNxx HCS03.1E-W0150-A-05-xNxx HCS03.1E-W0210-A-05-xNxx HCS03.1E-W0350-A-05-xNxx
HCS04.2E-W0290-N-0x-xNxN HCS04.2E-W0350-N-0x-xNxN HCS04.2E-W0520-N-0x-xNxN HCS04.2E-W0640-N-0x-xNxN HCS04.2E-W0790-N-0x-xNxN HCS04.2E-W1010-N-0x-xNxN HCS04.2E-W1240-N-0x-xNxN HCS04.2E-W1540-N-0x-xNxN
HMU05.1N-F0140-0350-N-4A-D7-NN[2)] HMU05.1N-F0170-0430-N-4A-D7-NN[2)] HMU05.1N-F0220-0510-N-4A-D7-NN[2)] HMU05.1N-F0270-0660-N-4A-D7-NN[2)] HMU05.1N-F0340-0820-N-4A-D7-NN[2)] HMU05.1N-F0430-1040-N-4A-D7-NN[2)] HMU05.1N-F0540-1300-N-4A-D7-NN[2)] HMU05.1N-F0680-1690-N-4A-D7-NN[2)]

1) As of week 30/2007

2) No restriction as regards the production period

Tab. 5-16: Power sections

☞ The message "F8118 Invalid power section/firmware combination" is output for devices of an older production date.

Drive systems

For HCS01, HCQ, HCT, KMS and KSM, there are no restrictions as regards the production period.

Drive systems
HCS01.1E-W00xx-A-0x-x-xx-EC-xx-xx-NN-FW
KMS02.1B-A0xx-P-D7-ET-xxx-xx-xx-FW
KSM02.1B-0xxC-xxN-xx-Hxx-ET-xx-D7-xx-FW
KMS03.1B-xxxx-P-D7-ET-END-xx-xx-FW
HCQ02.1E-W-00xx-A-03-B-L8-1S-xx-xx-NN-xx
HCT02.1E-W00xx-A-03-B-xx-xx-xx-xx-NN-xx

Tab. 5-17: Drive systems

Control sections and optional modules

In their basic configuration, all control sections already contain modules for encoder evaluation (EC) and master communication (ET, S3, CC). The table below shows the control sections supported by the MPx-20VRS firmware, as well as possible optional modules.

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

Control section types →		CSE02.1	CSB02.1 CSB02.5	CDB02.1	CSH02.1 CSH02.5
		ECONOMY "Single-axis"	BASIC "Single-axis"	BASIC "Multi-axis"	ADVANCED "Single-axis"
Firmware variant →		MPE-20VRS	MPB-20VRS	MPM-20VRS	MPC-20VRS
Optional modules for master communication					
PB	PROFIBUS-DP	-	■	■	■ 3)
CN	CANopen	-	■	-	■ 3)
ET	MultiEthernet	-	-	-	■ 3)
Optional modules for encoder evaluation					
EC	Multi-encoder interface	-	■ 2)	■	■

Overview of the functional scope

Control section types →		CSE02.1	CSB02.1 CSB02.5	CDB02.1	CSH02.1 CSH02.5
EM	Encoder emulation	-	■ 2)	■	■
Optional modules for safety technology					
L3	STO (Safe Torque Off)	■	■ 2)	■	■
S4	Safe Motion	-	■ 2)	■	■
SB	Safe Motion Bus	-	■ 2)	■	■
S5	Safe Motion	-	■ 2)	■	■
Optional modules for I/O extension					
DA	I/O extension digital/analog	-	■ 2)	■	■
Optional modules for communication					
ET	MultiEthernet	-	-	-	■
EP	Engineering Port	■	■ 1)	-	-

1)Only available with CSB02.1A
2)Only available with CSB02.1B
3)Only available with CSH02.xB-CC

Tab. 5-18: Supported control section configurations

In their basic configuration, all HCS01 controllers already contain modules for encoder evaluation (EC) and master communication (ET, S3, CC). The table below shows the optional modules supported by the MPx-20VRS firmware.

Device		HCS01.1		
		ECONOMY "Single-axis"	BASIC "Single-axis"	ADVANCED "Single-axis"
Firmware variant →		MPE-20VRS	MPB-20VRS	MPC-20VRS
Optional modules for master communication				
ET	MultiEthernet	-	-	■
PB	PROFIBUS-DP	-	■	■
CN	CANopen	-	■	■
Optional modules for encoder evaluation				
EC	Multi-encoder interface	-	■	■
EM	Encoder emulation	-	■	■

Device		HCS01.1		
Optional modules for safety technology				
L3	STO (Safe Torque Off)	■	■	■
L4	STO (Safe Torque Off) and SBC (Safe Brake Control)	■	■	■
S4	Safe Motion	-	■	■
SB	Safe Motion Bus	-	■	■
S5	Safe Motion	-	■	■
Optional modules for I/O extension				
DA	I/O extension digital/analog	-	■	■
Optional modules for communication				
ET	MultiEthernet	-	■	■
EP	Engineering Port	■	■	-

Tab. 5-19: Supported control section configurations

In their basic configuration, all distributed drive controllers KMS0x and KSM02 servo drives already contain the ET master communication module. The table below shows the optional modules supported by the MPx-20VRS firmware.

Device		KSM02.1	KMS02.1	KMS03.1
		BASIC "Single-axis"	BASIC "Single-axis"	BASIC "Single-axis"
Firmware variant →		MPB-20VRS	MPB-20VRS	MPB-20VRS
Optional modules for master communication				
ET	MultiEthernet	-	-	-
Optional modules for encoder evaluation				
ENH	Encoder HIPERFACE®	-	■	-
END	Encoder HIPERFACE ® and digital encoder	-	-	■
Optional modules for safety technology				
L3	Safe Torque Off (STO)	■	■	■
S3	Safe Motion (without SBC)	■	■	-
SD	Safe Motion	■	■	■
Optional module MultiEthernet				
TO	MultiEthernet output coupling	■	■	■
ES	External master communication MultiEthernet	■	■	■

Tab. 5-20: Supported control section configurations

Overview of the functional scope

The table below shows the optional modules for compact multi-axis converters HCT and HCQ supported with MPx20VRS.

Device		HCT02.1	HCQ02.1
		BASIC "Multi-axis"	BASIC "Multi-axis"
Firmware variant →		MPM-20VRS	MPM-20VRS
Optional modules for master communication			
ET	Multi-protocol EtherNet	■	-
PB	PROFIBUS	■	-
L8	Embedded PC, LX 800	■	■
Optional modules for encoder evaluation			
Number of encoder evaluations in basic device		4	5
Optional modules for I/O extension			
D1	Digital I/O extension (DEA40.1)	■	■

Tab. 5-21: Supported control section configurations

All controllers or control sections have a different number of interfaces for optional modules, which are listed in the table below.

Controller or control section	Number of optional module slots
KMS02.1, KSM02.1, KMS03.1	1
HCS01, HCQ02.1, HCT02.1, CSB02.1A, CSE02.1	2
CSB02.xB, CSH02.x	3
CDB02.1	4

Tab. 5-22: Number of optional card slots

5.1.8 Supported motors and measuring systems

Supported motors

The following table contains an overview of the Rexroth motors supported by this firmware:

Rexroth housing motors		Rexroth kit motors	
Synchronous	Asynchronous	Synchronous	Asynchronous
MSK (IndraDyn S) MSM MS2N	MAD (IndraDyn A) MAF (IndraDyn A) MAL	MLF (IndraDyn L) MBS (IndraDyn H) MCL MBT (IndraDyn T)	1MB

Tab. 5-23: Appropriate Rexroth motors for IndraDrive

In addition to the Rexroth motors, it is basically possible to operate three-phase third-party motors (synchronous and asynchronous motors) at IndraDrive controllers. However, it is necessary to check whether the specific motor type can be controlled (see chapter "Third-party motors" in "Rexroth

IndraDrive, Drive System, R911309636, DOK-INDRV*-SYSTEM*****-PR0x-….").

☞ The operation of SBC motors of the manufacturer Parker is directly supported by motor-type-specific parameters made available in the encoder data memory!

Supported measuring systems

Supported encoder systems

Encoder systems with a supply voltage of **5 and 12 V**:

- MSM motor encoder (with HCS01 only)
- MSK motor encoder
- Sin-cos encoder 1 V_{pp}; HIPERFACE®
- Sin-cos encoder 1 V_{pp}; EnDat2.1
- Sin-cos encoder 1 V_{pp}; with reference track
- 5V-TTL square-wave encoder; with reference track
- Sin-cos encoder 1 V_{pp} and SSI encoder (combined encoder for SSI)
- SSI encoder
- Resolver, available with MPx20V06 and above
- EnDat 2.2
- Safety4Wire

Other encoder systems

For the following combinations, the evaluation of an analog enoder and additional Hall sensors is not yet supported in this firmware release of MPx20 and below:

- MCL motor with L1 option (analog Hall sensors)
- MCL motor with L0 option (digital Hall sensors)

5.1.9 Documentations

Drive systems, system components

Drive systems, system components

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

Overview of the functional scope

Title Rexroth IndraDrive …	Kind of documentation	Document typecode1) DOK-INDRV*-…	Material number R911…
Drive Controllers Control Sections CSB01, CSH01, CDB01	Project Planning Manual	CSH********-PRxx-EN-P	295012
Control Sections CSE02, CSB02, CDB02, CSH02	Project Planning Manual	Cxx02******-PRxx-EN-P	338962
Additional Components and Accessories	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)

Tab. 5-24: Documentations – Drive systems, system components

Drive Systems with Multi-Axis Drive Controllers

Title	Kind of documentation	Document typecode1)	Material 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 Accessories	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)

Tab. 5-25: Documentations – Drive Systems, System Components

Motors

Title Rexroth IndraDyn …	Type of documentation	Document typecode1) DOK-MOTOR*-…	Material 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
L Ironless Linear Motors MCL	Project Planning Manual	MCL********-PRxx-EN-P	330592
S Synchronous Motors MKE	Project Planning Manual	MKE*GEN2***-PRxx-EN-P	297663
S Synchronous Motors MSK	Project Planning Manual	MSK********-PRxx-EN-P	296289
S Synchronous Motors MSM	Data Sheet	MSM********-DAxx-EN-P	329338

Title Rexroth IndraDyn …	Type of documentation	Document typecode[1)] DOK-MOTOR*-…	Material number R911…
S Synchronous Motors MS2N	Project Planning Manual	MS2N*******-PRxx-EN-P	347583
T Synchronous Torque Motors	Project Planning Manual	MBT********-PRxx-EN-P	298798

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

Tab. 5-26: Documentations – motors

Cables

Title	Kind of documentation	Document typecode[1)] DOK-CONNEC-…	Material number R911…
Rexroth Connection Cables IndraDrive and IndraDyn	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")

Tab. 5-27: Documentations – Cables

Firmware

Title Rexroth IndraDrive ...	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
MPx-20 Functions	Application Manual	MP*-20VRS**-APxx-EN-P	345608
MPx-20 Version Notes	Release Notes	MP*-20VRS**-RNxx-EN-P	345606
Power Supply Basic PSB-20 Functions	Application Manual	PSB-20VRS**-APxx-EN-P	345612
Power Supply Basic PSB-19 Functions	Application Manual	PSB-19VRS**-APxx-EN-P	345602
MPx-18 Functions	Application Manual	MP*-18VRS**-APxx-EN-P	338673
MPx-18 Version Notes	Release Notes	MP*-18VRS**-RNxx-EN-P	338658
MPx-17 Functions	Application Manual	MP*-17VRS**-APxx-EN-P	331236
MPx-17 Version Notes	Release Notes	MP*-17VRS**-RNxx-EN-P	331588
MPx-16 Functions	Application Manual	MP*-16VRS**-APxx-EN-P	326767
MPx-16 Version Notes	Release Notes	MP*-16VRS**-RNxx-EN-P	329272

Overview of the functional scope

Title Rexroth IndraDrive ...	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
MPx-16 to MPx-20 and PSB Parameters	Reference Book	GEN1-PARA**-RExx-EN-P	328651
MPx-16 to MPx-20 and PSB Diagnostic Messages	Reference Book	GEN1-DIAG**-RExx-EN-P	326738
Integrated Safety Technology "Safe Torque Off" (as of MPx-16)	Application Manual	SI3-**VRS**-APxx-EN-P	332634
Integrated Safety Technology "Safe Motion" (as of MPx-18)	Application Manual	SI3*SMO-VRS-APxx-EN-P	338920
Rexroth IndraMotion MLD Libraries as of MPx-17	Reference Book	MLD-SYSLIB2-RExx-EN-P	332627
Rexroth IndraMotion MLD Libraries as of MPx-18	Reference Book	MLD-SYSLIB3-RExx-EN-P	338916
Rexroth IndraMotion MLD as of MPx-17	Application Manual	MLD2-**VRS*-APxx-EN-P	334351
Rexroth IndraMotion MLD As of MPx-18	Application Manual	MLD3-**VRS*-APxx-EN-P	338914

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

Tab. 5-28: Documentations – Firmware

Control unit

Title Rexroth IndraMotion MTX micro	Type of documentation	Document typecode[1)] DOK-MTXMIC-…	Material number R911…
Easy setup for Standard Turning and Milling Machines	Commissioning Manual	EASY*******-COxx-EN-P	332281
12VRS System Description	Manual	SYS*DES*V12-RExx-EN-P	334369
12VRS Functional Description	Manual	NC*FUNC*V12-APxx-EN-P	334357
12VRS Machine Parameters	Reference Book	MA*PAR**V12-RExx-EN-P	334365
12VRS Programming Manual	Manual	NC**PRO*V12-RExx-EN-P	334361

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

Tab. 5-29: Documentations – Control unit

5.2 Master communication

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

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine's range of motion (e.g., by 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".

5.2.1 Basic functions of master communication

Brief description

General information

The same basic functions of master communication for IndraDrive devices apply to:

- MultiEthernet interface with
  - sercos
  - EtherCAT®
  - PROFINET®
  - EtherNet/IP™
  - Ethernet POWERLINK
- Field bus interface
- Analog interface

The protocol is selected or deactivated via "P-0-4089.0.1, Master communication: Protocol" (alias: P-0-2310).

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

Notes on parameter access

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

- 4-byte EIDNs with sercos element and sercos instance = 0, which are available in the drive, can be accessed as 2-byte IDNs. Example: Parameter P-0-4006.0.0 via P-0-4006
- The below-mentioned 4-byte EIDNs with sercos element or sercos instance unequal 0 are mapped to the assigned 2-byte IDN parameters

4-byte EIDN parameter	2-byte IDN parameter
P-0-4089.0.1, Master communication: Protocol	P-0-2310, Master communication: Protocol
P-0-4089.0.2, Master communication: Device name	P-0-2311, Master communication: Device name

Overview of the functional scope

4-byte EIDN parameter	2-byte IDN parameter
P-0-4089.0.3, Device Address	P-0-2303, Device Address
P-0-4089.0.4, Active Device Address	P-0-2304, Active Device Address
P-0-4089.0.5, Master communication: Configuration	P-0-2318, Master communication: Configuration
P-0-4089.0.6, Sync failures monitoring threshold	P-0-2728, Sync failures monitoring threshold
P-0-4089.0.10, Master communication: MAC address device	P-0-2312, Master communication: MAC address device
P-0-4089.0.11, Master communication: MAC address Port1	P-0-2313, Master communication: MAC address Port1
P-0-4089.0.12, Master communication: MAC address Port2	P-0-2314, Master communication: MAC address Port2
P-0-4089.0.13, Master communication: IP address	P-0-2315, Master communication: IP address
P-0-4089.0.14, Master communication: Network mask	P-0-2316, Master communication: Network mask
P-0-4089.0.15, Master communication: Gateway address	P-0-2317, Master communication: Gateway address

Tab. 5-30: Parameters for configuring the master communication

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

Features

When the field bus card (PROFIBUS® and CANopen) has been plugged in, it is only possible to change between inactive master communication and PROFIBUS® or CANopen master communication. Switching to sercos®, EtherCAT®, EtherNet/IP™, PROFINET® or POWERLINK is impossible.

Without the field bus card, only sercos was possible as the master communication for IndraDrive Cs with the MPE-18VRS (Economy) firmware; with MPE-20VRS and above, EtherCAT (SoE and CoE) is available in addition to sercos.

- Protocol selection via the control panel or "P-0-4089.0.1, Master communication: Protocol" (alias: P-0-2310)
- IP engineering is supported depending on the protocol
- Master communication engineering is supported depending on the protocol
- Command processing

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

  → Individual state machines for master communication and device
  - According to the variant of master communication, the master communication state machine has a different functionality and complexity. The communication-specific states are distinguished and mapped to the status words of the corresponding master communication (e.g. for sercos: "S-0-0135, Drive status word"; "S-0-1045, sercos: Device Status (S-Dev)".
  - The device state machine is independent of the variant of master communication and maps the device-specific states to parameter

"S-0-0424, Status parameterization level". We always distinguish between the operating mode (OM) and the parameter mode (PM).

- Extended control options
  - Signal control word (S-0-0145) and signal status word (S-0-0144)
  - Multiplex channel

  See chapter "Control options / additional functions".

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

Pertinent parameters

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

Parameters for state machine and phase switching

- S-0-0011, Class 1 diagnostics
- S-0-0012, Class 2 diagnostics
- S-0-0013, 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

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

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

Field-bus-specific parameters

The following **additional** parameters are used for field buses:

- 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 analog interface

The following **additional** parameters are used for the analog interface:

- 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

5.2.2 Control options / additional functions

Configurable signal control word

Brief description

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

Possible applications

This functionality can be used, for example,

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

☞ For sercos and field bus interfaces the parameter "S-0-0145, Signal control word" has to be 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 a bit list to be defined which contains all the important pieces of status information of the drive for the control unit.

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 "multiplex channel" mechanism 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

Using 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 in every cycle with a cycle time of "T_{scyc} x quantity 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 and IndraDrive MLD-M are used, the multiplex channel is used for communication between MLC or MLD-M and the 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

Overview of the functional scope

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

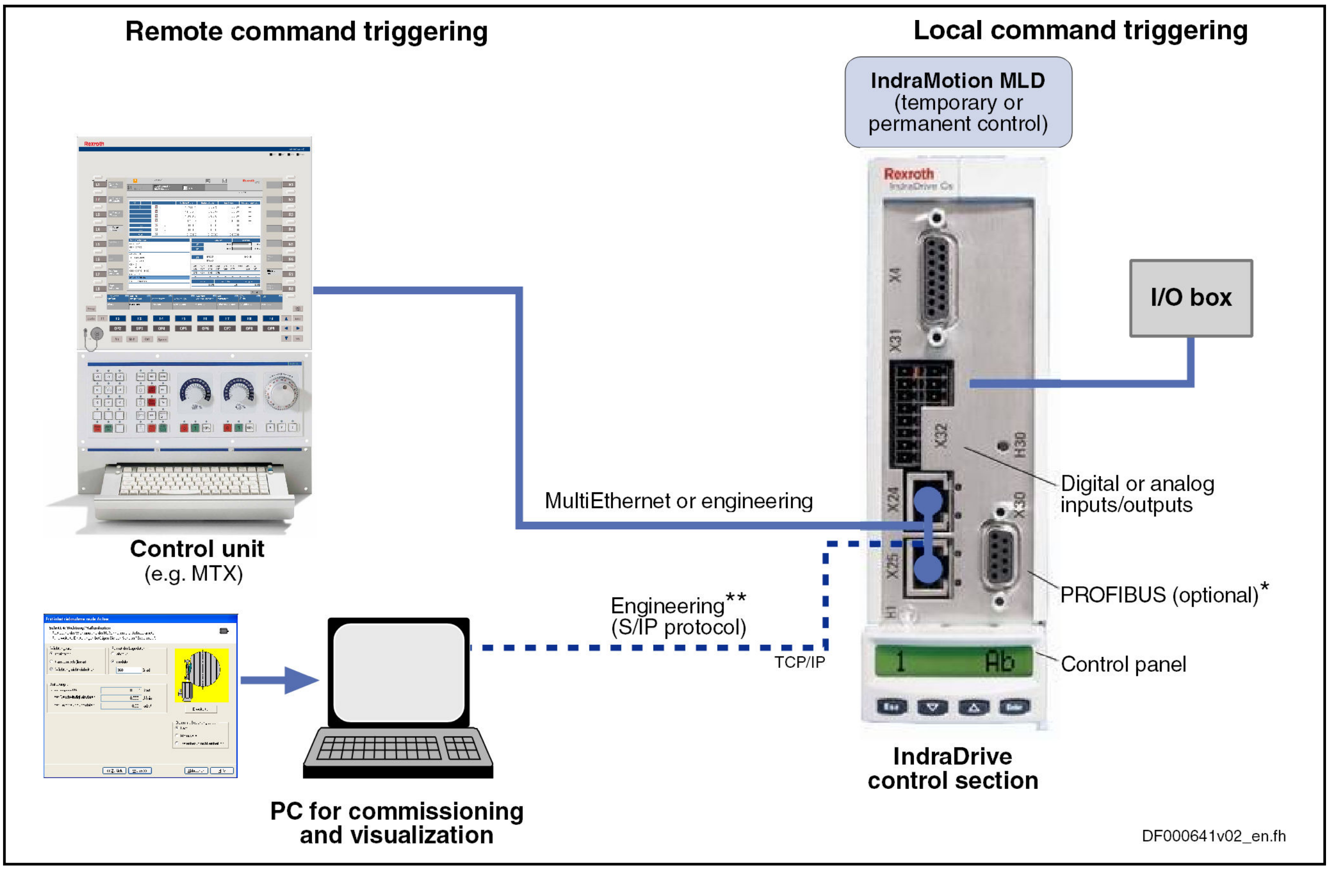
5.2.3 Master communication operating modes

Introduction and overview

Overview of commanding options and operating modes

An external control master (remote mode) can command the drive, or it can be commanded internally via IndraMotion MLD or the available inputs/outputs (local mode).

The figure below contains an overview of the drive commanding options.



* MultiEthernet is not available for PROFIBUS, interfaces can be used for engineering

** Only as of MPx17 and not possible for EtherCAT

Fig. 5-5: Overview of commanding options 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.

Overview of the functional scope

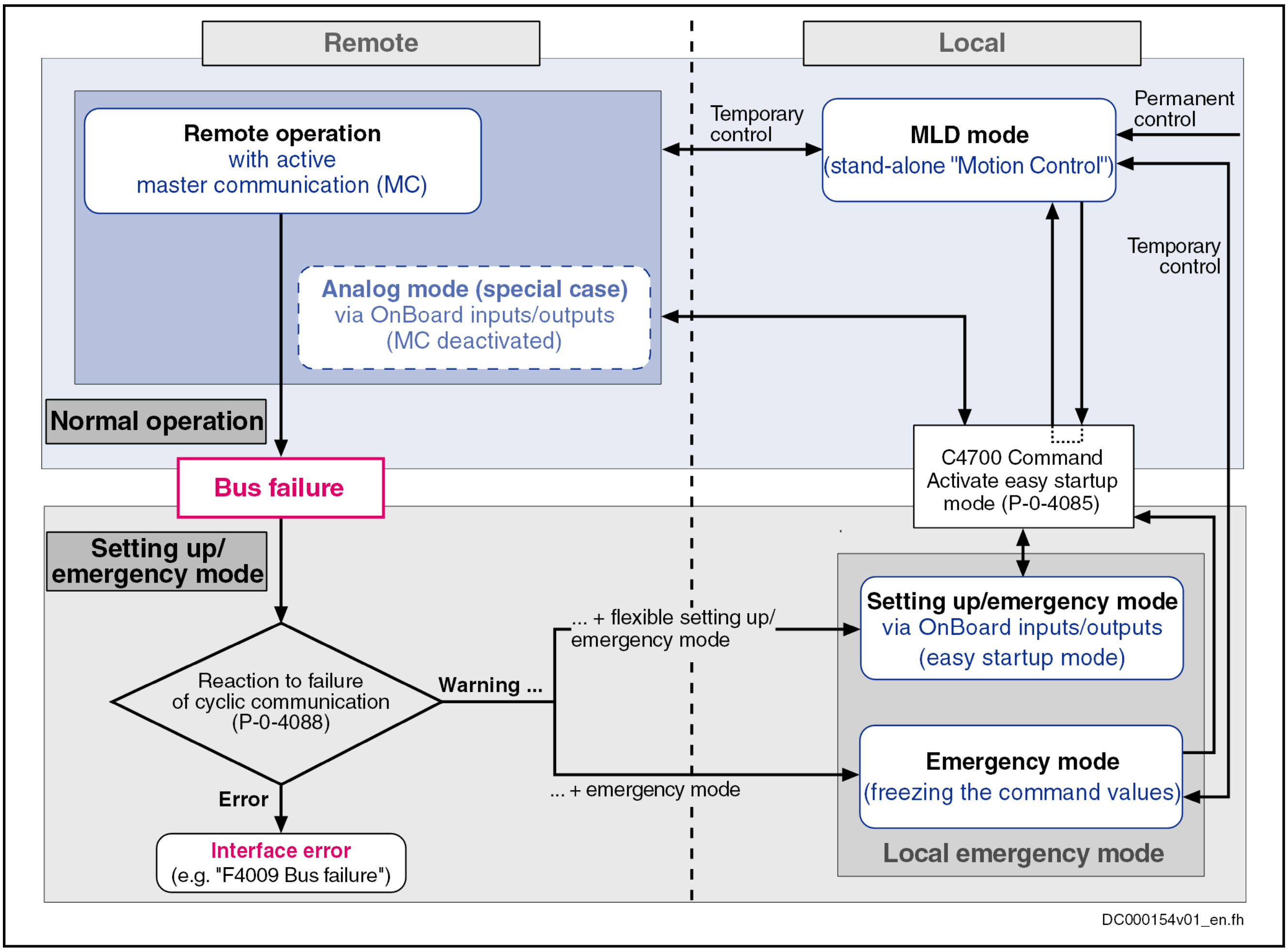


Fig. 5-6: Operating states and operating modes of master communication

Device control and state machine

According to the type 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 unit)

In the so-called normal operation, the command triggering for the drive takes place via an internal (IndraMotion MLD) or external control unit (e.g. IndraMotion MTX or MLC); we distinguish the following cases:

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

  Command triggering for the axis takes place via the master communication (sercos, field bus, analog interface).

  Special case [respective configuration via "P-0-4089.0.1, Master communication: Protocol" (alias: P-0-2310)]:

  – **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)

  See also "Special cases of operation with external control unit"

- **MLD mode** (stand-alone "Motion Control")

  → The PLC integrated in the drive (IndraMotion MLD) commands the axis or, in conjunction with cross communication (CCD), an entire axis group.

  → Configuration via parameter P-0-1367 (see also "Stand-alone motion control" in the separate documentation "IndraMotion MLD, Application Manual")

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). We distinguish the following operating modes:

- **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) or the internal control (IndraMotion MLD).

- **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.

5.2.4 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, Application: Profile type"	Master communication	Field bus or drive operation mode	Features
0x0000	PROFIBUS® CANopen PROFINET® EtherNet/IP™ sercos EtherCAT (CoE) POWERLINK	- With the profile type "No profile", all settings relevant to the profile type are deactivated - The profile type "No profile" is intended for MLD applications with "permanent control"	- Field bus control word and field bus status word are not available in the cyclic data - Field bus control word and field bus status word are deactivated and cannot be written via acyclic services - Free configuration of real-time data - Drive is controlled via MLD - Drive can be controlled via dig./analog inputs

Tab. 5-31: Profile type "No profile"

I/O mode positioning			
Content of "P-0-4084, Application: Profile type"	Master communication	Field bus or drive operation mode	Features
0x0002	PROFIBUS® CANopen PROFINET® EtherNet/IP™ POWERLINK	I/O mode positioning (positioning block mode, encoder 1, lagless)	- Up to 64 positioning blocks can be controlled via field bus - Apart from control word 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 "configurable signal status word" function

Tab. 5-32: Profile type "I/O mode positioning"

FSP Drive (sercos profile)			
Content of "P-0-4084, Application: Profile type"	Master communication	Field bus or drive operation mode	Features
0x0102	EtherNet/IP™ PROFINET® sercos PROFIBUS®	Drive profile acc. to sercos III	Control and status words used: S-0-0134/ S-0-0135 All operation modes are supported

Tab. 5-33: Profile type "FSP Drive (sercos profile)"

Overview of the functional scope

CiA402 drive profile			
Content of "P-0-4084, Application: Profile type"	Master communication	Field bus or drive operation mode	Features
0x0402	EtherCAT (CoE) POWERLINK CANopen (CoC)	Drive profile acc. to CiA402	Control word/status word: 0x6040/0x6041 Supported operation modes are • cyclic sync position mode • cyclic sync velocity mode • cyclic sync torque mode • homing mode

Tab. 5-34: Profile type "CiA402 drive profile"

Servodrive profile without evaluation of "drive enable" bit			
Content of "P-0-4084, Application: Profile type"	Master communication	Field bus or drive operation mode	Features
0xF002	POWERLINK EtherCAT (SoE)	Drive profile acc. to sercos II	S-0-0134, bit 14, not evaluated Control and status words used S-0-0134/ S-0-0135 All operation modes are supported

Tab. 5-35: Profile type "Servodrive without evaluation of „drive enable" bit"

FSP Drive without evaluation of "drive enable" bit			
Content of "P-0-4084, Application: Profile type"	Master communication	Field bus or drive operation mode	Features
0xF102	sercos EtherCAT (CoE) POWERLINK CANopen (CoC)	Drive profile acc. to sercos III	S-0-0134, bit 14, not evaluated Control and status words used S-0-0134/ S-0-0135 All operation modes supported

Tab. 5-36: Profile type "FSP Drive without evaluation of "drive enable" bit"

FF00

I/O mode positioning			
Content of "P-0-4084, Application: Profile type"	Master communication	Field bus or drive operation mode	Features
0xFF82	PROFIBUS® CANopen PROFINET® EtherNet/IP™ POWERLINK	I/O mode positioning (positioning block mode, encoder 1, lagless)	- Up to 64 positioning blocks can be controlled via field bus - Apart from control word 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 "configurable signal status word" function

Tab. 5-37: Profile type "I/O mode positioning"

I/O mode preset velocity			
Content of "P-0-4084, Application: Profile type"	Master communication	Field bus or drive operation mode	Features
0xFF92	PROFIBUS® CANopen PROFINET® EtherNet/IP™ POWERLINK	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 word 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 using "configurable signal status word" function

Tab. 5-38: Profile type "IO mod""e preset velocity"

Freely configurable mode			
Content of "P-0-4084, Application: Profile type"	Master communication	Field bus or drive operation mode	Features
0xFFFE	PROFIBUS® CANopen PROFINET® EtherNet/IP™ POWERLINK	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 reduced field bus control word		

Tab. 5-39: 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, Application: 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 state (e.g. Drive Halt, drive error, …) represents a specific internal and external behavior. The state can be exited by defined events (e.g. drive commands, switching of operation modes, …). Corresponding state transitions are assigned to the events. The interaction of control and status bits and the state transitions are called state machine.

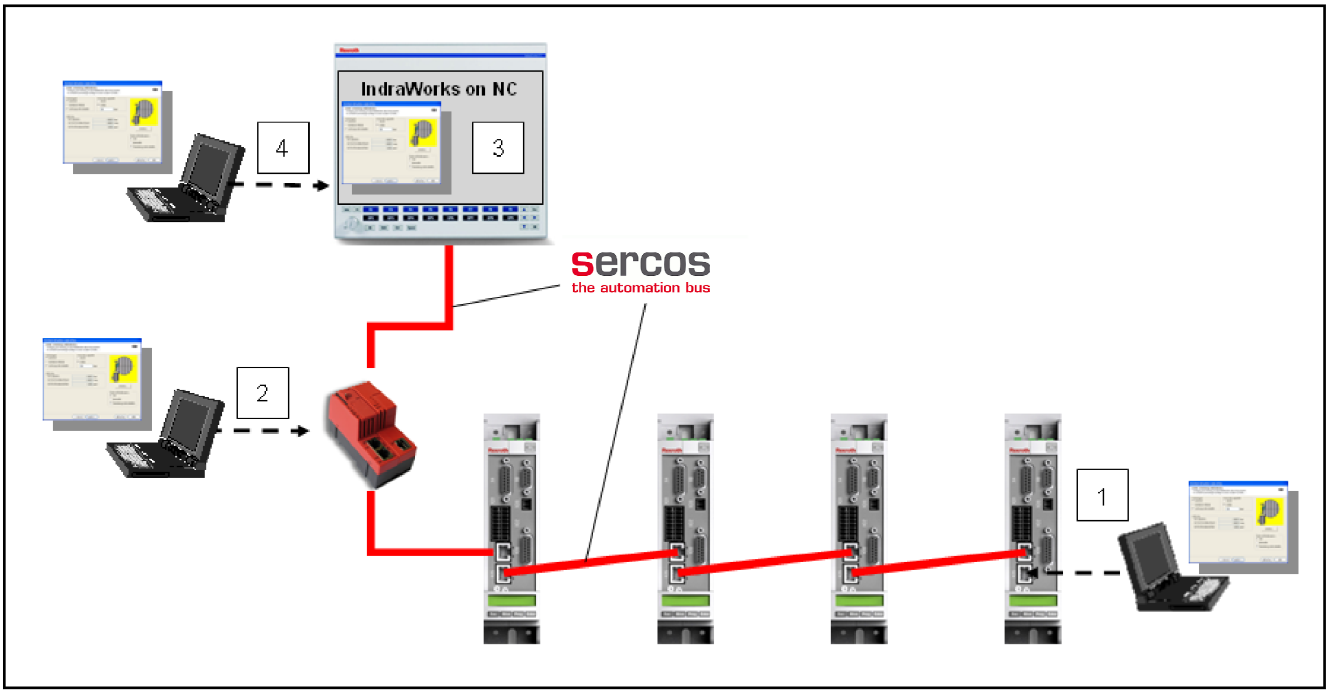
Abbreviations

- **i16**: Signed 16-bit variable (1 word) in Intel format
- **i32**: Signed 32-bit variable (2 words) in Intel format
- **u16**: Unsigned 16-bit variable (1 word) in Intel format
- **u32**: Unsigned 32-bit variable (2 words) in Intel format
- **ZKL1**: Class 1 diagnostics
- **ZKL2**: Class 2 diagnostics

5.2.5 sercos

Brief description

Topology



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

Fig. 5-7: Engineering options via sercos

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

We distinguish the following communication channels:

- **Cyclic data channel**

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

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

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

General features

- Hotplug is supported
- Standard sercos Diagnostic Trace
- 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 diagnostics
- 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

Overview of the functional scope

- Overall synchronization of all connected devices

Firmware-specific features

<table>
<tr><th colspan="3"></th><th>BASIC
MPB-20VRS</th><th>ECONOMY
MPE-20VRS</th><th>ADVANCED
MPC-20VRS</th><th>MULTIAXIS
MPM-20VRS</th></tr>
<tr><td>Position controller cycle</td><td>$T_{position}$</td><td>µs</td><td>250/500</td><td>1000</td><td>250</td><td>500</td></tr>
<tr><td rowspan="2">Master communication cycle time</td><td>min</td><td>µs</td><td>250/500</td><td>2000</td><td>250</td><td>500</td></tr>
<tr><td>max</td><td>ms</td><td>65</td><td>65</td><td>65</td><td>65</td></tr>
<tr><td rowspan="4">Motion data
for MDT/AT respectively
[excl. 2 byte connection control word (C_Con)]</td><td rowspan="2">T_{sercos}=$T_{position}$</td><td>Byte</td><td>26</td><td>26</td><td>26</td><td>26</td></tr>
<tr><td>IDN</td><td>12</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td rowspan="2">T_{sercos}>$T_{position}$</td><td>Byte</td><td>50</td><td>50</td><td>50</td><td>50</td></tr>
<tr><td>IDN</td><td>16</td><td>16</td><td>16</td><td>16</td></tr>
<tr><td colspan="2" rowspan="2">CC connections
[excl. 2 byte connection control word (C_Con)]</td><td>Byte</td><td>12</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td>IDN</td><td>2</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td colspan="2" rowspan="2">Safety connections</td><td>Byte</td><td>10</td><td>10</td><td>10</td><td>10</td></tr>
<tr><td>IDN</td><td>SMP Container</td><td>SMP Container</td><td>SMP Container</td><td>SMP Container</td></tr>
</table>

Tab. 5-40: sercos key data

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

☞ CC connections or connections for exchanging safety data were implemented in this firmware version in accordance with the sercos specification (SCP V1.1.2). Regarding use and configuration, see Technical Note "TN_332_CC-Verbindungen_SERCOS3_EIDN.pdf"

☞ 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 IDNs
- sercos cycle time > position cycle time → max. length 50 bytes / 16 IDNs

The NRT channel is only possible, if a time slot of more than 125 µs is available.

Hardware requirements

Optional module with sercos communication

IndraDrive Cs	
ECONOMY	HCS01.1E-W00xx-A-0x-E-S3-EC-NN-xx-NN-FW
IndraDrive control section	
ECONOMY	CSE02.1A-S3-EC-NN-xx-NN-FW

Tab. 5-41: Control section design for "sercos interface"

Optional module with MultiEthernet communication

IndraDrive Cs	
ADVANCED	HCS01.1E-W00xx-A-0x-A-CC-EC-xx-xx-NN-FW
IndraDrive Mi	
Distributed servo drive	KSM02.1B-xxxC-xxN-xx-Hxx-ET-NN-D7-xx-FW
Distributed drive controller	KMS02.1B-Axxx-P-D7-ET-xxx-xx-xx-FW KMS03.1B-xxxx-P-D7-END-xx-xx-FW
Drive connection box	KCU02.1N-ET-ET-025-NN-N-NN-NN
IndraDrive control sections	
BASIC single-axis	CSB02.1x-ET-EC-xx-xx-xx-NN-FW CSB02.5B-ET-EC-xx-xx-xx-NN-xx
BASIC double-axis	CDB02.1B-ET-EC-EC-xx-xx-xx-xx-NN-FW
ADVANCED single-axis	CSH02.1B-CC-EC-xx-xx-xx-NN-FW CSH02.5B-ET-EC-xx-xx-xx-NN-xx

Tab. 5-42: Control section design for MultiEthernet

Axis addressing

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").

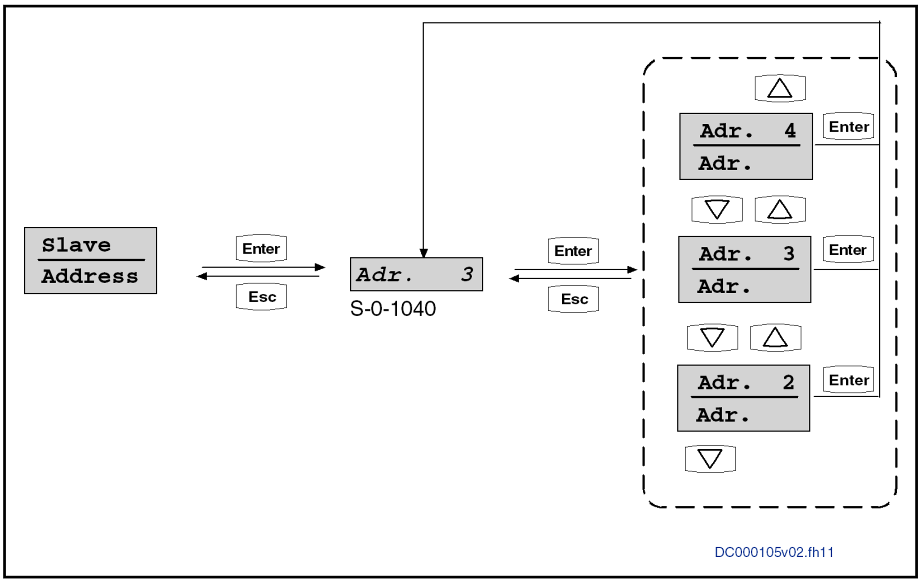


Fig. 5-8: Submenu for "Slave___" "_Addresss"

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

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

Pertinent parameters

Specific parameters for sercos communication:

- S-0-1000, sercos: SCP Type & Version

- S-0-1002, sercos: Communication Cycle time (tScyc)
- S-0-1003, sercos: Allowed MST losses
- S-0-1005, sercos: Minimum feedback processing time (t5)
- S-0-1006, sercos: AT0 transmission starting time (t1)
- S-0-1007, sercos: Feedback acquisition capture point (t4)
- S-0-1008, sercos: Command value valid time (t3)
- S-0-1009, sercos: Device Control (C-Dev) offset in MDT
- S-0-1010, sercos: Lengths of MDTs
- S-0-1011, sercos: Device Status (S-Dev) offset in AT
- S-0-1012, sercos: Length of ATs
- S-0-1013, sercos: SVC offset in MDT
- S-0-1014, sercos: SVC offset in AT
- S-0-1015, sercos: Ring delay
- S-0-1016, sercos: Slave delay (P/S)
- S-0-1017, sercos: NRT transmission time
- S-0-1019, Master comm. engineering over IP: MAC address
- S-0-1020, Master comm. engineering over IP: IP address
- S-0-1021, Master comm. engineering over IP: Network mask
- S-0-1022, Master comm. engineering over IP: Gateway address
- S-0-1023, sercos: SYNC jitter
- S-0-1024, C5300 sercos: SYNC delay measuring procedure command
- S-0-1026, sercos: Version of communication hardware
- S-0-1027.0.1, sercos: Requested MTU
- S-0-1027.0.2, sercos: Effective MTU
- S-0-1028, sercos: Error counter MST-P/S
- S-0-1031, sercos: Signal assignment TSx
- S-0-1034, sercos: PHY error counter Port1 and Port2
- S-0-1035, sercos: Error counter Port1 & Port2
- S-0-1035.0.1, sercos: Error counter P&S
- S-0-1036, sercos: Inter Frame Gap
- S-0-1037, sercos: Slave Jitter
- S-0-1040, Drive address of master communication
- S-0-1041, sercos: AT Command value valid time (t9)
- S-0-1042, sercos: Topology index
- S-0-1044, sercos: Device Control (C-Dev)
- S-0-1045, sercos: Device Status (S-Dev)
- S-0-1046, sercos: Slave addresses of the device
- S-0-1047, sercos: Maximum Consumer Activation Time
- S-0-1050.x.1, sercos Connection: Connection setup
- S-0-1050.x.2, sercos Connection: Connection number
- S-0-1050.x.3, sercos Connection: Telegram assignment
- S-0-1050.x.4, sercos Connection: Max. length of connection

- S-0-1050.x.5, sercos Connection: Current length of connection
- S-0-1050.x.6, sercos Connection: Configuration list
- S-0-1050.x.7, sercos Connection: Connection class
- S-0-1050.x.8, sercos Connection: Connection control (C-Con)
- S-0-1050.x.9, sercos Connection: State
- S-0-1050.x.10, sercos Connection: Producer cycle time
- S-0-1050.x.11, sercos Connection: Allowed data losses
- S-0-1050.x.12, sercos Connection: Error counter data losses
- S-0-1050.x.20, sercos Connection: IDN allocation of real-time bit
- S-0-1050.x.21, sercos Connection: Bit allocation of real-time bit
- S-0-1051, sercos Connection: Image of connection setups
- S-0-1060.x.1, sercos Connectiontype: Default configuration
- S-0-1060.x.2, sercos Connectiontype: Configuration mask
- S-0-1060.x.3, sercos Connectiontype: Max. quantity of conn. Capability
- S-0-1060.x.4, sercos Connectiontype: Max. Length of Connection
- S-0-1060.x.6, sercos Connectiontype: Configurable IDNs
- S-0-1060.x.7, sercos Connectiontype: Min. processing time
- S-0-1060.x.10, sercos Connectiontype: Minimum producer cycle time

Pertinent diagnostic messages

- A0000 Communication phase 0
- A0001 Communication phase 1
- A0002 Communication phase 2
- A0003 Communication phase 3
- A0008 sercos: NRT-Mode
- E4020 sercos: Ring interruption (FF to LF)
- E4040 sercos: Hot-plug error
- E4041 sercos: HP0 Cycle Time invalid
- E4042 sercos: HP0 MDT length invalid
- E4043 sercos: HP0 AT length invalid
- E4044 sercos: HP0 MTU size invalid
- E4045 sercos: HP0 NRT window invalid
- E4046 sercos: HP supported removed
- E4047 sercos: HP enabled removed
- F4001 Sync telegram failure
- F4002 RTD telegram failure
- F4003 Invalid communication phase shutdown
- F4004 Error during phase progression
- F4005 Error during phase regression
- F4006 Phase switching without ready signal
- F4017 sercos: Incorrect sequence during phase switch
- F4020 sercos: Cable break (L+F to NRT)

5.2.6 EtherCAT®

Brief description

Overview of the functional scope

Topology

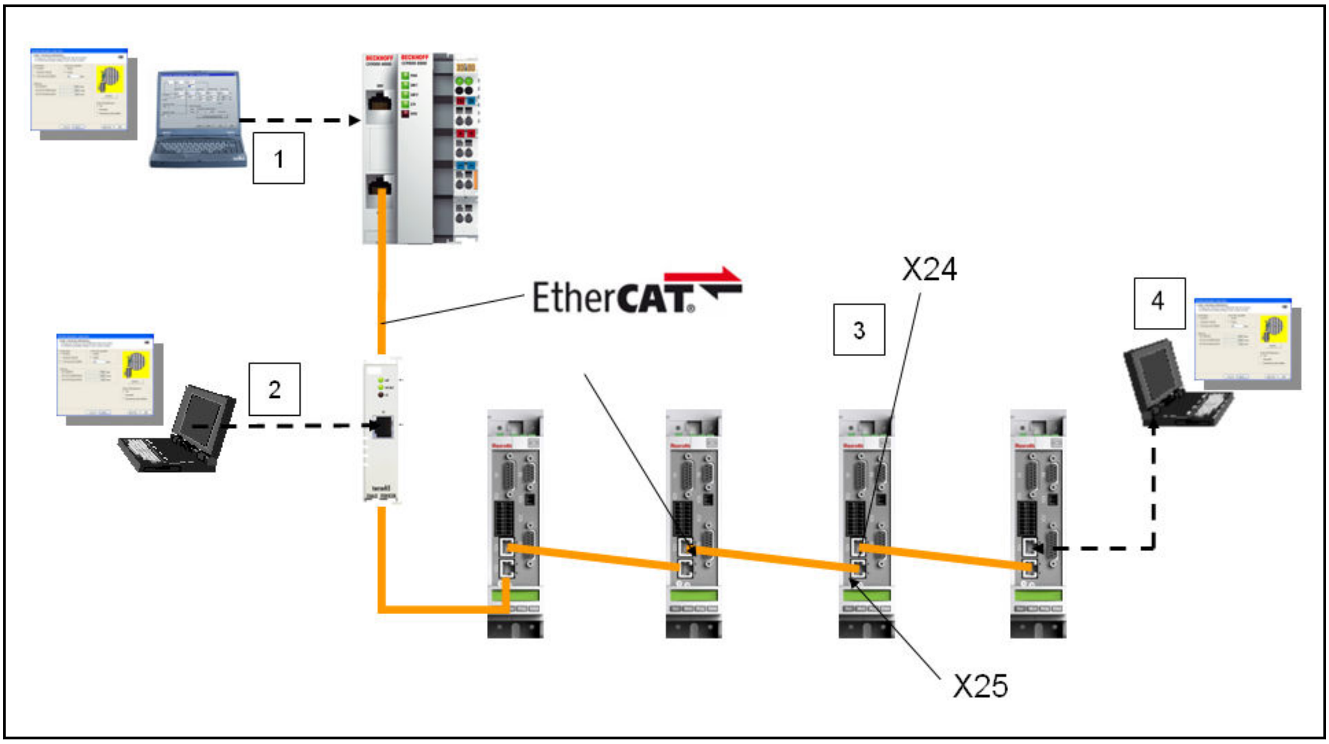


Fig. 5-9: Engineering options with EtherCAT®

1. Engineering network side (Engineering PC connected to control)
   - Using EoE

     Note: EtherCAT master has to support and serve EoE within the EtherCAT network and provides routing into EtherCAT network
   - Using ADS/Keba-dll

     Note: Only working with Beckhoff and Keba control
   - Using 3rd Party control connection

     Note: Control has to support and implement 3rd party interface
2. EtherCAT network side (Engineering PC connected to the EtherCAT network via a coupling device)

   Note: Connecting Engineering PC directly to the EtherCAT network is not supported due to limitations of EtherCAT
   - With the support for EoE using an Ethernet Switch Port (e.g., EL6601 by Beckhoff)

     Note: EtherCAT master has to support and serve EoE within the EtherCAT network
3. Drive side (Engineering PC directly connected to the drive)
   - Optional Engineering port with Economy and Basic IP20 devices

     Note: Option not available for IP65 devices
   - Engineering port with Advanced drives
4. Control side (IndraWorks running on the control)
   - Using EoE

     Note: EtherCAT master has to support and serve EoE within the EtherCAT network and provide an EoE Endpoint within the control
   - Using ADS/Keba-dll

Note: Only working with Beckhoff and Keba control

- Using 3rd Party control connection

  Note: Control has to support and implement 3rd party interface

IndraDrive controllers with MultiEthernet interface (ET) can be operated as EtherCAT® master communication. Via these modules it is possible to exchange real-time data with an EtherCAT® master. The "Servo Drive Profile over EtherCAT® (SoE)" is supported on the one hand, which is based on the drive profile from the SERCOS II specification. In addition, it is possible to operate the drive via CoE. The drive can then be operated via the DS402 profile of CiA.

We distinguish the following communication channels:

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

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

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

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

General features

- Transmission rate 100 Mbit/s
- Data transmission via Ethernet cable (CAT5e-copper)
- Topology: "Line"
- 16-bit sercos parameters of the drive are accessed via "SoE" protocol ("Servo Drive Profile over EtherCAT®" protocol)
- CANopen objects are accessed via CoE
- With CoE set it is possible to use the following CiA402 operation modes (see also chapter "Operation modes, field bus profile CiA402", chapter "Brief description" on page 280):
  - Cyclic sync position mode
  - Cyclic sync velocity mode
  - Cyclic sync torque mode
  - Cyclic homing mode
- EtherCAT® mailbox method for parameterization and diagnostics
- Cyclic data exchange of command values and actual values
- Free configuration of telegram contents
- Max. length of the configurable MDT/AT data, 15 IDNs with max. 48 bytes; if bus clock = position clock, the max. length is reduced by half to 24 bytes
- Cycle time: min. 250 µs (multiples of the position cycle time can be set)
- Optional synchronization via "distributed clock synchronization" (exact adjustment of distributed clocks)
- Synchronization between time command value takes effect and measurement starting time of the actual values for all drives on a ring when using Distributed Clocks
- Overall synchronization of all connected drives to the master when using Distributed Clocks

Overview of the functional scope

- Non-synchronous operation without synchronization via "Distributed Clock" is possible
- FSoE is supported
- Configured Station Address is supported

Comparison of ADS - EoE

	ADS	EoE
Parameter w / r	Yes (16 bits only, alias required)	Yes
FWA update	No	Yes
Transmission rate	O	+
Openness	Beckhoff only	Yes
Parameters via control unit	Yes	Yes
Solution		Switch port function in an IndraDrive master axis. As a prerequisite, the control unit has to support EoE Endpoint.
CoE / SoE	SoE only	CoE and SoE

ADS Automation Device Specification by Beckhoff

Tab. 5-43: Comparison of ADS - EoE

Hardware requirements

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

IndraDrive Cs	
BASIC	HCS01.1E-W00xx-A-0x-B-ET-EC-xx-xx-NN-FW
ADVANCED	HCS01.1E-W00xx-A-0x-A-CC-EC-ET-xx-NN-FW
ECONOMY	HCS01.1E-W00xx-A-0x-E-S3-EC-EP-xx-NN-FW
IndraDrive Mi	
Distributed servo drive	KSM02.1B-xxxC-xxN-xx-Hxx-ET-NN-D7-xx-FW
Distributed drive controller	KMS02.1B-Axxx-P-D7-ET-xxx-xx-xx-FW KMS03.1B-xxxx-P-D7-ET-END-xx-xx-FW
Drive connection box	KCU02.1N-ET-ET*-025-NN-N-NN-NN
IndraDrive control sections	
Basic control section - single-axis	CSB02.1x-ET-EC-xx-xx-xx-NN-FW CSB02.5B-ET-EC-xx-xx-xx-NN-FW
Basic control section - double-axis	CDB02.1B-ET-EC-EC-xx-xx-xx-xx-NN-FW
Economy control section - single-axis	CSE02.1A-S3-EC-NN-L3-NN-FW
Advanced control section - single-axis	CSH02.1B-CC-ET-xx-xx-NN-FW CSH02.5B-ET-xx-xx-xx-NN-xx

* See central standard ZN 41001-021

Tab. 5-44: Control section design for EtherCAT

Axis addressing

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". Alternatively, the address can be directly changed or displayed via the parameter"P-0-4089.0.3, Device Address" (alias: P-0-2303). The topology address of the drive is assigned by the master and displayed in the parameter "P-0-4089.0.4, Active Device Address" (alias: P-0-2304), and cannot be changed. With EtherCAT®, this address is used as the "Device Identification Value / 2nd Address".

Pertinent parameters

- P-0-4089.0.3, Device Address
  (alias: P-0-2303)
- P-0-4089.0.4, Active Device Address
  (alias: P-0-2304)

- 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

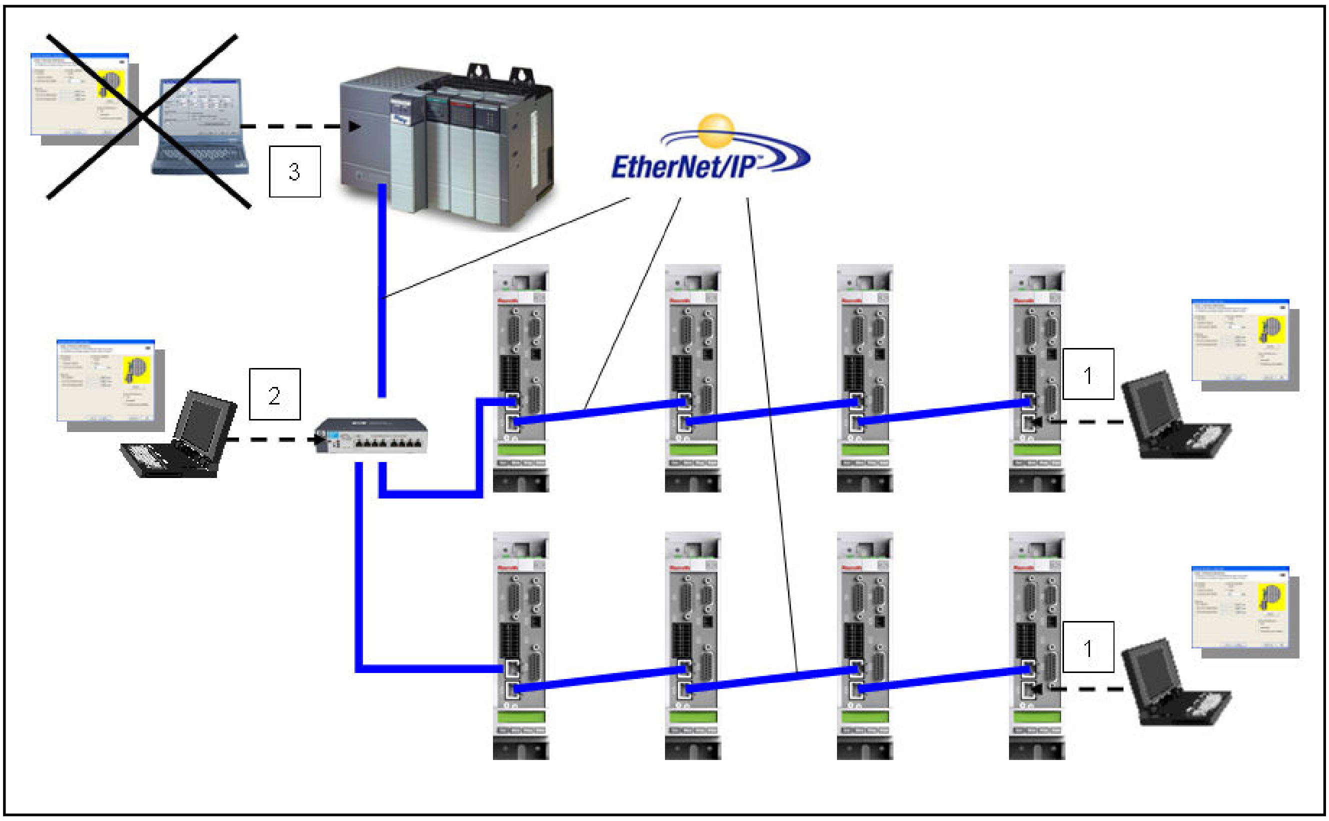
- C0101 Invalid parameters (-> S-0-0021)
- C0104 Config. IDN for MDT not configurable
- C0105 Maximum length for MDT exceeded
- C0106 Config. IDNs for AT not configurable
- C0107 Maximum length for AT exceeded
- C0108 Time slot parameter > sercos cycle time

- C0112 Set timing not permissible
- C0113 Relation TNcyc (S-0-0001) to TScyc (S-0-0002) error
- C0114 T4 > TScyc (S-0-0002) - T4min (S-0-0005)
- C0201 Invalid parameters (->S-0-0423)
- C0299 Configuration changed. Restart
- E4005 No command value input via master communication
- F4002 RTD telegram failure
- F4009 Bus failure

5.2.7 EtherNet/IP(TM) interface

Brief description

Topology



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

Fig. 5-10: EtherNet/IP(TM) topology

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

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

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

Features

- 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**eviceNet **V**endors **A**ssociation)
- EtherNet/IP™ Level 2 server
- Cyclic exchange via "Ethernet/IP™ I/O messaging" (Class 1)
- Acyclic data exchange via "Ethernet/IP™ Unconnected Explicit Messaging" and "Explicit Messaging" (Class 3)
- The smallest supported cycle time (API → Actual Packet Interval) is 2 ms.
- Configurable cyclic data up to 15 parameters (incl. field bus control word and field bus status word) in both data directions (max. 48 bytes or 24 words)

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

- Supported field bus profiles:
  - 0x0000: "No profile"
  - 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

The "Ethernet/IP™" master communication requires the following control section design:

IndraDrive Cs	
BASIC	HCS01.1E-W00xx-A-0x-B-ET-EC-xx-xx-NN-FW
ADVANCED	HCS01.1E-W00xx-A-0x-A-CC-EC-ET-xx-NN-FW
IndraDrive Mi	
Distributed servo drive	KSM02.1B-xxxC-xxN-xx-Hxx-ET-NN-D7-xx-FW
Distributed drive controller	KMS02.1B-Axxx-P-D7-ET-xxx-xx-xx-FW KMS03.1B-xxxx-P-D7-ET-END-xx-xx-FW

Overview of the functional scope

Drive connection box	KCU02.1N-ET-ET*-025-NN-N-NN-NN
IndraDrive control sections	
Basic control section - single-axis	CSB02.1x-ET-EC-xx-xx-xx-NN-FW CSB02.5B-ET-EC-xx-xx-xx-NN-FW
Basic control section - double-axis	CDB02.1B-ET-EC-EC-xx-xx-xx-xx-NN-FW
Advanced control section - single-axis	CSH02.1B-CC-ET-xx-xx-NN-FW CSH02.5B-ET-xx-xx-xx-NN-xx

* See central standard ZN 41001-021

Tab. 5-45: Control section design for Ethernet/IP™

Axis addressing

With EtherNet/IP the master communication address is an IP address. It is set in "P-0-4089.0.13, Master communication: IP address" (alias: P-0-2315).

☞ The device address set in "P-0-4089.0.3, Device Address" (alias: P-0-2303) is applied to the parameter "P-0-4089.0.4, Active Device Address" (alias: P-0-2304) after the device has been restarted. This address is shown on the display and is irrelevant for the EtherNet/IP communication!

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 (alias: P-0-2311)
- P-0-4089.0.10, Master communication: MAC address device (alias: P-0-2312)
- P-0-4089.0.13, Master communication: IP address (alias: P-0-2315)
- P-0-4089.0.14, Master communication: Network mask (alias: P-0-2316)
- P-0-4089.0.15, Master communication: Gateway address (alias: P-0-2317)

Profile type parameters

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

See "Profile types (with field bus interfaces)"

Parameters for extended communication

Additional parameters are used for extended communication.

See the following sections:

- "Configurable signal control word"
- "Configurable signal status word"
- "Multiplex channel"

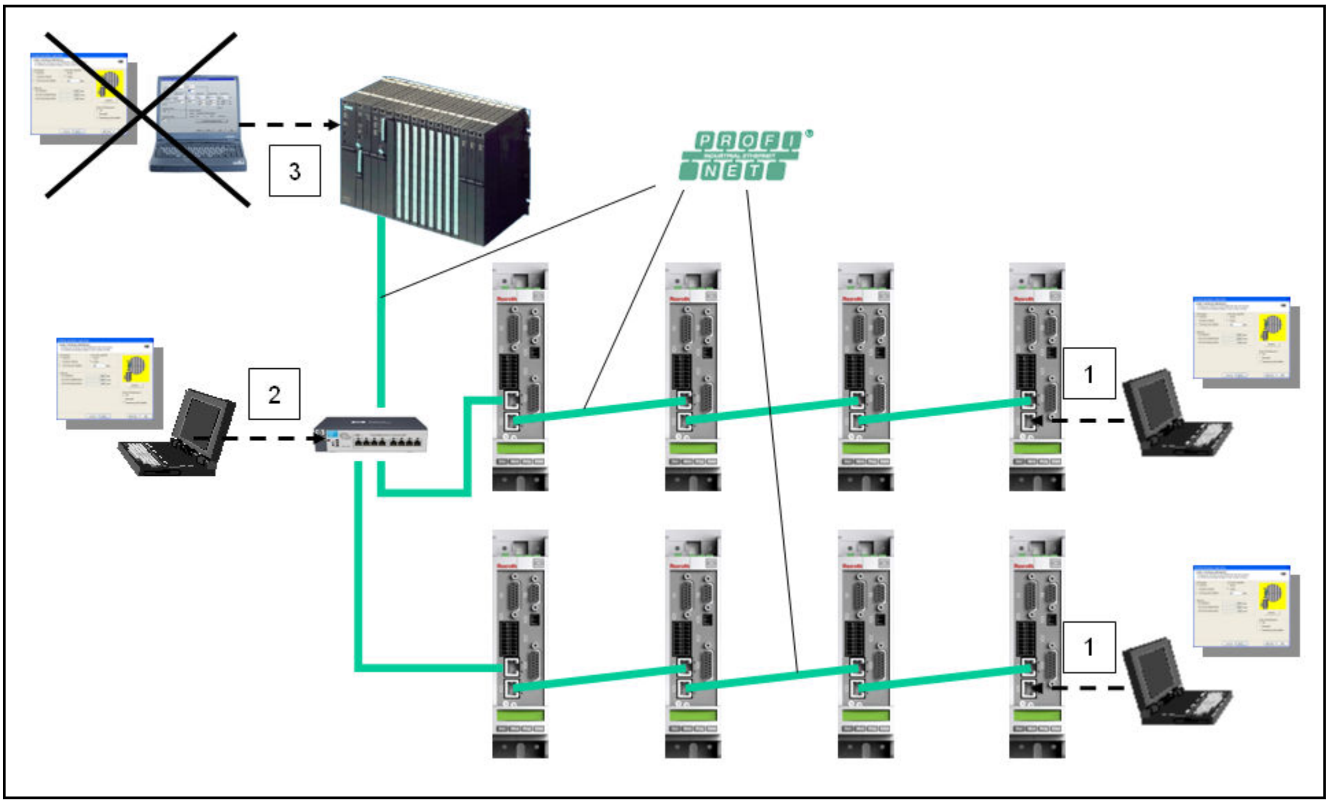
Pertinent diagnostic messages

- 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
- F4011 Communication watchdog: Overload of cyclic communication

5.2.8 PROFINET®

Brief description

Topology



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

Fig. 5-11: Engineering options 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) **safe, axis-specific process data channel** (PROFIsafe).

> The **safe, axis-specific process data channel** is not available with MPx18VRS and above. For configuration, however, the module "F-Module not used" has to be integrated!

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

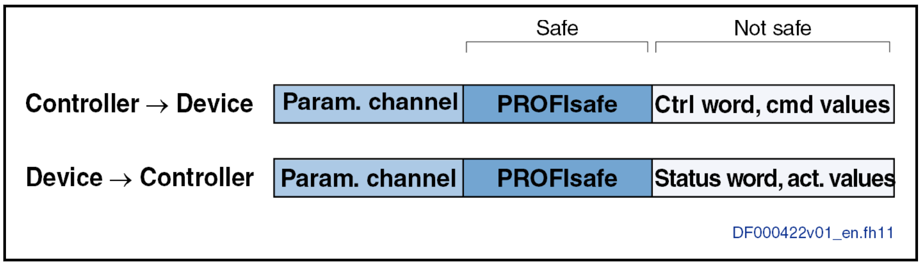


Fig. 5-12: Cyclic data channel overview

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

Features

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

- Ethernet in accordance with IEEE 802.3 and prioritization in accordance with IEEE 802.1Q
- 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 (Discovery and Basic Configuration)
- The smallest supported cycle time (I/O cycle updating time) is 2 ms.

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

- Configurable cyclic data up to 15 parameters (incl. field bus control word and field bus status word) in both data directions (max. 48 bytes or 24 words)

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

☞ The parameter "P-0-4076, Field bus: Process data - updating clock" is used to set the update cycle with which the process data from the MultiEthernet interface are applied to the 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 are made available by the administrative office of the PNO (PROFIBUS Nutzerorganisation e. V.).

☞ It is recommended that

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

---

- Additional optional parameter channel in the cyclic channel with up to 16 bytes (8 words)
- LED for diagnosing PROFINET® status (network status)
- LEDs for displaying the link/activity status
- CCA and RT_CLASS_1 are supported
- Diagnostic messages and alarms are not used due to reasons of compatibility with IndraDrive 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

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

Overview of the functional scope

IndraDrive Cs	
BASIC	HCS01.1E-W00xx-A-0x-B-ET-EC-xx-xx-NN-FW
ADVANCED	HCS01.1E-W00xx-A-0x-A-CC-EC-ET-xx-NN-FW
IndraDrive Mi	
Distributed servo drive	KSM02.1B-xxxC-xxN-xx-Hxx-ET-NN-D7-xx-FW
Distributed drive controller	KMS02.1B-Axxx-P-D7-ET-xxx-xx-xx-FW KMS03.1B-xxxx-P-D7-ET-END-xx-xx-FW
Drive connection box	KCU02.1N-ET-ET*-025-NN-N-NN-NN
IndraDrive control sections	
Basic control section - single-axis	CSB02.1x-ET-EC-xx-xx-xx-NN-FW CSB02.5B-ET-EC-xx-xx-xx-NN-FW
Basic control section - double-axis	CDB02.1B-ET-EC-EC-xx-xx-xx-xx-NN-FW
Advanced control section - single-axis	CSH02.1B-CC-ET-xx-xx-NN-FW CSH02.5B-ET-xx-xx-xx-NN-xx

* See central standard ZN 41001-021

Tab. 5-46: Control section design for MultiEthernet

Axis addressing

A node in PROFINET is addressed using the so-called device name. This name is saved in P-0-4089.0.2 (alias: P-0-2311) and can be changed there.

☞ The device address set in "P-0-4089.0.3, Device Address" (alias: P-0-2303) is applied to the parameter "P-0-4089.0.4, Active Device Address" (alias: P-0-2304) after the device has been restarted. This address is shown on the display and is irrelevant for the PROFINET communication!

Pertinent parameters

Communication parameters

Specific parameters for communication via PROFINET®:

- P-0-4089.0.11, Master communication: MAC address Port1 (alias: P-0-2313)
- P-0-4089.0.12, Master communication: MAC address Port2 (alias: P-0-2314)

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 (alias: P-0-2311)

- P-0-4089.0.10, Master communication: MAC address device (alias: P-0-2312)
- P-0-4089.0.13, Master communication: IP address (alias: P-0-2315)
- P-0-4089.0.14, Master communication: Network mask (alias: P-0-2316)
- P-0-4089.0.15, Master communication: Gateway address (alias: P-0-2317)

Profile type parameters

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

See "Profile types (with field bus interfaces)"

See also "Engineering/diagnostic interfaces"

Parameters for extended communication

Additional parameters are used for extended communication.

See the following sections:

- "Configurable signal control word"
- "Configurable signal status word"
- "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
- F4011 Communication watchdog: Overload of cyclic communication
- F4012 Incorrect I/O length

5.2.9 Ethernet POWERLINK

Brief description

Topology

Overview of the functional scope

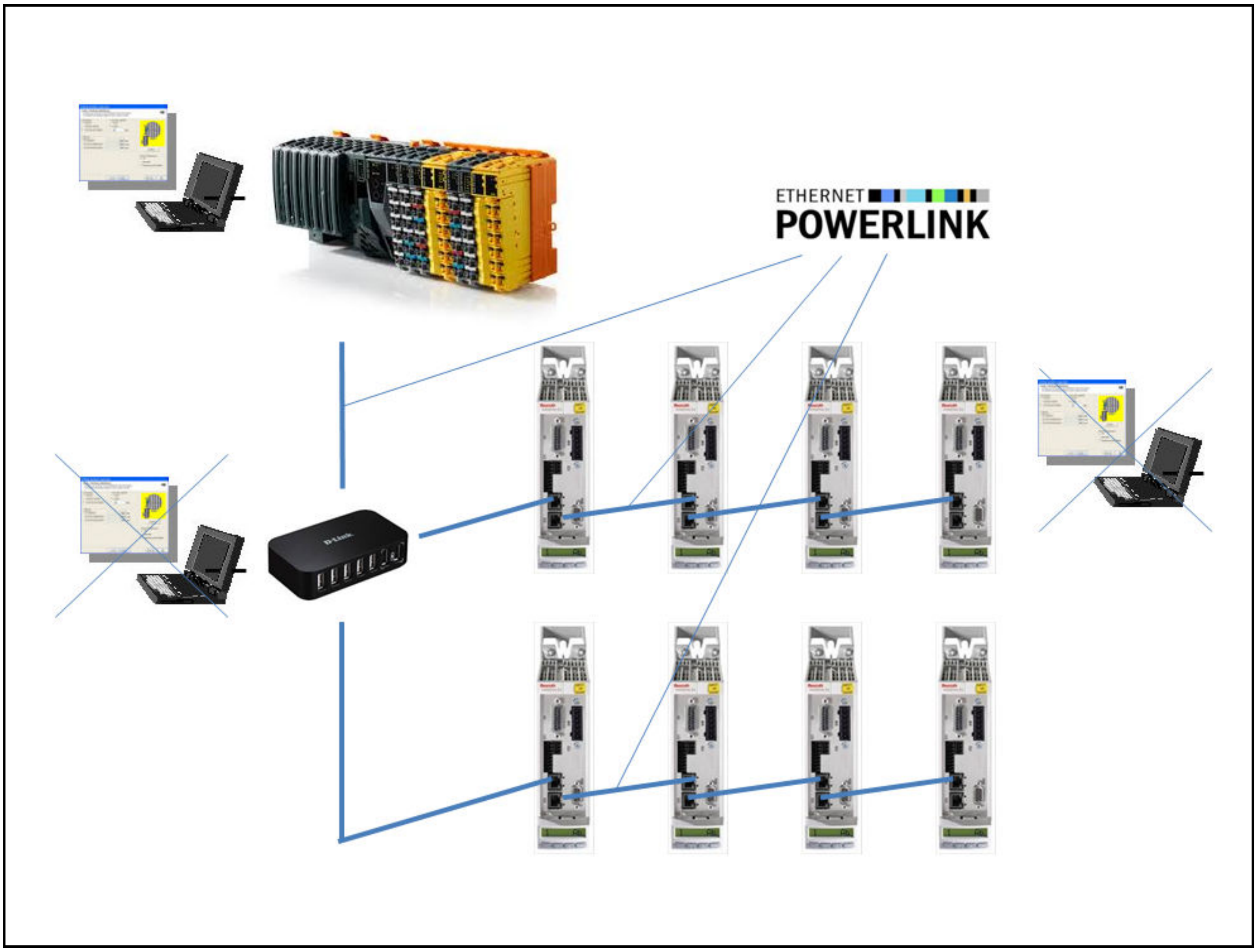


Fig. 5-13:

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

Features

- Transmission rate 100 Mbit/s (semi-duplex)
- Data transmission via Ethernet cable (CAT5e-copper)
- Topology: "Star", "line" (with integrated cut through switch)
- Depending on the variant that is used and the performance that has been set, the smallest supported cycle time is 250 µs. Generally, integral multiples of the position controller cycle time can be set. Any cycle time is supported in non-synchronized operation.
- Configurable cyclic data up to a maximum of 15 parameters (incl. profile-dependent control word and status word) in both data directions (max. 48 bytes or 24 words)

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

Ethernet POWERLINK addressing

Each Ethernet POWERLINK node (MN, CN and router) has an unequivocal Node ID within an Ethernet POWERLINK segment. The Node ID is configured via the parameter "P-0-4089.0.3, Device Address" (alias: P-0-2303). The value that was set is applied as the active Node ID when the drive is booted up. The currently active Node ID is displayed via the parameter "P-0-4089.0.4, Active Device Address" (alias: P-0-2304). If drive controller has an address selector switch, the setting of the switch is always displayed in P-0-4089.0.3. The Node IDs 1 to 239 are used for a "Controlled Node".

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

IP addressing

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

- IPV4 address

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

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

  Host ID value range of the drive: 1-239

  192.168.100.POWERLINK Node ID

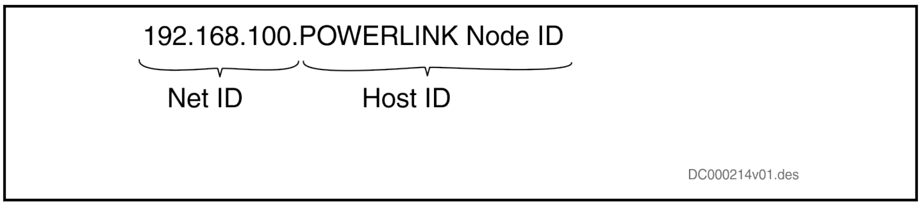


Fig. 5-14: IPV4 address

Subnet mask

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

Default gateway

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

Pertinent diagnostic messages

- A0004 Initialization
- A0005 Pre-Operational
- A0025 Basic ethernet mode
- A0026 Ready to operate
- C0229 Field bus: IDN for cycl. command val. not configurable
- C0230 Field bus: Max. length for cycl. command val. exceeded
- C0231 Field bus: IDN for cycl. actual val. not configurable
- C0232 Field bus: Length for cycl. actual values exceeded
- C0233 Field bus: Tcyc (P-0-4076) incorrect
- E4005 No command value input via master communication
- E4006 Communication module overload
- E4011 Communication watchdog: Overload of cyclic communication
- F4011 Communication watchdog: Overload of cyclic communication
- F4012 Incorrect I/O length
- C0201 Invalid parameters (->S-0-0423)
- C0299 Configuration changed. Restart

Diagnostics

STATUS/ERROR LED

The bicolor BUS LED at the housing of the drive controller (H24) is available for Ethernet POWERLINK communication diagnostics.

Overview of the functional scope

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

Tab. 5-47: S/E LED blinking codes of HydraulicDrive controller with Ethernet POWERLINK

These codes comply with the POWERLINK specification.

☞ For commissioning using IndraWorks, observe that the IP address of the device via the master communication is 192.168.100.POWERLINK Node ID (see chapter "Brief description" on page 131).

Timing

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

- Synchronous processing

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

- Cyclic processing

  If it suffices to process the process data cyclically, the synchronous processing can be deactivated. This is parameterized by activating bit 0 in "P-0-4089.0.5, Master communication: Configuration" (alias: P-0-2318). POWERLINK cycle times such as 400 µs, 800 µs etc. are then possible.

5.2.10 PROFIBUS-DP

Brief description

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

Cyclic data channel (PROFIBUS-DP)

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

The cyclic data channel is 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) **safe, axis-specific process data channel** (PROFIsafe).

The **safe, axis-specific process data channel** is not available with MPx18VRS and above. For configuration, however, the module "F-Module not used" has to be integrated!

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

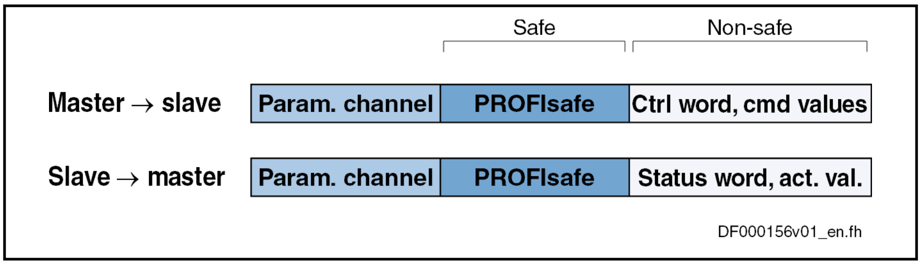


Fig. 5-15: Cyclic data channel overview

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

Features

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

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

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

- Additional optional parameter channel in the cyclic channel with up to 16 bytes (8 words)
- Monitoring of the cyclic data exchange (watchdog function)
- LED for diagnosing the PROFIBUS interface
- Supported DPV0 services:
  - Slave_Diag (read diagnostic data)
  - Get_Cfg (read configuration data)

  - Set_Prm (transmit parameterization data)
  - Chk_Cfg (check configuration data)
  - Data Exchange (transfer I/O data)
  - Global Control (synchronization)
  - RD_Outp (read output data)
  - RD_Inp (read input data)
- Supported DPV1 Class 1 services
  - DDLM_Initiate (establishment of connection)
  - DDLM_Read (acyclic read access)
  - DDLM_Write (acyclic write access)
  - DDLM_Abort (abortion of connection)
  - DDLM_Idle (connection monitoring)
- Up to two DPV1 class 2 connections are supported
- TCI (Tool Calling Interface) is supported
- 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

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

IndraDrive Cs	
BASIC	HCS01.1E-W00xx-A-0x-B-ET-EC-PB-xx-NN-FW
ADVANCED	HCS01.1E-W00xx-A-0x-A-CC-EC-PB-xx-NN-FW
IndraDrive control sections	
Basic control section - single-axis	CSB02.1x-ET-EC-PB-xx-xx-NN-FW CSB02.5B-ET-EC-PB-xx-xx-NN-xx
Basic control section - double-axis	CDB02.1B-ET-EC-EC-PB-xx-xx-xx-NN-FW
Advanced control section - single-axis	CSH02.1B-CC-EC-PB-xx-xx-NN-FW CSH02.5B-CC-EC-PB-xx-xx-NN-xx

Tab. 5-48: Control section design for PROFIBUS

In the case of devices with PROFIBUS option, it is only possible to change between inactive master communication and PROFIBUS master communication. Switching to sercos, EtherCAT, EtherNet/IP or PROFINET is impossible.

Axis addressing

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

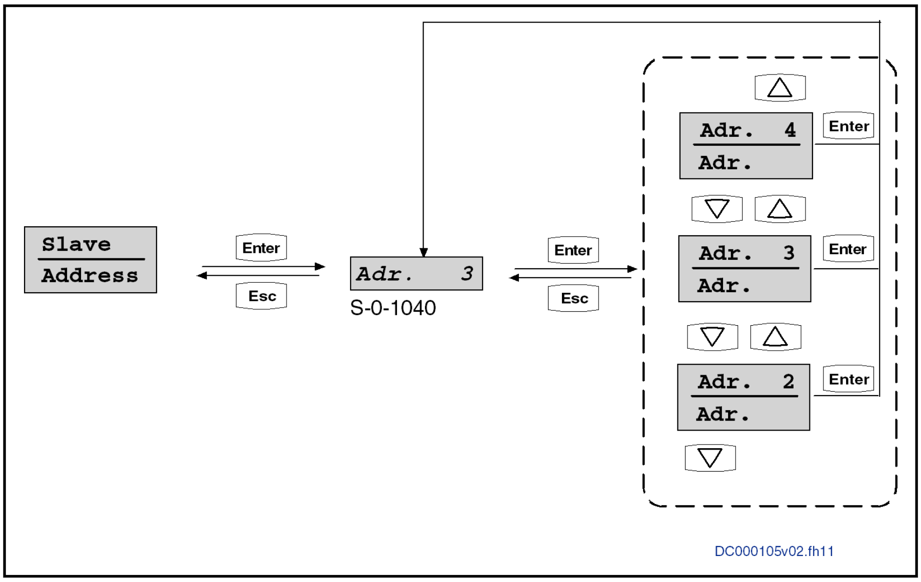


Fig. 5-16: Submenu for "Slave___" "_Addresss"

Alternatively, the address can be directly 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

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

See "Profile types (with field bus interfaces)"

Parameters for extended communication

Additional parameters are used for extended communication.

See the following sections:

- "Configurable signal control word"
- "Configurable signal status word"
- "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
- F4009 Bus failure
- F4012 Incorrect I/O length

5.2.11 CANopen-based communication

General information

Communication Objects (0x1000 to 0x1FFF)

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

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

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

Index	Subindex/ SubNumber	Description	Parameters
0x1000	0x00	ParameterName = Device Type ObjectType = 0x7 DataType = 0x7 DefaultValue = 0x00000192 AccessType = ro	0x00FF0192
0x1001	0x00	ParameterName = Error Register ObjectType = 0x7 DataType = 0x5 AccessType = ro	
0x1018	5	ParameterName = Identity Object ObjectType = 0x9	
	0x00	ParameterName = Number Of Entries DataType = 0x5 DefaultValue = 4 AccessType = ro	
	0x01	ParameterName = Vendor ID DataType = 0x7 DefaultValue = 0x24 AccessType = ro	36

Index	Subindex/ SubNumber	Description	Parameters
	0x02	ParameterName = Product Code DataType = 0x7 DefaultValue = 0x4 AccessType = ro	4
	0x03	ParameterName = Revision Number DataType = 0x7 AccessType = ro	P-0-1509: Element 5 (release)
	0x04	ParameterName = Serial Number DataType = 0x7 AccessType = ro	P-0-1509: Element 3 (serial no.)

Tab. 5-49: Specified CANopen Objects

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

Manufacturer-specific objects (0x2000 to 0x3FFF)

Manufacturer-specific objects

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

Subindex	Description
0	Number of parameter sets (1 or 8)
1	Operating data set 0
2	Operating data set 1 (if available)
3	Operating data set 2 (if available)
4	Operating data set 3 (if available)
5	Operating data set 4 (if available)
6	Operating data set 5 (if available)
7	Operating data set 6 (if available)
8	Operating data set 7 (if available)
10	Index of list pointer
11	List element to which element 10 points (only for list parameter)
12...18	List element to which element 10 points (if 8 parameter sets available); only for list parameter
21	Name of parameter
22…28	Name of parameter (if 8 parameter sets available)
31	Attribute of parameter
32…38	Attribute of parameter (if 8 parameter sets available)
41	Unit of parameter

Overview of the functional scope

Subindex	Description
42…48	Unit of parameter (if 8 parameter sets available)
51	Minimum value of parameter
52…58	Minimum value of parameter (if 8 parameter sets available)
61	Maximum value of parameter
62…68	Maximum value of parameter (if 8 parameter sets available)
71	Maximum length of list parameter
72…78	Maximum length of list parameter (if 8 parameter sets available)
81	Actual length of list parameter
82…88	Actual length of list parameter (if 8 parameter sets available)

Tab. 5-50: Structure of manufacturer-specific objects

List access

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

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

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

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

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

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

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

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

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

The changes are discarded when the control voltage fails.

5.2.12 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 an analog command value to be assigned 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.

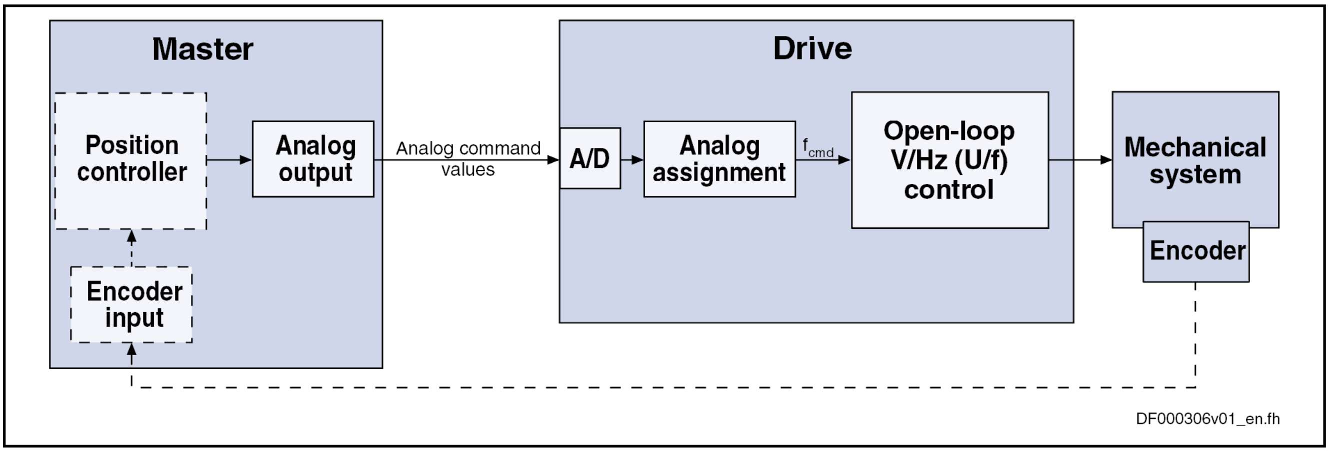


Fig. 5-17: Open-loop operation with analog interface (with optional position feedback to the control unit)

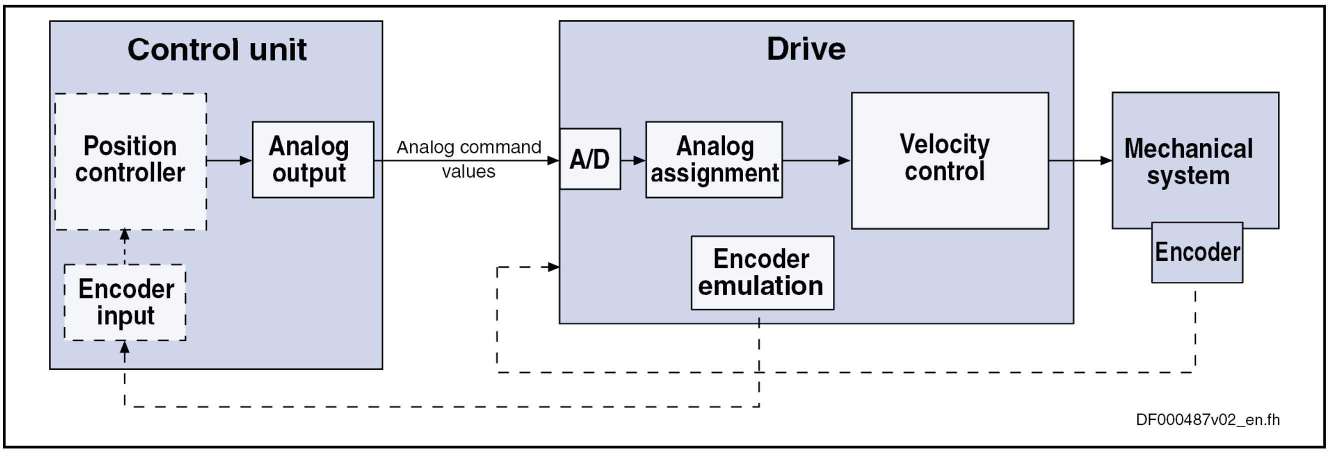


Fig. 5-18: Closed-loop operation with analog interface (with analog command value input and SSI emulation)

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 inputs/outputs (drive enable, Drive Halt, …).

The analog interface is configured via the parameter "P-0-2945, Configuration of analog mode".

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 controller clock $T_{position}$ (see also "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 controller clock $T_{position}$
  - Assignment channel B → assignment in clock of 2 ms
  - Assignment channel C → 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:
    - "Drive enable" and "Drive Halt" signals
    - 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

Availability

All drive controllers except for KSM02/KMS02 and KMS03 provide the analog mode option. For this purpose, the master communication has to be deactivated using "P-0-4089.0.1, Master communication: Protocol" (alias: P-0-2310).

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-0-2945, Configuration of analog mode
- 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
- P-0-0215, Analog input, assignment A, signal value at 0
- 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
- P-0-0238, Analog input, assignment B, signal value at 0
- P-0-0239, Analog input, assignment B, dead zone
- P-0-3901, Adjustment values of control section

Encoder emulation:

- P-0-0900, Encoder emulation signal selection list
- P-0-0901.x.1, Encoder emulation signal selection
- P-0-0901.x.2, Encoder emulation control parameter
- P-0-0901.x.3, Encoder emulation resolution
- P-0-0901.x.4, Encoder emulation zero pulse offset

5.2.13 RIL_ModbusTCP

The field bus protocol "Modbus TCP" is used to exchange data between Ethernet devices which support the Modbus protocol.

In this case, the drive-internal PLC assumes the role of the "Modbus TCP" server (master) to which the "Modbus TCP" clients (slaves) can connect.

Using the function blocks contained in the "RIL_ModbusTCP" library, both a "Modbus TCP" server and a "Modbus TCP" client can be implemented.

The library is supported by several targets and therefore described in the "Basic Libraries, IndraLogic 2G" documentation.

5.3 Motor, drive mechanics, measuring systems

⚠ 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".

5.3.1 General information on motor operation with IndraDrive

Basics on the motors to be controlled

Brief description

The controllers of the IndraDrive range allow both synchronous motors, asynchronous motors and reluctance motors to be controlled.

Types of construction

The following types of construction are possible:

- Rotary motors (asynchronous, synchronous, synchronous with reluctance, reluctance motors)
- Linear motors (synchronous only)

Both types of construction 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

The motors controlled by IndraDrive are protected against thermal damage. This is done by evaluating a motor-side temperature sensor and using a firmware-side motor temperature model.

Particularly the motor temperature model allows motors in the case of high overload and also motors without a temperature sensor to be thermally protected.

For details, see chapter "Motor temperature monitoring".

Diagnostic motor operation data

The firmware provides the option to collect dynamic operating data of the motor and store them (operating hours counter, thermal and mechanical operating data, operational performance). The data are stored in the encoder data memory (if available), otherwise in the parameter memory.

Adjusting mains voltage / motor

Motors whose winding insulation is not suited for the maximum nominal DC bus voltage of DC750V, can be protected against inadmissibly high voltage by specifying the maximum DC bus voltage allowed for these motor types. The braking resistor threshold is adjusted to the value of this parameter and the DC bus voltage is limited to this value ("output stage locked"). If the DC bus voltage to be expected is higher than the one allowed for the motor, you must check whether the DC bus voltage can be dropped to a value allowed for the motor by reducing the mains voltage.

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.

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

- 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.

☞ For series applications, the motor-specific data, motor control parameters, commutation offset, where applicable, and application-specific data of third-party motors with the appropriate encoder data memory can be stored in the motor encoder memory.

Motor holding brakes

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

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

Motor fan control

In combination with temperature-measuring temperature sensors (KTY84, PT1000, K227), the motor fan can be controlled in a temperature-dependent way (with MPx20V06 and above). When the motor temperature has reached a threshold value to be set, a signal is output that switches on the motor fan:

- Digital signal for relay- or contactor-switched motor fans
- Analog signal as the command value for frequency converter controlled motor fans

The motor fan is switched off or stopped with a hysteresis of 10K below the switch-on temperature.

Hardware data

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

To use the temperature-dependent fan control, the required outputs (digital or analog) have to exist and be available for this purpose.

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
- S-0-0533, Nominal torque/force of motor
- S-0-0534, Maximum torque/force of motor
- P-0-0018, Number of pole pairs/pole pair distance
- P-0-0051, Torque/force constant
- P-0-0113, Bipolar velocity limit value of motor
- P-0-0510, Rotor inertia
- P-0-0640, Cooling type
- P-0-0853, Max. DC bus voltage, motor
- P-0-4014, Type of construction of motor
- P-0-4044, Phase inductance of preconnected choke
- P-0-4048, Stator resistance

Synchronous motor parameters:

- P-0-4016, Direct-axis inductance of motor
- P-0-4017, Quadrature-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
- P-0-3940, Motor torque/force at nominal current when using reluctance
- P-0-3941, Motor torque/force at maximum current when using reluctance
- P-0-3942, Reluctance angle at nominal motor current

- P-0-3943, Reluctance angle at maximum motor current

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-0-4032, Motor type plate data
- P-0-4036, Rated motor speed
- 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

The motors controlled by IndraDrive are protected against thermal damage. This is done by evaluating a motor-side temperature sensor and using a firmware-side motor temperature model. The drives can evaluate the following temperature sensors:

- PTC thermistor KTY84 (temperature measurement)
- PTC thermistor PT1000 (temperature measurement)
- Thermal switches SNM130DK and SNM150DK (switching performance)
- NTC thermistor K227 (temperature measurement)

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

A three-phase a.c. motor is heated up by:

- Operation under load that torque-proportionally generates current and causes ohmic losses in den motor windings.
- No-load operation, magnetic reversal losses are torque-proportionally generated in the rotor and laminated stator cores.

A temperature sensor installed in the motor windings detects

- current-dependently caused motor temperature rise in the nominal load range, immediately
- merely speed-dependently caused temperature rise in the rotor and laminated stator cores, but only in the case of a considerable temperature gradient

Warning against thermal switch-off

It the motor temperature can be measured using a temperature sensor, it is monitored for the value range allowed for the motor. When the motor temperature has reached the allowed maximum value, an error reaction is triggered and the motor is ultimately switched off with an error message. Before the motor is switched off due to thermal reasons, a warning is output above a temperature threshold so that the control master can recognize that switch-off is imminent and reduce the motor load, if necessary.

Reducing the warning and shutdown temperature of MS2N motors

Due to the rotor temperature rise of MS2N synchronous motors rotating in no-load operation and the temperature sensor installed in the stator, or in the motor winding, the warning temperature threshold and the shutdown temperature are reduced:

- The reduction compensates the temperature gradient between the rotor and the stator-side temperature sensor.
- The reduction increases with the average operating speed of the motor.

Motor temperature model

Notably in overload motor operation the temperature measurement by the temperature sensor is prone to errors though, because the thermal winding-temperature sensor contact resistance can only measure the temperature developed in the winding with a big delay compared to its development.

If the motor has stopped or turns very slowly, the rotor risks remaining in a position opposite the stator that can permanently cause a maximum current amplitude in a motor phase. This heats up the motor much more in the affected winding than in the other windings. Thanks to the temperature model calculation, the motor current also in this case is limited to the allowed continuous current in due time!

The motor temperature model also allows motors without a temperature sensor to be thermally protected.

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
- P-0-3060.0.3, Speed-dependent motor shutdown temperature reduction
- P-0-3060.0.4, Motor mounting situation
- P-0-3060.0.5, Motor shutdown temperature reduction/1000rpm

Pertinent diagnostic messages

- E2021 Motor temperature outside of measuring range
- E2051 Motor overtemp. prewarning
- F2019 Motor overtemperature shutdown
- F2021 Motor temperature monitor defective

5.3.2 Rexroth motors

Basics on Rexroth motors

Brief description

Classification

Rexroth's "Electric Drives and Controls" technology field 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.

Thermal motor monitoring

Rexroth motors are thermally monitored by the controller and protected against overheating. For this purpose, the current motor temperature is measured by temperature sensors installed in the motor winding. Simultaneously, the thermal load is calculated using a temperature model. Depending on temperature thresholds that can be set, the controller generates a warning or switches the motor off.

☞ Rexroth motors, by motor parameters made available and temperature evaluation adjusted in an optimum way, guarantee easy commissioning, full output performance and high 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 providing cost-efficient motors depending on the application.

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

- Encoders with sine signal and HIPERFACE® interface (1 Vpp)
- Encoders with sine signals (1 Vpp) and EnDat2.1 interface
- Encoders with sine signals (1 Vpp)
- Safety4Wire encoders
- Encoders of MSM motors with digital interfaces

All encoder systems supported by this firmware and suitable on the motor side can be used together with Rexroth kit motors (see chapter 5.3.7 "Supported measuring systems" on page 177).

Pertinent parameters

The "type plate" memory range contains the parameters listed below, among others. The parameters, which if applicable are converted depending on the scaling, are automatically copied to the parameters active for control (see "Pertinent parameters" in chapter "Basics on the motors to be controlled" on page 143).

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-0-3008, Commutation offset, type plate
- P-0-3015, Flux-generating current, limit value, type plate
- 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-0-3023, Current limit value of demagnetization, type plate
- P-0-3044, Motor torque at nominal current with reluctance, type plate
- P-0-3045, Motor torque at maximum current with reluctance, type plate
- P-0-3046, Reluctance angle at nominal motor current, type plate
- P-0-3047, Reluctance angle at maximum motor current, type plate
- P-0-3048, Motor control configuration, 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

Only for absolute encoders (multi-turn):

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

Parameters for motor holding brake (if available):

- P-0-3010, Torque of motor holding brake, type plate
- P-0-3011, Holding brake current, type plate
- P-0-2206, Drive On delay time, type plate
- P-0-2207, Drive Off delay time, 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, the default control loop parameters and, where required, the delay times for the holding brake (P-0-2206, P-0-2207) can be loaded to the drive controller. They are useful start values for further 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
- F2008 RL The motor type has changed.
- F2104 Commutation offset invalid

Rexroth housing motors

Rexroth housing motors with encoder data memory

Motor series

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

- MSK, MSM
- MAD, MAF

Brief description

Rexroth motors with encoder data memory provide the highest convenience for commissioning, because all data for motor control come "on board" in the motor encoder and are automatically activated. Thanks to the continuing development of the motor properties and firmware functions, the current motor ranges have different encoder data memory structure versions that support extended functions, where applicable:

Motor	Encoder memory version	P-0-3100	Comment
MSK, MAD, MAF, KSM	4.1	0x0401	Standard
	4.2	0x0402	IndraDrive Mi
	4.3	0x0403	4.1 + Diagnostic data of motor operation
	4.4	0x0404	4.3 + Field weakening
	4.5	0x0405	4.4 + Torque constant correction
	4.6	0x0406	4.5 + MSK133 reluctance utilization
MSM	5.1	0x0501	Standard
SBC (Parker)	6.1	0x0601	Standard
MS2N with encoder performance A	4.6 and 7.1	0x0406 0x0701	4.5 + MSK133 Standard reluctance utilization
MS2N with encoder performance C	7.1	0x0701	Standard

Tab. 5-51: Versions and properties of encoder memory integrated in motors

The improved encoder memory version 7 is used for the new MS2N motor range with MPx20 and above. Its data structure is more transparent for the user and compared to the previous encoder memory versions it can be used with a higher flexibility for future motor functions:

Structure of the encoder memory parameters depending on the upload to the device:

- Parameters loaded during boot-up or during the run-up to OM:
  - P-0-3071, Identification data, type plate (compact parameter)
  - P-0-3072, Motor: Static type data, type plate(compact parameter)
  - Diagnostic motor data with
    - P-0-3051, Encoder memory, operating hours counter, motor
    - P-0-3052, Encoder memory, thermal operating data, motor
    - P-0-3053, Encoder memory, mechanical operating data, motor
  - P-0-3075, Application-specific data, type plate(compact parameter)
- Parameters only loaded when "loading the control loop default values (RL)":
  - "P-0-3073, Motor: Control loop default values, type plate" (compact parameter), it additionally contains the new parameter "P-0-3945, Motor control configuration", as well as bit 0 and bit 2 of "P-0-3009, Holding brake control word, type plate".

The so-called "compact parameters" are also new. In contrast to the fixed data structure of older encoder memory versions, they can be flexibly configured with data.

MPx20 allows data to be written to the motor encoder data memory with the master password having been set.

Pertinent parameters

See "Pertinent parameters" in the section "Basics on Rexroth motors"

In addition to the parameters listed above there are other parameters for the data transfer from the encoder data memory to 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
- P-0-1035, Content of encoder memory optional slot 5
- P-0-1036, Content of encoder memory optional slot 6

Pertinent diagnostic messages

See "Pertinent diagnostic messages" in the section "Basics on Rexroth motors"

Rexroth housing motors without encoder data memory

Motor series

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

- MAL

Brief description

See section "Basics on Rexroth motors"

Pertinent parameters

See "Pertinent parameters" in the section "Basics on Rexroth motors"

Pertinent diagnostic messages

See "Pertinent diagnostic messages" in the section "Basics on Rexroth motors"

For further details, see section "Basics on Rexroth motors"

Rexroth kit motors

General information

Kit motors consist of individual components that are mounted to a moving and a 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
- Bearing

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 manufactured 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 associated with "synchronous motors":

- Linear motors MLF and MCL
- 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 implemented 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, the use of 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 success of the respective method depending on the drive mechanics:

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

  → Distance measurement, currentless (only possible for linear Rexroth 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-wave 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!

For the description of the methods for commutation setting, see "Drive control: Commutation setting"

Pertinent parameters

See "Pertinent parameters" in the section "Basics on Rexroth motors"

Pertinent diagnostic messages

See "Pertinent diagnostic messages" in the section "Basics on Rexroth motors"

For further information, see section "Basics on Rexroth motors"

Rexroth kit motors, asynchronous

Brief description

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

- 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 implemented with high resolution! Avoid using encoders with square-wave signals!

Pertinent parameters

See "Pertinent parameters" in the section "Basics on Rexroth motors"

Pertinent diagnostic messages

See "Pertinent diagnostic messages" in the section "Basics on Rexroth motors"

For further information, see section "Basics on Rexroth motors"

5.3.3 Third-party motors at IndraDrive controllers

General information on third-party motors

Today, machine axes are mainly moved with electric drives. Standard motors are used in most cases, as this is the most cost-efficient solution.

Special requirements

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

Motor designs not included in product range

For these cases, the drive supplier is requested to provide, apart from the deliverable standard drive consisting of (standard) motor, controller, cable and, if required, machine control unit, drives with motors that are not included in their 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

To successfully and fail-safely control 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 required manufacturer-side motor data" have to be made available for the motor suitability test!

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

How to commission?

First, the motor parameter values have to be determined (see section "Determining the parameter values for motor and motor control"). The parameter values of motor control are calculated by means of a command internally in the firmware.

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

5.3.4 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.

The following motor holding brake types are possible:

- Electrically releasing brakes (self-holding) for servo drives
- Electrically clamping 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 control 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**

Monitoring the brake current

Brief description

Fields of application

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

Monitoring for wire break, brake current and short circuit is only available with HCS01 devices!

Background

Particularly with vertical servo axes, the reliable function of a holding brake is fundamentally important to the operational safety of a machine. Using the "function check of the motor holding brake", the holding brake can be checked for wear and corrosion. It is up to the user, however, to use this function check or not.

Even with a cyclical function check, wire break occurring in the meantime would cause the brake to be accidentally applied and possibly destroyed before the malfunction could be recognized by the next function check. Between the function check intervals, the monitoring of the brake current, which is always active, detects faults with the holding brake control and signals 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 the case of "wire break" and "short circuit", the error message "F2068, Brake error" is generated. 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. due to brake control via relays.

The status of the holding brake current monitoring is displayed in "P-0-0539, Holding brake status word"; with IndraDrive Cs, 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

The "brake current monitoring" function does not require any specific hardware!

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

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 are not 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 clamping 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 clamping 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!

☞ To impede axis motion, the motor winding short circuit can be activated or maintained for synchronous motors already decelerated. The operating principle, however, does not totally correlate with the operating principle of a motor holding brake, but the motion-impeding function can be advantageously used at machine axes, where applicable.

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 has to be suited for the voltage that is output, the holding brake current should not exceed the allowed maximum value of the respective device (see documentation "Supply Units and Power Sections; Project Planning Manual for Controllers"); if necessary, the holding brake has to be controlled separately.

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

- C2000 Command Release motor holding brake
- C2001 Command not enabled
- C3800 Command Apply motor holding brake
- F6024 Maximum braking time exceeded

Function check of 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 a cyclic brake check to be performed in accordance with EN-13849-1, Cat. 2, or the dynamization/check of one of two redundant holding systems to be performed in accordance with EN-13849-1, Cat. 3.

Requirements

The function check is only possible in the case of motor control with motor encoder, not for sensorless motors! The holding brake must be controlled by the drive controller (if necessary via relay, if the required brake current cannot be supplied via the drive controller).

Overview of the functional scope

Application

The function check can also be carried out for an axis-side, external braking device, if it is controlled by the drive controller. The measuring system used for the function check (motor encoder or external encoder) has to be connected stiffly and in a backlash-free way to the holding brake. Tolerated motion range with the holding brake applied:

- Rotary motor: Max. 2° of a motor revolution (360°)
- Linear motor: Max. 1/180 of a pole pair distance (in mm)

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

- C2100 Command Holding system check
- C2101 Holding system check only possible with drive enable
- C2103 Holding brake: Torque too low
- C2104 Command execution impossible
- C2105 Load of holding system greater than test torque
- C2106 Test torque of holding system not reached
- C3900 Command Holding brake resurfacing
- C3901 Resurfacing of holding brake only possible with drive enable
- C3902 Error during resurfacing of holding brake
- C3903 Command execution impossible
- E3115 Prewarning, end of brake check time interval
- F3115 Brake check time interval exceeded

5.3.5 Motor fan control

Brief description

For energy-efficient motor operation, IndraDrive controllers can switch on and off a possibly existing motor fan, depending on the motor temperature rise. In the case of high-performance controllers, an analog voltage signal is output proportionally to the motor temperature rise. This voltage signal can be used to control the motor fan speed.

If it is impossible to measure the motor temperature, the motor load is nevertheless determined using the firmware-side temperature model, and the motor fan can thus be controlled in an energy-efficient way.

In the following cases, for example, the motor temperature cannot be measured:

- No temperature sensor has been installed in the motor.
- The existing temperature sensor has switching characteristic.

Hardware data

To switch the motor fan on and off, a digital signal is generated that can be used via a digital output, for example. For this purpose, an unassigned digital output of the control section has to be assigned.

The HMU05 power section provides an analog output DC0...10V for variable-speed motor fan control.

Pertinent parameters

- S-0-0201, Motor warning temperature
- P-0-3060.0.1, Motor fan switch-on temperature
- P-0-3061, Status of motor fan control
- P-0-0468, Prewarning threshold of therm. motor load
- P-0-0512, Temperature sensor

5.3.6 Measuring systems, general information

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 state of the physical value to be controlled, the so-called actual value.

We distinguish the following drive control loops:

- 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 measurement system and time-derivation
- Position control loop

  → Actual value by evaluating the position measurement 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.

Position measurement options

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

- At the motor only (measured via encoder 1/motor encoder)

- or -

- Both at the motor and at the drive mechanics (measured via encoder 1/ motor encoder and encoder 2)

☞ In the case of field-oriented motor control (FOC), a motor encoder is always required, the measurement at the load is optional; thus, the encoder at the load is called "optional encoder" or "external encoder".

- Both at the axis mechanics input (encoder 1) and at the load (encoder 2). At the motor in the case of electro-hydraulic applications (functional package "Sytronix")

☞ In electro-hydraulic applications (functional package "Sytronix"), the electric motor and other hydraulic components (pump, hydraulic motor, cylinder) together are called "actuator". The actuator drives the axis mechanics. Position measurement is possible at the actuator output (encoder 1) or at the load (encoder 2), the motor encoder generally is only used for velocity measurement (motor speed)!

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.

Position feedback value representation

The position information of the encoder may take the form of

- analog voltage signals with sine-shaped curve at constant velocity or square-shaped curve and 90° phase offset ("analog encoders"; measurement free of delay, but can only be evaluated in relative form)
- digital encoder signal with defined number of increments per single encoder revolution ("single-turn"), multiple encoder revolution ("multi-turn") or measuring distance and a serial transmission protocol ("digital encoders"; absolute actual position values in a limited distance or angle range).
- combination of analog voltage signals and digital encoder signal ("combined encoders"; absolute initial position value detection by digital encoder signal in relation to "single-" or "multi-turn range" or measuring distance)

Evaluating position measurement

The encoder evaluation uses a specific method allowing encoders in the future to be evaluated simultaneously by multiple drives. The physical information directly provided by the position encoder is converted to the standardized **SIII Encoder Profile.** Via the Sercos master communication level or in the CCD group, the standardized position feedback values and encoder status information are thus available to each connected drive for evaluation!

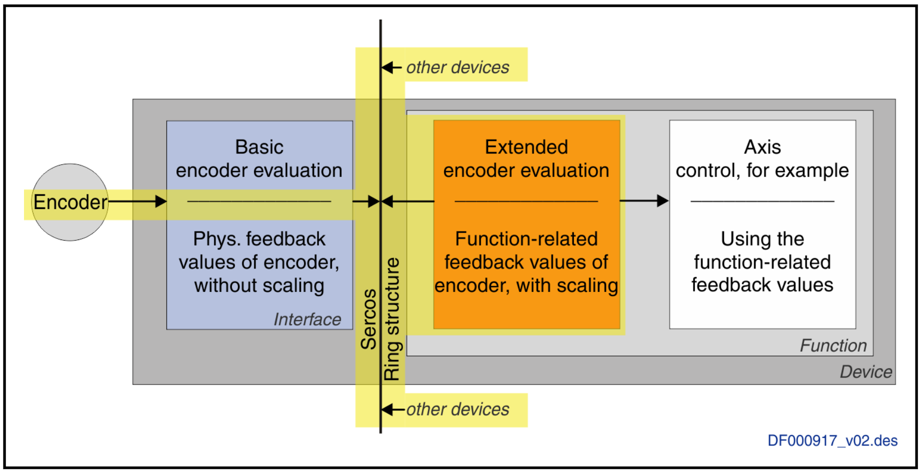


Fig. 5-19: Principle of encoder evaluation based on Sercos, for an encoder connected to a device interface

Basic encoder evaluation

Using the Basic encoder evaluation (ENCB), the position information of a physical encoder is converted to the standardized **SIII Encoder Profile**. The evaluation is related to the encoder interface or the encoder slot. Encoder-related position or velocity feedback values and status information can be made available on the SIII master communication or CCD level and can be used by other controllers.

The Basic encoder evaluation provides the following data regarding the connected encoder:

- Physical actual position, encoder-based
- Position resolution
- Encoder status, error codes
- Absolute position range
- Overflow threshold for position values
- Cycle time for encoder output data

The Basic encoder evaluation has to be informed of the physical data of the connected encoder:

- Phys. Encoder type
- Phys. encoder properties, like rotary encoder or linear encoder
- Phys. encoder resolution, analog and/or digital
- If necessary, distance-coded reference offsets A and B (see also chapter "Distance-coded reference marks cannot yet be used" on page 20)
- Where applicable, transmission protocol configuration in the case of a digital encoder

Extended encoder evaluation

The Extended encoder evaluation (ENCE) is the axis-related evaluation of encoder-related position feedback values and status information. The data can come from a Basic encoder evaluation in the same controller or have been transmitted by the Sercos master communication or CCD level. The Extended encoder evaluation works with the usual scalings and references:

- Motor or load reference
- Rotary or linear scaling (mapping of motor - load mechanical transmission)
- SI units or others

The follwoing functions are available as Extended encoder evaluation:

- Motor encoder
- Position control encoder (encoder 2 or encoder 1)
- Measuring encoder

The Basic encoder evaluation data of an encoder are assigned to each function by selecting an encoder interface or, if applicable, the master communication or CCD interface.

ENCB - ENCE parameter structure

The parameter structure of the Basic encoder evaluation and of the Extended encoder evaluation input is as follows:

Encoder evaluation	ENCB		ENCE
Current data, feedback values	S-0-0600.x.y	=>	S-0-0610.x.y
Output data configuration	S-0-0601.x.y	=>	S-0-0611.x.y
Physical encoder configuration	S-0-0602.x.y		
Instanciated parameters S-0-????.x.y: "x": structure instance index; "y": structure element number			
	Index "x" with ENCB (slot-related): 1: X4 (opt. 1, preferred slot encoder 1/mot. encoder 2: X8 (opt. 2) (etc., see below)		Index "x" with ENCE (function-related): 1: Encoder 1/motor encoder 2: Encoder 2 3: Measuring encoder 4: Motor encoder (cplx. actuator)

Index "x": Significance differs with ENCB and ENCE parameters, see table above!
ENCB Encoder Basic evaluation (interface- or slot-related)
ENCE Encoder Extended evaluation (function-related: motor encoder, position control encoder (encoder 2) or measuring encoder)

Tab. 5-52: ENCB configuration and ENCB output data, as well as ENCE input data, parameter structure

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☞ The IDN of the ENCE input data correspond to those of the ENCB output data, but the numbering is increased by +10!

Precision, resolution

The precision of the position measurement depends on:

- The resolution of the measuring system [e.g., division periods (DP)/revolution or DP in µm (linear encoders) for analog encoders; increments/revolution or increments per measuring distance (linear encoders) for digital encoders]
- The absolute encoder precision
- The digitalization quality of analog encoder signals

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.

Furthermore, it is possible to monitor the compliance of the actual position values, if another encoder (encoder 2) is arranged at the axis mechanics in addition to the encoder 1/motor encoder.

See also "Monitoring the measuring systems"

Hardware requirements

The Basic encoder evaluation data of an encoder are assigned to the respective function by selecting an encoder interface

Optional interfaces are available to connect the measuring systems to the controller or control section. Using the parameters "P-0-0077, Assignment of encoder 1->interface" (depending on "P-0-0560, Configuration of actuator") and "P-0-0078, Assignment of encoder 2->interface", it is possible to set the interface of which the position data are assigned to the respective function.

See also documentations "Rexroth IndraDrive Cs, Drive Systems" and "Rexroth IndraDrive HCQ, Drive Systems"

The following points apply to the parameters P-0-0077 or P-0-0080 and P-0-0078:

- For motors with motor encoder data memory, the value for parameter P-0-0077 or P-0-0080 is automatically set correctly.
- For motors without motor encoder data memory (e.g., Rexroth kit motors),the value for parameter P-0-0077 or P-0-0080 has to be set manually.
- In the case of an optional position control encoder (encoder 2), the value for parameter P-0-0078 has to be set manually, too.

Pertinent parameters

- S-0-0051, Position feedback value of encoder 1
- S-0-0053, Position feedback value of encoder 2
- S-0-0115, Encoder 2, type of position encoder
- S-0-0277, Encoder 1, type of position encoder
- S-0-0278, Maximum travel range
- P-0-0129, Internal position data format

Physical configuration of Basic encoder evaluation

IDN	Name
S-0-0602.x.1	Phys. Encoder type
S-0-0602.x.2	Phys. Encoder properties
S-0-0602.x.3	Phys. Encoder resolution (analog)
S-0-0602.x.4	Phys. Encoder resolution (digital)
S-0-0602.x.5	Phys. distance-coded reference offset A
S-0-0602.x.6	Phys. distance-coded reference offset B
S-0-0602.x.7	Phys. Encoder protocol configuration
S-0-0602.x.8	Phys. max. initialization speed

Overview of the functional scope

IDN	Name
S-0-0602.x.136	Phys. encoder evaluation configuration

The placeholder "x" (structure index) is the number of the device interface to which the encoder is connected:

- **1**: X4 (single-axis device), X4.1 (double-axis and multi-axis device)
- **2**: X8 (single-axis device), X4.2 (double-axis and multi-axis device)
- **3**: X8.1 (double-axis device), X4.3 (multi-axis device)
- **4**: X10 (single-axis device), X4.4 (multi-axis device)
- **5**: X8 (multi-axis device)
- **6**: X8.2 (double-axis device)

Output data of Basic encoder evaluation

IDN	Name
S-0-0600.x.1	Encoder status
S-0-0600.x.2	Position
S-0-0600.x.10	Marker position

The placeholder "x" (structure index) is the number of the device interface to which the encoder is connected:

- **1**: X4 (single-axis device), X4.1 (double-axis and multi-axis device)
- **2**: X8 (single-axis device), X4.2 (double-axis and multi-axis device)
- **3**: X8.1 (double-axis device), X4.3 (multi-axis device)
- **4**: X10 (single-axis device), X4.4 (multi-axis device)
- **5**: X8 (multi-axis device)
- **6**: X8.2 (double-axis device)

Parameters for configuring the Basic encoder evaluation

IDN	Name
S-0-0601.x.1	Encoder data out configuration
S-0-0601.x.2	Resolution of position
S-0-0601.x.6	Absolute position range
S-0-0601.x.10	Overflow threshold position
S-0-0601.x.11	Encoder available data out
S-0-0601.x.12	Encoder refresh time data out

IDN	Name
S-0-0601.x.136	Multi-encoder interface configuration
The placeholder "x" (structure index) is the number of the device interface to which the encoder is connected: • 1: X4 (single-axis device), X4.1 (double-axis and multi-axis device) • 2: X8 (single-axis device), X4.2 (double-axis and multi-axis device) • 3: X8.1 (double-axis device), X4.3 (multi-axis device) • 4: X10 (single-axis device), X4.4 (multi-axis device) • 5: X8 (multi-axis device) • 6: X8.2 (double-axis device)	

Extended input parameters for the Basic encoder output data

IDN	Name
S-0-0610.x.1	Encoder status
S-0-0610.x.2	Position unscaled (input)
S-0-0610.x.10	Marker position
The number of the function is assigned to the placeholder "x" (structure index) (encoder 1/motor encoder: "1"; encoder 2: "2"; measuring encoder: "3"; motor encoder (with a complex actuator): "4")	

Extended input parameters for encoder data configuration

IDN	Name
S-0-0611.x.2	Resolution position (input)
S-0-0611.x.6	Absolute position range (input)
S-0-0611.x.10	Overflow threshold position (input)
S-0-0611.x.12	Encoder refresh time data out (input)
S-0-0611.x.136	Serial number of encoder
The number of the function is assigned to the placeholder "x" (structure index) (encoder 1/motor encoder: "1"; encoder 2: "2"; measuring encoder: "3"; motor encoder (with a complex actuator): "4")	

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

Overview of the functional scope

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 the 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 drive mechanics, the drive will signal this faulty state.

Pertinent parameters

- S-0-0391, Monitoring window feedback 2
- P-0-0095, Absolute encoder monitoring window, encoder 1
- P-0-0096, Absolute encoder monitoring window, encoder 2
- P-0-0177, Encoder 1, absoute encoder buffer
- P-0-0178, Encoder 2, absoute encoder buffer
- P-0-0185, Encoder 2 control word
- P-0-0242, Current actual slip value
- P-0-0243, Maximum occurred actual slip value
- P-0-0244, Monitoring window of slip
- P-0-0391, Actual position value difference encoder1 - encoder2

Pertinent diagnostic messages

- E2074 Encoder 1: Encoder signals disturbed
- E2075 Encoder 2: Encoder signals disturbed
- F2036 Excessive position feedback difference
- F2042 Encoder 2: Encoder signals incorrect
- F2048 Low battery voltage
- F2074 Actual pos. value 1 outside absolute encoder window
- F2075 Actual pos. value 2 outside absolute encoder window
- F2174 Loss of encoder 1 reference
- F2175 Loss of encoder 2 reference
- F8022 Enc. 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 an appropriate signal specification.

Both 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, S3 or M1, M3: HIPERFACE® encoders, single- or multi-turn type for MSK motors
- Motor encoder performance A and B for MS2N motors (HIPERFACE® encoders as single- or multi-turn type)

  Motor encoder performance C for MS2N motors (Safety4Wire encoder as single- or multi-turn type)
- Motor encoder option S2 or M2: EnDat2.1 encoders, single- or multi-turn type for MSK, MAD, MAF motors

Absolute encoders for kit motors and external encoders

For kit motors or directly at the load, the following measuring systems to be evaluated in absolute form can be used:

- EnDat2.1 encoders (Heidenhain)
- EnDat2.2 encoders (Heidenhain)

☞ Multi-turn function via battery backup is not supported with EnDat.

- HIPERFACE® encoders (Stegmann)
- SSI encoders (with appropriate SSI signal specification)
- Combined encoders for SSI (with appropriate SSI signal specification and 1Vpp SinCos signals)
- Safety4Wire encoder (Hengstler)

Establishing axis-related absolute position

The actual position values of an absolute encoder first only relate to the encoder itself. Due to the mostly undefined mounting situation of the encoder to motor or load, it is necessary to determine the position offset between encoder and axis zero point once at the initial commissioning (see also "Establishing the position data reference: Establishing position data reference for absolute measuring systems").

Hardware requirements

For the position and homing signal specification of digital transmission protocols of third-party encoders, see chapter "Supported measuring systems".

Pertinent parameters

- S-0-0115, Encoder 2, type of position encoder
- S-0-0277, Encoder 1, type of position encoder
- S-0-0278, Maximum travel range
- S-0-0378, Absolute encoder range, encoder 1
- S-0-0379, Absolute encoder range, encoder 2

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 comply with the applicable specifications.

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

- Axes with relative position encoder have to go through a homing procedure after switching on to establish the position data reference to the axis 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, synchronous motors are not immediately ready for operation!

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.
- According to experience, the costs of the encoder are 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 position

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.

The position data reference to the axis is established by either

- 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, see also chapter "Distance-coded reference marks cannot yet be used" on page 20.

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 chapter "Establishing the position data reference": "Establishing position data reference for relative measuring systems").

Hardware requirements

For the specifications of position and reference signals, see chapter "Supported measuring systems".

Pertinent parameters

- S-0-0115, Encoder 2, type of position encoder
- 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, Encoder 1, type of position encoder
- 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
- 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 purpose, it is necessary to move to a defined axis position and set the actual position value to an axis-related value at a defined position (exception: For relative encoders with distance-coded reference marks, movement is only required over two marks!)

> The evaluation of distance-coded reference marks is not yet supported in this firmware release of MPx20 and below!

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 drive mechanics. 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 type 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 (see also chapter "Distance-coded reference marks cannot yet be used" on page 20), 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 marker:

- The master starts the "NC-controlled homing" command and, for searching the reference point or dedicated point, must 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 encoders 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, Encoder 2, type of position encoder
- S-0-0175, Offset of position feedback value of encoder 1
- S-0-0176, Offset of position feedback value of encoder 2
- S-0-0277, Encoder 1, type of position encoder
- S-0-0403, Position feedback value status

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 drive mechanics.

Establishing position data reference using 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 drive mechanics and encoder systems are mechanically connected without slip (slip control is possible!).

"Set absolute position" command

It is recommended to start the "set absolute position" 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 position" can also be executed with the 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's 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 "drive-controlled homing procedure" command 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 position"

By starting the "set absolute position" command, 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 position" are made via parameter settings.

Assigning the axis-related actual position value with "drive-controlled homing procedure"

By starting the "drive-controlled homing procedure" command, 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 of encoder 1
- S-0-0054, Reference distance of encoder 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, Encoder 1, absoute encoder buffer
- P-0-0178, Encoder 2, absoute encoder buffer
- 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 of 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 has been 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 load (external or optional encoder).

For information on encoder arrangement and drive mechanics, see also "Drive mechanics and measuring system arrangement"

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 necessary 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 series 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.

Overview of the functional scope

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"

The initial speed of the operation mode can be limited, for one axis with safety technology, to an additional speed value [product from "SMO: active speed threshold" (P-0-3238) and "SMO: evaluation factor speed limit "(P-0-3218)] when activated in the parameter "SMO: Configuration support functions" (P-0-3219), see also the separate documentation "Rexroth IndraDrive, Integrated Safety Technology "Safe Motion" (as of MPx-18)" (DOK-INDRV*-SI3*SMO-VRS-AP**-EN-P; Mat. No. R911338920), chapter "Additional and auxiliary functions".

Pertinent parameters

Parameters for relative measuring systems:

- S-0-0041, Homing velocity
- S-0-0042, Homing acceleration
- S-0-0052, Reference distance of encoder 1
- S-0-0054, Reference distance of encoder 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 of encoder 1
- S-0-0151, Reference offset of encoder 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 of position feedback value of encoder 1
- S-0-0176, Offset of position feedback value of encoder 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 (see also chapter "Distance-coded reference marks cannot yet be used" on page 20):

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

Parameters for homing at travel range limit switches:

- S-0-0532, Travel range limit parameter
  (Alias: 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"
- S-0-0530, Clamping torque

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:

- C4302 Distance home switch - reference mark erroneous
- C4304 Homing impossible with absolute encoder
- C4306 Reference mark not detected
- C4307 Reference cam input not assigned
- C4308 Pos. stop a. HW lim. switch not allowed f. modulo axes
- C4400 Calculate displacement procedure command

Drive-controlled homing

Brief description

Basic sequence of "search for dedicated point"

After "S-0-0148, C0600 Drive-controlled homing procedure command" has been activated, 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"

NC-controlled homing

Brief description

Sequence of NC-controlled homing

For NC-controlled homing the master (NC control unit) 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/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

- C3300 Set coordinate system procedure command
- C3400 Shift coordinate system procedure command
- C0600 Drive-controlled homing procedure command

Detecting the marker position

Brief description

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

With the "detect marker position" function, which is activated via the corresponding command, it is possible to check whether the reference mark of an incremental measuring system is detected without error.

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

- C1400 Command Get marker position

5.3.7 Supported measuring systems

Analog encoders

Brief description

The term "analog encoders" describes position measuring systems that...

- display actual position values by two different analog voltage signals and
- have no data memory.

The two voltage signals are generated by a sensor unit in interaction with a material measure. The material measure is the division of the measuring range into equal sections called "division periods (DP)".

Over the distance of a division period, two similar signal curves with an offset of 90° are generated within a defined voltage value range and cyclically repeated in all division periods.

The material measure type determines the absolute and relative precision of the position encoder. The required number of division periods is joined over the position measuring range to be represented by measurement.

The division period ia also called

- "line" (cf. number of lines of a rotary position encoder) or
- "cycle" (cf. number of cycles of a rotary position encoder)

The precision of a position measuring system is significantly determined by:

- Number of division periods per position measuring range (resolution)
- Linearity of the measured position values over one line (cycle) and over the entire position measuring range

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☞ The number of lines or cycles per revolution is specified for rotary position encoders, the length of a division period for linear encoders.

Analog position measuring systems typically can only be evaluated in relative form. Absolute position measurement is only possible over one division period, the position measuring range, however, always covers many division periods. Therefore, absolute evaluation over the position measuring range is impossible! As an aid for establishing the position data reference to the drive mechanics, analog measuring systems for the most part come with reference signals ("reference marks"). Usual reference mark designs that IndraDrive can evaluate:

- One reference mark per revolution (rot. encoder) or position measuring range (linear encoder)
- Multiple equidistant reference marks over the position measuring range (linear encoder)
- Multiple distance-coded reference marks per revolution (rot. encoder) or position measuring range (linear encoder), see also chapter "Distance-coded reference marks cannot yet be used" on page 20

The reference marks have a fixed mechanical relation to the material measure (encoder shaft for rotary encoders or linear scale for linear encoders)

The electrical encoder signals are read by the encoder interface in the velocity controller clock and immediately used to determine the actual position values.

The analog position measuring systems supported by IndraDrive are:

- Encoders with sine signals with differential voltage value range 1Vpp (Heidenhain standard)
- Encoders with square-wave signals 5VTTL
- Resolver encoders (with MPx20V06 and above)

In the "Basic encoder evaluation", the analog electrical encoder signals are converted to evaluable encoder-related position and status information without any relevant delay (see chapter "Basics on the motors to be controlled" on page 143). These pieces of information are immediately available via the master communication level, particularly for motor control. Due to their high resolution (AD conversion), encoders with sine signals are basically suited very well for motor control, e.g. for asynchronous motors. For the immediate operability of synchronous motors, it is necessary, however, to detect the position of the magnets to the windings before motor control is activated, but this is impossible due to the merely relative position measurement. Combined encoders have therefore performed well in controlling synchronous motors. Combined encoders combine absolute position detection with analog signals that can only be evaluated in relative form (see also chapter "Combined encoders", chapter "Brief description " on page 180).

☞ For maximum force generation, synchronous motor control requires the current in the windings to be suitably assigned to the permanent magnetic field of the motor. This is achieved by the motor-specific commutation offset value. This value is determined during the initial commissioning of the motor and stored in the motor encoder or in the axis parameter set. The motor-specific commutation offset value only enables the synchronous motor to be immediately operational, if the position of the magnets to the windings was determinded before motor control had been activated!

Special case resolver encoder

The resolver encoder uses the transformer principle for position detection. It consists of two windings with an offset of 90°, both windings have the same number of pole pairs (one or multiple pole pairs). If a resolver encoder is used as motor control encoder and the same number of pole pairs is selected for the resolver encoder and the synchronous motor, the position of the magnets to the windings is always detected correctly. The synchronous motor is immediately operational, if the motor-specific commutation offset value is known.

☞ As a motor encoder, a resolver encoder has the property of "commutation encoder", if the number of pole pairs is advantageously selected (same number of pole pairs as the motor or number of pole pairs "1")!

Digital encoders

Brief description, fields of application

Digital encoders provide absolute position information within the absolute measuring range of the respective encoder. The signal transmission is serial. The main field of application of serial encoders in electric drive technology is the position control loop; the advantage of the absolute position information outweighs the basic disadvantage of a delay required to make actual values available due to the serial transmission of the absolute position. In many applications, particularly with master-side cycle times in the range of milliseconds, the quality of the actual position values made available by serial encoders is perfectly sufficient.

The digital actual position values are cyclically transmitted by a serial protocol. The serial protocol can also contain information on the encoder status and on error states detected on the encoder side, or other data. In most cases, digital encoders have a data memory containing the relevant data of its own encoder required for operation. In addition, a memory range for user-side data (OEM range) can be used with some encoder types.

Types of design

Rotary digital encoders:

- One encoder revolution is represented with an encoder-specific number of "single-turn" bits (position resolution in incr./revolution).
- The number of encoder revolutions is represented with the "multi-turn" bits (absolute measuring range of encoder).

Linear digital encoders:

- Due to the encoder-specific number of position bits, the length of the measuring range is represented (absolute measuring range with resolution in mm/incr.)

IndraDrive supports the following digital position measuring systems:

- Encoders with EnDat2.2 interface
- Encoders with SSI interface
- Encoders with Panasonic interface (motor encoder of MSM motors)
- Encoders with Safety4Wire interface (motor encoder option of MS2N motors)

In the "Basic encoder evaluation", the electrical encoder signals are converted to evaluable encoder-related position and status information (see chapter "Basics on measuring systems, resolution"). These pieces of information are available via the master communication level for controlling the axis drives.

Due to the absolute position measurement, it is possible to immediately detect the position of the magnets to the motor windings for controlling synchronous motors, high-quality motor control, however, requires actual position values that are as free of delay as possible. The following encoders have therefore performed well in controlling synchronous motors:

- Combined encoders that combine absolute digtital-serial position detection with analog signals that can be evaluated without a delay (see chapter "Combined encoders").
- Digital encoders only if a very high data transmission speed is possible (e.g., EnDat2.2).

Combined encoders

Brief description

High-quality motor control requires actual position values that are free of delay. In the "Basic encoder evaluation", signals of analog encoders are converted without any relevant delay to encoder-related, relative position information that can be evaluated in control tasks.

For the immediate operability of synchronous motors, it is furthermore necessary to detect the position of the magnets to the windings before motor control is activated, but this is generally impossible with anaolg encoders.

Combined encoders have therefore performed well in controlling synchronous motors. Combined encoders combine analog signals that can be evaluated in relative form with absolute, digital-serial position detection.

Combining a digital-serial encoder (see chapter "Digital encoders") with an analog encoder (see chapter "Analog encoders") is a cost-efficient solution for absolute measuring systems (e.g., "combined encoder for SSI") for synchonous motor control that uses standardized components. In this case, the absolute value of the SSI encoder is used for the commutation angle, the analog signals (e.g., encoder with sine signals, 1 Vpp) are used for motor control.

IndraDrive supports the folloiwng combined encoders:

- Encoders with EnDat 2.1 interface
- Encoders with HIPERFACE interface
- Analog encoders with SSI interface ("combined encoders for SSI")

The following combined encoders are not yet supported (see also chapter 4.2 "Incompatible functions and functional changes " on page 19):

- Analog encoders with digital Hall sensors
- Analog encoders with analog Hall sensors

Absolute measuring systems

Encoders with EnDat 2.1, HIPERFACE and SSI interface provide a range of absolute position detection:

- One revolution in the case of single-turn encoders

- An encoder-specific number of revolutions in the case of multi-turn encoders
- The absolute encoder range that can be digitally displayed in the case of linear encoders

☞ The absolute actual position values are cyclically transmitted by a serial protocol. The serial protocol can also contain information on the encoder status and on error states detected on the encoder side. EnDat2.1 and Hiperface encoders (type ID: FFh) have a data memory containing the relevant data of its own encoder required for operation. In addition, an OEM range can be used for user-side data.

Relative measuring systems with Hall sensors

Analog encoders with additional Hall sensors (digital oder analog) do not provide absolute but only relative position measurement, but notably with linear Rexroth motors they can detect the position of the magnets to the windings before motor control is activated. This allows the suitable commutation angle for synchronous motor control to be immediately provided. The Hall sensors only take effect as "commutation encoders".

☞ The evaluation of an analog enoder with additional analog or digital Hall sensors is not yet supported!

Types of design

Encoder designation	Required number of encoder interfaces	Mechanical design	Components
EnDat 2.1	1	Rotar, linear	Combined on manufacturer-side (1Vpp, EnDat), order code: EnDat01, EnDat02 (not EnDat21!)
Hiperface	1	Rotar, linear	Combined on manufacturer-side (1Vpp, HIPERFACE), type ID: FFh
Combined encoder for SSI	1	Rotar, linear	Combined on manufacturer-side (1Vpp, SSI), SICK/STEGMANN
Analog encoder with digital Hall sensors	1	Linear only	Motor MCP...-L0.... (dig. HS), SHL03, encoder with 1Vpp (or 5VTTL)
Analog encoder with analog Hall sensors	2	Linear only	Motor MCP...-L1.... (anal. HS), encoder with 1Vpp (or 5VTTL) Motor MLF, SHL02 (anal. HS), encoder with 1Vpp (or 5VTTL)

SHL03 Rexroth Hall sensor adapter box for digital Hall sensors
MCP...-L0... Primary part of a Rexroth MCL motor (ironless) with "digital Hall unit" option
MCP...-L1... Primary part of a Rexroth MCL motor (ironless) with "analog Hall unit" option
MLF Linear Rexroth kit motor
SHL02 Rexroth Hall sensor box

Tab. 5-53: Overview of encoder interface assignment, designs and components regarding combined encoders

In the "Basic encoder evaluation", the electrical encoder signals are converted to evaluable encoder-related position and status information (see chapter "Basics on measuring systems, resolution", "Precision, resolution" on page 162). These pieces of information are available to the axis drives via the master communication level for motor and axis control.

5.3.8 Drive mechanics and measuring system arrangement

Brief description

Workpiece processing and material molding require energy that the main drive makes available for a machine. Flexible production also requires auxiliary or servo drives allowing tools to take action in the production process. Basically, a drive consistis of an axis mechanics to which an active torque/force source (e.g., an electric motor, generally speaking: an actuator) is connected. The entire energy transmission line is called drive mechanics:

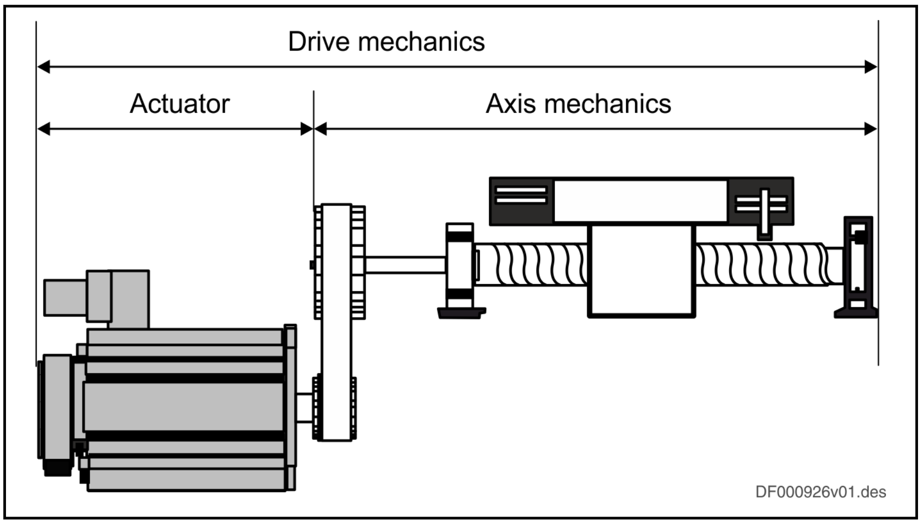


Fig. 5-20: Schematic diagram of a drive

Actuator

Energy source of the drive mechanics, generates torque/force or pressure and hereby provides for the required motion of the axis mechanics.

The following actuators are normally used:

- Electric motor
- Hydraulic motor or hydraulic cylinder
- Sytronic unit (electric motor, pump, hydraulic motor or hydraulic cylinder)

Due to their transmission behavior, two types of actuators are distinguished:

- "Simple actuator": Linear transmission behavior (electric motor directly drives the axis mechanics)
- "Complex actuator": Non-linear transmission behavior (electric motor drives the axis mechanics via non-linear transmission elements)

☞ The "simple actuator" corresponds to the servo or main drive motor that drives an axis mechanics. "Complex actuator" refers to an axis mechanics driven by a sytronic unit of electric motor, pump, hydraulic motor or hydraulic cylinder that has a non-linear transmission behavior.

The distinction between "simple" and "complex" actuators has consequences for the arrangement of the measuring systems within the drive mechanics. Complex actuators are only supported in the functional firmware package "Sytronix". The other functional firmware packages work like the in the previous firmware versions, "simple" actuator = electric motor!

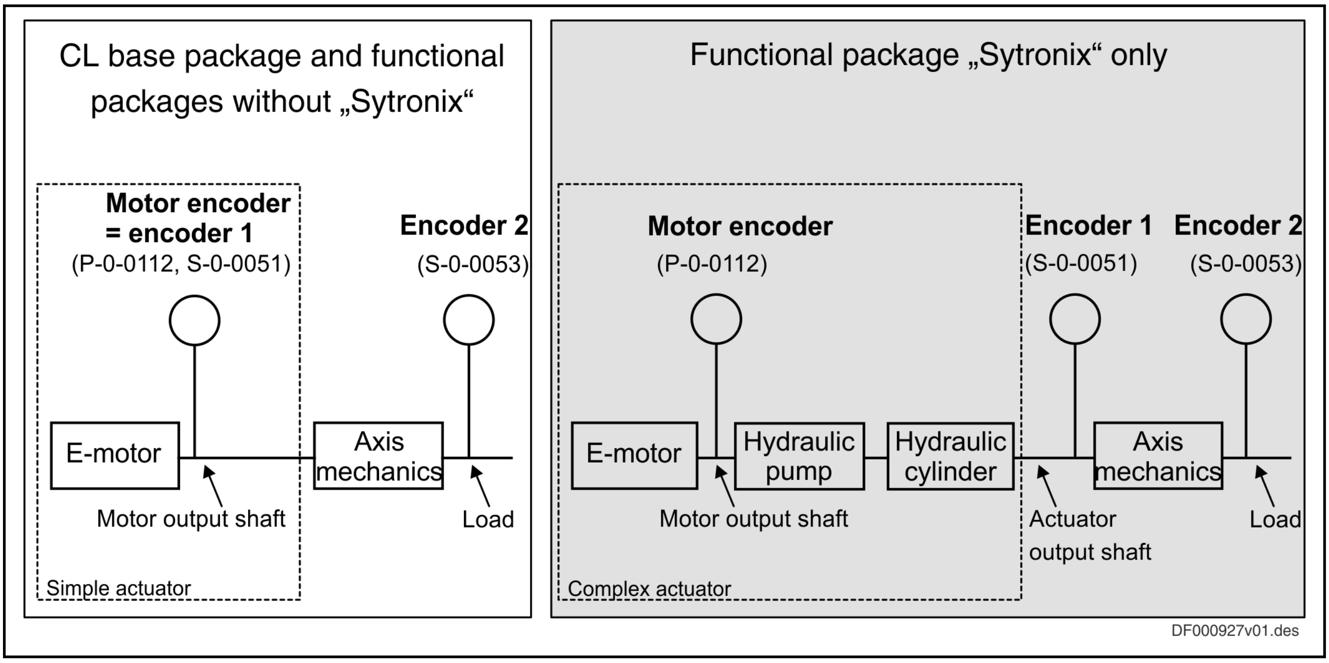


Fig. 5-21: Comparing a simple actuator to a complex actuator

Measuring systems/control encoders

The measuring systems of the drive mechanics are used for different control tasks:

- Motor encoder for velocity control
- Encoder 1 and encoder 2 for position control, encoder 1 on the actuator output side, encoder 2 on the load side

If the drive mechanics contains a simple actuator, position control can be performed with the motor encoder (= encoder 1) or, if necessary, with a load-side measuring system (encoder 2); motor control and the velocity control of the actuator (= motor) is generally performed via the motor encoder (= encoder 1). If the drive mechanics contains a complex actuator, position control can be performed with encoder 1, the motor encoder in this case is only used for motor control and for the velocity control of the actuator.

Motor encoder

High-precision motor control 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
- Position control loop, if applicable

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.

Position control encoder

Depending on the mechanical properties of the drive system between the motor output shaft and the load or the actuator output shaft, it may be necessary to close the position control loop via a separate position encoder if a motor encoder cannot correctly represent the position at the axis mechanics:

- Axis mechanics with slip
- Gear backlash or a low degree of stiffness in the axis mechanics, etc.

- Non-linear actuator behavior between motor and actuator output shaft

The position control encoder can also be used as a measuring wheel encoder (frictionally engaged on the 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 with gearbox

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 gearbox.

☞ With 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 gearbox with i = "1" or when there is no encoder gearbox available.

With MPx16V04 and above:

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:

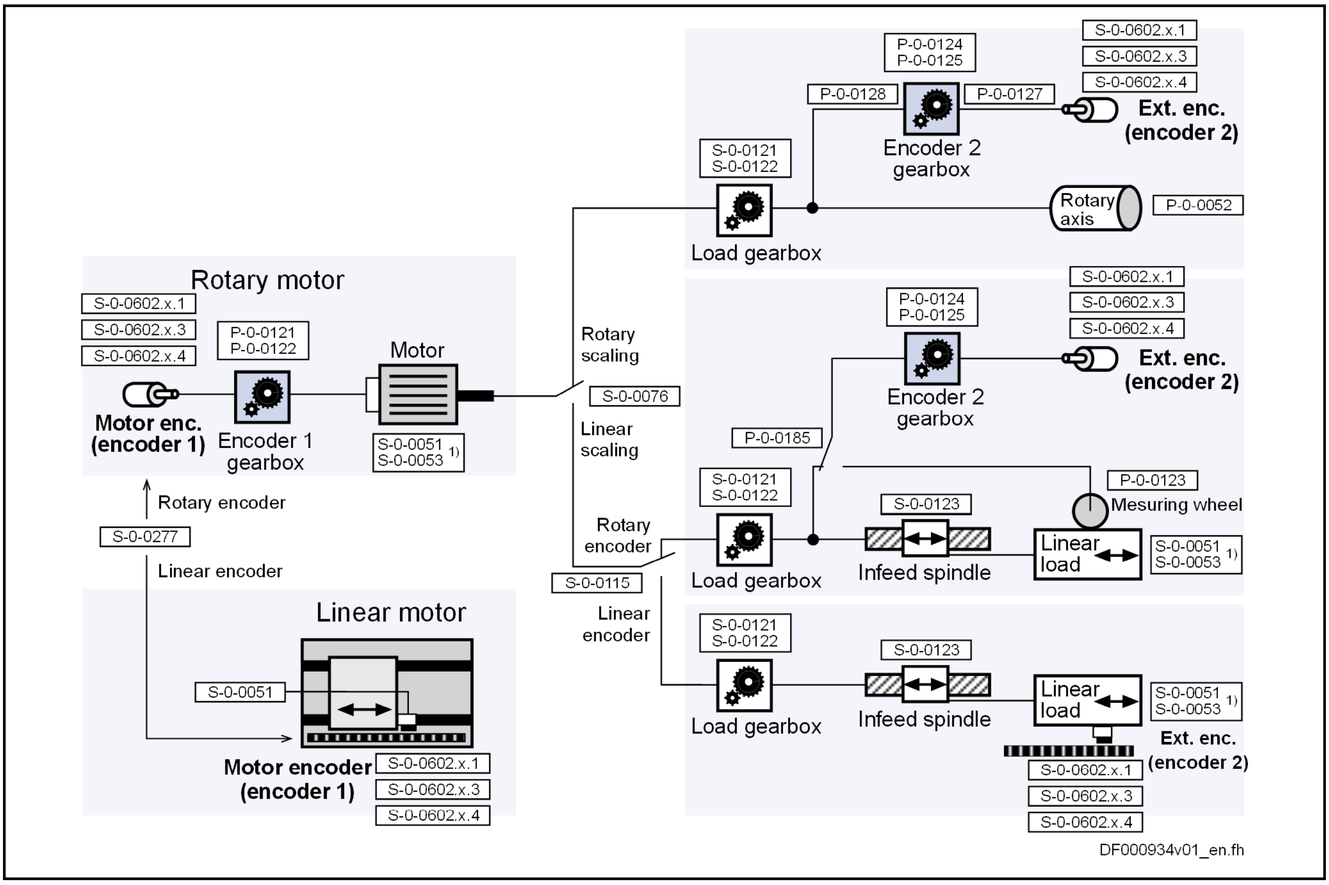
- if an n-fold motor revolution (n is an integer) yields exactly one encoder revolution

Case 2, Multi-turn encoder:

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

Arrangement options of measuring systems

The figure below shows an overview of arrangement options of measuring systems with a drive mechanics exemplarily driven by a motor (= simple actuator).



1)	S-0-0051 or S-0-0053, depending on scaling (S-0-0076)
S-0-0051	Position feedback value of encoder 1
S-0-0053	Position feedback value of encoder 2
S-0-0076	Position data scaling type
S-0-0115	Encoder 2, type of position encoder
S-0-0121	Input revolutions of load gear
S-0-0122	Output revolutions of load gear
S-0-0123	Feed constant
S-0-0277	Encoder 1, type of position encoder
P-0-0121	Encoder 1, gear turns, mechanical system side
P-0-0122	Encoder 1, gear turns, encoder side
P-0-0124	Encoder 2, gear turns, mechanical system side
P-0-0125	Encoder 2, gear turns, encoder side
P-0-0123	Encoder 2 feed constantV
P-0-0185	Encoder 2 control word

Fig. 5-22: Overview of arrangement options of drive mechanics and measuring systems with a simple actuator (= motor)

☞ With a complex actuator, the actuator output shaft takes effect on encoder 1, the motor encoder, however, remains related to the motor output shaft (see fig. 5-21 "Comparing a simple actuator to a complex actuator" on page 183).

Hardware requirements

For connecting the measuring systems to the controller, there are 2 optional interfaces available. Writing the parameters "P-0-0077, Assignment of encoder 1->interface" and "P-0-0078, Assignment of encoder 2->interface" defines the interface to which the respective encoder is connected.

Pertinent parameters

- S-0-0115, Encoder 2, type of position encoder
- S-0-0121, Input revolutions of load gear
- S-0-0122, Output revolutions of load gear
- S-0-0123, Feed constant
- S-0-0277, Encoder 1, type of position encoder
- P-0-0121, Encoder 1, gear turns, mechanical system side
- P-0-0122, Encoder 1, gear turns, encoder side
- P-0-0123, Encoder 2 feed constant
- P-0-0124, Encoder 2, gear turns, mechanical system side
- P-0-0125, Encoder 2, gear turns, encoder side
- P-0-0185, Encoder 2 control word

5.3.9 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
- Analog input 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
- Pressure and flow rate data (with functional package Sytronix only)

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 (numerical value) can only be evaluated as a physical value, when the numerical 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

- Pressure and flow rate

Preferred scaling/parameter scaling

To simplify the scaling definition so-called "preferred scalings" were predefined. Physical data, however, can also be exchanged in the control-internal format, i.e. without specific reference to physical units. For this purpose, 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").

For axes with an 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

The following parameters are only available for the functional package Sytronix:

- S-0-0805, Pressure polarity parameter
- S-0-0806, Pressure data scaling type
- S-0-0807, Pressure data scaling factor
- S-0-0808, Pressure data scaling exponent
- S-0-0845, Flow data scaling type
- S-0-0846, Flow data scaling factor
- S-0-0847, Flow data scaling exponent
- S-0-0848, Flow polarities

5.4 Drive control

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

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine’s range of motion (e.g., by 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".

5.4.1 Overview of drive control

Brief description

Basic principles and terms

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

- **Open-loop axis control** or **open-loop operation**(V/Hz [U/f] control)

  → Open-loop-controlled operation without encoder information
- **Closed-loop axis control** or **closed-loop operation** (different control methods)
  - **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 as you have to choose between open-loop and closed-loop base package!

<table>
<tr><th>Operation mode / command value adjustment</th><th>Control mode</th><th>Functional principle of motor</th><th>Encoder available</th><th>Required base package</th><th>Method of control</th></tr>
<tr><td rowspan="2">V/Hz (U/f) control with command value adjustment of the velocity control</td><td rowspan="2">Voltage-controlled operation</td><td rowspan="2">Asynchronous</td><td>Yes</td><td>Closed-loop</td><td>Not relevant</td></tr>
<tr><td>No</td><td>Open-loop</td><td>V/Hz (U/f) control</td></tr>
<tr><td rowspan="4">Torque/force control</td><td rowspan="4">Field-oriented current control</td><td rowspan="2">Asynchronous</td><td>Yes</td><td>Closed-loop</td><td>FOC control</td></tr>
<tr><td>No</td><td>--</td><td>No method available</td></tr>
<tr><td rowspan="2">Synchronous</td><td>Yes</td><td>Closed-loop</td><td>FOC control</td></tr>
<tr><td>No</td><td>--</td><td>No method available</td></tr>
<tr><td rowspan="4">Velocity control / velocity synchronization</td><td rowspan="4">Velocity control</td><td rowspan="2">Asynchronous</td><td>Yes</td><td>Closed-loop</td><td>FOC control</td></tr>
<tr><td>No</td><td>Open-loop</td><td>FXC control 1)</td></tr>
<tr><td rowspan="2">Synchronous</td><td>Yes</td><td>Closed-loop</td><td>FOC control</td></tr>
<tr><td>No</td><td>Closed-loop</td><td>FOCsl control</td></tr>
<tr><td rowspan="4">Position control, drive-controlled positioning, positioning block mode, phase synchronization, electronic Cam</td><td rowspan="4">Position control</td><td rowspan="2">Asynchronous</td><td>Yes</td><td>Closed-loop</td><td>FOC control</td></tr>
<tr><td>No</td><td>Closed-loop</td><td>FXC control 2)</td></tr>
<tr><td rowspan="2">Synchronous</td><td>Yes</td><td>Closed-loop</td><td>FOC control</td></tr>
<tr><td>No</td><td>Closed-loop</td><td>FOCsl control</td></tr>
</table>

1) Although the „Open-Loop“ functional base package of the firmware is required, the drive control works in closed-loop operation.

2) Only with external encoder

Tab. 5-54: Overview: Operation modes and available control methods

See also the section "Overview of functions/functional packages"

Principles of drive control

Overview of open-loop axis control

Open-loop axis control (or "open-loop operation") allows open-loop-controlled operation of the drive without motor encoder (V/Hz [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 thereof are not possible.

See "Voltage-controlled open-loop operation (V/Hz [U/f] Control)"

Overview of the functional scope

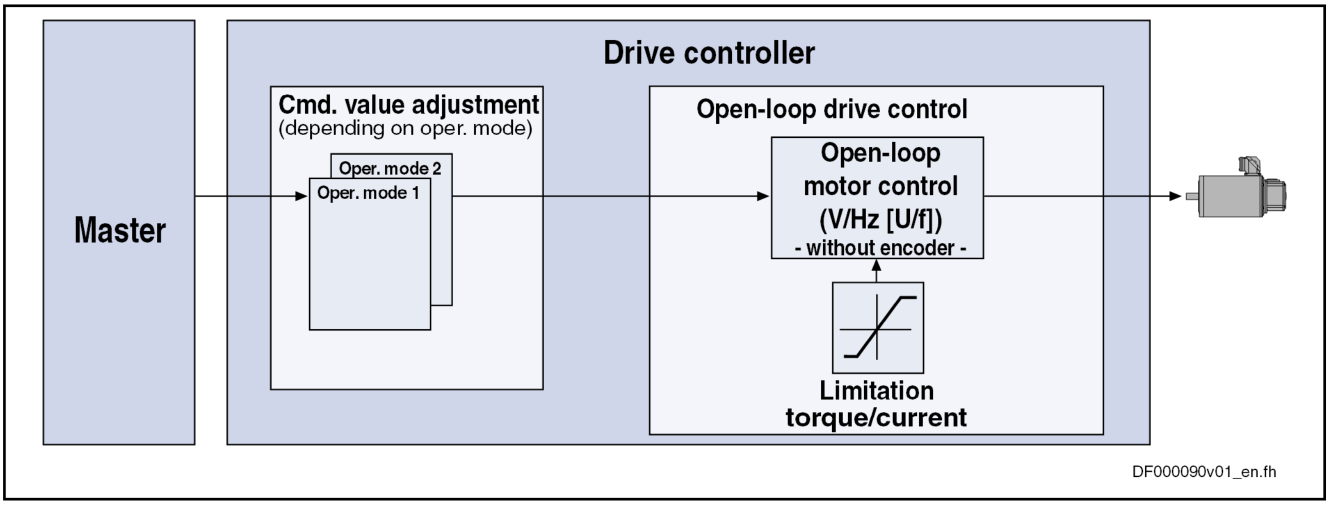


Fig. 5-23: Principle of open-loop drive control (open-loop operation)

See also the section "Closed-loop axis control (closed-loop operation)" and 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".

Closed-loop axis control (or "closed-loop operation") allows closed-loop-controlled operation of the drive; two principles of drive control are distinguished:

- **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 modes (drive-controlled positioning, positioning block mode)

  – Synchronization 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 sensorless velocity control.

See the section "Field-oriented current control"

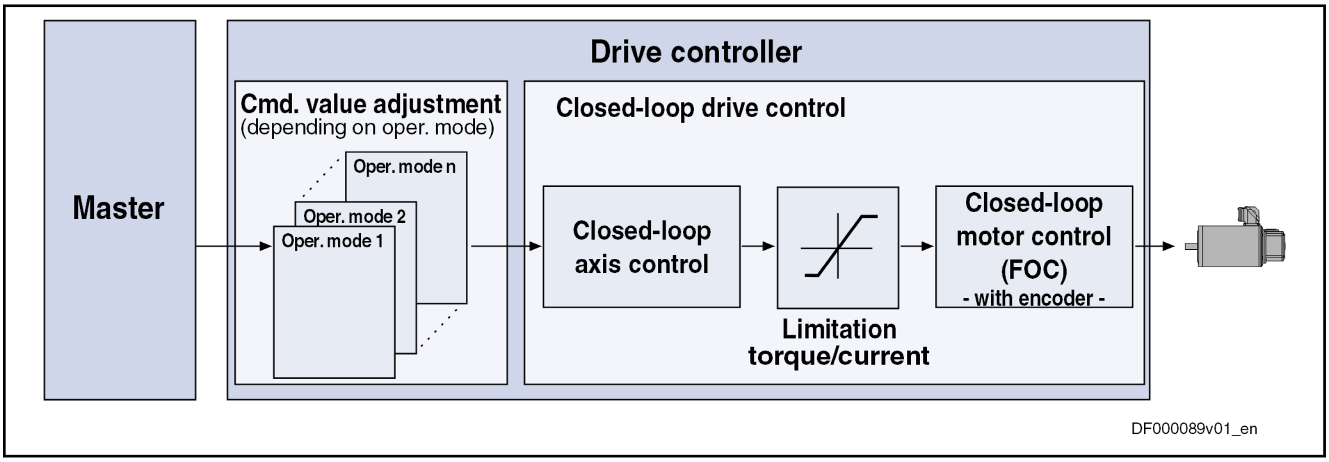


Fig. 5-24: Principle of closed-loop drive control (closed-loop operation)

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 controllers (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 is not 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" 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 modes, the position control loop, apart from the current and velocity control loops, is closed internally (in the drive):

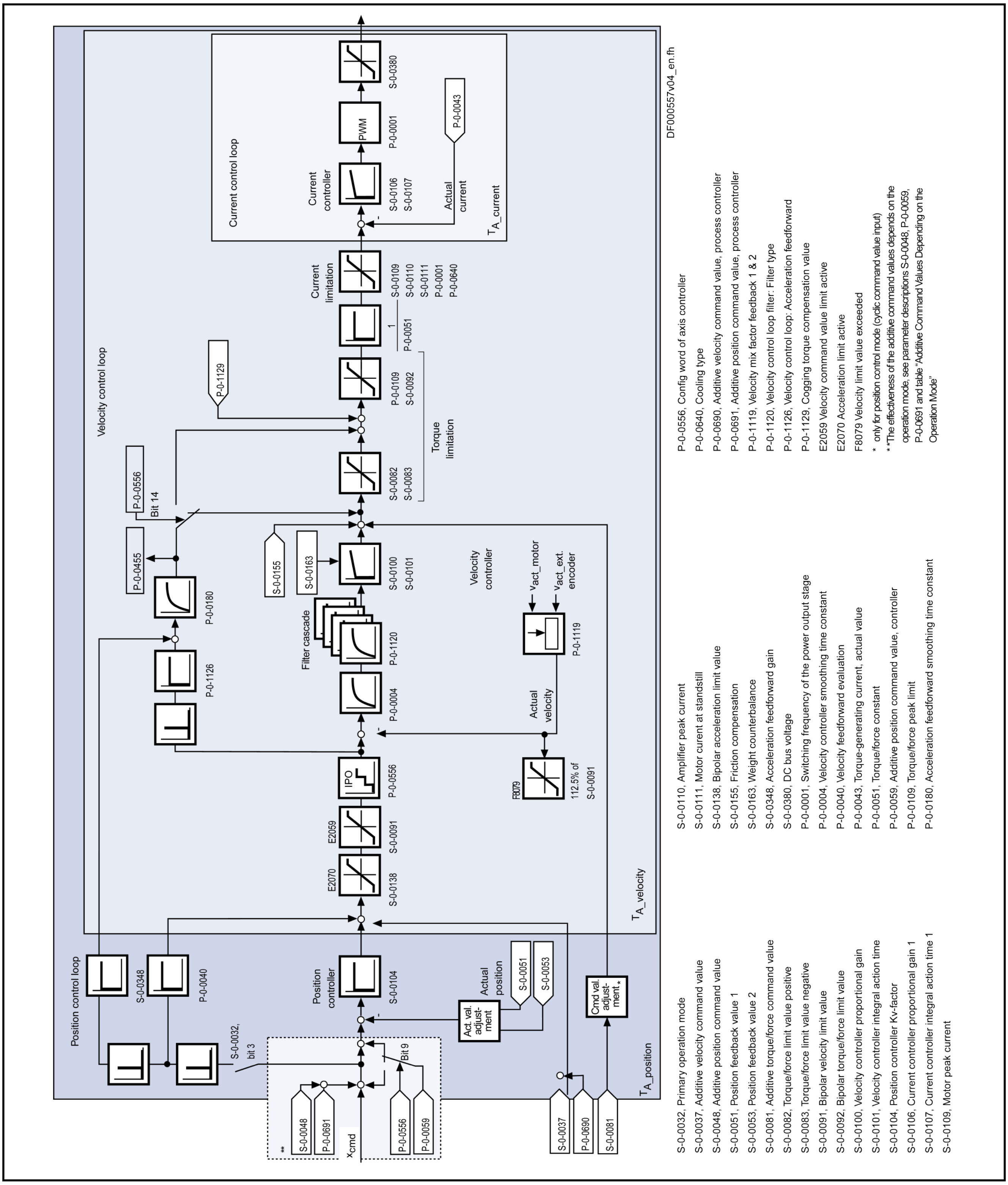
- Position control with cyclic command value input
- Drive-internal interpolation
- Positioning modes (drive-controlled positioning, positioning block mode)

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).

Overview of the functional scope

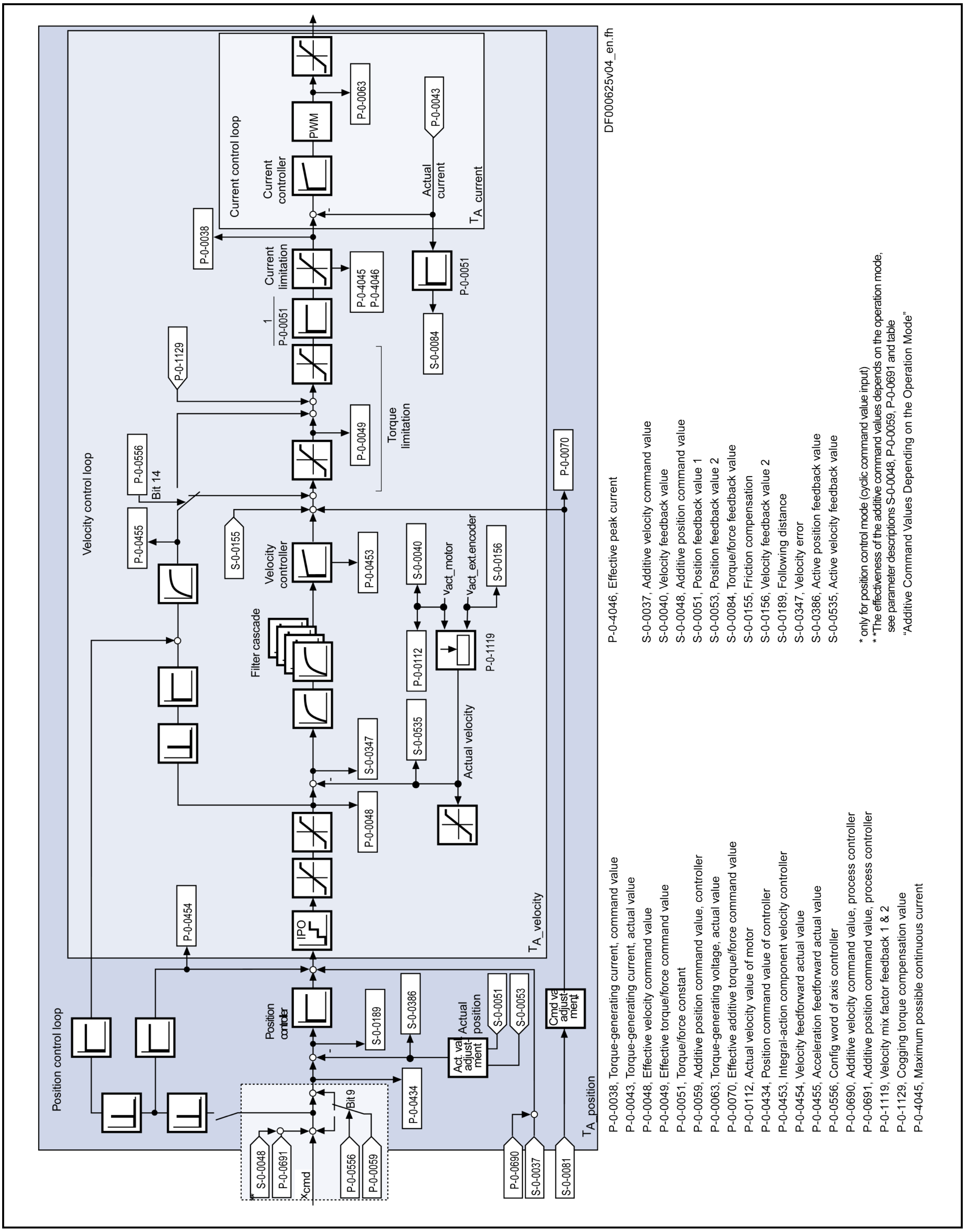
Control loop structure with setting parameters



T_A Sampling times (see table in the section "Features of the control loops")

Fig. 5-25: 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



T_A	Sampling times (see table in the section "Features of the control loops")

Fig. 5-26: Overall structure of the control loops with display parameters (exam-

ple)

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 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 controller clock ($T_{A\_position}$)	1000 µs	250 µs	500 µs
Velocity controller clock ($T_{A\_velocity}$)	500 µs	125 µs	250 µs
Current controller clock ($T_{A\_current}$)	125 µs	62.5 µs	125 µs

Tab. 5-55: Cycle and switching times to be achieved with IndraDrive

☞ All performance data are summarized under "System overview: Performance data".

Current controller

The current controller is characterized by the following features:

- PI controller 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 controller parameters in the case of saturation phenomena
- Precontrol of e.m.f.

Velocity controller

The velocity controller is characterized by the following features:

- PI controller 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 controller 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
- Filter options for filtering encoder noise and resonance frequencies are available
  – One 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

For the MPE firmware variant, only two 2nd order filters are available.

- Acceleration feedforward can be set in parameter "P-0-1126 Velocity control loop: Acceleration feedforward"
- Option to mix the actual velocity value used for control from the actual value of the motor-side and load-side encoder using a "mix factor" "P-0-1119 Velocity mix factor feedback 1 & 2"
- Limitation of command acceleration (change in velocity command value) in velocity control by setting in parameter "S-0-0138, Bipolar acceleration limit value"
- Limitation of the command velocity using parameters
  - S-0-0113, Maximum motor speed
  - 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

See also "Velocity controller (with the respective filters)"

Position controller

The position controller is characterized by the following features:

- P-controller, can be set via "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 control, the actual value of the motor encoder or of the optional encoder can be used as the actual position value. It is possible, however, to use both actual position values for position control ("hybrid actual position value").

See also "Position controller (with respective feedforward functions and actual value adjustment)"

General notes on commissioning and application

Additive command values and options for accessing outer 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-0-0690	P-0-0059	S-0-0048	P-0-0691
V/Hz (U/f) control (command value processing in velocity control)	--	--	--	--	--	--
Torque/force control	■	--	--	--	--	--
Velocity control / velocity synchronization	■	■	■	--	--	--

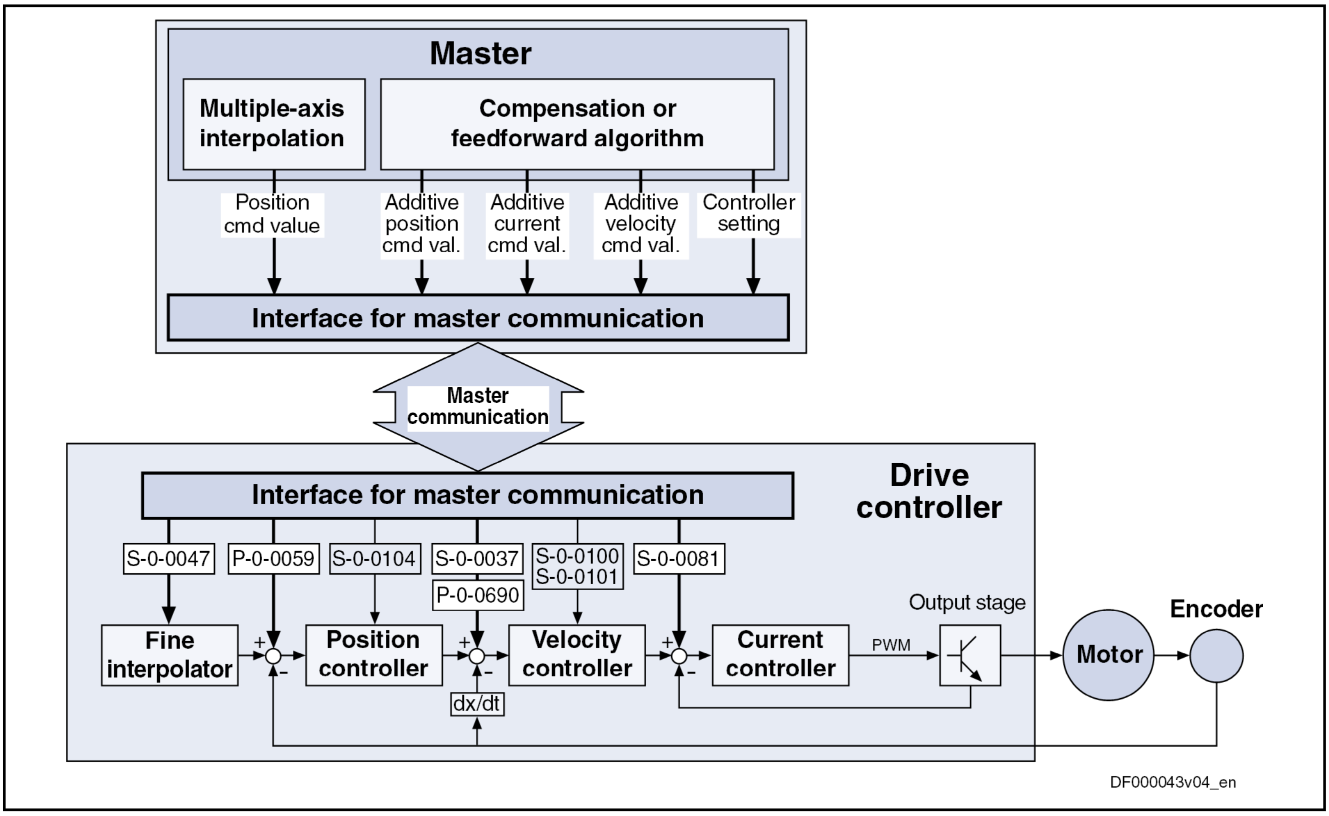
Overview of the functional scope

Operation mode	S-0-0081	S-0-0037	P-0-0690	P-0-0059	S-0-0048	P-0-0691
Position control	■	■	■	■	--	--
Drive-internal interpolation	■	■	■	■	--	--
Drive-controlled positioning	■	■	■	■	--	--
Positioning block mode	■	■	■	■	--	--
Position synchronization • Phase synchronization • Electronic cam • MotionProfile	■	■	■	--	■	■

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
P-0-0690 Additive velocity command value, process loop
P-0-0691 Additive position command value, process loop

Tab. 5-56: 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:



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. 5-27: Structural overview including access options (example for operation mode "position control with cyclic command value input")

Notes on commissioning of the control loop setting

The control loop settings in a digital drive controller are very important for the features of the servo axis.

To optimize the control loop setting, application-specific controller parameters are available for all digital Rexroth drives.

Order of Manual Control Loop Setting

Due to the cascade structure of the control loops, it is necessary to parameterize them "from the inside to the outside". The resulting order for setting the control loops is as follows:

1. Current control loop

   For **Rexroth motors with motor encoder data memory** (MSK and MKE series), the optimization of the current controller is not required, as the respective parameter values (S-0-0106 and S-0-0107) are read from the motor encoder data memory.

   For all **Rexroth motors without motor encoder data memory** (e.g. linear motors), the parameter settings can be taken from a central motor database via the "IndraWorks Ds/D/MLD" commissioning tool.

The commissioning of **third-party motors** (including control loop settings) is described in the respective sections on third-party motors in this documentation (see "Third-Party Motors at IndraDrive Controllers").

2. **Velocity control loop**

   The settings of the velocity controller (S-0-0100 and S-0-0101) with the respective filters (P-0-0004 and P-0-1120, P-0-1121, P-0-1122, P-0-1123, P-0-1140, P-0-1141, P-0-1142, P-0-1143) on the one hand depend on the motor parameters (inertia and torque/force constant), on the other hand they strongly depend on the mechanical properties (load inertia/mass, friction, rigidity of the connection, ...). Therefore, manual or automatic optimization is often necessary.

3. **Position control loop**

   In general, the position control loop only has to be adjusted to the dynamics of the outer velocity controller, as well as to the kind of preset command values (jerk, acceleration and interpolation procedure).

Default settings in the motor encoder data memory [load defaults procedure (motor-spec. controller values)]

"Load defaults procedure (motor-spec. controller values)" command

For all Rexroth motors of the series with motor encoder data memory (e.g., MKE, MSK and possibly MAD and MAF), the basic settings for the controllers are saved and can be loaded to the drive by executing the "load defaults procedure" command (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 the "load defaults procedure" command is internally started by pressing the "Esc" key on the control panel, 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"

☞ To start the "load defaults procedure" command, the value "0" (default setting) has to have been set in the parameter "P-0-4090, Configuration for loading default values".

When the motor default values are loaded, 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 control 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, the following control loop parameter is set to the firmware-side default value when the motor default values are loaded, although no default value has been stored for it in the motor data memory:

- 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.

5.4.2 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 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 (V/Hz [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 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 the specified motor control mode. The table below contains an overview for selecting the method.

Overview of the functional scope

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 modes Velocity control Torque/force control
without Motor encoder	Asynchronous motor	FXC	Only single-motor operation!	Position control modes Velocity control
		V/Hz (U/f) control	Parallel operation of motors is possible!	Velocity control
without Motor encoder	Synchronous motor	FXC	Only single-motor operation!	Position control modes Velocity control

Tab. 5-57: 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 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 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 (V/Hz [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 V/Hz (U/f) characteristic can be selected

Operation mode with V/Hz (U/f) control

For voltage-controlled operation without motor encoder, only the "velocity control" 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 fans) by adjusted ("square") V/Hz (U/f) characteristic to reduce the motor losses
- Performance losses compared to velocity control with motor encoder

☞ Torque/force control and position control modes cannot be used for voltage-controlled operation without motor encoder!

See the main section "Voltage-controlled open-loop operation (V/Hz [U/f] control)"

Notes on how to select the 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:

<table>
<tr><th>Motor type</th><th>Motor encoder available?</th><th>Parallel connection of motors?</th><th>Motor control method</th><th>Notes on use</th></tr>
<tr><td rowspan="2">Synchronous motor</td><td>No</td><td>No</td><td rowspan="2">FOC</td><td>For standard applications with medium demands on quality of control and dynamic response</td></tr>
<tr><td>Yes</td><td>Rotary: No
Linear: Yes [1)]</td><td>For standard applications with high demands on quality of control and dynamic response</td></tr>
</table>

Overview of the functional scope

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	V/Hz (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 orientation according to motor data

Tab. 5-58: Basic selection criteria for the motor control method

See also "Overview of drive control"

Operating properties for controlling 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 restrictions)
	Position control/positioning (incl. synchronization)	Yes	Yes (with restrictions, external encoder required)
Torque limitation		Yes	Yes
Maximum torque		High	Medium
Dynamics		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

<table>
<tr><th>Motor characteristic</th><th>FOC</th><th>FXC</th></tr>
<tr><td rowspan="2">Validity (availability) of the position information</td><td>Absolute encoder: In PM + OM</td><td rowspan="2">Depending on load-side encoder type used</td></tr>
<tr><td>Relative encoder: In OM</td></tr>
</table>

PM Parameter mode
OM Operating mode

Tab. 5-59: Comparison of sensorless motor control and motor control with encoder for synchronous motors

Operating properties for controlling asynchronous motors

Observe the following differences for controlling asynchronous motors as regards operation with and without encoder:

<table>
<tr><th colspan="2">Motor characteristic</th><th>FOC</th><th>FXC</th><th>V/Hz (U/f) control</th></tr>
<tr><td rowspan="2">Speed working ranges</td><td>Basic speed range</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Field weakening range</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td rowspan="3">Supported operation modes</td><td>Torque/force control</td><td>Yes</td><td>No</td><td>No</td></tr>
<tr><td>Velocity control (incl. synchronization)</td><td>Yes</td><td>Yes
(with restrictions)</td><td>Yes
(with restrictions)</td></tr>
<tr><td>Position control/positioning (incl. synchronization)</td><td>Yes</td><td>Only with external position encoder</td><td>No</td></tr>
<tr><td colspan="2">Torque limitation</td><td>Yes</td><td>Yes</td><td>No
(only stall protection controller)</td></tr>
<tr><td colspan="2">Maximum torque</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td colspan="2">Dynamics</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td colspan="2">Running smoothness/speed quality</td><td>High
(depending on measuring system, motor type, mechanical system)</td><td>Medium</td><td>Low</td></tr>
<tr><td colspan="2">Torque ripple</td><td>Low (< ± 5%)</td><td>High</td><td>High</td></tr>
<tr><td colspan="2">Required precision of the motor parameters</td><td>Low</td><td>Low</td><td>High, if high performance has to be reached</td></tr>
<tr><td colspan="2">Robustness</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td colspan="2">Sensitivity against disturbances</td><td>Low</td><td>High</td><td>High</td></tr>
<tr><td colspan="2" rowspan="2">Validity (availability) of the position information</td><td>Absolute encoder:
In PM + OM</td><td rowspan="2">Depending on load-side encoder type used</td><td rowspan="2">Not available</td></tr>
<tr><td>Relative Encoder:
In OM only</td></tr>
</table>

PM Parameter mode
OM Operating mode

Tab. 5-60: Comparison of sensorless motor control and motor control with encoder for asynchronous motors

Motor control frequency

Brief description

General information

The speed of three-phase a.c. motors depends on the frequency of the voltage applied at the motor. The maximum possible frequency of the motor voltage provided by the controller depends on the PWM frequency with which the power output stage is controlled (clocked).

PWM frequency in Hz	Max. motor control frequency in Hz	
Value in P-0-0001	Static PWM*)	Dynamic PWM
2000	200	--
4000	400	665
8000	800	1330
12000	1200	2000
16000	1600	2660

*) See also "Supply Units and Power Sections, Project Planning Manual"

Tab. 5-61: PWM frequency settings and maximum motor control frequency with static and dynamic PWM

Information on sizing

☞ The required PWM frequency has to be observed when selecting the controller because the continuous controller current is affected by the PWM frequency setting:

- Due to continuous controller current, select the lowest possible PWM frequency
- Due to 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 4 kHz, 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 following PWM frequencies are available:

Device/firmware and/or Control section/firmware	Available PWM frequencies / Hz	Dynam. PWM or vel.-dep. most advantageous PWM
IndraDrive Cs with MPE firmware CDB02.1 with MPM FWA	4000 8000	No No
IndraDrive Cs with MPB/MPC firmware CSB02.1 with MPB FWA CSH02.x with MPC FWA	2000 4000 8000 12000 16000	No Yes*) Yes Yes Yes

*) Not for MPB with "Advanced" performance

Tab. 5-62: 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 (V/Hz [U/f] control)

Brief description

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

The drive function "voltage-controlled open-loop operation of asynchronous motors without encoder in V/Hz (U/f) control" is made available in the "open-loop" base package in the "velocity control" mode. When the expansion package "synchronization" has been enabled, the operation mode "velocity synchronization with real/virtual master axis" is additionally available.

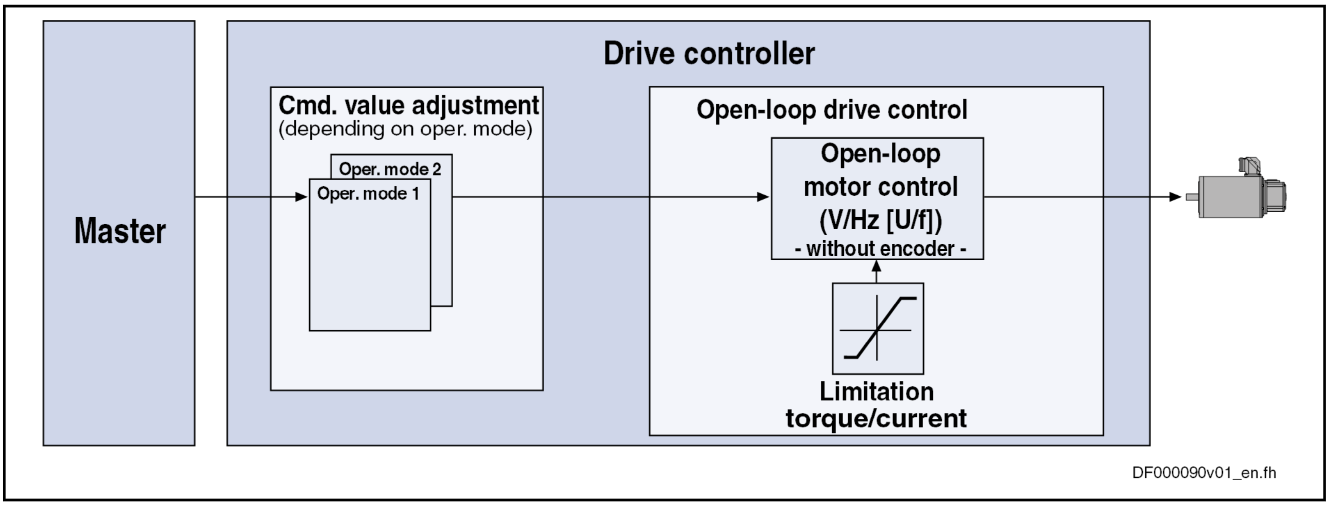


Fig. 5-28: Principle of V/Hz (U/f) control

V/Hz (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 controller** (PI controller 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 using a **V/Hz (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 controller

Overview of the functional scope

- **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 of encoder 1
- 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 controller 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").

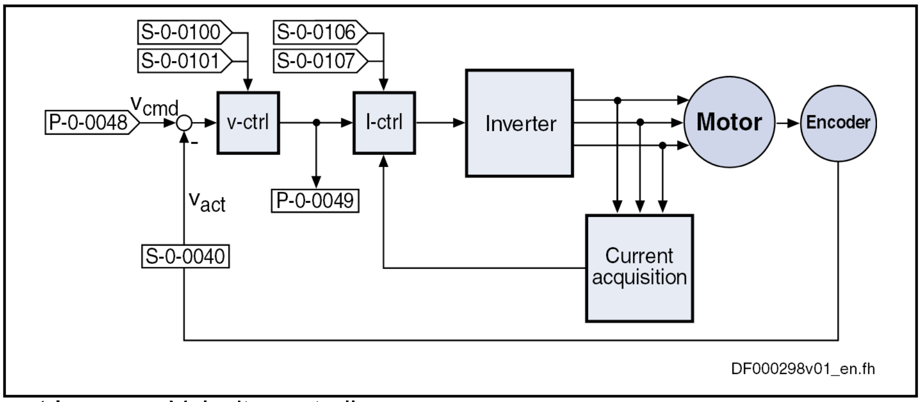
For information regarding the commissioning of the current controller for third-party motors, see "Third-party motors at IndraDrive controllers"!

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 controller for I_d
- I_q (torque-generating current) → PI controller for I_q

The figure below illustrates the principle of field-oriented current control for operation with motor encoder:



v-ctrl Velocity controller
I-ctrl Current controller

Fig. 5-29: 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-axis and q-axis to increase dynamics
- Voltage controller for operation in the field weakening range
- Activation of the optimum current controller proportional gain value, depending on the current PWM frequency when loading the default values (motor-specific controller val.)

Features of synchronous motor control

In the case of **synchronous motors**, field-oriented current control additionally has the following features:

Overview of the functional scope

- 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 controller for correcting the flux feedforward
  – Flux controller 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 controller 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-0-3945, Motor control configuration
- P-0-4002, Charact. of quadrature-axis induct. of motor, inductances
- P-0-4003, Charact. of quadrature-axis inductance of motor, currents

Voltage controller 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
- F2077 Current measurement trim wrong
- F8060 Overcurrent 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, except MPE-20VRS.

For asynchronous and synchronous motors, flux-controlled, sensorless motor operation is available in the base packages "open-loop" and "closed-loop" of the mentioned firmware variants and can be used in the "velocity control" mode and in position-controlled operation modes which use position encoder 2 (external encoder).

When using the firmware expansion package "synchronization", it is also possible to run the operation mode "velocity synchronization with real/virtual master axis".

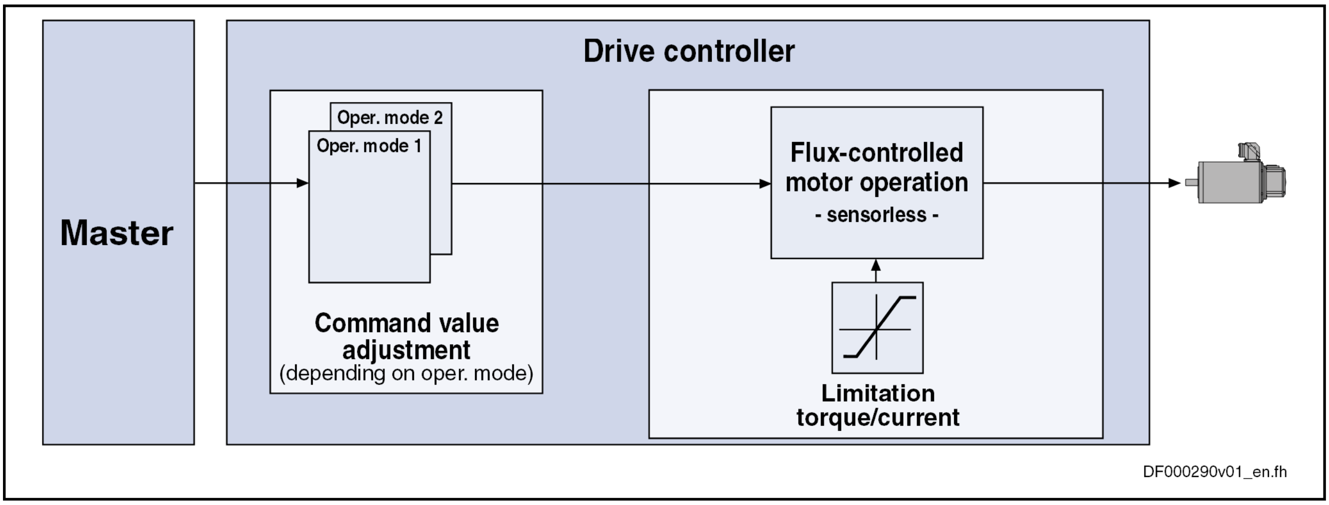


Fig. 5-30: Principle of sensorless, flux-controlled motor operation

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-0-0594, 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, 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

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 controller, voltage controller, current controller, ...) 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 drive 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 "IndraWorks Ds/D/MLD" commissioning tool from the motor data base (DriveBase)

    - or -

  – Individual parameters manually written via the Engineering Port 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:

- C3200 Command 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.
- C3600 Command Motor data identification:
  1. Identifying (or optimizing) the motor parameter values.

     Note: Appropriate start values already have to be available!
  2. Calculating the values of the motor control parameters.
- C4600 Command Calculate motor control parameters:

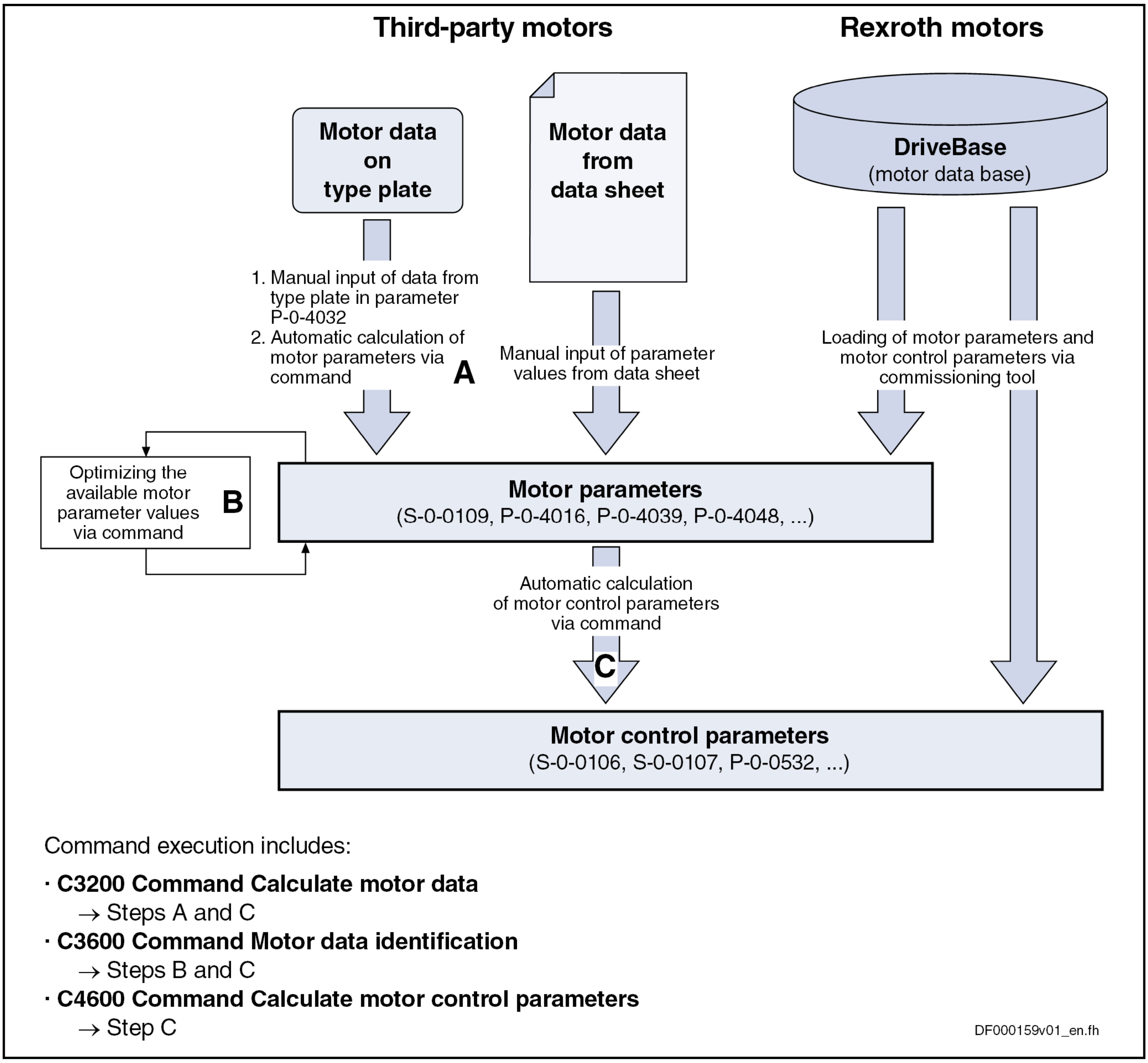
  Calculating the values of the motor control parameters from the motor parameters for synchronous motors and, if necessary, for asynchronous motors (after manual input of motor data in motor parameters)

☞ 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 can be found in the section "Third-party motors at 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:

Overview of the functional scope



P-0-4032 Motor type plate data

Fig. 5-31: Determining motor and motor control parameters for motors without motor encoder data memory

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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 controllers are required.

See "Closed-loop axis control (closed-loop operation)"

See the "Notes on commissioning" in the section "Third-party motors at 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

- C3200 Command Calculate motor data
- C3201 Incorrect input for current
- C3202 Incorrect input for voltage
- C3203 Incorrect input for frequency
- C3204 Incorrect input for speed
- C3205 Incorrect input for power factor
- C3206 Incorrect input for power
- C3207 Type plate list incomplete
- C3208 Error when writing parameters (->S-0-0423)
- C3209 Command execution impossible
- 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
- 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
- C4600 Command Calculate motor control parameters
- C4601 Error when writing parameters (->S-0-0423)

5.4.3 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 V/Hz (U/f) control.

☞ The method of open-loop/closed-loop motor control is selected via the relevant bits of "P-0-0045, Control word of current controller".

See also the section "Motor control"

Overview of the functional scope

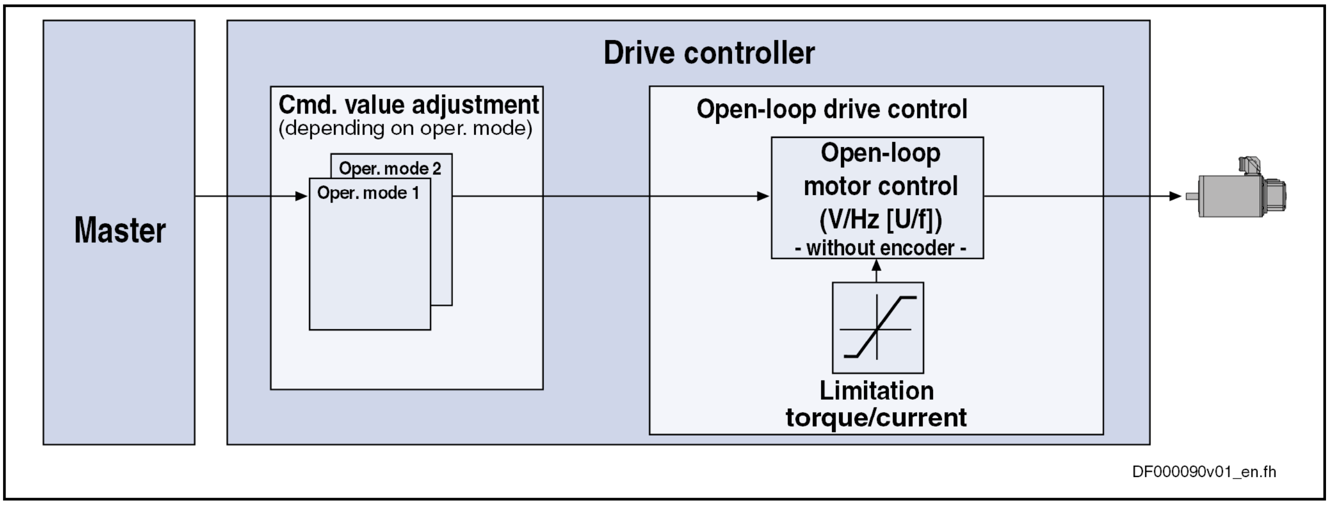

Fig. 5-32: Principle of drive control in open-loop operation

Features

The open-loop 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 controller** (PI controller 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 a **V/Hz (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 controller** 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 of encoder 1
- 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

- F8079 Velocity limit value exceeded (S-0-0091)

5.4.4 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 controllers (position, velocity and current) are interconnected. Depending on the active operation mode, there are different controller 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 section "Overview of drive control" (see "Control loop structure with setting parameters" or "Control loop structure with display parameters").

Features of the control loops

To simplify the parameterization of the control loops and to increase the performance, a number of standardizations and structural changes have been carried out.

Current controller, velocity controller and position controller are described in the section "Performance (controller cycle times)" (see "Overview of drive control, features of the control loops").

Possibilities of accessing outer control loops

In closed-loop operation, it is possible to add command values in addition to the command values available in the control loop. In closed-loop operation, it is possible to access the outer control loops from a higher-level operation mode (see "Additive command values and options for accessing outer control loops").

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 current control loops:

- Position control with cyclic command value input
- Drive-internal interpolation
- Positioning modes (drive-controlled positioning, positioning block mode)

See also description of the respective operation mode.

Velocity control

In the "velocity control" 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" 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"

Notes on commissioning for control loop setting

The control loop settings in a digital drive controller are very important for the features of the servo axis.

To optimize the control loop setting, application-specific controller parameters are available for all digital Rexroth drives.

Order of Manual Control Loop Setting

Due to the cascade structure of the control loops, it is necessary to parameterize them "from the inside to the outside". The resulting order for setting the control loops is as follows:

1. **Current control loop**

   For **Rexroth motors with motor encoder data memory** (MSK and MKE series), the optimization of the current controller is not required, as the respective parameter values (S-0-0106 and S-0-0107) are read from the motor encoder data memory.

   For all **Rexroth motors without motor encoder data memory** (e.g. linear motors), the parameter settings can be taken from a central motor database via the "IndraWorks Ds/D/MLD" commissioning tool.

   The commissioning of **third-party motors** (including control loop settings) is described in the respective sections on third-party motors in this documentation (see "Third-Party Motors at IndraDrive Controllers").

2. **Velocity control loop**

   The settings of the velocity controller (S-0-0100 and S-0-0101) with the respective filters (P-0-0004 and P-0-1120, P-0-1121, P-0-1122, P-0-1123, P-0-1140, P-0-1141, P-0-1142, P-0-1143) on the one hand depend on the motor parameters (inertia and torque/force constant), on the other hand they strongly depend on the mechanical properties (load inertia/mass, friction, rigidity of the connection, ...). Therefore, manual or automatic optimization is often necessary.

3. **Position control loop**

   In general, the position control loop only has to be adjusted to the dynamics of the outer velocity controller, as well as to the kind of preset command values (jerk, acceleration and interpolation procedure).

Default settings in the motor encoder data memory ("load motor default values")

"Load motor default values" command

For all Rexroth motors of the series with motor encoder data memory (e.g., MKE, MSK and possibly MAD and MAF), the basic settings for the controllers are saved and can be loaded to the drive by executing the "load motor default values" command (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" key on the control panel, the "load motor default values" command 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"

☞ To start the "load motor default values" command, the value "0" (default setting) has to have been set in the parameter "P-0-4090, Configuration for loading default values".

When the motor default values are loaded, 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 control 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 parameter is set to the firmware-side default value even though no default value has been stored in the motor data memory for this parameter.

- 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 axis control setting in closed-loop operation.

- Together, the settings of axis control and the drive mechanics (e.g. stiffness/elasticity and load inertia/load mass) determine the control loop dynamics to be achieved.
- The required control loop dynamics depends on the application type (such as machine tool and handling axis).
- It allows setting the control loop parameters in such a way that they are adjusted to the application type and the axis structure (e.g., direct connection and drive with gearbox/toothed wheel), as well as to the mechanical properties of the axis.

Features

The function has the following features:

- The function is started with the command "P-0-0162, C1800 Command Drive optimization/command value box" and controlled with the parameter "P-0-0165, Drive optimization, control word"
- Once the function was started with the command "C1800 Command Drive optimization/command value box", it can be subsequently started using the display.
- With the start of the function, switching to a drive-internal operation mode takes place and the drive makes itself independent of the control unit.
- The result of the control loop setting (achieved control loop dynamics) can be influenced via "P-0-0163, Damping factor for autom. controller setting" und "P-0-0164, Application for autom. controller setting".
- Via "P-0-0165, Drive optimization, control word" it is possible, by selecting the corresponding bit, to activate the respective subfunction of the automatic setting of axis control:
  – Calculation of velocity and/or position controller parameters (drive does not move)

- Optimization of velocity and/or position controller parameters (drive moves)
- Determination of acceleration feedforward (drive does not move)
- Determination of load inertia (drive moves)
- Determination of maximum acceleration (drive does not move)

Depending on the settings in "P-0-0165, Drive optimization, control word", it is necessary to move the drive to carry out the automatic setting of axis control. The drive moves when the load inertia is determined and when the velocity and position control loops are optimized.

- If motion is not required, the command can already be started in phase 4 (bb: drive ready for operation).
- If motion is required, drive enable (AF) is necessary to start the command.
  - The type of motion, oscillating motion or motion in one direction, and, if applicable, the direction of motion, positive or negative direction, are automatically determined from the processing format, absolute or modulo format, of the position data, "S-0-0076, Position data scaling type" (bit 7) and the "S-0-0393, Command value mode".
  - The travel range is defined either by inputting position limits or a travel distance.

When the IndraWorks engineering tool (13V06 and above) is used to control the function, further features are available:

- Automatic determination of the mechanical properties of antiresonance and resonance frequencies:

  "P-0-0181, Drive optimization: Antiresonance frequency"

  "P-0-0182, Drive optimization: Resonance frequency"
- Automatic setting of the speed control loop filters depending on the antiresonance and resonance frequencies

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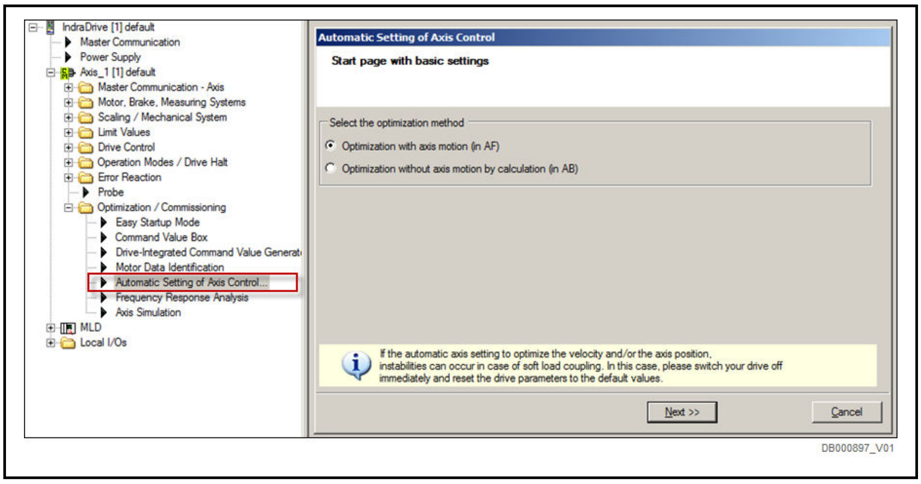

Fig. 5-33: IndraWorks start dialog "Automatic setting of axis control"

Pertinent parameters

- P-0-0161, Drive optimization: Periodic time

- 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
- P-0-0181, Drive optimization: Antiresonance frequency
- P-0-0182, Drive optimization: Resonance frequency

Pertinent diagnostic messages

- C1800 Command Drive optimization/command value box
- C1801 Start requires drive enable
- C1802 No useful motor data
- 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
- C1808 Drive not homed
- E2049 Positioning velocity >= limit value (S-0-0091)
- E2055 Feedrate override S-0-0108 = 0

Velocity controller (with 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 closed-loop operation (current and velocity) can be carried for all types of motors with encoder and for asynchronous motors without encoder.

☞ The motor control type is selected via "P-0-0045, Control word of current controller" (bit 14,15).

Overview of the functional scope

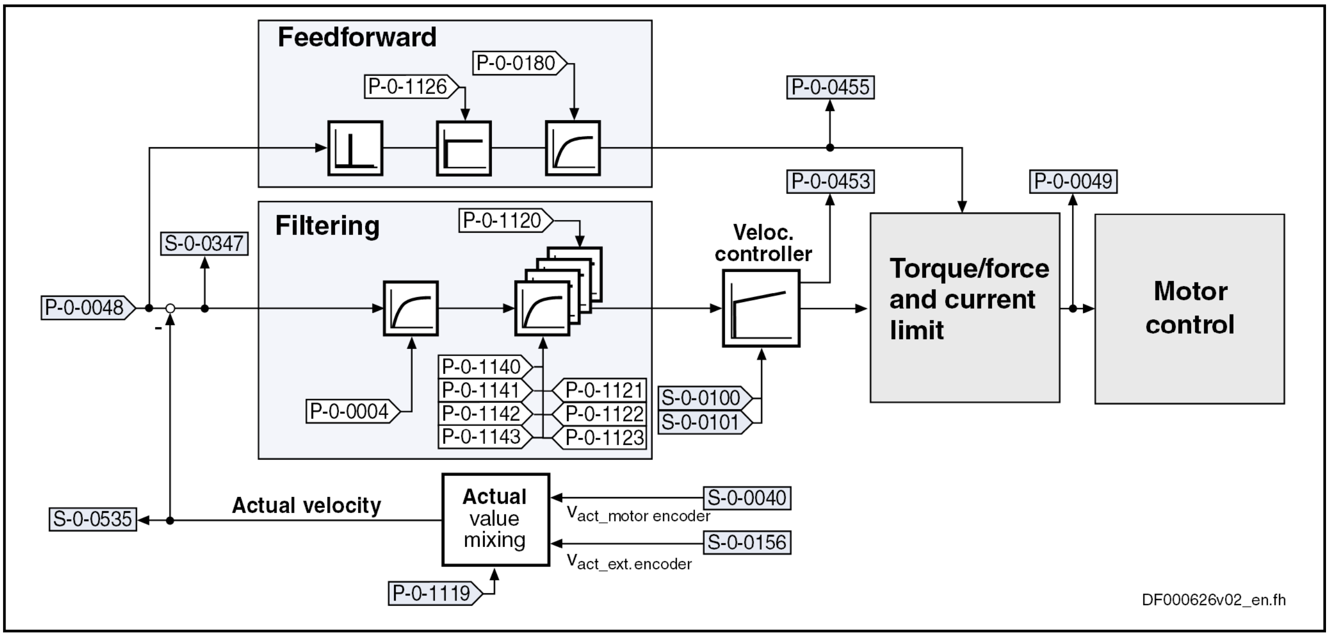

Fig. 5-34: Structure of the velocity controller

The following description is restricted to the velocity controller including the respective options of filtration and feedforward. The processing of the velocity command value is described within the "velocity control" mode.

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
  - Executing the "load defaults procedure (motor-spec. controller values)" function once

    \- or -
  - Manual optimization (see description below)

    \- or -
  - Automatic parameterization 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 controller calculations (see "Performance data").
- Possibility of mixing the velocities of motor encoder and optional encoder
- 4 freely configurable 2nd order filters (e.g., band-stop filters) for filtering resonance frequencies

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For firmware variant MPE, only 2 freely configurable filters are available.

- Low-pass filter to attenuate interference frequencies, to be set via P-0-0004 (VZ1)
- Fine interpolation of the position controller command values (can be switched on via P-0-0556, bit 0)
- Monitoring of the velocity control loop (can be switched off via 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 of encoder 1
- 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-0-0156, Velocity feedback value of encoder 2
- S-0-0164, Acceleration feedback value encoder 1
- S-0-0347, Velocity error
- S-0-0535, Active velocity feedback value
- 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 controller (with respective feedforward functions and actual value adjustment)

Brief description

The following section only describes the position controller with the respective feedforward options (velocity and acceleration feedforward).

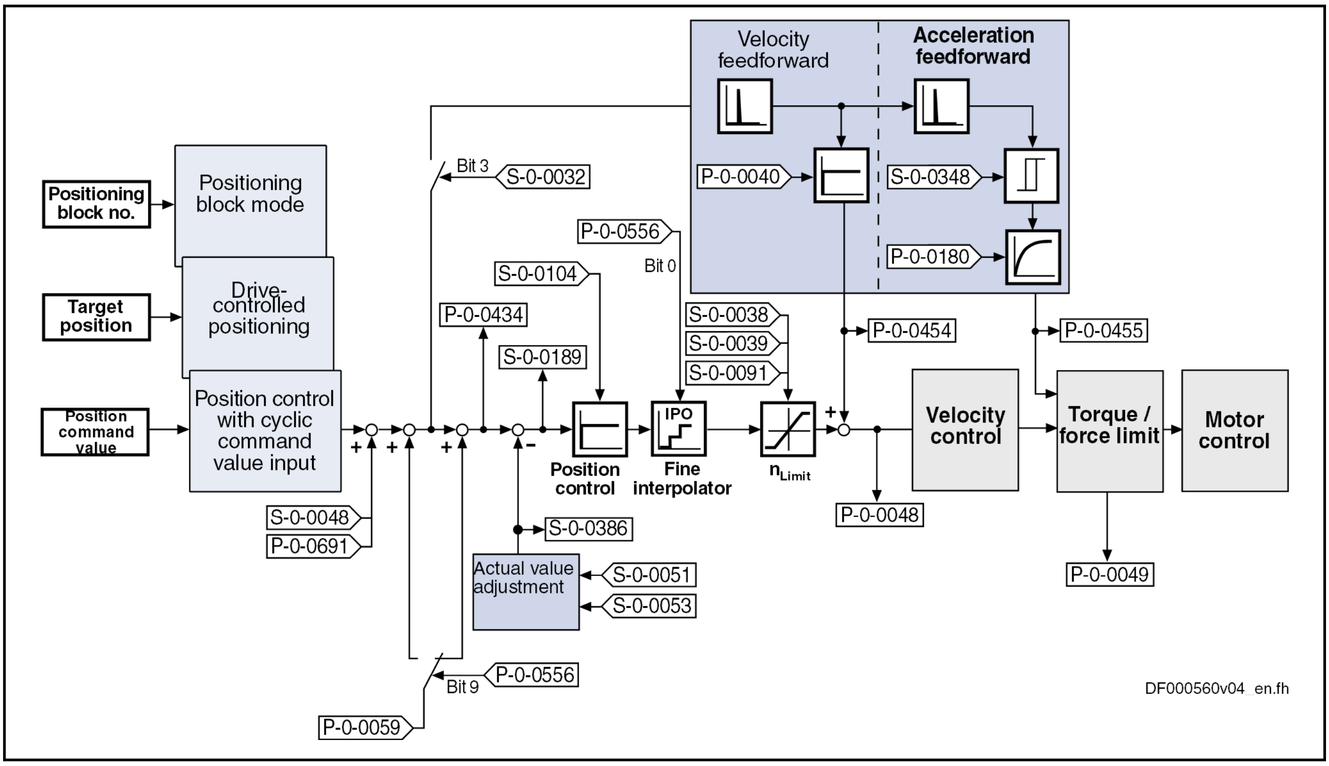

Fig. 5-35: Structure of the position controller

The preprocessing of the position command value (command value adjustment) is described in the corresponding section of the position control mode (e.g. position control with cyclic command value input, positioning block mode, ...).

Features

- Digital proportional controller, 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 controller calculations (see "Performance data").
- With lag error or lagless, i.e. with velocity feedforward
- Model monitoring 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 of encoder 1
- S-0-0048, Additive position command value
- S-0-0051, Position feedback value of encoder 1
- S-0-0053, Position feedback value of encoder 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

5.4.5 Commutation setting

Basics on commutation setting

Brief description

General information

Significance of commutation offset

Synchronous three-phase a.c. motors are only operational, when the current in the primary part has been correctly assigned to the permanent magnetic field in the secondary part. For this purpose, the position of the primary part (motor windings) with respect to the pole pairs of the secondary part must always be known to control. Depending on the primary part position signaled by the motor encoder, the "commutation offset" is used to generate the current in the three-phase windings such that a force effect is produced in the motor.

A synchronous motor can only produce the maximum torque or the maximum force in relation to the motor current if the value of the commutation offset is correct. Otherwise, the ratio of torque/force to motor current (torque/force constant) would be lower and not ideal. A highly incorrect value implies the danger of the motor moving in an uncontrolled way.

If the motor encoder is not mounted 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 provided in the motor encoder data memory. The user does not need to set the commutation offset!
- Synchronous Rexroth kit motors consist 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 on the user side after the motor has been completed.

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

  – Linear motors LSF, MLF
  – Rotary motors MBS and MBT

Motor encoders for synchronous motors

Absolute motor encoders should ideally 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 when the commutation offset had been determined and stored in the drive during the initial commissioning of the motor.

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 an additional Hall sensor component or option, because with regard to commutation setting the relative motor encoder then behaves like an absolute motor encoder.

☞ The evaluation of an analog enoder with additional analog or digital Hall sensors is not yet supported in this firmware release of MPx20 and below!

☞ If you use a relative motor encoder, using the additional Hall sensor component is absolutely recommended for linear Rexroth motors! In this way, the highest safety is achieved with regard to correct motor function and compliance with the performance 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 synchronous Rexroth kit motors (see above); however, the Hall sensor box SHL02.1 cannot be used for linear third-party motors.

Overview of the motor encoders to be used for synchronous motors

Motor encoder	Synchronous Rexroth kit motor (rotary, linear)	Synchronous Rexroth kit motor (linear) with SHL02 or Hall unit	Third-party synchronous motor
Absolute	+	--	+
Relative	o	+	o

+ Advantageous combination
o Combination possible, initial commissioning might possibly require especially trained staff
-- Combination not useful

Tab. 5-63: Possible combinations of motor encoders and synchronous motors for which commutation setting is required

☞ The motor encoder should be realized with 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 gearbox 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 at the axis, the external encoder, with slip-free drive mechanics, can be used as an **absolute commutation encoder** for the motor (for special cases, see below).

Pertinent parameters

Besides the motor parameters (see overview of parameters in "Basics on the motors to be controlled"), there are further parameters available for commutation setting:

- 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 drive mechanics.

The following methods are possible:

- **Calculation method**

  → For relative motor encoder when using the additional Hall sensor component SHL02 (distance measurement, currentless → only possible with linear Rexroth kit motors MLF, 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 linear Rexroth 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 table below for "Restrictions for saturation method"

- **Sine-wave 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 table below for "Restrictions for sine-wave method"

Determination methods, firmware dependency

Firmware variant	Method for determining the commutation			
	Calculation method	Measuring method	Saturation method	Sine-wave method
MPE	-	■	■	-
MPB	■	■	■	■
MPC	■	■	■	■
MPM	■	■	■	■

■ Available
- Not available

Tab. 5-64: Methods for determining the commutation offset that are available in the firmware variants

Recommendations for selecting the determination method:

Motor type	Determination method (and motor encoder that can be used)			
	Calculation method (relative linear encoder with additional Hall sensor component)	Measuring method (absolute linear encoder only)	Saturation method* (absolute or relative motor encoder)	Sine-wave 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 with "Hall unit..." option)	+	--	o
Sy. third-party motors (rotary and linear)	--	--	+	o

+ Recommended method
o Method not recommended
-- Method not possible
* See application-related restrictions

Tab. 5-65: Recommendations for selecting determination method for commutation offset depending on motor type (for Rexroth motors)

☞ Evaluation of the additional Hall sensor component is not yet supported in this firmware release and the releases below!

☞ The sine-wave 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 without or with only little saturation effects (e.g. ironless motors or motors with high 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")!
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%!
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 motor motion!

Tab. 5-66: 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 little friction!
Linear axes in Gantry arrangement	Only balanced (e.g. horizontal) axes with little friction! In addition, both drives have to carry out sequential commutation settings, "AF" should not be active at the other drive!
Axis with holding brake (e.g. vertical axis)	Holding brake must be released to determine the commutation offset successfully. Only balanced 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"!

Tab. 5-67: Typical applications and restrictions for sine-wave method

Restrictions for motors with relative motor encoders and digital Hall sensors

The respective restrictions are explained in the subchapter.

Identifying the motor encoder

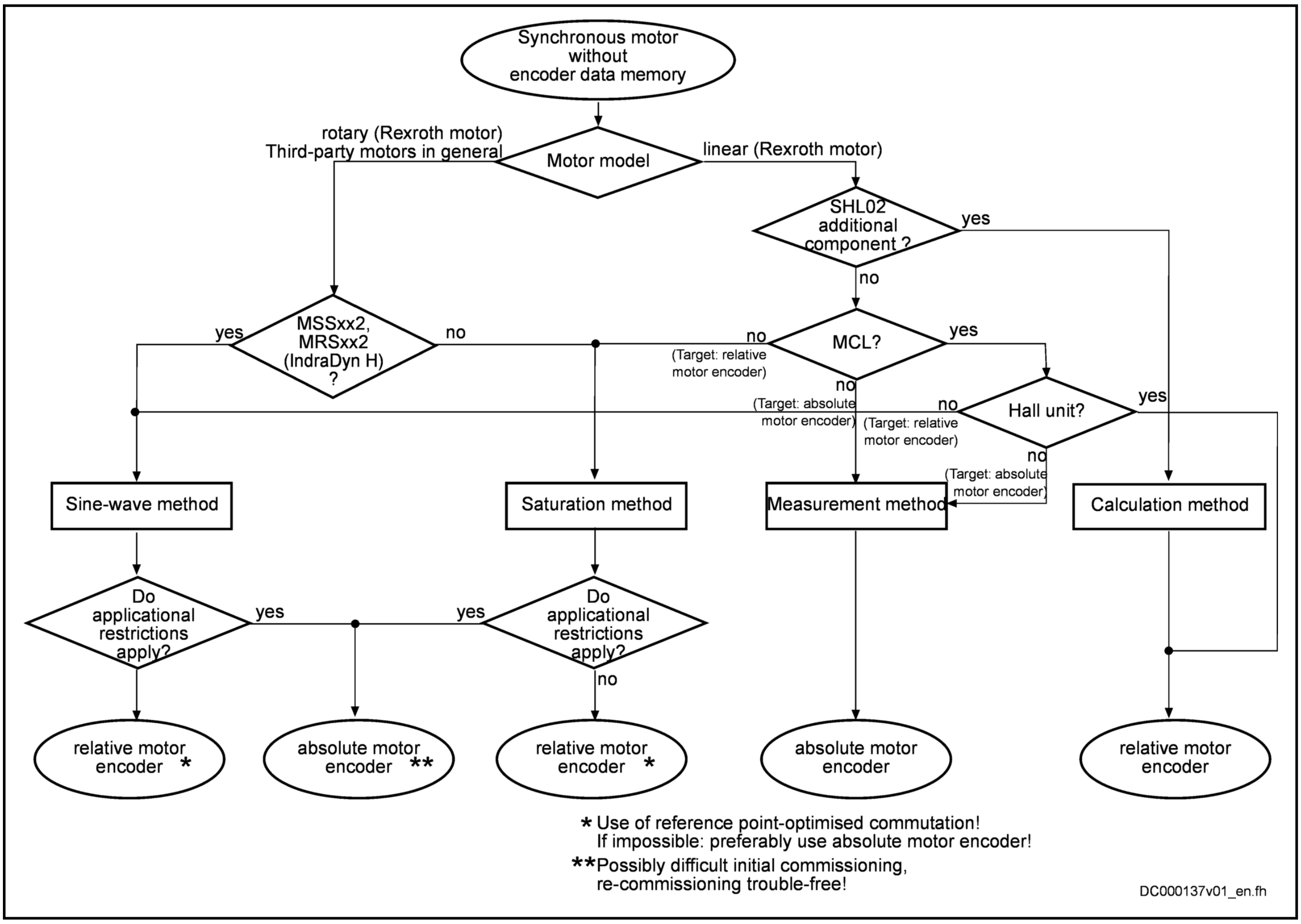

Fig. 5-36: Identifying the absolute or relative motor encoder depending on the motor and application-related restrictions

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☞ Evaluation of the SHL02 additional component and of the Hall unit is not yet supported in this firmware release of MPx20 and below!

Effect of an encoder gearbox

If a motor encoder to be evaluated in absolute form is connected via 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. Therefore, the motor encoder to be evaluated in absolute form now behaves like a relative motor encoder as regards commutation.

In two special cases, however, absolute commutation encoder evaluation (rotary encoders only) is possible for synchronous motors with encoder gearbox:

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

  - If an n-fold motor revolution (n is an integer) results in exactly one encoder revolution

- Case 2, multi-turn encoder:

  - If exactly one motor revolution results in 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 at the axis, the external encoder, with slip-free drive mechanics, can be used as an absolute commutation encoder for the motor. If this is the case, the external encoder can be assigned as a commutation encoder in "P-0-0185, Encoder 2 control word". The same information applies as for synchronous motors with motor encoder that can be evaluated in absolute form.

☞ Using an external encoder as a commutation encoder is not yet supported in this firmware release and the releases below!

Determining the commutation offset

The active commutation offset value is contained in parameter "P-0-0521, Effective commutation offset". Due to its relevance for the torque/force development of the motor and the operational safety, P-0-0521 is always write-protected.

Depending on the motor encoder used, the commutation offset has to be determined in the following circumstances:

- With absolute motor encoder only during **initial commissioning** of the motor
- With relative motor encoder both during **initial commissioning** of the motor and each time the drive has been switched on (**recommissioned**)

☞ For synchronous Rexroth motors with integrated motor encoders (e.g., MSK motors), the initial commissioning was already performed at the factory and the motor-specific commutation offset value was determined and is provided in the motor encoder data memory. The user does not need to set the commutation offset!

Initial commissioning and recommissioning

During the initial commissioning of Rexroth kit motors and synchronous third-party motors, the commutation offset is determined during the initial commissioning of the motor with a suitable method made available by 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 system and electromagnetic factors. But as the torque/force development of the motor mainly depends on the quality of the commutation offset value, this value should be thoroughly optimized during the initial commissioning of the motor.

However, to do this it is necessary to allow the parameter "P-0-0521, Effective commutation offset", which is normally write-protected, to be written so that the value can also be optimized manually if necessary. For this purpose, the drive provides the "initial commissioning mode" (activated in "P-0-0522, Control word for commutation setting").

The optimum value of the commutation offset identified during 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 has to be saved in the "initial commissioning mode" in an appropriate way so that it is available during recommissioning:

- **For motors with absolute motor encoder, as well as with relative motor encoder 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 stored value takes effect again. If the motor encoder has a data memory, the value of P-0-0521 is also saved in "P-0-3008, Commutation offset, type plate".

- **For motors with relative motor encoder and motors with additional digital Hall sensors (digital Hall unit with MCL, third-party motors):**

  The value of the effective commutation offset (P-0-0521) is saved in "P-0-0508, Commutation offset" in reference to a fixed, reproducible motor or axis position. This requires drive actions initiated by the user (drive-controlled homing or merely moving the motor). When the drive is recommissioned, it is firstly the automatic commutation setting that takes place after drive enable (AF) has been set for the first time, or "P-0-0509, Commutation offset coarse" is firstly applied to P-0-0521 in the case of digital Hall sensors. By actions of the drive triggered on the user side (drive-controlled homing or moving the motor), the value stored in P-0-0508 takes effect in an optimizing way for the automatically determined commutation offset (P-0-0521) as a correction value is determined and added.

☞ By adding a correction value, the effective commutation offset (P-0-0521), when the motor is recommissioned, achieves the quality of the value of the initial commissioning. This results in reproducible drive behavior with respect to torque/force development. The determination of the correction value is supported by the reference mark of the motor encoder or the homing dedicated position of the axis; for this reason, the correction method is called "optimum commutation offset with regard to reference point".

Basic notes on commissioning

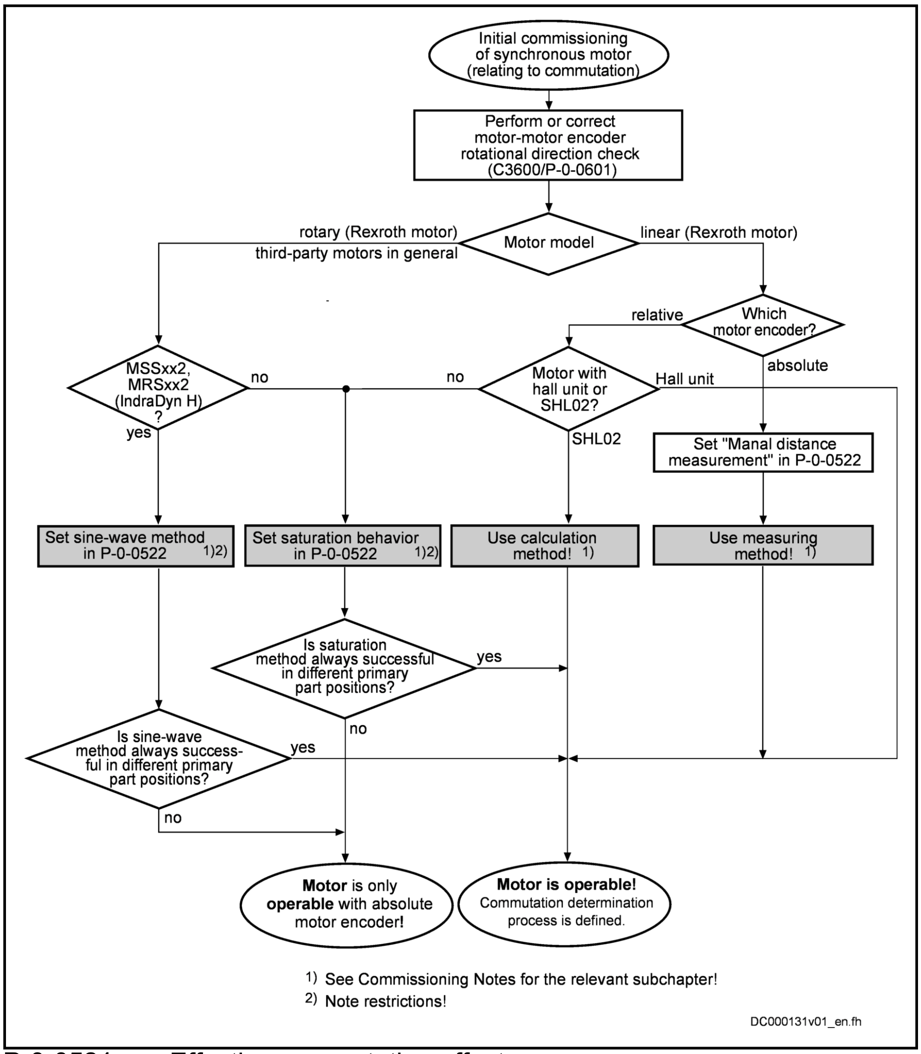
Explanations on the initial commissioning of a synchronous motor

Determining the commutation offset during the initial commissioning of a synchronous motor is of particular relevance. There are different methods available or applicable for determining the commutation offset, depending on the motor and motor encoder. The effectiveness of the determined value should be checked and, if necessary, optimized during initial commissioning.

Selecting the method for determining the commutation offset

After the motor had been selected and application-related restrictions of the methods for commutation setting had been checked, an absolute or relative motor encoder was selected and a method for commutation setting was determined. If the determined method is unknown at initial commissioning, the appropriate method can be identified by means of the selected motor and motor encoder:

Overview of the functional scope



P-0-0521 Effective commutation offset
P-0-0522 Control word for commutation setting
P-0-0601 Configuration motor data identification

Fig. 5-37: Selecting the method for determining commutation offset during initial commissioning of synchronous motor

Checking the rotational direction motor - motor encoder

To successfully determine the commutation offset, it is imperative that the rotational direction of the motor matches the rotational direction of the motor encoder. This is the case if the position feedback value of the motor encoder (S-0-0051) shows increasing position feedback values at positive torque/force command value (S-0-0080 or P-0-0049) (take possible negations of the polarity parameters into account!).

☞ If the rotational direction of the motor does not match the rotational direction of the motor encoder, the motor cannot follow the command value with the determined commutation offset. It moves to a close-by rest position or carries out uncontrolled movements. The error message F8010 might occur, but not necessarily!

The "check of the rotational direction" (C3600, configured in P-0-0601) requires a slight motor motion (approx. half an el. pole). A possibly available holding brake is released for this purpose. When an axis is at the mechanical limit stop, an error message is likely to occur!

☞ The "check of the rotational direction" is not suited to non-equilibrated, vertical axes! The axis will drop down when the holding brake is released after C3600 was started!

Effect of an encoder gearbox

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)

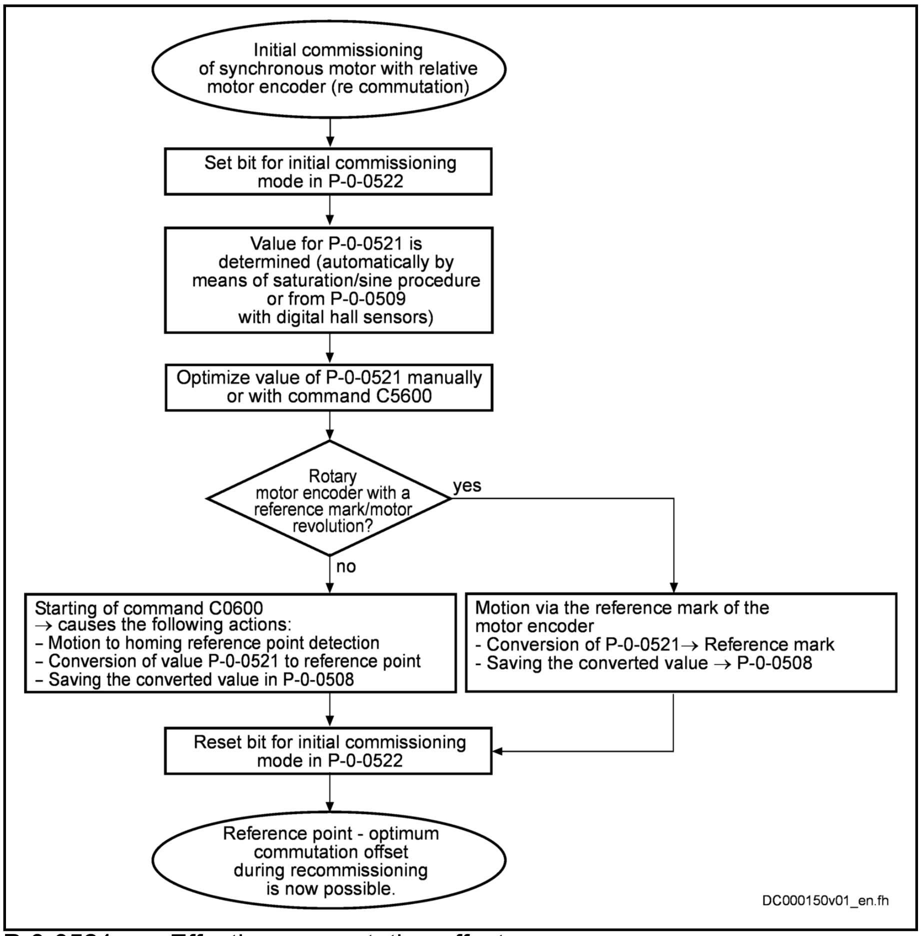
Storage procedure of the optimum commutation offset

The determined commutation offset must initially be optimized during initial commissioning to obtain the maximum torque/force development of the motor during recommissioning of the drive. For options and methods, see below.

The value of the effective commutation offset (P-0-0521), optimized if necessary, is stored in different ways, depending on the absolute or relative motor encoder, with active "initial commissioning mode":

- With an absolute motor encoder, directly in P-0-0508 or P-0-3008
- With a relative motor encoder, the optimized value is converted to a reproducible dedicated point fixed with reference to the motor and stored in P-0-0508

Overview of the functional scope



P-0-0521	Effective commutation offset
P-0-0522	Control word for commutation setting
P-0-0508	Commutation offset
P-0-0509	Commutation offset, coarse
C0600	Drive-controlled homing procedure command
C5600	Command subsequent optimization of commutation offset

Fig. 5-38: Storage procedure of the optimum commutation offset in P-0-0508 during initial commissioning for subsequently using the "optimum commutation offset with regard to reference point" during recommissioning

Manually optimizing the offset value

The automatically determined value for the commutation offset is stored in parameter "P-0-0521, Effective commutation offset". If the initial commissioning mode is active (respective bit in P-0-0522), the value of P-0-0521 can be manually optimized. Optimization should be carried out using a force measurement device.

$$(P\text{-}0\text{-}0521)_m = (P\text{-}0\text{-}0521)_a \pm 150$$

m	Manually
a	Automatically determined

Fig. 5-39: Range of values for optimizing the commutation offset

NOTICE **Property damage caused by errors when controlling motors and moving parts!**

Before manually optimizing the commutation offset, move the axis to a non-critical position!

Optimizing the offset value by means of command

The value determined for "P-0-0521, Effective commutation offset" can be checked by the controller and subsequently optimized. "P-0-0518, C5600 Command subsequent optimization of commutation offset" is used for this purpose. The drive has to be in drive enable (AF) and in standstill. In addition, the axis has to be able to move sufficiently (motion range see table).

Motor design	Motion range	Reference
Rotary	± 10 angular degrees	Motor shaft
Linear	± 0.1 × pole pair distance	Primary part

Tab. 5-68: Minimum required motion range for executing command C5600

The controller optimizes the commutation offset which is already operational (value stored in P-0-0521) by transmitting test signals to the motor. The information for improving the commutation offset is taken from the motor motion (actual position value). Upon successful execution of command C5600, an improved value is available in parameter P-0-0521.

☞ It is always recommended to execute "C5600 Command Subsequent optimization of commutation offset" if none of the restrictions mentioned for the sine-wave method (see above) exists!

NOTICE **Property damage caused by errors when controlling motors and moving parts!**

Before automatically optimizing the commutation offset, move the axis to a noncritical position and make sure axis can move!

Storing the "optimum commutation offset with regard to reference point"

For synchronous motors with relative motor encoder, the effective commutation offset (P-0-0521) is determined and, if necessary, optimized in the "initial commissioning mode" (P-0-0522). In order that the quality of the commutation offset of initial commissioning can be reproduced when the motor is recommissioned, the commutation offset is converted to a reproducible dedicated point fixed with reference to the motor and then stored in "P-0-0508, Commutation offset":

- When the drive passes the reference mark with activated "cyclic marker evaluation" (S-0-0277) in the case of motors with one reference mark per motor revolution, the controller, in "P-0-0508, Commutation offset", stores the value of P-0-0521 converted to the mark ("Optimization of the value of P-0-0521..." has to have been activated in P-0-0522).
- When the drive passes the dedicated point for homing by executing "S-0-0148, C0600 Drive-controlled homing procedure command" in the case of motors with several reference marks or none per motor revolution or linear motor travel range, the controller, in "P-0-0508, Commutation offset", stores the value of P-0-0521 converted to this dedicated point ("Optimization of the value of P-0-0521..." has to have been activated in P-0-0522).

☞ The reproduction of the dedicated point is realized by the reference mark of the motor encoder or the dedicated position for homing the axis. The value converted to this dedicated position is used to determine the correction value; therefore, the method was called "optimum commutation offset with regard to reference point".

Explanations on the recommissioning of a synchronous motor

Readiness for operation of a synchronous motor is given after switch-on (recommissioning after initial commissioning already taken place), when the controller has determined a commutation offset value for this motor or activated a stored value.

Synchronous motor with absolute motor encoder

There is immediate readiness for operation with absolute motor encoders. The commutation offset value (P-0-0508, P-0-3008) stored in the controller or in the motor encoder during initial commissioning is activated by applying it to parameter "P-0-0521, Effective commutation offset".

Synchronous motors with relative motor encoder and additional Hall sensor components (analog and digital)

There is immediate readiness for operation with relative motor encoders and additional Hall sensor components: "P-0-0521, Effective commutation offset" immediately gets an operational value:

- With SHL02 and Hall unit, analog: The value of P-0-0508, Commutation offset, saved during initial commissioning, is applied to P-0-0521.
- With Hall unit, digital: The value of "P-0-0509, Commutation offset coarse", supplied for MCL motors or determined and saved during initial commissioning, is applied to P-0-0521.

☞ Evaluation of additional Hall sensor components is not yet supported in this firmware release and the releases below!

Synchronous motor with relative motor encoder

With relative motor encoders, the drive, at first drive enable after switch-on or after re-initialization of the measuring system, automatically determines the commutation offset. When "AF" is set, this is done by a method with current ("Overview of methods for determining the commutation offset", see above). The value is contained in parameter P-0-0521 and refers to the position of the axis at switch-on.

Optimum commutation offset with regard to reference point

The "optimum commutation offset with regard to reference point" is only relevant to synchronous motors with relative motor encoder, also if a Hall unit, digital, is additionally used.

☞ With absolute motor encoders, and relative motor encoders with SHL02 or Hall units, analog, the commutation offset does not need to be corrected during recommissioning!

The "automatic optimization" of the value of "P-0-0521, Effective commutation offset" has to be activated for use in "P-0-0522, Control word for commutation setting". Consequently, the value of the currently effective commutation offset (P-0-0521) converted to the same dedicated position is compared, during recommissioning, to the value stored in "P-0-0508, Commutation offset":

- For motors with one reference mark per motor revolution: When the drive has passed the reference mark of the motor encoder ("cyclic marker evaluation" must have been activated in S-0-0277!).
- For motors with several reference marks or none per motor revolution or linear motor travel range: When the dedicated point for homing has been passed after the start of "C0600 Drive-controlled homing procedure command".

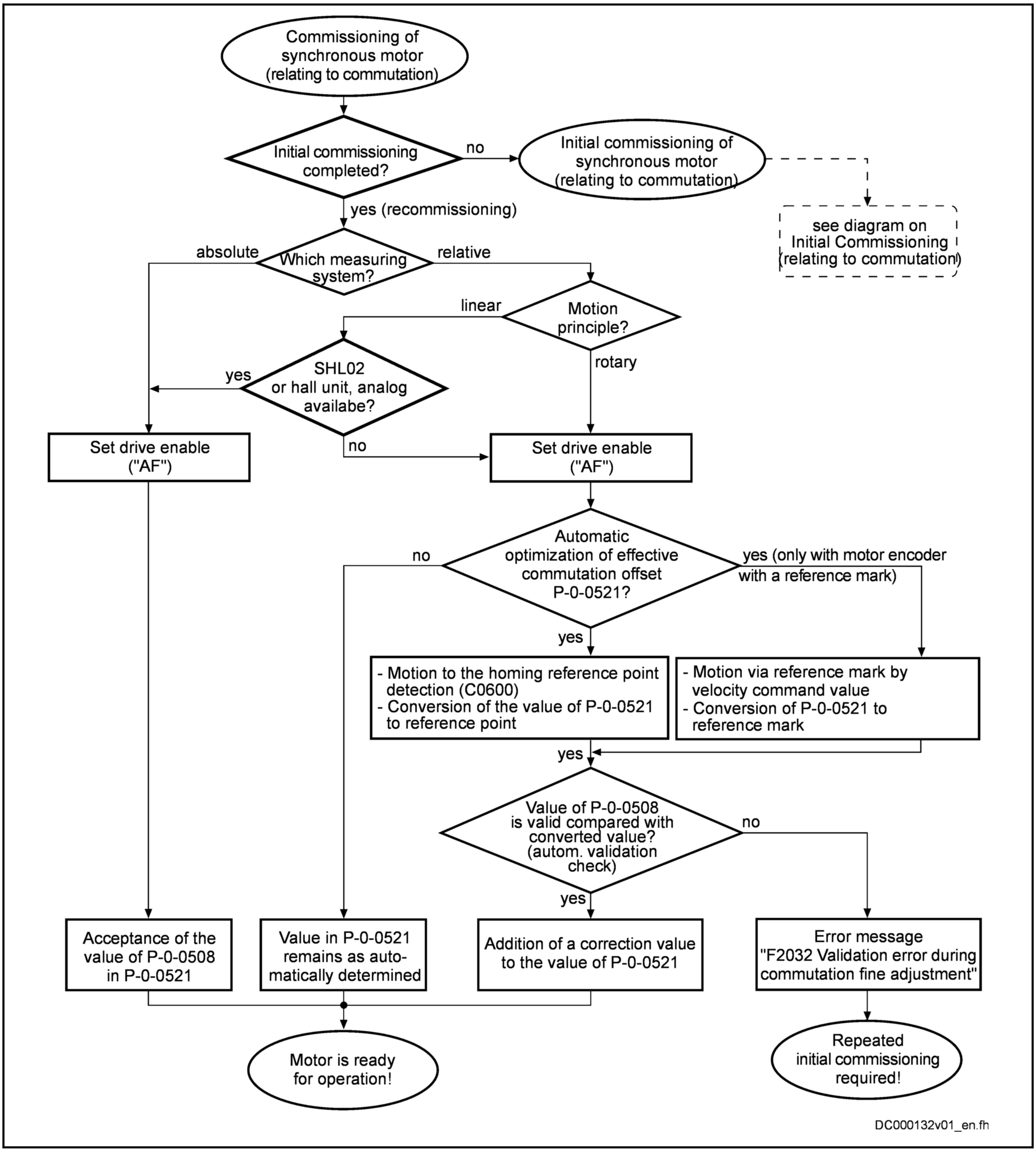
If the result of the comparison is verisimilar, the difference of the two values is added as a correction value to the current value of "P-0-0521, Effective commutation offset". In this way, the quality of the commutation offset now effective complies with the value stored during initial commissioning.

If the result of the comparison is not verisimilar, the value in parameter P-0-0508, Commutation offset might be wrong (e.g., inverted value). The error message "F2032 Validation error during commutation fine adjustment" is generated and the drive switches off.

☞ If the automatic optimization of the commutation offset is not desired, it can be deactivated via P-0-0522, Control word for commutation setting. This causes the commutation offset determined at AF to remain effective and unmodified!

☞ If the "optimum commutation offset with regard to reference point" is used, the effective commutation offset (P-0-0521), after the motor has been recommissioned, achieves the quality of the value stored when the drive was commissioned for the first time. The resulting drive behavior is reproducible with regard to the torque/force development!

Overview of the functional scope



P-0-0521 Effective commutation offset
P-0-0522 Control word for commutation setting
P-0-0508 Commutation offset

Fig. 5-40: Recommissioning procedure of a synchronous motor after initial commissioning was carried out

Commutation setting of linear Rexroth motors MLF, MCL

Brief description

Linear Rexroth kit motors of the MLF and MCL series 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.

Motor with absolute motor encoder

The operatability of the synchronous motor can only be established on site by determining and setting the commutation offset. For motors with a motor encoder to be evaluated in absolute form, this is done once during initial commissioning.

Motor with relative motor encoder

For synchronous motors with relative motor encoder, it is necessary to redetermine the commutation offset each time the drive is switched on. Deviating commutation offset values might occur when the commutation offset is determined again; this can cause less force development at the same motor current.

To prevent this, it is recommended that Hall sensor components, developed especially for linear Rexroth motors be used in addition to the relative motor encoder.

☞ Evaluation of the additional Hall sensor components is not yet supported up to and including the firmware release MPx20V08!

Analog Hall sensors

Via analog signals of the Hall sensors, the controller detects the position of the motor windings compared to the magnetic field of the motor; therefore, the commutation setting is also completed with the 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 at the drive controller for evaluating the analog Hall sensor signals. It is therefore necessary to use a controller with 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 MCL motors in Economy applications. Using 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 a pole pair). This allows the motor to run immediately after switch-on with at least 50% of the possible motor power.

The subsequent homing procedure of the relative measuring system allows full motor power to be achieved again, if this was prepared accordingly during the initial commissioning. The current state of the performance of the motor is diagnosed and can be queried on the control master side.

☞ To evaluate the digital Hall sensor signals, the additional component "SHL03" is required (bringing together the motor encoder and Hall sensor signals). The controller just needs a control section with one encoder input only. Economy control sections can therefore 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 methods:

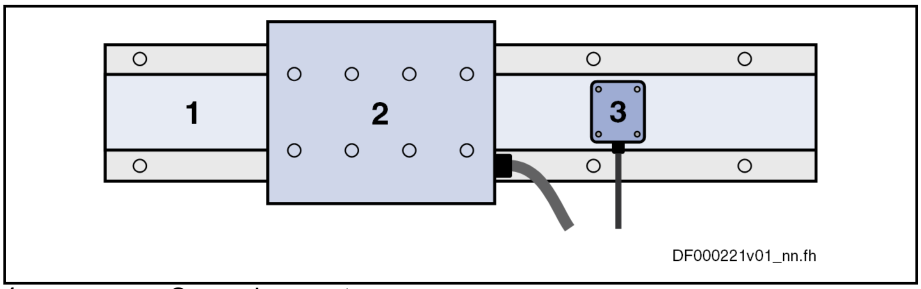
- Saturation method for MLF motors
- Sine-wave method for MCL motors

Each time the drive is switched on again, the commutation setting is performed again with the disadvantages listed above. These disadvantages can be compensated for by using the "optimum commutation offset with regard to reference point".

☞ Application-related restrictions are to be noted for the saturation and sine-wave methods! Using the "optimum commutation offset with regard to reference point" is highly 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 linear Rexroth MLF motors.



1 Secondary part
2 Primary part
3 Hall sensor box SHL02 (connected to the primary part)

Fig. 5-41: Linear Rexroth motor with Hall sensor box SHL02

For information on mounting and connection, see the documentation on the 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 linear Rexroth MCL motors. The Hall unit is optional; it can be directly ordered, but it can also be retrofitted.

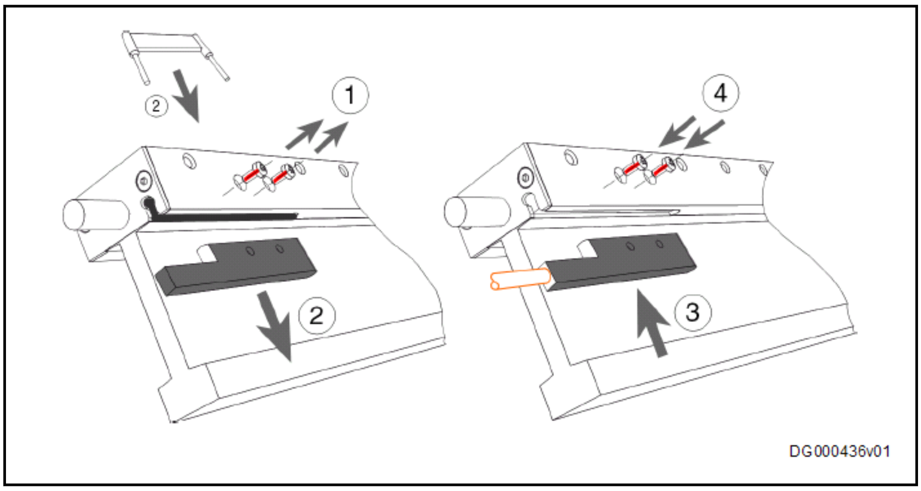


Fig. 5-42: "Hall unit" option of MCL motors, disassembling the dummy unit, retrofitting the Hall unit

Information regarding dismounting/assembly and connection is contained in the "Ironless Linear Motors MCL" documentation.

Commutation setting by means of 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 is one of these methods; it is does not require motor motion. A possibly available holding brake should remain applied!

☞ For synchronous Rexroth motors with integrated motor encoder (MSK, 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 als relevant to linear synchronous Rexroth kit motors, if they have only been equipped with a relative motor encoder, or to motors with a motor encoder which can be evaluated in absolute form, if distance measurement at the axis is impossible due to the mounting.

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 restrictions must be observed.

☞ The restrictions 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.

Commutation setting by means of sine-wave method

Brief description

For synchronous motors, IndraDrive controllers, in addition to the saturation method, 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 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-wave method is suitable for both the initial commissioning and the recommissioning, although the restrictions must be observed.

☞ The restrictions to be observed when using the sine-wave 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.

5.4.6 Limitations

Overview of limitations

To protect the drive mechanics, the controllers and the motors against overload, IndraDrive devices feature different limitation options:

- 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 (V/Hz [U/f] control)

With voltage-controlled, sensorless open-loop operation, the following limitations are available to protect the device or motor:

- Torque/force limitation via stall protection controller
- Current limitation via current limitation controller
- 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 drive 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)
- Current torque/force command value displayed in "P-0-0049, Effective torque/force command value"
- Process torque or process force displayed 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 analyzing 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 limits are implemented in the drive, which allow the velocity command value to be limited to a freely defined amount or to different positive and negative value.

Features

- Unipolar velocity limit values (S-0-0038, S-0-0039), scaled, with reference to load where applicable
- Cyclically configurable, bipolar velocity limit value (S-0-0091), scaled, with reference to load if necessary
- Bipolar velocity limit value (P-0-0113) of the motor, unscaled, with reference to the motor only

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!

Implementing 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 **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

- Monitoring of 2 travel range limit switches (Limit+, Limit-) at the drive is possible
- Signal behavior of travel range limit switches can be set (N/C-N/O)
- Activation of travel range limit switches via parameter
- Reaction (error/warning) when exceeding travel range can be set
- Status display of the 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

Overview of the functional scope

Features of position limit values

- 2 position limit values ("software limit switches") can be parameterized; only operational when axis has been homed
- Reaction (warning/error) to exceeded values can be set
- Activation of position limit values via parameter
- Automatic relation 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
- S-0-0478, Position/travel range limit status
  (Alias: P-0-0091, Position/travel range limit status)
- S-0-0532, Travel range limit parameter
  (Alias: 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
- F6028 Position limit value exceeded (overflow)
- 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

5.4.7 Power supply

Brief description

Power supply options

The following IndraDrive devices are supported by this firmware:

- Single-axis converters of the IndraDrive Cs range (HCS01.1 controllers)
- Multi-axis converters (HCQ, HCT controllers)
- Single-axis converters of the IndraDrive C range (HCS02.1, HCS03.1, HCS04.2 controllers)
- Single- and double-axis inverters of the modular IndraDrive M range (HMS01.1, HMS02.1, HMD01.1 controllers)
- Single-axis inverters of the distributed IndraDrive Mi range (KSM02.1, KMS02.1 controllers)

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 and a DC bus coupled, modular drive system.

Possible device combinations and mains connection

The possible device combinations are only described in principle for the purpose of explanation. As regards combinations of device types actually possible and specific facts to be observed, see the separate documentations.

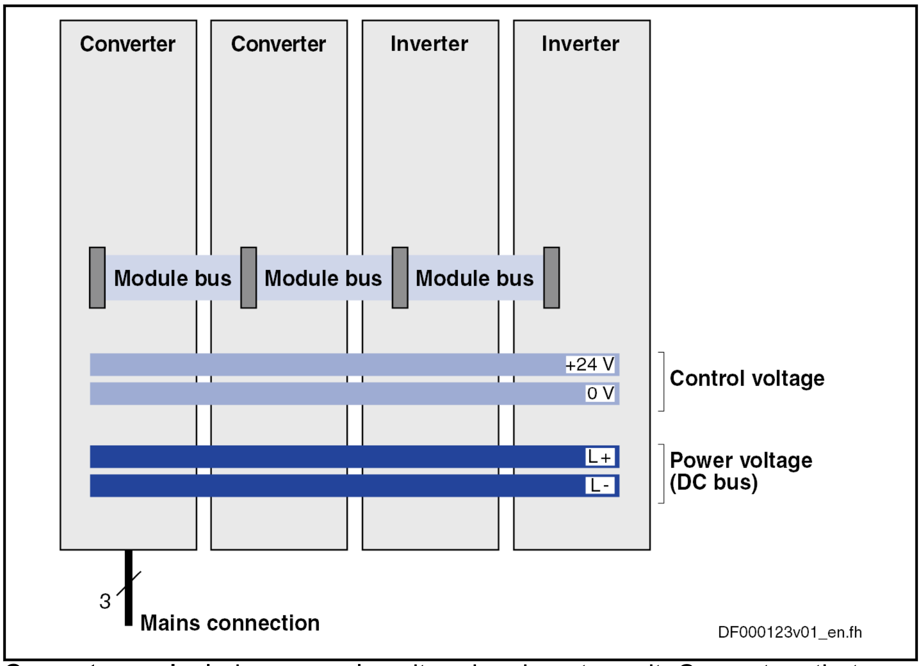
Title Rexroth IndraDrive …	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
Cs Drive Systems with HCS01	Project Planning Manual	HCS01******-PRxx-EN-P	322210
Drive Systems with HMV01/02, HMS01/02, HMD01, HCS02/03	Project Planning Manual	SYSTEM*****-PRxx-EN-P	309636
Supply Units, Power Sections	Project planning	HMV-S-D+HCS-PRxx-EN-P	318790
Drive Controllers HCS04.2E	Project Planning Manual	HCS04.2****-PRxx-EN-P	327334
Mi Drive Systems with KCU02, KSM02, KMS02	Project Planning Manual	KCU02+KSM02-PRxx-EN-P	335703

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

Tab. 5-69: Documentations for the project planning of drive systems

Central supply

The figure below illustrates the principle of central supply:



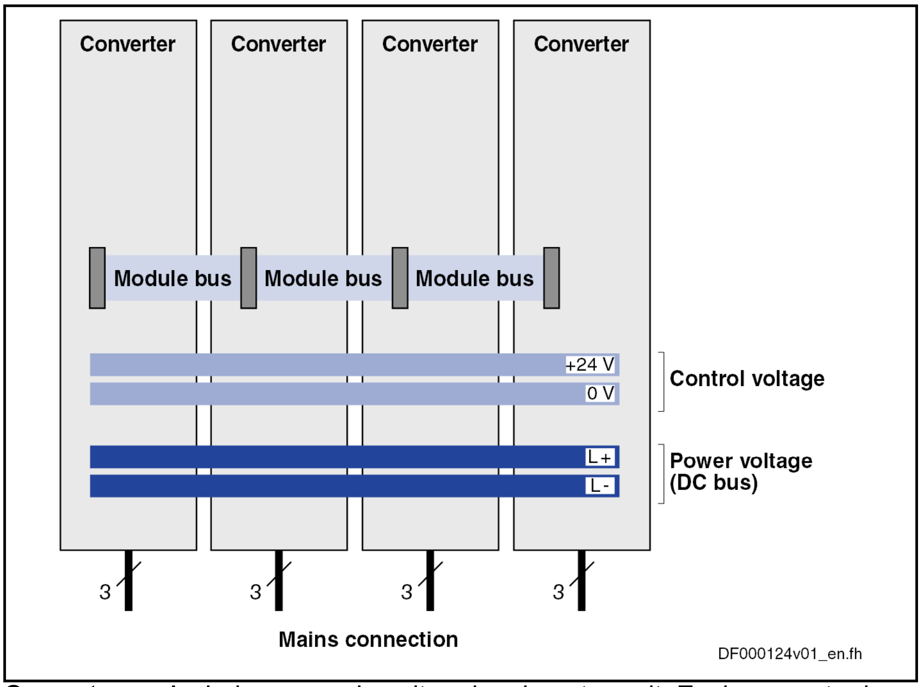
Converter Includes a supply unit and an inverter unit. Converters that are supplied via the DC bus have to be operated in the inverter mode (see P-0-0860).

Inverter Only consists of the inverter unit and is always supplied via the DC bus

Fig. 5-43: Mains supply via converter

Group supply

The figure below illustrates the principle of group supply:



Converter Includes a supply unit and an inverter unit. Each converter is directly supplied by the mains.

Fig. 5-44: Mains supply via all devices

☞ With IndraDrive C and IndraDrive M, the module bus has an eight-wire design (ribbon cable) and with IndraDrive Cs it has a two-wire design. Devices with module buses of different designs cannot be operated at the common DC bus.

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 an internal communication between the supply unit and the axis inverters.
- Single-axis converters (IndraDrive Cs, IndraDrive C), as well as inverters and supply units of the modular series (IndraDrive M), are interconnected via the module bus.

Note regarding single-axis converters IndraDrive Cs/C

A single-axis converter combines 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 at a DC bus

Note regarding multi axis converters

A multi-axis converter combines the supply unit and several inverters in one device. It always works as a "drive system" (several drives the DC buses and module buses of which are interconnected). 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 energy absorption capacity 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 series, an internal braking resistor is available or an external braking resistor can be connected.

Module bus The module bus is used for the communication of all nodes at the DC bus. It protects the components by switching the power off. The collective package reaction of all nodes is also initiated via the module bus. The wiring of the hardware, connections and signals is described in the documentation of the devices (Project Planning Manual).

Pertinent parameters and diagnostic messages

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-0-0815, Nominal mains voltage crest value
- P-0-0816, Amplifier temperature 2
- 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
- E8026 Undervoltage in power section
- E8028 Overcurrent in power section
- E8057 Device overload, current limit active
- E8058 Drive system not ready for operation
- E8819 Mains failure
- 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

5.5 Operation modes

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

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine's range of motion (e.g., by 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".

5.5.1 General information on the operation modes

Assignment to the functional packages

For the assignment to the functional packages, see chapter "Overview of functions/functional packages, supported operation modes".

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"). They are assigned and configured 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" has been enterd 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 by the input in drive control words which depend on the type of master communication:

- S-0-0134, Master control word
- P-0-4077, Field bus: Control word
- P-0-4068, Field bus: Control word IO
- P-0-4028, Device control word
- P-0-0120, Control word easy startup

For axis commanding by the integrated MLD control and the use by the easy startup mode, there are 8 more internal operation modes available (permanently configured internally), so that a total of 16 operation mode preselection parameters are available. It is possible to choose between these operation modes in operation, and due to drive-controlled transition functions it is possible to switch between the operation modes in running operation.

The effective input is displayed in the bits 8, 9, 11 and 12 of the parameter "P-0-0116, Device control: Control word".

The following applies to parameter P-0-0116:

- Bits 8 and 9 → Selecting primary operation mode and secondary operation modes 1 to 3
- Bit 11 → Selecting secondary operation modes 4 to 7 (sercos only)

☞ 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.

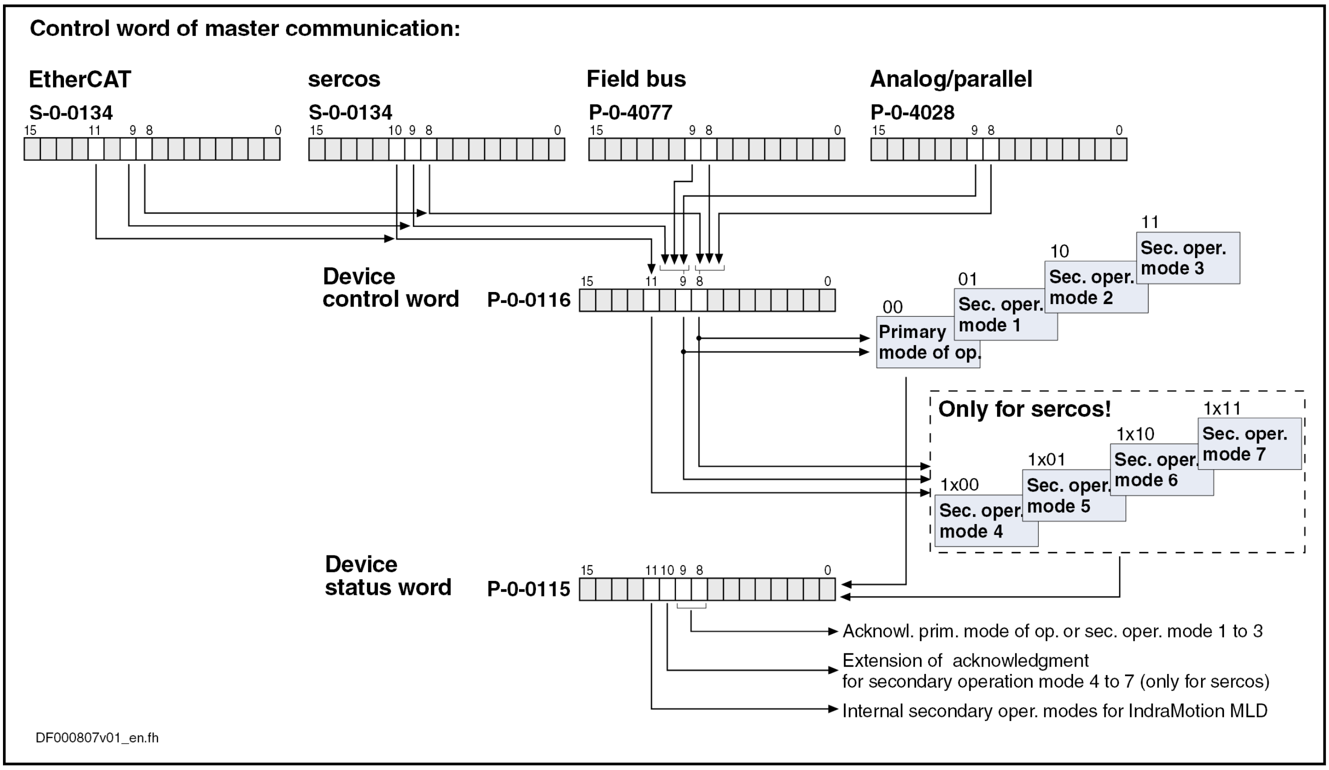


Fig. 5-45: Operation mode selection via control word

☞ 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. "C00A0101" 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, P-0-4028 oder P-0-0116).

☞ The change of operation modes is carried out within one position controller clock (Advanced: 250 µs; Basic: 500 µs). Another position controller 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 position, ...) 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 calue 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 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:

- "Drive-controlled positioning" mode

  Acceptance of preset command value (position, velocity) by toggling bit 0 of parameter "S-0-0346, Positioning control word"

  → **Toggle mechanism**

- "Positioning block mode"

  Acceptance of the positioning block selected via "P-0-4026, Positioning block selection" by a positive 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:

- "Drive-controlled positioning" mode

  The drive acknowledges the command value acceptance by toggling bit 0 of parameter "S-0-0419, Positioning command acknowledge".
- "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.

5.5.2 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"

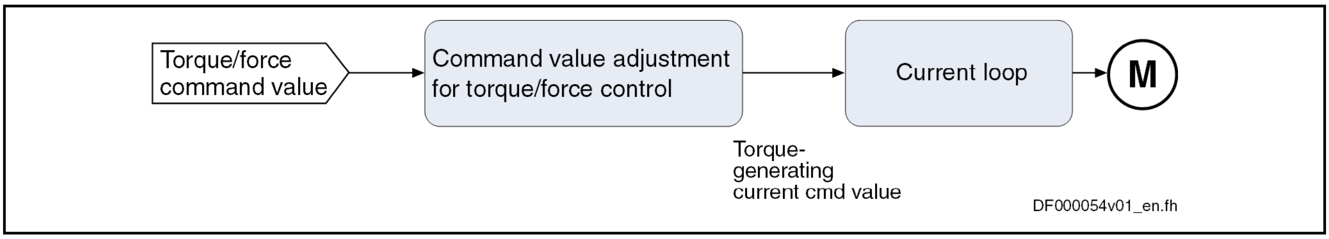


Fig. 5-46: "Torque/force control" block diagram

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 controller; value of S-0-0081 can be added as an 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

5.5.3 Velocity control

Brief description

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

In the "velocity control" mode, a velocity command value is preset for the drive. The velocity command value is limited by ramps and filters.

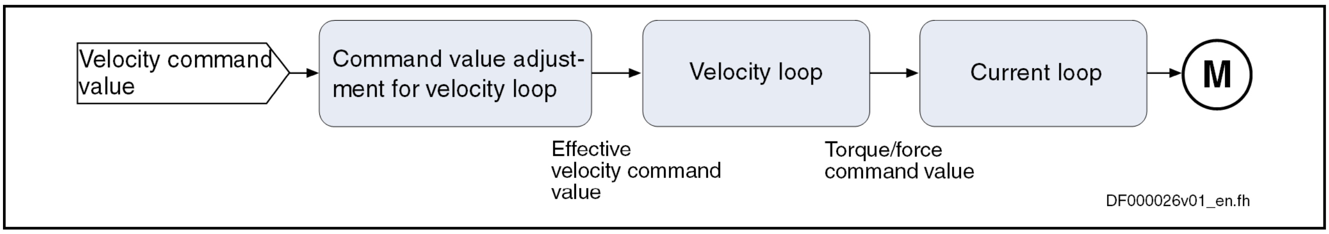


Fig. 5-47: "Velocity control" block diagram

Features

- An external velocity command value is preset (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 binary-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 takes place with selectable velocity and run-up stop that can be parameterized
- Velocity control via a digital PI controller with extensive filter measures
- Monitoring of the command velocity and actual velocity for exceeding parameter "S-0-0091, Bipolar velocity limit value"
- Additional monitoring for the motor-related limit values "S-0-0113, Maximum motor speed" and "P-0-0113, Bipolar velocity limit value of motor"
- 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 controller clock; the 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 controller internally generates the torque/force command value to which the value of the parameter can be added as an additive component
- Control word and status word especially for "velocity control" mode (P-0-1200 and P-0-1210)

Pertinent parameters

- S-0-0036, Velocity command value
- S-0-0037, Additive velocity command value
- S-0-0040, Velocity feedback value of encoder 1
- S-0-0091, Bipolar velocity limit value
- S-0-0100, Velocity loop proportional gain
- S-0-0101, Velocity loop integral action time
- S-0-0113, Maximum motor speed
- S-0-0156, Velocity feedback value of encoder 2
- S-0-0535, Active velocity feedback value
- P-0-0004, Velocity loop smoothing time constant
- P-0-0048, Effective velocity command value
- P-0-0113, Bipolar velocity limit value of motor
- P-0-0556, Config word of axis controller
- P-0-1119, Velocity mix factor feedback 1 & 2

  (not valid for MPE firmware)
- 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

5.5.4 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 controller.

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 operation mode was activated (see "Pertinent diagnostic messages" below).

Overview of the functional scope

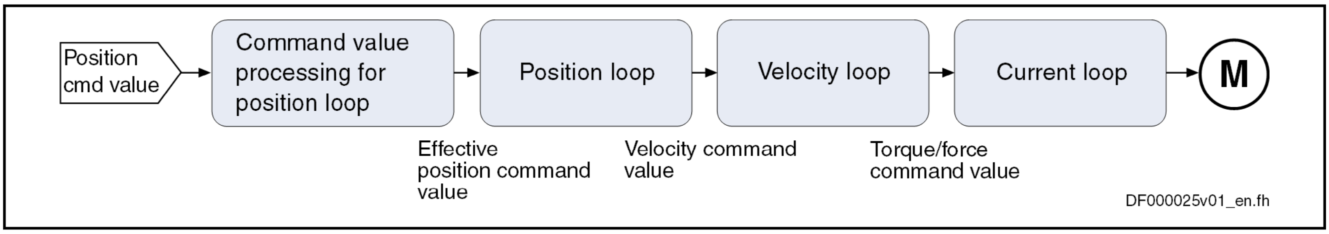


Fig. 5-48: "Position control with cyclic command value input" block diagram

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; displayed in parameter "P-0-0042, Current position command average value filter order"
- Fine interpolation of position command value of the control unit to position controller 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…150 % (default = 100 %)
- Cyclic acceptance of an additive torque/force command value of the control unit (external acceleration feedforward)

☞ The condition for this operation mode is synchronous communication between the control unit 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-0-0152, Synchronization completed
- P-0-0154, Synchronization direction
- 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 drive-side error reaction. The user is then responsible for initiating an appropriate reaction via the control master.

5.5.5 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 controller.

There are different forms of the "drive-internal interpolation" mode which result in the corresponding diagnostic messages when the operation mode was activated (see "Pertinent diagnostic messages" below).

Overview of the functional scope

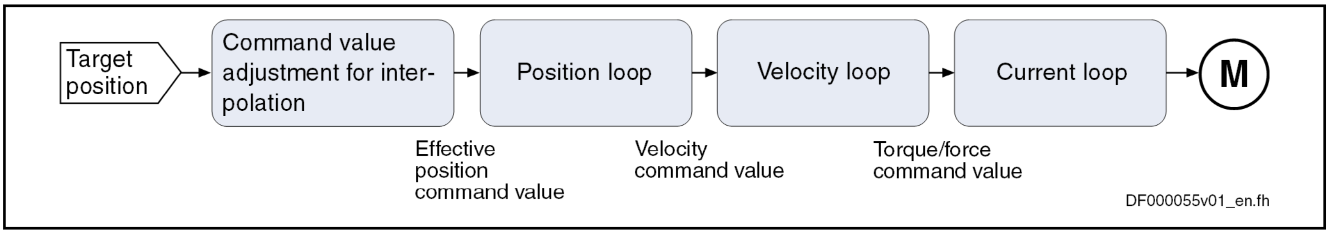


Fig. 5-49: "Drive-internal interpolation" block diagram

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 to the position controller 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"

☞ When using safety technology, the positioning velocity can be limited by "P-0-3238, SMO: Active velocity threshold" , see also "Rexroth IndraDrive, Integrated Safety Technology "Safe Motion" (as of MPx-18)" (DOK-INDRV*-SI3*SMO-VRS-AP**-EN-P; mat. no. R911338920).

☞ The initial speed of the operation mode can be limited, for one axis with safety technology, to an additional speed value [product from "SMO: active speed threshold" (P-0-3238) and "SMO: evaluation factor speed limit "(P-0-3218)] when activated in the parameter "SMO: Configuration support functions" (P-0-3219), see also the separate documentation "Rexroth IndraDrive, Integrated Safety Technology "Safe Motion" (as of MPx-18)" (DOK-INDRV*-SI3*SMO-VRS-AP**-EN-P; Mat. No. R911338920), chapter "Additional and auxiliary functions".

- 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 of encoder 1" (motor encoder) or "S-0-0053, Position feedback value of encoder 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 operation 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

5.5.6 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 a single axis to be positioned in a time-optimized way. 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 controller 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 "Pertinent diagnostic messages" below).

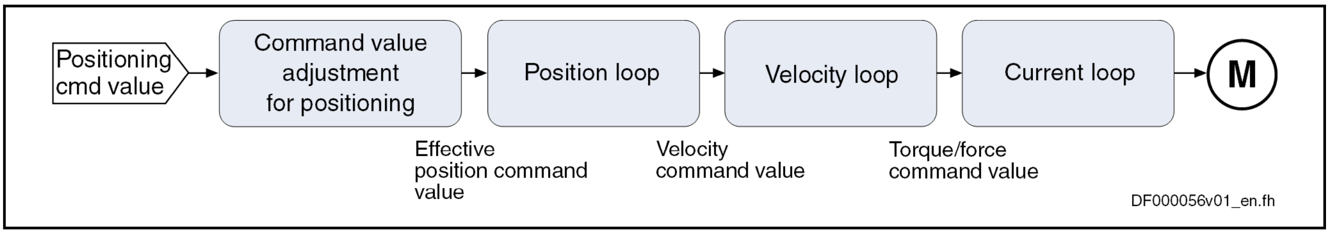


Fig. 5-50: Drive-controlled positioning block diagram

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 to the position controller 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"

☞ When using safety technology, the positioning velocity can be limited by "P-0-3238, SMO: Active velocity threshold" , see also "Rexroth IndraDrive, Integrated Safety Technology "Safe Motion" (as of MPx-18)" (DOK-INDRV*-SI3*SMO-VRS-AP**-EN-P; mat. no. R911338920).

☞ The initial speed of the operation mode can be limited, for one axis with safety technology, to an additional speed value [product from "SMO: active speed threshold" (P-0-3238) and "SMO: evaluation factor speed limit "(P-0-3218)] when activated in the parameter "SMO: Configuration support functions" (P-0-3219), see also the separate documentation "Rexroth IndraDrive, Integrated Safety Technology "Safe Motion" (as of MPx-18)" (DOK-INDRV*-SI3*SMO-VRS-AP**-EN-P; Mat. No. R911338920), chapter "Additional and auxiliary functions".

- 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 of encoder 1" (motor encoder) or "S-0-0053, Position feedback value of encoder 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

5.5.7 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.

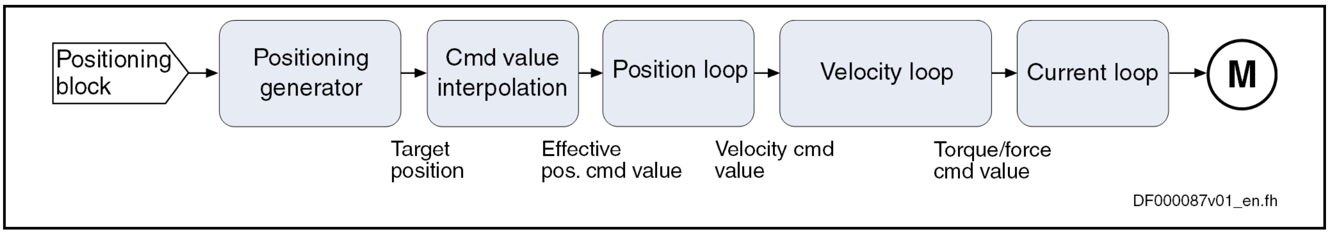


Fig. 5-51: "Positioning block mode" block diagram

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 to the position controller 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: With field bus drives, the I/O mode is an exception. In these cases, acceptance takes place by a positive 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 advancing:
  - 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

☞ When using safety technology, the positioning velocity can be limited by "P-0-3238, SMO: Active velocity threshold" , see also "Rexroth IndraDrive, Integrated Safety Technology "Safe Motion" (as of MPx-18)" (DOK-INDRV*-SI3*SMO-VRS-AP**-EN-P; mat. no. R911338920).

☞ The initial speed of the operation mode can be limited, for one axis with safety technology, to an additional speed value [product from "SMO: active speed threshold" (P-0-3238) and "SMO: evaluation factor speed limit "(P-0-3218)] when activated in the parameter "SMO: Configuration support functions" (P-0-3219), see also the separate documentation "Rexroth IndraDrive, Integrated Safety Technology "Safe Motion" (as of MPx-18)" (DOK-INDRV*-SI3*SMO-VRS-AP**-EN-P; Mat. No. R911338920), chapter "Additional and auxiliary functions".

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 unit 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
  – Executing 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

5.5.8 Synchronization modes

Basic functions of the synchronization modes

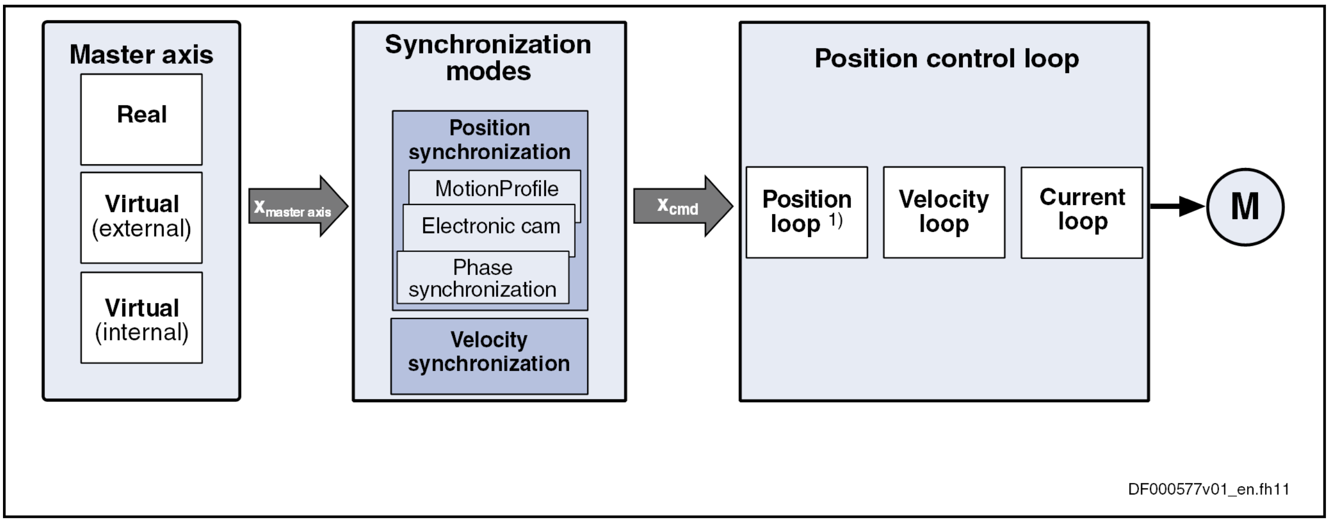
Overview

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 controller with "velocity synchronization" mode

Fig. 5-52: 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 gearbox with fine adjustment
- Drive-controlled dynamic synchronization

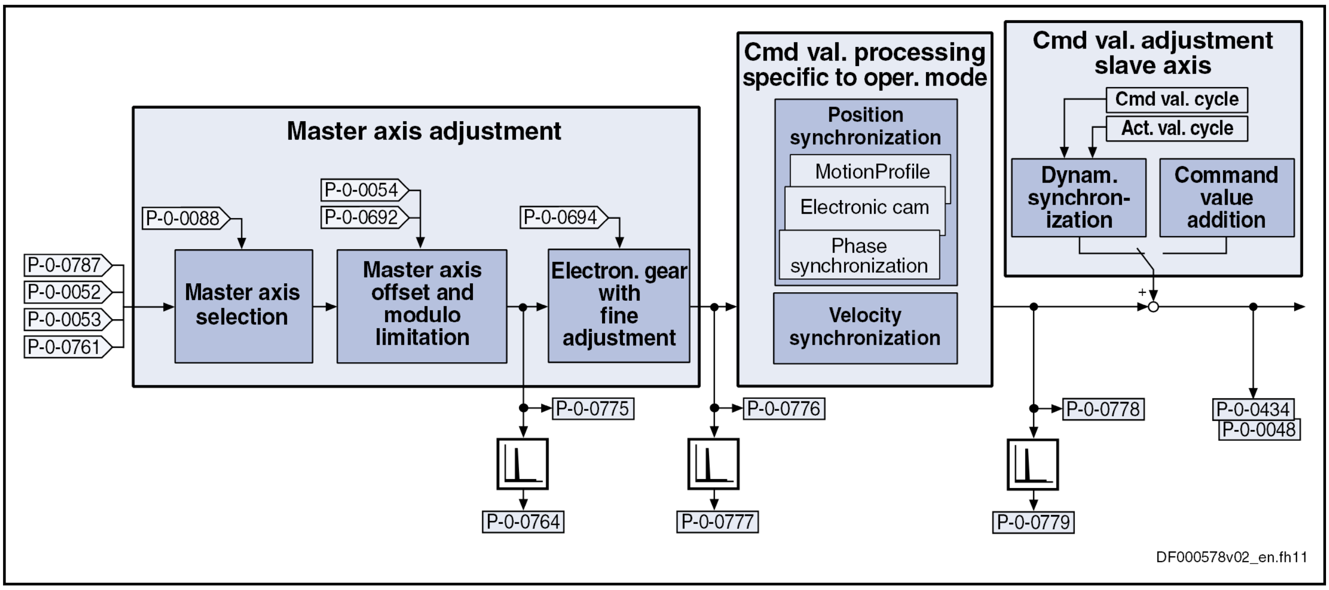
Overview of the functional scope

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-0-0088	Control word synchronization modes
P-0-0434	Position command value of controller
P-0-0692	Additive position command value, process controller
P-0-0694	Gear ratio fine adjustment, process controller
P-0-0761	Master axis position for slave axis
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. 5-53: 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 to the drive. The control unit 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 following the command values derived from the master axis is referred to as slave axis.

Command value cycle:

In processes with different machining cycles, the slave axis has to be able to synchronize over several master axis revolutions or divisions of a master axis revolution. This possibility is given via the so-called command value cycle. The modulo value of the command value cycle is calculated internally depending on the electronic gearbox (P-0-0156, Master drive gear input revolutions; P-0-0157, Master drive gear output revolutions) and the values "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 mode is active (P-0-0753, Position actual value in actual value cycle). The user can define 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 position control loop.**

The travel distance for synchronization is determined using the "actual position value in the actual value cycle" and the synchronization range that was set (see parameter description "P-0-0155, Synchronization mode") when one of the operation modes of 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, Modulo value).

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 has to be specified such that it corresponds to an integral multiple of the command value cycle or the modulo range (S-0-0103, Modulo value).

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.

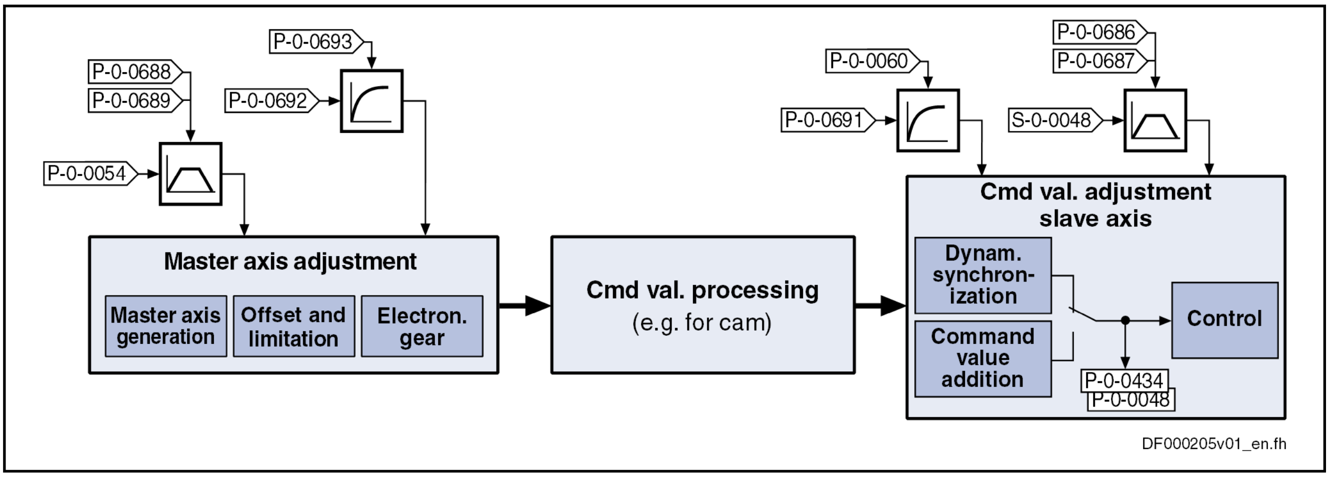


Fig. 5-54: Possibilities of command value addition for master and slave axis

Velocity synchronization with real/virtual master axis

Brief description

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

In the operation mode "velocity synchronization with real/virtual master axis", the drive follows a preset master axis velocity at a synchronous velocity.

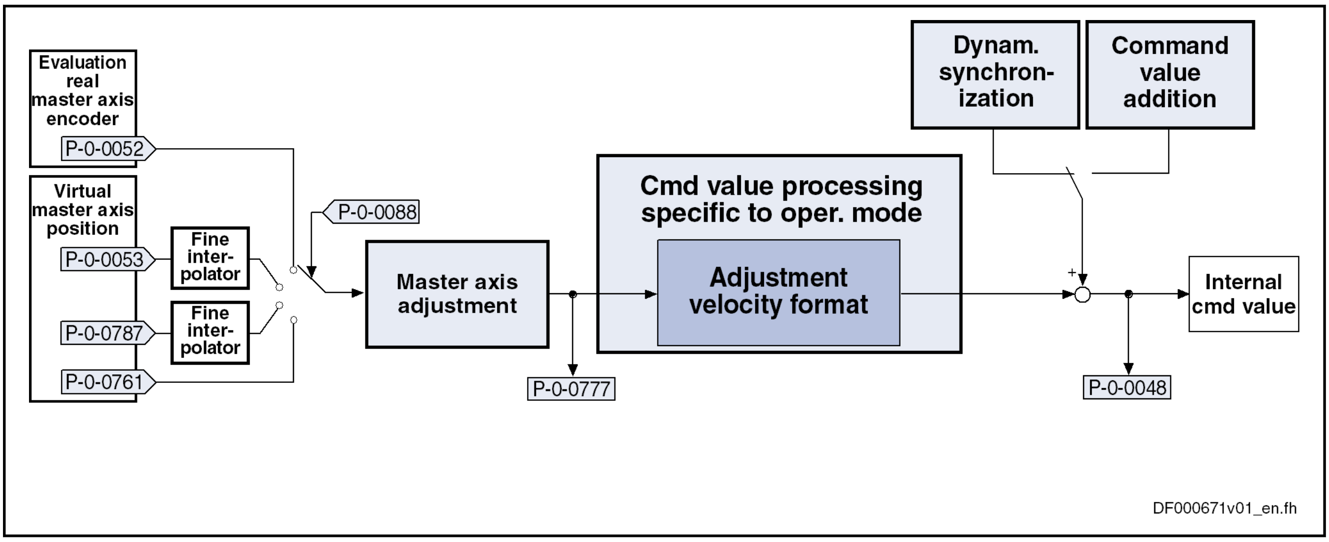
The real master axis velocity is generated by a measuring encoder; in contrast, the virtual master axis velocity is preset by the master.

See also "Dynamic Synchronization of the Slave Axis" in the section "Basic Functions of the Synchronization Modes"

Features

- Effective velocity command value (P-0-0048) determined 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 for 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-0-0088	Control word synchronization modes
P-0-0761	Master axis position for slave axis
P-0-0777	Effective master axis velocity
P-0-0787	Group axis 1 position

Fig. 5-55: 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

How to use the operation 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 gearbox. A defined tension can be set by the fine adjustment of the gearbox.

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 operation mode "phase synchronization with real/virtual master axis", the drive follows a preset master axis position in an absolute or relative phase synchronous way.

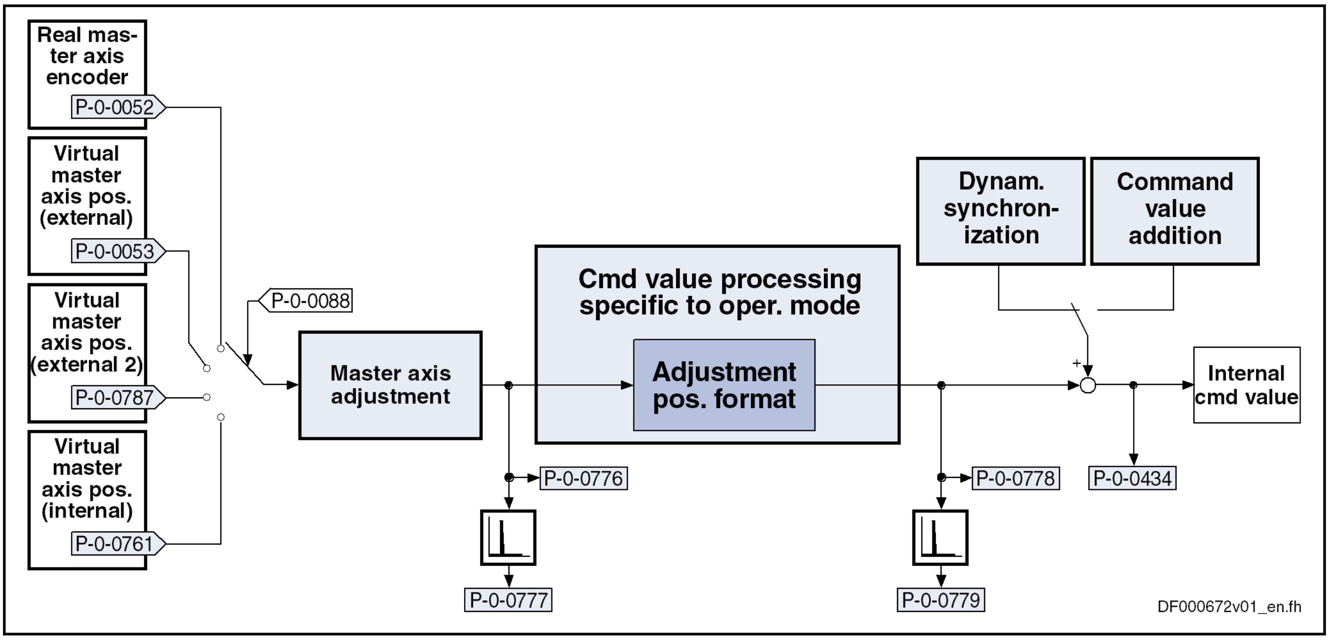
The real master axis velocity is generated by a measuring encoder; in contrast, the virtual master axis velocity is preset by the master.

See also "Dynamic synchronization of the slave axis" in the section "Basic functions of the synchronization modes"

Features

- Determining 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-0-0088	Control word synchronization modes
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
P-0-0787	Group axis 1 position

Fig. 5-56: 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 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".

"Absolute phase synchronization" application

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 "phase synchronization" mode. The drive synchronizes with a position command value that is generated from master axis position and additive position command value.

"Relative phase synchronization" application

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.

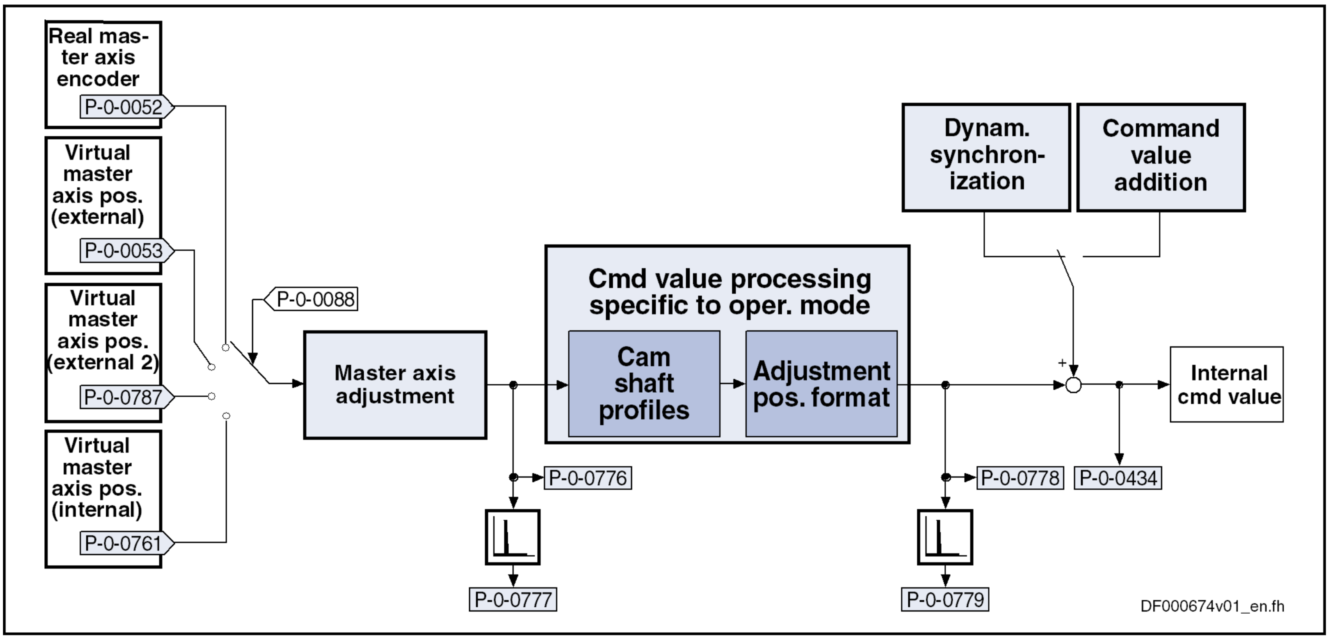
See also "Dynamic synchronization of the slave axis" in the section "Basic functions of the synchronization modes"

Features

- 4 cam tables with a max. of 1024 data points (P-0-0072, P-0-0092, P-0-0780, P-0-0781)
- 4 cam tables 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 table
- 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-0-0088	Control word synchronization modes
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
P-0-0787	Group axis 1 position

Fig. 5-57: 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, lagless

☞ The position synchronization 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".

Overview of the functional scope

Pertinent parameters

In addition to the general parameters of all synchronization modes, there are other parameters involved in this operation 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 table, 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 operation 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.

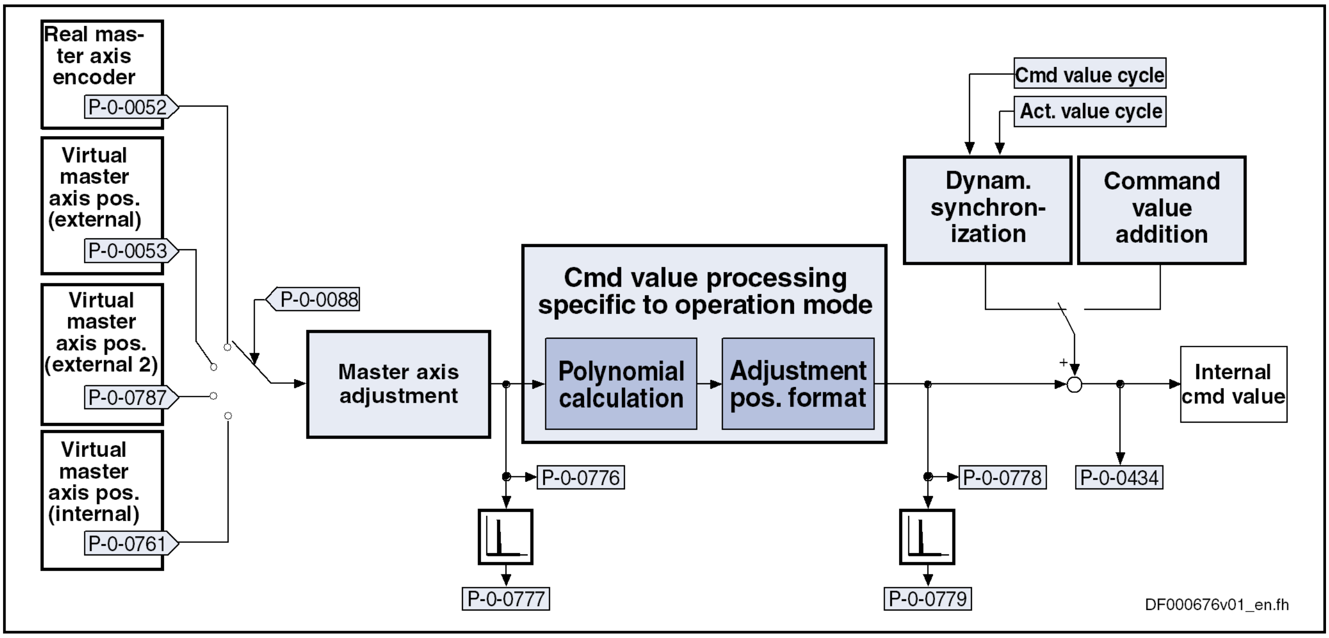
See also "Dynamic synchronization of the slave axis" in the section "Basic functions of the synchronization modes"

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 implemented by 5th order polynomial or, in the case of rest in rest, alternatively by an inclined sine curve
- Individual distance for each motion step
- Dynamic angle offset and angle offset at begin of table
- 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:

Overview of the functional scope



P-0-0052 Actual position value of measuring encoder
P-0-0053 Master axis position
P-0-0088 Control word synchronization modes
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. 5-58: Function blocks of the "MotionProfile" mode

Variants of the operation mode

The following variants can be configured:

- Position synchronization: MotionProfile
  - Motion Profile with real master axis, encoder 1
  - Motion Profile 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 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 operation 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 table, 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 operation 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"

5.5.9 CiA402 field bus profile, operation modes

Brief description

The drive supports the CAN-in-Automation profile for electric drives (CiA402). It includes a specific control word and status word, its own state machine, its own operation modes and its own scaling system.

All CANopen-specific objects are internally mapped to parameters and thus can also be reached by MLD or the oscilloscope, for example.

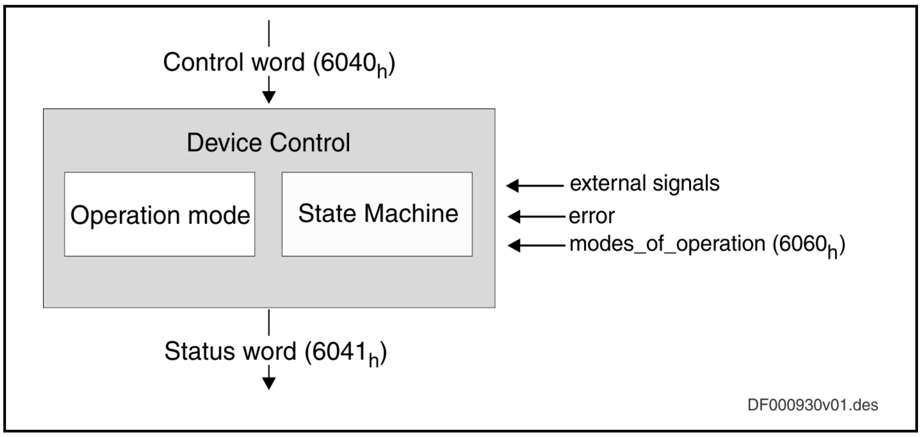


Fig. 5-59: Control word, status word

The supported CiA-specific operation modes are described in the chapters below.

The control word 0x6040 controls the drive state. The status word 0x6041 displays the state of the drive. The active operation mode is selected using the object 0x6060, the active operation mode is displayed in the object 0x6061.

There are the following influences on the state machine:

- Control word 0x6040
- External signals
- Internal signals, such as error

Control word and status word

The individual bits in the control word and status word partly have a defined significance, partly they depend on the active operation mode.

Bits in the device control word 0x6040

Bit	Name
0	Switch On
1	Disable Voltage

Bit	Name
2	Quick Stop
3	Enable Operation
4..6	Operation Mode Specific
7	Reset Fault
8	Halt
9	Operation Mode Specific
10	Reserved
11..15	Manufacturer Specific

Tab. 5-70: Bits in the device control word 0x6040

Bits in the device status word 0x6041

Bit	Name
0	Ready to Switch On
1	Switched On
2	Operation Enabled
3	Fault
4	Voltage Enabled
5	Quick Stop
6	Switch On Disabled
7	Warning
8	Manufacturer Specific
9	Remote
10	Target Reached
11	Internal Limit Active
12/13	Operation Mode Specific
14/15	Manufacturer Specific

Tab. 5-71: Bits in the device status word 0x6041

Scaling with active CiA 402

The specification CiA402 2v03000115 forms the basis of the scaling system with active CiA 402.

☞ Please always use the current specification!

Position scaling

The position data scaling is defined in the object 60A8h: SI unit position.

Exponent		Unit		Unit of time		Reserved	
31	24	23	16	15	8	7	0
MSB							LSB

Rotary:	Unit degree [41h]
	Exponent 0.. -6 [00h ..FAh]
	Other units are not supported
Linear:	Unit m [01h]
	Exponent -3.. -9 [FDh ..F7h]
	Other units are not supported
Incremental:	Exponent 0 [00h]
	(incremental scaling is not supported)
The unit of time is not required:	[00h] not defined

The position scaling uses the following conversion parameters:

- Object 608Fh: Position encoder resolution
  Position encoder resolution = encoder increments / motor revolution
- Object 6091h: Gear ratio
  Gear ratio = motor revolution / load revolution
- Object 6092h: Feed constant
  Feed constant = distance / gearbox load rev [mm/rev]
  (with rot. scaling = 1 "inactive")

The position polarity can be selected using the object 607Eh: Polarity.

Position polarity	Velocity polarity	Reserved	
7	6	5	0
MSB			LSB

Velocity scaling

The velocity data scaling is defined in the object 60A9h: SI unit velocity.

Exponent		Unit		Unit of time		Reserved	
31	24	23	16	15	8	7	0
MSB							LSB

Rotary:	Unit rev [B4h]
	Unit of time min [47h]
	Exponent 0.. -6 [00h ..FAh]
	Unit of time s [03h]
	Exponent 0.. -9 [00h ..FAh]
Linear:	Unit m [01h]
	Unit of time min [47h]
	Exponent -3.. -9 [FDh ..F7h]
	Unit of time s [03h]
	Exponent -3.. -9 [FDh ..F7h]

The velocity scaling uses the conversion parameters:

- Object 608Fh: Position encoder resolution

Position encoder resolution = encoder increments / motor revolution

- Object 6091h: Gear ratio
  Gear ratio = motor revolution / load revolution
- Object 6092h: Feed constant
  Feed constant = distance / gearbox load rev [mm/rev]
  (with rot. scaling = 1 "inactive")
- Object 6096h: Velocity factor
  Velocity scaling conversion factor

The velocity polarity can be selected using the object 607Eh: Polarity.

Position polarity	Velocity polarity	Reserved	
7	6	5	0
MSB			LSB

Acceleration scaling

The acceleration data scaling is defined in the object 60AAh: SI unit acceleration.

Exponent		Unit		Unit of time		Reserved	
31	24	23	16	15	8	7	0
MSB							LSB

Rotary:	Unit rad [10h]
	Unit of time s² [57h]
	Exponent 0.. -6 [00h ..FAh]
Linear:	Unit m [01h]
	Unit of time s² [57h]
	Exponent 03.. -9 [FDh ..F7h]

The acceleration scaling uses the following conversion parameters:

- Object 608Fh: Position encoder resolution
  Position encoder resolution = encoder increments / motor revolution
- Object 6091h: Gear ratio
  Gear ratio = motor revolution / load revolution
- Object 6092h: Feed constant
  Feed constant = distance / gearbox load rev [mm/rev]
  (with rot. scaling = 1 "inactive")
- Object 6097h: Acceleration factor
  Acceleration scaling conversion factor

As defined in CiA 402, the velocity polarity is used.

Torque/force scaling

The torque/force data scaling is percentage-based, in relation to object 6076h: Motor rated torque.

Temperature scaling

The temperature scaling can be set in Celsius or Fahrenheit using the manufacturer-specific parameter.

0x20D0 (S-0-0208, Temperature data scaling type)

Temperature data scaling

- Unit Celsius (0.1 degrees)

5.6 Extended axis functions

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

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine's range of motion (e.g., by 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".

5.6.1 Availability of the extended axis functions

For an overview that illustrates in which base or functional packages the respective extended axis function is available, see chapter "Overview of functions/functional packages, availability of the extended axis functions".

5.6.2 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 performed 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 (incl. internal PLC operation modes). Otherwise the control mode velocity is active.

With the Drive Halt configuration (P-0-0558, bit 1, bit 2), the type of control can also be freely selected.

- Bit 1 = 1, bit 2 = 1: Position control
- Bit 1 = 1, bit 2 = 0: Velocity control

With the "Drive Halt" configuration (P-0-0558, bit 0 = 1), it is possible to switch to the "operational stop" function. Then the operation modes "velocity control", "drive-internal interpolation", "drive-controlled positioning" and "positioning block" are stopped internally with Vcmd = 0. After "Drive Halt" has been removed, the motion is re-activated.

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 operating stop for the operation modes "drive-controlled positioning" and "drive-internal interpolation". However, this function has its own control signal.

Features

- Activated via the "halt bit" of master communication (see "Device Control and State Machines")
- Active operation mode interrupted; drive remains in control (after setting the "halt bit" the interrupted operation 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" takes effect during shutdown.
- "Drive Halt" acknowledged 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

5.6.3 Error reactions

Overview of error reactions

Depending on the operation mode that is used and certain parameter settings, the drive controller carries out monitoring functions. An error message is generated by the drive controller, if a state is detected that no longer allows correct operation.

Errors are classified into error classes. The error class is represented by the first two digits of the diagnostic message number.

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 that occurred
- The setting 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. The motor phase short circuit error reaction for F8xxx is an exception. Here it is possible to set that a motor phase short circuit is maintained after the error reaction was completed.

Power off depends on the setting in P-0-0118!

Overview of the functional scope

Error classes There are different error classes with increasing priority:

Diagnostics Number and Error class	Control unit reaction according to "P-0-0117, Activation of control unit reaction on error"	Power supply switched off according to "P-0-0118, Power supply, configuration"	Drive-side error reaction according to "P-0-0119, Best possible deceleration"
F2xxx Non-fatal error	■ NC ■ MLD	■	■
F28xx Non-fatal error	■ NC ■ MLD	**General shutdown** of power supply, because the errors are related to the converter's power supply	■
F3xxx Non-fatal Safety technology error	■ NC ■ MLD	■	■
F4xxx Master communication errors	- NC ■ MLD	■	■
F6xxx Emergency stop error	-	■	■
F7xxx Safety technology error	-	■	■ At the end of each F7 error reaction, the drive goes torque-free.
F8xxx Fatal error	-	■	■ At the end of the error reaction, the drive goes torque-free. It is possible to set the configuration in a manner such that the motor phase short circuit is maintained.
F8022 Fatal encoder errror	-	■	■ Only controlled deceleration is possible! At the end of the error reaction, the drive goes torque-free. It is possible to set the configuration in a manner such that the motor phase short circuit is maintained.
F83xx Fatal safety technology error	-	■	■
F9xxx Fatal system error	-	■	**Always torque disable**

Tab. 5-72: Error classes and drive reaction

☞ The error class defines the drive behavior in the case of error. The "fatal system error" (E-xxxx) has the highest priority.

Best possible deceleration

Brief description

The error reaction "best possible deceleration", which can be set in "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)
- Drive enable is removed
- Drive-controlled transition to the special mode standstill SS1ES/SS1
- Travel range errors (F6xxx)
- Safety technology errors (F7xxx)
- Fatal errors (F8xxx), if possible, or controlled deceleration in the case of F8022
- Fatal warnings (E8xxx)

One of the following reactions for "best possible deceleration" can be set in P-0-0119:

- Velocity command value reset (emergency stop)
- Velocity command value reset with ramp and filter (emergency stop)
- Velocity command value reset with ramp and filter (quick stop)
- Return motion
- Emergency stop by means of motor winding short circuit
- Torque disable

See also parameter description "P-0-0119, Best possible deceleration"

In the case of fatal system errors (F9xxx), the setting in P-0-0119 is without effect; the drive immediately goes torque-free. Shutdown on the drive side is no longer possible!

Pertinent parameters

- S-0-0138, Bipolar acceleration limit value
- S-0-0273, Maximum drive off delay time
- S-0-0349, Bipolar jerk limit
- S-0-0372, Drive Halt acceleration bipolar
- S-0-0429, Emergency halt deceleration

- P-0-0045, Control word of current controller
- P-0-0055, Return distance
- P-0-0056, Return velocity
- P-0-0057, Return acceleration
- P-0-0058, Return jerk
- P-0-0109, Torque/force peak limit
- P-0-0119, Best possible deceleration
- P-0-0525, Holding brake control word
- P-0-0569, Maximum stator frequency slope

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 the package reaction to be activated for individual axes only. 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 system"):

- Machine tools (e.g. milling, turning, grinding machines)
- Gear cutting machines (toothed wheel machining)
- Printing mechanisms of printing machines, etc.

By setting the error reaction of the drive system devices according to the application, the following damage can be minimized:

- Machine damage
- Tool/workpiece/material damage

⚠ WARNING **The package reaction is not suitable to avoid 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

Tab. 5-73: Examples of settings in P-0-0117 and P-0-0118, depending on the priority of appropriate error reactions (with general conditions)

The mentioned examples are not binding and only 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

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 in the case of error, too, 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. In this, the MLD reaction and the NC reaction are differentiated functionally insofar as by means of IndraMotion MLD, even for an interface error (F4xxx) an error reaction to be defined by the user can be executed for the (local) axis.

Prerequisite for using the MLD error reaction is the enabling of the PLC function in the drive (see "Enabling 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

5.6.4 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 a selectable drive reaction (see Parameter Description "P-0-0008, Activation E-Stop function") via a digital input of the drive controller.

There are the following options when 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, it is not necessary to clear the diagnostic message!

Pertinent parameters

- P-0-0008, Activation E-Stop function
- P-0-0119, Best possible deceleration
- P-0-0223, E-Stop input
- P-0-0249, E-Stop and safety zones

Pertinent diagnostic messages

- E8034 Emergency-Stop activated
- F4034 Emergency-Stop activated
- F6034 Emergency-Stop activated

5.6.5 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 the static friction to be compensated by adding a torque/force command value, depending on the direction of movement.

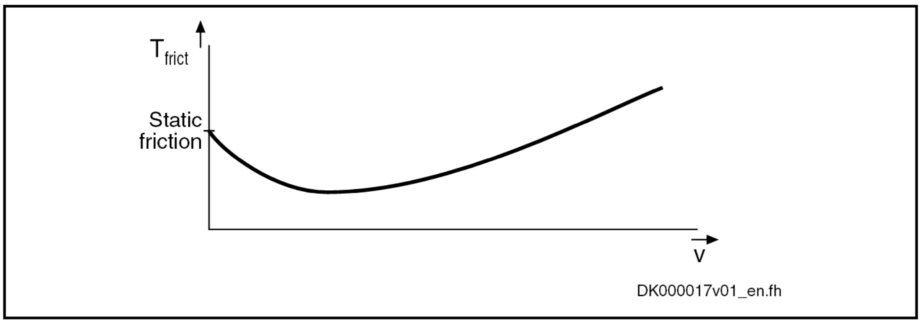


Fig. 5-60: Friction torque curve with static friction

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

IndraDrive controllers provide the following correction functions to compensate the mechanically caused position error sources:

- 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 achieved 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 drive control require an unequivocal position reference from the motor measuring system to the motor.

The range in which the cogging torque compensation takes effect can cover the entire travel range of an axis, but can also be restricted to a definable position range. The restricted position range can be less than one motor revolution (rotary motor) or one pole pair distance (linear motor). The drive controller determines the compensation values at axis motion with constant velocity and the values, depending on the direction of motion and referring to the position, are stored in tables.

Hardware requirements

The motor has to be equipped with a motor encoder. Cogging torque compensation is impossible in 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
- P-0-1145, Cogging torque compensation: Lower position limit
- P-0-1146, Cogging torque compensation: Upper position limit
- P-0-1147, Cogging torque compensation: Offset positive
- P-0-1148, Cogging torque compensation: Offset negative

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
- C4806 Cogging torque compensation: Measuring range invalid

Correcting the torque/force constant

Brief description

Fields of application

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

Displaying the motor load, load limit values

With IndraDrive devices, the current motor load is determined on the drive side and displayed. The load can be limited by means of the drive controller.

The unit of the load display and load limit value input can be selected:

- Percentage-based, in relation to the continuous motor current or nominal motor current
- Physical, 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 has to be activated separately!

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-0-0472, Motor saturation current
- 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
- P-0-3945, Motor control configuration
- S-0-0533, Nominal torque/force of motor
- S-0-0534, Maximum torque/force of motor

Pertinent diagnostic messages

- None -

5.6.6 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 the motor-operated driving rolls and the 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.

Overview of the functional scope

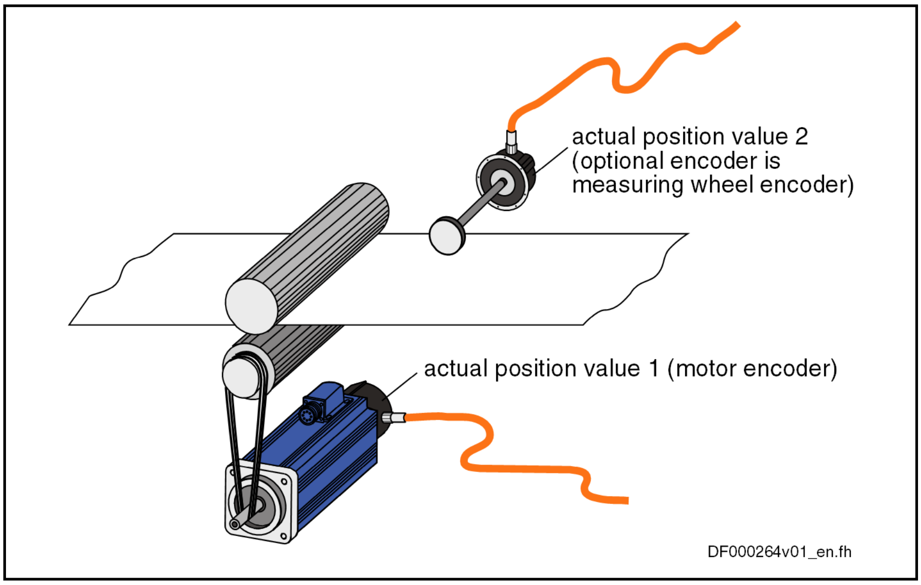


Fig. 5-61: Typical arrangement of a drive for material infeed with measuring wheel encoder

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 "Reference documentations").

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, Encoder 2, type of position encoder
- P-0-0123, Encoder 2 feed constant
- P-0-0124, Encoder 2, gear turns, mechanical system side
- P-0-0125, Encoder 2, gear turns, encoder side
- P-0-0185, Encoder 2 control word

Pertinent diagnostic messages

- F2036 Excessive position feedback difference

5.6.7 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
- S-0-0331, Status "n_feedback = 0"
- S-0-0530, Clamping torque

Pertinent diagnostic messages

- C1300 Positive stop drive procedure command
- C1301 Class 1 diagnostics error at command start

5.6.8 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 a 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!

Overview of the functional scope

Pertinent parameters

- P-0-0185, Encoder 2 control word

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

5.6.9 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 might 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

5.6.10 Parameter set switching

Brief description

Assignment to functional firmware package, see chapter "Availability of the Extended Axis Functions".

IndraDrive devices are equipped with eight parameter sets (MPB-20VRS, MPC-20VRS, MPE-20VRS) or four parameter sets (MPM-20VRS), and it is possible to switch between these parameter sets during operation. One of the switchable parameter sets is always active. Switching takes place upon command of the control master.

Notes on application

By switching parameter sets during operation, the values of certain parameters can be adjusted to the different operation phases and machining processes. This supports the workflow in flexible manufacturing plants.

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

Switchable parameter sets are available in all firmware derivatives. Under the application-related point of view, they are divided into the following groups:

- Application parameters
- Control loop parameters
- Load gear parameters
- Winding parameters
- Motor control and motor encoder parameters

Depending on the firmware derivative and the selected functional package, there are the following options:

- MPB, MPC derivatives:
  - Functional package MSP:

    8 switchable parameter sets, full range of parameters
  - Functional packages SNC, SRV, SYX:

    8 switchable parameter sets

    Application and control loop parameter groups only
- MPE derivative:

  - 8 switchable parameter sets, full range of parameters
- MPM derivative:
  - Functional package MSP:
    Full range of parameters
    4 switchable parameter sets
  - Functional packages SNC, SRV:
    Application and control loop parameter groups only

☞ In the MPB, MPC and MPM derivatives, there are no switchable parameter sets in the Open-Loop and Closed-Loop base packages. To obtain the switchable parameter sets function, an alternative functional package, such as MSP, SNC, SRV, SYX, has to be activated. The MPE derivative is an exception, since it already contains the switchable parameter sets functionality in its Open-Loop and Closed-Loop base packages.

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)

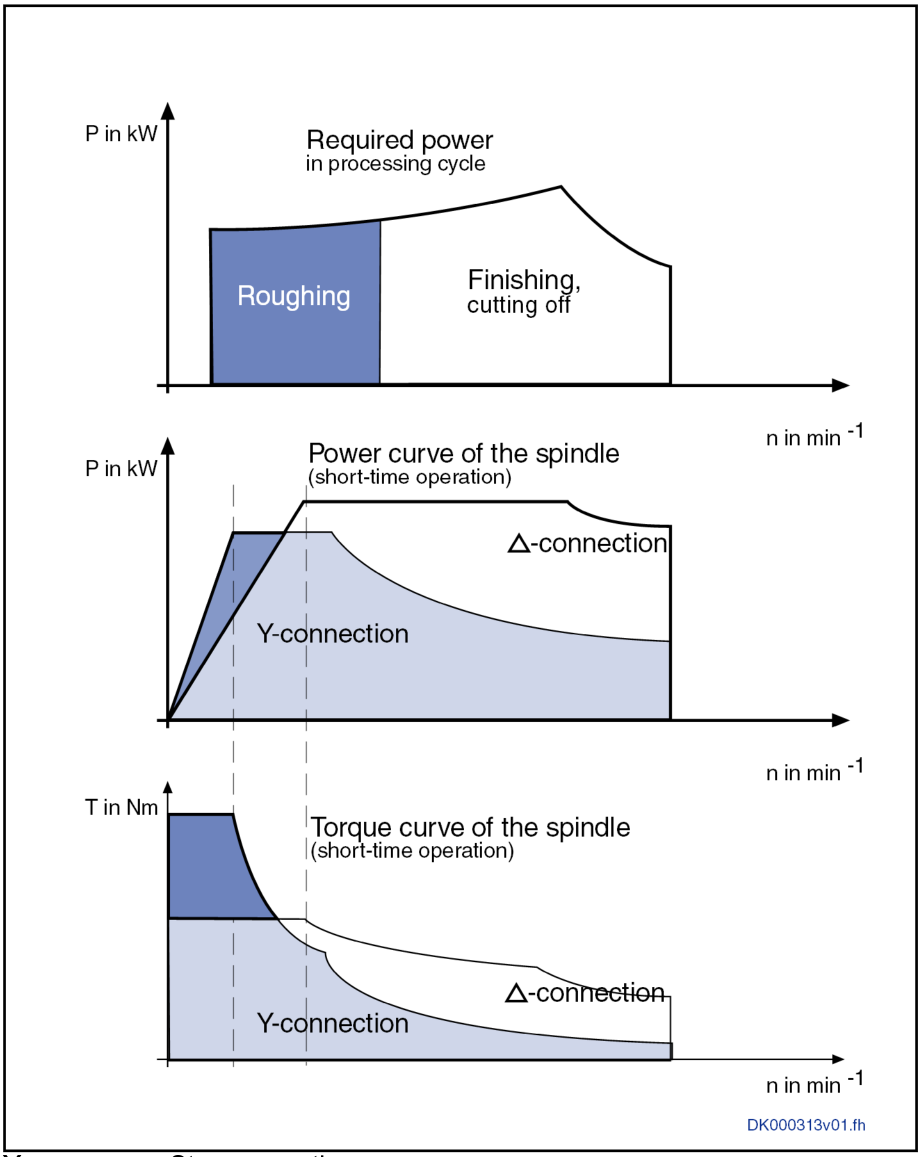
5.6.11 Star-delta switching

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 adjusted to various processing requirements:

- Material removal (roughing): High torque, low speed
- Fine-machining (finishing): High speed, low torque



Y Star connection

D Delta connection

Fig. 5-62: Schematic operating characteristics of a spindle drive with star-delta switchable motor

The spindle output capacity with star connection is just 2/3 of the output capacity with delta connection, i.e. the star-delta-switching is not a complete replacement for gear switching because the same output capacity is available for each gear stage! The increased torque in short-time operation with star connection compared to delta connection is not accompanied by an increase in the permanent torque of the spindle!

☞ Instead of with star-delta-switching, the increase in the short-time operation torque can also be achieved with an increased type current of the controller by a motor the winding of which has internally been unchangeably star-connected or delta-connected. This eliminates the contactor circuit that is not maintenance-free over the long term and with which additional wiring effort and braking problems in case of mains power failure are associated!

Star-delta switching is generally unsuitable for milling spindles, due to the long run-up times with the star connection!

Features

Motor design

Star-delta switching can only be used with Rexroth motors or with third-party motors specifically designed for this purpose. With these motors, all six winding ends of the three-phase a.c. motor are routed into the motor's terminal box. Standard motors have a fixed internal wiring and only three power connections are accessible!

Procedure of star-delta switching

IndraDrive controllers support star-delta switching of synchronous and asynchronous three-phase a.c. motors in the following way:

- Due to switchable parameters, one parameter set with all relevant motor parameters is assigned to each connection type of the motor in the controller. A functional package providing "parameter set switching" is required for this purpose.
- Star-delta switching can be performed during operation, i.e. with an active drive. The controller converts the motor control voltage to the new connection type and, in doing so, achieves the imperceptible transition of the connection types. However, the controller does not control the contactors for switching the motor windings; this must be carried out externally by the control master.
- Each connection type must be put into operation individually 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 to the other connection type is triggered by the switching of parameters (parameter set switching).

Pertinent parameters

- P-0-2216, Parameter set switching, configuration
- S-0-0216, C4100 Switch parameter set command
- S-0-0217, Preselect parameter set command
- S-0-0219, IDN-list of parameter set

Pertinent diagnostic messages

- C4100 Switch parameter set command

5.6.12 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 application

With speed oscillation the main drive supports the following applications, for example:

- Meshing the toothed wheels when switching a gear train
- Engaging form-fitting clutches (e.g., connecting i.c. engine equipment under test to test stands)

Pertinent parameters

- S-0-0190, C4200 Drive-controlled oscillation procedure command
- 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

5.6.13 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 "parking axis" function can be activated via command.

When a drive has been put into the "parking axis" state, 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. The power supply for the encoder is switched off. This allows, for example, the motor and the motor encoder to be uncoupled in the "parking axis" state 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

5.6.14 Integrated safety technology

Brief description

Optional modules of the integrated safety technology

To employ the integrated safety technology with the corresponding control sections or drive systems, at least the following firmware version or higher has to be used in the drive:

<table>
<tr><th>Device</th><th>Optional modules for IndraDrive Cs</th><th>Safety functions selected via</th><th>Firmware version</th></tr>
<tr><td rowspan="5">HCS01.1</td><td>L3, STO (Safe Torque Off)</td><td>24 V inputs at the drive controller</td><td>MPx-17V06 and above</td></tr>
<tr><td>L4, STO (Safe Torque Off)
and SBC (Safe Brake Control)</td><td>24 V inputs at the drive controller</td><td>MPx-16V14 and above</td></tr>
<tr><td>S4, Safe Motion</td><td>24 V inputs at the safety zone module "HSZ01" or safety bus</td><td>MPB/MPC-18V08 and above</td></tr>
<tr><td>S5, Safe Motion</td><td>24 V inputs at the safety zone module "HSZ01" or safety bus</td><td rowspan="2">MPx-20 and above</td></tr>
<tr><td>SB, Safe Motion Bus</td><td>Safety bus</td></tr>
<tr><td></td><td>Optional modules for IndraDrive Mi</td><td></td><td></td></tr>
</table>

Overview of the functional scope

<table>
<tr><td rowspan="2">KSM02.x</td><td>L3, Safe Torque Off (STO)</td><td>24 V inputs at the drive controller</td><td>MPB-17V08 and above (KSM02.x)</td></tr>
<tr><td>S3, Safe Motion (without SBC)</td><td>Safety bus</td><td>MPB-18V08 and above</td></tr>
<tr><td rowspan="3">KMS02.x</td><td>L3, Safe Torque Off (STO)</td><td>24 V inputs at the drive controller</td><td>MPB-17V10 and above (KMS02.x)</td></tr>
<tr><td>S3, Safe Motion (without SBC)</td><td rowspan="2">Safety bus</td><td rowspan="2">MPx-20 and above</td></tr>
<tr><td>SD, Safe Motion</td></tr>
<tr><td rowspan="2">KMS03.x</td><td>L3, Safe Torque Off (STO)</td><td>24 V inputs at the drive controller</td><td rowspan="2">MPx-20 and above</td></tr>
<tr><td>SD, Safe Motion</td><td>Safety bus</td></tr>
<tr><td></td><td>Optional modules for IndraDrive M / IndraDrive C</td><td></td><td></td></tr>
<tr><td rowspan="4">Cxx02.1</td><td>L3, STO (Safe Torque Off)</td><td>24 V inputs at the drive controller</td><td rowspan="2">MPx-18V08 and above</td></tr>
<tr><td>S4, Safe Motion</td><td>24 V inputs at the safety zone module "HSZ01" or safety bus</td></tr>
<tr><td>S5, Safe Motion</td><td>24 V inputs at the safety zone module "HSZ01" or safety bus</td><td rowspan="2">MPx-20 and above</td></tr>
<tr><td>SB, Safe Motion Bus</td><td>Safety bus</td></tr>
<tr><td></td><td>Optional modules für IndraDrive ML / IndraDrive CL</td><td></td><td></td></tr>
<tr><td rowspan="4">CSx02.5</td><td>L3, STO (Safe Torque Off)</td><td>24 V inputs at the drive controller</td><td>MPx-19V02 and above</td></tr>
<tr><td>S4, Safe Motion</td><td>24 V inputs at the safety zone module "HSZ01" or safety bus</td><td rowspan="3">MPx-20 and above</td></tr>
<tr><td>S5, Safe Motion</td><td>24 V inputs at the safety zone module "HSZ01" or safety bus</td></tr>
<tr><td>SB, Safe Motion Bus</td><td>Safety bus</td></tr>
</table>

Tab. 5-74: Integrated safety technology and required firmware

Certification

The safety technology was certified by TÜV Rheinland ®; certificates are available on the Internet or Extranet. The NRTL listing by TÜV Rheinland of North America is in preparation.

Requirements that can be realized

The integrated safety technology is independent of

- Type of master communication
- Higher-level control unit
- Supply modules

It is available as a functional characteristic of the standard drive system. The following requirements can be implemented in the machine or in the installation:

- Measures in accordance with 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 ISO 13849-1 Category 4 PL e and IEC 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 IEC 60204-1 (homogeneous redundancy).

Integrated safety technology "Safe Torque Off" and "Safe Brake Control"

Overview of safety functions

Definition

- "Safe Torque Off" means application-related safety functions which are applicable for personal protection at machines according to ISO 13849-1 Category 4 PL e and IEC 62061 SIL 3.
- "Safe Brake Control" means application-related safety functions which are applicable for personal protection at machines according to ISO 13849-1 Category 4 PL e and IEC 62061 SIL 3.

The optional safety technology modules "L3" (STO) and "L4" (STO and SBC) are used to exclusively support the safety technology function group "Safe standstill" with the following functions:

Safety technology functions	Optional modules			
	IndraDrive Cs (HCS01.1)	IndraDrive Mi (KSM02.x, KMS02.x)	IndraDrive M / IndraDrive C (Cxx02.x)	IndraDrive ML / IndraDrive CL (Cxx02.5)
The energy supply to the drive is interrupted in a safe way. The drive cannot generate any torque/force and, as a consequence, it cannot generate any dangerous motions, either.	L3, Safe Torque Off (STO) L4, Safe Torque Off (STO) and Safe Brake Control (SBC)	L3, Safe Torque Off (STO)	L3, Safe Torque Off (STO)	L3, Safe Torque Off (STO)
With "Safe brake control", the motor holding brake is switched off safely (via two channels).	L4, Safe Torque Off (STO) and Safe Brake Control (SBC)	-	-	-
With "Safe stop 1", the energy supply to the motor is safely interrupted. The motor cannot generate any torque/any force and therefore no dangerous movements. The duration of the transition to "Safe stop 1" is monitored. "Safe stop 1" (Emergency stop) is only possible in conjunction with an external, time-delayed safety selection device.	L3, Safe Torque Off (STO) L4, Safe Torque Off (STO) and Safe Brake Control (SBC)	L3, Safe Torque Off (STO)	L3, Safe Torque Off (STO)	L3, Safe Torque Off (STO)

Tab. 5-75: Safety technology functions depending on the optional modules

Notes on commissioning

Using the optional safety technology modules "L3" (STO) or "L4" (STO and SBC) does not require any kind of separate commissioning. The corresponding wiring is sufficient.

For details of the function, notes on commissioning and application examples, see separate documentation "Rexroth IndraDrive, Integrated Safety Technology as of MPx-1x (Safe Torque Off)" (DOK-INDRV*-SI3-**VRS**-APxx-EN-P; mat. no. R911332634.)

Integrated safety technology "Safe Motion"

Overview of safety functions

With the firmware MPx-20 and above, the optional safety technology modules "Safe Motion" ("S3", "S4", "S5", "SB" and "SD") make available the following functions for safe motion monitoring and safe standstill monitoring:

Safety technology function	Available with optional safety technology module					SIL	Notes
	IndraDrive Mi		IndraDrive Cs, IndraDrive M / IndraDrive C (Cxx02 control section) and IndraDrive ML				
	S3 (KMS02 and KSM02)	SD (KMS02 and KMS03)	S4	S5	SB		
Safety Zone Acknowledge (SZA) The safety technology function can only be used in conjunction with the safety zone module (HSZ01). Using "Safety zone acknowledge" and the safety zone module "HSZ", an acknowledgment master can monitor the safety of a safety zone and acknowledge the safety to a higher-level control unit. It is also possible for the acknowledgment master of the safety zone to directly control a safety door locking device connected to the safety zone module.	–	–	✓	✓	–	3	
Safe Door Locking (SDL) The safety technology function can only be used in conjunction with the safety zone module (HSZ01). The locking device of an interlocking guard is controlled via two channels when the safe zone acknowledgment signals "Safety" and the user by means of a pushbutton requests the safety door to be unlocked. The position of the locking device is safely monitored.	–	–	✓	✓	–	3	
Safe Zone Error (SZE) The safety technology function can only be used in conjunction with the safety zone module (HSZ01). The "Safe zone error" function is a subfunction of the safety function "Safety zone acknowledge". The "Safe zone error" function allows locally present safety technology errors to be signaled by the zone nodes to all zone nodes via a safe output and to trigger individual error reactions. It is also possible for the acknowledgment master of a safety zone to signal zone errors via the safe communication to the higher-level control unit.	–	–	✓	✓	–	3	
Safe Torque Off (STO) The energy supply to the drive is interrupted in a safe way. The drive cannot generate any torque/force and, as a consequence, it cannot generate any dangerous motions, either.	✓	✓	✓	✓	✓	3	
Safe Operating Stop (SOS) With the safety function "Safe operating stop", the drive is in controlled standstill, i.e. all control functions between the electronic control unit and the drive are maintained. The dual-channel monitoring prevents the drive from carrying out dangerous movements due to errors although the energy supply is not interrupted.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"

Safety technology function	Available with optional safety technology module					SIL	Notes
	IndraDrive Mi		IndraDrive Cs, IndraDrive M / IndraDrive C (Cxx02 control section) and IndraDrive ML				
	S3 (KMS02 and KSM02)	SD (KMS02 and KMS03)	S4	S5	SB		
Safe Brake Control (SBC) With the safety function "Safe brake control", the motor holding brake is switched off safely (via two channels).	–	✓	✓ *	✓ *	✓ *	3	* With IndraDrive M / IndraDrive C (Cxx02 control section) and IndraDrive ML, the safety technology function can only be used in conjunction with a control module (HAT02.1).
Safe Maximum Speed (SMS) The safety function "Safe maximum speed" by dual-channel monitoring prevents the drive from exceeding the preset velocity limit value.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safe Direction (SDI) The safety function "Safe direction" ensures by dual-channel monitoring that motion is only possible in one direction.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safely Limited Speed (SLS) The safety function "Safely limited speed" monitors via two channels that the drive does not exceed a previously defined limitation of the velocity window.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safely Monitored Transient Oscillation (SLS-LT) Using a velocity window and a tolerance time, the safety function "Safely monitored transient oscillation" monitors the transient oscillation with regard to a "Safely-limited speed".	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safely Limited Increment (SLI) The safety function "Safely limited increment" monitors via two channels that the drive moves only within the maximum increment.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safe Stop 1 (SS1) When the transition function "Safe stop 1 (SS1)" is activated, the drive is stopped in a safely monitored way. After the stopping process has been completed, the safety function "Safe torque off (STO)" is activated and the energy supply to the motor is safely interrupted. The motor cannot generate any torque/any force and therefore no dangerous movements.	✓	✓	✓	✓	✓	3	SS1, time-monitored
						2 / 3*	SS1, delay monitoring * SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safe Stop 2 (SS2) When the transition function "Safe stop 2" is activated, the drive is stopped in a safely monitored way. After the deceleration process has been completed, the safety function "Safe operating stop" is activated and it is safely prevented that the motor deviates from the stopping position by more than a specified absolute value.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safely Monitored Deceleration (SMD) Given a change in the operating status or in the case of an error reaction, the safety function "Safely monitored deceleration" monitors via two channels whether the actual velocity of the drive is within a parameterized velocity envelope curve.	✓	✓	✓	✓	✓	2 / 3*	* SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"

Overview of the functional scope

Safety technology function	Available with optional safety technology module					SIL	Notes
	IndraDrive Mi		IndraDrive Cs, IndraDrive M / IndraDrive C (Cxx02 control section) and IndraDrive ML				
	S3 (KMS02 and KSM02)	SD (KMS02 and KMS03)	S4	S5	SB		
Safely Monitored Position (SMP) The safety function "Safely monitored position" monitors whether or not the parameterized position range is exceeded in positive or negative direction.	✓	✓	✓	✓	✓	2 / 3*	With MPx-20V06 and above, available with firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS" * SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safely Limited Position (SLP) The safety function "Safely limited position " monitors via two channels that the drive can be decelerated within the parameterized **position limits** with the current velocity and the parameterized minimum delay.	✓	✓	✓	✓	✓	2 / 3*	With MPx-20V06 and above, available with firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS" * SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safely Limited End Position (SLE) The safety function "Safely limited end position" monitors via two channels that the drive can be decelerated within the parameterized **end position limit value** with the current velocity and the parameterized minimum delay.	✓	✓	✓	✓	✓	2 / 3*	With MPx-20V06 and above, available with firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS" * SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safe CAM (SCA) The safety function "Safe CAM" monitors via two channels whether or not the axis is within a position range defined by the switch-on und switch-off thresholds (cam range) and makes available the result via the status words.	✓	✓	✓	✓	✓	2 / 3*	With MPx-20V08 and above, available with firmware option (FWS) "SAFETY-PLUS" or "SIL3-PLUS" * SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"
Safe Homing Procedure With the auxiliary function "Safe homing procedure", another homing event is expected at a separate position after the functional homing procedure. The second homing event is used to verify the functional homing procedure.	✓	✓	✓	✓	✓	2 / 3*	Available in MPx-20V06 and above * SIL 3 is only attained with firmware option (FWS) "SIL3-MOTION" or "SIL3-PLUS"

Tab. 5-76: Functions for safe motion monitoring and safe standstill monitoring

Notes on commissioning

The optional safety technology modules "Safe Motion" ("S3" and "S4") are commissioned via dialogs using the "IndraWorks Ds/D/MLD" commissioning tool (supported ≥ IndraWorks 13V08).

The optional safety technology modules "Safe Motion" ("S5", "SB" and "SD") are commissioned via dialogs using the "IndraWorks Ds/D/MLD" commissioning tool (supported ≥ IndraWorks 14V10).

In the condition as supplied, i.e. also after a firmware update / firmware upgrade, the safety technology is in the following "SafetyDefault" state:

- The output stage is locked, i.e. the axis has gone torque-free
- Safety status: "Axis not safe"
- The digital local outputs have been set to "0"
- The brake output has been deactivated (an electrically releasing brake is applied)

For the functional commissioning, it is first necessary to set "P-0-3201, SMO: Configuration of functional commissioning", bit 0 = 1.

For details of the function, notes on commissioning and application examples, see separate documentation "Rexroth IndraDrive; Integrated Safety Technology "Safe Motion" (as of MPx-18)" (DOK-INDRV*-SI3*SMO-VRS-APxx-EN-P; mat. no. R911338920).

5.7 Optional device functions

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

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine’s range of motion (e.g., by 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".

5.7.1 Availability of the optional device functions

For an overview that illustrates in which base or functional packages the respective optional device function is available, see chapter "Overview of functions/functional packages, Availability of the optional device functions".

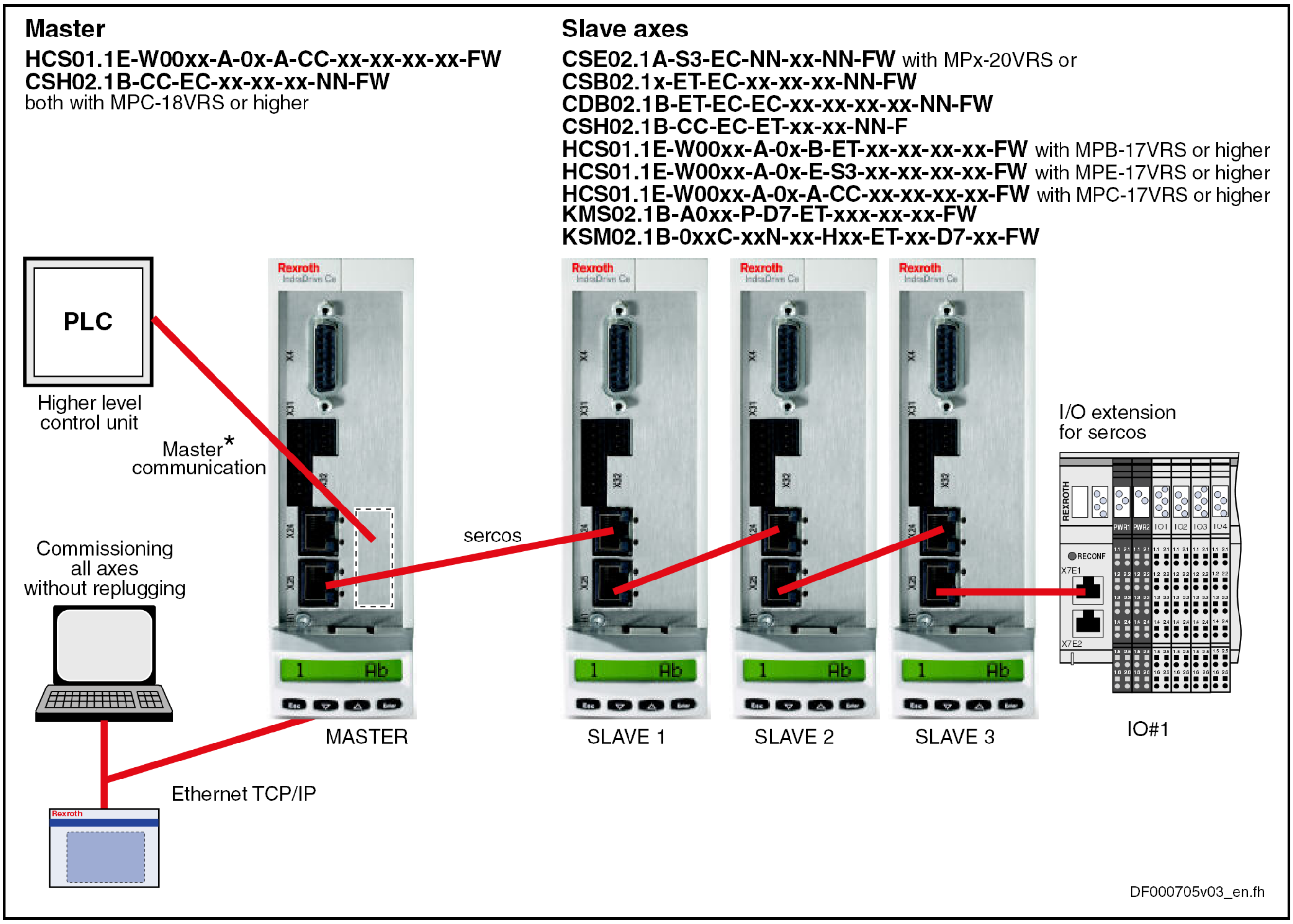
5.7.2 Cross communication (CCD)

Brief description

Overview

The IndraDrive "cross communication" device function (Cross Communication Drives → CCD) allows axes to be electronically (digitally) coupled and I/O modules to be connected for IndraMotion MLD.

Overview of the functional scope



* Master communication (MC), optional (alternatively no MC or PROFIBUS® or MultiEthernet)

Fig. 5-63: Hardware topology of drive cross communication (CCD)

Bus topology

Configuration of the CCD slaves and communication with the external control unit always takes place via the CCD master drive, as the individual CCD slaves are connected to the master via a sercos 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 master connection").

CCD modes (types of coupling)

When cross communication (CCD) is used between the drives, we distinguish the following variants (CCD modes):

- CCD system mode

  CCD slaves have a direct logic connection to the field bus master. Command triggering and input of process data take place via an external control unit.

- 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 unit, but only to MLD-M in the CCD master. MLD-M commands and inputs process data in the CCD master.

Features

The device function "cross communication (CCD)" is characterized by the following features:

- Hotplug with sercos is supported
- Synchronization of CCD slaves to CCD master
- Transmission of freely configurable external **process data** (command values and actual values of the external control unit)
- Command value linking by transmission of freely configurable process data of the CCD axes (e.g. master/slave, Gantry axis)
- SLc03 safety control is supported
- Connection of I/O extensions for sercos via CCD (a maximum of 4 modules per CCD master) (only in MLD-M system mode)
- CCD (sercos) 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 (see "sercos")
- 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, …)
- CCD slaves are commanded depending on selected CCD mode via external control unit or internally via MLD in CCD master
- Possible compensation of transmission time / dead time of the cyclic process data
- Generation of up to 3 master axis positions for master axis linking
- Max. number of CCD slaves: 7 or 9 (depends on CCD mode; see "Functional description of the CCD modes, 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 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 control units is not available in the CCD master.
- sercos I/O extensions only possible in MLD-M system mode

Hardware requirements

The drive function "cross communication" requires the following control section design:

Overview of the functional scope

CCD master	
HCS01.1E-W00xx-A-0x-A-CC-xx-xx-xx-xx-FW	IndraDrive Cs Advanced - single-axis
CSH02.1B-CC-EC-xx-xx-xx-NN-FW	IndraDrive: Advanced control section - single-axis
CCD slaves	
CSE02.1A-S3-EC-xx-xx-xx-FW	IndraDrive: Economy control section - single-axis
CSB02.1x-ET-EC-xx-xx-xx-NN-FW	IndraDrive: Basic control section - single-axis
CDB02.1B-ET-EC-EC-xx-xx-xx-xx-NN-FW	IndraDrive: Basic control section - double-axis
CSH02.1B-CC-EC-ET-xx-xx-NN-FW	IndraDrive: Advanced control section - single-axis
HCS01.1E-W00xx-A-0x-B-ET-xx-xx-xx-xx-FW	IndraDrive Cs Basic - single-axis
HCS01.1E-W00xx-A-0x-E-S3-xx-xx-xx-xx-FW	IndraDrive Cs Economy - single-axis
HCS01.1E-W00xx-A-0x-A-CC-xx-xx-xx-xx-FW	IndraDrive Cs Advanced - single-axis
KMS02.1B-A0xx-P-D7-ET-xxx-xx-xx-FW	IndraDrive Mi, distributed drive controller
KSM02.1B-0xxC-xxN-xx-Hxx-ET-xx-D7-xx-FW	IndraDrive Mi, distributed servo drive

Tab. 5-77: Hardware requirements

See documentation "Control Sections for Drive Controllers; Project Planning Manual"

Firmware requirements

When using the "cross communication" drive function, observe the following aspects regarding the firmware:

- This drive function is supported with the firmware version MPx04 and above.
- The CCD master has to be operated with a firmware of version MPC-18VRS and above.

  In this case, CCD slaves cannot be operated with MPx04 to MPx08.
- 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-0-1640, 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-0-1800.0.1, CCD: Configuration
- P-0-1800.0.10, CCD: Cycle time
- P-0-1800.0.3, CCD: Control word
- P-0-1800.0.30, CCD: Extrapolated cmd value IDN list signal selection
- P-0-1800.0.31, CCD: Extrapolated cmd value signal selection
- P-0-1800.0.32, CCD: Number of extrapolation steps
- P-0-1800.0.33, CCD: Extrapolated command value
- P-0-1800.0.5, CCD: Allowed telegram failures

- P-0-1801.0.1, CCD: Slave identification
- P-0-1801.0.10, CCD: Addresses of projected drives
- P-0-1801.0.11, CCD: Addresses of projected I/Os
- P-0-1801.0.2, CCD: Command topology addresses
- P-0-1801.0.20, CCD: Command topology
- P-0-1801.0.21, CCD: Actual topology
- P-0-1801.0.22, CCD: Slave addresses at end of line
- P-0-1801.0.23, C7100 CCD: Command Close ring
- P-0-1801.0.3, CCD: Actual topology addresses
- P-0-1801.0.4, CCD: Slave information at topology location
- P-0-1801.0.5, C7000 CCD: Command adjust slave addresses
- P-0-1802.0.1, C7400 CCD: Switching to phase 2
- P-0-1802.0.2, C7500 CCD: Switching to phase 4
- P-0-1802.0.3, CCD: Command communication phase
- P-0-1802.0.4, CCD: Actual communication phase
- P-0-1803.2.1 - P-0-1803.8.1,
  CCD: Slave address in high level network
- P-0-1803.2.11 - P-0-1803.10.11,
  CCD: Configuration list master communication cmd values
- P-0-1803.2.12 - P-0-1803.10.12,
  CCD: Configuration list master communication actual values
- P-0-1803.2.20 - P-0-1803.10.20,
  CCD: Master comm. C0100 Comm. phase 3 transition check
- P-0-1803.2.21 - P-0-1803.10.21,
  CCD: Master comm. C5200 Comm. phase 4 transition check
- P-0-1803.2.22 - P-0-1803.10.22,
  C5300 CCD: sercos SYNC delay measuring procedure command
- P-0-1803.2.24 - P-0-1803.10.24,
  CCD: Master communication gateway parameter pool 1
- P-0-1803.2.25 - P-0-1803.10.25,
  CCD: Master communication gateway parameter pool 2
- P-0-1804.1.1 - P-0-1804.10.1,
  CCD: Configuration list signal status word
- P-0-1804.1.2 - P-0-1804.10.2,
  CCD: Configuration list signal control word
- P-0-1804.1.3 - P-0-1804.10.3,
  CCD: Assignment list signal status word
- P-0-1804.1.4 - P-0-1804.10.4,
  CCD: Assignment list signal control word
- P-0-1805.1.1 - P-0-1805.10.1,
  CCD: Configuration list master cmd values
- P-0-1805.1.2 - P-0-1805.10.2,

CCD: Configuration list actual master values
- P-0-1805.1.3 - P-0-1805.10.3,
  CCD: Configuration list slave cmd values
- P-0-1805.1.4 - P-0-1805.10.4,
  CCD: Configuration list actual slave values
- P-0-1806.1.1 - P-0-1806.14.1,
  CCD: Slave IP address
- P-0-1806.1.10 - P-0-1806.14.10,
  CCD: Resource-Status (S-Res)
- P-0-1806.1.11 - P-0-1806.14.11,
  CCD: Resource-Control (C-Res)
- P-0-1806.1.2 - P-0-1806.14.2,
  CCD: Device Status (S-Dev)
- P-0-1806.1.3 - P-0-1806.14.3,
  CCD: Device Control (C-Res)
- P-0-1806.1.4 - P-0-1806.14.4,
  CCD: Connection-Control #0 (C-Con)
- P-0-1806.1.5 - P-0-1806.14.5,
  CCD: Connection-Control #1 (C-Con)
- P-0-1807.x.1, CCD connection: Configuration
- P-0-1807.x.10, CCD connection: Producer cycle time
- P-0-1807.x.11, CCD connection: Allowed losses of producer data
- P-0-1807.x.12, CCD connection: Error counter data losses
- P-0-1807.x.2, CCD connection: Connection number
- P-0-1807.x.20, CCD connection: IDN allocation of real-time bits
- P-0-1807.x.21, CCD connection: Bit number allocation of real-time bits
- P-0-1807.x.3, CCD connection: Telegram assignment
- P-0-1807.x.4, CCD connection: Max. length of connection
- P-0-1807.x.5, CCD connection: Current connection length
- P-0-1807.x.6, CCD connection: Configuration list
- P-0-1807.x.7, CCD connection: Assigned connection capability
- P-0-1807.x.8, CCD connection: Connection control (C-Con)
- P-0-1807.x.9, CCD connection: State
- P-0-1808.1.1 - P-0-1808.10.1,
  CCD: Diagnostic message number, slave
- P-0-1808.1.10 - P-0-1808.10.10,
  CCD: Active actual position value
- P-0-1808.1.11 - P-0-1808.10.11,
  CCD: Actual velocity value
- P-0-1808.1.12 - P-0-1808.10.12,
  CCD: Actual torque/force value
- P-0-1808.1.13 - P-0-1808.10.13,

CCD: Status word synchronous operation modes
- P-0-1808.1.2 - P-0-1808.10.2,
  CCD: Signal status word
- P-0-1808.1.20 - P-0-1808.10.20,
  CCD: Command value data container 1 4Byte
- P-0-1808.1.21 - P-0-1808.10.21,
  CCD: Command value data container 2, 4Byte
- P-0-1808.1.22 - P-0-1808.10.22,
  CCD: Command value data container 3, 4Byte
- P-0-1808.1.23 - P-0-1808.10.23,
  CCD: Command value data container 4, 4Byte
- P-0-1808.1.3 - P-0-1808.10.3,
  CCD: Signal control word
- P-0-1808.1.30 - P-0-1808.10.30,
  CCD: Command value data container 1, 2Byte
- P-0-1808.1.31 - P-0-1808.10.31,
  CCD: Command value data container 2, 2Byte
- P-0-1808.1.32 - P-0-1808.10.32,
  CCD: Command value data container 3, 2Byte
- P-0-1808.1.33 - P-0-1808.10.33,
  CCD: Command value data container 4, 2Byte
- P-0-1808.1.40 - P-0-1808.10.40,
  CCD: Actual value data container 1, 4Byte
- P-0-1808.1.41 - P-0-1808.10.41,
  CCD: Actual value data container 2, 4Byte
- P-0-1808.1.42 - P-0-1808.10.42,
  CCD: Actual value data container 3, 4Byte
- P-0-1808.1.43 - P-0-1808.10.43,
  CCD: Actual value data container 4, 4Byte
- P-0-1808.1.50 - P-0-1808.10.50,
  CCD: Actual value data container 1, 2Byte
- P-0-1808.1.51 - P-0-1808.10.51,
  CCD: Actual value data container 2, 2Byte
- P-0-1808.1.52 - P-0-1808.10.52,
  CCD: Actual value data container 3, 2Byte
- P-0-1808.1.53 - P-0-1808.10.53,
  CCD: Actual value data container 4, 2Byte
- P-0-1810.0.10, CCD: Diagnostic message text
- P-0-1810.0.11, CCD: Diagnosis code
- P-0-1810.0.12, CCD: Error counter Port-1
- P-0-1810.0.13, CCD: Error counter Port-2
- P-0-1810.0.15, CCD: AT error counter

- P-0-1810.0.16, CCD: Axis error
- P-0-1810.0.2, CCD: Status word
- P-0-1810.0.3, CCD: Timing settings
- P-0-1815.0.1, CCD: Master communication, synchronization input value
- P-0-1815.0.2, CCD: Master communication, synchronization output value
- P-0-1816.0.1, CCD: Master communication, synchronization counter
- P-0-1816.0.2, CCD: Master communication, synchronization P-gain
- P-0-1816.0.3, CCD: Master communication, synchronization I-gain
- P-0-1816.0.4, CCD: Master communication, synchronization error window
- P-0-1816.0.5, CCD: Master communication, synchronization delay
- P-0-1820.0.1, CCD: Master axes configuration list
- P-0-1820.0.2, CCD: Source of measuring encoder position feedback value
- P-0-1820.0.3, CCD: Actual position value of measuring encoder
- P-0-1820.0.4, CCD: Axis position selection
- P-0-1821.1.1 - P-0-1821.3.1,
  CCD: Position command value for master axis n
- P-0-1821.1.2 - P-0-1821.3.2,
  CCD: Master axis n, filter type
- P-0-1821.1.3 - P-0-1821.3.3,
  CCD: Master axis n, filter corner frequency
- P-0-1821.1.4 - P-0-1821.3.4,
  CCD: Master axis n, number of extrapolation steps
- P-0-1821.1.5 - P-0-1821.3.5,
  CCD: Master axis n, master axis position
- P-0-1822.0.1,
  CCD: Default master axis selection for the IndraDrive axes
- P-0-1822.0.2,
  CCD: Master axis selection for the IndraDrive axes
- P-0-1823.1.1 - P-0-1823.10.1,
  CCD: Default synchronization mode for axis n
- P-0-1823.1.2 - P-0-1823.10.2,
  CCD: Master axis position for axis n

☞ The standard sercos parameters (e.g., "S-0-1002, sercos: Communication Cycle time (tScyc)" etc.) are used to configure the sercos communication in the slaves.

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
- 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

5.7.3 Rexroth IndraMotion MLD (drive-integrated PLC)

Brief description

"IndraMotion MLD" provides the function of a PLC integrated in the drive in accordance with IEC 61131-3 with the following scope of functions:

- **Integrated logic control** (standard PLC tasks)
  – Compliant with IEC-61131-3
  – Online change
  – Debugging
- **Integrated multi-axis/single-axis motion control**

  → Motion function block according to PLCopen positioning and synchronization mode
  – Programming via ST, SFC, FBD and LD
  – Library management with system and user libraries
- **Basis for technology functions**

  → Examples: Following-on cutting devices, process controller (register controller, winding computation, Productivity Agent, IndraMotion for Handling, IndraMotion for Metal Forming, …

☞ This optional extension of the drive functionality is described in detail in the separate documentation "Rexroth IndraMotion MLD (2G) as of MPx18" (DOK-INDRV*-MLD3-**VRS*-AP**-EN-P; mat. No. R911338914).

Hardware requirements / characteristics

According to the design, the expansion packages "IndraMotion MLD" require one of the following control section designs:

- **IndraMotion MLD-M** (multi-axis motion control; "MPC" firmware only)
  – Single-axis device ADVANCED (HCS01.1E-W0xx-A-02-A-...)

- Single-axis control section ADVANCED (CSH02.1B-CC-EC-...)
- As stand-alone multi-axis Motion Logic Control using CCD (Cross Communication Drives) on the basis of sercos

- **IndraMotion MLD-S** (single-axis motion control; "MPB" / "MPC" firmware only)
  - Single-axis device ADVANCED (HCS01.1E-W0xx-A-02-**A**-...)
  - Single-axis device BASIC (HCS01.1E-W0xx-A-02-**B**-...)
  - Single-axis control section BASIC (CSB02.1B-ET-EC-...)
  - Single-axis control section ADVANCED (CSH02.1B-CC-EC-...)
  - Single-axis control section ADVANCED (CSH02.1B-S3-EC-...)
  - IndraDrive Mi, distributed drive controller (KMS02.1B-A0xx-P-D7-ET-...)
  - IndraDrive Mi, distributed drive controller (KMS03.1B-...
  - IndraDrive Mi, distributed servo drive (KSM02.1B-0xxC-xxN-xx-Hxx-ET-...)
  - As intelligent servo axis (extension of drive functionality) - stand-alone single-axis Motion Logic Control

Firmware requirements

In the **MPx-20VRS** firmware, the "IndraMotion MLD" function is available in the following variants:

- Advanced design (**MPC**)
- Basic single-axis design (**MPB**)

Using the "IndraMotion MLD" function generally requires the enabling of one of the additive functional packages **TF, MA, ML or ME.**

See also sections:

- "Overview of functions/functional packages"

- "Enabling functional packages"

Features/characteristic values

The functional packages "IndraMotion MLD" include the following general features/characteristic values:

- It is possible to configure up to 4 different user tasks. Possible task types:
  - Periodic (min. cycle time: 1 ms for Advanced; 2 ms for Basic)
  - Free-running (permanently cyclic)
  - Event-triggered (min. reaction time: 1 ms for Advanced; 2 ms for Basic)
- Memory resources:

  MPB-20
  - Internal code memory: 2 MB (program, constants, management)
  - Data memory: 3 MB (variables, instances, management)
  - Storage of the boot project: 650 kB in parameters, >2 MB on µSD card
  - Retain memory: 472 bytes (incl. persistent variables)

  MPC-20
  - Internal code memory: 12 MB (program, constants, management)

  - Data memory: 9 MB (variables, instances, management)
  - Storage of the boot project: 650 kB in parameters, 8 MB on µSD card
  - Retain memory: 31704 bytes (incl. persistent variables)
- Digital inputs/outputs:
  - 1…7 digital inputs, 1 switchable digital input/output at x31

    → PLC and drive share the inputs!
  - 1 relay output at x47

    → PLC and drive share the inputs!
- Analog inputs/outputs:
  - 1 analog input (+/-10 V differential input) at x32
- Inputs/outputs on remote axes:
  - Digital and analog inputs/outputs of the slaves connected to sercos can be read and written.
  - Number of inputs/outputs depends on the used hardware of the slaves
- sercos I/O
  - Evaluating Inline Block IOs - each block with 32 inputs or with 16 inputs and 16 outputs
  - Evaluating Inline Modular IOs - max. 4 bus terminals with 16 modules (nodes) each
  - Connecting up to 4 more drives as Sercos peripherals (PLC drives)

☞ A total of 4 more peripherals can be configured. Drives, Block IOs or IO bus couplers (Modular IOs, S20,...) are counted among the peripherals.

- Parameters for general purpose:
  - Parameters for process image: PII inputs
    - 20 input words of 2 bytes each
    - 8 input words of 4 bytes each
  - Parameters for process image: POI outputs
    - 20 output words of 2 bytes each
  - Global registers (4 bytes)
    - 32 buffered parameters
    - 32 unbuffered parameters
  - List parameters (4 bytes)
    - 1 list register with 8192 values (not buffered)
    - 3 list registers with 1024 values (buffered)
  - 2 global text registers with 255 characters each
  - Display format of the global registers that can be parameterized
  - Name, unit and limit values of the global registers can be configured via PLC functions
- Other features:

- Extensive debug options (Single-Step, Watch, Force/Write, Breakpoints, Powerflow)
- File access from the PLC (saving source code on μSD card, …)
- Symbol files are stored on μSD card for accessing PLC variables of the HMI
- Source download (with μSD card only)
- Access to Ethernet interface

Pertinent parameters

PLC parameters for general purpose:

- P-0-1350, PLC control word
- P-0-1351, PLC status word
- P-0-1352, PLC user program administration data
- P-0-1361, PLC program name
- P-0-1362, PLC boot project info
- P-0-1363, PLC project info
- P-0-1367, PLC configuration

User program (filing):

- P-0-1353, PLC user program area 0
- P-0-1354, PLC user program area 1
- P-0-1355, PLC user program area 2
- P-0-1356, PLC user program area 3
- P-0-1357, PLC user program area 4
- P-0-1358, PLC user program area 5

Process input images PIIs

- P-0-1390, PLC input WORD0 AT %IB0
  to
  P-0-1409, PLC input WORD19 AT %IB38
- P-0-1440, PLC input DWORD25 AT %IB100
  to
  P-0-1447, PLC input DWORD32 AT %IB128

Process output images POIs

- P-0-1410, PLC output WORD0 AT %QB0
  to
  P-0-1429, PLC output WORD19 AT %QB38

Global PLC registers, unbuffered:

- P-0-1270, PLC Global Register A0
  to
  P-0-1301, PLC Global Register A31

Global text registers, unbuffered:

- P-0-1387, PLC Global Register AT0
  to
  P-0-1388, PLC Global Register AT1

Global list register, unbuffered:

- P-0-1368, PLC Global Register AL0

Global PLC registers, buffered:

- P-0-1370, PLC Global Register G0
  to
  P-0-1385, PLC Global Register G15
- P-0-1316, PLC Global Register G16
  to
  P-0-1331 PLC Global Register G31

Global list registers, buffered:

- P-0-1389, PLC Global Register GL0
- P-0-1311, PLC Global Register GL1
- P-0-1312, PLC Global Register GL2

To configure the display format of the registers:

- P-0-1386, PLC display format Global Register

5.7.4 Digital inputs/outputs

Brief description

General information

In their basic variant, all IndraDrive systems and control sections already have configurable digital inputs/outputs.

Hardware requirements

The table below shows the number and function of the digital inputs/outputs.

Drive system / control section	Basic device (on board)		"DA" option		
	Number of standard inputs (probe inputs thereof)	Number of switchable Inputs/outputs	Number Inputs	Number Outputs	Number of switchable Inputs/outputs
HCS01.1	7 (2)	1	6	6	2
HCQ02.1, HCT02.1	16 (-)	-	-	-	-
KSM02.1, KMS02.1, KMS03.1	-	4	-	-	-
CSB02.1A, CSE02.1A	7 (2)	1	-	-	-
CDB02.1B	14 (4)	8	6	6	2
CSB02.xB, CSH02.xB	11 (2)	5	6	6	2

Tab. 5-78: Drive system / control section, number of inputs/outputs

For further hardware properties, see the respective Project Planning Manual.

Features

- Sampling of digital inputs and outputs or transmitting data to them is done in the position controller 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):
- Probe inputs are queried in steps of µs
- 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
- 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 an 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

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

Digital inputs

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

Digital outputs

- P-0-0304, Digital outputs, output image of device
- P-0-0310, Digital outputs, assignment list
- P-0-0311, Digital outputs, bit numbers
- P-0-0312, Digital outputs, assignment sub-device
- P-0-0313, Digital outputs, output image sub-device
- P-0-0316, Digital outputs, assignment connector and pin

Pertinent diagnostic messages

- F2010 Error when initializing digital I/O (-> S-0-0423)

5.7.5 Analog outputs

Brief description

Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

In accordance with the drive system or control section, IndraDrive controllers have a different number of analog outputs.

The drive function "analog outputs" allows analog signal values to be output for commissioning and optimizing drives with appropriate measuring devices (e.g., oscilloscope, multimeter), as well as for visualizing the contents of drive parameters.

Hardware requirements

The table below shows the number of analog outputs in accordance with the drive system or control section type:

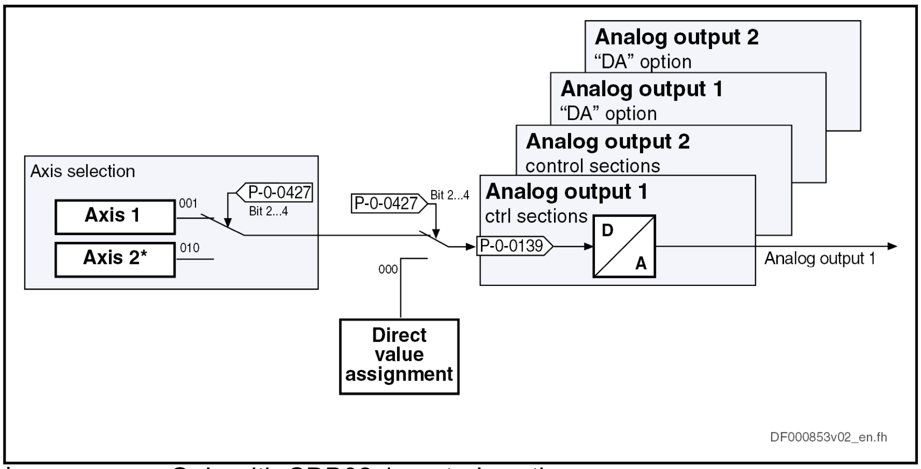
Drive system / control section	Basic device (on board)	"DA" option
	Number of analog outputs	Number of analog outputs
HCS01.1	-	2 [1)]
HCQ02.1, HCT02.1	-	-
KSM02.1, KMS02.1	-	-
CSB02.1A	-	-
CDB02.1B CSB02.1B, CSH02.1B	2	2

1) Not with HCS01 Economy

Tab. 5-79: Analog inputs

Overview

The figure below illustrates the interaction of the two analog output channels with the analog outputs.



* Only with CDB02.1 control section

Fig. 5-64: Assignment mechanism for the analog outputs

Features

General features:

- Analog outputs are updated in position controller clock (see "Performance data")
- Analog outputs can be written via master communication (cyclic or acyclic channel)
- Internal status variables and signals (= parameter contents) are output as analog voltage signals at output terminal connectors of the drive controller (see separate documentation "Control Sections for Drive Controllers; Project Planning Manual")
- Monitoring function with regard to double assignment of outputs
- Variable scaling of analog outputs
- Switching of the behavior at the limits of voltage range that can be displayed between overflow and limitation
- Parameterizable output offset or parameterizable reference value

For the technical properties of the analog inputs, see the respective Project Planning Manual.

Pertinent parameters

Configuring the analog outputs:

- P-0-0426, Analog output IDN list of assignable parameters
- P-0-0427, Control parameter of analog output

Analog output 1:

- P-0-0418, Analog output 1, signal value at 0V
- P-0-0420, Analog output 1, signal selection
- P-0-0422, Analog output 1, scaling [1/V]
- P-0-0139, Analog output 1

Analog output 2:

- P-0-0419, Analog output 2, signal value at 0V
- P-0-0423, Analog output 2, signal selection
- P-0-0425, Analog output 2, scaling [1/V]
- P-0-0140, Analog output 2

Analog output 3:

- P-0-0428, DA: Analog output 1, signal value at 0V
- P-0-0459, DA: Analog output 1, signal selection
- P-0-0463, DA: Analog output 1, scaling [1/V]
- P-0-0414, DA: Analog output 1

Analog output 4:

- P-0-0429, DA: Analog output 2, signal value at 0V
- P-0-0462, DA: Analog output 2, signal selection
- P-0-0464, DA: Analog output 2, scaling [1/V]
- P-0-0415, DA: Analog output 2

5.7.6 Analog inputs

Brief description

Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

In accordance with the drive system or control section, IndraDrive controllers have a different number of analog inputs. This allows analog voltage and current values to be processed from command values in the drive.

Hardware requirements

The table below shows the number of analog inputs in accordance with the drive system or control section type:

Drive system / control section	Basic device (on board)		"DA" option
	Number of analog inputs	Number of remote analog inputs	Number of analog inputs
HCS01.1	1	3	2 1)
HCQ02.1, HCT02.1	-	-	-
KSM02.1, KMS02.1, KMS03.1	-	-	-
CSB02.1A, CSE02.1A	1	3	-

Drive system / control section	Basic device (on board)		"DA" option
	Number of analog inputs	Number of remote analog inputs	Number of analog inputs
CDB02.1B	2	3	2
CSB02.xB, CSH02.xB	3	3	2

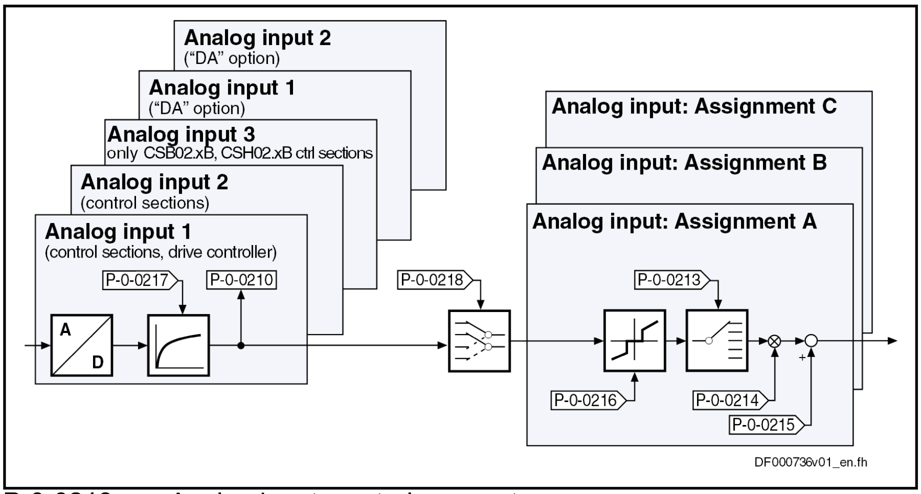
1) Not with HCS01 Economy

Tab. 5-80: Analog inputs

For further hardware properties, see the respective Project Planning Manual.

Overview

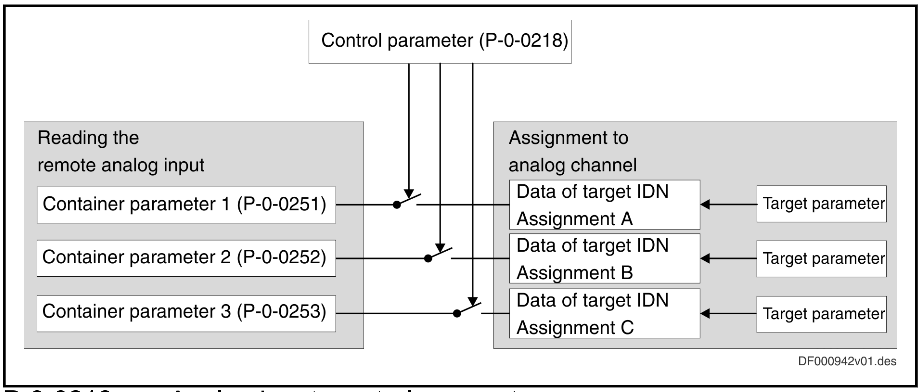
The figure below illustrates the assignment options of the analog inputs.



P-0-0218 Analog input, control parameter

Fig. 5-65: Overview: Analog input and assignment

The figure below illustrates the assignment options of the remote analog inputs.



P-0-0218 Analog input, control parameter
P-0-0251 Remote analog input 1
P-0-0252 Remote analog input 2
P-0-0253 Remote analog input 3

Fig. 5-66: Assignment options of the remote analog inputs

Features

General features:

- 3 assignment mechanisms (assignment A, B, C) with different sampling rates are possible
  - Assignment channel A works in position controller clock (see "Performance data")

  – Assignment channels B and C work in 2 ms clock
- Assignment to command value/limit value/control parameters of the drive by means of adjustable scaling
- Variable scaling
- Parameterizable dead zone to suppress zero drift
- Automatic offset and amplification adjustment via command is possible
- Low-pass filtering to be activated for the analog channel
- Analog input designed as differential input
- Parameterizable wire break monitoring
- Input voltage range of ± 10V
- Analog inputs 2 (not with CDB02.1B) and 3, as well as analog inputs 1 and 2 of optional module DA, can also be set as current inputs +/-20 mA or +4...+20 mA.
- 3 remote analog inputs can be assigned via master communication

☞ For the technical properties of the analog inputs, see the respective Project Planning Manual.

Pertinent parameters

Configuration
- P-0-0255, Analog input; hardware configuration
- 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

Analog input values:
- P-0-0210, Analog input 1
- P-0-0211, Analog input 2
- P-0-0228, Analog input 3
- P-0-0229, DA: Analog input 1
- P-0-0208, DA: Analog input 2
- P-0-0217, Analog input 1, time constant input filter
- P-0-0231, Analog input 2, time constant input filter
- P-0-0232, Analog input 3, time constant input filter
- P-0-0233, DA: Analog input 1, time constant input filter
- P-0-0234, DA: Analog input 2, time constant input filter
- P-0-0251, Remote analog input 1
- P-0-0252, Remote analog input 2
- P-0-0253, Remote analog input 3

Assignment A:
- P-0-0213, Analog input, assignment A, target parameter
- P-0-0214, Analog input, assignment A, scaling
- P-0-0215, Analog input, assignment A, signal value at 0
- P-0-0216, Analog input, assignment A, dead zone

Assignment B:

- P-0-0236, Analog input, assignment B, target parameter
- P-0-0237, Analog input, assignment B, scaling
- P-0-0238, Analog input, assignment B, signal value at 0
- P-0-0239, Analog input, assignment B, dead zone

Assignment C:

- P-0-0245, Analog input, assignment C, target parameter
- P-0-0246, Analog input, assignment C, scaling
- P-0-0247, Analog input, assignment C, signal value at 0
- P-0-0248, Analog input, assignment C, 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
- F2270 Analog input, wire break

5.7.7 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 can be used as input variable for the position synchronization modes and the "velocity synchronization" mode.

There are three ways of generating the master axis position:

- Format conversion of an actual position value or a position command value of the local axis or of an axis connected via CCD **[1]**
- Generation of 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]**

Overview of the functional scope

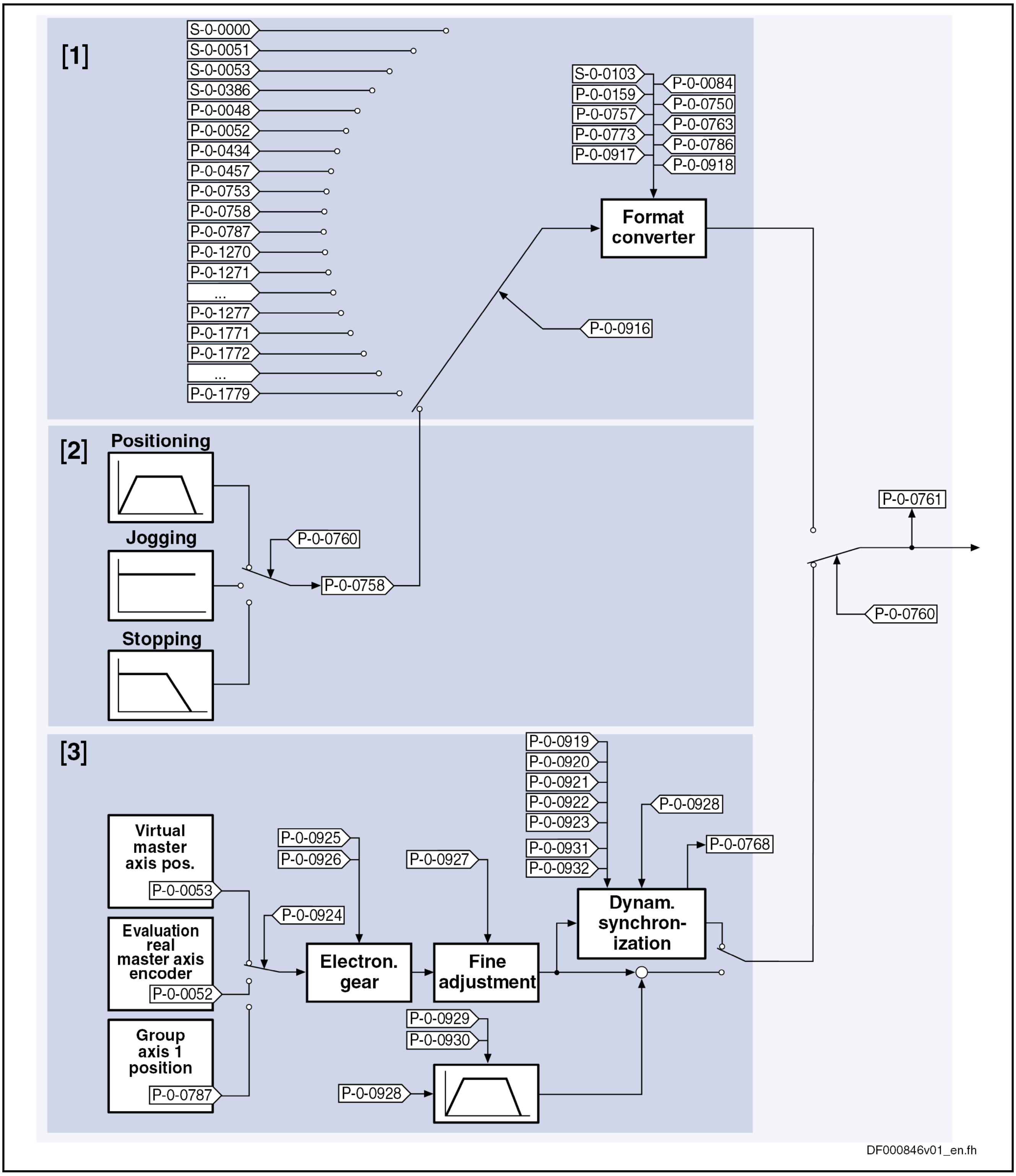


Fig. 5-67: Possibilities of generating the master axis position for the slave axis

Features

Features of the generation of 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 "virtual master axis" position format to master axis format ("virtual master axis" modulo value → $2^{P\text{-}0\text{-}0084}$ × P-0-0750 bzw $2^{P\text{-}0\text{-}0773}$ × 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 gearbox 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
- Activation by means of functional block "MB_GearInPos"; deactivation by means of 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

5.7.8 Drive-integrated command value generator

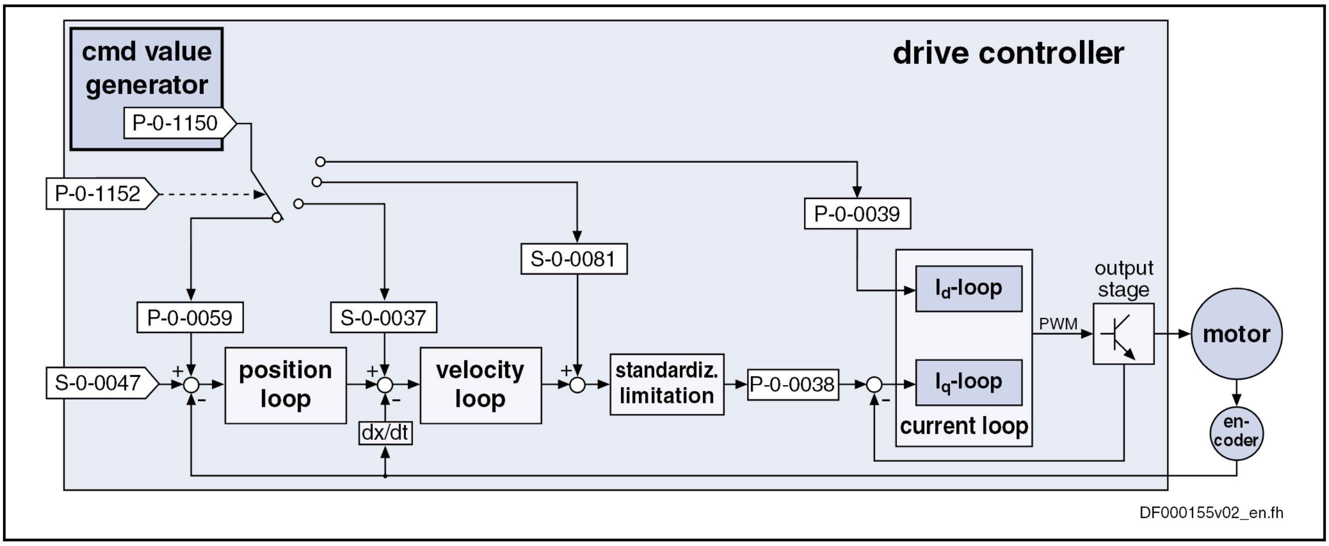
Brief description

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 shapes (square wave, sine, noise, sine sweep) that are added to the closed control loop as command values.

In conjunction with the integrated oscilloscope function, the 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. 5-68: Points at which "command value generator" function can take effect

Features

- Possibility of generating different signal shapes that are added as additive 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 controller clock; **current command values** in the velocity controller 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

5.7.9 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 provides the possibility to internally (independent of the master) generate a command value characteristic that can be defined by the user. In this way, 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"). It is only necessary to set drive enable 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".

For more details on the manual control loop setting, see section "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 motion" (reversing 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. The drive-internal command value box is activated 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

5.7.10 Encoder emulation

Brief description

Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

By means of encoder emulation is it possible to convert available encoder signals (encoder 1, encoder 2 or measuring encoder) or internal position command values into one of the following two formats:

- **Signals of an incremental encoder (track A, track B and zero pulse with 5V TTL or 24V level)**
- **Serial 24-bit position of an absolute encoder (SSI format, Gray-coded)**

The absolute encoder emulation is not yet available in this MPx20 release!

This allows, for example, evaluating the signals in a higher-level master in order to close the position control loop in the external control unit in conjunction with the freely parameterizable resolution and the data reference.

Using the encoder emulation in **precision applications** (mostly in machine tool applications) is considered as **critical** and always **has to be carefully considered** beforehand!

For sophisticated applications for which the position control loop is closed by means of emulation, Rexroth recommends to use digital interfaces, such as sercos.

See "Restrictions" in the section "Notes on commissioning"

Incremental encoder emulation

Incremental encoder emulation is the simulation of a real incremental encoder by the drive controller.

For incremental encoder emulation, we distinguish between

- Signal emulation

  - and -

- Motor encoder emulation

In the form of **incremental encoder signals**, a higher-level numeric control (NC) receives information about the velocity of the motor connected to the controller. By integration of these signals, the control unit receives the required position information and it is thereby possible to close a higher-level position control loop.

Emulation takes place in scaling-dependent (see S-0-0076) or encoder-related form, the resolution is input in lines/revolution (1 line corresponding to 4 increments) or in mm or inch.

Features of incremental encoder emulation

- Cyclic calculation of the increments output by the emulator in the position controller clock (see "Performance data")
- Freely selectable position signals for emulation (P-0-0900, P-0-0901.x.1)
- Parameterizable resolution (lines/revolution or mm resp. inch)
- Encoder-related emulation (incremental)

- Dead time compensation that can be activated (P-0-0901.x.2, Bit 3)
- Shiftable zero pulse (P-0-0901.x.4)
- Parameterizable cyclic zero pulse output for zero pulse distance (P-0-0901.x.4) and position data reference (P-0-0901.x.2)
- Encoder emulation can be switched off in operation (→ pause)
- Internal clock increase of incremental encoder emulation to reduce zero pulse jitter and frequency jitter
- Signal-related or motor-encoder-related emulation to be freely selected (→ influence on position of zero pulse!)

Absolute encoder emulation

☞ The absolute encoder emulation is not yet available in this MPx20 release!

Absolute encoder emulation means that the drive controller has the option of simulating a real absolute encoder in the **SSI data format**. It is thereby possible to transmit the position in the SSI data format to the connected control unit (NC) and to close the position control loop via the control unit.

☞ Emulation takes place in scaling-dependent form (see S-0-0076) and the resolution is input in bits.

Features of absolute encoder emulation

- Cyclic calculation of the position output by the emulator in the position controller clock (see "Performance data")
- Freely selectable position signals for emulation (P-0-0900, P-0-0901.x.1)
- Parameterizable resolution (bits)
- Scaling-related emulation (S-0-0076)
- Synchronization of SSI emulation to SSI clock

Hardware requirements

The encoder emulation function of the firmware requires the following device design:

IndraDrive Cs	
BASIC	HCS01.1E-W00xx-A-0x-B-ET-EC-EM-xx-NN-FW
ADVANCED	HCS01.1E-W00xx-A-0x-A-CC-EC-EM-xx-NN-FW
IndraDrive control sections	
Basic control section - double-axis	CDB02.1B-ET-EC-EC-EM-xx-xx-xx-NN-FW
	CDB02.1B-ET-EC-EC-yy-xx-xx-EM-NN-FW for yy = PB, EC or EM
Advanced control section - single-axis	CSH02.1B-CC-EC-EM-xx-xx-NN-FW
	CSH02.1B-CC-EC-yy-xx-EM-NN-FW for yy = ET, PB, CN or EC

Basic control section - single-axis	CSB02.1B-ET-EC-yy-xx-EM-NN-FW for yy = PB, CN or EC	
	CSB02.1x-ET-EC-EM-xx-xx-NN-FW	

PB	PROFIBUS
EC	Encoder IndraDyn / Hiperface / 1 Vpp /TTL / EnDat
EM	Encoder emulation
ET	MultiEthernet
CN	CANopen

Tab. 5-81: Control section design for encoder emulation

With double-axis control sections, encoder emulation is simultaneously possible in both axes. Requirements for device configuration: See Project Planning Manual for Control Sections.

Pertinent parameters

- P-0-0900, Encoder emulation signal selection list
- P-0-0901.x.1, Encoder emulation signal selection
- P-0-0901.x.2, Encoder emulation control parameter
- P-0-0901.x.3, Encoder emulation resolution
- P-0-0901.x.4, Encoder emulation zero pulse offset
- P-0-0901.x.5, Encoder emulation zero pulse distance
- P-0-0901.x.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

The structure instance ("x" digit) of the parameter IDN represents the optional slot of encoder emulation (EM) in the corresponding control section or HCS01 device, e.g. P-0-0901.x.1 with x = 2 means that the optional slot of the encoder emulation is slot 2.

Pertinent diagnostic messages

- C0242 Multiple configuration of a parameter (->S-0-0423)
- C0260 Incremental enc. emulator resol. cannot be displayed
- F2053 Incr. encoder emulator: Pulse frequency too high
- F2054 Incr. encoder emulator: Hardware error

5.7.11 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

- Implementing a maximum of **8 dynamic position switch points** (switch cams) in the position controller clock
- Freely **selectable reference signals** (P-0-0130) for generating the switch cams, all 8 cams refer 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)

5.7.12 Probe function

Brief description

A probe is a contact element that when activated triggers a pulse which starts a measuring process. Probes are mostly activated by axis motion over a machine part (cam etc.) at the axis mechanics. Measured values are position feedback values, points of time and time intervals. The measuring process delay opposite the triggering pulse is minimized by fast digital inputs.

Assignment to functional firmware package, see chapter "Availability of the Optional Device Functions".

Features

- 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, separately for each edge (positive/negative) up to 50000 µs
- 2 probes (S-0-0401 / S-0-0402) can be evaluated per axis.
- The two probe evaluations (S-0-0401, S-0-0402) can be assigned to any input that can handle probes. Several probe evaluations can use the

same input. For HCS01 it is the digital inputs I_1 and I_2, for HCT, HCQ it is the inputs I2 and I3.

- Measuring accuracy depends on hardware design, see section "X31, Digital inputs, digital output" and section "Digital inputs - probe" in the documentation "Rexroth IndraDrive Cs, Drive Sytems with HCS01" (DOK-INDRV*-HCS01******-PR01-EN-P; mat. no. R911322210)

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

5.7.13 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 can be connected to a shaft or axis via a gearbox and 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 dedicated 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 to adjust the actual position value to the axis or shaft once at the initial commissioning ("set absolute position").

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->interface" is used to determine the interface to which the respective encoder is connected.

For multi-axis drive controllers (HCT, HCQ), it is only possible to assign a measuring encoder to one axis. The assignment is made in parameter "P-0-0079, Assignment measuring encoder->interface". If a measuring encoder was assigned to several axes, an error message will be displayed!

For multi-axis control sections (HCQ / HCT), the measuring encoder can only be connected to the X8 interface (option 5)!

Pertinent parameters

- P-0-0052, Actual position value of measuring encoder
- P-0-0079, Assignment measuring encoder->interface
- 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, Measuring encoder gearbox revolutions, encoder side
- P-0-0128, Measuring encoder gearbox revolutions, mechanical side
- P-0-0179, Absolute encoder buffer, measuring encoder
- P-0-0328, Measuring encoder properties
- P-0-0329, Actual pos. smoothing time constant for 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-0-1022, Absolute encoder offset 3, encoder memory

Pertinent diagnostic messages

- C0291 Incorr. parameterization of measuring enc. (hardware)
- C0292 Measuring encoder unknown
- C0293 Modulo value for measuring encoder cannot be displayed
- C0294 Incorrect measuring encoder configuration
- 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 drive-side error reaction. It is then the responsibility of the user to initiate 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

5.8 Handling, diagnostic and service functions

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

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine's range of motion (e.g., by 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".

5.8.1 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 operating data to be accessed via

- the Engineering Port

- or -

- a master communication interface suited for data transfer.

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

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.

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 on an external data carrier
- Control master → saving the parameter values on a 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

Parameter values need to be loaded in the following cases:

- Initial commissioning of the motor (loading the default values and motor-specific parameter values)
- Serial commissioning of machine axes at series machines (loading the parameter values saved after initial commissioning)
- Reestablishing a defined initial state (repeated loading of the values saved after initial commissioning)
- Replacing the controller for servicing (loading the current parameter values saved before servicing)

Options for loading parameter values to the controller:

- Motor encoder data memory → loading the parameter values by command or via the control panel during initial motor commissioning
- "IndraWorks Ds/D/MLD" commissioning tool → loading the parameter values from an external data carrier
- Control master → loading the parameter values from a master-side data carrier

Checksum of parameter values

By means of checksum comparison, the control master can determine whether the values of the application-specific parameter values currently active in the drive comply with the values saved on the master side.

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-0-0660.0.1, Configurable factory default values

- 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 defaults procedure:

- 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
- C0720 SMO: Load defaults procedure command
- C0721 SMO: Load defaults procedure not possible
- C0722 SMO: Error in load defaults procedure
- C0723 SMO: Error in deactivation
- C0730 Load defaults procedure command (MLD)
- C0740 Command Activate field bus profile settings
- C0743 Error in activation of field bus profile settings
- C0750 Load defaults procedure command (factory settings)
- C0751 Parameter default value incorrect (-> S-0-0423)
- C0752 Locked with password
- C0761 Factory default values incorrect (->S-0-0423)
- C0799 An invalid index was set

Backup working memory procedure:

- C2202 Error when writing data to non-volatile memory
- C2200 Backup working memory procedure command

Load working memory:

- C2300 Load working memory procedure command
- C2301 Error when reading non-volatile memory
- C2302 Error when converting parameters

Selectively backup working memory procedure:

- C2400 Selectively backup working memory procedure command
- C2402 Error when saving parameters

Other diagnostic messages:

- F2100 Incorrect access to command value memory
- F2102 It was impossible to address I2C memory
- 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

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

- Parameters that are generally write-protected, such as motor parameters, hardware code parameters, encoder parameters, error memory, etc. ("administration parameters"). The values of these parameters guarantee the correct function and performance of the 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

5.8.2 Central Backup & Restore

Brief description

Fields of application

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 optional memory 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).

There are the following options:

- Save, restore or update an MLD project including the MLD retain data
- Save, restore or update the operating data of one or several axes
- Carry out the 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

Overview of functions

Creating a machine archive

Using the command C6500, all application-relevant data are centrally stored on the SD card of the CCD master.

- Backup operation data ("S-0-0192, IDN-list of all backup operation data")
- MLD application ("P-0-1353, PLC user program area 0" to "P-0-1358, PLC user program area 5") incl. retain data ("P-0-1359, PLC retain data"), or boot project from optional memory card
- Retain data of the device ("P-0-0192, Error memory of diagnostic numbers")
- Firmware

☞ When machine archive is created, the operating data of all CCD slaves are saved on the SD card of the CCD master. Therefore, the execution of the command might take several minutes. During this time, write access to the operating data to be saved should be avoided to ensure the consistency of the machine archive.

Restoring the device data

Using the command "C6600 Restore device data", the device data stored in the machine archive are automatically restored on all drives of the CCD group. When the replacement of a device was detected, the data of the machine archive in the strict mode are automatically loaded to the replacement device, before the progression to the operating mode takes place.

Updating the device data

It is possible to make available a valid machine archive as an update. These data are activated in the drives using the command "C6700 Update of device data".

☞ The update does not modify the retain data.

Hardware requirements

IndraDrive Cs Advanced with SD card required.

Pertinent parameters

- P-0-0665, C6500 Command Archive device data
- P-0-0666, C6600 Command Restore device data
- P-0-0668, Device data archiving, configuration
- P-0-0669, Device data archiving, status
- P-0-0195, IDN list of retain data (replacement of devices)
- P-0-1360, PLC program identifier
- P-0-1518, Module code of control section
- P-0-1521, Programming module identifier
- S-0-0030, Manufacturer version
- S-0-0192, IDN-list of all backup operation data

- S-0-0531, Checksum of backup operation data

Pertinent diagnostic messages

- C0200 Exit parameterization level procedure command
- C0201 Invalid parameters (->S-0-0423)
  to
  C0299 Configuration changed. Restart

- 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

- C2200 Backup working memory procedure command
- C2202 Error when writing data to non-volatile memory
- E2667 Machine archive is not up-to-date

5.8.3 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 state by means of drive-internal, priority-dependent generation of diagnostic messages

> ☞ With MPx-18 and above, the diagnostic message number is generated in accordance with the sercos specification. For this purpose, the bits 31-24 in the parameter "S-0-0390, Diagnostic message number" are written, too; these bits were always "0" in previous versions. In the control panel and in IndraWorks dialogs, these bits are hidden so the display remains unchanged there.
>
> If the diagnostic messages are to be displayed in S-0-0390 as in the previous versions, bit 0 has to be set in "P-0-0006, Diagnostic message configuration".

- Collective messages for various status messages

Additionally, there are parameters for all important operating data 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-0-0375, Diagnostic numbers list
- S-0-0390, Diagnostic message number
- S-0-1302.0.3, Application type
  (S-0-0142 only exists as a legacy (or alias) parameter for S-0-1302.0.3.)
- 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 (status 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)

Operating hours counter

Extended diagnostic possibilities

Brief description

There are operating hours counters available in the drive that separately record the operating times for control section and power section. The respective operating time is displayed in the parameters P-0-0190 or P-0-0191. These times are directly stored from the control section or power section so that assignment is maintained also for servicing.

Pertinent parameters

- S-0-1305.0.1, System time
- S-0-1305.0.2, System fine time
- S-0-1305.0.3, System coarse time

- P-0-0190, Operating hours control section
- P-0-0191, Operating hours power section

The parameter "P-0-0190, Operating hours control section" displays the operating time of the control section 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.

The 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 the power section and control section have been separated.

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
- P-0-0194, Error memory power section

The contents of the parameters P-0-0192 and P-0-0193 are stored on the control section. The content of parameter P-0-0194 is stored on the power section.

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.

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 unequal zero
  - Motor temperature is greater than 10 K below the 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 as a criterion e.g., for axis mechanics lubrication intervals.

Pertinent parameters

- S-0-1300.20.12, Serial Number; motor (motor encoder memory version 7)

  alias "P-0-2584, Serial Number"
- 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; (motor encoder memor version ≥ 4.3)
- P-0-2055, Serial number, motor; (motor encoder memor version 7)

Load preview

Brief description

When operating electric drives, there also is power dissipation when the motor delivers power or torque/force. For electrical equipment and electrical components, there is a maximum allowed operating temperature due to the materials used up to which the equipment can be operated safely in the long term. This temperature determines the allowed continuous load of the electrical components.

Overload capacity

The temperature rise of electrical components based on current supply runs in parallel with their thermal time constants. As long as the maximum allowed operating temperature has not been reached, an electrical component can be overloaded, that is to say short-term operation with more than the allowed continuous load. This causes the temperature rise to occur more quickly but does not pose a problem as long as the permissible operating temperature is not exceeded.

If the allowed operating temperature is reached, the overload must be reduced to the allowed continuous load so that the electrical component is not damaged. Rexroth drives feature overload limiting functions for the various drive components relevant to performance:

- Motor
- Inverter of the controller
- Braking resistor of the supply unit or converter

Protective functions

The functions for protection against inadmissible load are provided on the hardware or firmware side:

- Hardware-side temperature measurement in the motor windings and at the controller's heat sink
- Firmware-side temperature model calculation for temperatures at temperature-sensitive components not measurable on the hardware side.

With hardware-side temperature measurement, only the temperature rise processes that take place in the seconds range can be recorded; the temperature rise that takes place more quickly can only be monitored using firmware-side model calculation anyway.

Overload limitation

The high overload capacity of electric drives can only be realized such that operational safety is ensured by using temperature model calculation and automatic overload limits:

- Current limitation by controller temperature model (inverter)
- Current limitation by motor temperature model

- Power limitation with braking resistor temperature model

Load preview

Limits that intervene automatically do protect the electrical components from damage, but also affect the torque or power output of the drive and can lead to shutdown due to resulting errors or rejects during processing. Early detection and reporting of threatening limitations is possible with the "load preview" function for the three temperature model calculations mentioned above:

- Running the machining cycle with the heaviest load
- Determining the difference of the load curve (difference between maximum value and start value)
- Determining a threshold value fo the load at which the expected load difference is still just possible without reaching the limit
- Signaling when the thermal load has reached the defined threshold value.

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

5.8.4 Control panel

Brief description

IndraDrive controllers are equipped with a control panel.

The control panel fulfills the following 2 main functions:

1. Storing the device data incl. firmware, parameters and retain data. An optional SD card can be plugged in the optional SD card slot at the left side of the control panel to obtain memory space that can be used in applications.
2. Displaying basic information and executing selected basic functions using 4 keys (Up, Down, Enter, Esc).

As a standard, the control panel display shows current operating states, command and error diagnostics, as well as any present warnings. In addition, the display always shows the currently valid master communication address of the device.

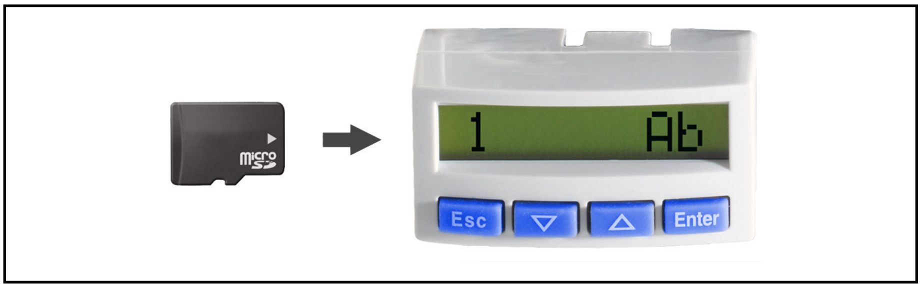


Fig. 5-69: Control panel of IndraDrive Cs Advanced with optional memory card

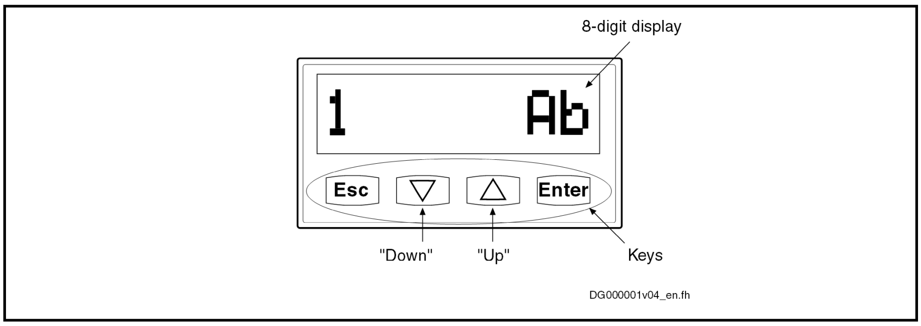


Fig. 5-70: Schematic illustration of the IndraDrive Cs control panel

The four keys can be used to display extended diagnostic messages and trigger simple commands (in addition to master communication, IndraWorks or NC control). The menus are all in English; any present diagnostic and error messages are displayed in the language set in parameter "S-0-0265, Language selection".

Display options of the control panel

The display of the IndraDrive controller automatically shows

- Status of the master communication
- Operating status
- Commands and diagnostic command messages
- Warnings and diagnostic error messages
- Extended displays such as contents of type designation of firmware active in the device or safety technology code (if safety technology option available)

Control panel variants

There are the following control panel variants

1. Standard control panel
2. Advanced control panel incl. slot for optional memory card

   The Advanced control panel is available for Advanced, Basic and Economy devices. It features an additional memory that makes available a high quantity of retain data for MLD. This function is only available for Advanced devices.

   In addition, the Advanced control panel features an SD card slot for an optional memory card. When using the opt. memory card, extended functions are available in the drive:

   2.1 Backup and Restore function

   2.2 File storage using an FTP server

   2.3 Memory space that can be used in applications for MLD (not for Economy)

As a standard, Advanced devices are supplied with an Advanced control panel, for Basic and Economy devices it can be optionally ordered.

3. VCP operator terminal, optional

   As an option, an operator terminal can additionally be connected to the drive via an Ethernet connection. VR operator terminals are freely programmable, i.e. it is possible to implement application-dependent settings and diagnostic messages.

Setting options using the control panel

The following settings can be made using the control panel:

- Setting the 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

Activating commands via the control panel

The following commands can be activated using the control panel:

- Activating "S-0-0262, C07_x Load defaults procedure command" (loading controller parameters or basic parameters)
- Activating other commands, such as:
  – C0300 Set absolute position procedure command
  – C2000 Command Release motor holding brake

Configuring the control panel

The main menu can be reached via the Enter key. The control panel can be configured to a limited extent:

- It is possible to choose between the edit mode and the view mode of the control panel.
  – "P-0-0680, Control panel: Configuration", bit 14 = 0, Edit Mode,

    changes can be made using the control panel.
  – "P-0-0680, Control panel: Configuration", bit 14 = 1, View Mode,

    editing via the control panel is disabled. If the modification screen is activated on the display for a datum which basically can be changed, the "Edit disabled" message is generated, it is impossible to change the value.

    However, a temporary edit mode can be activated by keeping ESC +ENTER pressed for 8 seconds. If the main menu is started in this way, parameters can be adjusted as usual.
- Before a value is changed, the additional "OK?" query is displayed. It has to be confirmed with the ENTER key before a value is actually changed. This is to prevent accidental changes.
- Bit 15 = "1" in "P-0-0680, Control panel: Configuration" can be used to deactivate the output of diagnostic texts. In this case, the diagnostic message number is always output, the diagnostic text is not displayed.

5.8.5 Firmware replacement

Brief description

Basic principles

Explanation of terms

The following cases are distinguished for firmware exchange:

- **Release update**

  An old firmware release contained in the device (e.g. MPB20V**04**) is replaced by a new firmware release (e.g. MPB20V**06**).
- **Version upgrade**

The old firmware version contained in the device is replaced by a new firmware version (example: MPB**18**V10 is replaced by MPB**20**V06).

- **Release downgrade**

  A new firmware release contained in the device (e.g. MPB20**V06**) is replaced by an old firmware release (e.g. MPB20**V04**).

- **Version downgrade**

  The new firmware version contained in the device is replaced by an old firmware version (example: MPB**20**V06 is replaced by MPB**18**V10).

☞ The following chapters regarding the release update, release downgrade, version upgrade und versions downgrade exclusively apply to devices of the IndraDrive Cs type, as well as control sections (CSB02, CSH02, CDB02, CSE02) and IndraDrive Mi (KSM02, KMS02, KMS03). This information does **not** apply to IndraDrive HCQ / HCT, but is described in the separate documentation "Rexroth IndraMotion MTX micro12VRS System Description" (DOK-MTXMIC-SYS*DES*V12-PR01-EN-P, mat. no. R911334369).

Procedure

Firmware for IndraDrive can be replaced using the following hardware and software:

- Computer with FireFox or Internet Explorer web browser or
- Computer with "IndraWorks" software or
- Computer with TFTP client
- IndraMotion Service Tool (IMST) or IndraDrive Service Tool (IDST) (with MPx18V10 and above)

☞ "IndraMotion Service Tool (IMST)" or "IndraDrive Service Tool (IDST)" allow accessing the drive system, e.g. for remote diagnostics. Besides, authorized users can handle different service cases with IMST or IDST, such as replacing drive components, loading parameters or updating/upgrading the drive firmware.

"IndraMotion Service Tool (IMST)" additionally analyzes drive systems connected via cross communication (CCD). Further information on "IndraMotion Service Tool (IMST)" and "IndraDrive Service Tool (IDST)" is described in the separate documentation „Rexroth IndraDrive Service Tools IMST/IDST“ (DOK-IM*MLD-IMSTIDSTV13-RE**-EN-P; mat. no. R911342652).

☞ The "IndraWorks" commissioning software can be ordered from Rexroth.

The scope of supply of "IndraWorks" contains a documentation which describes the operation of the program.

To be noticed

After every firmware replacement (release update/downgrade and version upgrade/downgrade), check the following parameters for validity:

- P-0-2003, Selection of functional packages
- P-0-4089.0.1, Master communication: Protocol

It might possibly be necessary to set them valid during the first run-up after the firmware replacement.

IndraDrive HCQ / IndraDrive HCT

The firmware replacement for "IndraDrive HCQ"/"IndraDrive HCT" is described in the documentation "Rexroth IndraMotion, MTX micro 12VRS, System Description" (DOK-MTXMIC-SYS*DES*V12-PR01-EN-P, material number R911334369).

Preparations and conditions for firmware replacement

Preparing the firmware replacement

Make the following preparations for firmware replacement:

1. Drive controller must be on (24 V supply).
2. Drive controller should **not** be in operating mode (communication phase 4) [cf. P-0-0115].
3. It is recommended to save the backup parameters before replacing the firmware (see Functional Description "Loading, storing and saving parameters").

General notes on how to proceed

Observe the following points when carrying out the firmware replacement:

- For firmware replacement via IndraWorks or IndraMotion Service Tool (IMST) resp. IndraDrive Service Tool (IDST), Ethernet communication with the drive has to be possible. (IMST and IDST are available with MPx18V10 and above.)
- Do not switch off the 24 V control voltage while replacing the firmware.
- The firmware replacement always has to be carried out completely.

Communication types

The engineering communication works in different ways, depending on the activated bus system (cf. P-0-4089.0.1). The settings and conditions have to be made and complied with according to the bus system used. For further information see "chapter TCP/IP communication".

Via the programming module, the active IP settings can be viewed or adjusted, if necessary (see Functional Description "Standard control panel").

☞ After the IP settings have been changed, the device has to be restarted to activate the settings. If several devices have been connected via the master communication bus, you have to make sure that an unequivocal IP address is assigned to each node.

IP configuration in the Easy Menu

See Functional Description "Standard control panel"

IP settings on the computer

See Microsoft help, keyword "LAN connection"

Firmware release update

General information

Before the firmware release update, it is recommended to save the backup parameters of the drive!

☞ If the firmware is replaced for a device with active Safe Motion, this procedure has to be recorded in the machine logbook, together with the axis identifier (P-0-3235.0.1), configuration type data (P-0-3234.0.1) and parameterization type data (P-0-3234.0.4).

Firmware release update with a computer

> ☞ If the safety technology options Sx (S3, S4, S5, SB, SD) are used, the system checks whether firmware and parameter set are compatible. This prevents the safety technology from being operated with an incompatible parameter set. Incompatible changes typically do not occur in the case of a release update. In the case of an incompatibility, it is possible to either
>
> - continue with the existing parameterization by reloading the originally available firmware, or
> - continue with the new firmware by means of initial commissioning (incl. loading of basic parameters for SMO contained therein)

1. Connect the drive to the computer (recommended: Cat5e Ethernet cable)
2. Load firmware

   There are three possibilities of performing a firmware release update using a computer:

   - Using IndraWorks
   - With a TFTP client
   - Via the supplied web interface IMST or IDST.

     This option only applies to firmware updates of MPx18V10 and above; IMST and IDST are not available for older versions.

   1. *Firmware download with IndraWorks*

      1.1 Call "IndraWorks".

      1.2 Load project for the 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 the upper part of the dialog and start firmware download via "Download" button.

      Firmware download runs automatically and all required firmware components are loaded to drive.

      1.6 After firmware download has been completed, close "Firmware management" window.

   2. *Firmware download with a TFTP client*

      2.1 The firmware update service is made available via a TFTP server. The command for transmitting the firmware is the "put" command. The TFTP client has to transmit the file in the binary format.

☞ It is possible to carry out a firmware release update **without IndraWorks** with any TFTP client supporting this command (e.g., Windows command line program "tftp.exe").

Example (with "Microsoft Windows consoles TFTP client"):

To carry out a firmware release update, only a "put" request is transmitted. Do not use an optional alternative name for the file on the target. The IP address of IndraDrive has to be specified as the target (the standard is 192.168.0.1): `tftp -i 192.168.0.1 put FWA-INDRV_-MPB-17V12-D5.ibf`

The parameter "-i" means that the file is to be transmitted in binary form.

See also Functional Description: "Firmware download via TFTP server"

3. *Firmware download with IMST/IDST (with MPx18V10 and above)*
   - 3.1 Enter IP address of IndraDrive in web browser
   - 3.2 Log in as service user at web interface
   - 3.3 In navigation tree on the left side select "Firmware update" dialog in "Service" folder
   - 3.4 Select new firmware by clicking "Search" button, firmware update is started by clicking download button

3. Restart drive

   At the end of the update, IndraWorks and IMST/IDST automatically provide the option to restart IndraDrive using the reboot command S-0-1350. As an alternative, IndraDrive can be restarted by resetting the control voltage
4. Put machine into ready-for-operation status again according to machine manufacturer's instructions.
5. Check functions of the drive.
6. For axes with active Safe Motion: Record the firmware replacement in the machine logbook, together with the axis identifier (P-0-3235.0.1), configuration type data (P-0-3234.0.1) and parameterization type data (P-0-3234.0.4).

Firmware version upgrade

General information

When firmware in a drive controller is replaced by firmware of a **more recent version**, this is called firmware version upgrade (e.g., FWA-INDRV*-MPB-**18**V10-D5 replaced by FWA-INDRV*-MPB-**20**V06-D5).

☞ **Before** the firmware version upgrade is carried out, all parameters have to be saved (e.g., with "IndraWorks"). **After** the firmware has been replaced, the command "C07_1 Load defaults procedure command (factory settings)" is automatically executed. To bring the drive controller to the ready-for-operation state again, the parameter values have to be restored by loading the parameter file saved before.

Saving parameter values

Before the firmware upgrade, all application-specific parameter values have to be saved on a data carrier. The parameter backup can be carried out by means of:

- "IndraWorks" commissioning software

  → Saving parameter values on external data carrier

- or -

- IndraMotion Service Tool (IMST) or IndraDrive Service Tool (IDST) (with MPx18V10 and above)

  → Saving parameter values on external data carrier

- or -

- Control master

  → Saving parameter values on master-side data carrier

Version upgrade with "IndraWorks"

Requirements

The following requirements should have been fulfilled in order that carrying out the firmware version upgrade with "IndraWorks" makes sense:

- Existing Ethernet connection between PC and drive controller
- The current parameterization of the axis was saved.

When upgrading from MPB16VRS to MPB17VRS, for example, the error F8100 is sometimes generated during the drive controller's first run-up. This error can be cleared via the display and will not occur again during the next booting process.

Firmware upgrade with "IndraWorks"

Carrying out the firmware version upgrade with "IndraWorks" requires the following steps:

1. Load firmware

   1.1 Call "IndraWorks".

   1.2 Load project for the corresponding 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 the upper part of the dialog and start firmware download via "Download" button.

   Firmware download runs automatically and all required firmware components are loaded to drive.

   1.6 After firmware download has been completed, close "Firmware management" window.

   1.7 Reboot drive controller

2. Put drive into ready-for-operation state

   ⇒ Switch project "online"!

   After project has been switched "online", a message sometimes signals that "IndraWorks" could not establish communication to drive via Ethernet interface, as drive-internal settings for Ethernet communication were reset.

⇒ In this case, reconfigure communication via "Search for devices" button!

⇒ As firmware in drive no longer complies with version stored in project, a corresponding message is displayed. Select desired option in dialog to make drive available in project again and allow reestablishing communication to device.

⇒ Manually set functional package and master communication protocol via corresponding parameters.

⇒ Activate command "C0750 Load defaults procedure command (factory settings)". All buffered parameters are thereby set to their default values.

☞ For axes with **active Safe Motion**, the parameterization of the old firmware version can be applied. For this purpose, the scaling of the command "C0750 Load defaults procedure command (factory settings)" has to be set to without "Safe Motion (SMO)" in "P-0-4090, Configuration for loading default values". The Safe Motion then remains active even in the case of a version upgrade, and it is not necessary to recommission Safe Motion or repeat the acceptance test.

With active Safety bus communication, the device data sheets have to be updated in the safety control.

---

3. **Load parameter values**

   ⇒ Load parameter file which was saved!

   ⇒ Switch off drive and restart it so that the parameterization becomes active.

4. **Put machine into ready-for-operation state**

   ⇒ Put machine into ready-for-operation state again according to machine manufacturer's instructions!

   ⇒ Check functions of drive!

Firmware release downgrade

General information

Before the firmware release downgrade, it is recommended to save the backup parameters of the drive!

☞ If the firmware is replaced for a device with active Safe Motion, the saving of the parameters has to be recorded in the machine logbook, together with the axis identifier (P-0-3235.0.1), configuration type data (P-0-3234.0.1) and parameterization type data (P-0-3234.0.4).

If the safety technology options Sx (S3, S4, S5, SB, SD) are used, the system checks whether firmware and parameter set are compatible. This prevents the safety technology from being operated with an incompatible parameter set ("C0213 SMO: Incorrect parameterization" or "C8214 SMO: Incorrect configuration"). Incompatible parameter sets are involved when using Safe Motion functions no longer available in the currently loaded firmware (old firmware release).

In the case of an incompatibility, there are two options:

- Either continue with the existing parameterization by reloading the originally available firmware,
- or perform the complete initial commissioning with the new firmware, including the loading of the basic parameters for SMO.

Firmware release downgrade with a computer

To carry out the firmware release downgrade, please refer to the description of the firmware release update. (chapter "Firmware release update with a computer" on page 354)

Firmware version downgrade

General information

When firmware in a drive controller is replaced by firmware of an **older version**, this is called firmware version downgrade (e.g., FWA-INDRV*-MPB-**20**V06-D5 replaced by FWA-INDRV*-MPB-**18**V10-D5).

Before the firmware version downgrade is carried out, all parameters have to be saved (e.g., with "IndraWorks"). **After** the firmware has been replaced, the command "C07_1 Load defaults procedure command (factory settings)" is automatically executed. To bring the drive controller to the ready-for-operation state again, the parameter values have to be restored by loading the parameter file saved before.

Saving parameter values

Before the firmware version downgrade, all application-specific parameter values have to be saved on a data carrier. The parameter backup can be carried out by means of:

- **"IndraWorks" commissioning software**

  → Saving parameter values on external data carrier

- or -

- IndraMotion Service Tool (IMST) or IndraDrive Service Tool (IDST) (with MPx18V10 and above)

  → Saving parameter values on external data carrier

- or -

- **Control master**

  → Saving parameter values on master-side data carrier

Firmware version downgrade with "IndraWorks"

Requirements

The following requirements should have been fulfilled in order that carrying out the firmware version downgrade with "IndraWorks" makes sense:

- Existing Ethernet connection between PC and drive controller
- The current parameterization of the axis was saved.

Firmware version downgrade with "IndraWorks"

Carrying out the firmware version downgrade with "IndraWorks" requires the following steps:

1. **Load firmware**

   1.1 Call "IndraWorks".

   1.2 Load project for the 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 the upper part of the dialog and start firmware download via "Download" button.

   Firmware download runs automatically and all required firmware components are loaded to drive.

   1.6 After firmware download has been completed, close "Firmware management" window.

   1.7 Reboot drive controller

☞ For axes with **active Safe Motion**, the axis after the booting process detects an incompatible SMO parameter image and generates the error "F8324 SMO: Error in activation". The incompatible SMO parameter image can be deleted with the command "C0720 SMO: Load defaults procedure command" or within the scope of the "C0750 Load defaults procedure command (factory settings)". Afterwards, the Safe Motion has to be recommissioned.

Unless the command "C0720 SMO: Load defaults procedure command" or "C0750 Load defaults procedure command (factory settings)" has been started, the SMO parameter image is still completely available. If the axis is downgraded to the original firmware version, the axis can be operated without recommissioning the Safe Motion.

---

2. **Put drive into ready-for-operation state**

   ⇒ Switch project "online".

   After project has been switched "online", a message sometimes signals that "IndraWorks" could not establish communication to drive via Ethernet interface, as drive-internal settings for Ethernet communication were reset.

   ⇒ In this case, reconfigure communication via "Search for devices" button!

   ⇒ As firmware in drive no longer complies with version stored in project, a corresponding message is displayed. Select desired option in dialog to make drive available in project again and allow reestablishing communication to device.

⇒ Manually set functional package and master communication protocol via corresponding parameters.

⇒ Activate command "C0750 Load defaults procedure command (factory settings)". All buffered parameters are thereby set to their default values.

3. **Load parameter values**

   ⇒ Load parameter file which was saved.

   ⇒ Switch off drive and restart it so that the parameterization becomes active.

4. **Put machine into ready-for-operation state**

   ⇒ Put machine into ready-for-operation state again according to machine manufacturer's instructions.

   ⇒ Check functions of drive.

Possible problems during firmware replacement

General information

After an incomplete firmware update, the drive controller possibly is no longer operable.

Firmware replacement is carried out incompletely, if one of the following situations occurs during the sequence of firmware replacement:

- 24 V supply of control section is switched off
- Connection to drive is interrupted (e.g., defective interface cable)
- Update software / computer crashes

If there is no valid firmware available in the control section, the loader is started. The text "LOADER active! IP address: 192.168.0.1" appears on the display in light writing. With the loader, it is possible to replace the firmware of the control section.

☞ Upon successful firmware replacement in the control section, a restart has to be carried out.

Firmware replacement in control section in the case of error

The following steps are required for loading the firmware to the control section in the case of error:

1. Call "IndraWorks".
2. In menu, call firmware management under **Tools drive ▸ Firmware management**.

   A new window opens in which firmware file last used is displayed on PC.

3. Select the "Download via Ethernet" tab.
4. Set IP address "192.168.0.1".
5. Highlight desired firmware (*.ibf file) and start firmware download via **Download** button.
6. Firmware download runs automatically and all required firmware components are loaded to drive.
7. After firmware download has been completed, close "Firmware management" window.
8. Restart drive.

5.8.6 Optional memory

Brief description

Fields of application

When MLD is used, the external memory card is particularly important. The drive-integrated PLC can also be used without the memory card, but in this case some options are missing, such as the loading of source code. If an external memory card is used for the options of MLD, the memory card has to have been plugged before the drive is started.

The external memory card provides the following options for MLD:

- Storing the source code of a PLC application
- Restoring a PLC project from the loaded source code
- Accessing file level via FTP server
- Using a web application via web server
- Expanded MLD project (4 MB of memory space)
- Backup & Restore of the operating data (retain data, parameters)
- MLD programs can use memory to store user data

Overview of functions

With MPx20 (MPC20 / MPB20) and above, the file system is available with MLD if a µSD card has been plugged. The optional memory serves as a backup memory. If a memory card has been plugged when the device is booted up, the card is checked for a valid partition. Besides, the following folders are created as a standard, unless they had already ben created:

Folder	Significance
USER	This directory is reserved for user files which can be accessed from the PLC via FTP or using the IndraWorks file Explorer.
PLC	Storage location of files managed by IndraLogic
Backup	Internal memory of the Backup & Restore function for retain data and parameters
Documentation	Can be employed by the user to store machine-specific documentation of their installation/machine
Tools	The user can store tools in this directory.
Temp	Folder is at free disposal, contains temporary files

Tab. 5-82: List of automatically created folders

It is impossible to use a memory card plugged during operation. To use the memory card, the device has to be restarted. This can be done, for example, via "S-0-1350, C6400 reboot command".

Features

- Using a partition
- Capacity limited to a max. of 2 GB
- Only Bosch Rexroth SD cards are allowed

Hardware requirements

HCS devices in Basic and Advanced design

HMS devices in Basic and Advanced design

Pertinent parameters

- P-0-1521 Programming module identifier
- P-0-4066 Card Identification Data

Pertinent diagnostic messages

- C6500 Archive device data
- C6600 Restore device data

Overview of the functional scope

- C6700 Update of device data
- F2101 File system structure error on the memory card
- F2120 Memory card could not be initialized

5.8.7 Replacing the controller

Overview

A controller of the IndraDrive range consists of the components power section, control section and programming module / control panel (incl. firmware). The control section can be configured with additional components (e.g., optional safety technology module). The control section and power section are firmly connected to each other; only Rexroth service engineers or especially trained users are allowed to replace individual components. The paragraphs below describe how to replace the complete drive controller.

The controller has to be replaced by a device of identical type. This is the only way to ensure that the originally configured functions can be used in unchanged form.

When using devices with integrated safety technology, make sure by organizational measures that only an authorized person replaces the device, e.g., by a lockable control cabinet. Also make sure that the device replacement is not carried out for several axes at a time to avoid accidentally interchanging the axes.

A device intended for replacement that has already been in operation (thus is not in the factory-new condition as supplied), has to be brought to the condition as supplied again ["load defaults procedure (factory settings)", command C0750] before it is used.

The figure below illustrates the basically required individual steps.

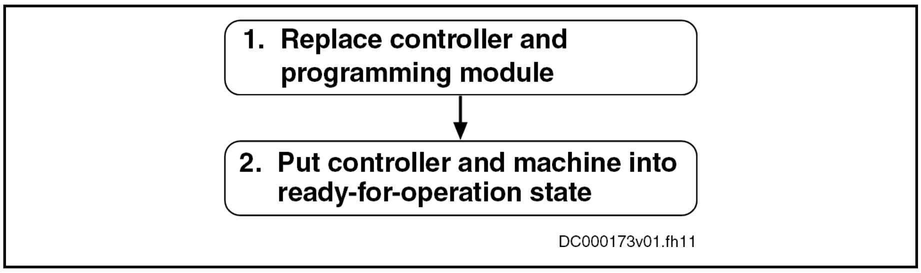


Fig. 5-71: Sequence of drive controller replacement

"IndraMotion Service Tool (IMST)" or "IndraDrive Service Tool (IDST)" allow accessing the drive system, e.g. for remote diagnostics. Besides, authorized users can handle different service cases with IMST or IDST, such as replacing drive components, loading parameters or updating/upgrading the drive firmware.

"IndraMotion Service Tool (IMST)" additionally analyzes drive systems connected via cross communication (CCD). Further information on "IndraMotion Service Tool (IMST)" and "IndraDrive Service Tool (IDST)" is described in the separate documentation „Rexroth IndraDrive Service Tools IMST/IDST“ (DOK-IM*MLD-IMSTIDSTV13-RE**-EN-P; mat. no. R911342652).

How to proceed when replacing drive controllers

Replacing the drive controller and the programming module

1. Open the main switch
2. Make sure the main switch cannot be switched on again.
3. Make sure drive controller is de-energized.

   WARNING! Lethal electric shock from live parts with more than 50 V! Before working on live parts: De-energize system and secure power switch against unintentional or unauthorized reconnection. Wait at least **30 minutes** after switching off the supply voltages to allow **discharging**. Make sure voltage has fallen below 50 V before touching live parts.
4. Separate connection lines from controller.
5. Dismount drive controller from control cabinet.
6. Dismount programming module / control panel
   - With IndraDrive C/M/Cs: Pull off programming module / control panel from defective device.
   - With IndraDrive Mi: Remove programming module (X107) from defective device, note down positions of address selector switches S4 and S5 (address selector switches below connections X103.1 and X103.2).
7. Mount programming module / control panel
   - With IndraDrive C/M/Cs: Plug programming module / control panel of defective device onto new controller.
   - With IndraDrive Mi:
     1. Set the address selector switches in the same way as for the defective device.
     2. Dismount cover above slot X107.
     3. Plug programming module of defective device onto replacement device.
     4. Mount cover above slot X107.

        NOTE: Damage to the programming module caused by penetrating dirt or moisture. When mounting the cover of X107, make sure that the sealing ring is undamaged and is seated correctly.
8. Mount new controller.

☞ The controller has to be replaced by a device of identical type. This is the only way to ensure that the originally configured functions can be used in unchanged form.

---

9. Connect device according to machine circuit diagram

Putting drive controller and machine into ready-for-operation state

1. Restore control voltage.
2. Put machine into ready-for-operation state again according to the machine manufacturer's instructions.
3. Activate safety technology (only with active Safe Motion with Sx option)

   With single-axis devices, the following message appears on the display of the control panel during the booting process:

   "Load new Safety?"

With double-axis devices, the following message appears on the display of the control panel during the booting process:

"**.1 Load new Safety?**" for Axis 1 or "**.2 Load new Safety?**" for Axis 2

Pressing the "Enter" key at the control panel acknowledges the message. The safety technology parameters are now loaded from the control panel to memory of the optional safety technology module.

☞ IndraDrive Mi does not feature a control panel; this is why the parameter image of safety technology has to be activated by executing the command "P-0-3231.0.3, C8300 SMO: Command Activate parameter image", e.g., using IndraDrive Service Tool (IDST).

The error "F8330, SMO: Configuration data record has not been activated" generated during boot-up signals that the active image identifier on the programming module does not comply with the image identifier that was stored on the safety technology hardware. After the command C8300 has been successfully executed, the error must be cleared by the "clear error" command (C0500). The command execution is described in the Functional Description of the firmware, see chapter "Command processing".

---

4. Check functions of the drive.
5. Check safety technology parameters (only with active Safe Motion with Sx option)

   Completing the process, it is necessary to check, with activated safety technology, whether the correct safety technology parameters have been loaded for the drive.

   The replacement of the device has to be recorded in the machine logbook. For this purpose, the data of the following safety technology parameters have to be accordingly documented and checked for correctness (these data can be queried via the control panel in the "SMO Info" menu; for IndraDrive Mi, the data have to be read, e.g. by means of the IndraDrive Service Tool (IDST), because IndraDrive Mi does not feature a control panel):

   - P-0-3230, SMO: Password level
   - P-0-3235.0.1, SMO: Active axis identifier
   - P-0-3234.0.1, SMO: Configuration checksum
   - P-0-3234.0.2, SMO: Operating hours at last change of configuration
   - P-0-3234.0.3, SMO: Configuration change counter
   - P-0-3234.0.4, SMO: Parameterization checksum
   - P-0-3234.0.5, SMO: Operating hours at last change of parameterization
   - P-0-3234.0.6, SMO: Parameterization change counter

Possible problems during controller replacement

Display defective or programming module defective

If the programming module / the display is defective, the parameter values saved after initial commissioning must be loaded.

NOTICE

The parameter values saved after initial commissioning are not generally suited for reestablishing the operatability of the drive after a device has been replaced!

Check actual position values and active target position before setting drive enable!

When firmware and drive parameters are to be transmitted to the replacement controller, the required firmware and a parameter backup of the respective axis must be available.

1. Reestablish the control voltage supply of the controller.
2. Carry out firmware update, see also chapter "Firmware replacement"
3. Via the "IndraWorks" commissioning tool or the control master, load parameter file to controller:
   - "IndraWorks" commissioning tool

     Load parameter values saved after initial commissioning to controller.
   - "IMST" or "IDST" service tools

     Load parameter values saved after initial commissioning to controller.
   - Control master

     Load axis-specific parameter values saved after initial commissioning [according to list parameters "S-0-0192, IDN-list of all backup operation data" and "P-0-0195, IDN list of retain data (replacement of devices)"].

☞ With active Safe Motion, initial or serial commissioning of the drive controller is required after the programming module has been replaced!

☞ In the case of drives with absolute value encoder and modulo format, the position data reference has to 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"!

5.8.8 Enabling functional packages

Brief description

The user can scale the scope of functionality of the IndraDrive firmware. This allows the scope of firmware functions to be adjusted to the respective requirements and, if necessary, reduced in its complexity.

The 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
- S-0-1350, C6400 reboot command
- P-0-2002, Oper. hours of contr. sect. at change of functional packages
- P-0-2003, Selection of functional packages
- P-0-2004, Active functional packages

Pertinent diagnostic messages

- C0202 Parameter limit error (->S-0-0423)
- C0299 Configuration changed. Restart

5.8.9 Extended diagnostic functions

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 the internal firmware sequence to be reproduced, 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 you have to take into account that first the patch address and then the oscilloscope signal is assigned. This has to 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 are 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 function:

- P-0-0480, Patch function 1, source pointer

- P-0-0481, Patch function 1, attribute
- P-0-0482, Patch function 1, bit mask
- P-0-0483, Patch function 1, exponent
- P-0-0485, Patch function 1, display
- P-0-0486, Patch function 2, source pointer
- P-0-0487, Patch function 2, attribute
- P-0-0488, Patch function 2, bit mask
- P-0-0489, Patch function 2, exponent
- P-0-0491, Patch function 2, display

RMS value generator in the drive

Brief description

Fields of application

To evaluate the thermal load of drive controller and motor over a machine cycle, the total rms value of the output current of the output stage is the decisive characteristic value.

Overview of functions

The drive cyclically generates the rms value of the output current of the output stage. Via a control bit, the beginning and the end of the cycle are defined.

Pertinent parameters

- P-0-0610, Control word of current rms value generator
- P-0-0611, Current rms value

Pertinent diagnostic messages

None

5.8.10 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:

- Measured value recording

  It is possible to record 8 channels at the same time, the signals being selected by configuring signal selection lists (IDN lists).
- Configuration (basic settings)

  The control/status block determines the basic functions (start/stop, time resolution, size of memory, operation mode). The current 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:

- **Measured value recording**
  - Up to 8 channels with up to 8192 measured values each (the total should not exceed 32,768 measured values)
  - Time resolution to be freely selected in steps of the position controller clock (see "Performance data")
  - Signal selection by indicating the IDN of the respective parameter
  - Data of the SMO option Sx (S3, S4, S5, SB and SD) can at maximum be updated and recorded in the cycle time of the SMO application cycle (t = 1 ms)
- **Configuration (basic settings)**
  - Multi-channel display in "IndraWorks Ds/D/MLD"
  - More than 100 different measuring and trigger signals (cf. P-0-0149)
  - Up to 4 PLC variables can be recorded using PLC patch variables
  - Expanded oscilloscope function using 2 patch functions
  - Expanded oscilloscope function using 2 average value filters for display
- **Trigger function**
  - Trigger signal selection by indicating the parameter IDN
  - Internal trigger or external trigger
  - External trigger with trigger offset determination for synchronizing multiple-axis measurements
  - Unit of trigger level adjusting to trigger signal selection
  - Possibility of triggering at internal memory contents with patch signal
  - Possibility of triggering at PLC variable with patch signal
  - Time stamp for trigger time is mapped to parameter "P-0-0035.0.1, Oscilloscope: Trigger time".
- **Trend mode**

  It is possible to switch from a single measurement (Single Shot) to a continuous measurement (trend mode).
  - Recording of up to 4 channels in a cyclic mode
  - Signal selection via the previous parameters
  - Values are administrated in a buffer memory and cyclically called
  - IndraWorks can read this buffer memory and display it continuously
  - Setting of time resolution and signal selection only in trend mode that has been switched off
  - Allowed time resolutions have to be multiples of 2 ms
  - Single Shot mode cannot be used in parallel

Pertinent parameters

- P-0-0020, Oscilloscope: Operation mode
- P-0-0136, Oscilloscope: Manual trigger signal
- P-0-0279, Oscilloscope: Trend mode, time resolution
- P-0-0280, Oscilloscope: Trend mode, list of measured values

Control/status:

- P-0-0028, Oscilloscope: Control word
- P-0-0029, Oscilloscope: Status word
- P-0-0031, Oscilloscope: Time resolution
- P-0-0032, Oscilloscope: Size of memory
- P-0-0149, Oscilloscope: Signal selection list
- P-0-0150, Oscilloscope: Number of valid measured values

Measuring channels:

- P-0-0021, Oscilloscope: List of measured values 1
- P-0-0022, Oscilloscope: List of measured values 2
- P-0-0023, Oscilloscope: Signal selection 1
- P-0-0024, Oscilloscope: Signal selection 2
- P-0-0145, Oscilloscope: List of measured values 3
- P-0-0146, Oscilloscope: List of measured values 4
- P-0-0147, Oscilloscope: Signal selection 3
- P-0-0148, Oscilloscope: Signal selection 4
- P-0-0274, Oscilloscope: List of measured values 5
- P-0-0275, Oscilloscope: List of measured values 6
- P-0-0270, Oscilloscope: Signal selection 5
- P-0-0271, Oscilloscope: Signal selection 6
- P-0-0276, Oscilloscope: List of measured values 7
- P-0-0277, Oscilloscope: List of measured values 8
- P-0-0272, Oscilloscope: Signal selection 7
- P-0-0273, Oscilloscope: Signal selection 8

Trigger function:

- P-0-0025, Oscilloscope: Trigger mask
- P-0-0026, Oscilloscope: Trigger signal selection
- P-0-0027, Oscilloscope: Trigger level
- P-0-0030, Oscilloscope: Trigger edge
- P-0-0033, Oscilloscope: Number of measured values after trigger event
- P-0-0035, Oscilloscope: Trigger control offset
- P-0-0036, Oscilloscope: External trigger signal
- P-0-0037, Oscilloscope: Internal trigger signal

5.8.11 Options for integrated energy and power measurement

Brief description

Fields of application

Mounting energy costs increasingly require the project planning of automation systems to conform with energy efficiency. To discover energy saving potentials, it is of crucial significance to analyze the energy consumption of the individual system components. For this purpose, the IndraDrive system makes available specific energy and power values which allow analyzing and evaluating the energy consumption on the drive level.

As a standard, the IndraDrive system provides this function in its basic configuration. By using IndraDrive, installations in the industrial production automation can therefore benefit from this functionality, independently of their respective industrial sector and by deriving measures of increase in energy efficiency from the measured variables.

Overview of functions

The figure below shows an overview of the energy and power values of the IndraDrive system for a single-axis system.

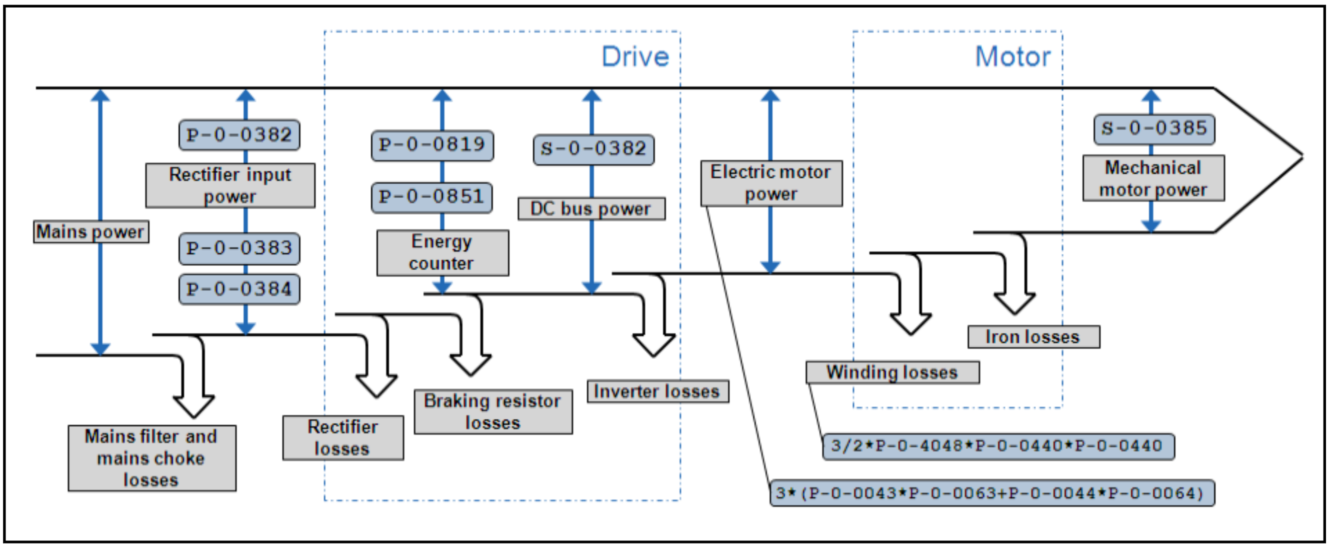


Fig. 5-72: Energy and power values of the IndraDrive system

We distinguish between

- axis-related values (S-0-0385, S-0-0382, P-0-0819, P-0-0851) and
- device-related values (P-0-0382, P-0-0383, P-0-0384).

The energy and power requirements of an individual axis can be determined by means of the above axis-related values. These parameters are available in each axis. Mains-side energy and power values are device-related and only available for converters. They can be used to determine the total power requirements of a drive system.

Features

- Determining the axis-specific power requirement
- Calculating the motor power dissipation
- Determining the total energy absorption of a drive system
- Drawing up a power balance of the drive system
- Discovering optimization potentials for saving energy
- Determining the maximum mains input current (HCS01.1E-W0054 only)
- Including the energy and power values in IndraWorks is possible
- Depicting dynamic power processes in the position controller cycle

Hardware and software requirements

The availability of the energy and power values depends on the hardware:

- Axis-related values are axis parameters and available for all IndraDrive devices: S-0-0385, S-0-0382, P-0-0851 and P-0-0819.
- Mains-side values are device parameters and therefore only available for converters: P-0-0382, P-0-0383 und P-0-0384. The significance of the displayed value depends on the topology and available sensors: Only converters without DC bus connection or converters which do not supply any other inverters via the DC bus, and the HCS01.1E-W0054

device, provide correct values. In all other cases, the mains-side values cannot be calculated due to the restricted sensor system. The displayed values are not correct. For an overview of the availability of the energy and power values depending on the hardware used, see chapter "Determining the energy and power values" .

☞ In order that the energy and power values are correctly displayed, it is obligatory to **activate** the **output stage compensation**. For this purpose, set bit 5 of parameter "P-0-0045, Control word of current controller".

Pertinent parameters

- S-0-0040, Velocity feedback value of encoder 1
- S-0-0084, Torque/force feedback value
- S-0-0109, Motor peak current
- S-0-0110, Amplifier peak current
- S-0-0111, Motor current at standstill
- S-0-0380, DC bus voltage
- S-0-0381, DC bus current
- S-0-0382, DC bus power
- S-0-0383, Motor temperature
- S-0-0385, Motor power
- S-0-0533, Nominal torque/force of motor
- S-0-0534, Maximum torque/force of motor
- 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-0-0051, Torque/force constant
- 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-0-0114, Undervoltage threshold
- P-0-0382, Mains power
- P-0-0383, Mains energy counter
- P-0-0384, Short-term mains energy counter
- P-0-0440, Actual output current value (absolute value)
- P-0-0450, Current torque/force constant
- P-0-0532, Premagnetization factor
- P-0-0556, Config word of axis controller
- P-0-0819, Energy counter
- P-0-0833, Braking resistor threshold
- P-0-0851, Short-time energy counter
- P-0-0853, Max. DC bus voltage, motor
- P-0-0860, Converter configuration
- P-0-4048, Stator resistance

Pertinent diagnostic messages

None

5.9 Engineering/diagnostic interfaces

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

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine’s range of motion (e.g., by 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".

5.9.1 IndraMotion Service Tool (IMST), IndraMotion Diagnostic Tool (IDST)

"IndraMotion Service Tool (IMST)" and "IndraMotion Diagnostic Tool (IDST)" are web-based applications that allow access to a drive system via an Ethernet connection.

Original Equipment Manufacturers (OEM), end users and customer advisors can access the drive system with the help of IMST or IDST, in order to carry out remote diagnoses for example. Besides, authorized users can handle different service cases with IMST or IDST, such as replacing drive components, loading parameters or updating/upgrading the drive firmware.

"IndraMotion Service Tool (IMST)" additionally analyzes drive systems connected via cross communication (CCD). Further information on "IndraMotion Service Tool (IMST)" and "IndraMotion Diagnostic Tool (IDST)" is described in the separate documentation „Rexroth IndraMotion, MLD 13VRS, Service Tool“ (DOK-IM*MLD-IMSTIDSTV13-RE**-EN-P; mat. no. R911342652).

5.9.2 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 for TCP/IP communication are suitable as connection options. This can be an inactive port of the master communication card (e.g., sercos or EtherNet/IP™), a separate Engineering port (if present) or optionally an inactive port of the master communication interface of the CCD master.

The IP communication always respects the properties of the connected interface.

Example of sercos master communication

For sercos, in addition to the time-controlled transmission of sercos-type Ethernet telegrams (MDT and AT), the Unified Communication Channel (UCC) exists, with which IP telegrams are transmitted in a specially reserved time slot.

Therefore, for sercos, 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

If the TCP/IP communication is used in the drive, different application options are available that are summarized in the following table.

Connection	Server application	Exemplary client applications
SIP protocol	Parameter access	IndraWorks Engineering with CCD master
SIP protocol	Parameter access	IndraWorks parameter application
TFTP	Firmware update service	Carrying out a firmware update
HTTP	Web server	Displaying the IndraMotionServiceTool
FTP	File server	File access to the optional memory card (only available, if optional memory card plugged during boot-up)

Tab. 5-83: Overview of the possible applications

Pertinent parameters

Command parameters:

- S-0-1048, C6100 Command Activate IP settings

IP parameters:

- S-0-1019, Master comm. engineering over IP: MAC address
- S-0-1020, Master comm. engineering over IP: IP address
- S-0-1021, Master comm. engineering over IP: Network mask
- S-0-1022, Master comm. engineering over IP: Gateway address
- P-0-1044, Master comm. engineering over IP: Status IP communication
- P-0-1530, Engineering: MAC address
- P-0-1531, Engineering: IP address
- P-0-1532, Engineering: Network mask
- P-0-1533, Engineering: Gateway address
- P-0-1544, Engineering: Status IP communication
- P-0-1640, CCD: MAC address
- P-0-1641, CCD: IP address
- P-0-1642, CCD: Network mask
- P-0-1643, CCD: Gateway address
- P-0-1644, CCD: Status IP communication
- P-0-4089.0.10, Master communication: MAC address device
- P-0-4089.0.13, Master communication: IP address
- P-0-4089.0.14, Master communication: Network mask
- P-0-4089.0.15, Master communication: Gateway address

Pertinent diagnostic messages

- C6101 Incorrect IP settings
- F2190 Incorrect Ethernet configuration

5.9.3 S/IP protocol

Brief description

Fields of application

S/IP allows all drive parameters to be easily accessed.

Typical fields of application are:

- Communication with the drive for Engineering via IndraWorks
- Replacing cyclic bus communication to control simple axis applications without real-time requirements e.g. in positioning block mode or with drive-controlled positioning

Overview of functions

Features

- TCP/IP-based protocol
- The protocol focuses on the exchange of data and requires minimum administration overhead.
- User-defined busy timeout (time until the drive sends a defined response)
- User-defined lease timeout (time as of which the connection is released again if no new requests are made)
- Proprietary service for reading all the information from a parameter in a request
- Up to 2 connections are possible simultaneously

Pertinent diagnostic messages

The following error messages have been defined, and the drive directly returns them in an individual service:

Name	Value in the telegram	Significance
CONNECTION_ERROR	1	Error when establishing the connection
ABORTED	2	Process was aborted
UNKNOWN_MESSAGE_TYPE	3	Message type in the header is unknown
SERVICE_SPECIFIC	4	Service-specific error, e.g. "Operation data is write protected"

Tab. 5-84: S/IP error classes

5.9.4 Firmware download via TFTP server

Brief description

Fields of application

If a firmware download is to be carried out, a TFTP server is available for this purpose. This makes it possible to download new firmware to the device.

Overview of functions

Identifying firmware

A special "ReadRequest" can be used to identify firmware existing in the device. For this purpose, the "firmware" string is transmitted in the "ReadRequest".

The response telegram contains a data package, the first four bytes of which are the control section circuit board code and the following content is the manufacturer version (cf. S-0-0030.0.0).

Firmware download

The download procedure is started using a WriteRequest. To do this, the drive has to be in PM. Here the "WriteRequest" also initiates the connection to the TFTP server.

Then "DataRequests" is used to download the firmware to the device. In this connection, the device performs several checks:

- Can the new firmware file be used with this device (compatibility check)?
- Was the correct quantity of data transmitted (data integrity check)?
- Was the firmware file transferred correctly and was it valid (validity check)?

Error diagnostics

Any possible error that occurs during this procedure is returned via the ErrorFrame in the TFTP. The error text is available as a plain text.

Features

The TFTP server of an IndraDrive device has the following features:

- A TFTP connection does not know any authentication
- The following five package types are present in a TFTP connection:
  - "ReadRequest" (reading of files from server/drive starts)
  - "WriteRequest" (writing of files from server/drive starts)
  - "Data" (data are transmitted)
  - "Acknowledge" (data packages are confirmed)
  - "Error" (any type of error message)
- Each data package has to be confirmed with "Acknowledge" before the next data package is transmitted.

Pertinent diagnostic messages

Occurring errors are transmitted in plain text via "TFTP ErrorFrame" (see description of diagnostic message: "Firmware download")

5.9.5 File handling by FTP via Ethernet

Brief description

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

Via an integrated FTP server, IndraDrive devices with Ethernet communication can access the data of the optional memory card by means of FTP connection. This allows reading or writing data/directories on the memory card.

Overview of the functional scope

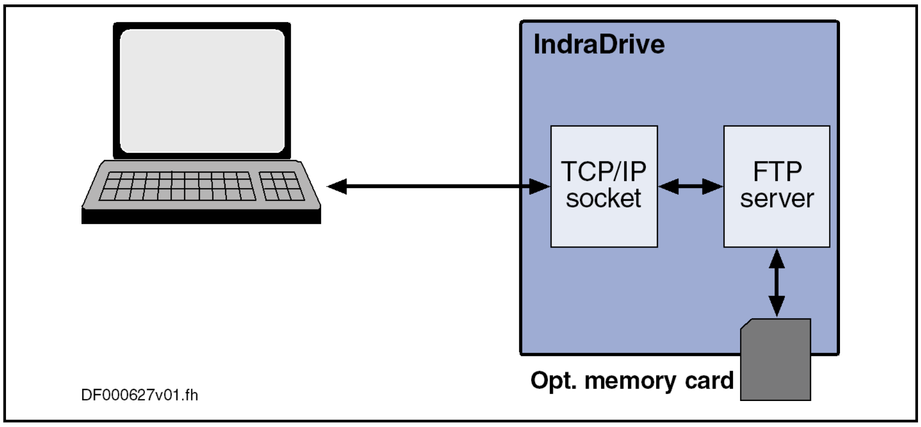


Fig. 5-73: Schematic illustration of FTP file handling

Features

The FTP server of an IndraDrive device has the following features:

- Two types of login to the FTP server:
  - Anonymous login (read-only data access)
  - User login (read and write access to data)
- A maximum of 2 simultaneous connections
- The effective transmission rate depends on processor load and current drive status

  The transmission rate is approx. 450 kbytes/s for download (STOR command) and 300 kbytes/s for upload (RETR command) with an active connection. If 2 FTP connections are simultaneously active (download or upload), the effective transmission rate is dramatically reduced in both directions.

Hardware requirements

The following hardware requirements must have been fulfilled:

- IndraDrive Cs Advanced with Advanced display
- Memory card plugged before booting up

If no memory card was recognized during boot-up, the parameter "P-0-4066, Card Identification Data" contains the value 0xFFFFFFFF.

Pertinent parameters

- P-0-4066, Card Identification Data
- S-0-1020, Master comm. engineering over IP: IP address
- P-0-1531, Engineering: IP address
- P-0-1641, CCD: IP address

5.10 Commissioning

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

- Keep free and clear of the ranges of motion of machines and moving machine parts.
- Prevent personnel from accidentally entering the machine's range of motion (e.g., by 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".

5.10.1 Commissioning motors

Checking the Installation/Assembly

Checking the Assembly

Check the assembly of the IndraDrive controllers and supply units as well as motors with regard to correct implementation, according to the data contained in respective Project Planning Manual.

Checking the Installation

Check the wiring of control cabinet and machine with regard to correct implementation, according to the data contained in the Project Planning Manual and the recommendations in the documentation "Electromagnetic Compatibility (EMC) in Drive and Control Systems".

Initial commissioning/serial commissioning

Brief description

The drive can be commissioned after assembly and installation have been correctly implemented.

Initial commissioning

The initial commissioning of a drive differs from the commissioning of other identical drives (serial commissioning).

The initial commissioning is carried out in the following steps:

- Establishing the operability of the drive (including the required measuring systems)
- Adjusting the drive behavior to the requirements of the application
- Adjusting the master communication interface between master and drive
- Integrating drive functionalities in the machine processes

In each of the mentioned steps, values of relevant parameters are adjusted to the requirements. The result of the initial commissioning is a drive the behavior of which is exactly adjusted to the axis. By storing the values of the initial commissioning in the form of a parameter set the drive behavior can be reproduced.

Serial commissioning

For the commissioning of other identical axis drives at machines of the same type, the set of parameter values determined during the initial commissioning is loaded to the respective controller (serial commissioning). It is thereby possible

- to exactly reproduce the drive behavior

- and -

- to reduce the effort for further commissioning to a little adjustment work and, if necessary, the search for and elimination of assembly/installation errors.

Commissioning options

As a matter of principle, commissioning can be carried out using

- the "IndraWorks Ds/D/MLD" commissioning tool by Rexroth which is connected to the drive via sercos interface, via an engineering interface, via Ethernet or a field bus,
- the control panel of the controller and digital and analog input signals,
- a control unit connected to the drive via a master communication interface.

Two-step commissioning

It is basically recommended to always carry out both the initial commissioning and the serial commissioning in two steps:

- 1st objective: Initial start of the motor
- 2nd objective: Providing drive functions for the machine axis

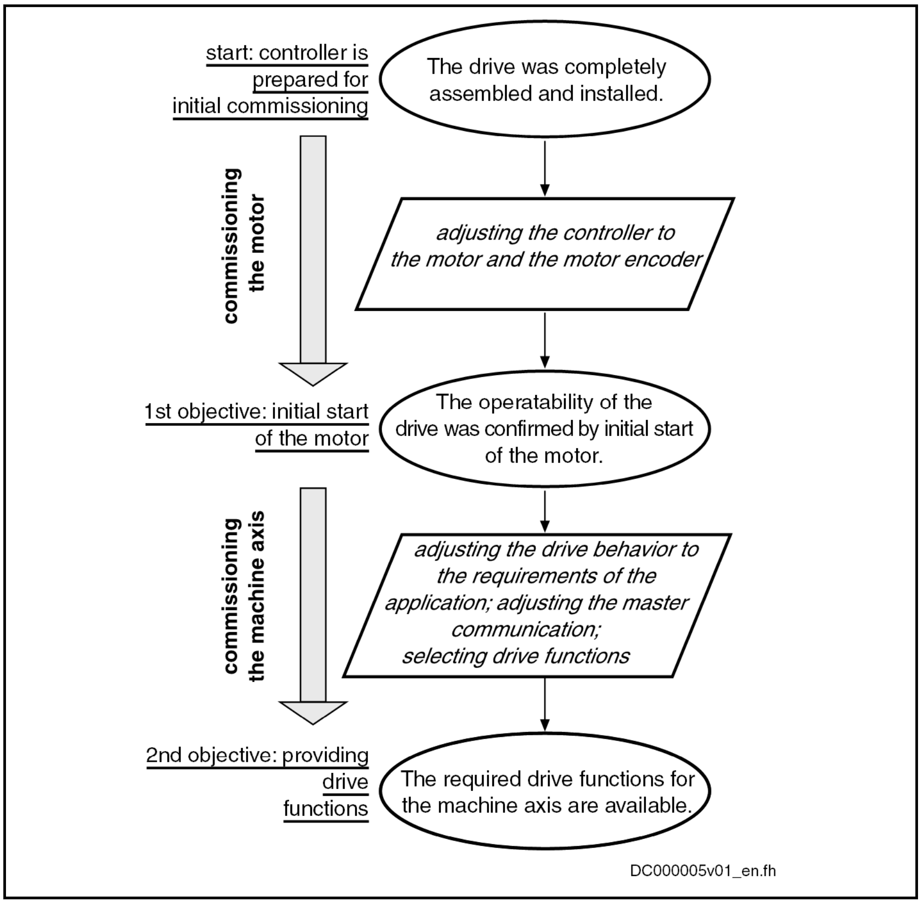


Fig. 5-74: Two-step drive commissioning (schematic)

In the first step, the two-step procedure ensures the operability of the drive (1st objective during initial commissioning and serial commissioning). In the second step, the drive functions required for the machine axis and the drive's advantageous properties are individually adjusted to the machine axis in a reasonable order (2nd objective during initial commissioning) or the expected functional principle is checked (2nd objective during serial commissioning).

☞ As a matter of principle, it is advantageous to establish the operability of a drive independent of a higher-level control system. The drive should therefore first be commissioned as a self-contained unit via "IndraWorks Ds/D/MLD" or in the "Easy-Startup" mode!

See the following sections:

- "Initial start in "easy startup" mode"

- "Initial start with the commissioning tool"

Initial start in "easy startup" mode

Brief description

The so-called "easy startup mode" allows moving the drive without connected or active control unit (or master communication master) or external command value box. When using a Rexroth motor with encoder data memory, this is also possible without using a commissioning PC, because all motor and controller parameters are stored in the encoder data memory.

☞ The easy startup mode is therefore particularly suited for the **initial commissioning** of individual axes, as well as for maintaining an **emergency mode** when the control unit has failed.

Features

- **Activating** the "easy startup" mode via:
  - Engineering interface or digital inputs
  - Control panel of drive controller
- Automatic **deactivation** of master communication interface (see P-0-4077, S-0-0134) and activation of "P-0-0120, Control word easy startup"
- Activation of **drive enable** (P-0-0120, bit 15) via:
  - The digital input assigned to drive enable (differs in accordande with hardware designs, see default assignment under "Automatic configuration of the inputs")
  - Engineering interface when configuration of digital inputs for "easy startup" mode made before was removed
- Drive moves in "velocity control" mode with a parameterizable velocity command value (cf. P-0-1206) without external command value box
- Selecting the **travel direction** (positive/negative) via digital input signals (see parameter "P-0-1200, Control word 1 velocity control")

Overview of the functional scope

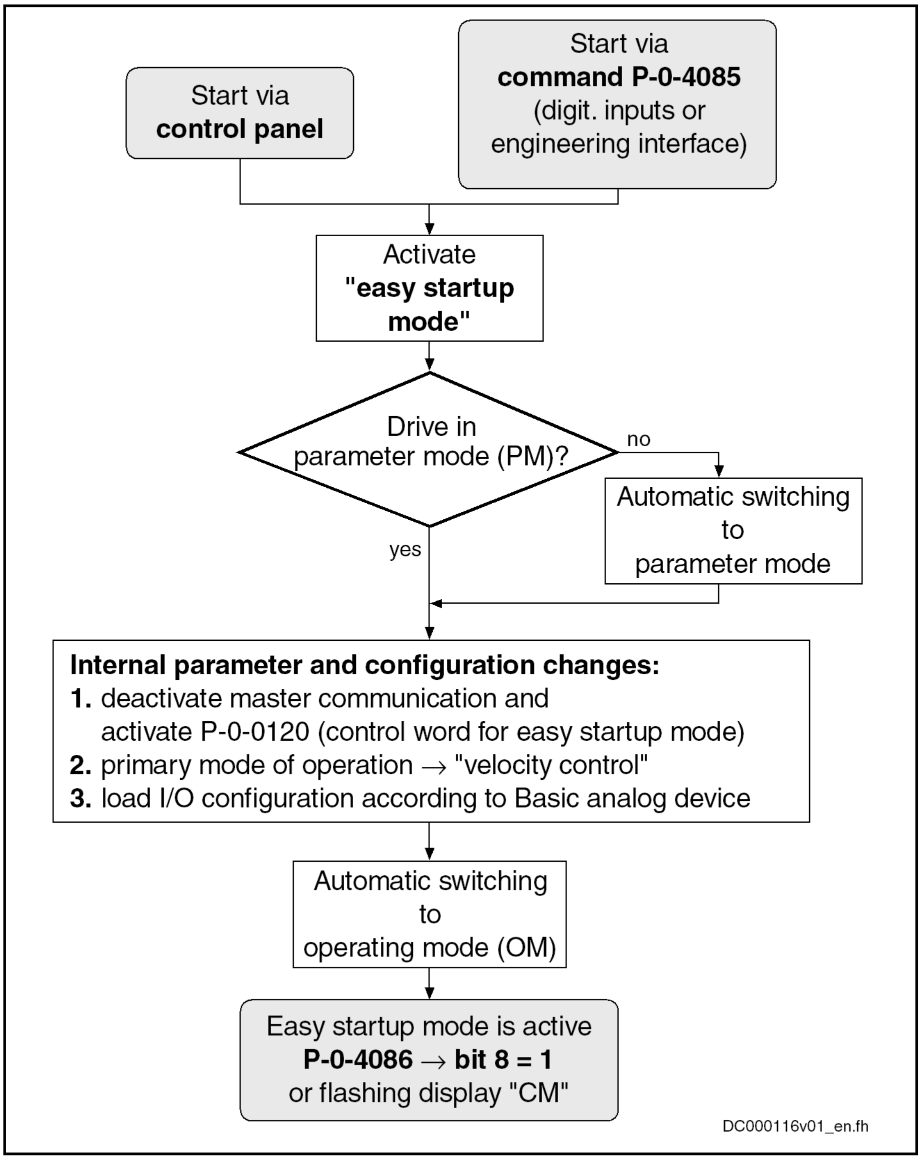


Fig. 5-75: Activating the "easy startup" mode, overview

Hardware requirements

For the "easy startup" mode, the digital inputs at interface X31 have to be wired as follows:

- X31/1 +24V for activating drive enable
- X31/6 +24V for activating the positive direction of rotation
- X31/7 +24V for activating the negative direction of rotation

Pertinent parameters

- S-0-0032, Primary operation mode
- S-0-0091, Bipolar velocity limit value
- P-0-0120, Control word easy startup
- P-0-0300, Digital inputs, assignment list
- P-0-0301, Digital inputs, bit numbers
- P-0-1200, Control word 1 velocity control
- P-0-1206, Memory of velocity command values
- P-0-4085, C4700 Command Activate easy startup mode
- P-0-4086, Master communication status

Pertinent diagnostic messages

In the "easy startup" mode, additional simple diagnostic texts appear on the display of the control panel in "light writing":

- When the "easy startup" mode has been activated, the display changes between the drive address and the message "CM" (Commissioning Mode).
- During commissioning, the relevant messages appear on the display.

Initial start with the commissioning tool

Brief description

Establishing the operability of the drive

After complete and correct assembly and wiring of the drive or the drives it is advisable to establish the operability. With drives of the IndraDrive range, this can be done very easily by means of initial start in the "easy startup" mode (velocity-controlled operation, master communication master not required) in conjunction with the Rexroth "IndraWorks Ds/D/MLD" commissioning tool.

According to the available equipment, the initial commissioning of the motor is supported as follows:

- If there is **no** commissioning tool (e.g. PC) available, Rexroth motors with encoder data memory can be easily commissioned in the "easy startup" mode. The motor parameters and motor control parameters of these motors are automatically loaded from the data memory to the controller by switching control voltage on.
- IndraDrive: If a PC with Rexroth commissioning tool is available, the motor parameters and motor control parameters of motors without encoder data memory can be loaded from the internal database of the commissioning tool to the controller via the Engineering interface. This allows initial commissioning in the "easy startup" mode for these motors, too.

Available commissioning tools

Rexroth provides the following commissioning tools (software) for drives:

- IndraDrive: IndraWorks Ds/D/MLD

IndraWorks Ds/D/MLD

"IndraWorks Ds/D/MLD" is a component of the "IndraWorks" software range which supports parameterization and commissioning of control units and drives by Rexroth.

The "IndraWorks Ds/D/MLD" commissioning tool provides the following options and advantages:

- The functions and features made available by the drive are structurally visualized, the respective parameter values are displayed in their functional context.
- Parameter values can be directly changed and thereby adjusted to the respective requirements.
- The parameter values available in the drive can be saved drive-externally as a group (parameter set), e.g. on the PC hard disk, and can be reloaded from the hard disk.
- Diagnostic messages and operating status messages are displayed in clearly arranged form.
- For the purpose of commissioning, commands can be started.
- Via the "easy startup" mode, IndraDrive devices can be commissioned and moved.

5.10.2 Commissioning machine axes

Procedure for Commissioning

The drive supports different commissioning procedures. The type of commissioning depends on the existing machine components (control, drive controllers, motor, mechanical system). Commissioning is carried out using one of the commissioning tools available.

Commissioning Procedure

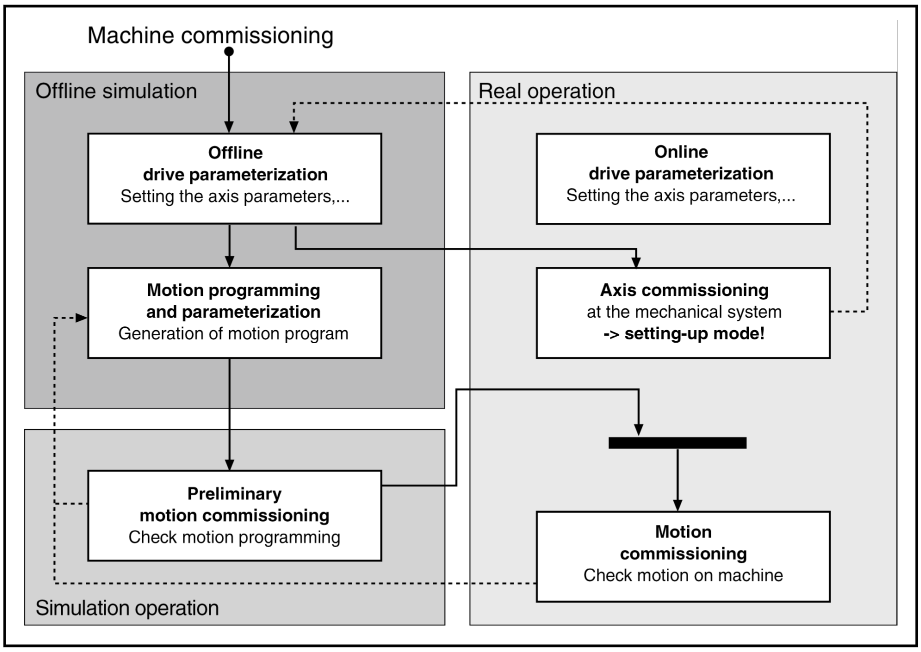


Fig. 5-76: Overview of Procedures for Commissioning

Real Operation

In real operation all necessary components are available. The drive controller is parameterized online; then commissioning of the drive mechanics can be carried out in the setting-up mode. The machine is then commissioned using a control unit.

Offline Simulation

The offline simulation does not require any machine component. The drive controller is parameterized offline; the parameters are then applied to the drive controller during transition to real operation. A drive-internal control (MLD) can also be parameterized offline, and motion programs can be created offline.

Simulation mode

In simulation mode only the drive controller is required, parameterization is made online. With the axis simulation the velocity and actual position values are simulated, the drive can be operated in velocity- and position-controlled operation modes. A higher-level control unit can thus test its motion programs even without motor or mechanical system.

Overview and practical tips

Brief description

Before commissioning machine-axis-specific functions, it is useful to make sure that the drive, consisting of controller, motor and motor encoder, is operational. The best way to do this is the initial start of the drive with the PC-based "IndraWorks Ds/D/MLD" commissioning tool by Rexroth (see "Initial start with the commissioning tool").

If possible, machine axis-specific functions should also be commissioned using "IndraWorks Ds/D/MLD". The advantage is that the correct sequence of an axis-specific function can be configured and ensured independent of the control unit. Further commissioning of the drive, with widely complete configuration, is then easier for the control unit.

5.10.3 Axis simulation

Brief description

Contained in **base package** of variants **MPB, MPM and MPE** in **open-loop and closed-loop** characteristic.

The "simulation mode" function is made available for the function check of control units. It provides the possibility for the control unit to execute a program check without axis motion. For this purpose, only a drive control section is required of the drive, the power supply, motor and encoder are not used; therefore, the drive is directly ready for enabling ("AB") in the operating mode.

The function is implemented with the "Parking axis" command. For this purpose, the "permanently parked axis" function is activated with the parameter "P-0-0399, Configuration of simulation mode". The command and thereby the axis simulation are automatically started during the transition to the operating mode.

Pertinent parameters

- P-0-0399, Configuration of simulation mode
- S-0-0448, Set absolute position control
- S-0-0139, C1600 Parking axis procedure command
- S-0-0147, Homing parameter

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- Detailed description of malfunction and circumstances
- Type plate specifications of the affected products, in particular type codes and serial numbers
- Your contact data (phone and fax number as well as your e-mail address)

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Notes

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