Rexroth

ECODRIVE03/DURADRIVE
Drives for General Automation with Fieldbus Interfaces

Functional Description: FGP 20VRS

SYSTEM200

DOK-DRIVE*-FGP-20VRS**-FK01-EN-P

Rexroth Indramat

Title ECODRIVE03/DURADRIVE
Drives for General Automation with Fieldbus Interfaces

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Purpose of Documentation The following documentation describes the functions of the firmware FWA-DRIVE*-FGP-20VRS.

Record of Revisions

Description	Release Date	Notes
DOK-DRIVE*-FGP-20VRS**-FK01-EN-P	03.2002	First Release

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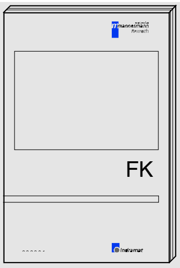
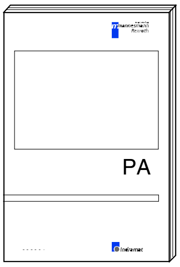
Summary of Documentation - Overview



Functional Description:

Description of all implemented Function based on SERCOS Parameters

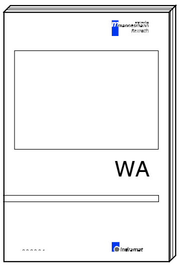
Order designation:
DOK-DRIVE*-FGP-20VRS**-FK01-EN-P



Parameter Description:

A description of all parameters used in the firmware

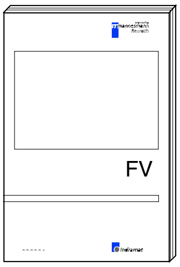
Order designation:
DOK-DRIVE*- FGP -20VRS**-PA01-EN-P



Troubleshooting Guide:

-Explanation of the diagnostic states
-How to proceed when eliminating faults

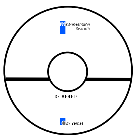
Order designation:
DOK-DRIVE*- FGP -20VRS**-WA01-EN-P



Firmware Version Notes:

Description of new and changed functions in terms of the derivatives:
FWA-ECODR3- FGP 03VRS-MS

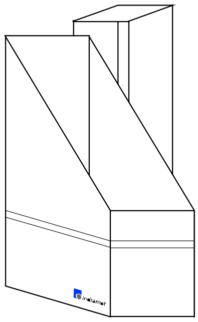
Order designation:
DOK-DRIVE*- FGP-20VRS**-FV01-EN-P



CD: DRIVEHELP

Collection of Windows help systems which contains documentation on firmware types

Order designation:
DOK-GENERL-DRIVEHELP**-GEXX-MS-D0600



Order designation
DOK-DRIVE*- FGP -20VRS**-7201-EN-P

Notes

Contents

Notes

1 System overview

1.1 ECODRIVE03/DURADRIVE – the universal drive solutions for automation

The **ECODRIVE03/DURADRIVE** automation systems for universal use are particularly efficient solutions for control tasks.

The characteristics of these systems are their excellent performance data, wide range of functions and favorable price-performance ratio.

In addition, **ECODRIVE03/DURADRIVE** feature easy mounting and installation, as well as a high degree of plant availability, and allow saving system components.

ECODRIVE03/DURADRIVE can be used to realize a multitude of drive tasks in most diverse applications.

Typical applications are:

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

1.2 The ECODRIVE03/DURADRIVE drive families

For the ECODRIVE03/DURADRIVE family there are three firmware types for different applications:

FWA-DRIVE*-SMT-2xVRS-MS
- Drives for Machine Tool Applications with SERCOS and Parallel Interface

FWA-DRIVE*-SGP-2xVRS-MS
- Drives for General Automation with SERCOS and Parallel Interface

FWA-DRIVE*-FGP-2xVRS-MS
- Drives for General Automation with Fieldbus Interfaces

The present Functional Description refers to the firmware type:

FWA-DRIVE*-FGP-20VRS-MS
"Drives for General Automation with Fieldbus Interfaces"

For the other firmware types mentioned there are separate documentations available.

1.3 Drive controllers

Within the drive controller families ECODRIVE03 and DURADRIVE, you can choose from various devices. The differences between the devices are due to different current ratings and different device concepts (interfaces, supported motor types and measuring systems).

Command communication interface

Interfaces Apart from a serial interface, there are the following command communication interfaces available:

Command communication interface	DURADRIVE	ECODRIVE03 DKCxx.3-016-7-FW (*1)	ECODRIVE03 DKCxx.3-040-7-FW DKCxx.3-100-7-FW DKCxx.3-200-7-FW
SERCOS	yes	yes	yes
Analog	no	no	yes
Parallel	no	yes	yes
INTERBUS	yes	yes	yes
PROFIBUS	yes	yes	yes
CANopen	yes	yes	yes
DeviceNet	yes	yes	yes

*1: With regard to the devices of the DKCxx.3-016-7-FW type, please note the information in the glossary

Fig. 1-1: Command communication interface

Note: With the FWA-DRIVE*-FGP-2xVRS-MS firmware only the command communication interfaces INTERBUS, PROFIBUS, CANopen and DeviceNet can be operated.

Supported motor types

With the devices of the DURADRIVE family, you can operate all motors made by Rexroth Indramat. You can also operate all motors made by Rexroth Indramat with the devices of the ECODRIVE03 family, except for the 16-ampere device (product name DKCxx.3-016-7-FW).

On the DKCxx.3-016-7-FW devices you can only operate Rexroth Indramat motors of the MKD type or third-party motors with resolver.

Note: With regard to the devices of the DKCxx.3-016-7-FW type, please note the information in the glossary.

Supported measuring systems

- HSF
- Resolver
- Sine encoder with $1V_{pp}$ signals
- Encoder with EnDat interface
- Resolver without feedback data memory
- Resolver without feedback data memory with incremental sine encoder
- Gearwheel encoder with $1V_{pp}$ signals
- Square-wave encoder

Note: You cannot connect an optional measuring system to DKCxx.3-016-7-FW devices!

The combinations of optional encoder and motor encoder that are possible for all other drive controllers are described under "Setting the measuring systems".

1.4 Function overview: FWA-DRIVE*-FGP-20VRS-MS

Operating modes

Operating mode	DURADRIVE	ECODRIVE03 DKCxx.3-016-7-FW (*1)	ECODRIVE03 DKCxx.3-040-7-FW DKCxx.3-100-7-FW DKCxx.3-200-7-FW
Torque/force control	only possible via CCM (SERCOS)	only possible via CCM (SERCOS)	yes
Velocity control	only possible via CCM (SERCOS)	only possible via CCM (SERCOS)	yes
Position control	yes	yes	yes
Drive internal interpolation	yes	yes	yes
Jogging	only possible via CCM (SERCOS)	yes	yes
Positioning block mode	only possible via CCM (SERCOS)	yes	yes
Drive-controlled positioning	yes	yes	yes
Stepper motor mode	no	yes	yes
Synchronous operating modes with virtual master axis	yes	yes	yes
Synchronous operating modes with real master axis	yes	no	yes

*1: With regard to the devices of the DKCxx.3-016-7-FW type, please note the information in the glossary

CCM: command communication module

Fig. 1-2: Operating modes

Basic drive functions

The following basic drive functions can be used by all drive controllers of the DURADRIVE and ECODRIVE03 product families:

- Diagnosis: extensive diagnostic functions
- Basic parameters: basic parameter set can be activated for defined setting of the drive parameters to default values.
- Customer password
- Error memory and hours-run meter
- Support of 5 languages for the parameter names and units, as well as for the diagnoses
  - German
  - English
  - French
  - Spanish
  - Italian
- Adjustable drive-internal position resolution
- Evaluation of absolute measuring systems by setting absolute measurement
- Modulo function
- Torque/force limit to be parameterized
- Current limit
- Velocity limit
- Travel range limit:

  by means of travel range limit switches and/or

  position limit values
- Drive error reaction:
  - Best possible deceleration "Velocity command value reset"
  - Best possible deceleration "Disable torque"
  - Best possible deceleration "Velocity command value to zero with filter and ramp"

    Power off on error

    NC response in error situation

    E-Stop function
- Position control loop setting

  Basic load (read feedback data memory)

  Acceleration feedforward

  Velocity feedforward

  Automatic control loop setting
- Velocity control loop monitoring
- Position control loop monitoring
- Drive halt

The following basic drive functions differ with regard to their availability for the drive controllers of the DURADRIVE and ECODRIVE03 product families:

Basic drive function	DURADRIVE	ECODRIVE03 DKCxx.3-016-7-FW (*1)	ECODRIVE03 DKCxx.3-040-7-FW DKCxx.3-100-7-FW DKCxx.3-200-7-FW
Evaluation of optional (load-side) encoders for position and/or velocity control	yes	no	yes
Control loop setting with velocity mix factor	yes	no	yes

*1: With regard to the devices of the DKCxx.3-016-7-FW type, please note the information in the glossary

Fig. 1-3: Basic drive functions

Optional drive functions

- Configurable system status word
- Configurable system control word
- Oscilloscope function
- Command "Parking axis"
- Dynamic position switch
- Command "Get mark position"
- DISC
- EcoX communication

The following optional drive functions differ with regard to their availability for the drive controllers of the DURADRIVE and ECODRIVE03 product families:

Optional drive function	DURADRIVE	ECODRIVE03 DKCxx.3-016-7-FW *2)	ECODRIVE03 DKCxx.3-040-7-FW DKCxx.3-100-7-FW DKCxx.3-200-7-FW
Command "Drive-controlled homing procedure"	yes	yes *1)	yes
Command "Set absolute measurement"	yes	yes *1)	yes
Measuring probe function	yes	yes *1)	yes
Encoder emulation	yes	no	yes
Measuring wheel mode	yes	no	yes
Analog outputs	yes	no	yes
Analog inputs	yes	no	yes

*1): Availability restricted, because optional encoder cannot be connected

*2): With regard to the devices of the DKCxx.3-016-7-FW type, please note the information in the glossary

Fig. 1-4: Optional drive functions

Notes

2 Important directions for use

2.1 Appropriate use

Introduction

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

The products may only be used in the manner that is defined as appropriate. If they are used in an inappropriate manner, then situations can develop that may lead to property damage or injury to personnel.

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

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

Areas of use and application

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

Control and monitoring of the motors may require additional sensors and actors.

Note: The drive controllers may only be used with the accessories and parts specified in this document. If a component has not been specifically named, then it may not be either mounted or 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 function descriptions.

Every drive controller has to be programmed before starting it up, making it possible for the motor to execute the specific functions of an application.

The drive controllers of the ECODRIVE03 family are designed for use in single or multiple-axis drive and control applications.

To ensure an application-specific use, the drive controllers are available with differing drive power and different interfaces.

Typical applications of drive controllers belonging to the ECODRIVE03 family are:

- handling and mounting systems,
- packaging and foodstuff machines,
- printing and paper processing machines and
- machine tools.

The drive controllers may only be operated under the assembly, installation and ambient conditions as described here (temperature, system of protection, humidity, EMC requirements, etc.) and in the position specified.

2.2 Inappropriate use

Using the drive controllers outside of the above-referenced areas of application or under operating conditions other than described in the document and the technical data specified is defined as “inappropriate use".

Drive controllers may not be used if

- they are subject to operating conditions that do not meet the above specified ambient conditions. This includes, for example, operation under water, in the case of extreme temperature fluctuations or extremely high maximum temperatures or if
- Rexroth Indramat has not specifically released them for that intended purpose. Please note the specifications outlined in the general safety instructions!

3 Safety Instructions for Electric Drives and Controls

3.1 Introduction

Read these instructions before the initial startup of the equipment in order to eliminate the risk of bodily harm or material damage. Follow these safety instructions at all times.

Do not attempt to install or start up this equipment without first reading all documentation provided with the product. Read and understand these safety instructions and all user documentation of the equipment prior to working with the equipment at any time. If you do not have the user documentation for your equipment, contact your local Rexroth Indramat representative to send this documentation immediately to the person or persons responsible for the safe operation of this equipment.

If the equipment is resold, rented or transferred or passed on to others, then these safety instructions must be delivered with the equipment.

WARNING

Improper use of this equipment, failure to follow the safety instructions in this document or tampering with the product, including disabling of safety devices, may result in material damage, bodily harm, electric shock or even death!

3.2 Explanations

The safety instructions describe the following degrees of hazard seriousness in compliance with ANSI Z535. The degree of hazard seriousness informs about the consequences resulting from non-compliance with the safety instructions.

Warning symbol with signal word	Degree of hazard seriousness according to ANSI
DANGER	Death or severe bodily harm will occur.
WARNING	Death or severe bodily harm may occur.
CAUTION	Bodily harm or material damage may occur.

Fig. 3-1: Hazard classification (according to ANSI Z535)

3.3 Hazards by Improper Use

DANGER

High voltage and high discharge current! Danger to life or severe bodily harm by electric shock!

DANGER

Dangerous movements! Danger to life, severe bodily harm or material damage by unintentional motor movements!

WARNING

High electrical voltage due to wrong connections! Danger to life or bodily harm by electric shock!

WARNING

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

CAUTION

Surface of machine housing could be extremely hot! Danger of injury! Danger of burns!

CAUTION

Risk of injury due to improper handling! Bodily harm caused by crushing, shearing, cutting and mechanical shock or incorrect handling of pressurized systems!

CAUTION

Risk of injury due to incorrect handling of batteries!

3.4 General Information

- Rexroth Indramat GmbH is not liable for damages resulting from failure to observe the warnings provided in this documentation.
- Read the operating, maintenance and safety instructions in your language before starting up the machine. If you find that you cannot completely understand the documentation for your product, please ask your supplier to clarify.
- Proper and correct transport, storage, assembly and installation as well as care in operation and maintenance are prerequisites for optimal and safe operation of this equipment.
- Only persons who are trained and qualified for the use and operation of the equipment may work on this equipment or within its proximity.
  - The persons are qualified if they have sufficient knowledge of the assembly, installation and operation of the equipment as well as an understanding of all warnings and precautionary measures noted in these instructions.
  - Furthermore, they must be trained, instructed and qualified to switch electrical circuits and equipment on and off in accordance with technical safety regulations, to ground them and to mark them according to the requirements of safe work practices. They must have adequate safety equipment and be trained in first aid.
- Only use spare parts and accessories approved by the manufacturer.
- Follow all safety regulations and requirements for the specific application as practiced in the country of use.
- The equipment is designed for installation in industrial machinery.
- The ambient conditions given in the product documentation must be observed.
- Use only safety features and applications that are clearly and explicitly approved in the Project Planning Manual.
  For example, the following areas of use are not permitted: construction cranes, elevators used for people or freight, devices and vehicles to transport people, medical applications, refinery plants, transport of hazardous goods, nuclear applications, applications sensitive to high frequency, mining, food processing, control of protection equipment (also in a machine).
- The information given in this documentation with regard to the use of the delivered components contains only examples of applications and suggestions.
  The machine and installation manufacturer must
  - make sure that the delivered components are suited for his individual application and check the information given in this documentation with regard to the use of the components,
  - make sure that his application complies with the applicable safety regulations and standards and carry out the required measures, modifications and complements.
- Startup of the delivered components is only permitted once it is sure that the machine or installation in which they are installed complies with the national regulations, safety specifications and standards of the application.

- Operation is only permitted if the national EMC regulations for the application are met.
  The instructions for installation in accordance with EMC requirements can be found in the documentation "EMC in Drive and Control Systems".
  The machine or installation manufacturer is responsible for compliance with the limiting values as prescribed in the national regulations.
- Technical data, connections and operational conditions are specified in the product documentation and must be followed at all times.

3.5 Protection Against Contact with Electrical Parts

Note: This section refers to equipment and drive components with voltages above 50 Volts.

Touching live parts with voltages of 50 Volts and more with bare hands or conductive tools or touching ungrounded housings can be dangerous and cause electric shock. In order to operate electrical equipment, certain parts must unavoidably have dangerous voltages applied to them.

DANGER

High electrical voltage! Danger to life, severe bodily harm by electric shock!

⇒ Only those trained and qualified to work with or on electrical equipment are permitted to operate, maintain or repair this equipment.

⇒ Follow general construction and safety regulations when working on high voltage installations.

⇒ Before switching on power the ground wire must be permanently connected to all electrical units according to the connection diagram.

⇒ Do not operate electrical equipment at any time, even for brief measurements or tests, if the ground wire is not permanently connected to the points of the components provided for this purpose.

⇒ Before working with electrical parts with voltage higher than 50 V, the equipment must be disconnected from the mains voltage or power supply. Make sure the equipment cannot be switched on again unintended.

⇒ The following should be observed with electrical drive and filter components:

⇒ Wait five (5) minutes after switching off power to allow capacitors to discharge before beginning to work. Measure the voltage on the capacitors before beginning to work to make sure that the equipment is safe to touch.

⇒ Never touch the electrical connection points of a component while power is turned on.

⇒ Install the covers and guards provided with the equipment properly before switching the equipment on. Prevent contact with live parts at any time.

⇒ A residual-current-operated protective device (RCD) must not be used on electric drives! Indirect contact must be prevented by other means, for example, by an overcurrent protective device.

⇒ Electrical components with exposed live parts and uncovered high voltage terminals must be installed in a protective housing, for example, in a control cabinet.

To be observed with electrical drive and filter components:

DANGER

High electrical voltage on the housing!
High leakage current! Danger to life, danger of injury by electric shock!

⇒ Connect the electrical equipment, the housings of all electrical units and motors permanently with the safety conductor at the ground points before power is switched on. Look at the connection diagram. This is even necessary for brief tests.

⇒ Connect the safety conductor of the electrical equipment always permanently and firmly to the supply mains. Leakage current exceeds 3.5 mA in normal operation.

⇒ Use a copper conductor with at least 10 mm^2 cross section over its entire course for this safety conductor connection!

⇒ Prior to startups, even for brief tests, always connect the protective conductor or connect with ground wire. Otherwise, high voltages can occur on the housing that lead to electric shock.

3.6 Protection Against Electric Shock by Protective Low Voltage (PELV)

All connections and terminals with voltages between 0 and 50 Volts on Rexroth Indramat products are protective low voltages designed in accordance with international standards on electrical safety.

WARNING

High electrical voltage due to wrong connections! Danger to life, bodily harm by electric shock!

⇒ Only connect equipment, electrical components and cables of the protective low voltage type (PELV = Protective Extra Low Voltage) to all terminals and clamps with voltages of 0 to 50 Volts.

⇒ Only electrical circuits may be connected which are safely isolated against high voltage circuits. Safe isolation is achieved, for example, with an isolating transformer, an opto-electronic coupler or when battery-operated.

3.7 Protection Against Dangerous Movements

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

- improper or wrong wiring of cable connections
- incorrect operation of the equipment components
- wrong input of parameters before operation
- malfunction of sensors, encoders and monitoring devices
- defective components
- software or firmware errors

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

The monitoring in the drive components will normally be sufficient to avoid faulty operation in the connected drives. Regarding personal safety, especially the danger of bodily injury and material 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.

⚠ DANGER

Dangerous movements! Danger to life, risk of injury, severe bodily harm or material damage!

⇒ Ensure personal safety by means of qualified and tested higher-level monitoring devices or measures integrated in the installation. Unintended machine motion is possible if monitoring devices are disabled, bypassed or not activated.

⇒ Pay attention to unintended machine motion or other malfunction in any mode of operation.

⇒ Keep free and clear of the machine's range of motion and moving parts. Possible measures to prevent people from accidentally entering the machine's range of motion:

- use safety fences
- use safety guards
- use protective coverings
- install light curtains or light barriers

⇒ Fences and coverings must be strong enough to resist maximum possible momentum, especially if there is a possibility of loose parts flying off.

⇒ Mount the emergency stop switch in the immediate reach of the operator. Verify that the emergency stop works before startup. Don't operate the machine if the emergency stop is not working.

⇒ Isolate the drive power connection by means of an emergency stop circuit or use a starting lockout to prevent unintentional start.

⇒ Make sure that the drives are brought to a safe standstill before accessing or entering the danger zone. Safe standstill can be achieved by switching off the power supply contactor or by safe mechanical locking of moving parts.

⇒ 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
- ensuring sufficient equilibration of the vertical axes

The standard equipment motor brake or an external brake controlled directly by the drive controller are not sufficient to guarantee personal safety!

⇒ Disconnect electrical power to the equipment using a master switch and secure the switch against reconnection 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 electronics circuits and supply leads. If the use of such equipment cannot be avoided, verify the system and the installation for possible malfunctions in all possible positions of normal use before initial startup. If necessary, perform a special electromagnetic compatibility (EMC) test on the installation.

3.8 Protection Against Magnetic and Electromagnetic Fields During Operation and Mounting

Magnetic and electromagnetic fields generated near current-carrying conductors and permanent magnets in motors represent a serious health hazard to persons with heart pacemakers, metal implants and hearing aids.

WARNING

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

⇒ Persons with heart pacemakers, hearing aids and metal implants are not permitted to enter the following areas:

- Areas in which electrical equipment and parts are mounted, being operated or started up.
- Areas in which parts of motors with permanent magnets are being stored, operated, repaired or mounted.

⇒ If it is necessary for a person with a heart pacemaker to enter such an area, then a doctor must be consulted prior to doing so. Heart pacemakers that are already implanted or will be implanted in the future, have a considerable variation in their electrical noise immunity. Therefore there are no rules with general validity.

⇒ Persons with hearing aids, metal implants or metal pieces must consult a doctor before they enter the areas described above. Otherwise, health hazards will occur.

3.9 Protection Against Contact with Hot Parts

CAUTION

Housing surfaces could be extremely hot! Danger of injury! Danger of burns!

⇒ Do not touch housing surfaces near sources of heat! Danger of burns!

⇒ After switching the equipment off, wait at least ten (10) minutes to allow it to cool down before touching it.

⇒ Do not touch hot parts of the equipment, such as housings with integrated heat sinks and resistors. Danger of burns!

3.10 Protection During Handling and Mounting

Under certain conditions, incorrect handling and mounting of parts and components may cause injuries.

CAUTION

Risk of injury by incorrect handling! Bodily harm caused by crushing, shearing, cutting and mechanical shock!

⇒ Observe general installation and safety instructions with regard to handling and mounting.

⇒ Use appropriate mounting and transport equipment.

⇒ Take precautions to avoid pinching and crushing.

⇒ Use only appropriate tools. If specified by the product documentation, special tools must be used.

⇒ Use lifting devices and tools correctly and safely.

⇒ For safe protection wear appropriate protective clothing, e.g. safety glasses, safety shoes and safety gloves.

⇒ Never stand under suspended loads.

⇒ Clean up liquids from the floor immediately to prevent slipping.

3.11 Battery Safety

Batteries contain reactive chemicals in a solid housing. Inappropriate handling may result in injuries or material damage.

CAUTION

Risk of injury by incorrect handling!

⇒ Do not attempt to reactivate discharged batteries by heating or other methods (danger of explosion and cauterization).

⇒ Never charge non-chargeable batteries (danger of leakage and explosion).

⇒ Never throw batteries into a fire.

⇒ Do not dismantle batteries.

⇒ Do not damage electrical components installed in the equipment.

Note: Be aware of environmental protection and disposal! The batteries contained in the product should be considered as hazardous material for land, air and sea transport in the sense of the legal requirements (danger of explosion). Dispose batteries separately from other waste. Observe the legal requirements in the country of installation.

3.12 Protection Against Pressurized Systems

Certain motors and drive controllers, corresponding to the information in the respective Project Planning Manual, must be provided with pressurized media, such as compressed air, hydraulic oil, cooling fluid and cooling lubricant supplied by external systems. Incorrect handling of the supply and connections of pressurized systems can lead to injuries or accidents. In these cases, improper handling of external supply systems, supply lines or connections can cause injuries or material damage.

CAUTION

Danger of injury by incorrect handling of pressurized systems !

⇒ Do not attempt to disassemble, to open or to cut a pressurized system (danger of explosion).

⇒ Observe the operation instructions of the respective manufacturer.

⇒ Before disassembling pressurized systems, release pressure and drain off the fluid or gas.

⇒ Use suitable protective clothing (for example safety glasses, safety shoes and safety gloves)

⇒ Remove any fluid that has leaked out onto the floor immediately.

Note: Environmental protection and disposal! The media used in the operation of the pressurized system equipment may not be environmentally compatible. Media that are damaging the environment must be disposed separately from normal waste. Observe the legal requirements in the country of installation.

Notes

4 General instructions for commissioning

4.1 Definition of terms, introduction

It is helpful to explain the terms used in this document so that they will be better understood.

Parameters

Communication with the drive occurs (with a few exceptions) with the help of parameters.

They can be used for

- Setting the configuration
- Parameterizing the controller settings
- Handling drive functions and commands
- Cyclical or acyclical (depending on requirements) transmission of command and actual values

Note: All of the drive's operating data are identified by IDNs.

The data status

Each parameter is provided with a data status, which can also be read. It serves the following purposes:

- Identifying the validity/invalidity of the parameter
- Contains the command acknowledgement if the parameter acts as a command

(see also chapter: "Commands")

Parameter structure

There are seven different data block elements for each parameter. These can be read/write accessed either via a user data interface by a higher-ranking control or a parameterization interface.

Element No.	Designation	Remarks
1	ID Number	parameter identification / reading of data status
2	Name	can be changed in language selection
3	Attribute	contains data length, type and decimal places
4	Unit	can be changed in language selection
5	Minimum input value	contains the minimum input value of the operating data
6	Maximum input value	contains the maximum input value of the operating data
7	Operating data	actual parameter value

Fig. 4-1: Data block or parameter structure

Write accessibility

There is write access only for the operating data; all other elements can only be read.

The operating data can be write-protected either continuously or temporarily.

The write accessing of the operating data depends on the relevant communication phase or on whether a password has been activated.

Possible error messages when reading and writing operating data

see chapter "Error messages"

Data storage

Non-volatile parameter storage registers

Various non-volatile parameter storage registers that buffer operating data are contained in the drive.

The operating data apply to:

- setting the configuration and
- parameterizing the controller settings

With each write access of an operating date the date is stored.

The following modules contain non-volatile memories:

- Drive controller
- Motor feedback (optional)
- Programming module

Parameters stored in the drive controller

All operating data that refer only to the drive controller and that cannot be changed by the user are stored in the drive controller.

This applies to the following parameters:

- **S-0-0110, Amplifier peak current**
- **S-0-0140, Controller type**
- **P-0-0190, Operating hours control section**
- **P-0-0191, Operating hours power section**
- **P-0-0192, Error recorder, diagnosis number**
- **P-0-0193, Error recorder, operating hours control section**
- **P-0-0520, Hardware code**
- **P-0-4000, Current-zero-trim phase U**
- **P-0-4001, Current-zero-trim phase V**
- **P-0-4002, Current-amplify-trim phase U**
- **P-0-4003, Current-amplify-trim phase V**
- **P-0-4024, Test status**
- **P-0-4035, Trim-current**
- **P-0-4053, Intermediate DC bus voltage gain adjust**
- **P-0-4054, Resolver input offset**
- **P-0-4055, Resolver input, amplitude adjust**
- **P-0-4058, Amplifier type data**
- **P-0-4059, Brake resistor data**
- **P-0-4061, Mains voltage gain adjust**

- **P-0-4088, Serial number**
- **P-0-4089, Production index**

Parameter storage in motor feedback

All motor-dependent parameters are stored in the motor feedback in the case of MHD, MKD and MKE motors. Additionally, parameters for the "load default" function and parameters containing position encoder data are stored here.

All parameters stored in the motor feedback data memory exist with both parameter block number 0 and 7.

Note: The parameters of parameter block number 0 take effect in the drive.

Parameters stored in programming module

All application parameters are stored in the programming module (control loop, mechanical system, interface parameters and so on).

All IDNs backed up in this module are listed in parameter **S-0-0192, IDN-list of backup operation data**.

If the programming module is exchanged, then these application parameters must be read out beforehand so that they can be written to the new module after the exchange.

Note: When devices are exchanged, the programming module can be used for the new device. In this way the characteristics (firmware and parameters) of the device that has been exchanged can be easily transferred to the new device.

Data backup

Backup & restore

To save the data of the axis, all important and changeable parameters of the axis are stored in the list **S-0-0192, IDN-List of backup operation data**. By saving the parameters listed there with the control or parameterization interface, you can obtain a complete data backup of this axis after the initial commissioning (backup & restore function).

Note: Parameter **S-0-0269, Parameter buffer mode** is insignificant as all parameters are backed up in a NOVRAM.

Basic parameter block

At delivery, the drive parameters contain basic values fixed at the factory. By executing the command **P-0-4094, C800 Command Base-parameter load** it is possible to reproduce this state at any time. The structure of the basic parameter block is such that

- all optional drive functions are deactivated,
- limit values for position are deactivated,
- limit values for torque/force are set to high values and
- limit values for velocity and acceleration are set to low values.

Velocity control is the mode set.

Note: The basic parameter block does not guarantee that the drive matches the machine. Only in certain cases does it guarantee that the drive matches the connected motors and measuring systems. The relevant settings must be made when commissioning the axis for the first time.

See also chapters: "Basic drive functions" and "Commissioning guidelines"

Running the "load basic parameter block" function automatically

The programming module contains the drive firmware. In case firmware is exchanged for a different firmware version (with a different number of buffered parameters), the drive controller will detect this the next time the control voltage is switched on. In this case, the message "**PL**" appears on the 7-segment display. By pressing the "**S1**" key, the basic parameter block is activated.

Note: Any previous parameter settings are lost with the firmware exchange followed by "load basic parameter block". If this is to be prevented, then the parameters must be stored prior to the exchange and must be reloaded after the firmware exchange and basic parameter block load.

Note: As long as the drive displays "PL" and the command is active, then communication via the serial interface (with DriveTop) is impossible.

Password

The respective parameters are listed in **S-0-0279, IDN-list of password-protected operation data**. To secure these parameters against unwanted or non-authorized changes, they can be write-protected by the activation of a customer password.

By editing **S-0-0279, IDN-list of password-protected operation data** the user can select the parameters which are to be write-protected with a password.

Note: **The default value of S-0-0279, IDN-list of password-protected operation data** corresponds to the contents of **S-0-0192, IDN-list of backup operation data**.

Accessing the password

The password is accessed with parameter **S-0-0267, Password**.

Allowable characters and length

The password

- has to have at least 3 characters
- must not have more than 10 characters
- can only include the characters a-z and A-Z and the numbers 0-9

3 different password states are possible

The password function can have three different states. Depending on the sequence of characters entered for **S-0-0267**, the current password state can be changed.

The following figure illustrates possible password states and the sequence of characters for parameter **S-0-0267**.

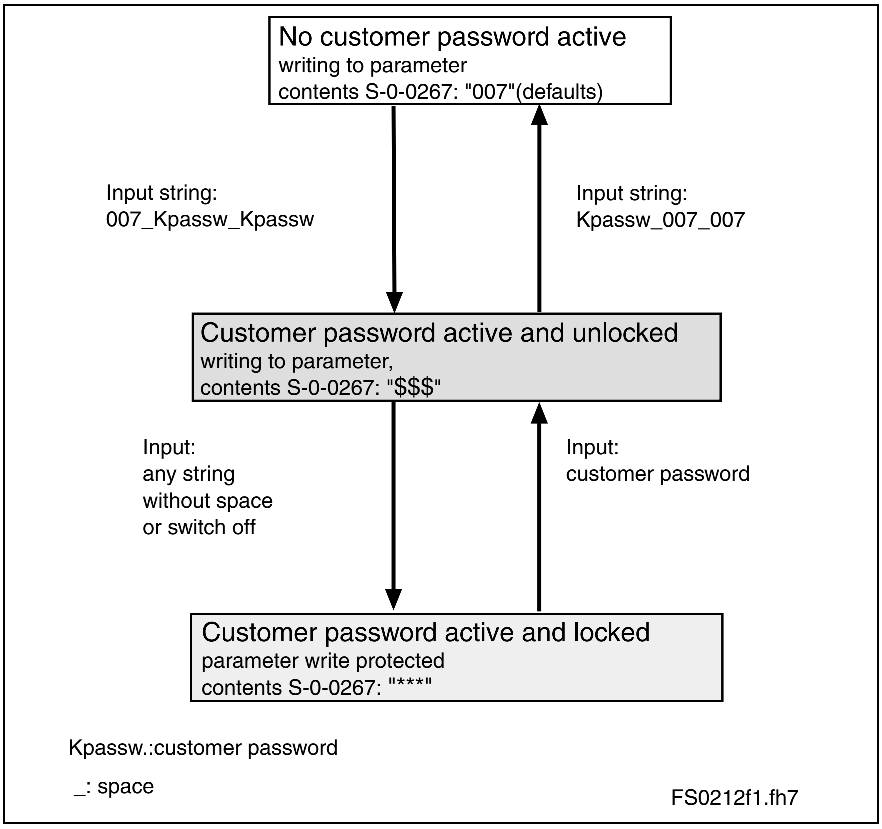


Fig. 4-2: Possible password states

Note: **If the customer password is activated and unlocked (content of** S-0-0267= "$$$"), then the drive is locked after switching the drive off (contents of S-0-0267= "****").

Note: Parameters that are stored in the data memory of the motor feedback or drive controller cannot be changed by the user.

Master password

Rexroth Indramat reserves the right to use a master password function.

Commands

Commands are used to control complex functions in the drive. For example, the functions "Drive-controlled homing procedure" or "Transition check for communication phase 4" are defined as commands.

A primary control can start, interrupt or clear a command.

Each command has a parameter with which the command can be controlled.

While a command is being executed, the diagnostic message "Cx" or "dx" appears in the display, where x is the number of the command.

Note: Each command that is started must be cleared again.

List of all procedure commands

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

Command types

There are 3 command types.

- Drive control commands
  - Possibly lead to an automatic drive motion
  - Can be started only when controller enable has been set
  - Deactivate the active operating mode during its execution
- Monitor commands
  - Activate or deactivate monitors or features in the drive
- Management commands
  - execute management tasks; cannot be interrupted

Command input and acknowledgement

Control and monitoring of command execution occurs via the command input and command acknowledgement. The command input tells the drive if the command should be started, interrupted or ended. The command input is the operating data of the applicable parameter.

The command input value can be:

- not set and not enabled (0)
- interrupted (1)
- set and enabled (3)

In the acknowledgement, the drive informs about the extent to which a command has been executed. This is then displayed in the data status of the command parameter.

See also chapter: "Parameters"

Note: The command status can be obtained by conducting a command to write data to parameter element 1 (data status).

Data status

The condition can be:

- not set and not enabled (0)
- in process (7)
- error, command execution impossible (0xF)
- command execution interrupted (5)
- command properly executed (3)

Command change bit

The command change bit in the drive status word helps the control recognize a change in the command acknowledgement by the drive. The bit is set by the drive, if the command acknowledgement changes from the condition in process (7) to the condition error, command execution not possible (0xF) or command properly executed (3). The bit is cleared, if the master clears the input (0).

The control system will recognize, if the drive sets the command change bit. The control system can read the corresponding data status of the command or commands, which it has set sometime but has not yet cleared. The control system will recognize from this, whether the command ended with or without an error in the drive. Afterwards this command has to be cleared by the control.

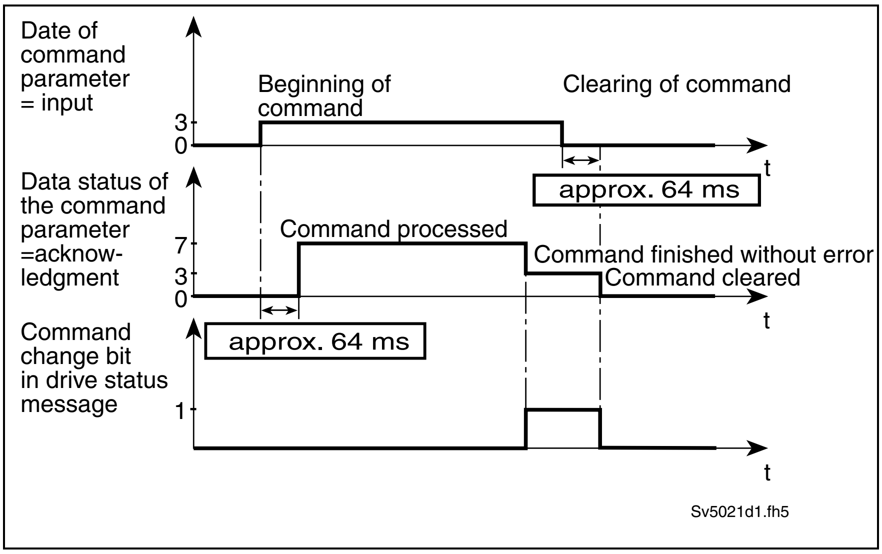


Fig. 4-3: Input, acknowledgement and command change bit during proper execution

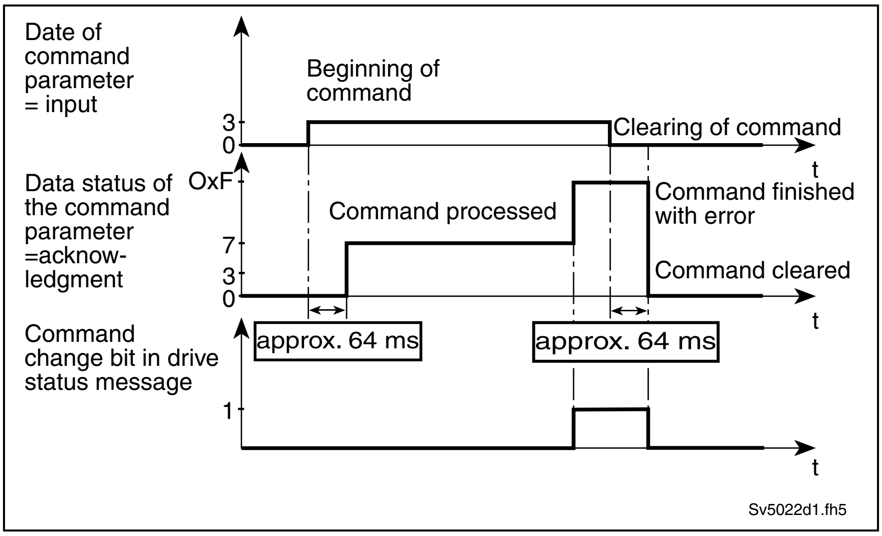


Fig. 4-4: Input, acknowledgement and command change bit during erroneous execution

A delay time of up to 64 ms can occur in the drive between receiving the command input and setting the command acknowledgement.

Operating modes

Operating modes define which command values will be processed in which format, in order to lead to the desired drive motion. They do not define how these command values will be transmitted from a control system to the drive.

One of the four selectable operating modes (S-0-0032 … S-0-0035) is active when

- the control and power supply are ready for operation
- the controller enable signal sees a positive edge

The drive displays "AF".

Note: All implemented operating modes are stored in parameter **S-0-0292, List of all operation modes**.

See also chapter: "Operating modes"

Warnings

Many areas are monitored in connection with operating modes and parameter settings. A warning will be generated if a state is detected that allows proper operation for the time being, but will eventually generate an error and thereby lead to an automatic shutdown of the drive if this state continues.

Note: Warnings do not cause automatic shutdown; exception: fatal warnings.

Warning classes

Warnings can be divided into 2 classes. They are differentiated by whether the drive executes an automatic reaction or not when the warning appears.

Note: The warning class can be regognized in the diagnostic message.

Warning class	Diagnostic message	Drive reaction
Not fatal	E2xx E3xx	without drive reaction
Interface	E4xx	without drive reaction
Fatal	E8xx	automatic reaction, specifically in terms of the occurring warning

Fig. 4-5: Breakdown of the warning classes

Note: Warnings cannot be cleared. They persist until the conditions that lead to the warning are no longer present.

Errors

Depending on the active operating mode and parameter settings, many monitoring functions are carried out. An error message is generated by the drive controller, if a condition is encountered which no longer allows correct operation.

Error classes

Errors are divided into four different error classes with different drive error reaction. The error class is evident from the diagnostic message:

Error class	Diagnostic message	Drive reaction
Not fatal	F2xx F3xx	In accordance with best possible deceleration
Interface	F4xx	In accordance with best possible deceleration
Travel range	F6xx	Speed command value switched to zero
Fatal	F8xx	Switch to torque-free state

Fig. 4-6: Error class divisions

Drive error reaction

If an error state is detected in the drive, the drive error reaction will automatically be executed as long as the drive is in control. The display flashes Fx / xx.

The drive’s reaction to interface and non-fatal errors can be parameterized with **P-0-0119, Best possible deceleration**. The drive switches to torque-free operation at the end of each error reaction.

Clearing errors

Errors are not automatically cleared; they have to be cleared externally by:

- initiating the command **S-0-0099, C500 Reset class 1 diagnostic** or
- pressing the "S1" key or
- positiv edge at the input "clear error".

If the error state is still present, then the error will be immediately detected again.

Clearing errors when controller enable is set

If an error is discovered while operating with controller enable being set, the drive will execute an error reaction. The drive automatically deactivates itself at the end of each error reaction; in other words, the power stage is switched off and the drive switches from an energized to a de-energized state.

To reactivate the drive:

- clear the error

  AND
- again input a positive edge for controller enable

Note: In the case of fieldbus drives the state machine must first be initialized, if necessary.

Error memory and operating hours counter

Error memory

Once errors are cleared, they are stored in an error memory. The last 19 errors are stored there and the times they occurred. Errors caused by a shutdown of the control voltage (e. g. **F870 +24Volt DC error**) are not stored in the error memory.

Operating hours counter

In addition, there are operating hours counters for control and power sections of the drive controller. For this function the following parameters are available:

- **P-0-0190, Operating hours control section**
- **P-0-0191, Operating hours power section**
- **P-0-0192, Error recorder diagnosis number**
- **P-0-0193, Error recorder, operating hours control section**

IDN lists of parameters

There are parameters in the drive that, in turn, contain ID numbers of drive parameters. These support the handling of the drive parameters with parameterization programs (e. g. DriveTop).

S-0-0017, IDN-list of all operation data

The IDNs of all parameters in the drive are stored in parameter **S-0-0017, IDN-list of all operation data**.

S-0-0192, IDN-list of backup operation data

In parameter **S-0-0192, IDN-list of backup operation data** the IDNs of all those parameters are stored, that are stored in the programming module. These are the parameters that are needed for a proper operation of the drive. The control or the parameterization program uses this IDN list to make a backup copy of the drive parameters.

S-0-0021, IDN-list of invalid op. data for comm. Ph. 2

In parameter **S-0-0021, IDN-list of invalid op. data for comm. Ph. 2**, the drive enters the IDNs of the parameters which are recognized as invalid in command **S-0-0127, C100 Communication phase 3 transition check**. Parameters are recognized as invalid if:

- their checksums, that are stored together with the operating data in a non-volatile memory (programming module, amplifier or motor feedback data memory), do not match the operating data,
- their operating data is outside of the minimum/maximum input range or
- their operating data has violated the plausibility rules.

In any event, the parameters entered in **S-0-0021, IDN-list of invalid op. data for comm. Ph. 2** upon negative acknowledgement of command **S-0-0127, C100 Communication phase 3 transition check** must be corrected.

S-0-0022, IDN-list of invalid op. data for comm. Ph. 3

In parameter **S-0-0022, IDN-list of invalid op. data for comm. Ph. 3** the drive enters the IDNs of the parameters which are recognized as invalid or configured in an inadmissible way in command **S-0-0128, C200 Communication phase 4 transition check**.

Parameters are recognized as invalid if:

- their checksums, that are stored together with the operating data in a non-volatile memory (programming module, amplifier or motor feedback data memory), do not match the operating data,
- their operating data are outside of the minimum/maximum input range or
- their operating data has violated the plausibility rules.

Parameters can be recognized as configured in an inadmissible way, if they have been configured more than once for parameter write by a cyclic interface.

In any event, the parameters entered in **S-0-0022, IDN-list of invalid op. data for comm. Ph. 3** upon negative acknowledgement of command **S-0-0128, C100 Communication phase 4 transition check** must be corrected.

S-0-0018, IDN-list of operation data for CP2

The IDNs that were checked for validity in command **S-0-0127, C100 Communication phase 3 transition check** are stored in the data of **S-0-0018, IDN-list of operation data for CP2**.

S-0-0019, IDN-list of operation data for CP3

The IDNs that were checked for validity in command **S-0-0128, C200 Communication phase 4 transition check** are stored in the data of **S-0-0019, IDN-list of operation data for CP3**.

S-0-0025, IDN-list of all procedure commands

The IDNs of all the commands in the drive are stored in the data of **S-0-0025, IDN-list of all procedure commands**.

4.2 Parametrization Mode - Operating Mode

Note: A drive controller with fieldbus interface immediately switches into operating mode when switched on.

The switch from parametrization to operating mode is controlled by start and end commands

- **S-0-0127, C100 Communication phase 3 transition check**
- **S-0-0128, C200 Communication phase 4 transition check**
- **P-0-4023, C400 Communication phase 2 transition**

It is necessary to trigger the transition command **P-0-4023, C400 Communication phase 2 transition** to get into parametrization mode.

Note: In order to be able to switch between the parametrization mode and operating mode, it is only possible to start a transition command, if the drive is not in control mode or command communications is not active.

The current status of command communications is in parameter **P-0-4086, Command communication status**.

If the drive reaches phase 4 without an error, then the message (H1) "**bb**" appears on the 7-segment display on the front of the drive amplifier. The corresponding diagnosis is: **A013 Ready for power on**

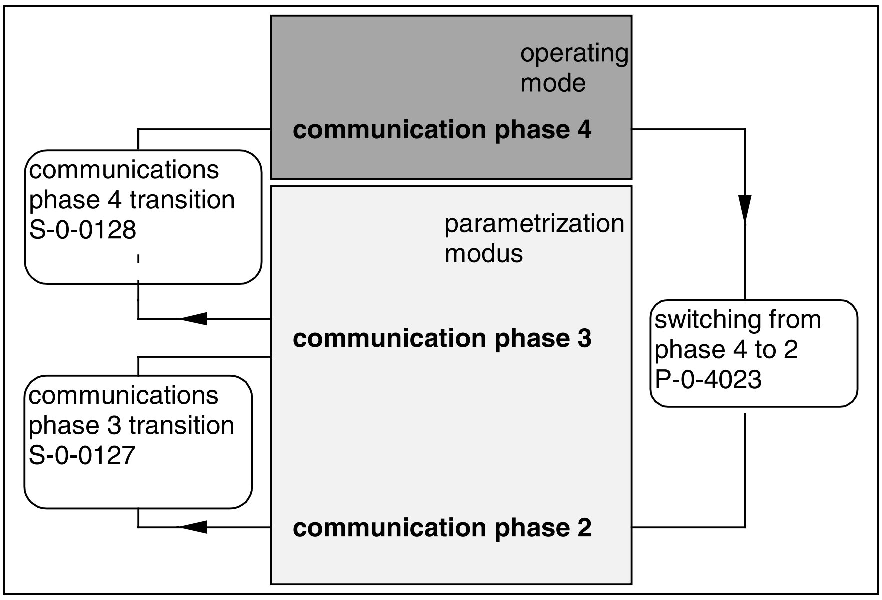


Fig. 4-7: The communications phases

Note: The evaluation of the measuring systems as well as the processing of the encoder emulation's only takes place in operating mode. Switching from operating mode into parametrization mode means that these functions are no longer active. The switch into operating mode always starts a new initialization of all the functions within the drive.

Checks in the Transition Commands

To switch from communication phases 2 to 3 and 3 to 4, it is necessary to activate transition checks in the drive first. This includes a number of checks and parameter conversions.

Note: The reasons for and assistance with transition command errors are specified in the diagnostics description.

S-0-0127, C100 Communication phase 3 transition check

The timing of command communications is checked in transition command C1. These checks are irrelevant for those units without command communications. (Examples of command communications are SERCOS, Profibus and so on.)

The following checks are conducted in the C1 command.

Checking the telegram configuration of the command communications

This checks as to whether the parameters selected for the configurable data block in the master data telegram or drive data telegram may be configured or not. It also checks whether the allowable length of the configurable data blocks has been retained or not.

The following command errors can occur, in this case: :

- **C104 Config. IDN for MDT not configurable**
- **C105 Configurated length > max. length for MDT**
- **C106 Config. IDN for AT not configurable**
- **C107 Configurated length > max. length for AT**

Checking validity of communications parameters

If the checksum of one of the parameters needed to progress into phase 3 is faulty, then command error:

- **C101 Invalid communication parameter (S-0-0021)**

is generated. The ID no. of the faulty parameters are listed in:

- **S-0-0021, IDN-list of invalid op. data for comm. phase 2**

They are made valid by writing into them.

Extreme value check of the communications parameters

If an error occurs during the extreme value check of those parameters relevant to the command communications, then command error

- **C102 Limit error communication parameter (S-0-0021)**

is generated. The ID numbers of the faulty parameters are listed in

- **S-0-0021, IDN-list of invalid op. data for comm. phase 2**

and must then be corrected.

Checking plausibility and maintaining the marginal conditions for command communications

Checking the timing parameters for command communications in terms of plausibility and maintaining marginal conditions.

The following command errors can occur:

- **C112 TNcyc (S-0-0001) or TScyc (S-0-0002) error**
- **C113 Relation TNcyc (S-0-0001) to TScyc (S-0-0002) error**
- **C114 T4 > TScyc (S-0-0002) - T4min (S-0-0005)**

S-0-0128, C200 Communication phase 4 transition check

During this command, the following checks are run.

Checking P-0-4014 for plausibility

If in parameter **P-0-4014, Motor type** 1 (MHD) or 5 (MKD/MKE) are selected and the motor feedback data memory has not found that type, then command error

- **C204 Motor type P-0-4014 incorrect**

is generated.

Checking validity

If the checksum of one of the parameters needed to progress into phase 4 is faulty, then command error:

- **C201 Invalid parameter(s) (->S-0-0022)**

is generated. The ID number of the faulty parameters are listed in

- **S-0-0022, IDN list of invalid op. data for comm. phase 3**

and are made valid by writing into.

Reading the controller memory

The drive controller reads the non-volatile memory, e.g., EEPROM, of the drive controller operating data. If an error occurs during this process, then command error:

- **C212 Invalid amplifier data (->S-0-0022)** appears**.**

The ID number of the faulty parameter is written in

- **S-0-0022, IDN-list of invalid op. data for comm. phase 3.**

Checking whether optional encoder is needed

If operating mode parameters **S-0-0032..35** or referencing parameter **S-0-0147** bit3 dictates that a second encoder is required but a "0" is entered in parameter **P-0-0075, Feedback type 2** then the faulty parameter(s) is listed in:

- **S-0-0022, IDN-list of invalid op. data for comm. phase 3**

Command error

- **C210 Feedback 2 required (->S-0-0022)** appears.

Checking whether motor encoder is available

Check whether a motor encoder is available (**P-0-0074, Feedback type 1** = 0) and no "2" is entered in function parameter **P-0-0185, Function of encoder 2** for load-side motor encoder. If this is the case, then command error

- **C236 Feedback 1 required (P-0-0074)**

is generated.

Checking motor encoder settings

If the encoder parametrized in parameter **P-0-0074, Feedback type 1** is not available, or its data cannot be read, then this error message is generated

- **C217 Feedback1 data reading error**

Checking optional encoder settings

If the encoder interface selected in parameter **P-0-0075, Feedback type 2** is already occupied by the motor encoder, then this error message is generated:

- **C234 Encoder combination not possible**

generated.

If a second encoder with feedback data memory is used but its data cannot be read, then error message

- **C218 error when reading data of encoder 2**

is generated. If parameter **P-0-0185, Function Encoder 2** "load-side motor encoder" is selected, but there is no rotary asynchronous motor, then error message

- **C235 Load-side motor encoder only with asynchronous motor**

is generated.

Reading out feedback data memory

The parameters stored in the memory of motors with feedback data memory are read. If an error occurs during this process, then command error

- **C211 Invalid feedback data (->S-0-0022)** is generated.

Checking maximum travel range

Check whether an internal position resolution has been set via parameter **S-0-0278, Maximum travel range** which guarantees the correct commutation of the motor. If not, then this command error appears:

- **C223 Input value for max. range too high.**

Checking scaling

Check internal ability to illustrate conversion factors from display format to an internal one and vice versa for scaling-dependent data. If an error occurs, then one of the following command errors can be generated:

- **C213 Position data scaling error**
- **C214 Velocity data scaling error**
- **C215 Acceleration data scaling error**
- **C216 Torque/force data scaling error**

Checking all parameters for extreme values and possible bit combinations

All parameters are checked for maintaining extreme values or permissible bit combinations. If an error occurs, then command error

- **C202 Parameter limit error (->S-0-0022)**

is generated. The ID number o the faulty parameter is listed in

- **S-0-0022, IDN-list of invalid op. data for comm. phase 3**

and must be corrected.

Checking modulo range

Checking whether an activated modulo scaling of the position from parameter **S-0-0103, Modulo value** is possible. If it is not, then command error

- **C227 Modulo range error**

is generated.

Checking the conversion of internal formats

The physical values of parameters (input format with decimal places and units) are converted to internal formats. This conversion is monitored. If incongruencies are detected during this process, then command error

- **C203 Parameter calculation error (->S-0-0022)**

is generated. The ID number of the faulty parameter is listed in

- **S-0-0022, IDN-list of invalid op. data for comm. phase 3**

and must be corrected.

Checking encoder initialization

Encoder initialization is listed. Errors can occur depending on encoder type (e.g., index length wrong in DSF feedback). Then one of the following command error

- **C220 Feedback 1 initializing error**
- **C221 Feedback 2 initializing error**

is generated.

Absolute encoder monitoring

If the actual position of an absolute encoder is outside of the range of the current actual position prior to the last shutdown, +/- **P-0-0097, Absolute encoder monitoring window,** then error

- **F276 Absolute encoder outside of monitoring window**

is generated. The acknowledgement of the transition command is not faulty in this case but rather the error must be cleared by executing command **S-0-0099, C500 Reset class 1 diagnostics**.

(Also see section: "Clearing Errors").

4.3 Commissioning guidelines

In order to make sure that all necessary parameterization processes are carried out in the drive, (initial) commissioning should be carried out with DriveTop.

Motor configuration

Motors without data memory

This commissioning step is needed in the case where the motor used does not have a motor feedback memory. It is necessary with these motors to

- enter the parameters for motor features (peak current, maximum velocity, etc.) using the data sheet or, by means of DriveTop, accept the parameters from the motor data bank,
- parameterize the parameters for the motor temperature warning and switch-off thresholds and
- given a motor holding brake, these parameters must be set accordingly.

Motors with data memory

Those motors with data memory, such as

- MHD, MKD, MKE motors,

are recognized by the drive and the respective motor parameters are automatically set.

(See also chapter: "Setting the motor type".)

Setting the fieldbus communication

P-0-4084, Profile type must be set in this step to be able to select the operating mode wanted and its relevant profile interpreter (including status machine).

To ensure the functioning of the related operating modes (S-0-0032 ... S-0-0035), it is necessary to carry out:

- operating mode-specific settings (e.g., positioning block data in positioning block mode),
- operating mode-relevant limit value settings,
- command value filter settings that may be necessary and
- definitions of the operating modes available.

Note: In the case of command communication using a Profibus it is also possible in this step to define the parameter channel in the real time channel with **P-0-4083, Length of parameter channel**. For CANbus it is necessary to also set the **P-0-4079, Fieldbus baudrate**.

(See also section: "Profile types".)

Presetting the axis mechanics and measuring systems

In this step, the parameters needed for determining and processing position, velocity and acceleration data are set. These include the following parameters for the following settings:

- mechanical gear ratio between motor and load as well as any existing feedrate constants of linear drives,
- scaling settings for the data format of all position, velocity and acceleration parameters of the drive; these settings determine, for example, whether the data are related to motor shaft or load and which LSB valence they have (e.g. position data with 0.0001 degrees or 0.00001 inches and so on),
- interfaces, rotational directions and the resolution of the motor encoder, and where available, optional encoders.

(See also chapters: -"Physical values display format"
-"Mechanical transmission elements"
-"Setting the measurement system").

Setting the error reactions and E-stop

In this step, the reaction of the drive in the event of an error as well as in the event of activation of the drive's own **E-stop input** is set.

The following parameterization processes must be performed:

- type and mode of error reactions in drive
- selection whether NC reaction (only with SERCOS) in case of error is to be carried out
- selection whether, and if so when, the power supply is switched off and whether a package reaction (only with SERCOS) is to be carried out
- configuration of the E-stop input

(See also chapter: "Drive error reaction")

Presetting the control loops

The parameters for current, velocity and position control loops are set in this step. This is done either by:

- executing command **P-0-0162, D900 Command Automatic control loop adjust**
  During the execution of the command, the setting for the velocity controller and the position controller is determined as well as the load inertia.

- or -

- executing command **S-0-0262, C700 Command basic load** or
- **inputting** the controller values specified in the **data sheet**

Setting the control loop in this way ensures a good level of quality for most applications. Should additional optimization of the control loop parameters (velocity and position control loop parameters, compensation functions and precontrol) become necessary, this should be carried out in the commissioning step "Optimizing the control loops".

(See also chapter: "Control loop settings")

Checking axis mechanics and measuring systems

The presettings made in "Presetting the axis mechanics and measuring systems" are checked and, if necessary, modified in this step. This means that the axis must be moved by jogging, for example.

The following checks must be made:

- Check of the rotational direction of the motor encoder. With non-inverted position polarity (**S-0-0055, Position polarities** = 0), the values in parameter **S-0-0051, Position feedback 1 value** should have a rising order with a clockwise rotation of the motor shaft (in the case of linear motors, towards power connector). (This check need not be performed with MHD and MKD motors.) If this is not the case, then bit 3 in **S-0-0277, Position feedback 1 type** should be inverted.
- By moving the axes and examining the position feedback value of the motor encoder in parameter **S-0-0051, Position feedback 1 value** it is possible to control whether the encoder indicates a travelled distance correctly. If not, then the settings for mechanical gear ratio, feedrate constants and encoder resolution must be checked.

- Given a second encoder, by moving the axis and examining the position feedback value of the second encoder in parameter **S-0-0053, Position feedback 2 value** it is possible to control whether the encoder indicates a travelled distance correctly. **S-0-0051, Position feedback 1 value** and **S-0-0053, Position feedback 2 value** should run in parallel when jogging a specific distance. If not, then check the settings in **P-0-0075, Feedback type 2**, **S-0-0117, Feedback 2 Resolution, S-0-0115, Position feedback 2 type** and **P-0-0185, Function of encoder 2**.

(See also chapters: -"Physical values display format"
-"Mechanical transmission elements"
-"Setting the measurement system").

Limits for position, velocity and torque

In this step the limits for the travel range are conducted by setting

- position limit values and/or
- travel range limit switches

The limit values for the axis velocity and maximum drive torque/force are also parametrized in this step.

(See also chapters: -"Torque/force limit"
-"Travel range limits"
-"Limiting velocity")

Optimizing the control loops

This step is only necessary if the settings for velocity and position control loops in section "Presetting the control loops" did not achieve the required quality. In this case, optimize the control behavior as follows:

- modify the parameters for velocity and position control loops
- if necessary, activate the acceleration pre-control
- if necessary, activate the velocity mixture and
- if necessary, activate the notch filter.

(See also chapter: "Control loop settings")

Establishing absolute reference measurement

In this step the absolute reference measurement is set in terms of the machine zero point of the position feedback values from motor encoder and possibly optional encoder. At first the position feedback values show any value, not machine zero point related values. By conducting

- set absolute measurement (with absolute encoders) or
- drive-controlled homing

the coordinate systems of the position encoder and the coordinate system of the machine are made congruent.

(See also chapter: -"Drive-controlled homing"
-"Setting the absolute measurement")

Other settings

In this step

- the drive halt function is parameterized,
- the language is selected,
- general status messages are set and
- optional drive functions are set.

(See also chapters: -"Drive Halt"
-"S-0-0013, Class 3 diagnostics"
-"S-0-0182, Manufacturer class 3 diagnostics"
-"Optional drive functions"
-"Language selection"

Controlling the drive sizing

The power-related drive checks are conducted in this step. It is checked whether the continuous and peak power of drive amplifier and motor meet the requirements. The following checks are conducted for this purpose:

- Generated torque/force of motor is checked. At a constant speed 60% and in rapid traverse 75% of the continuous torque at standstill of the motor should not be exceeded.
- During the acceleration phase 80% of the maximum torque of the motor/controller combination may not be exceeded.
- The thermal load of the drive amplifier should equal a maximum of 80%.

(See also chapter: "Current limit")

With vertical axes, the weight compensation must be set in such a way that the current consumption with upwards and downwards motions of the machine axes has the same minimum value.

Check the regenerated peak power and regenerated continuous power.

4.4 Diagnostics

Overview of diagnostics

The diagnostics can be divided into 2 groups:

- options for recognizing the current drive status by means of the priority-dependent, drive-internal generation of diagnoses and
- collective messages for diverse status messages

Additionally, there are parameters for all important operating data that can be transmitted both via master communication (SERCOS, Profibus, ...), as well as the parameterization interface (RS-232/485 in the ASCII protocol or SIS serial Rexroth Indramat protocol).

Drive-internal diagnostics

The current operating status of the drive depends on:

- any present errors
- any present warnings
- commands executed
- the signal "Drive Halt"
- the execution of an error reaction
- the automatic drive check or self-adjustment
- the active operating mode

Whether the drive is ready for operation or in parameter mode also is displayed.

The current operating status can be determined from

- the 2-part seven-segment display (H1 display)
- the diagnostic parameter **S-0-0095, Diagnostic message**
- the parameter **S-0-0390, Diagnostic message number**
- the parameter **P-0-0009, Error message number**
- the parameter **S-0-0375, List of diagnostic numbers**

The current diagnostic message with the highest priority is always shown in the

- H1 display,
- **S-0-0095, Diagnostic message**and
- **S-0-0390, Diagnostic message number**.

The parameter **P-0-0009, Error message number** will only contain a value unequal to 0 if an error is present. The last displayed diagnostic numbers are displayed in chronological order in parameter **S-0-0375, List of diagnostic numbers**. An overview of all diagnostic messages can be found in the diagnostic description "Troubleshooting Guide".

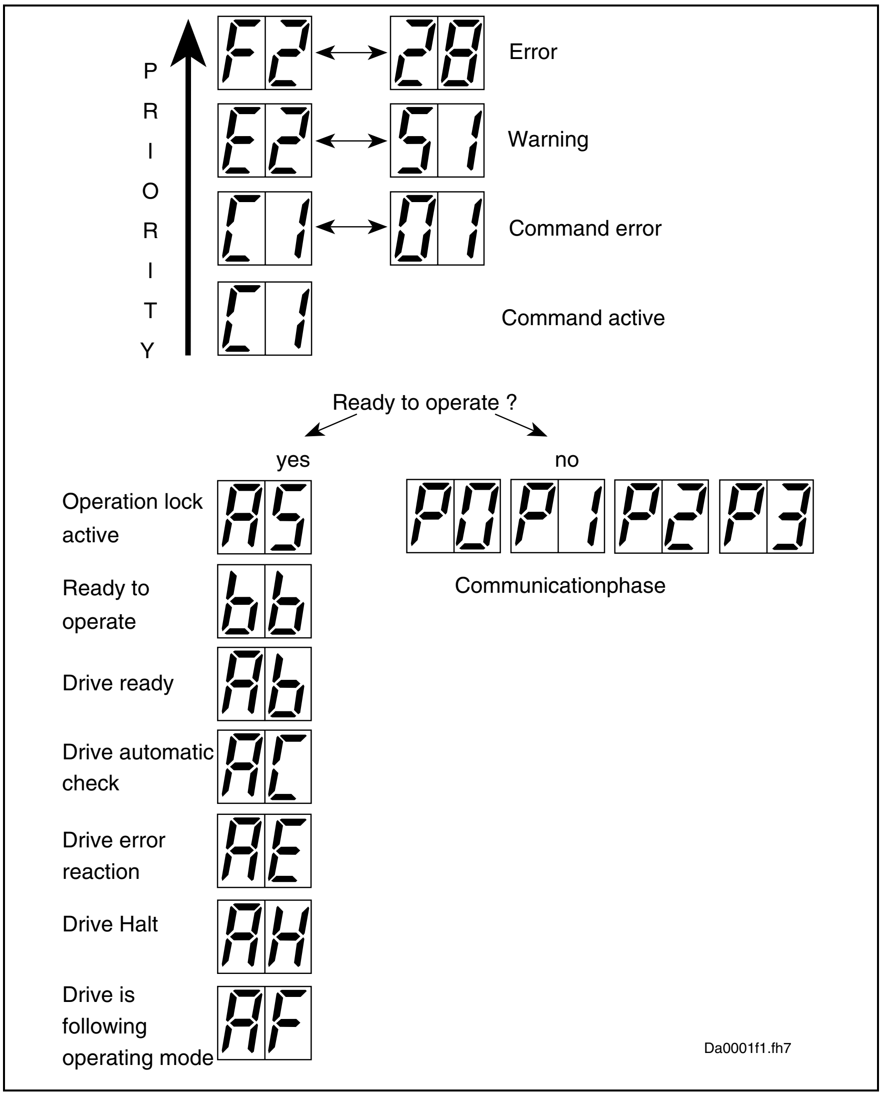


Fig. 4-8: Priority-dependent diagnostic information on the H1 display

Diagnostic message composition

Each operating status is designated with a diagnostic message, which consists of a

- diagnostic message number and a
- diagnostic text

For example, the diagnostic message for the non-fatal error "Excessive Control Deviation" is displayed as follows.

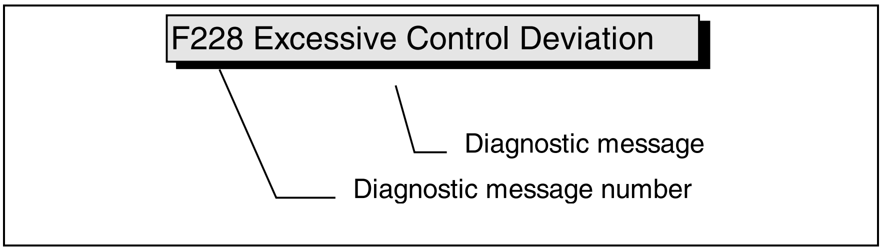


Fig. 4-9: Diagnostic message composition with a diagnostic message number and text

The H1 display alternates "F2" and "28". The diagnostic message number appears in hexadecimal format in the parameter **S-0-0390, Diagnostic message number**. In this example, this would be (0x)F228. The diagnostic message number and the diagnostic text are contained as a string **F228 Excessive deviation** in the parameter **S-0-0095, Diagnostic message**. The parameter **P-0-0009, Error message number** contains 228 (dec).

H1 display

The diagnostic number appears on the two-part seven-segment display (H1). The form of the display emerges from the figure "Priority-dependent display of the diagnostic message on the H1 display".

With the help of this display, it is possible to quickly determine the current operating status without using a communication interface.

The operating mode cannot be seen on the H1 display. If the drive follows the operating mode and no command was activated, then the symbol AF appears on the display.

Diagnostic message in plain text

The diagnostic message in plain text contains the diagnostic number followed by the diagnostic text. It can be read with the parameter **S-0-0095, Diagnostic message** and directly displays the operation status on an operator interface.

The language of the diagnostic message in plain text can be changed.

Diagnostic message number

The diagnostic message number contains only the diagnostic number without the text. It can be read with the parameter **S-0-0390, Diagnostic message number** and is a language-independent possibility to determine and display the drive status on an operator interface.

Error number

The error number contains only the error number without the diagnostic text. It can be read with the parameter **P-0-0009, Error message number** and is a language-independent possibility to determine and display an error condition on an operator interface. This parameter only contains a value unequal to 0 if an error is present in the drive.

An error is formed from the bottom 3 digits of the diagnostic number. For example, the error **F228 Excessive deviation** with the diagnostic message number "(0x)F228" would produce the error number "228."

List of diagnostic numbers

The 50 previously displayed diagnostic numbers are displayed in chronological order in parameter **S-0-0375, List of diagnostic numbers**. Every change in contents of **S-0-0390, Diagnostic message number** means that the old contents are transferred into **S-0-0375, List of diagnostic numbers**. If **S-0-0375, List of diagnostic numbers** is read, then the last replaced diagnostic number appears in the first element; the diagnostic number displayed penultimately is displayed in the second element and so on.

The following illustration explains the relationship between **S-0-0375, List of diagnostic numbers** and **S-0-0390, Diagnostic message number** with the use of an example.

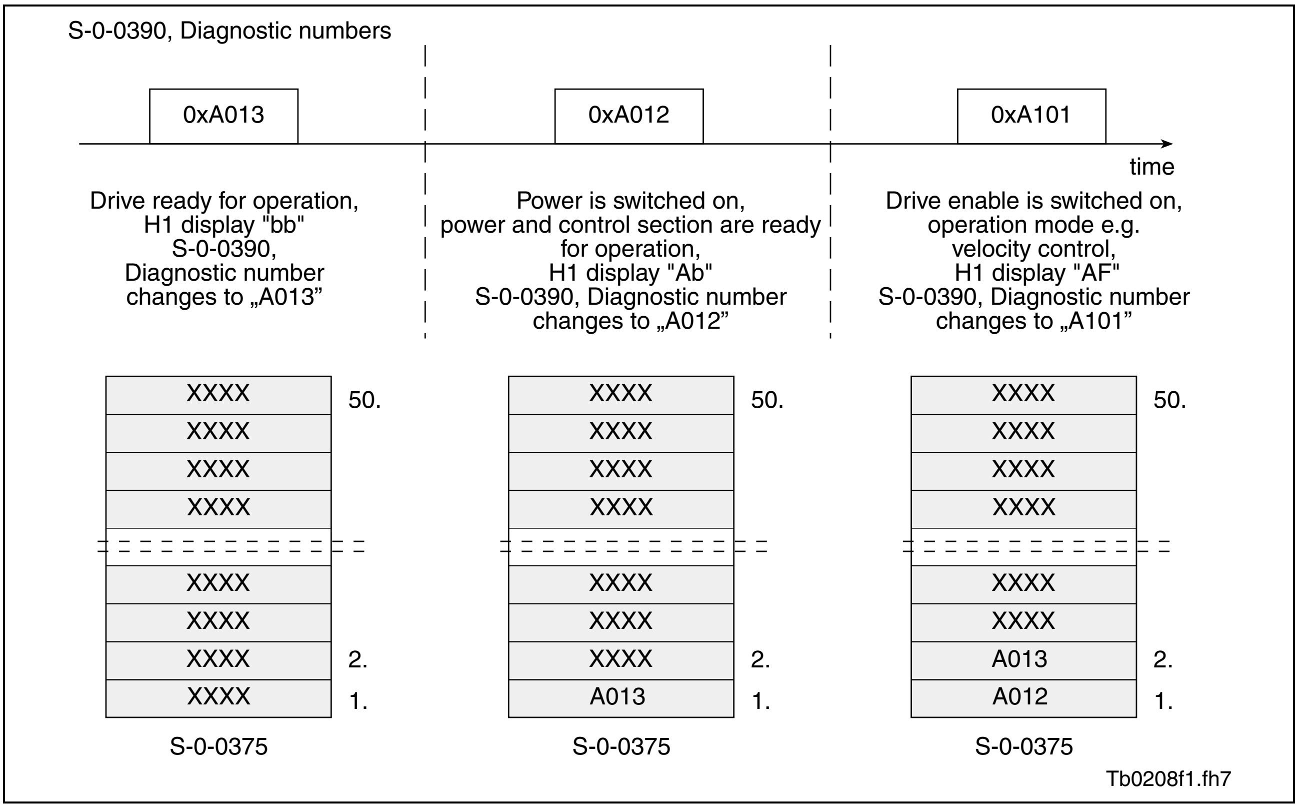


Fig. 4-10: Example for generating **S-0-0375, List of diagnostic numbers**

Permanently-Configured Collective Indication

There are parameters that represent a collective indication for the display of operating states. These are individually listed

- **S-0-0011, Class 1 diagnostics**
- **S-0-0012, Class 2 diagnostics**
- **S-0-0013, Class 3 diagnostics**
- **S-0-0182, Manufacturer class 3 diagnostics**

S-0-0011, Class 1 diagnostics

In parameter **S-0-0011, Class 1 diagnostics** there are bits for the various errors. A bit is set in this parameter in the event of a drive error. Simultaneously, bit Drive lock, error in class 1 diagnostics is set in the **drive status word.**

All bits in class 1 diagnostics, are cleared upon execution of the command **S-0-0099, C500 Reset class 1 diagnostic**.

(See section: "Clearing Errors")

The following bits are supported in status class 1.

S-0-0011, Class 1 diagnostics

- **Bit 1** : Excess amplifier temperature switching off
- **Bit 2** : Excess motor temperature switching off (see also S-0-0204)
- **Bit 4** : Control voltage error
- **Bit 5** : Feedback error
- **Bit 9** : Under-running voltage error
- **Bit 11**: Excessive control deviation
- **Bit 12** : Communication error
- **Bit 13** : Position limit has been exceeded
- **Bit 15** : Manufacturer error

Fig. 4-11: S-0-0011, Class 1 diagnostics

S-0-0012, Class 2 diagnostics

There are bits for various warnings in this parameter. In the event of a warning, a bit is set in this parameter. Simultaneously, bit Change bit class 2 diagnostics is set in the **drive status word.** This change bit is cleared by reading **S-0-0012, Class 2 diagnostics.** Via parameter **S-0-0097, Mask class 2 diagnostic** warnings can be masked in terms of their effect on the change bit.

The following bits are supported in class 2 diagnostics.

- **Bit 0:** Overload warning
- **Bit 1:** Amplifier over-temperature
- **Bit 2:** Motor over-temperature warning
- **Bit 3:** Cooling error warning
- **Bit 4:** reserved
- **Bit 5:** Positioning velocity > nlimit
- **Bit 6:** reserved
- **Bit 7:** reserved
- **Bit 8:** reserved
- **Bit 9:** reserved
- **Bit 10:** reserved
- **Bit 11:** reserved
- **Bit 12:** reserved
- **Bit 13:** Target position outside of position limits
- **Bit 14:** reserved
- **Bit 15:** Manufacturer warning

Fig. 4-12: S-0-0012, Class 2 diagnostics

Each of these messages is stored in turn in its own parameter (S-0-0310..S-0-0323).

S-0-0013, Class 3 diagnostics

Various messages about operating states are stored here . If the state of a message changes, then a bit is set here as well in **drive status word** (**Change bit class 3 diagnostics**). This change bit is cleared again by reading **S-0-0013, Class 3 diagnostics.** Via parameter **S-0-0098, Mask class 3 diagnostic** warnings can be masked in terms of their effect on the change bit.

The following bits are supported in class 3 diagnostics.

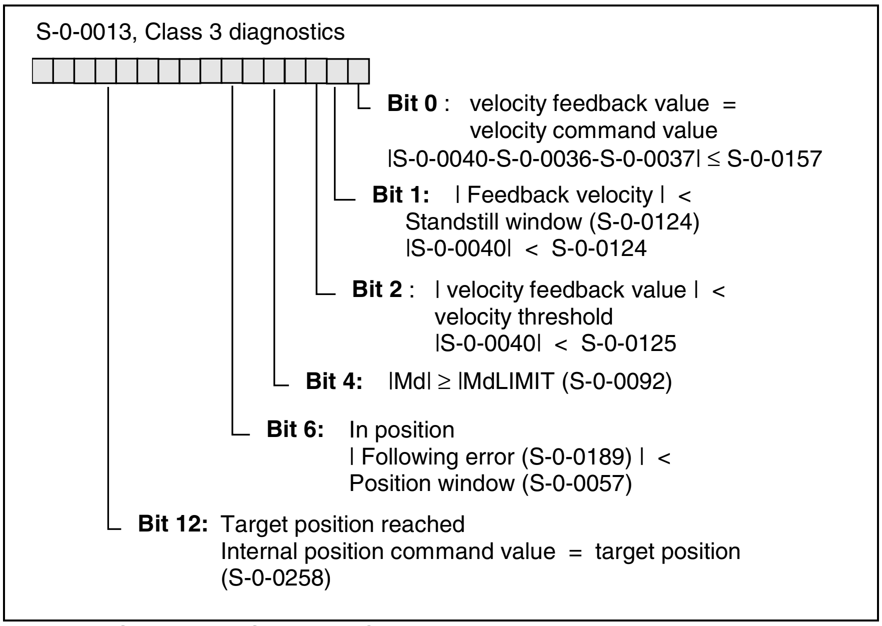


Fig. 4-13: Structure of S-0-0013, Class 3 diagnostics

Each of these messages is stored in turn in its own parameter (S-0-0330..S-0-0342).

Change bit of class 2 and 3 diagnostics in the drive status word

If the state of a bit changes in **S-0-0012, Class 2 diagnostics** or **S-0-0013, Class 3 diagnostics** then the change bit status class 2 or 3 is set in the drive status word. A read access to both parameter clears this change bit. By setting the change bit as a result of a bit toggle in S-0-0012 or S-0-0013 it is possible to mask with the help of parameter **S-0-0097, Mask class 2 diagnostic** or **S-0-0098, Mask class 3 diagnostic**.

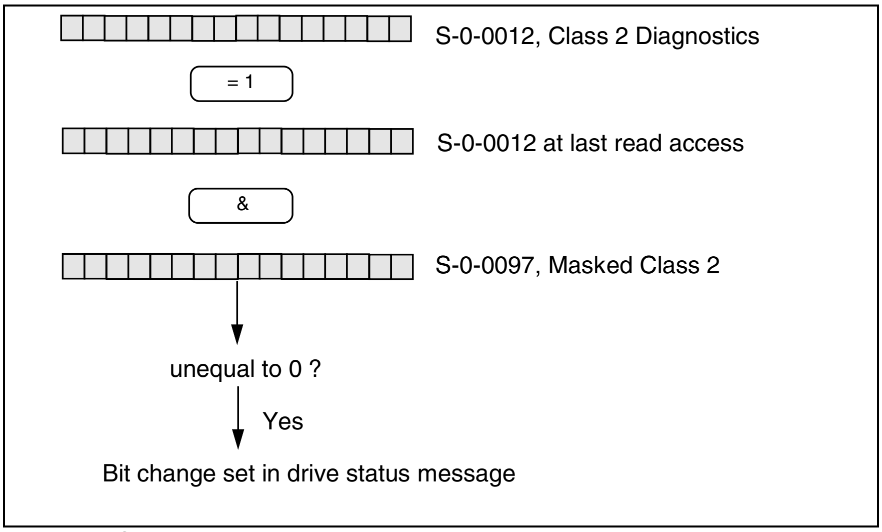


Fig. 4-14: Generating the change bit of class 2 diagnostics

S-0-0182, Manufacturer class 3 diagnostics

In parameter **S-0-0182, Manufacturer class 3 diagnostics** various messages about the operating states are stored there as well. If the state of a message changes, then this is not signalled with a change bit.

The following bits are supported in manufacturer's class 3 diagnostics.

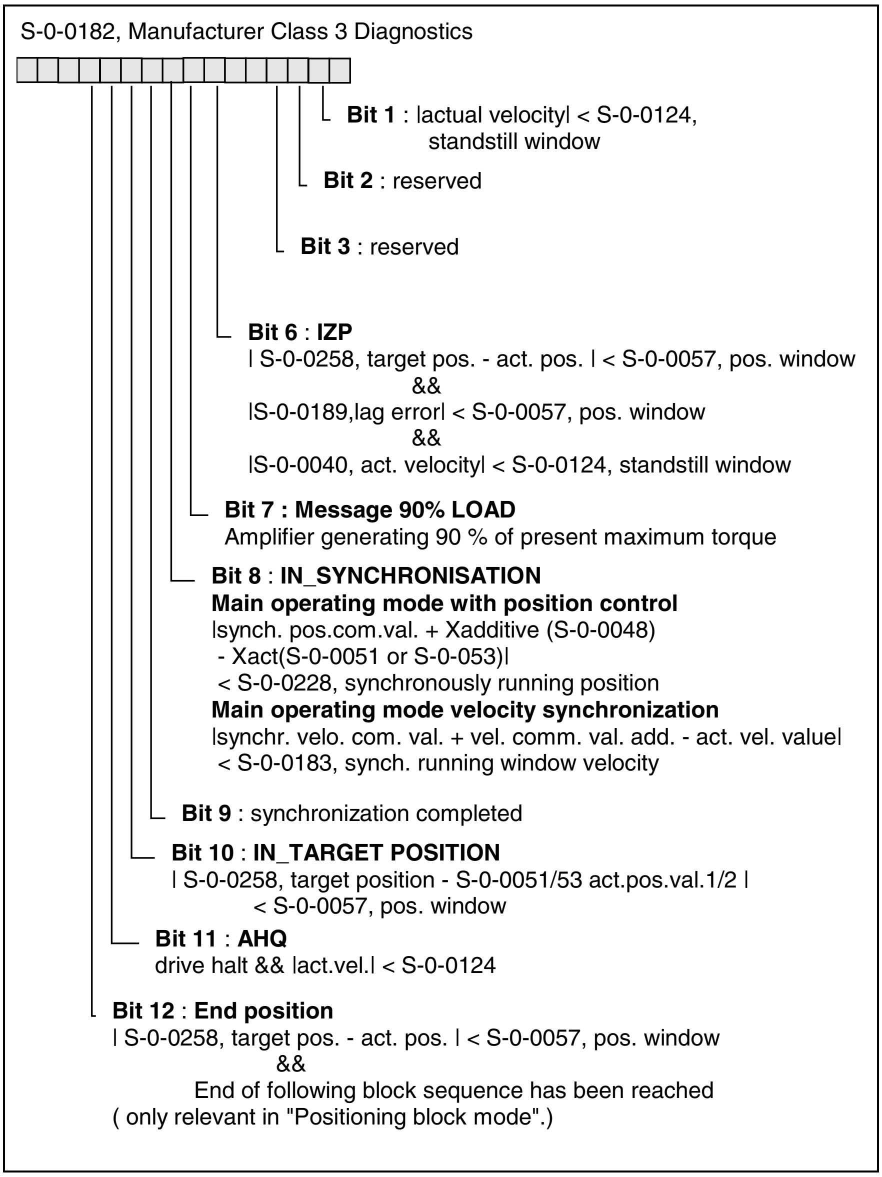


Fig. 4-15: Structure of S-0-0182, Manufacturer class 3 diagnostics

4.5 Language selection

With the parameter **S-0-0265, Language Selection** you can switch between several languages for

- parameter names and units
- diagnostic texts

The following languages are implemented:

Value of S-0-0265	Language
0	German
1	English
2	French
3	Spanish
4	Italian

Fig. 4-16: Language selection

4.6 Firmware update with the "Dolfi" program

With the help of the "Dolfi" program it is possible to conduct firmware updates for a drive controller via the serial interface.

The "Dolfi" program can be ordered from one of our sales and service facilities with item number **SWA-DOL*PC-INB-01VRS-MS-C1,44-COPY** or part number **279804**.

Together with the program you will receive a documentation that describes how to handle the program and how to replace the firmware.

Notes

5 Command Communication via Field Bus

5.1 Bus-Independent Features

Profile

For communication via field bus the drive functions are made available via easily operable interfaces.

The functionalities are covered according to the respective valid field bus standards (e.g. according to DriveCom (INTERBUS) and ProfiDrive (PROFIBUS)). In addition all the operating modes defined for the drive are available via the field bus (see also chapter "Profile Types").

Pertinent Parameters

For the communication via field bus the following parameters are relevant:

- **P-0-4073, CANopen event mask**
- **P-0-4074, Field bus data format**
- **P-0-4075, Field bus watchdog time**
- **P-0-4076, Field bus container object**
- **P-0-4077, Field bus control word**
- **P-0-4078, Field bus status word**
- **P-0-4079, Field bus baudrate**
- **P-0-4080, Real-time input object structure**
- **P-0-4081, Real-time output object structure**
- **P-0-4082, Length of real-time data channel In**
- **P-0-4083, Length of parameter channel in DP**
- **P-0-4084, Profile type**
- **P-0-4085, Field bus version**
- **P-0-4087, Length of real-time data channel Out**

For the internal data exchange between drive and master communication unit the following parameters are relevant:

- **S-0-0001, NC Cycle time (TNcyc)**
- **S-0-0002, SERCOS Cycle time (Tscyc)**
- **S-0-0007, Feedback acquisition starting time (T4)**
- **S-0-0008, Command valid time (T3)**

Setting the Slave Address

The slave address is set on the firmware module, which is plugged into the drive controller.

Example

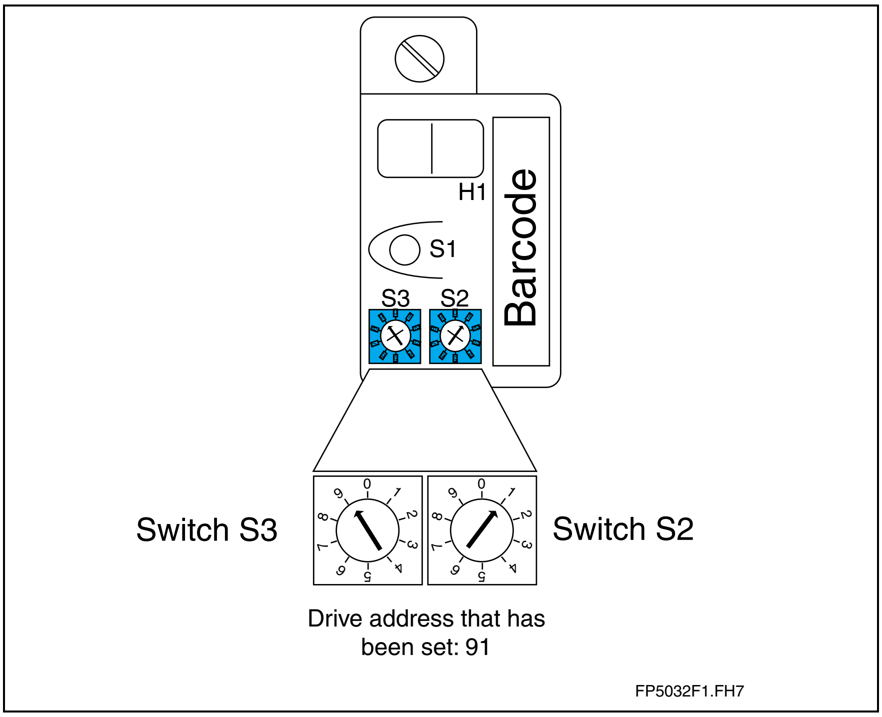


Fig. 5-1: Setting of the slave address on the firmware module

Programmable Addresses

The drive controllers support the slave addresses 1 ... 99 (decimal).

Depending on the field bus type the following restrictions apply:

PROFIBUS-DP:	2 ... 99
DeviceNet:	1 ... 63
CANopen:	1 ... 99
INTERBUS-S:	INTERBUS addresses are automatically assigned by the master. The address set on the firmware module is not effective.

Note: The slave address 0 does not exist and must not be used in any applications.

The parameter **P-0-4022, Drive address** only applies to the serial interface X2, to the field bus always the address set on the firmware module applies. So it is possible to set different addresses for the field bus and the serial interface.

The slave address is read during the startup of the drive controller (switching from parameter mode to operating mode) and is used to for the parameterization of the field bus connection.

Note: A change of the slave address becomes effective only after the startup of the drive controller, i.e. the slave address has to be set before switching on the drive!

Object Mapping

Principles

Object mapping means accessing the drive parameters via an acyclical service of the respective field bus. All S-0-xxxx and P-0-xxxx parameters can be accessed.

The P-7-xxxx parameters can not be accessed via object mapping but the following P-7-xxxx parameters are mirrored in P-0-xxxx parameters:

P-7-0004 => **P-0-0004, Velocity loop smoothing time constant**

P-7-0018 => **P-0-0018, Number of pole pairs/pole pair distance**

P-7-0051 => **P-0-0051, Torque/force constant**

P-7-0508 => **P-0-0508, Commutation offset**

P-7-0510 => **P-0-0510, Moment of inertia of the rotor**

P-7-0511 => **P-0-0511, Brake current**

P-7-0540 => **P-0-0540, Torque of motor brake**

P-7-4047 => **P-0-4047, Motor inductance**

P-7-4048 => **P-0-4048, Stator resistance**

If other P-7-xxxx parameters have to be accessed the SIS format has to be used (see "SIS protocol").

The following acyclical services permit the access to the parameter:

- CANopen: Service Data Objects (SDO)
- DeviceNet: Explicit Messaging
- INTERBUS: Peripherals Communication Protocol (PCP)
- PROFIBUS: manufacturer-specific parameter channel

Sub-Index and Attributes

Each parameter consists of various elements. These elements are accessed via the sub-index (CANopen, INTERBUS and PROFIBUS) or via the attribute (DeviceNet) of the parameter channel.

Especially important is the sub-index/the attribute 7, where the operating data (parameter value) is stored.

Sub-index/ attribute	Data type	Access	Description
0	UINT8	R	Highest sub-index (only CANopen)
1	UINT16	R/W	IDN
2	visible string	R	Name
3	UINT16	R	Attribute
4	visible string	R	Unit
5	2..32 bytes	R	Minimum input value
6	2..32 bytes	R	Maximum input value
7	2..32 bytes	R/W	Operating data (as sub-index 10)
8	UINT16	R	Maximum length of list (elements)
9	UINT16	R/W	Actual length of list (elements)
10	2..4 bytes	R/W	Operating data single parameters (as sub-index 7)
10	4..110 bytes	W	Write operating data list parameters (as sub-index 7), start index + values
10	2..32 bytes	R	write operating data list parameters (as sub-index 7), values list elements 1-16 with 2 byte parameters, list elements 1-8 with 4 byte parameters
11...137	2...32 bytes	R	maintaining operating data for read list parameters

Fig. 5-2: Description of the sub-index / attributes

The operating data of simple parameters (parameters of the type byte, word or double word) is accessed via the sub-index 10 (or sub-index 7). Elements of list parameters are not directly addressable. Reading out sub-index 10 (or 7) gives the first 32 bytes of the list, e.g. 8 values for double word parameters — provided that the list has at least 8 elements. The write data of the parameters are readable via the sub-indices 2-6.

Data Formats

All values are transmitted in the usual data format for the field bus, e.g. for DeviceNet and CANopen in the Intel format, for PROFIBUS and INTERBUS in the Motorola format.

Note: Some field bus masters have problems handling the various data formats. Parameter **P-0-4074, Field bus data format** enables the individual adaptation of the format.

Sub-Index / Attribute 1, IDN

In the SERCOS specification the sub-index / attribute 1 has a special relevance. Here it is not the IDN that is returned (since for reading an IDN it has to be known) but the status of a command. If the IDN of a parameter is read that does not represent a command then the value 0 is returned.

Sub-Index / Attribute 2, Name

In sub-index / attribute 2 the name of SERCOS parameters is returned. This sub-index is read-only. A field of bytes is returned which contains the respective characters of the name.

Note: The returned number can be up to 60 characters long depending on the name. This might lead to memory problems with some masters.

Sub-Index / Attribute 3, SERCOS Attribute

With sub-index / attribute 3 the SERCOS attribute is returned. It contains information about the data type, the number of decimal places and further information. It is always a 32-bit value and is read-only.

Sub-Index / Attribute 4, Unit

Sub-index / attribute 4 contains the unit of the respective SERCOS parameter as a string. A field of bytes is returned which contains the respective characters of the unit. The field is up to 12 characters long.

Sub-Index / Attribute 5, Minimum Input Value

In sub-index / attribute 5 the minimum input value of the respective SERCOS parameter is returned. Depending on the data type a 16-bit or a 32-bit value will be returned. This value is read-only.

Sub-Index / Attribute 6, Maximum Input Value

In sub-index / attribute 6 the maximum input value of the respective SERCOS parameters is returned. Depending on the data type a 16-bit or a 32-bit value will be returned. This value is read-only.

Sub-Index / Attribute 7, Data

See sub-index 10.

Sub-Index / Attribute 8, Maximum Length of List

Sub-index / attribute 8 exists for every parameter and gives the maximum length of the parameter in elements. For simple parameters the returned value is always 1, for lists the maximum permitted length in elements is given. A word is returned which is read-only.

Sub-Index / Attribute 9, Actual Length of List

Sub-index / attribute 9 exists for every parameter and gives the actual length of the parameter in elements an For simple parameters the returned value is always 1, for lists the maximum permitted length in elements is given. A word is returned which is readable and writable.

Sub-Index / Attributes 10 to 137, Data

Sub-index / attribute 7 and the sub-indices / attributes 10 to 137 contain the data of the SERCOS parameter. Depending on the data type of the SERCOS parameter there are five different possibilities: word, double word, field of bytes, field of words and field of double words. These sub-indices / attributes may be read-only, are only writable during specific states of the controller or are always writable.

If a list is not writable with elements although the maximum number of elements is not yet reached, the actual length has to be adapted accordingly. To do this write the sub-index and increase the value according to the desired number of list elements.

Drive Parameterization via Field Bus

Simple Field Bus-Neutral Parameter Access Through Object Assignment (e. g. Index, Sub-Index)

The parameterization of the drive requires the transmission of a number of parameters and lists, which are maintained in the drive according to the SERCOS specification.

The parameterization can be performed via:

- serial interface (e. g. DriveTop) or
- the respective acyclical channel of the field bus (e. g. PCP). All parameters of the group 0 (S-0-xxxx, P-0-xxxx) can be read and written through object accesses.

Note: From version FGP03VRS the parameter communication was simplified and unified considerably with the introduction of **field-bus-transcending objects**. For more detailed information on this see the paragraph on the object directory of the field bus specific part.

Reading and Writing of "Simple Parameters"

For simple parameters the sub-index 10 (or 7) can be used both for reading and writing.

Reading of List Parameters

For all list parameters a specified sequence has to be observed for reading a list or a part of a list. Starting with sub-index 10 each sub-index returns a data block of up to 32 bytes, independent of the type of the parameter. One element of the list corresponds to one value of the list (e. g. one word or double word). The formula for accessing a specific element is calculated as follows:

sub-index / attribute = 10 + ((element# * data type) DIV 32)

element# the number of the desired element within the list (starting with 1).

data type is the length in bytes of the data types used in the list (e. g. 2 for words).

DIV is a division. For reasons of run time optimization the division could also be realized as a shift command by 5 decimal places to the right.

When the respective sub-index is called a block with 32 bytes is returned. The desired element is a part of that 32 bytes bock. The exact position within this data block can be calculated as follows:

First byte = ((element# * data type) MOD 32) - data type

Last byte = ((element# * data type) MOD 32) - 1

MOD is a residual value calculation. For reasons of run time optimization it should be realized as a masking with AND 31 (AND 0x0F).

The first byte of the data block starts with number 0.

If the list is shorter than 32 bytes, or just filled partially or not at all the returned length is correspondingly shorter or 0. If the complete list has to be read, start with sub-index 10 and read out each following sub-index until the returned length is smaller than 32 bytes.

Note: For CANopen there is no possibility for returning a length value of 0. In that case an error is generated.

Writing of List Parameters

The writing of list parameters differs from reading in that the access is only ever to sub-index 10. If someone tries to write higher sub-indices an error is generated. As with reading, only a limited number of values can be written per acyclical access. The first word determines from which Position within the list the data are to be written. The position specification is done in elements, starting from element 1 (e. g. the value "4" with a list parameter of the data type 'word' would start writing from the 4th word in the list).

Then the data are transmitted which are to be written into the list. The number of data transmitted must not exceed 108 bytes.

If the list is empty (actual length too small), or if an attempt is made to write beyond the limits of the list an error is generated. The actual length of a list can be changed via sub-index 9.

Note: The number of the valid net data for an acyclical transmission is limited to a maximum length of 112 bytes per telegram because of an internal buffer (for PROFIBUS distributed to several communication cycles).

Downward Compatible Parameter Accesses

For downward compatibility with the previous field bus versions (FGP01VRS, FGP02VRS and FGP03VRS) the data exchange objects and the option of parameterization according to the SIS telegram are still available.

	FGP01VRS	FGP02VRS	FGP03VRS	FGP20VRS
Abbreviated format1	only with PROFIBUS	only with PROFIBUS	only with PROFIBUS	only with PROFIBUS
Abbreviated format3	No	only with PROFIBUS	only with PROFIBUS	only with PROFIBUS
Object accesses (index/sub-index)	No	no	yes	yes
SIS Format	No	yes	yes	yes
DPV1	No	no	no	only with PROFIBUS

Fig. 5-3: Table for overview

4 data exchange objects of different lengths are provided which are only accessible through the acyclical services "**Read**" and "**Write**" of the respective field bus:

object 5E70 16 bytes R/W

object 5E71 32 bytes R/W

object 5E72 64 bytes R/W

object 5E73 128 bytes R/W

Rexroth Indramat SIS Protocol

The reading or writing of a parameter generally complies with the rules specified in the Rexroth Indramat SIS protocol (see "SIS protocol").

5.2 Command Communication with PROFIBUS-DP

The drive controllers of the ECODRIVE03 and DURADRIVE families with master communication interface "PROFIBUS" support the protocol PROFIBUS-DP (V1).

Function Overview

The drive controllers with master communication interface "PROFIBUS" provide the following functional features:

- Support of the interfaces according to EN50170, vol. 2. Both wire types A and B according to EN50170, vol. 2 are supported.
- Support of all data rates according to EN50170, vol. 2, up to 12 Mbps with exclusive use of PROFIBUS-DP.
- Configurable cyclical data up to max. 18 bytes (incl. control and status word) in both data transmission directions
- Downward compatibility with PROFIBUS functions of the DKC3.1 and with the previous field bus versions for DKC03.3.
- Monitoring of the cyclical data exchange (watchdog function).
- For easy diagnosis of bus functions and the most important communication channels between drive and field bus: LED diagnosis array on front panel of the master communication interface.
- Upload/Download functions for all parameters of the drive possible via DPV1.
- Support of the Set-Param service of PROFIBUS-DP for automated commissioning of production machines.
- Possibility of synchronization via the PROFIBUS (Freeze and SYNC telegram!)

PROFIBUS Interface

- To ensure EN standards for EMC safety, the PROFIBUS interface is completely galvanically decoupled.
- As per EN50170, vol. 2, the module has a 9-pin D-subminiature plug-in connector for connecting to a PROFIBUS.
- To switch through bus signals to the other bus participants, plug-in connector INS 0450 is available.

Note: The bus coupling as spur occurs directly in the plug-in connector INS 0450. For transmission rates of >500kbits the use of this particular plug-in connector is obligatory. The use of any further spurs or additional plug-in connectors is not permitted.

- To maintain the bus functions, the unit into which the connector with the bus connection is plugged has to be in operation all the time.

Configuration of the PROFIBUS-DP Slave

Setting of Slave Address and Transmission Rate

The slave address is set with the switch on the address module. The range of valid values is 2 to 99. The transmission rate is set on the master and will automatically be recognized by the slave.

Configuration of Process Data

The PROFIBUS master communication interface can be configured according to the process requirements in the process data section.

The process data are configured independent of the field bus type.

The setting of **P-0-4084, Profile type** mostly brings with it a configuration of the process data (real-time data).

Note: With profile types P-0-4084=0xFFFE (freely configurable) or 0xFF82 (freely extendable) the configuration is left to the user.

See also chapter "Profile Types".

Parameter Channel

The parameterization can also be performed via the field bus, with the drive parameters written via the parameter channel. This type of configuration requires the implementation of the parameter channel for the master. For this implementation the use of the function blocks generated by the manufacturer is recommended (for Simatic and WIN-PCL). These are available free upon request or from the Intranet. Expert PLC programmers might also try to implement the channel themselves. This is supported by the available PLC function blocks and a Technical Note. Further information on request or from the Intranet.

Note: Both for the process input data and output data, changes in word length must always lead to modifications in the slave data stored in the master. So length changes in the cyclical channel do only become effective when the drive has been switched on again or with phase switching from parameter mode to operating mode.

P-0-4080, Real-time input object structure

The structure and thus the number of words and their assignment to objects (indices) for the process input data (slave → master) are represented in this parameter.

The master can use this configuration to get information on the situation of the individual real time data on the bus.

P-0-4081, Real-time output object structure

The structure of the process output data (master → slave) is stored in this parameter. This enables the read-out via the parameter channel of the current structure and thus the assignments at the bus.

Note: Up to 18 bytes in both data directions can be configured at the bus. Note that **P-0-4077, Field bus control word** and **P-0-4078, Field bus status word** always have to be configured first.

Data Direction

- **Data direction input**

The "data direction input" is the data transmission direction from slave to master.

- **Data direction output**

The "data direction output" is the data transmission direction from master to slave.

Length of the Process Data (PD) in the Drive Controller

Within the cyclical data channel there are the parameter channel (optional) and the range for the process data.

The PROFIBUS slave circuit permits a flexible configuration of the process data channel.

The length of the process data channel depends on the profile type which has been set. User-specific expansions of the process data channel can mean that individual drive controllers will have varying process data channel lengths, depending on the data direction.

Note: The available profile types are described in the chapter "Profile Types".

The data types of the process data channel can only be words or double words, not bytes. Length is specified in bytes for the sake of compatibility to other bus systems.

Length of the Process Data Channel

The length of the process data can range between 1 to 9 words or 2 to 18 bytes in either direction.

Length of Process Data in Drive Controller

The length of process data is determined by the contents of the configuration lists **P-0-4080, Real-time input object structure** or **P-0-4081, Real-time output object structure** and can be taken from the following parameters:

- **P-0-4082, Length of real-time data channel In** (slave → master)
- **P-0-4087, Length of real-time data channel Out** (master → slave)

The setting becomes effective with the startup of the drive controller into operating mode, so it has to be set before startup.

Note: Note that a change in the length of the process data also needs a change in the master configuration. The set length of the process data has to be in accordance with the projected length in the master.

Configuration via SET_PRM Service of PROFIBUS-DP

When setting up a production machine, for example, it is advisable to parameterize the drive from the field bus master. The master can, via the SET_PRM service, set the basic parameters on the slave so that the data length on the bus and in the operating mode of the drive are set. The user data of the SET_PRM service are generally set menu-driven via the configuration tool of the DP master with the help of the DDS file. These data (User_Prm_data) are documented below:

Arrangement User_Prm_data:

<table>
<tr><th colspan="2">P-0-4083, Length parameter channel</th><th colspan="2">P-0-4084, Profile type</th><th colspan="2">Number of elements of configuration list n in bytes</th><th colspan="5">P-0-4081, Real-time output object structure</th><th colspan="5">P-0-4080, Real-time input object structure</th></tr>
<tr><td>HB</td><td>LB</td><td>HB</td><td>LB</td><td>P-0-4081</td><td>P-0-4080</td><td>HB1</td><td>LB1</td><td>HB2</td><td>LB2</td><td>...</td><td>HBn</td><td>LBn</td><td>HBn+1</td><td>LBn+1</td><td>...</td></tr>
<tr><td colspan="2">Word 1</td><td colspan="2">Word 2</td><td colspan="2">Word 3</td><td colspan="2">Word 4</td><td colspan="2">Word 5</td><td>...</td><td colspan="2">Word n</td><td colspan="2">Word n+1</td><td>...</td></tr>
</table>

Fig. 5-4: Assignment in User_Prm_data

Note: Only the specifications of the length of the parameter channel and of the profile types are necessary, the other specifications are optional.

Acyclical Parameter Communication (Parameter Channel)

There are basically 2 possibilities for accessing all parameters of the drive acyclically:

- via the parameter channel defined in **the profile ProfiDrive V3** (standardized →DPV1)
- via the parameter channel represented in the **cyclical channel of PROFIBUS-DP** (specified by manufacturer)

Parameter Channel in the Cyclical Channel of PROFIBUS-DP

Since not every control supports the DPV1 services, a configurable parameter channel was implemented in the cyclical data of the ECODRIVE03/DURADRIVE; its length can be set from 0 to max. 12 bytes.

Cyclical Data Channel

The field bus provides data containers in which cyclical net data can be transmitted. This section is called cyclical data channel.

This cyclical data channel is divided into:

- a process data channel (real time channel) and
- an (optional) parameter channel

Process Data Channel

The real time channel (process data channel) contains firmly specified information. So this information can be directly interpreted by the receiver.

Parameter Channel

In the parameter channel any parameters can be transmitted. But for a parameter reading the PLC has to write a read request first. So the parameter channel does not have real time properties.

The cyclical data channel can be configured with the following parameters:

Parameter	Definition	I/O mode	Interpolation
P-0-4082	Length of cyclical data channel IN (slave→master) in bytes	2	24
P-0-4087	Length of cyclical data channel OUT (master →slave) in bytes	2	24
P-0-4083	Length of parameter channel in bytes	0	12

Fig. 5-5: Parameters to configure the cyclical data channel

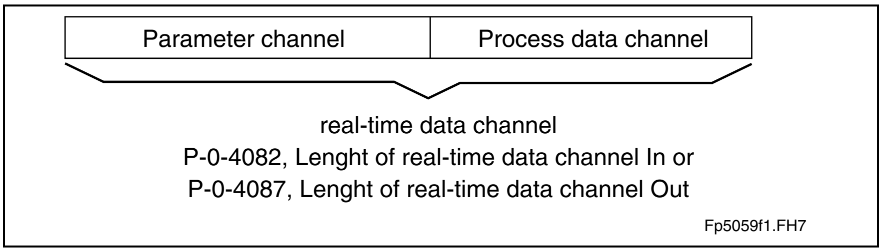


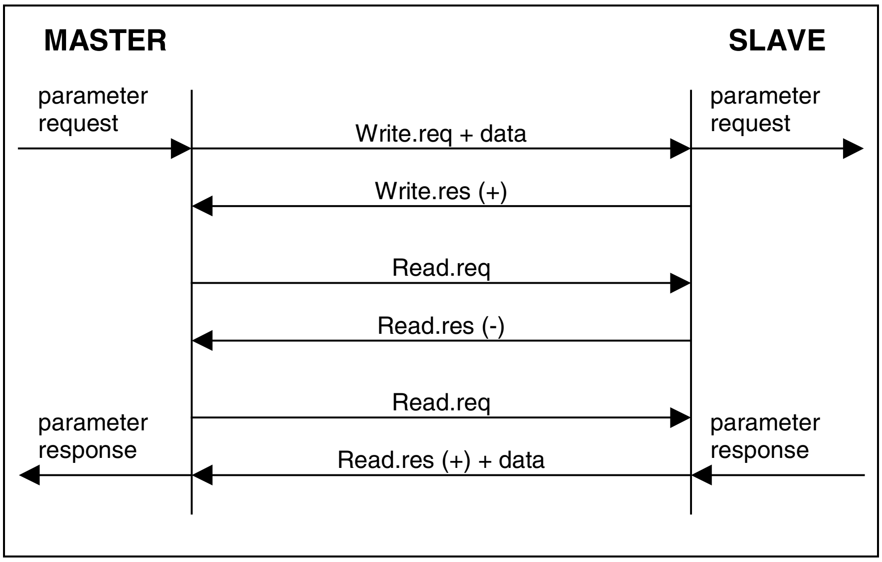
Fig. 5-6: Structure of the cyclical channel in PROFIBUS-DP

Note: The parameter channel is always at the beginning of the cyclical data channel. The length of the parameter channel and the length of the process data channel used for exchanging real time data make up the entire length of the cyclical data channel.

DPV1 Services

ProfiDrive V3-Telegram Frame (DPV1)

The parameter exchange described below is executed via DPV1 telegram frame. The following sequence is run:



The individual parameters are accessed with the services "**request parameter**" or "**change parameter**".

Note: Multi parameter requests are not supported at the moment.

Request Parameter

ProfiDrive V3 parameter request via DPV1

request header	request reference 1 to 255	request ID 1 = request parameter
	axis 0	number of parameters 1
parameter address	attribute 16 = value	number of elements 1 to 32
	parameter number	
	sub-index	

ProfiDrive V3 parameter response

response header	request ref. mirrored 1 to 255	response ID 1 = positive acknowledgement 129 = negative acknowledgement
	axis mirrored 0	number of parameters 1
parameter value(s)	format 65 = bytes 66 = word 67 = double word	number of values 1 to 32
	value(s) or error value	
	...	

Change Parameter

ProfiDrive V3 parameter request via DPV1

request header	request reference 1 to 255	request ID 2 = change parameter
	axis 0	number of parameters 1
parameter address	attribute 16 = value	number of elements 1 to 32
	parameter number	
	sub-index	
parameter value(s)	format 65 = bytes 66 = word 67 = double word	number of values 1 to 32
	value(s)	
	...	

DPV1 parameter response

response header	request ref. mirrored 1 to 255	response ID 2 = positive acknowledgement 130 = negative acknowledgement
	axis mirrored 0	number of parameters 1

Error Codes

The error codes are transmitted as words.

Number hex.	Number dec.	Description
0x0000	0	Invalid parameter number
0x0001	1	Parameter value not alterable
0x0002	2	Lower or upper value limit exceeded
0x0003	3	Faulty sub-index
0x0004	4	Access to non-indexed parameter
0x0005	5	Wrong data type
0x0006	6	Value only writable with 0
0x0007	7	Value not writable
0x0008	8	Reserved
0x0009	9	Parameter description does not exist
0x000A	10	Reserved
0x000B	11	Operating access denied
0x000C	12	Reserved
0x000D	13	Reserved
0x000E	14	Reserved
0x000F	15	No text field
0x0010	16	Reserved
0x0011	17	Request not possible because of operating status
0x0012	18	Reserved
0x0013	19	Reserved
0x0014	20	Invalid value
0x0015	21	Response too long
0x0016	22	Invalid parameter address
0x0017	23	Invalid format
0x0018	24	Number of elements to write differs from number of existing elements.
		Further error codes: see manufacturer's error codes

Object Accesses with PROFIBUS-DP

The access to the data of a parameter is executed via:

- index
- sub-index

Generating Laws for Object Index

S-Parameters

Hexadecimal: Index_{hex}=0x2000+IDN(S-0-xxxx)

Decimal: Index_{dez}=8192+IDN(S-0-xxxx)

P-Parameters

Hexadecimal: Index_{hex}=0x3000+IDN(P-0-xxxx)

Decimal: Index_{dez}=12288+IDN(P-0-xxxx)

Generating Laws for Object Sub-Index

Sub-index	Data type	Access	Description
1	UINT16	R/W	IDN
2	visible string	R	Name
3	UINT16	R	Attribute
4	visible string	R	Unit
5	2 or 4 bytes	R	Minimum input value
6	2 or 4 bytes	R	Maximum input value
7	2..32 bytes	R/W	Operating data (as sub-index 10)
8	UINT16	R	Maximum length of list (elements)
9	UINT16	R/W	Actual length of list (elements)
10	2..32 bytes	R/W	Operating data (as sub-index 7)
11...137	2...32 bytes	R	Continuation of operating data with lists

Fig. 5-7: Description of the sub-index

Examples for Access to the Data of an Object

Example 1: access to data of S-0-0051

$Index_{dez}$=8192+51=8243

attribute = 7, since access to data required

Example 2: access to data of P-0-0051

$Index_{dez}$=12288+51=12339

attribute = 7, since access to data required

Device Data Sheet

For each PROFIBUS-DP device a device data sheet (*.GS*) has to be logged which stores the data necessary for the operation of the device on the bus. This file is needed for each participant for the configuration of the bus master.

File Name

The device data sheet for ECODRIVE03/DURADRIVE is an ASCII file of the name **ECO3100D.GS***, where "*" is a wild card for the language marker (d=language-independent, g=German, e=English)

The device data sheet also contains the IDENT no. (100D hex) assigned by the PNO (PROFIBUS user organization) for the ECODRIVE03 device.

Note: The current device data sheet is filed during the installation of DriveTop in the directory "Indramat\Device Data Sheets", and the Intranet.

Diagnostic LEDs for PROFIBUS

For diagnosing the field bus interfaces there are 4 LEDs available on the front panel of the field bus unit. These LEDs mark the state of the synchronization between field bus interface and drive as well as the bus activity for cyclical data exchange.

LED designation	LED state	Definition
H30	ON	cyclical exchange of process data performed within watchdog time
H30	OFF	no data exchange or watchdog time lapsed
H31	Impulse	parameter access
H32/H33	flashing alternately	field bus unit and drive synchronized
H32/H33	flashing regularly	field bus unit and drive not synchronized
All LEDs	flashing regularly	severe error on field bus unit; switch unit off and on

Fig. 5-8: Diagnostic LEDs for PROFIBUS X30

Assigning PROFIBUS Plug-In Connector

See Project Planning Manual: "ECODRIVE" or "DURADRIVE"

5.3 Command Communication with INTERBUS

Function Overview

The drive controllers of the ECODRIVE03 and DURADRIVE families with master communication interface "INTERBUS" support the protocol "INTERBUS-S with PCP channel version PCP 2.0".

These drive controllers can transmit process data as well as parameters and data for objects of the PCP services if the master supports the PCP communication services.

Note: The connection of a master circuit that supports PCP 2.0 (G4) is recommended.

The drive controllers with master communication interface "INTERBUS-S" provide the following functional features:

- INTERBUS-S process data and PCP 2.0 (G4) channel (acyclical communication) are supported.
- Configurable process data up to 18 words in both data directions. The configuration can be read via PCP objects 0x6000 and 0x6001, or can be written through parameters P-0-4080 or P-0-4081 of the drive.
- Process data transmission monitored (watchdog function).
- LED diagnosis field complying with INTERBUS standard on front panel of master communication module for easy diagnosis of bus functions and the most important communications between drive and field bus.
- Direct accessing of drive parameters via PCP services Read and Write.
- Upload/download functions available for all drive parameters including lists of four arrays of 16 to 128 bytes data lengths through PCP services (Rexroth Indramat SIS protocol).

INTERBUS-S Interface

With the DKC04.3 and HDC01.1-AxxxN-IB01 devices the INTERBUS-S remote bus interface with copper cable is implemented. This exclusively supports a Baud rate of 500 kbits/s.

From firmware FGP20VRS upward the DKC14.3 and HDC01.1-AxxxN-IB02 devices with optic fiber connections are supported, too. These devices can be set with a switch to 500 kbits/s or 2 Mbit/s.

- To ensure EN standards for EMC safety, the INTERBUS interface is completely galvanically decoupled.
- According to DIN 19258, section 2, drive controllers with INTERBUS-S interface have two 9-pin D-subminiature plug-in connectors for connecting to the INTERBUS remote bus (incoming and outgoing lines).
- The devices with optic fiber connections are especially suited to operation in high-noise environments e.g. near welding robots. They provide a new fast-coupling mechanism for optic fibers.
- To maintain the bus functions, due to signal coupling the unit must always be operational (repeater function). If individual drives have to be switched off during operation a bus coupler has to be connected (e.g. IBS ST 24 BK RB-T of Phoenix Contact company).
- The diagnosis of the most important bus functions is done through the diagnostic LEDs on the INTERBUS-S interface.

Configuration of the INTERBUS Slave

Setting of Slave Address and Transmission Rate (Bus-Specific)

Note: For INTERBUS the slave address is defined by the sequence of participants on the bus and is not adjustable.

The Baud rate is set to 500 kbits/s fixed; for some devices the Baud rate can be set through a switch on the front panel.

The ring structure of the INTERBUS determines the location and the address of the slave in the ring uniquely. This address is also used as CR address (**C**ommunication **R**eference) for PCP. The CR is assigned automatically by the master. It is determined by the physical position of the drive in the INTERBUS ring.

Configuration of the PCP Channel in the Master

The maximum length for objects ("Message Length") has to be set to 240 bytes. For that the node description of the slave has to be changed in the master (e.g. with the help of the CMD tools of Phoenix Contact).

Configuration of the Process Data

The INTERBUS unit can be configured in accordance with the process requirements in the process data section.

The process data are configured independent of the field bus type. For this parameter **P-0-4084, Profile type** has to be set.

The field bus can also be used for parameterization by writing the drive parameters via the PCP channel with the objects assigned to the SERCOS parameters.

The state of these parameters can be read via these objects. Further, the INTERBUS-S objects 6000/6001, defined in profile 12 (sensor/actuator), can be read via the PCP channel.

This configuration option requires that the master supports the PCP services. Then a startup can be performed without the help of a PC.

Note: For both the process input data and output data, changes in word length must always lead to modifications in the respective slave data stored in the master. This is why length changes are only effective after the drive has been switched on again. Switching from parameter mode into operating mode does, however, not change the configuration. Instead, a reconfiguration request is sent to the master to tell it that the configuration will change with the next bus reset.

P-0-4081, Real-time output object structure (Object 6001)

The structure of the process output data is stored in this object. This means that the current structure and bus assignment can be read out on the PCP.

Data Direction

- **Data direction input**

This means slave to master.

- **Data direction output**

This means master to slave.

Process Data Input Description (Object 6000)

Object 6000 is the object corresponding to the drive parameter **P-0-4080, Real-time input object structure**. This object contains the representation of the structure i.e. the number of words and their assignment to objects (indices) for the process input data.

The user can read out the current structure via the PCP service "Read".

The master can draw the information on the location of the individual objects on the bus from this configuration.

The default configuration illustrates the structure of this object.

Basic structure:

- The structure of the process data description is specified in profile 12 of the INTERBUS.
- The length of object 6000 is determined by the maximum number of words on the bus.
- The bus length is entered in bytes (hexadecimal) in the first byte of object 6000.
- The entries for each byte on the bus follow this in ascending order. For each byte, an object number (index) is entered and an additional byte reserved for a sub-index if required. This byte is always zero!
- If an object is made up of several bytes (standard for ECODRIVE03 and DURADRIVE is a word structure of at least 2 bytes), then there is an entry for the object number only for the first byte. The object number for the other bytes is always zero.

Example

	Word 1	Word 2	Word 3	Word 4	Word 5	Word 6
Data-Out	6040	607A H	607A L	6081 H	6081 L	5FF1
Data-IN	6041	6064 H	6064 L	606C H	606C L	5FF6

Fig. 5-9: Default-configuration with profile type "Interpolation"

Sub-index	Value	Description
1	0x0C	number of process data in bytes (= P-0-4082)
2	0x6041	object 6041
3	0x00	2nd byte of object 6041
4	0x00	sub-index for object 6041 (always 00)
5	0x00	2nd byte on bus; still for object 6041 (Word)
6	0x00	2nd byte on bus; still for object 6041
7	0x00	sub-index for object 6041 (always 00)
8	0x60	3rd byte on bus; 6064 H
9	0x64	3rd byte on bus; 6064 H
10	0x00	sub-index for object 6064 (always 00)
11	0x00	4th byte on bus; still for object 6064 H (D-Word)
12	0x00	4th byte on bus; still for object 6064 H (D-Word)
13	0x00	sub-index for object 6064 (always 00)
14	0x00	5th byte on bus; still for object 6064 L (D-Word)
15	0x00	5th byte on bus; still for object 6064 L (D-Word)
16	0x00	sub-index for object 6064 (always 00)
17	0x00	6th byte on bus; still for object 6064 L (D-Word)
18	0x00	6th byte on bus; still for object 6064 L (D-Word)
19	0x00	sub-index for object 6064
20	0x60	7th byte on bus; object 606C H
21	0x6C	7th byte on bus; object 606C H
22	0x00	sub-index for object 606C
23	0x00	8th byte on bus; still object 606C (D-Word)
24	0x00	8th byte on bus; still object 606C (D-Word)
25	0x00	sub-index for object 606C
26	0x00	9th byte on bus; still for object 606C L (D-Word)
27	0x00	9th byte on bus; still for object 606C L (D-Word)
28	0x00	sub-index for object 606C
29	0x00	10th byte on bus; still for object 606C L
30	0x00	10th byte on bus; still for object 606C L
31	0x00	sub-index for object 606C
32	0x5F	11th byte on bus; object 5FF6 (Word)
33	0xF1	11th byte on bus; object 5FF6 (Word)
34	0x00	sub-index for object 5FF6
35	0x00	12th byte on bus; still for object 5FF6
36	0x00	12th byte on bus; still for object 5FF6
37	0x00	sub-index for object 5FF6

Fig. 5-10: Object 6000 process input data

Process Data Output Description (object 6001)

Object 6001 is the object corresponding to the drive parameter **P-0-4081, Real-time output object structure**. This object contains the representation of the structure of the process output data. So the current structure i.e. the assignments on the bus can be read out via PCP; i.e. the object contains the representation of the location and number of output words on the bus.

The structure corresponds completely to the process input data description in object 6000, but contains the objects associated with the output.

The description relates to the following default configuration for the profile type "Interpolation".

Example

	Word 1	**Word 2**	**Word 3**	**Word 4**	**Word 5**	**Word 6**
Data-Out	6040	607A H	607A L	6081 H	6081 L	5FF1
Data-IN	6041	6064 H	6064 L	606C H	606C L	5FF6

Fig. 5-11: Default configuration for profile type "Interpolation"

Bytes no.	Value	Description
1	0x0C	bus length PD in bytes
2	0x60	1st byte on the bus; 6040
3	0x40	1st byte on the bus; 6040
4	0x00	sub-index for object 6040 (always 00)
5	0x00	2nd byte on the bus; still for object 6040 (Word)
6	0x00	2nd byte on the bus; still for object 6040
7	0x00	sub-index for object 6040 (always 00)
8	0x60	3rd byte on the bus; 607A H
9	0x64	3rd byte on the bus; 607A H
10	0x00	sub-index for object 607A (always 00)
11	0x00	4th byte on the bus; still for object 607A H (D-Word)
12	0x00	4th byte on the bus; still for object 607A H (D-Word)
13	0x00	sub-index for object 607A (always 00)
14	0x00	5th byte on the bus; still for object 607A L (D-Word)
15	0x00	5th byte on the bus; still for object 607A L (D-Word)
16	0x00	sub-index for object 607A (always 00)
17	0x00	6th byte on the bus; still for object 607A (D-Word)
18	0x00	6th byte on the bus; still for object 607A (D-Word)
19	0x00	sub-index for object 607A
20	0x60	7th byte on the bus; object 6081 H
21	0x6C	7th byte on the bus; object 6081 H
22	0x00	sub-index for object 6081
23	0x00	8th byte on the bus; still object 6081 H (D-Word)
24	0x00	8th byte on the bus; still object 6081 H (D-Word)
25	0x00	sub-index for object 6081
26	0x00	9th byte on the bus; still for object 6081 L (D-Word)
27	0x00	9th byte on the bus; still for object 6081 L (D-Word)
28	0x00	sub-index for object 6081
29	0x00	10th byte on the bus; still for object 6081 L
30	0x00	10th byte on the bus; still for object 6081 L
31	0x00	sub-index for object 6081
32	0x5F	11th byte on the bus; object 5FF1 (Word; Dummy)
33	0xF1	11th byte on the bus; object 5FF1 (Word; Dummy)
34	0x00	sub-index for object 5FF1
35	0x00	12th byte on the bus; still for object 5FF1
36	0x00	12th byte on the bus; still for object 5FF1
37	0x00	sub-index for object 5FF1

Fig. 5-12: Object 6001 process output data

Length of the Cyclical Data Transfer in the Drive Controller

Master and slave exchange data for cyclical (process data) and acyclical communication (PCP services). The overall length of the transmitted data block corresponds to the sum of the process data and the width of the PCP channel.

The length of the process data depends on their configuration. By choosing a profile type in parameter **P-0-4084, Profile type**, default configurations can be set.

Note: With the freely configurable profile types (P-0-4084=0xFFFE or 0xFF82) user-specific extensions of the process data may have the effect that the drive controllers are operated with different lengths of process data for input and output directions. In this case place holder objects (P-0-4076) are inserted automatically to equalize the lengths.

The data type of process data can only be word or double word but not byte. Nevertheless, for reasons of compatibility with other bus systems they are specified in bytes.

Length of the PD Channel

The length of the process data has to be 1...9 words i.e. 2...18 bytes equally in both directions.

Setting of Length of the Process Data in Drive Controller

The length of the process data is determined by the contents of the configuration lists **P-0-4080, Real-time input object structure** (object 6000) and **P-0-4081, Real-time output object structure** (object 6001).

The length of the process data can be taken from parameters **P-0-4082, Length of real-time data channel In** and **P-0-4087, Length of real-time data channel Out**.

The setting becomes effective for the operating mode with the startup of the drive controller.

Note: Any change in the length of the process data also means a change in the configuration of the master. So the length of the process data has to be equal to the projected length in the master.

For INTERBUS: **P-0-4082 = P-0-4087!**

The length specified in SERCOS parameters **P-0-4082, Length of real-time data channel In** and **P-0-4087, Length of real-time data channel Out** is accepted directly by the INTERBUS slave circuit into objects 6000 and 6001 so that it is also possible to read out the configuration via the objects of the sensor/actuator profile 12 with PCP.

ID Code

The ID code of the INTERBUS interface is dependent on the set profile type (P-0-4084) and the width of the PCP channel (P-0-4083).

PCP channel width (P-0-4083) in bytes	Length cyclical channel (P-0-4082)	Length of the process data in bytes	ID code	INTERBUS length code
2	4	2	0xF3	0x02
2	6	4	0xF3	0x03
2	8	6	0xF3	0x04
2	10	8	0xF3	0x05
2	12	10	0xF3	0x0E [1)]
2	14	12	0xF3	0x0F [1)]
2	16	14	0xF3	0x06
2	18	16	0xF3	0x07
8	10	2	0xF1	0x05
8	12	4	0xF1	0x0E
8	14	6	0xF1	0x0F
8	16	8	0xF1	0x06
8	18	10	0xF1	0x07
8	20	12	0xF1	0x15 [1)]
8	24	16	0xF1	0x16 [1)]

1: master with firmware from version 3.2 upward

Fig. 5-13: Table for overview: ID codes for INTERBUS-S

Acyclical Parameter Communication (PCP Channel)

Principles

The overall number of data transmitted over the bus line between master and slave is made up from a section for the process data and a section for the PCP communication.

PCP Channel to be Used as an Option

<table>
<tr><td>PCP data</td><td>Process data</td></tr>
<tr><td colspan="2">data block that is cyclically transmitted between the slave and the master</td></tr>
</table>

Fig. 5-14: Structure of transmitted data

To achieve a high system flexibility all parameters (S-0-xxxx and P-0-xxxx) of the drive are accessible via objects with acyclical services (PCP services.

The parameters can be assigned to the process data (cyclical data) which are exchanged cyclically between the drive and the INTERBUS master.

A parameter which is assigned to the process data can no longer be written with the acyclical services (PCP).

PCP services

ECODRIVE / DURADRIVE devices support the PCP 2.0 version of Phoenix Contact with 1 word PCP length. It is also possible to set a fixed PCP length of 4 words through **P-0-4083, Length of parameter channel in DP**.

The connection of a master circuit of the G4 group is recommended.

Note: If the master does not support PCP communications then set **P-0-4083, Length of parameter channel in DP** in the drive to "2". This only increases the number of transmitted data by 2 bytes. It was specifically avoided, however, that the PCP channel could be switched off by entering P-0-4083=0 because then a start up without the help of a PC can not be guaranteed any longer.

Supported Services

- **Initiate** establish connection
- **Abort** terminate connection
- **Reject** reject invalid services
- **Identify** read manufacturer name, type, version
- **Status** read unit/user status
- **Get-OV** read object directory
- **Read** read variable
- **Write** write variable

Additional data of services are listed in the manuals of the specific master circuits employed.

Error Codes

There are specific error codes for the PCP services which are caused by the transmission of data via the field bus. These are listed in the descriptions for the respective field bus masters.

The following is a list of errors triggered by a communication problem between the field bus circuit and the drive:

Error code	Additional error code	Cause
0xF0	-	Timeout during transmission
0xF9	-	Attribute not writable
0xFA	-	The data format is invalid
0xFB	-	The specified sub-index does not exist
0xFC	-	The specified index does not exist
0xFD	0001	Service channel not open
0xFD	0009	Wrong access to element 0
0xFD	1001	Parameter number does not exist
0xFD	1009	Wrong access to element 1
0xFD	2001	Name does not exist
0xFD	2002	Name transmitted too short
0xFD	2003	Name transmitted too long
0xFD	2004	Name not alterable
0xFD	2005	Name momentarily write-protected
0xFD	3002	Attribute transmitted too short
0xFD	3003	Attribute transmitted too long
0xFD	3004	Attribute not alterable
0xFD	3005	Attribute momentarily write-protected
0xFD	4001	Unit does not exist
0xFD	4002	Unit transmitted too short
0xFD	4003	Unit transmitted too long
0xFD	4004	Unit not alterable
0xFD	4005	Unit momentarily write-protected
0xFD	5001	Minimum input value does not exist
0xFD	5002	Minimum input value transmitted too short
0xFD	5003	Minimum input value transmitted too long
0xFD	5004	Minimum input value not alterable
0xFD	5005	Minimum input value momentarily write-protected
0xFD	6001	Maximum input value does not exist
0xFD	6002	Maximum input value transmitted too short
0xFD	6003	Maximum input value transmitted too long
0xFD	6004	Maximum input value not alterable
0xFD	6005	Maximum input value momentarily write-protected
0xFD	7002	Data transmitted too short
0xFD	7003	Data transmitted too long
0xFD	7004	Data not alterable
0xFD	7005	Data momentarily write-protected
0xFD	7006	Data below min. input value
0xFD	7007	Data exceeding max. input value
0xFD	7008	Data incorrect
0xFD	7009	Data password protected
0xFD	8001	Service channel momentarily busy
0xFD	8002	Fault in service channel
0xFD	800B	Transmission interrupted
0xFD	800C	Unsolicited access

Fig. 5-15: Error codes with INTERBUS

Object Accesses with INTERBUS

Index	Data type	Object type	Access	PD	Object description
6000	PDB	Record	R	no	**P-0-4080, Real-time input object structure**
6001	PDB	Record	R	no	**P-0-4081, Real-time output object structure**
6003	U16	Variable	R/W	no	process data monitoring time

Fig. 5-16: Object directory for INTERBUS

Also, all parameters of the drive are available via the PCP services "Read" and "Write" (where permitted). The assignment of the objects (index and sub-index) to drive parameters is described in the following.

Object Definition

The access to the data of an object is performed via

- index
- sub-index

Generating Laws for the Object Index

S-Parameters

Hexadecimal: $Index_{hex}$=0x2000+IDN(S-0-xxxx)

Decimal: $Index_{dez}$=8192+IDN(S-0-xxxx)

P-Parameters

Hexadecimal: $Index_{hex}$=0x3000+IDN(P-0-xxxx)

Decimal: $Index_{dez}$=12288+IDN(P-0-xxxx)

Generating Laws for the Object Sub-Index

Sub-index	Data type	Access	Description
0			Not supported
1	UINT16	R/W	IDN
2	visible string	R	Name
3	UINT16	R	Attribute
4	visible string	R	Unit
5	2 or 4 bytes	R	Minimum input value
6	2 or 4 bytes	R	Maximum input value
7	2...32 bytes	R/W	Operating data (as sub-index 10)
8	UINT16	R	Maximum length of list (elements)
9	UINT16	R/W	Actual length of list (elements)
10	2...32 bytes	R/W	Operating data (as sub-index 7)
11...137	2...32 bytes	R	Continuation of operating data with lists

Fig. 5-17: Description of the sub-index

Examples for the Access to the Data of an Object

Example 1: access to the operating data of S-0-0051

$Index_{dez}$=8192+51=8243

- or -

$Index_{hex}$=0x2000 **OR** 0x0033=0x2033

attribute = 7, since access to the operating data required

Example 2: access to the operating data of P-0-0051

$Index_{dez}$=12288+51=12339

- or -

$Index_{hex}$=0x3000 **OR** 0x0033=0x3033

attribute = 7, since access to the operating data required

Diagnostic LEDs for INTERBUS

The diagnostic LEDs on the INTERBUS of the ECODRIVE03 / DURADRIVE controllers meet the requirements for INTERBUS certification.

LED designation	LED state	Description
H40 [Remote Check (RC)]	Green	Incoming cable OK
H41 [Bus Active (BA)]	Green	Data exchange active
H42 [Transmit/Receive (TR)]	Green	PCP transmission active
H43 [Remote Bus Disable(RD)]	Red	Switching off continued remote bus segment
H44 (Module status / Reconfiguration)	Green flashing (1 Hz)	Communication field bus drive OK
	Red flashing (1 Hz)	Communication field bus drive not synchronous
	Red	Initialization failed. Faulty unit.
	Green flashing (2 Hz)	While a reconfiguration request is pending in the slave this LED flashes at double frequency
H45 [operation LED (UL)]	Green	Power supply OK
All LEDs	Red flashing	Severe error on field bus unit. Switch device off/on.

Fig. 5-18: Diagnostic LEDs for INTERBUS

LED designation	LED state	Description
H140 [Remote Check (RC)]	Green	Incoming cable OK
H141 [Bus Active (BA)]	Green	Data exchange active
H142 [Transmit/Receive (TR)]	Green	PCP transmission active
H143 [Remote Bus Disable(RD)]	Red	Switching off continued remote bus segment
H144 (Module status / Reconfiguration)	Green flashing (1 Hz)	Communication field bus drive OK
	Red flashing (1 Hz)	Communication field bus drive not synchronous
	Red	Initialization failed. Faulty unit.
	Green flashing (2 Hz)	While a reconfiguration request is pending in the slave this LED flashes at double frequency.
H145 [operation-LED (UL)]	Green	Power supply OK
H146 [FO1]	Yellow	Incoming interface: Initialization faulty or MAU warning
H147 [FO2]	Yellow	Continuing interface: Initialization faulty or MAU warning
All LEDs	Red flashing	Severe error on field bus unit. Switch device off/on.

Fig. 5-19: Diagnostic LEDs for INTERBUS with optic fibers

Assignment of the INTERBUS-S Plug-In Connector X40 / X41

(See Project Planning Manual: "Signal assignment X40, INTERBUS-S, incoming and outgoing bus")

5.4 Command Communication with CANopen

Function Overview

In drive controllers DKC05.3 of the ECODRIVE03 family and in the HDC01-AxxxN-CN01 of the DURADRIVE family the protocol **CANopen according to Draft Standard DS301 Version 3.0** is implemented.

PDO and SDO

These devices can transmit process data via so-called **Process data objects (PDO)** as well as parameters and data via **Service data objects (SDO)** of the CANopen services.

Note: The process data are always transmitted via PDOs.

The CANopen drive controllers have the following features:

- Simple configuration through use of "predefined connection set" and "minimum boot-up" according to DS301
- The baud rates specified by CANopen (according to DS301) of 20, 50, 100, 125, 250, 500, 800 kbits/s and 1 Mbit/s are supported.
- Freely configurable process data channel with up to 18 bytes in both data directions via drive parameters
- Downwardly compatible with PROFIBUS functions of ECODRIVE01 through profile selection (I/O mode).
- Monitoring of process data transmission (watchdog function)
- Diagnostic LED array on the front panel of the master communication interface for easy diagnosis of bus functions and important communications between drive and field bus.
- All drive parameters can be read directly via SDO and (if permitted) written, too.
- Upload/download function available for all drive parameters including lists over four arrays of 16 to 128 bytes data length with SDO services
- Switchable event-controlled transmission of process data (default = not event-controlled)
- Synchronous data exchange possible (→ cyclical position control possible)

CANopen Interface

The drive controllers of the ECODRIVE03 and DURADRIVE families with master communication interface "CANopen" support the **CANopen Specification according to DS301**.

- For ensuring compliance with the EN standards for EMC safety the CANopen interface is completely galvanically decoupled.
- According to DS301 the CANopen interface is implemented as a 9-pin D-subminiature connector (plug) for coupling to the bus. The assignment complies with DS301.

Transmission of Process Data

Since with CANopen process data can be transmitted in an event-controlled way, for each PDO (process data object) a so-called event (**P-0-4073, CANopen event mask**) is defined. This enables the masking of individual bits for the status word, the changing of which triggers a COV (**C**hange **O**f **V**alue).

To prevent too frequent a transmission of values, each PDO can be assigned a blocking time. If a COV occurs after the transmission of the PDO, this is held back until the end of the blocking time. How this COV is interpreted depends on the type of transmission.

Note: For the event-controlled transmission of analog values an appropriate hysteresis and / or blocking time should be entered to avoid too high a bus load.

To enable a synchronized transmission of data a SYNC telegram was defined. It can be set so that each telegram is considered, or that only every 2nd to 240th telegram is considered. The counter for the SYNC telegrams starts with 0 at transition into the operational state. For the transmitted data this means:

- After the time set in parameter **S-0-0008, Command valid time (T3)** the synchronous receive PDOs become effective.
- After the time set in parameter **S-0-0007, Feedback acquisition starting time (T4)** the actual value of the synchronous PDOs are stored.

There is also the possibility to request the process data via the RTR service (Remote Transmit Request).

Transmission type	PDO transmission
0	With each SYNC if there is a COV
1 – 240	With each 1st to 240th SYNC
241 - 251	Reserved, corresponds to value 240
252	With the next SYNC following an RTR
253	Directly after an RTR
254	Not supported, corresponds to value 255
255	Directly after a COV

Data sent to the drive are always accepted. But for transmission types 0 to 240 the data only become effective dependent on the SYNC telegram. Here transmission type 0 corresponds to transmission type 1.

Note: A drive can be activated as a SYNC generator as well. But within the network there must only be one SYNC generator activated.

Node Guarding

The node guarding is operated through the identifier 1792 + address. This telegram contains 1 byte data.

Data		Node state
0	0	BOOTUP
4	132	STOPPED (Bit 7 toggles with each telegram)
5	133	OPERATIONAL (Bit 7 toggles with each telegram)
127	255	PRE-OPERATIONAL (Bit 7 toggles with each telegram)

After switch-on the drive automatically sends a Boot-up protocol. For the subsequent node guarding there are two different mechanisms:

- Monitoring in the drive through **P-0-4075, Field bus watchdog time**
- The drive controller has to receive at least one valid PDO1 during the set watchdog time. If this monitoring is to be disabled, in **P-0-4075** the value 65535 has to be set.

Node Guarding Protocol

In the Node Guarding Protocol the master sends an RTR. The drive responds with his node status and toggles bit 7. This occurs within an interval designated "Node Guard Time". If within this interval, multiplied by the "Life Time Factor", no RTR request is received an error is generated.

If the "Life Time Factor" is 0 the function is switched off.

EMCY Telegram

If an error occurs in the drive or if an error is reset, an EMCY telegram is sent. Transmitted are 8 bytes of data. For an error the telegrams are structured as follows:

Bytes	0	1	2	3	4	5	6	7
Data	0xFF	0xFF	0x07	error code		error number		

The **error code** corresponds to the error that is shown on the display of the drive controller.

The **error number** repeats the number of the error.

Example:

Error code: bytes 3=0x09; bytes 4=0xF4 (**F409 Bus failure**)

Error number: bytes 5=0x09; bytes 6=0x00; bytes 7=0x04

If the error is reset, this is confirmed by the sending of the following telegram:

Byte	0	1	2	3	4	5	6	7
Data	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00

The blocking time can be set to avoid that EMCY telegrams are sent too frequently.

Note: EMCY telegrams must not be requested via RTR.

Configuration of the CANopen Slave

Addressing of the CANopen Slave

Prioritizing

The address determines the priority of data sent from of the slave, with the lowest address having the highest priority. Usually the master has the highest priority i.e. the lowest address.

Predefined Connection Set

Each CANopen participant has to send data on the bus uniquely assigned to it. According to the **Predefined Connection Set** of DS301 this means that for the slave an address unique to it on the whole bus is necessary. This address is set on the plugged-in firmware module.

Note: According to CANopen the address is settable in the range of 1...127, but for ECODRIVE- / DURADRIVE devices only addresses up to 99 can be set.

Address 0 is not permitted.

Configuration of the Process Data (PDO)

The process data are configured independent of the field bus type.

The setting in **P-0-4084, Profile type** generally also configures the process data.

Note: Profile types P-0-4084 = 0xFFFE or 0xFF82 are an exception here. The user is actually required to configure this profile type.

See also chapter "Profile Types".

Parameterization can also be done through the field bus by writing the parameters over the SDO services with the relevant values. In the same way the parameters can be read over SDO services.

The configuration of the process data is contained in the CANopen objects 1600 (P-0-4081) and 1A00 (P-0-4080).

The configuration entered in parameters **P-0-4080, Real-time input object structure** and **P-0-4081, Real-time output object structure** is taken over into operating mode when the drive is started up.

P-0-4080, Real-time input object structure (PDO Mapping Objects 1A00, 1A01, ...)

This object describes the structure of the PDOs sent from slave to master, i.e. this represents the length and the assignment of the PDOs with objects (indices) for the process input data.

The user can read out the existing structure over the SDO read service.

The master can use this configuration to determine which object in which PDO is transmitted at which location.

Note: Up to 3 PDOs with up to 8 bytes length each in both data directions can be configured.

P-0-4081, Real-time output object structure (PDO Mapping Objects 1600, 1601, ...)

This object contains the structure of the process output data (master→slave). So over SDO Read the current structure and thus the assignment of the PDOs can be read.

Note: Both for the process input data and process output data changes in word length must always lead to a modification in the data stored in the master for this slave. So PDO changes only become effective when the drive is switched on anew or the phase is switched from parameter mode to operating mode.

Data Direction

- **Data direction input**

This means slave to master.

- **Data direction output**

This means master to slave.

Number and Length of the PDO in the Drive Controller

The CANopen slave circuit permits a flexible configuration of the process data. The process data in CANopen is divided into process data objects (PDOs).

Length and number of PDOs are dependent on the setting of **P-0-4084, Profile type**. It is also possible with the freely-configurable profile types (P-0-4084 = 0xFFFE) to make user-specific expansions in the process data so that the drives may operate with different PDO configurations.

Since all data of the drive are at least two bytes long a PDO can only contain words or a double words, not bytes as data types. Nevertheless for reasons of compatibility with other bus systems the length is specified in bytes.

The configuration of length is generally determined automatically through the choice of profile type.

Note: A double word must never be divided into 2 PDOs.

Length of the Process Data

The length of the process data (max. 3 PDOs) has to be within the range of 2...18 bytes. It is given in parameters **P-0-4082, Length of real-time data channel In** and **P-0-4087, Length of real-time data channel Out**.

Parameter Communication with CANopen

SDO Services

ECODRIVE / DURADRIVE devices with CANopen interface support the data defined in the **Predefined Connection Set** of CANopen DS301.

So the following data identifiers (COB-ID) are defined:

COB-ID (hex.)	COB-ID (dec.)	description
0x000	0	NMT, master → DKC or HDC
0x080	128	SYNC, master → DKC or HDC
0x080 + address	128 + address	EMCY, DKC or HDC → master
0x180 + address	384 + address	PDO1, DKC or HDC → master
0x200 + address	512 + address	PDO1, master → DKC or HDC
0x280 + address	640 + address	PDO2, DKC or HDC → master
0x300 + address	768 + address	PDO2, master → DKC or HDC
0x380 + address	896 + address	PDO3, DKC or HDC → master
0x400 + address	1024 + address	PDO3, master → DKC or HDC
0x580 + address	1408 + address	SDO, DKC or HDC → master
0x600 + address	1536 + address	SDO, master → DKC or HDC
0x700 + address	1792 + address	Node Guarding

Further data of the services are given in the manuals of the specific master circuits employed.

Error Code

For the SDO services there are errors caused by the transmission of the data over the field bus. They have the following error codes:

Error code	Cause
0x0800 0x0000	General error
0x0609 0x0011	Sub-index does not exist
0x0601 0x0000	Access to object is not supported
0x0609 0x0031	The value of the written parameter is too high
0x0609 0x0032	The value of the g written parameter is too low
0x0607 0x0010	The data type used is unknown, the length of the transmitted data does not match
0x0607 0x0012	The data type used is wrong, the length of the transmitted data is too large
0x0607 0x0013	The data type used is wrong, the length of the transmitted data is too small
0x0604 0x0041	The object cannot be assigned to any PDO
0x0604 0x0042	The number and length of the assigned objects exceeds the length of the PDO
0x0604 0x0043	General incompatibility with parameter access
0x0503 0x0000	The toggle bit has not changed
0x0602 0x0000	The index does not exist
0x0800 0x0021	The drive does not permit data transmission
0x0800 0x0022	The drive is in a state where no data exchange is possible
0x0606 0x0000	Hardware faulty

Fig. 5-20: Error codes with CANopen

CANopen-Specific Object Directory

To achieve a high system flexibility all data are accessible via objects. These objects can be assigned to the process data and transmitted cyclically. The communication objects defined by CANopen in DS301 are provided. Also possible is the acyclical transmission via SDO, but no process data (see contents of **P-0-4081, Real-time output object structure**) may be written by the master via SDO.

Object Definition

To simplify the acyclical access the objects were assigned to drive parameters (index and sub-index). This is described below.

The access to the data of an object is executed through

- index
- sub-index

Generating Laws for the Object Index

S-Parameters

Hexadecimal: $Index_{hex}$=0x2000+IDN(S-0-xxxx)

Decimal: $Index_{dez}$=8192+IDN(S-0-xxxx)

P-Parameters

Hexadecimal: $Index_{hex}$=0x3000+IDN(P-0-xxxx)

Decimal: $Index_{dez}$=12288+IDN(P-0-xxxx)

Generating Laws for the Object Sub-Index

Sub-index	Data type	Access	Description
0	UINT8	R	Number of the sub-indices
1(!)	UINT16	R/W	IDN
2	visible string	R	Name
3	UINT16	R	Attribute
4	visible string	R	Unit
5	2 or 4 bytes	R	Minimum input value
6	2 or 4 bytes	R	Maximum input value
7	2...32 bytes	R/W	Operating data (as sub-index 10)
8	UINT16	R	Maximum length of a list (elements)
9	UINT16	R/W	Actual length of a list (elements)
10	2...32 bytes	R/W	Operating data (as sub-index 7)
11...137	2...32 bytes	R	Continuation of the operating data with lists

!: The FGP20 firmware does not support the sub-index 1. Please observe the information below.

Fig. 5-21: Description of the sub-index

Note: Deviating from the parameter access through object mapping described, the FGP20 does not support the sub-index 1 any more. Instead of that the sub-index 0 was implemented which is mapped as follows.

Parameter type	Read access to sub-index 0	Write access to sub-index 0
simple parameter	corresp. to sub-index 7	corresp. to sub-index 7
command	corresp. to sub-index 1	corresp. to sub-index 7
list	corresp. to sub-index 10	corresp. to sub-index 10

Sub-indices 7 and 10 can still be accessed. All parameters were included in the EDS file. To avoid inflating this, the sub-indices were not entered.

Examples for the Access to the Data of an Object

Example 1: access to the data of S-0-0051

$Index_{dez}$=8192+51=8243

- or -

$Index_{hex}$= 0x2000 **OR** 0x0033=0x2033

Attribute = 0, 7 or 10, since access to the data required

Example 2: access to the data of P-0-0051

$Index_{dez}$= 12288+51=12339

- or -

$Index_{hex}$= 0x3000 **OR** 0x0033=0x3033

Attribute = 0, 7 or 10, since access to the data required

Electronic Data Sheet

For each CANopen device an EDS file (*.EDS) has to be logged which stores the data necessary for the operation on the bus. This file is needed for each participant for the configuration of the bus master.

File Name

The EDS file for ECODRIVE03/DURADRIVE is an ASCII file with the name "**DKC05P3.EDS**".

In the EDS file all objects in the device are described.

Note: With the installation of DriveTop the EDS file is stored in the directory "Indramat\Device Data Sheets", as well as the Intranet.

Diagnostic LEDs for CANopen

For field bus interface diagnoses there are 6 LEDs available on the front panel of the field bus unit. These indicate the state of synchronization between field bus interface and drive as well as bus activity for cyclical data exchange.

Each LED has four possible states: red, green, orange, and off .

When starting up the CANopen unit the LEDs are automatically tested. This is visible in the LEDs continuously running through color sequences of red, green and orange.

Description of LEDs during unit operation:

LED designation	LED state	Description
H50 (initialization)	Red	Initialization failed. Unit faulty.
	Green	Unit OK
H51 (operation LED)	Red	Operating error (bus off). To many errors detected on bus. Possible causes: • wrong Baud rate set • cable faulty
	Green	Operation OK
H52 (SDO-request)	Green (impulse)	SDO received
H53 (SYNC)	Green	SYNC message received For each incoming SYNC the LED is switched to green for 200 ms. With the usual high frequencies the LED will be glowing green continuously
	off	No SYNC received
H54 [Internal synchronization (Alive LED)]	Red flashing	No synchronization of the field bus unit with the drive
	Green flashing	Synchronization of the field bus unit with the drive achieved
H55 (PDO_data)	Green	Process data transmission (PDO) active. The green LED is switched on with each incoming PDO for 20ms. With the usual high frequencies the LED will be glowing green continuously
All LEDs	flashing regularly	Severe error on the field bus unit. Switch off/on device.

Fig. 5-22: Diagnostic LEDs for CANopen

5.5 Command Communication with DeviceNet

General

The drive controllers of the ECODRIVE03 and DURADRIVE families with master communication interface "DeviceNet" support the protocol **DeviceNet according to ODVA Specification 2.0**.

With these drive controllers process data can be transmitted via so-called "Polled I/O" (cyclical services, and drive parameters can be transmitted via "Explicit Message" (acyclical services) of the DeviceNet.

Note: The process data are always transmitted through "Polled I/O".

To achieve the greatest possible system flexibility, all data can be accessed via objects. In DeviceNet these objects can be addressed through class, instance and attribute. Some of these objects can be assigned to the polled I/Os as process data and thus be cyclically transmitted. There is also the option of transmitting via "Explicit Message", but no objects defined as process data must be transmitted by the master (**P-0-4081, Real-time output object structure**) via Explicit Message.

Functional Overview

The DeviceNet master communication interface provides the following functional features:

- DeviceNet General Device according to ODVA specification 2.0. ("ODVA" stands for "**O**pen **D**eviceNet **V**endor Association")
- Easy configuration by implementing Group 2 only Server.
- Support of all data rates:
  - 125 kbits/s (up to a distance of 500 m)
  - 250 kbits/s (up to a distance of 250 m)
  - 500 kbits/s (up to a distance of 100 m)
- Freely configurable process data up to 9 words in both data directions through drive parameters **P-0-4080, Real-time input object structure** and **P-0-4081, Real-time output object structure**.
- Monitoring of process (watchdog function).
- Array of diagnostic LEDs on front panel of master communication interface for easy diagnosis of bus functions and the most important communications between drive and field bus.
- All parameters of the drive are directly readable via "Explicit Message" and (if permitted) writable also.
- Upload/download functions available for all drive parameters including lists over four arrays of 16 to 128 bytes data length with "Explicit Message" services (Rexroth Indramat SIS protocol).

DeviceNet Interface

The drive controller with master communication interface "DeviceNet" support the DeviceNet ODVA Specification 2.0.

- For ensuring the standards on EMC safety the DeviceNet-interfaces are completely galvanically decoupled.
- According to ODVA Specification 2.0 drive controllers with master communication interface "DeviceNet" have a Phoenix COMBICON plug-in connector (Open Screw Connector) for connection to the bus.

Setting of Slave Address and Transmission Rate (bus-specific)

The address determines the priority of messages from the slave, with the lowest address carrying the highest priority. Generally, the master has the highest priority and therefore the lowest address.

MAC ID

Each DeviceNet participant has to send messages to the bus that are uniquely assigned to it. According to the DeviceNet specification this requires a slave address (MAC ID) that is unique for the whole bus. This address is set on the plugged-in firmware module.

Note: According to ODVA Specification 2.0, addresses ranging from 1 to 63 can be set. However, for the ECODRIVE03 / DURADRIVE devices, addresses up to a maximum of 99 can be set. Invalid addresses are treated as address 63.

Watchdog Function

The time monitoring of the data exchange of the real time data is specified to 4 times the "expected packet rate" (class 5, instance 2, attribute 9) according to the DeviceNet specification. This data is written by the master stored in drive parameter **P-0-4075, Field bus watchdog time**.

Explicit Message

The ECODRIVE03 / DURADRIVE devices are Group 2 only servers and support the acyclical data exchange via "Explicit Message".

Further data for the services are given in the manuals of the specific master circuits employed.

Note: For the ControlLogix, for the time being the SIS protocol is required since otherwise for each parameter used a communication connection has to be projected.

Electronic Data Sheet

For each DeviceNet unit an EDS file (*.EDS) has to be logged. This contains the data needed for operation of the unit on the bus. This file is needed for the configuration of the bus master for each participant.

File Name

The EDS file for an ECODRIVE03 / DURADRIVE devices with DeviceNet interface (DKC06.3) is an ASCII file with the name **DKC06P3.EDS**

All the objects in the unit are described in this EDS file.

Note: With the installation of DriveTop the EDS files are stored in the directory "Indramat\Device Data Sheets", as well as on the Intranet.

DeviceNet-Specific Object Directory

The communication objects defined for DeviceNet in ODVA Specification 2.0 are provided.

By mapping the parameters to objects (class, instance and attribute) all drive parameters (parameter set 0) are readable and writable via "Explicit Message". The addressing is performed through a direct conversion of the parameter number into an object with:

- class
- instance
- attribute

Generating Laws for Object Class

The S-parameters are mapped to the classes 101 to 117:

- $\text{class} = 101 + [\text{IDN}(S-0-xxxx)-1]/255$ **S-parameters**

The P-parameters are mapped to the classes 118 to 134:

- $\text{class} = 118 + [\text{IDN}(P-0-xxxx)-1]/255$ **P-parameters**

with S-0-xxxx or P-0-xxxx: IDN of the parameters.

Generating Laws for Object Instance

- $\text{instance} = \text{IDN}(S-0-xxxx) - [(\text{Klasse}-101)\cdot 255]$ **S-parameters**
- $\text{instance} = \text{IDN}(P-0-xxxx) - [(\text{Klasse}-118)\cdot 255]$ **P-parameters**

with S-0-xxxx or P-0-xxxx: IDN of the parameters.

Generating Laws for the Attribute

Generating laws for object attribute: Through the attributes the elements of the parameters can be addressed:

Attribute	Data type	Access	Description
1	UINT16	R/W	IDN
2	visible string	R	Name
3	UINT16	R	Attribute
4	visible string	R	Unit
5	2 or 4 bytes	R	Minimum input value
6	2 or 4 bytes	R	Maximum input value
7	2..32Byte	R/W	Operating data (as sub-index 10)
8	UINT16	R	Maximum length of a list (elements)
9	UINT16	R/W	Actual length of a list (elements)
10	2..32Byte	R/W	Operating data (as sub-index 7)
11...137	2...32Byte	R	Continuation of the operating data with lists

Fig. 5-23: Meaning of the attributes

Example 1: access to the data of S-0-0051

$$\text{class} = 101 + [\text{IDN}(S-0-0051)-1]/255 = 101 + 50/255 = 101$$

$$\text{instance} = \text{IDN}(S-0-0051) - [(\text{class}-101)\cdot 255] = 51 - 0\cdot 255 = 51$$

attribute = 7 (or 10), since access to the data

Example 2: access to the data of P-0-0051

$$\text{class} = 118 + [\text{IDN}(S-0-0051) - 1]/255 = 118 + 50/255 = 118$$

$$\text{instance} = \text{IDN}(P-0-0051) - [(\text{class} - 118) \cdot 255] = 51 - 0 \cdot 255 = 51$$

attribute = 7 (or 10), since access to the data

Data Exchange Objects

The data exchange objects provide access to parameters via the SIS protocol.

Error Code

During the accessing of objects via "Explicit Message", errors may occur that are caused by the transmission of the data via the field bus. These are specified in the documentation on the field bus master used and can also be found in the DeviceNet specification (Volume 1, Appendix H).

Errors that are caused by a communication problem between the field bus circuit and the drive are listed in the following. In the "Explicit Message" they appear as an "Additional Error". There are the following error types:

List of errors caused by wrong access:

Error code	Additional error	Cause
0xF0	-	Timeout during the transmission
0xF9	-	The attribute is not writable
0xFA	-	The data format is invalid
0xFB	-	The specified class / instance does not exist
0xFC	-	The specified attribute does not exist
0xFD	01	Service channel not open
0xFD	09	Wrong access to element 0
0xFD	11	Parameter number does not exist
0xFD	19	Wrong access to element 1
0xFD	21	Name does not exist
0xFD	22	Name transmitted too short
0xFD	23	Name transmitted too long
0xFD	24	Name not alterable
0xFD	25	Name momentarily write-protected
0xFD	32	Attribute transmitted too short
0xFD	33	Attribute transmitted too long
0xFD	34	Attribute not alterable
0xFD	35	Attribute momentarily write-protected
0xFD	41	Unit does not exist
0xFD	42	Unit transmitted too short
0xFD	43	Unit transmitted too long
0xFD	44	Unit not alterable
0xFD	45	Unit momentarily write-protected
0xFD	51	Minimum input value does not exist
0xFD	52	Minimum input value transmitted too short
0xFD	53	Minimum input value transmitted too long
0xFD	54	Minimum input value not alterable
0xFD	55	Minimum input value momentarily write-protected
0xFD	61	Maximum input value does not exist
0xFD	62	Maximum input value transmitted too short
0xFD	63	Maximum input value transmitted too long
0xFD	64	Maximum input value not alterable
0xFD	65	Maximum input value momentarily write-protected
0xFD	72	Data transmitted too short
0xFD	73	Data transmitted too long
0xFD	74	Data not alterable
0xFD	75	Data momentarily write-protected
0xFD	76	Data smaller than min. input value
0xFD	77	Data larger than max. input value
0xFD	78	Data not correct
0xFD	79	Data password-protected
0xFD	81	Service channel momentarily busy
0xFD	82	Fault in service channel
0xFD	8B	Transmission interrupted
0xFD	8C	Invalid access

Fig. 5-24: Error codes with DeviceNet

The Assembly Object

The data of the "Polled I/O" are exchanged via the "Assembly Object". The following correspondences apply:

Instance 1=Output Object and **Instance 2=Input Object**.

In addition the attributes 1 and 2 according to ODVA Specification 2.0 are implemented, which provide the possibility of reading out the configuration of the "Assembly Object" through a DeviceNet diagnostic tool.

attribute 1: UINT16 number of data objects in Assembly

attribute 2: ARRAY of STRUCT list of data objects in Assembly

Attribute 3 contains the drive objects configured as process data.

Definition of structure:

UINT16	Size of the object in bits
UINT16	Size of the object description in bytes
ARRAY of BYTE	Symbolic object path class/ instance/attribute

Configuration of the DeviceNet Slave

Configuration of the Process Data ("Polled I/O")

The process data ("Polled I/O") are configured independent of the field bus type.

The setting in **P-0-4084, Profile type** generally also configures the "Polled I/O" (cyclical services).

Note: Profile types P-0-4084 = 0xFFFE or 0xFF82 are an exception here. The user is actually required to configure this profile type.

See also chapter "Profile Types".

The parameterization can also be done via the field bus, writing the drive parameters through "Explicit Message".

The values set for these parameters can also be read through "Explicit Message". Alternatively the assignment of the "Polled I/O" can be read through the attribute 2 of the respective "Assembly Object" according to ODVA Specification 2.0 via "Explicit Message".

The configuration entered in the parameters become effective with the startup of the drive into operating mode.

P-0-4080, Real-time input object structure

Input Assembly Class 4, Instance 2, attribute 1+2

In this object the structure of the data sent from slave to master (process data) in "Polled I/O" is described i.e. the length and the assignment with objects (Class/Instance/attributes) for the process input data.
The user can read out the existing structure via the Read service of the "Explicit Message".

The master can use this configuration for determining which object ís transmitted in which location of the "Polled I/O".

P-0-4081, Real-time output object structure

Output Assembly Class 4, Instance 1, attribute 1+2

In this object the structure of the "Polled I/O" from master to slave is stored. So via the Read service of the "Explicit Message" the current structure i.e. the assignment of the "Polled I/O" can be read out.

Note: Both for the process input data and process output data changes in word length must always lead to a modification in the data stored in the master for this slave. So changes of these values only become effective when the drive is switched on anew or the phase is switched from parameter mode to operating mode.

Data Direction

- **Data direction input**

This means slave to master.

- **Data direction output**

This means master to slave.

Note: Up to 18 bytes data (incl. field bus control word, field bus status word) per data direction can be configured.

Number and Length of the Process Data ("Polled I/O") in the Drive Controller

The DeviceNet slave circuit allows a flexible configuration of the "Polled I/O".

The length of the process data ("Polled I/O") is dependent on the setting of **P-0-4084, Profile type**. Additionally, for the freely configurable profile types (P-0-4084 = 0xFFFE or 0xFF82) user-specific extensions of the process data may mean that the drives may operate with different data lengths for the "Polled I/O".

Since all data of the drive controller are at least 2 bytes long, the "Polled I/O" may only contain words or double words but not bytes as data types. Nevertheless, the length is specified in bytes for reasons of compatibility with other bus systems.

The configuration of the length is usually done automatically by selecting a specific operating mode.

Length of the PD Channel

The length of the process data (PD) can be between 2...18 bytes. It can be specified separately for both directions (**P-0-4082, Length of real-time data channel In** or **P-0-4087, Length of real-time data channel Out**).

The transmission is performed data-consistently over the whole length.

Diagnostic LEDs for DeviceNet

For field bus interface diagnoses there are 6 LEDs available on the front panel of the DeviceNet unit. These indicate the state of synchronization between field bus interface and drive as well as bus activity for cyclical data exchange ("Polled I/O).

Each LED has four possible states: red, green, orange, and off.

When starting up the DeviceNet unit the LEDs are automatically tested. This is visible in the LEDs continuously running through color sequences of red, green and orange.

Description of LEDs during unit operation:

LED designation	LED state	Description
H60		Not assigned
H61 (Module status)	Red	Non-recoverable error, replace unit
	Red flashing	Recoverable error
	Green flashing	Configuration error
	Green	Operation OK
H62 ("Explicit Message" request)	Green (Impulse)	During Read/Write via "Explicit Message"
H63 (Network status)	off	Not Online
	green flashing	Online but no connection to master
	Green	Online with connection to master
	Red flashing	Monitoring time exceeded for I/O connection
	Red	Critical connection error (double MAC-ID or bus off)
H64 [(Internal synchronization) Alive LED]	red flashing	No synchronization of the field bus unit with the drive
	green flashing	Synchronization of the field bus unit with the drive achieved
H65 (I/O-Status)	off	No I/O connection
	Green	I/O connection OK, outputs valid and inputs active
	Green flashing	Outputs inactive (are not sent by master)
	Red flashing	Monitoring time exceeded for I/O connection
All LEDs	flashing regularly	Severe error on field bus unit switch off/on device

Fig. 5-25: Diagnostic LEDs for DeviceNet

Notes

6 Profile Types

6.1 General Introduction

Overview of the Profile Types Supported

P-0-4084, Profile type	Drive controller	Function compatibility	Fieldbus or drive operating mode	Description
		I/O profile types		
FF80h	PROFIBUS INTERBUS CANopen DeviceNet	PDP03VRS(1) FGP01VRS(2) FGP02VRS(3) FGP03VRS(4)	**I/O mode with block acknowledge** (Positioning block mode lag error free with encoder 1)	This profile type makes functional compatibility to control (**DKC3.1**) possible with up 64 positioning block via the fieldbus. 16 bits each for I/O data are transmitted.
FF81h	PROFIBUS INTERBUS CANopen DeviceNet	FGP02VRS FGP03VRS	**I/O mode** with cam status (Positioning block mode lag error free with encoder 1)	This profile type makes it possible, as with P-0-4084=0xFF80, to control up to 64 positioning blocks via the fieldbus. But instead of the travel block acknowledge, the first 8 cam status bits are stored in the status word.
FF82h	PROFIBUS INTERBUS CANopen DeviceNet	FGP02VRS FGP03VRS	**I/O mode** free expandable (pos. block mode lag free with encoder 1 + expandable real time data channel)	This profile type makes it possible, as with P-0-4084=0xFF80, to control up to 64 positioning blocks via the fieldbus. But in addition to control and status words, more real time data can be configured in lists P-0-4080 and P-0-4081. The function of the bits in the fieldbus status words can be freely configured via the config. signal status word.
		Rexroth Indramat – specific profile types		
FF91h	PROFIBUS INTERBUS CANopen DeviceNet	FGP02VRS FGP03VRS	drive internal interpolation (lag free with encoder 1)	This profile type makes cyclic settings of freely selectable target positions and velocities possible. All real time data needed for execution are pre-configured in lists P-0-4080 and P-0-4081. Control and status words have the same structure as in free config. operating mode (0xFFFE)
FF92h	CANopen DeviceNet	FGP02VRS FGP03VRS	cyclic position control (lag free with encoder 1)	This profile needs clock-synchronous and cyclic transmission of position setpoints in „cyclic position control“ modes. All real time data needed are pre-configured in lists P-0-4080 and P-0-4081. Control and status words have the same structure as in free config. operating mode (0xFFFE).
FF93h	PROFIBUS INTERBUS CANopen DeviceNet	Function compatible to profile type velocity control 2	velocity control (with filter and ramp)	This profile makes cyclic setting of velocity setpoints in „velocity control“ mode possible. All real time data needs are pre-configured in lists P-0-4080 and P-0-4081. Control and status words have same structure as free config. operating mode (0xFFFE).
FFFEh	PROFIBUS INTERBUS CANopen DeviceNet	FGP02VRS FGP03VRS (makes possible function compatibility to profile position target setting)	Free configurable mode (without profile interpreter)	This profile allows free configuring of real time data as well as selection of operating mode possible, i.e. access to all drive functions! Control and status word have an Indramat-specific structure. This choice is also suited for operation with analog setpoints in commissioning phase.

Fig. 6-1: Supported profile types: FWA-ECODR3-FGP-03VRS
FWA-ECODR3-FGP-20VRS

Complete designations of firmware:

(1) FWA-ECODRV-PDP-03VRS-MS

(2) FWA-ECODR3-FGP-01VRS-MS

(3) FWA-ECODR3-FGP-02VRS-MS

(4) FWA-ECODR3-FGP-03VRS-MS

Definitions

Drive profiles

A drive profile defines

- the structure of fieldbus control and status words (**P-0-4077**, **P-0-4078**)
- the structure and contents of real time channel (**P-0-4080**, **P-0-4081**)
- active operating mode (**S-0-0032**, **S-0-0033**, **S-0-0034**, **S-0-0035**)
- the behavior of any present status machines (I/O mode or Rexroth Indramat status machines).

By selecting a profile type, the commissioning of fieldbus drives becomes very easy for the user. The advantage of a profile is that the selection of all the important settings for the desired drive functions can be performed automatically. As profile types are defined independent of the bus, the porting of applications from one fieldbus to the next also becomes easy.

Status machines

A state (e.g., drive halt, drive error and so on) represents a specific drive condition which can be exited by means of a defined event (e.g., drive command, operating mode commutations and so on). State transitions are assigned to the events. The interaction of control and status bits as well as the state transitions is defined as a status machine.

Intel/ Motorola format

(see section: "Command communication via fieldbus")

Abbreviations

- **i16**: 16 bit variable with sign(1 word) in Intel format
- **i32**: 32 bit variable with sign(2 words) in Intel format
- **u16:** 16 bit variable without sign(1 word) in Intel format
- **u32**: 32 bit variable without sign(2 words) in Intel format
- **ZKL1:** Status class 1
- **ZKL2**: Status class 2
- **ZKL3**: Status class 3

Allocation to Drive-Internal Modes

By setting a profile type (P-0-4084) the main operating mode in the drive is also set!

Operating modes used

The following relationship exists between

P-0-4084, Profile type and **S-0-0032, Primary mode of operation**:

- **I/O mode** with 16 bit status and control word
  (P-0-4084=0xFF80 → functionally compatible to DKC3.1!)
  This means that the drive is run in "Positioning block mode without lag error with encoder 1"!
- **Position control** with cyclic position setpoint (DKC4.3, DKC5.3)
  This means the drive is run in "Cyclic position control without lag error with encoder 1"!
- **Drive-internal interpolation**
  This means that the drive is run in "Drive internal interpolation without lag error with encoder 1".
- **Velocity control**
  This means the drive is run in "Velocity control mode".
- **Free configurable modes**
  - no profile-dependent settings and checks
  - free configuration of real time channel using configuration lists P-0-4080 and P-0-4081
  - makes analog operation for initial start up possible

Note: In all settings except free configurable mode, the 1st auxiliary operating mode is automatically "jogging". To use it, the auxiliary operating mode (generally 1st aux. mode) must also be selected.

6.2 I/O Mode

Basic I/O mode function

General features of I/O modes

The drive is run in “positioning block mode, lag free with encoder 1”.

- In this mode, up to 64 programmable positioning blocks can be selected and started via 6 bits in the 16 bit wide control word (known from DKC3.1).
- Via 2 bits in **P-0-4077, fieldbus control word** the jog function can be activated. As 1st auxiliary mode, jog mode has been set!
- With Profibus-DP an optional parameter channel with **P-0-4083, Length of parameter channel in DP** (maximum 6 words) can be activated. (Default: **P-0-4083** = 0 → without parameter channel).
- In I/O mode the real time channel is made up of one word (16 bits), of **P-0-4077, Fieldbus control word** and **P-0-4078, Fieldbus status word.**

Structure of real time channel in I/O mode

Master → Slave

In real time channel of fieldbus, the data configured in **P-0-4081, Real-time output object structure** are transmitted from master to drive:

Parameter	Format
P-0-4077, Fieldbus control word	I16 -> (1 word)

Slave → Master

In real time channel of fieldbus, data configured in **P-0-4080, Real-time input object structure** are transmitted from drive to master.

Parameter	Format
P-0-4078, Fieldbus status word	I16 -> (1 word)

Sequence of data in real time data channel:

	Word1
Master → Slave	**P-0-4077, Fieldbus control word**
Slave → Master	**P-0-4078, Fieldbus status word**

Fig. 6-2: Contents of real time channel in I/O mode

Status machine in I/O mode (Fieldbus control and status word)

Structure of P-0-4077, Fieldbus control word (P-0-4084 = 0xFF8X)

Note: The structure of **P-0-4077, Fieldbus control word** is identical in all three possible I/O modes (P-0-4084 = 0xFF80, 0xFF81 and 0xFF82).

Bit	Assignment	Description
0	drive enable	**1:** drive enable **0:** drive lockout (**S-0-0134**, Bit14)
1	drive start	**1:** drive start **0:** drive halt (**S-0-0134**, Bit13)
2	drive-controlled to zero (referencing)	**1:** command "C6" start (**S-0-0148** = 11b) **0:** command "C6" end (**S-0-0148** = 0b)
3	strobe	**0>1:** travel block change (**S-0-0346**)
4	positioning with limited velocity	**1:** limited velocity with **S-0-0259, Positioning Velocity** as limit
5	reset error (F-Reset)	**1:** reset error command "C5" start (**S-0-0099, C500 Reset class 1 diagnostic**) **0:** command "C5" end
6	Jog +	**1:** jog forward (**P-0-4056**, Bit0) with **P-0-4030, Jog velocity**
7	Jog -	**1:** jog backwards (**P-0-4056**, Bit1) with **P-0-4030, Jog velocity**
8-13	travel block select	**P-0-4026, Process block selection** (Bit 0 – Bit6)
14-15	not assigned	

Fig. 6-3: Structure of P-0-4077, fieldbus control word in I/O mode

Structure of P-0-4078, fieldbus status word (P-0-4084 =0xFF8X)

- Structure of **P-0-4078, Fieldbus status word** is in all three I/O modes (P-0-4084 = 0xFF80, 0xFF81 and 0xFF82) the same as **S-0-0144, Signal status word**. Here, the structure of S-0-0144 (and P-0-4078) with P-0-4084 = 0xFF80 and P-0-4084=0xFF81 is permanently pre-configured.
- Only in freely expandable I/O mode (P-0-4084=0xFF82) can the structure be selected via configuration list **S-0-0026, Configuration list signal status word** and **S-0-0328, Assign list signal status word**.
- The profile types for P-0-4084=0xFF80 (I/O mode with block acknowledge) and P-0-4084=0xFF81 (I/O mode with cam status) are only different in terms of the definition of bits 0 and 1 and from bit 8 to bit 15. (see structure of P-0-4078).

Profile type	Bit	Assignment	Description
P-0-4084=0xFF80	**0**	active mode (in 0xFF80)	**1:** jog **0:** positioning
	1	point of removal (WSP) (in 0xFF80)	**1:** to the right of point of removal **0:** to the left of WSP (**P-0-0135**, Bit0)
P-0-4084=0xFF81	**0**	warning (in 0xFF81)	**1:** active (**S-0-0135**, Bit12) **0:** not active
	1	E-Stop-Status (in 0xFF81)	**1:** active (**P-0-0223**, Bit0) **0:** not active
P-0-4084=0xFF80 or P-0-4084=0xFF81	**2**	In reference	**1:** drive homed (**S-0-0403**, Bit0)
	3	In motion	**1:** In motion (**S-0-0013**, Bit1)
	4	In Position	**1:** drive within positioning window & no following block (**S-0-0182**, Bit12)
	5	Error-Flag	**1:** no error (**S-0-0135**, Bit13) **0:** error
	6	ready to operate Display bb	**1:** ready (**S-0-0135**, Bit14)
	7	power Display Ab	**1:** power is on (**S-0-0135**, Bit15)
P-0-4084=0xFF80	**8 - 13**	travel block acknowledge	**P-0-4051, Process block acquittance** (Bit 0 – Bit5)
	14-15	not assigned	
P-0-4084=0xFF81	**8-15**	cam status	**P-0-0135**, **Status position switch** (Bit 0 – Bit7)

Fig. 6-4: Structure of P-0-4078, fieldbus status word in I/O mode in profile type
P-0-4084=0xFF80 and 0xFF81

How control and status bits work together (status machine)

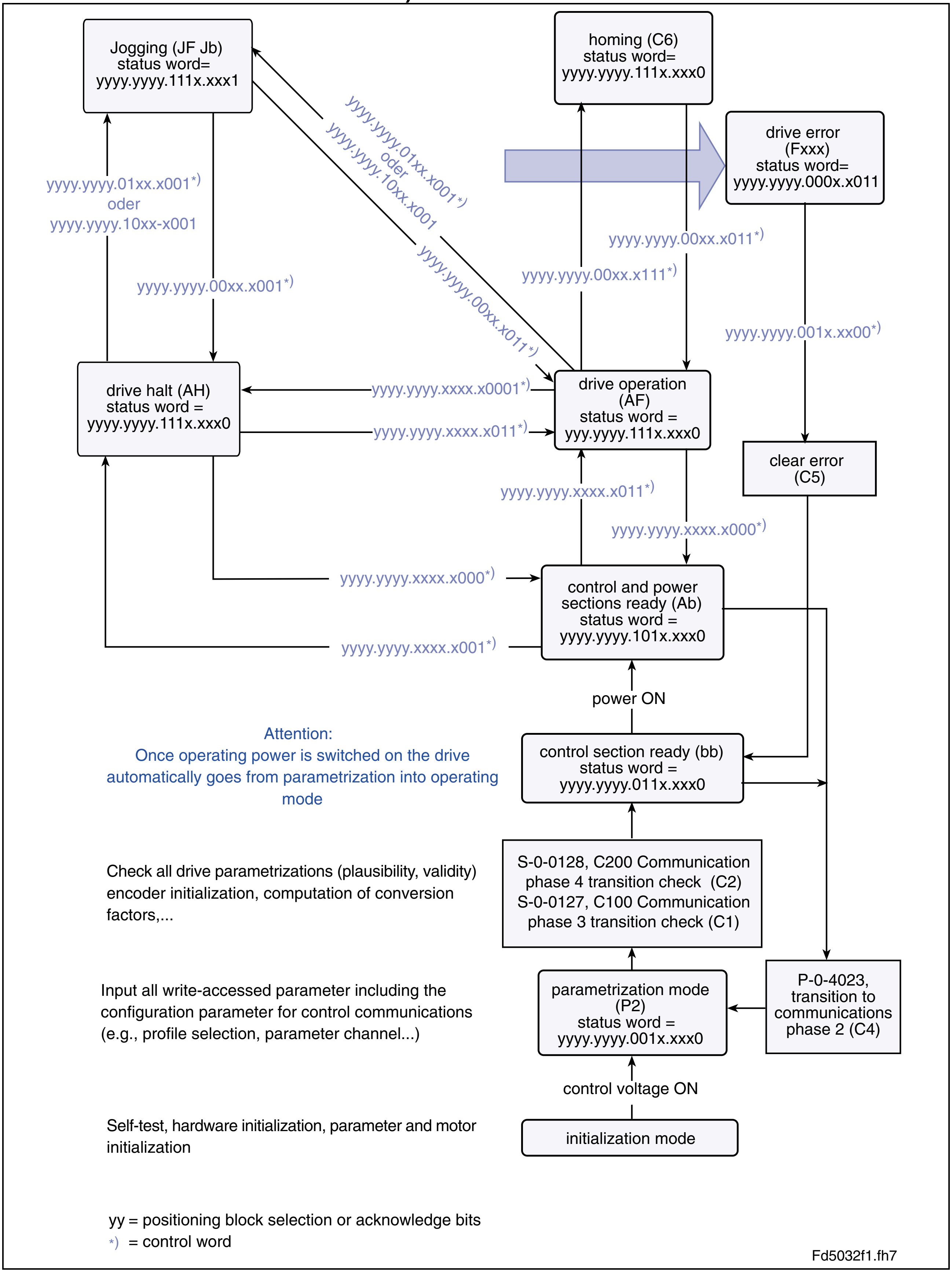


Fig. 6-5: Structure of status machine in I/O mode

Note: The data for the fieldbus status word refer to the I/O mode with block acknowledge (P-0-4084=0xFF80). In the other two types (0xFF81 and 0xFF82) only in bit 0, 1 and bit 8–15 have a different definition.

I/O Mode-Default Setting

Features of the I/O mode default setting

- Fixed length of real-time channel of 2 bytes. This also fixes the length of the cyclic data channel (**P-0-4082** = **P-0-4087** = 2 + **P-0-4083**)!
- Bits 0 to 5 of **P-0-4051, Process block acquittance** are copied on to bits 8-13 of **P-0-4078, Fieldbus status word** (also see "Fig. 6-4: Structure of P-0-4078, fieldbus status word in I/O mode")
- In the real time channel only **P-0-4077, Fieldbus control word** and **P-0-4078, fieldbus status word** are transmitted.
- The structure of **P-0-4077, fieldbus control word** (also see "Fig. 6-3: Structure of P-0-4077, fieldbus control word in I/O mode") is identical to the structure in the I/O mode with cam status (**P-0-4084, Profile type** = 0xFF81)!

Note: With this profile selection, the functional compatibility to the drive controllers DKC3.1 is established! Controls that process the real time data in Motorola format have the high and low bytes swapped in comparison with the DKC3.1!

I/O mode with cam (P-0-4084= 0xFF81)

Features of the I/O mode with cams

- Fixed length of real time channel of 2 bytes. The length of the cyclic data channel thus follows (**P-0-4082** = **P-0-4087** = 2 + **P-0-4083**)!
- Bits 0..7 of **P-0-0135, Status position switch** are copied to bits 8-15 of **P-0-4078, Fieldbus status word**
- Along with bits 8–15, bit 0 and bit 1 of **P-0-4078, Fieldbus status word** also have a different meaning from the backwards compatible profile type (**P-0-4084** = 0xFF80) (also see "Fig. 6-4: Structure of P-0-4078, fieldbus status word in I/O mode")!
- In the real time channel only **P-0-4077, Fieldbus control word** and **P-0-4078, Fieldbus status word** are transmitted**.**
- The structure of **P-0-4077, Fieldbus control word** (also see "Fig. 6-3: Structure of P-0-4077, fieldbus control word in I/O mode") is identical to the structure in I/O mode with block acknowledgement (**P-0-4084, Profile type** = 0xFF80)!

I/O mode freely expandable (P-0-4084= 0xFF82)

Features of the freely expandable I/O mode

- The user can freely expand the length of cyclic data channel **P-0-4082** or **P-0-4087** up to a maximum of 9 words. In addition to the fieldbus control and status words, additional real time data can be configured via configuration lists **P-0-4080, Real-time input object structure** and **P-0-4081, Real-time output object structure**.
- The structure of **P-0-4077, Fieldbus control word** (also see "Fig. 6-3: Structure of P-0-4077, fieldbus control word in I/O mode") is identical to the structure in I/O mode with block acknowledgement (**P-0-4084** = 0xFF80).
- The contents of **P-0-4078, Fieldbus status word** is the same as that in **S-0-0144, Signal status word**, and can be freely parametrized via configuration lists **S-0-0026, Configuration list signal status word** and **S-0-0328, Assign list signal status word**.

6.3 Rexroth Indramat specific profile types

Basic function of Rexroth Indramat Profile

To use the numerous and extensive functions of a Rexroth Indramat fieldbus drive it is necessary, in addition to the backwards compatible I/O mode of the DKC3.1 to define further profiles. This necessitates a new structure for **P-0-4077, Fieldbus control word** and **P-0-4078, Fieldbus status word.**

A differentiation must in this case be made between:

- Fixed pre-defined profiles (**0xFF91**→drive-internal interpolation, **0xFF93**→velocity control and **0xFF92**→cyclic position control)
- and a completely free, configurable profile type (P-0-4084 = **0xFFFE**)

Each fieldbus drive of Rexroth Indramat, regardless of the command communications interface, is equipped with a uniform “status machine”. This includes a complete structure of the **P-0-4077, fieldbus control word** and **P-0-4078, fieldbus status word**. The interaction and the definition of the individual bits is described in the following section.

"Rexroth Indramat status machine" of the drives

To explain how the individual bits work together, it is necessary to first explain the structure of the fieldbus control and status words.

Note: Parameters **S-0-0134, Master control word** and **S-0-0135, Drive status word** are only used for drive diagnostics. The actual control and status information is contained in **P-0-4077, Fieldbus control word** and **P-0-4078, Fieldbus status word**. These are always part of the real time channel.

Structure of P-0-4077, Field bus control word (Rexroth Indramat Profile)

Bit	Name	Definition
0	Setpoint acceptance	a bit change indicates (**S-0-0346**, Bit0) – a pos. block activated – or position setting accepted
1	operating mode set	**0->1:** change to operating mode **1->0:** change to parametrization mode
2	drive to zero point	**0->1:** reference command "C6" start (**S-0-0148** =11b) **1->0:** reference command "C6" end (**S-0-0148** = 0b)
3	absolute / relative (only effective when used with **S-0-0282, Positioning command value**)	**0: S-0-0282, Positioning command value** is processed as abs. target pos. in drive **1: S-0-0282, Positioning command value** is processed as rel. travel path in drive (S-0-0393, Bit3)
4	Immediate block change (only effective when used with **S-0-0282, Positioning command value**)	**0: S-0-0282, Positioning command value** not activated until target position is reached **1: S-0-0282, Positioning command value** is immediately accepted after setpoint acceptance is toggled (S-0-0393, Bit4)
5	error delete	**0->1:** clear error command "C5" start **1->0:** command "C5" end
6	jog forward	**1:** jog forward (**P-0-4056**, Bit0=1)
7	jog backwards	**1:** jog backwards (**P-0-4056**, Bit1=1)
8, 9	setpoint operating mode	**00:** main mode (**S-0-0134**, Bit 8,9) **01:** 1st auxiliary mode (e.g., jog) **10:** 2nd auxiliary mode **11:** 3rd auxiliary mode
10,11	reserved	--
12	IPOSYNC	Interpolator cycle (only in cycl. pos. control) toggles when new setpoint is transmitted
13	drive halt	**1->0:** Edge causes standstill of drive (**S-0-0134**, Bit 13)
14	drive enable	**1->0:** Edge causes immediate torque to zero (**S-0-0134**, Bit 14)
15	drive ON	**1->0:** Edge causes best possible standstill as per **P-0-0119** (**S-0-0134**, bit 15)

Fig. 6-6: Structure of P-0-4077, fieldbus control word in Rexroth Indramat profiles

Structure of P-0-4078, fieldbus status word (Rexroth Indramat-Profiles)

Note: The definition of bit4 in **P-0-4077, Fieldbus control word** (setpoint reached) depends on profile type. With velocity control the information “Setpoint velocity reached” is displayed there. Whereby, in interpolation, the “In position” information is displayed.

Status word for freely configurable modes

Bit	Name	Definition
0,1	operating mode-acknowledge	**10:** Phase4 (operating mode) **01:** Phase3 **00:** Phase 2 (parametrization mode)
2	In-reference	**1:** drive homed (**S-0-0403**, Bit0)
3	In standstill	**1:** drive stands (**S-0-0013**, Bit1)
4	Setpoint reached	**1:** target position reached (**S-0-0182**, Bit10) **<u>Exceptions:</u>** -Profile type velocity control: **1:** setpoint velocity reached (**S-0-0013**, Bit 0) - Profile type cyclic position control **1:** In position (**S-0-0013**, Bit 6)
5	command change bit	**1:** if command status has changed **0:** if command status has not changed
6	operating mode-error	**1:** error in transition command **0:** no error in transition command
7	Status setpoint processing	**1:** drive does not follow setpoint (e.g., if drive halt active) **0:** drive follows setpoint
8, 9	actual operating mode	**00:** main mode **01:** 1st aux. mode (e.g., jog) **10:** 2nd aux. mode **11:** 3rd aux. mode (**S-0-0135**, Bit 8,9)
10	Setpoint acknowledge	the drive acknowledges by toggling the bit (S-0-0419, Bit0) the acceptance of **S-0-0282, Positioning command value**
11	Message ZKL3	the bit is set when a status class 3 message is present
12	warning ZKL2	the bit is set when a status class 2 warning is present
13	drive error ZKL1	the bit is set when a status class 1 error is pending (drive locked) **S-0-0135**, Bit 13)
14, 15	ready to operate	**00:** not ready for power **01:** ready for power **10:** control and power sections ready and torque free **11:** in operation, with torque (**S-0-0135**, bits 14,15)

ZKL1: Status class 1
ZKL2: Status class 2
ZKL3: Status class 3

Fig. 6-7: Structure P-0-4078, fieldbus status word in Rexroth Indramat profiles

Interaction of Control and Status Bits (status machine)

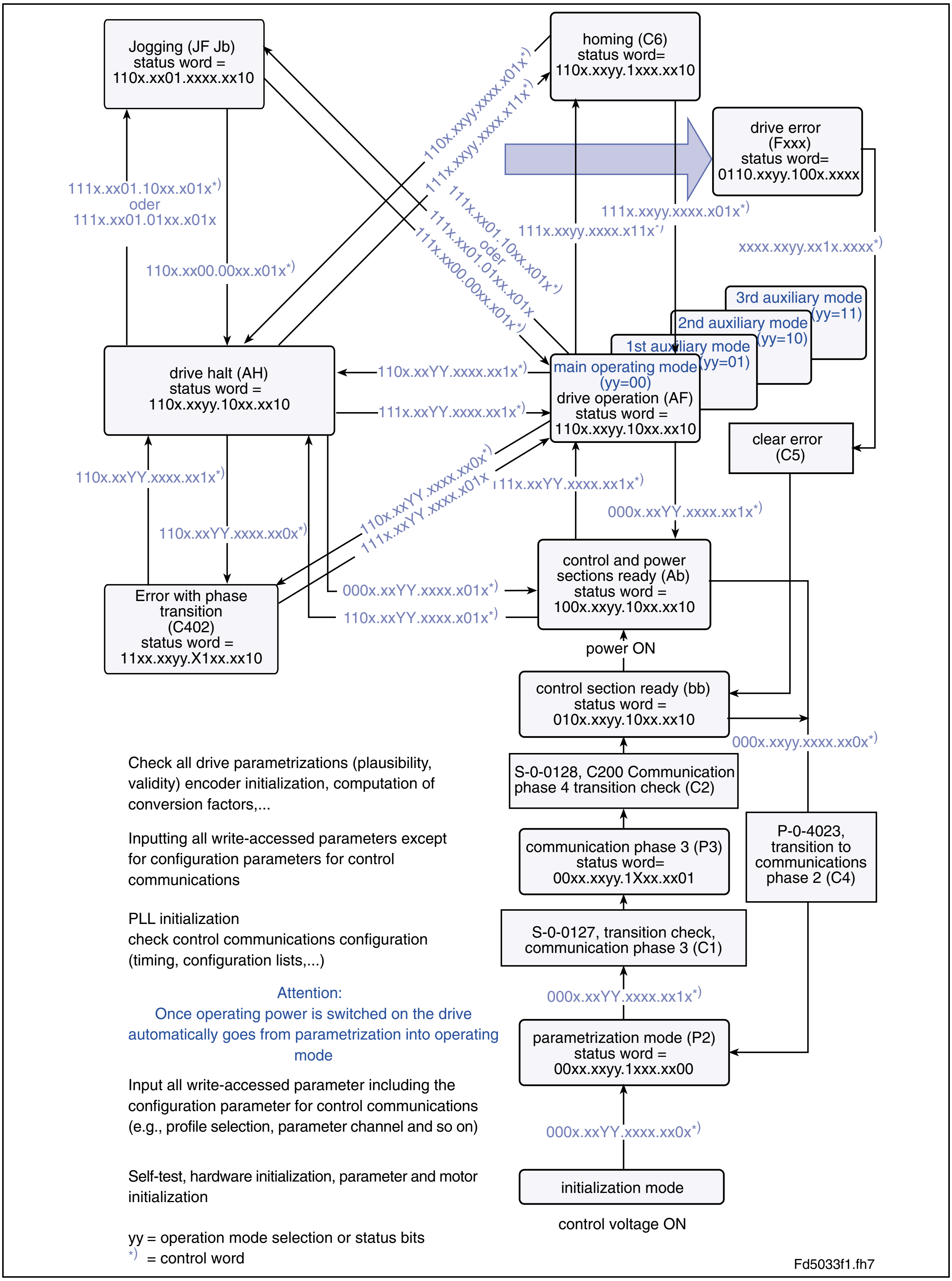


Fig. 6-8: Rexroth Indramat status machine (phase transition via fieldbus)

Drive-internal interpolation (P-0-4084= 0xFF91)

Features

- The main operating mode “drive-internal interpolation lag-free with encoder 1" is set. Also see: "operating mode drive-internal interpolation". The first auxiliary mode is set to jog.
- The entire contents of the real time data channel is set with **P-0-4084, Profile type**. Via the fieldbus, parameters **S-0-0258, Target position** and **S-0-0259, Positioning Velocity** and **S-0-0051, Position feedback 1 value** and **S-0-0040, Velocity feedback value** are cyclical transmitted.
- In this profile type, the Rexroth Indramat specific definitions for fieldbus control and status words apply (also see section: Rexroth Indramat status machine" of the drives). Bits 0, 3, 4 and 12 in **P-0-4077**, **Fieldbus control word**, and bit10 in **P-0-4078, Fieldbus status word** are not relevant in this profile type.
- Length of cyclic data channel fixed with:
  P-0-4082 = **P-0-4087** = 12 Byte [+ **P-0-4083]**
- The optional parameter channel can be expanded in Profibus-DP with **P-0-4083, Length of parameter channel in DP** to 6 words! (Default: **P-0-4083** = 0 → without parameter channel) !

Note: To use the functional expansion (transition absolute/relative) of the drive-internal interpolation, it is necessary to change into freely configurable mode (P-0-4084 = 0xFFFE). Then in the list P-0-4081 replace **S-0-0258, Target position** with **S-0-0282, Positioning command value**!

Structure of the Real Time Data Channel

Master → Slave

In the real time channel of the fieldbus, the travel block data configured in **P-0-4081, Real-time output object structure** are transmitted from the master to the drive.

Parameter	Format
P-0-4077, Fieldbus control word	i16 -> (1 word)
S-0-0258, Target position	i32 -> (2 words)
S-0-0259, Positioning Velocity	i32 -> (2 words)
P-0-4076, Fieldbus container object	i16 -> (1 word)

Slave → Master

In the real time channel of the fieldbus, the travel blocks configured in **P-0-4080, Real-time input object structure** are transmitted from the drive to the master:

Parameter	Format
P-0-4078, Fieldbus status word	i16 -> (1 word)
S-0-0051, Position feedback 1 value	i32 -> (2 words)
S-0-0040, Velocity feedback value	i32 -> (2 words)
S-0-0390, Diagnostic message number	u16-> (1 word)

Sequence in real time data channel:

	word1	word2	word3	word4	word5	word6
Master→ Slave	P-0-4077	S-0-0258,H	S-0-0258,L	S-0-0259,H	S-0-0259,L	P-0-4076
Slave →Master	P-0-4078	S-0-0051,H	S-0-0051,L	S-0-0040,H	S-0-0040,L	S-0-0390

Fig. 6-9: Contents of real time channel in profile type interpolation

Cyclic Position Control (P-0-4084= 0xFF92)

Features

- In the main operating mode, “cyclic position control with encoder 1" is set. The 1st auxiliary mode is jog!
- The entire contents of the real time data channel is fixed with the setting in **P-0-4084, Profile type**. Parameters **S-0-0047, Position command value** and **S-0-0051, Position feedback 1 value** are cyclically transmitted via the fieldbus. The position setpoint processing in the drive is synchronised using a software PLL to the synchronization telegram (SYNC pulse) of the fieldbus.
- In this profile type, the Rexroth Indramat specific definitions of the fieldbus control and status word apply. Bits 0, 3 and 4 in **P-0-4077, Fieldbus control word** (also see "Fig. 6-6: Structure of P-0-4077, fieldbus control word in Rexroth Indramat profiles"), as well as bit10 in **P-0-4078, Fieldbus status word** (also see "Fig. 6-7: Structure P-0-4078, fieldbus status word in Rexroth Indramat profiles") are not relevant in this profile type.
- **Bit 4** in **P-0-4078, Fieldbus status word** (setpoint reached) signals in this profile type that the drive is IN position (**S-0-0013**, Bit 6).
- Length of the cyclic data channel is fixed with:
  P-0-4082 = **P-0-4087** = 8 bytes + **P-0-4083**

Structure of the Real Time Data Channel

Master → Slave

In the real time channel of the fieldbus, the data configured in **P-0-4081, Real-time output object structure** are transmitted from master to drive.

Parameter	Format
P-0-4077, Fieldbus control word	i16 -> (1 word)
S-0-0047, Position command value	i32 -> (2 words)
P-0-4076, Fieldbus container object	i16 (1 word)

Slave → Master

In the real time channel of the fieldbus, the data configured in **P-0-4080, Real-time input object structure** are transmitted from drive to master.

Parameter	Format
P-0-4078, Fieldbus status word	i16 -> (1 word)
S-0-0051, Position feedback 1 value	i32 -> (2 words)
S-0-0390, Diagnosis message number	u16-> (1 word)

Real time data channel sequence:

	Word1	Word2	Word3	Word4
Master → Slave	**P-0-4077**	**S-0-0047**,H	**S-0-0047**,L	**P-0-4076**
Slave → Master	**P-0-4078**	**S-0-0051**,H	**S-0-0051**,L	**S-0-0390**

Fig. 6-10: Contents of real time channel in cyclic position control

Profile Type, Speed Control (P-0-4084= 0xFF93)

Features

- The main operating mode "Velocity control with filter and ramp" is set. (Also see: "Operating mode velocity control"). The 1st auxiliary mode is jog. (Also see section: "operating mode: jog")
- The contents of the real time data channel is fixed with **P-0-4084, Profile type**. Via the fieldbus, **S-0-0036, Velocity command value** and **S-0-0040, Velocity feedback value** are transmitted.
- In this profile type the Rexroth Indramat specific definitions for the fieldbus control and status words apply. Bits 0, 3, 4 and 12 in **P-0-4077**, **Fieldbus control word** (also see "Fig. 6-6: Structure of P-0-4077, fieldbus control word in Rexroth Indramat profiles"), as well as Bit10 in **P-0-4078, Fieldbus status word** (also see "Fig. 6-7: Structure P-0-4078, fieldbus status word in Rexroth Indramat profiles") are not relevant in this profile type.
- **Bit 4** in **P-0-4078, Fieldbus status word** (setpoint reached) signals in this profile type that the setpoint speed has been reached(**S-0-0013**, Bit 0).
- the parameter channel can be set in Profibus-DP with **P-0-4083** to 6 words! (Default: **P-0-4083** = 0 → without parameter channel)!
- Length of cyclic data channel is fixed with:
  P-0-4082 = **P-0-4087** = 12 Byte + **P-0-4083**

Structure of Real Time Data Channel

Master → Slave

In the real time channel of the fieldbus, the data configured in **P-0-4081, Real-time output object structure** are transmitted from master to drive:

Parameter	Format
P-0-4077, Fieldbus control word	i16 -> (1 word)
S-0-0036, Velocity command value	i32 -> (2 words)
P-0-4076, Fieldbus container object	i16 -> (1 word)
P-0-4076, Fieldbus container object	i16 -> (1 word)
P-0-4076, Fieldbus container object	i16 -> (1 word)

Note: Filling-out with **P-0-4076, Fieldbus container object** is only necessary with Interbus-S (because of the bus structure), in order to keep the length of the real time channel constant.

Slave → Master

In the real time channel of the fieldbus, the configured data in **P-0-4080, Real-time input object structure** are transmitted from drive to master.

Parameter	Format
P-0-4078, Fieldbus status word	i16 -> (1 word)
S-0-0040, Velocity feedback value	i32 -> (2 words)
S-0-0390, Diagnostic message number	u16-> (1 word)
S-0-0051, Position feedback 1 value	i32 -> (2 words)

Sequence in real time data channel:

	word1	word2	word3	word4	word5	word6
Master → Slave	**P-0-4077**	**S-0-0036**,H	**S-0-0036**,L	**P-0-4076**	**P-0-4076**	**P-0-4076**
Slave → Master	**P-0-4078**	**S-0-0040**,H	**S-0-0040**,L	**S-0-0390**	**S-0-0051**,H	**S-0-0051**,L

Fig. 6-11: Structure of real time channel in velocity control

Freely configurable operating mode (P-0-4084=0xFFFE)

Features

- The structure (content) of the real time data channel must be defined via the configuration lists in **P-0-4080** and **P-0-4081**. No profile-dependent settings and checks are carried out!
- In this profile type the Rexroth Indramat specific definitions for the fieldbus control and status words apply. Some bits (e.g., Bit 0, 3, 4 and 12 in **P-0-4077**, **Fieldbus control word** (also see "Fig. 6-6: Structure of P-0-4077, fieldbus control word in Rexroth Indramat profiles"), as well as Bit10 in **P-0-4078, Fieldbus status word** (also see "Fig. 6-7: Structure P-0-4078, fieldbus status word in Rexroth Indramat profiles") can, of course, only be used in conjunction with specific operating modes. This is clarified in the following examples.
- This profile type enables the use of the entire drive functionalities (e.g., velocity synchronization, multiplex channel and more).
- The main and auxiliary modes can be freely selected via **S-0-0032, S-0-0033, S-0-0034** and **S-0-0035**.

Structure of real time data channel

Note: **P-0-4077, Fieldbus control word** as well as **P-0-4078, Fieldbus status word** must always assume 1st place in the configuration list **P-0-4080** and **P-0-4081**!

Master → Slave

In the real time channel of the fieldbus the data configured in **P-0-4081, Real-time output object structure** are transmitted from master to drive.

Parameter	Format	Object
P-0-4077, Fieldbus control word	i16 -> (1 word)	6040
Optional setpoints	:	

Note: The cyclic configurable setpoints are in the list parameter **S-0-0188, List of the configurable data in the MDT**.

Slave → Master

In the real time channel of the fieldbus, the data configured in **P-0-4080, Process data input description** are transmitted from drive to master:

Parameter	Format	Object
P-0-4078, fieldbus status word	i16 -> (1 word)	6041
optional actual values	:	

Note: The cyclic configurable actual values are in the list parameter **S-0-0187, List of configurable data in the AT**.

Sequence in real time data channel:

	word1	word2	...	word n
Master → Slave	**P-0-4077**	setpoint1	...	
Slave → Master	**P-0-4078**	actual value1	...	

Fig. 6-12: Contents of real time channel in freely configurable mode

6.4 Example configurations for Rexroth Indramat profile

All the following examples relate to the freely configurable mode (**P-0-4084 = 0xFFFE**), as this is the most flexible mode in which to use the complete range of drive functions via the fieldbus.

Operating with analog setpoints (Fieldbus master not active)

Features

- It is possible to run the drive via analog velocity or torque setpoints.
- The control of the drive enable or drive halt does not run over the fieldbus, but rather over hardware inputs (X1 pin3, pin4) as long as the fieldbus communication is not active (e.g., removed bus connector). The status of the command communications is in parameter **P-0-4086, Command communication status**.

Parametrization

To parametrize the analog mode

- set profile type to freely configurable mode (**P-0-4084** = 0xFFFE)
- set the main mode to velocity control with filter and ramp (**S-0-0032** = 10b)
  (Also see: "operating mode: velocity control")
- configure velocity setpoint at analog input 1 (**P-0-0213** = **S-0-0036**)
- the relevant evaluation of analog input must be set via **P-0-0214**
- all entries in configuration list **P-0-4080, P-0-4081**, must be cleared (**S-0-0036** may not be cyclically configured!).

Using the Rexroth Indramat Positioning Setting

Features

- In this operating mode a drive functionality is achieved which can be compared with the position target setting of DRIVECOM (function compatibility).
- By configuring **S-0-0282, Positioning command** as a cyclic setpoint bits 0, 3, 4 in **P-0-4077, Fieldbus control word** can be used to directly switch from relative to absolute positioning (function compatibility with position target setting).

Parametrization

To parametrize the positioning setting

- set profile type to freely configurable mode (**P-0-4084** = 0xFFFE)
- set main operating mode to “positioning command” (**S-0-0032** = 10 0001 1011b) (Also see: "operating mode: drive-internal interpolation"

Master → Slave

In the real time channel of the fieldbus, the data configured in **P-0-4081, Real-time output object structure** are transmitted from master to drive.

Parameter	Format
P-0-4077, Fieldbus control word	I16 -> (1 word)
S-0-0282, Positioning command	I32 -> (2 words)
S-0-0259, Positioning Velocity	I32 -> (2 words)
P-0-4076, Fieldbus container object	I16 -> (1 word)

Slave → Master

In the real time channel of the fieldbus, the data configured in **P-0-4080, Real-time input object structure** are transmitted from drive to master.

Parameter	Format
P-0-4078, Fieldbus status word	I16 -> (1 word)
S-0-0051, Position feedback 1 value	I32 -> (2 words)
S-0-0040, Velocity feedback value	I32 -> (2 words)
S-0-0390, Diagnostic message number	U16-> (1 word)

Sequence in real time data channel:

	word1	**word2**	**word3**	**word4**	**word5**	**word6**
Master→ Slave	**P-0-4077**	**S-0-0282**,H	**S-0-0282**,L	**S-0-0259**,H	**S-0-0259**,L	**P-0-4076**
Slave →Master	**P-0-4078**	**S-0-0051**,H	**S-0-0051**,L	**S-0-0040**,H	**S-0-0040**,L	**S-0-0390**

Fig. 6-13: Contents of real time channel in Indramat positioning setting

Using the multiplex channel in positioning block mode

By using the multiplex channel, the number of cyclically transmitted data bytes can be increased. This means that the use of this option always makes sense if the real time channel does not suffice for the pending task.

Also see section: "Multiplex channel".

Features

- By using the multiplex channel, the number of cyclically transmitted real time data can be increased.
- Since **S-0-0362, List index, MDT data container A** is also configured, single elements in list parameters (**P-0-4006**, **P-0-4007** and **P-0-4009**) can also be changed via the real time channel (multiplex channel).
- By evaluating **S-0-0368, Addressing for data container A** and **S-0-0362, List index, MDT data container A** in the master, a check (handshake) for the multiplex channel can be implemented.

Note: The multiplexed real time data are processed in the drive as is the rest of the real time data, i.e., the values are not buffered!

Parametrization

To use the multiplex channel, the following parametrization is necessary:

- set profile type to freely configurable mode (**P-0-4084** = 0xFFFE)
- set parameter **S-0-0032, Primary mode of operation** e.g., to "positioning block mode, lag free with encoder 1"
- The configuration lists of the multiplex channel **S-0-0370, S-0-0371** can be parametrized as follows:

S-0-0370, Configuration list MDT data container

Contents of S-0-0370	Index
P-0-4006, Process block target position	0
P-0-4007, Process block velocity	1
P-0-4008, Process block acceleration	2

S-0-0371, Configuration list AT data container

Contents of S-0-0371	Index
P-0-4006, Process block target position	0
P-0-4007, Process block velocity	1
P-0-4008, Process block acceleration	2
S-0-0040, Velocity feedback value	3

The configuration lists P-0-4080, P-0-4081 can be parametrized as follows:

Master → Slave

Parameter	Format
P-0-4077, Fieldbus control word	I16 -> (1 word)
P-0-4026, Process block selection	I16 -> (1 word)
S-0-0368, Addressing for data container A	I16 -> (1 word)
S-0-0362, List index, MDT data container A	I16 -> (1 word)
S-0-0360, MDT Data container A	I32 -> (2 words)

Slave → Master

In the real time channel of the fieldbus, the data configured in **P-0-4080, Real-time input object structure** are transmitted from drive to master.

Parameter	Format
P-0-4078, Fieldbus status word	I16 -> (1 word)
P-0-4051, Process block acquittance	I16 -> (1 word)
S-0-0051, Position feedback 1 value	I32 -> (2 words)
S-0-0364, AT Data container A	I32 -> (2 words)
S-0-0368, Addressing for data container A	I16 -> (1 word)
S-0-0362, List index, MDT data container A	I16 -> (1 word)

Sequence in real time data channel:

	word1	word2	word3	word4	word5	word6	word7	word8	word9
Master→ Slave	P-0-4077	P-0-4026	S-0-0368	S-0-0362	S-0-0360,L	S-0-0360,H			
Slave → Master	P-0-4078	P-0-4051	S-0-0051,H	S-0-0051,L	S-0-0368,L	S-0-0362,L	S-0-0364,L	S-0-0364,H	

Fig. 6-14: Contents of real time channel in positioning block mode with multiplex channel

Using the signal control and status words

By using **S-0-0145, Signal control word** and **S-0-0144, Signal status word** the user has the option to configure control and status bits in the drive himself, which are also transmitted along with the fieldbus control and fieldbus status word in real time via the fieldbus.

Also see section "Configurable signal control word" and "Configurable signal status word".

Features

- By using **S-0-0144** and **S-0-0145** 16 more freely configurable control and status bits become available.
- Makes possible the start of commands which are entered in list **S-0-0399, IDN list of configurable data in the signal control word** via a bit in the signal control word (compare with signal control word).
- Makes possible the reading of any bit in any parameter (compare with signal status word).

Parametrization

The following settings are needed:

- To configure the bit strips, use the configuration lists **S-0-0026**, **S-0-0328** (for **S-0-0144**) and **S-0-0027**, **S-0-0329** (for **S-0-0145**).
- To use the function, select profile type "freely configurable mode" (**P-0-4084** = 0xFFFE).
- Parameter **S-0-0032, Primary mode of operation** e.g., can be set to "drive-internal positioning setting, lag error free with encoder 1".
- The configuration lists **P-0-4080** and **P-0-4081** must be parametrized as follows:

Master → Slave

Parameter	Format
P-0-4077, Fieldbus control word	I16 -> (1 word)
S-0-0282, Positioning command	I32 -> (2 words)
S-0-0259, Positioning Velocity	I32 -> (2 words)
S-0-0145, Signal control word	I16 -> (1 word)

Slave → Master

In the real time channel of the fieldbus, the travel block data configured in **P-0-4080, Real-time input object structure** are transmitted from drive to master.

Parameter	Format
P-0-4078, Fieldbus status word	I16 -> (1 word)
S-0-0051, Position feedback 1 value	I32 -> (2 words)
S-0-0040, Velocity feedback value	I32 -> (2 words)
S-0-0390, Diagnostic message number	I16-> (1 word)
S-0-0144, Signal status word	I16 -> (1 word)

Sequence in real time data channel:

	word1	word2	word3	word4	word5	word6	word7
Master→ Slave	P-0-4077	S-0-0282,H	S-0-0282,L	S-0-0259,H	S-0-0259,L	S-0-0145	P-0-4076
Slave → Master	P-0-4078	S-0-0051,H	S-0-0051,L	S-0-0040,H	S-0-0040,L	S-0-0390	S-0-0144

Fig. 6-15: Contents of real time channel in interpolation with signal control and status words

Cam mode with real master axis

Features

- In this operating mode the drive itself generates the position setpoints out of a per cent value table dependent on the position of the master axis encoder. These table values are multiplied by the so-called hub and then become the synchronous position setpoint. The drive controls the actual position value based on this synchronous position setpoint.
- By emulating the actual position value of a master drive axis, a master axis coupling between a "Master drive" and a slave drive can be realized.

Parametrization

To parametrize the cam function with real master axis

- set **P-0-4084, Profile type** =0xFFFE (freely configurable mode)
- parameter **S-0-0032, Primary mode of operation** must be set to "cam, lag error free with encoder 1"
- for an optional encoder, select for example., **P-0-0075** = 5, for relative master axis encoder
- use **S-0-0145, Signal control word** and **S-0-0144, Signal status word**, to transmit the mode-specific control and status bits in a cyclical manner
- parametrize configuration lists **P-0-4080, P-0-4081** as follows (suggested values):

Master → Slave

In the real time channel of the fieldbus, the data configured in **P-0-4081, Process data output descriptions** are transmitted from master to drive.

Parameter	Format
P-0-4077, Fieldbus control word	I16 -> (1 word)
S-0-0145, Signal control word	I16 -> (1 word)
S-0-0048, Position command value additional	I32 -> (2 words)
P-0-0156, Master drive gear input revolutions	I16 -> (1 words)
P-0-0157, Master drive gear output revolutions	I16 -> (1 words)
P-0-0093, Cam shaft distance	I32 -> (2 words)

Slave → Master

In the real time channel of the fieldbus, the real time data configured in **P-0-4080, Process data input description** are transmitted from drive to master.

Parameter	Format
P-0-4078, Fieldbus status word	I16 -> (1 word)
S-0-0144, Signal status word	I16 -> (1 word)
S-0-0051, Position feedback 1 value	I32 -> (2 words)
S-0-0040, Velocity feedback value	I32 -> (2 words)
S-0-0390, Diagnostic message number	I16-> (1 word)

Sequence in real time data channel:

	word1	**word2**	**word3**	**word4**	**word5**	**word6**	**word7**	**word8**
Master→ Slave	P-0-4077	S-0-0145	P-0-0156	P-0-0157	S-0-0048,H	S-0-0048,H	P-0-01	P-0-4076
Slave → Master	P-0-4078	S-0-0144	S-0-0051,H	S-0-0051,L	S-0-0040	S-0-0040	S-0-0390	

Fig. 6-16: Contents of the real time channel in the cam with real master axis

6.5 Multiplex channel

Overview

The multiplex channel makes it possible to update a limited cyclical data channel. This also enables cyclical list element accessing with index changes.

Note: To be able to use the mechanism it is necessary to use command communication via SERCOS or field bus (e.g PROFIBUS, INTERBUS, ...) and configure the multiplex parameters in the cyclical telegrams. The use of the multiplex channel is only possible when selecting the "freely-configurable operating mode" (P-0-4084 = 0XFFFE).

With the help of the multiplex channel it is possible:

- to cyclically exchange more parameter contents despite limited maximum number of transmittable bytes in the master data telegram and drive telegram.
- to access individual list elements using both indices **S-0-0362** and **S-0-0366**.
- by incrementing index **S-0-0368** to transmit in each cycle the multiplexed data with a cycle time of **Tscyc * number of multiplex data**.
- to switch the index in terms of the operating mode and thus to transmit only those parameters needed for the activated mode.

Pertinent parameters

The following parameters have been implemented for this purpose:

- **S-0-0360, MDT Data container A**
- **S-0-0362, List index, MDT data container A**
- **S-0-0364, AT Data container A**
- **S-0-0366, List index, AT data container A**
- **S-0-0368, Addressing for data container A**
- **S-0-0370, Configuration list for the MDT data container**
- **S-0-0371, Configuration list for the AT data container**

Functional principle multiplex channel

Configuration

S-0-0370, Configuration list for the MDT data container

Those IDNs are entered in parameter **S-0-0370, Configuration list for the MDT data container** which, dependent on the index in **S-0-0368, Addressing for data container A**, low byte, are transmitted in **S-0-0360, MDT Data container A**. Write accessing S-0-0370 is only possible in communication phase 2.

S-0-0371, Configuration list for the AT data container

Those IDNs are entered in parameter **S-0-0371, Configuration list for the AT data container A** which, dependent on the index in **S-0-0368, Addressing for data container A**, high byte, are transmitted in **S-0-0364, AT Data container A**. Write accessing S-0-0371 is only possible in communication phase 2.

Note: A maximum of 32 IDNs can be configured in S-0-0371.

Addressing the data containers

Parameter **S-0-0368, Addressing for data container A** contains indices for the selection of the parameters transmitted in the data containers.

The figure below illustrates the configuration lists with the maximum number of elements (32).

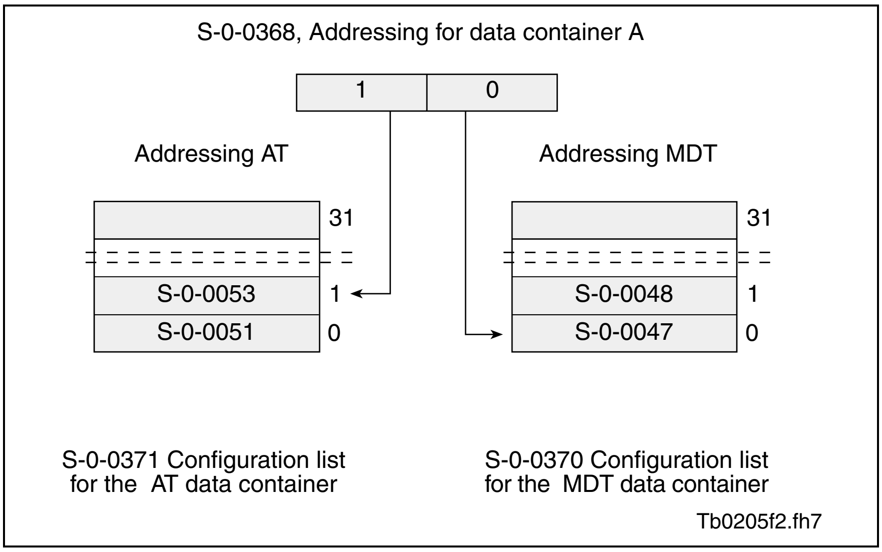


Fig. 6-17: Functional principle of addressing data container A

Note: Only bits 0..5 (for MDT) and bits 8..13 (for AT) are used for addressing with parameter S-0-0368. The other bits are cut off. This is why no value exceeding 31 can be used for addressing.

Note: Parameter **S-0-0368, Addressing for data container A** can, depending on requirements, be configured in MDT, write accessed via the non-cyclical data channel or some other interface.

Using the data containers

S-0-0360, MDT Data container A

In parameter **S-0-0360, MDT Data container A** the master transmits the data which will be written to the target parameter in the drive.

The target parameter is the parameter addressed via S-0-0368 in the configuration list (S-0-0370).

Note: Parameter **S-0-0360** is not write accessible via the non-cyclical data channel. The display format is hexadecimal without decimal places.

S-0-0364, AT Data Container A

The drive copies the data of the source parameter into parameter S-0-0364, AT Data container A.

The source parameter is the parameter addressed via S-0-0368 in the configuration list (S-0-0370).

Note: Parameter S-0-0364 is not write accessible via the non-cyclical data channel. The display format is hexadecimal without decimal places.

Processing single list elements

Using both addressing parameters

- **S-0-0362, List index, MDT data container A**
- **S-0-0366, List index, AT data container A**

it is possible to access single elements of list parameters. It is thus possible to write data to list parameters cyclically and by the element. The element of a list parameter to be written or read is addressed by both parameters.

Note: The parameters become effective if in **S-0-0368, Addressing for data container A** a list parameter has been addressed. If the addressed parameter is not a list parameter, then the evaluation of parameters S-0-0362 and S-0-0366 is terminated.

The following illustrates the processing of a list element with the use of the multiplex channel.

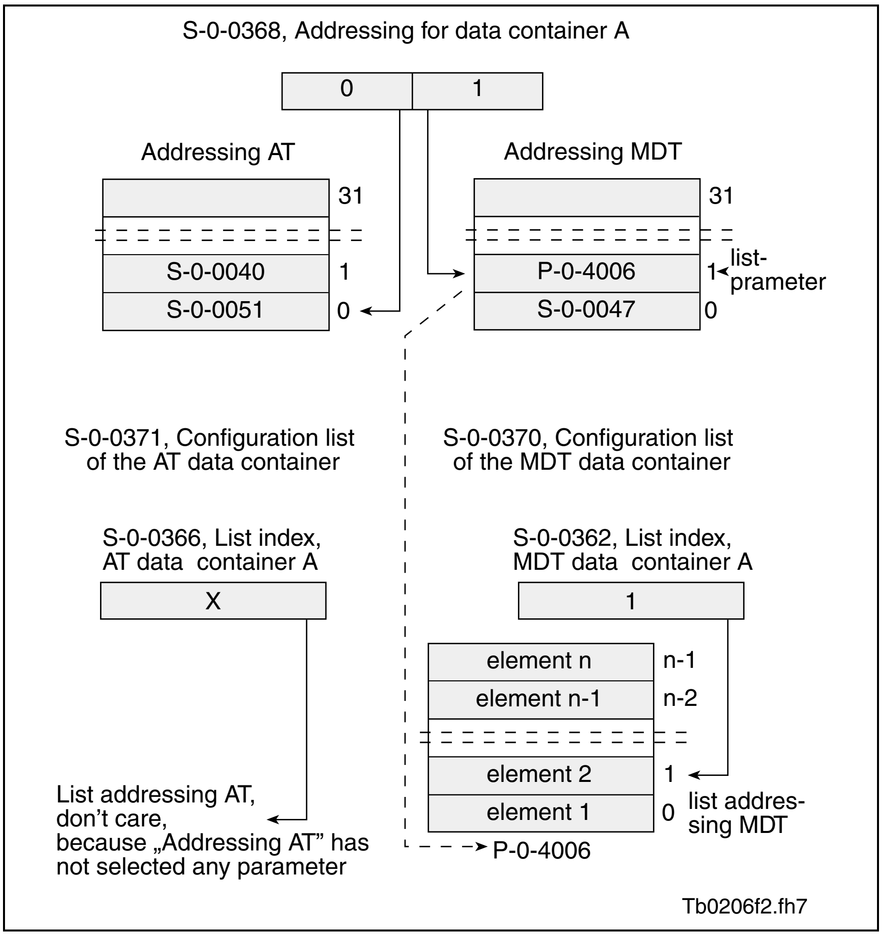


Fig. 6-18: Processing list elements with the multiplex channel, in this case for the MDT container

Diagnostic messages

In conjunction with the multiplex channel, various checks are conducted:

Checking the configured IDN order

The temporal sequence of the processing of cyclical MDT data in the drive has the order in which the configured IDNs are entered in parameter **S-0-0024, Config. list of the master data telegram**.

If both parameters **S-0-0360, MDT Data container A** and **S-0-0368, Addressing for data container A** are configured in the MDT, then the MDT data container will only be properly processed if the addressing was previously processed.

To maintain the correct order when configuring the MDT, the drive checks in command **S-0-0127, C100 Communication phase 3 transition check** whether the IDN S-0-0368 is configured before S-0-0360. If not, then the drive generates the command error message **C118, MDT order for configuration faulty**.

Checking the configuration lists

It must be ensured that the IDNs in the configuration lists can be cyclically configured.

This is why it is checked in command **S-0-0127, C100 Communication phase 3 transition check**, whether the IDNs are contained in the lists **S-0-0187, List of configurable data in the AT** or **S-0-0188, List of configurable data in the MDT**.

The following errors are possible:

If list **S-0-0370, Configuration list for the MDT data container** contains one or more IDNs which are not available or are not contained in **S-0-0188, List of configurable data in the MDT** then error message

- **C104 Configured ID number for MDT not configurable**

is generated.

If list **S-0-0371, Configuration list for the AT data container** contains one ore more IDNs that are not available or not contained in **S-0-0187, List of configurable data in the AT** then error message:

- **C106 Configurated ID numbers for AT not configurable**

is generated.

Checking for existing IDNs

When inputting S-0-0370 and S-0-0371 the following checks are conducted:

- It is checked whether the entered IDN is available. If not, then the non-cyclical data channel error message "0x1001, ID number not available" is generated.
- It is checked whether the entered IDN is available in parameter **S-0-0188, List of configurable data in the MDT**. If not, then the non-cyclical data channel error message "0x7008, Data not correct" is generated.

Checking the index

During operating time, the drive monitors whether the index shows non-initialized locations in lists S-0-0370, **Configuration list for the MDT data container** or S-0-0371, **Configuration list for the AT data container**.

If it does, then warning:

- **E408 Invalid addressing of MDT data container A** or
- **E409 Invalid addressing of AT data container A**

is generated.

Note: The warnings can only occur if the lists contain fewer IDN entries than is maximally possible.

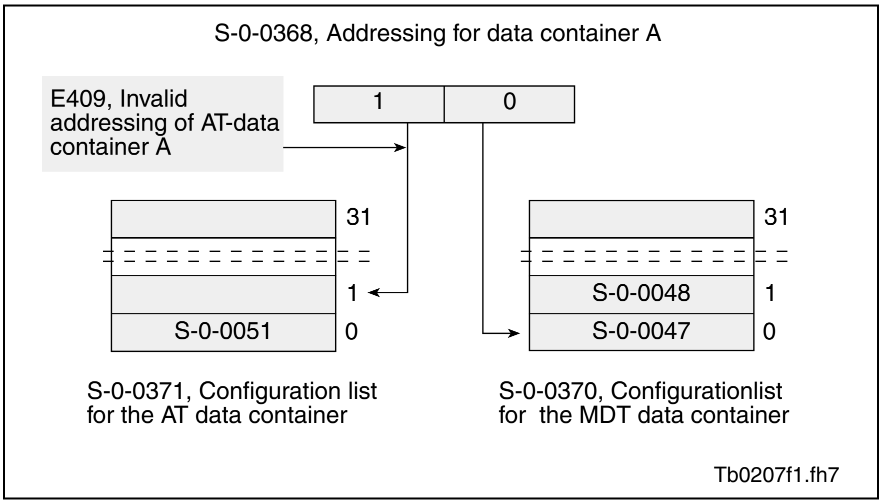


Fig. 6-19: Invalid addressing of AT data container A

Rexroth Indramat

Notes

7 Motor configuration

7.1 Characteristics of the different motor types

You can use the following motor types.

- MKD
- MKE
- MHD
- 2AD
- ADF
- 1MB
- MBS
- MBW
- LAR
- LSF
- LAF

The individual motor types can differ in the following points:

- Availability of data memory in the motor feedback for all motor-specific parameters
- Linear motor – rotary motor
- Synchronous motor - asynchronous motor
- Temperature monitoring function can be parameterized or not
- Motor encoder interface can be parameterized or has a fixed setting
- Type of temperature sensor
- Basic load (load default) is possible when a feedback data memory is available
- Start of commutation offset setting command possible or not

The individual motor types have the following characteristics

Motor type	Motor feedback data memory	sync./async.	Temp. mon. function	Motor-encoder interface	Load default	Temp. sensor[1]
MHD/MKD/MKE	yes	synchronous	fixed	fixed	possible	PTC
2AD/ADF	no	asynchronous	param.	param.	no	NTC
1MB	no	asynchronous	param.	param.	no	NTC
LAF/LAR	no	asynchronous	param.	param.	no	PTC
LSF	no	synchronous	param.	param.	no	PTC
2AD with PTC	no	asynchronous	param.	param.	no	PTC
MBS	no	synchronous	param.	param.	no	PTC

1: With the respective parameterization, it is also possible to evaluate the KTY84 temperature sensor

Fig. 7-1: Characteristics of the motor types

see also parameter description: "P-0-4014, Motor type"

Motor feedback data memory

For MHD, MKD and MKE motors, a motor feedback-data memory is provided, in which all motor-dependent parameters are stored. The drive controller recognizes this automatically and reads those parameters after turning on the device from the data memory during the command **S-0-0128, C200 Communication phase 4 transition check**.

The data memory contains values for the following parameters:

- **S-0-0109, Motor peak current**
- **S-0-0111, Motor current at standstill**
- **S-0-0113, Maximum motor speed (nmax)**
- **S-0-0141, Motor type**
- **P-0-0018, Number of Pole Pairs/Pole Pair**
- **P-0-0051, Torque/Force constant**
- **P-0-0510, Moment of inertia of the rotor**
- **P-0-0511, Brake current**

Note: For motor types without motor feedback memory it is necessary to input these parameters at the initial commissioning using the data sheet.

Linear motor – rotary motor

Depending on whether a linear or rotary motor is being used, changes in the units and the number of decimal places of the parameters will be made. The following table displays the differences in scaling of these parameters:

ID number	rotary motor	linear motor
S-0-0100	0.1 As/rad	0.1As/m
S-0-0113	0.0001 RPM	0.0001 mm/min
S-0-0116	Cycles/Rev.	0.00001 mm
P-0-0018	Pole pairs	0,1mm
P-0-0051	Nm/A	N/A
S-0-0348	mAs²/rad	mAs²/mm

Fig. 7-2: Scaling in linear and rotary motors

The selected motor type also affects the scaling of the position data.

For example, it is impossible to set rotary motor settings for linear motors and linear motor settings for rotary motors. This would generate the command error **C213 Position data scaling error** during a phase progression.

Synchronous motor – asynchronous motor

Specific parameters are used only for synchronous motors, others only for asynchronous motors.

There are differences in the use and check of the parameters in the command **S-0-0128, C200 Communication phase 4 transition check**.

Synchronous

- **P-0-4004, Magnetizing current** is set to 0 if need be
- **P-0-0508, Commutation offset** is checked for validity
- **P-0-4047, Motor inductance** is initialized

Asynchronous

- **P-0-4004, Magnetizing current** is initialized
- **P-0-0508, Commutation offset** is not checked

Temperature monitoring

The following parameters are used to monitor the motor temperature:

S-0-0201, Motor warning temperature

S-0-0204, Motor shutdown temperature

For MHD, MKD and MKE motors, the parameters have been set to the following values and cannot be changed:

S-0-0201, Motor warning temperature = 145.0°C

S-0-0204, Motor shutdown temperature = 155.0°C

For all other motor types the parameters can be parameterized. However, you must ensure that the switch-off limit is not set higher than the maximum permissible temperature of the motor.

The maximum input value for **S-0-0201, Motor warning temperature** is **S-0-0204, Motor shutdown temperature**.

If the temperature of the motor exceeds the value in **S-0-0201, Motor warning temperature**, the warning **E251 Motor overtemp. prewarning** is generated.

If the temperature rises to the motor switch-off temperature, the error message **F219 Motor overtemp. shutdown** is generated.

The minimum input value for **S-0-0204, Motor shutdown temperature** is **S-0-0201, Motor warning temperature**.

Note: To display the motor temperature, the parameter **S-0-0383, Motor Temperature** is used.

The drive controller checks for proper functioning of the motor temperature monitoring system. If discrepancies occur (temperature drops below –10° Celsius), the warning **E221 Warning Motor temp. surveillance defective** will be displayed for 30 seconds. After that, the error message **F221 Error Motor temp. surveillance defective** is generated.

Load default feature

MHD, MKD and MKE motors have a data memory in their feedbacks. In addition to all motor-dependent parameters, the data memory contains a set of default control parameters.

These parameters are activated with the load default feature.

(See also chapter: "Load default")

7.2 Setting the motor type

The motor type is set in terms of the motor that is used:

- automatically by reading the motor feedback data memory

- or -

- by inputting parameter **P-0-4014, Motor type**.

The motor type should be set at the beginning of the commissioning process because the motor type affects the drive functions.

See also chapter: "Characteristics of the different motor types"

Automatic setting of the motor type for motors with feedback data memory

The motor type can be automatically set if the motor is equipped with feedback data memory.

This is done by programming a valid value (1; 5) in the feedback data memory in parameter **P-7-4014, Motor type**, or a known motor type has been stored in parameter **S-7-0141, Motor type**. Motor types known to the firmware are:

- MHD (P-7-4014, Motor type == 1),
- MKD (P-7-4014, Motor type == 5) and
- MKE (P-7-4014, Motor type == 5)

If motors are recognized, then the following automatically takes place:

- the value of the parameter **P-0-4014, Motor type** is set to the corresponding value.
- the value of the parameter **P-0-0074, Feedback 1 type** is set to the defined value for the corresponding motor type.
- all bits except bit 6 (for absolute/not-absolute) are set to "0" in the parameter **S-0-0277, Position feedback 1 type**.
- all motor-dependent parameters are read out of the motor feedback data memory (see chapter: Parameter storage in motor feedback). The parameters in the motor feedback data memory are set with parameter block number 7. These are read and copied into the relevant parameters with parameter block number 0.
- the value of **S-0-0201, Motor warning temperature** will be set to 145.0°C, and the **S-0-0204, Motor shutdown temperature** will be set to 155.0°C.
- the value of **P-0-0525, Type of motor brake** is set to "0". The value of **P-0-0526, Brake control delay** is set to 150 ms.

Automatic settings take place, where possible, after the device is switched on but also during command **S-0-0128, C200 Communication phase 4 transition check**. During the command the error message **C204 Motor type P-0-4014 incorrect** is generated if a motor has been parameterized in **P-0-4014, Motor type** that should be automatically recognized, but the relevant settings are not contained in the motor feedback memory.

Setting of the motor type through P-0-4014, Motor type

For motors without motor feedback data memory, you have to set the motor type through **P-0-4014, Motor type**.

See also chapter: Characteristics of the different motor types

7.3 Asynchronous motors

With the firmware, you can use asynchronous motors in the entire rpm range, including field weakening.

In addition to the general motor parameters, you have to set the following asynchronous motor parameters for specific motors according to the Rexroth Indramat parameter lists:

- **P-0-4004, Magnetizing current**
- **P-0-4012, Slip factor**
- **P-0-0530, Slip Increase**
- **P-0-0531, Stall Current Limit**
- **P-0-0533, Flux Loop Prop. Gain**
- **P-0-0534, Flux Loop Integral Action Time**
- **P-0-0535, Motor voltage at no load**
- **P-0-0536, Motor voltage max.**

The user has one additional parameter to adjust the drive to his requirements.

- **P-0-0532, Premagnetization factor**

Basics on the asynchronous motor

There are three working ranges for asynchronous motors:

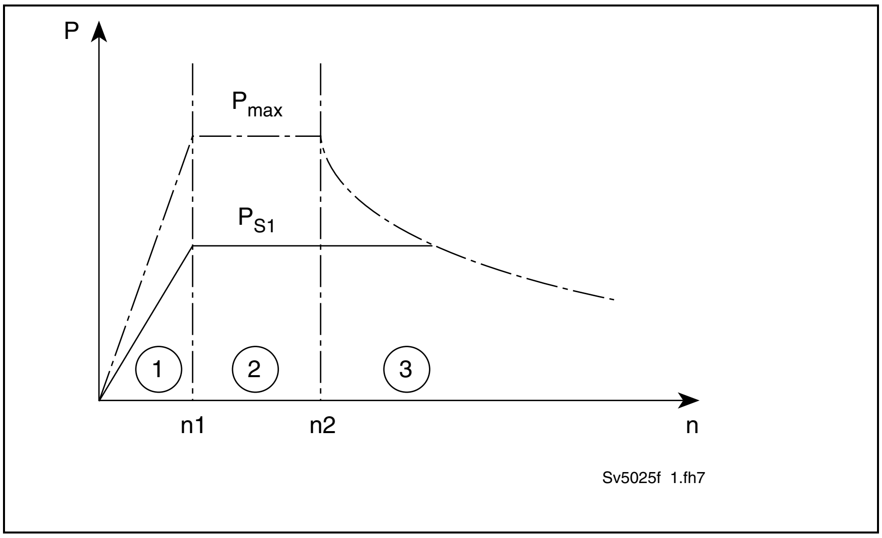


Fig. 7-3: Division of working ranges

Range 1 Basic speed range, defined by a constant torque and a fixed torque/force constant (**P-0-0051, Torque/force constant**). In idle, the programmed magnetization current flows. The motor voltage is less than the maximum control output voltage. The corner speed n1 is directly proportional to the DC bus voltage.

Range 2 Range of constant power. The motor voltage is constant; the idle voltage and the corresponding magnetization and torque constants fall with increasing speed, the slip is increased correspondingly.

The adjustment of magnetization current and slip is executed automatically by the flux loop. The voltage is decreased during idle to the motor idle voltage (P-0-0535), and with full load it is increased to the maximum motor voltage (P-0-0536).

Range 3 Range of decreasing peak power. The motor works at the stall current limit; through the vector control, the current is maintained at an efficient and stable level. According to the stall current factor (P-0-0531), the peak current will be decreased so that the maximum power cannot be exceeded. Further increase in current would lead only to wasted power and reduced output power. The peak power in range 3 is proportional to the square of the DC bus voltage. It is ensured that the maximum power is reached for each DC bus voltage without parameter adjustment.

The power in range 3 cannot be increased through the use of more powerful controllers.

Torque evaluation

100% torque refers to the motor's continuous torque at standstill according to the type plate. Since the peak torque of asynchronous motors is limited to 2.5 times the nominal value, you can reach torques up to 250 %.

The significance of the torque values changes in the field-weakening range since the torque in the controller is set equal to the torque-producing current Iq. The torque, however, is the product of Iq and air gap induction, which decreases in the field-weakening range. The assignment of the torque values in the different velocity ranges is displayed in the following figure:

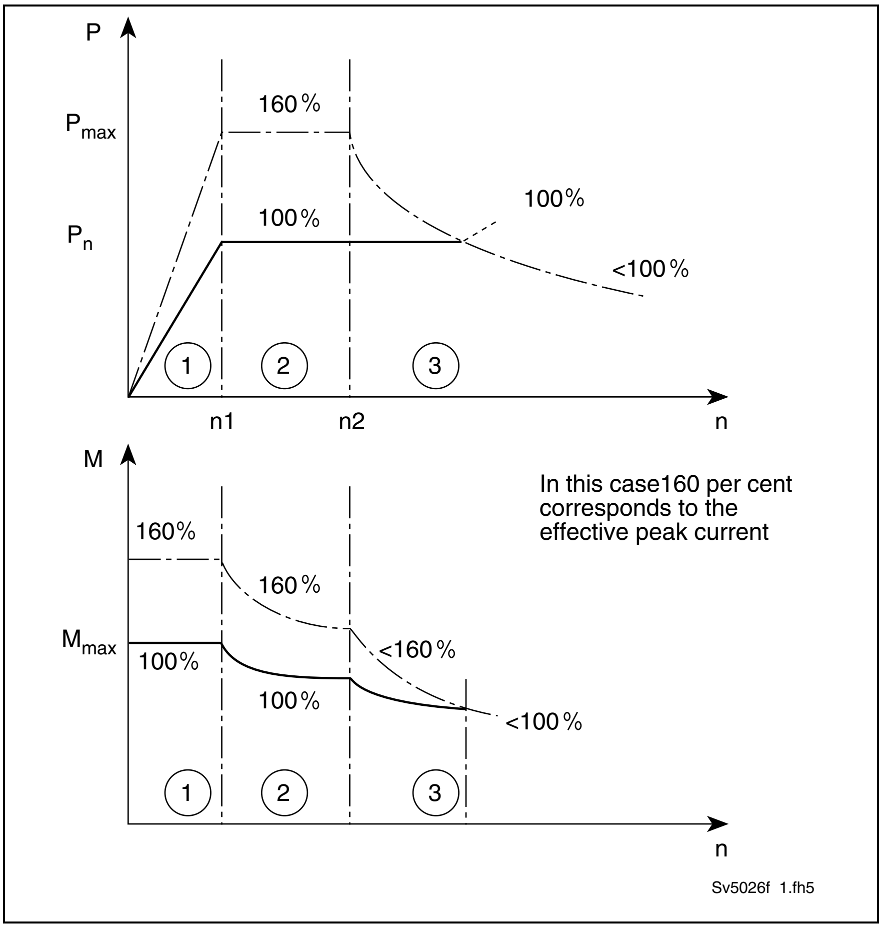


Fig. 7-4: Torque assignment

In range 1, the torque value is the actual torque. 100% = rated torque.

In range 2, the torque value corresponds to the power.
100% = rated power according to selection list. (The rated power of the motor type plate is not relevant in this case, since it could relate to a different DC bus voltage.)

Range 3 is similar to the evaluation of range 2, except that the preset torque decreases with the peak power in correspondence to the increasing speed. For high speed, the maximum torque value can drop below 100%.

In braking mode, you can reach 50% higher torque values in this range than in driving mode!

User-defined parameterization of the asynchronous motor

To operate an asynchronous motor, you have to set the specific motor parameters in the controller. The parameters are stored in the parameter memory and are therefore transferable to another controller.

Note: Motor-specific parameters are used by all controllers in the same manner. The resulting power characteristics curve depends on the current rating and especially on the DC bus voltage. One additional parameter is available so the user can optimize the drive with regard to his requirements.

Premagnetization factor

With **P-0-0532, Premagnetization factor** you can set the effective magnetization current.

The following applies:

effective magnetization current = magnetization current * premagnetization factor

Fig. 7-5: Calculation of the effective magnetization current

If the premagnetization factor is at 100%, the motor is completely magnetized. There is a linear connection between set current and torque according to the torque constant P-0-0051. The torque builds up without delay. The drive has perfect servo properties.

The disadvantages are the high iron loss and the higher noise under no or partial load, especially at a switching frequency of 4 kHz, when the full magnetization current is flowing. For main spindle applications, it has proven useful to reduce the premagnetization factor to 50%. Through this procedure, the motor stays cooler and is not as noisy, while peak power is maintained. The extended control start time (only for jumps that exceed half the peak torque) and the missing linearity of torque and voltage do not distort the main spindle drives.

The qualitative connection between premagnetization factor (pmf) and drive behavior is shown in the following figure:

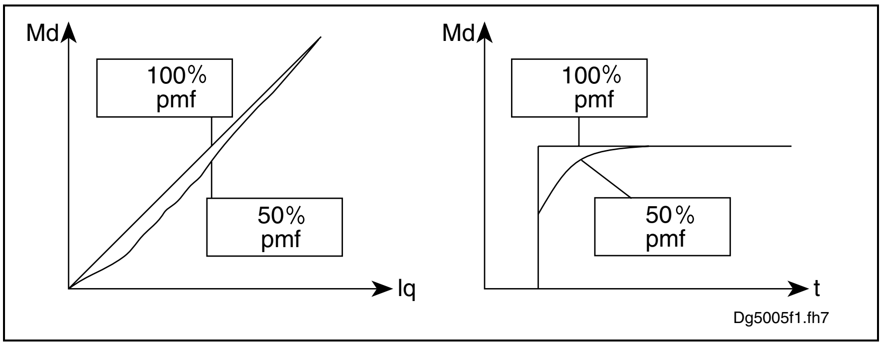


Fig. 7-6: Connection of premagnetization factor and drive behavior

The torque build-up is delayed by about 200 ms at 50 % premagnetization, because the air gap range can only increase slowly in relation to the rotor time constant.

By reducing the premagnetization factor, you can achieve better synchronous operation (in the one-thousandth degree range). This will reduce distorted torques, which result from saturation effects in the motor and from unavoidable deviations from an ideal sine form. To keep the torque linear in this case, the slip factor must be increased in the same measure at which the premagnetization factor was decreased.

CAUTION

Damage caused by overload of the motor!

⇒ If the premagnetization factor has been reduced in order to achieve better synchronous operation, this will reduce torque constant, continuous torque and peak torque.

Example: The synchronous operation is to be improved in a servo drive. The premagnetization factor is set to 40 %, and the slip factor is set to 2.5 times of the original value. The continuous and peak torque decrease to approximately 40 %. The corner speed increases to 2.5 times the speed.

7.4 Synchronous motors

With this drive firmware it is possible to run Rexroth Indramat housing motors of the types MHD, MKD and MKE, as well as rotary and linear synchronous kit motors of the types MBS and LSF.

Rexroth Indramat housing motors have stator, rotor, bearings and feedback built into the housing. They are equipped with a motor feedback data memory in which

- motor parameters
- motor encoder parameters
- synchronous motor-specific parameters and
- default control parameters

are stored. These motors are recognized by the firmware and the respective settings for them are executed automatically.

The compensation between the actual rotor position and the position supplied by the encoder is set at the factory for these motors. The resulting offset is stored in parameter **P-7-0508, Commutation offset** in the motor feedback memory (synchronous motor-specific parameter). Rexroth Indramat housing motors are configured ready for operation at the factory meaning that they can be run without having to make any other motor-specific settings.

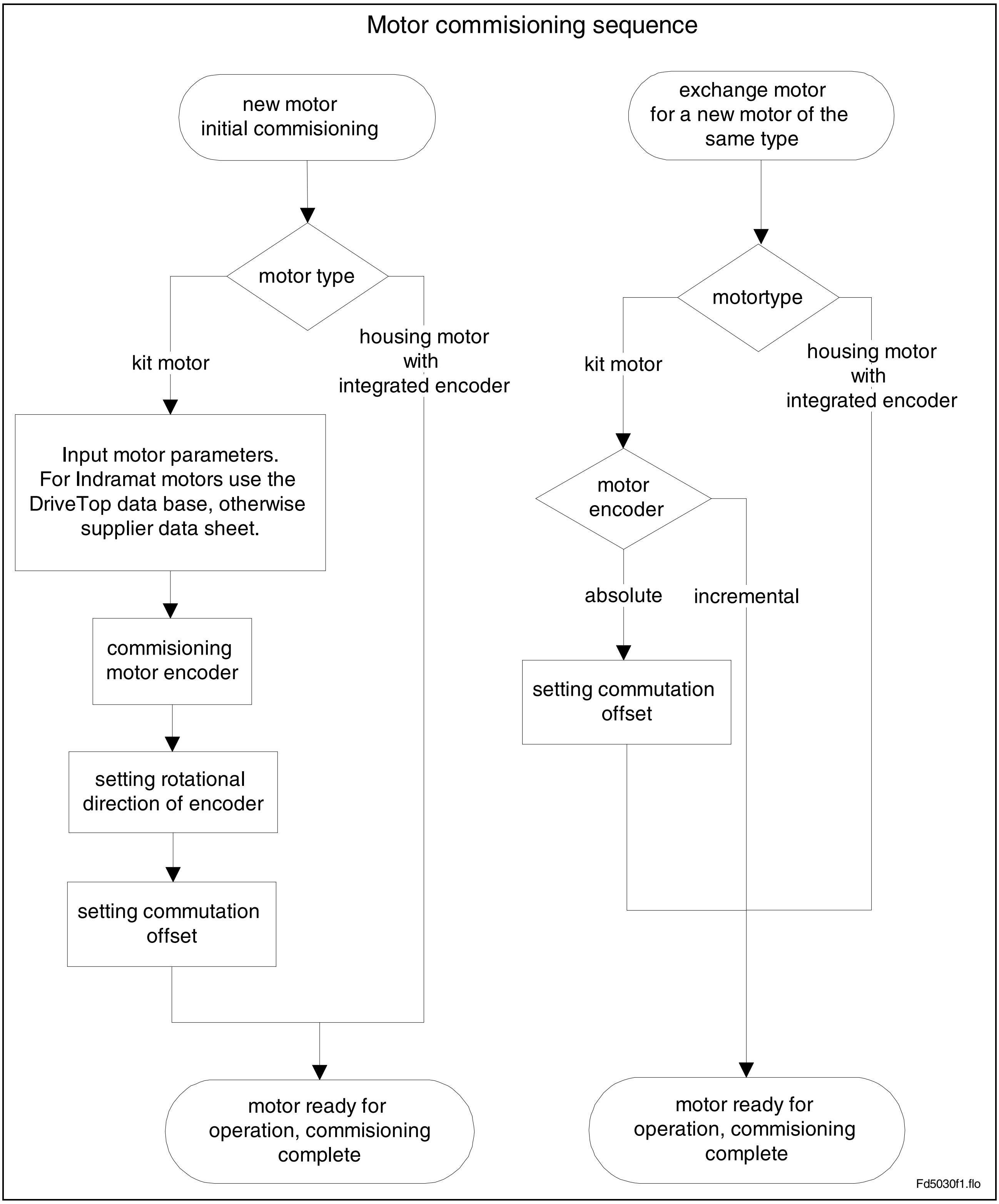


Fig. 7-7: Overview of motor commissioning

Commissioning synchronous kit motors

For synchronous kit motors it is necessary to carry out the following settings at commissioning:

- the commutation offset (see "Determining commutation offset") must be determined
- motor parameters must be input
- the motor encoder must be set (see chapter: "Motor encoder")
- the rotational direction of the motor encoder must be set (see chapter: "Command and actual value polarities")

The motor parameters can be input via the motor data base stored in the start up program DriveTop.

The commutation offset is determined with command **P-0-0524, D300 Commutation adjustment command**. This is done automatically in drives with an incremental motor encoder after the drive enable is applied.

Determining commutation offset

A condition for a constant torque of the synchronous machine is the permanent allocation between stator current vector and the rotor flow vector. If the angle between these two vectors γ = 90°, then the machine generates its maximum torque. The synchronous machine is operated in this state.

To set the stator current vector it is necessary to know the absolute rotor position. The difference between the original position of the motor encoder (original rotor position) and the absolute rotor position (in terms of the stator) is called the commutation offset. Once the offset is determined, the value is stored in parameter **P-0-0508, Commutation offset**.

When determining the offset at commissioning, the difference is made between absolute and incremental measuring systems used as motor encoder.

Motor with absolute measuring system

If the motor has a motor encoder which provides the absolute rotor position, it is necessary

- with the initial commissioning of the axis or
- after the measuring system has been replaced

to determine the commutation offset **once**.

WARNING

Error when activating motors and moving parts!

⇒ Commutation offset must be determined every time the mechanical reference between motor encoder and motor has changed. This is the case, for example, when the encoder or the motor have been exchanged.

Motor with incremental measuring system

If the motor is equipped with an incremental measuring system, the rotor position is unknown every time the control voltage is switched on. Commutation offset must be determined with every transition to operating mode (e.g. after control voltage is switched on).

Setting the motor encoder

The motor encoder is automatically set, when the drive enable has been applied.

How to determine the commutation setting

Four different methods (method 1, 2, 3a or 3b) have been implemented in the firmware to determine the commutation offset. The following figure illustrates the relationship between the motor encoder used and the method to be used.

Please observe the danger note for application 3!

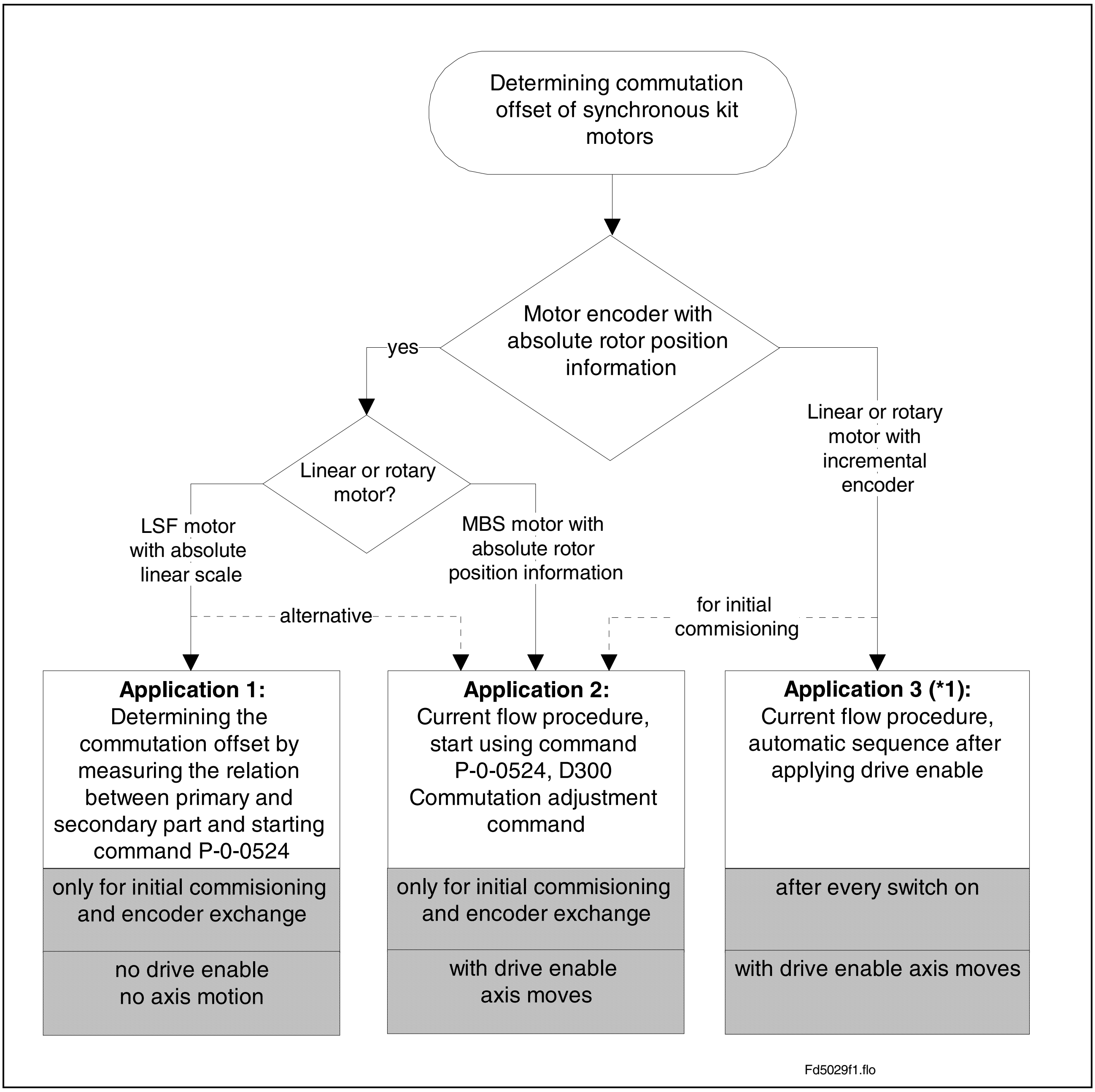


Fig. 7-8: Determining commutation offset in synchronous motors

(*1) **DANGER**

Application 3 (synchronous motor with incremental encoder) may not be used in conjunction with the following applications:

-vertical axes without weight compensation ("Hanging axes")

-jammed or blocked axes

⇒ Application 3 may only be used after the drive development department has been consulted and given permission!

Prerequisites

To successfully conduct this procedure, the following conditions must be met:

- The rotational direction of the encoder must be correctly set:
  - for rotary motors:
    If the motor moves clockwise (looking onto motor output shaft), then the value in parameter **S-0-0051, Position feedback 1 value** must be increasing.
  - for linear motors:
    If the primary part moves in direction of the front side at which the power cables of the motor branch off, the value in parameter **S-0-0051, Position feedback 1 value** must be increasing.

  The position polarity in **S-0-0055, Position polarities** may not be inverted in this case. If the value moves in the wrong direction, then the rotational direction of the motor encoder has to be inverted. Bit 3 of **S-0-0277, Position feedback 1 type** is used for this purpose.

  Also see chapters: "Command and actual value polarities" or "Motor encoder".
- The current and velocity control loop parameters must have default settings or must be parameterized in a reasonable way.

Application 1: Measuring the relation between primary and secondary part (for linear motors)

Overview

The commutation for linear synchronous motors (LSF) with absolute encoder systems can be determined by measuring the distance between the front side of the primary part and the adjusting device of the secondary part.

Note: The commutation offset is determined without axis motion.

Pertinent parameters

- **P-0-0508, Commutation offset**
- **P-0-0523, Commutation, probe value**
- **P-0-0524, D300 Commutation adjustment command**

Further prerequisites

In order to execute the command successfully, additional conditions must be met:

- The power cables of the motor must be correctly connected (assignment of the 3 phases).
- The drive must be in state **A013 Ready for power on**.
- The appropriate characteristic value (K_{mx}) of the primary part must have been determined for the motor.

Sequence

If the listed conditions have been met, the value for parameter **P-0-0523, Commutation, probe value** has to be calculated, according to the following formula, and entered:

$$P-0-0523 = d - K_{mx}$$

d: distance between front side of primary part and adjusting device
K_{mx}: characteristic value of primary part

Fig. 7-9: Determining the probe value for the commutation offset setting with linear servo motor (LSF)

Note: The distance between the front side of the primary part and the adjusting device is measured from the front side at which the power cables of the motor are **not** connected.

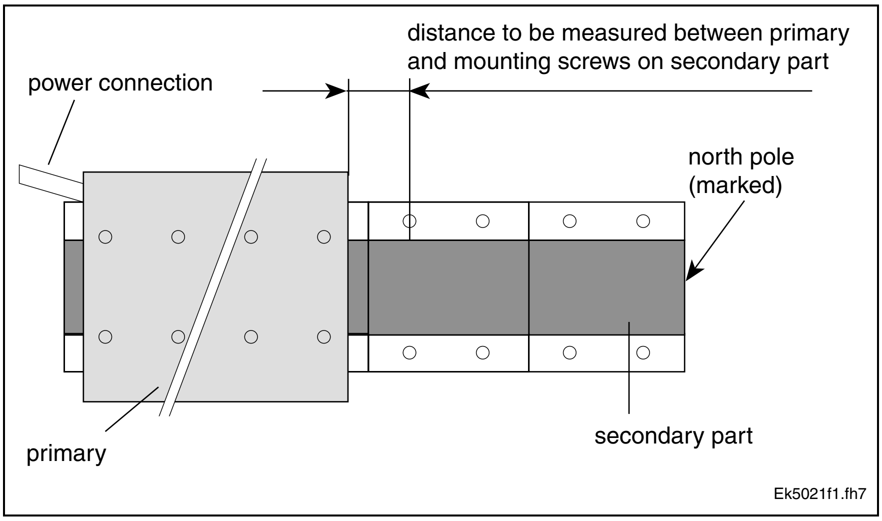


Fig. 7-10: Overview: determining the commutation offset for LSF

After the value has been entered, command **P-0-0524, D300 Commutation adjustment command** has to be started, the commutation offset is calculated.

Note: If the drive is in control mode at the start of the command (i. e. controller enable has been set and the drive is in the operating mode "Torque control"), the commutation offset is determined with the current flow procedure (application 2).

Afterwards the command has to be cleared again.

Application 2: Current flow procedure, start using command P-0-0524, D300 Commutation adjustment command

DANGER

The machine can be damaged if the procedure is performed incorrectly

⇒ Restrictions noted in section: "Current flow procedure restrictions (Application 2 and 3a)" must be taken into account.

Use of this procedure

This procedure is used in the following situations:

- The commutation procedure must be determined only once, at initial commissioning or when the encoder is exchanged, on rotary synchronous motors with motor encoders providing absolute rotor position information.
- At initial commissioning of linear motors with absolute encoder system, as an alternative for application 1.

- With linear or rotary synchronous motors with incremental encoders this procedure should be used at initial commissioning of the axis. In this case, parameters **P-0-0560, Commutation adjustment current** and **P-0-0562, Commutation adjustment periodic time** are determined and stored in the drive. With each new start of the axis, the commutation must be determined again if synchronous motors with incremental encoders are used. Application 3 is used to do this. As start values for the procedure, the parameter values determined at the initial commissioning for P-0-0560 and P-0-0562 are used.

Pertinent parameters

- **P-0-0508, Commutation offset**
- **P-0-0524, D300 Commutation adjustment command**
- **P-0-0560, Commutation adjustment current**
- **P-0-0562, Commutation adjustment periodic time**

Motor encoders with absolute rotor position information are available for the following encoder types (see also parameter description: **P-0-0074, Feedback 1 type**):

Values for P-0-0074, feedback 1 type with kit motors	**Motor encoder interface**
1	digital servo feedback (DSF) or resolver with feedback data memory
8	Heidenhain encoder with EnDat-Interface
10	resolver without feedback data memory *)
11	resolver + incremental encoder with sine signals without feedback data memory *)

*): There is no feedback memory with this type of encoder. This is why the commutation offset is stored in parameter **P-0-0508, Commutation offset** in the programming module. Upon replacement of the programming module the value of parameter **P-0-0508, Commutation offset** has to be re-entered or the parameters from the old module must be saved and loaded into the new module.

Fig. 7-11: Possible motor encoders for synchronous kit motors

Further prerequisites

To execute command **P-0-0524, D300 Commutation adjustment command**, the drive must be in state **A012 Control and power sections ready for operation**. The 7-segment display reads "Ab" in this case.

Sequence

To determine commutation offset the control sets command **P-0-0524, D300 Commutation adjustment command**. Upon completion of the command, the drive enable is switched off internally. To start the drive again, though, the control must complete the command and set the drive enable again.

The sequence is identical to the procedure described in chapter: "Application 3a: Current flow procedure, Automatic Sequence after applying drive enable".

Application 3a: Current flow procedure, automatic sequence after applying drive enable

DANGER

The machine can be damaged if the procedure is performed incorrectly

⇒ Take the restrictions listed in section: "Current flow procedure restrictions (Application 2 and 3a)" into account.

Use of this procedure

This procedure is automatically conducted in linear and rotary synchronous motors with incremental encoder systems whenever the unit is switched on.

Pertinent parameters

- **P-0-0508, Commutation offset**
- **P-0-0524, D300 Commutation adjustment command**
- **P-0-0560, Commutation adjustment current**
- **P-0-0562, Commutation adjustment periodic time**

Sequence

The commutation offset only has to be re-determined if the motor encoder has been re-initialized. This is conducted while switching from parameterization into operating mode. The automatic determination of the commutation after applying drive enable thus only takes place if the drive power is turned off and switched back on again or if the drive was switched into parameterization mode.

After setting the drive enable, the motor moves rapidly for about 2 seconds to the left and right. The determined commutation offset is stored in parameter **P-0-0508, Commutation offset**.

If commutation offset has been successfully determined, the drive switches into the parameterized operating mode. Diagnosis "AF" is displayed. In parameter **S-0-0135, Drive status word** the drive simultaneously signals the status "In operation under torque".

Note: Maximum motion equals

linear motors:	+/- 1 pole pair distance
rotary motors:	+/- 360 degrees/number of pole pairs

The drive starts the setting of the commutation offset with the values stored in parameters **P-0-0560, Commutation adjustment current** and **P-0-0562, Commutation adjustment periodic time**. If commutation offset cannot be determined with these values, then they are automatically changed by the drive controller and a new attempt is started. This means that first **P-0-0560, Commutation adjustment current** is increased to twice the motor standstill current. Then **P-0-0562, Commutation adjustment periodic time** is increased to 128 milliseconds.

Note: By changing the parameter values, the time that the drive needs for the commutation setting can increase considerably (up to two minutes). This is why an initial commissioning procedure is recommended.

Note: The setting of the commutation offset will possibly fail. In this case please refer to chapter "Diagnostic messages".

Initial commissioning

At initial commissioning the values, as described above, for **P-0-0560, Commutation adjustment current** and **P-0-0562, Commutation adjustment periodic time** are automatically determined by the drive controller and stored in the parameter module. These are then available as start values for setting the commutation offset which is started after transition to operating mode. This means that the drive saves the time needed to determine the best parameters for the commutation setting.

Conducting the initial commissioning:

1. Switch drive to operating mode (display "bb").
2. Switch on power (display "Ab").
3. Execute command **P-0-0524, D300 Commutation adjustment command**.
   The drive runs the commutation setting. After the command has been executed, the determined values of parameters **P-0-0560, Commutation adjustment current** and **P-0-0562, Commutation adjustment periodic time** are stored in the parameter memory. They can be used as start values for commutation settings in the future.

Current flow procedure restrictions (Application 2 and 3a)

General restrictions

In the case of axes with a high degree of friction and a high degree of external inertia, the drive cannot always determine the optimum value for commutation. The result is that, at every new automatic commutation setting, the drive uses slightly different internal control loop settings.

In these cases, the procedure should be combined with the correction of the commutation offset during the homing procedure (application 3b).

Restrictions when using holding brakes or clamps

For the current flow procedure it is necessary to ensure that the axis can move freely after drive enable is set by the control. If a holding brake or clamp is used, then it must be released before the control sets the drive enable. This is guaranteed to occur if the holding brake is connected to the controller.

DANGER

The machine can be damaged if the procedure is performed incorrectly!

Procedure not to be used with

⇒ "Hanging axes"

⇒ Permanently clamped or blocked axes

Restrictions with axes with dead stop

Note the following with axes with dead stop:

DANGER

The machine can be damaged in the case of axes with dead stop

⇒ Make sure that the axis is not at the dead stop when the drive enable is set.

Peculiarities of Gantry axes

Gantry axes require that the commutation is determined for each individual drive. This means that Gantry axes must be mechanically constructed in such a way that each drive can run the arrangement.

If commutation is not yet known (after going from parameter mode into operating mode) then drive enable can only be set for one drive. The second or other drives must be torque-free.

If the commutation setting of the first drive is finished, then it has to go torque-free before drive enable is set for the second drive of the axis (with commutation setting still to be carried out).

Diagnostic messages

In conjunction with the commutation setting, the following diagnostic messages can occur:

- **D300 Command adjust commutation**

The commutation setting command is set. Determining commutation offset is running or has been executed.

- **D311 Commutation offset could not be determined**

or

- **F811 Commutation offset could not be determined**

Commutation offset could not be determined. Possible causes:

- rotational direction of encoder was wrong
- axis mechanically blocked
- brake applied
- axis at dead stop

- **D301 Drive not ready for commutation command**

At command start (application 2) the drive must be in torque control. If not, then this command error is generated.

- **D312 Motion range exceeded during commutation**

or

- **F812 Motion range exceeded during commutation**

The axis has moved more than one pole pair distance (linear motor) or 360°/number of pole pairs (rotary motor). Possible causes:

- Parameter for commutation setting is too big
- mechanical motion generated from outside
- speed controller incorrectly parameterized

Application 3b: Current flow procedure, automatic sequence after applying drive enable and correction of the commutation offset during the homing procedure

CAUTION

The machine can be damaged if the procedure is performed incorrectly

⇒ Take the restrictions listed in section: "Current flow procedure restrictions (Application 2 and 3a)" into account.

Practical experience has shown that, due to the mechanical system, the commutation offset of the automatic commutation offset determination cannot be determined exactly enough for continuous operation (degree of friction too high or degree of inertia of the mechanical system too high etc.). The result is that the drive can only be moved with reduced nominal torque or nominal force. In order to be able to use an incremental measuring system for such applications, the commutation offset is switched, at a defined mechanical position (reference mark of the motor encoder), to an optimum value that has been determined during commissioning. After the commutation offset has been switched, the nominal data are available for the drive.

Additional parameters required

- **P-0-0507, Optimized commutation offset**
- **P-0-0538, Motor function parameter 1**

Sequence

During initial commissioning **P-0-0507, Optimized commutation offset** was determined. After the drive has been switched on and switched to the operating mode, a valid **P-0-0508, Commutation offset** is not yet available. By setting the drive enable signal the automatic commutation setting (see application 3a) determines **P-0-0508, Commutation offset**. With this parameter the drive can be moved. When command **S-0-0148, C600 Drive controlled homing procedure command** is started, the drive moves to the reference point of the machine. When passing the reference mark of the encoder, the drive switches to **P-0-0507, Optimized commutation offset**. From this moment on the nominal data are available for the motor.

Initial commissioning

For initial commissioning bits 4 and 5 in parameter **P-0-0538, Motor function parameter 1** must first be set. After switching to the operating mode it is first necessary to carry out commissioning – as described in application 3. The automatic commutation then works correctly in so far as the drive can move in position control, if the controller parameters have been set in a reasonable way.

In order to optimize the commutation offset, a constant torque/force must be input for the drive and the resulting actual torque/force must be measured with appropriate measuring equipment. By changing parameter **P-0-0508, Commutation offset** it is possible to determine the value at which the drive produces its maximum torque/force.

CAUTION

Property damage caused by uncontrolled drive motion!

⇒ The value of **P-0-0508, Commutation offset** may only be changed by a maximum of ±128, in order to avoid uncontrolled drive motion.

After optimizing the commutation offset, command **S-0-0148, C600 Drive controlled homing procedure command** has to be started. The drive moves in direction of the reference mark (see also: Drive-controlled homing). When passing the reference mark, the drive determines the optimum commutation offset with regard to the reference mark and stores it in the non-volatile memory in parameter **P-0-0507, Optimized commutation offset**.

Operation

For normal operation bit 5 of parameter **P-0-0538, Motor function parameter 1** has to be set to "0", bit 4 remains set to "1". The drive is now parameterized in such a way that each time the motor encoder is homed, the drive switches to the optimum commutation offset.

CAUTION

Property damage caused by uncontrolled drive motion!

⇒ If incorrect data are written to parameter **P-0-0507, Optimized commutation offset**, e. g. by loading the wrong parameter set, the wrong commutation offset is accepted when the drive passes the reference mark. The drive will possibly move in an uncontrolled way.

Diagnostic messages

If, in normal operation, the difference recognized between the offset values is too big after switching the commutation offset from the automatically determined offset to the optimized offset, it is assumed that the optimized commutation offset is incorrect. The drive switches to error state and displays **F880 Optimized commutation offset incorrect**.

The setting of the optimum commutation offset (P-0-0507) has to be carried out again.

Field weakening for synchronous motors

The working range of synchronous motors is limited, in conventional operation on converters, by the converter voltage. The motor reaches maximum speed once its no-load voltage has reached the converter voltage.

With field weakening for synchronous motors it has become possible to operate motors outside of this limitation.

If field weakening is to be used with synchronous motors then the following parameters must be set motor-specifically as stated in the Rexroth Indramat specifications:

- **P-0-4004, Magnetizing current**
- **P-0-0531, Stall current factor**
- **P-0-0533, Flux loop prop. gain**
- **P-0-0534, Flux loop integral action time**
- **P-0-0535, Motor voltage at no load**
- **P-0-0536, Motor voltage max.**
- **P-0-0532, Premagnetization factor**
- **P-0-0538, Motor function parameter 1**

Note: The motor must be suited for operating in the field-weakening range.

The function "Field weakening for synchronous motors" is activated with parameter **P-0-0538, Motor function parameter 1**.

7.5 Motor holding brake

A motor holding brake can be connected via a potential-free contact installed in the drive controller. The brake prevents unwanted axis movements when the drive enable signal is off (e.g. for a vertical axis without a counterweight).

Note: The holding brake for Rexroth Indramat housing motors is not a service brake. It wears down after about 20 000 motor revolutions if the brake is closed.

DANGER

Dangerous movements! Danger to personnel from falling or dropping axes!

⇒ The standard equipment motor brake or an external brake controlled directly by the drive controller are not sufficient to guarantee the safety of personnel!

⇒ Personnel safety must be acquired with higher-ranking, fail-safe procedures:

Dangerous areas should be blocked off with fences or grids.

Secure vertical axes against falling or slipping after switching off the motor power by, for example:

- Mechanically securing the vertical axes
- Adding an external brake / clamping mechanism
- Providing sufficient counterbalance for the axis.

Pertinent parameters

To set the motor holding brake, use the following parameters:

- **P-0-0126, Maximum braking time**
- **P-0-0525, Type of motor brake**
- **P-0-0526, Brake control delay**
- **P-0-0538, Motor function parameter 1**
- **P-0-0539, Brake status**
- **P-0-0540, Torque of motor brake**
- **P-0-0541, B200 Brake check command**
- **P-0-0542, B100 Command Release motor holding brake**

Note: The parameters for the motor holding brake (P-0-0525 and P-0-0526) are automatically set in motors with motor feedback data memory (MHD, MKD and MKE motors). For all other motor types, the values which must be entered are specified in the data sheet of the motor brake.

Parameter P-0-0126 must be parameterized in accordance with the machine requirements.

Setting the motor brake type

Using parameter **P-0-0525, Type of motor brake** it is possible to set the motor brake type.

It must be identified in terms of:

- self-releasing or self-holding brake
- spindle brake or servo brake

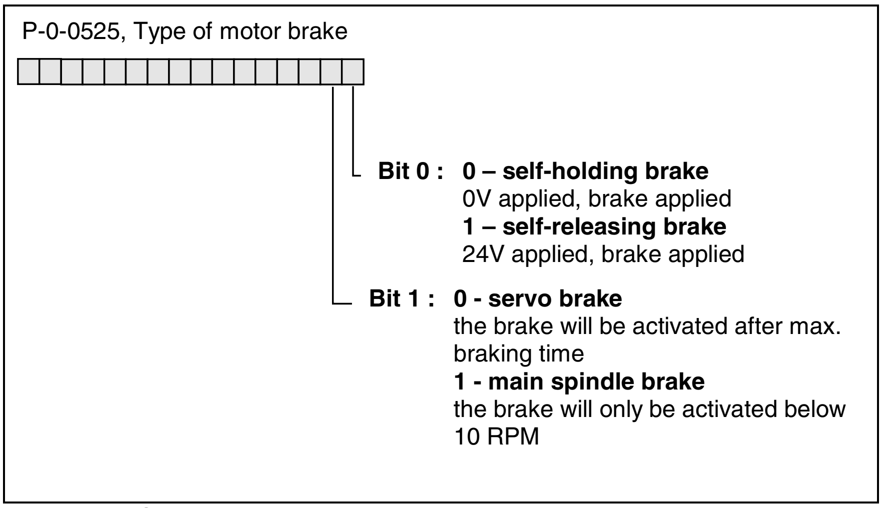


Fig. 7-12: Setting the motor brake type

Activating the motor holding brake depending on the type of holding brake

Spindle brake

Activating the motor holding brake always takes place with drive enable switched off, if the actual velocity of the motor is smaller than 10 rpm (rotary motor) or 10 mm/min (linear motor).

At the end of maximum braking time (P-0-0126) the set error reaction is completed and the drive goes torque-free.

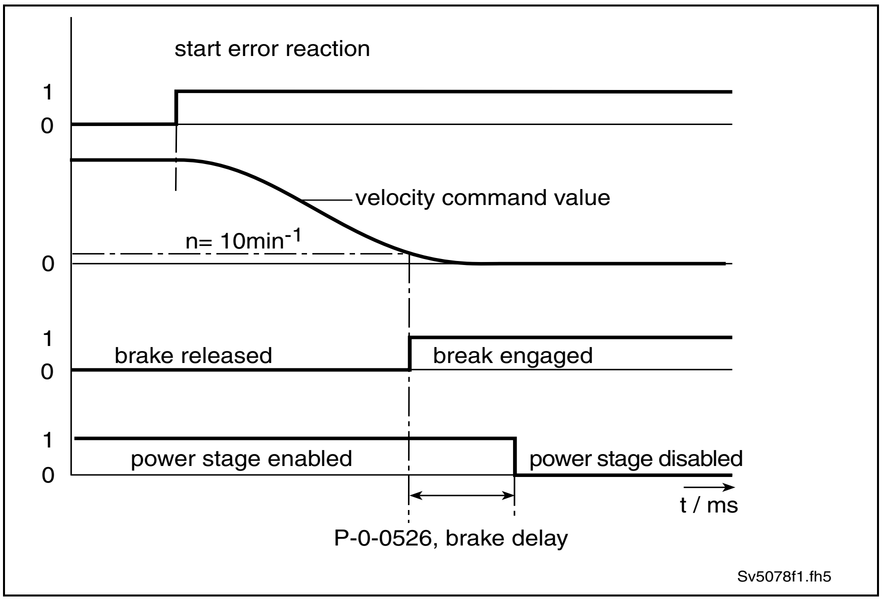


Fig. 7-13: Chronological diagram with command value to zero and **P-0-0525, Holding brake type**, bit 1=1 (spindle brake)

Behavior with servo brake

The brake is activated:

- as soon as the velocity falls below 10 rpm during the error reaction or
- no later than upon completion of the maximum braking time.

Correct braking time (braking time < P-0-0126):

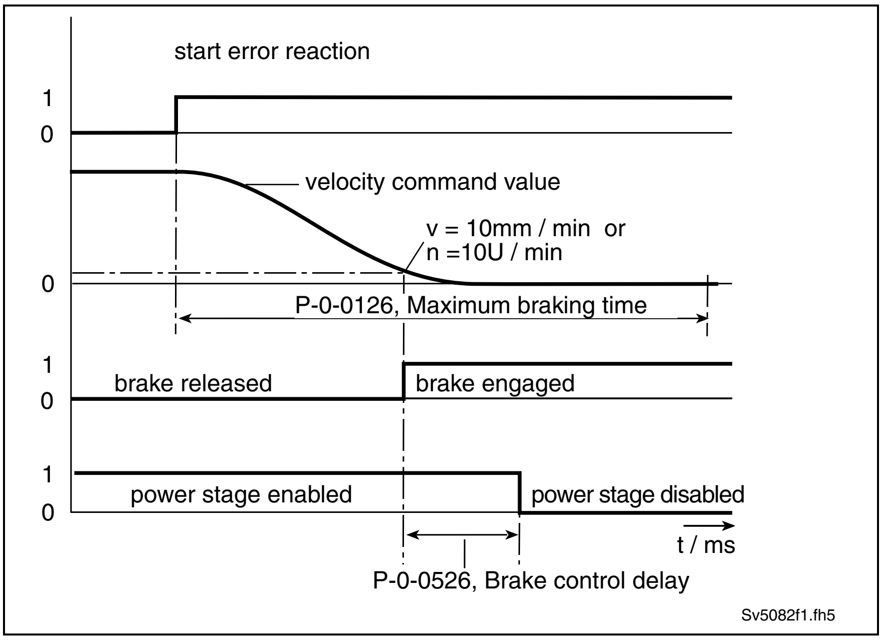


Fig. 7-14: Chronological diagram with command value to zero and **P-0-0525, Holding brake type**, bit 1=0 (servo brake) and actual braking time < P-0-0126

Incorrect braking time (braking time > P-0-0126)

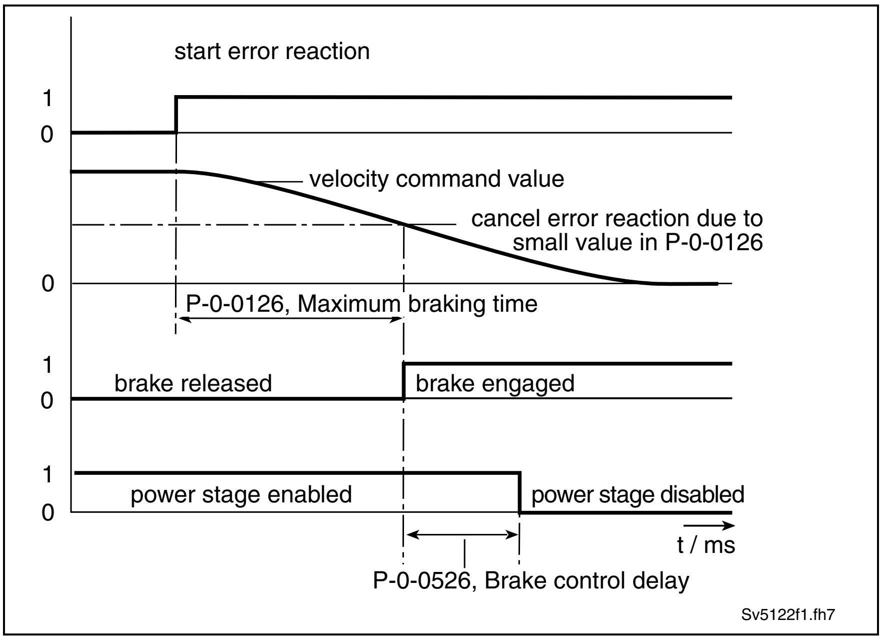


Fig. 7-15: Chronological diagram with command value to zero and **P-0-0525, Holding brake type**, bit 1=0 (servo brake) and actual braking time > P-0-0126

Setting the motor brake control delay

In **P-0-0526, Brake control delay** it is necessary to enter the time that can pass from the moment the motor brake is activated until the brake becomes actually effective.

The standard value that has been entered for the direct connection of holding brakes of Rexroth Indramat motors equals 150 ms.

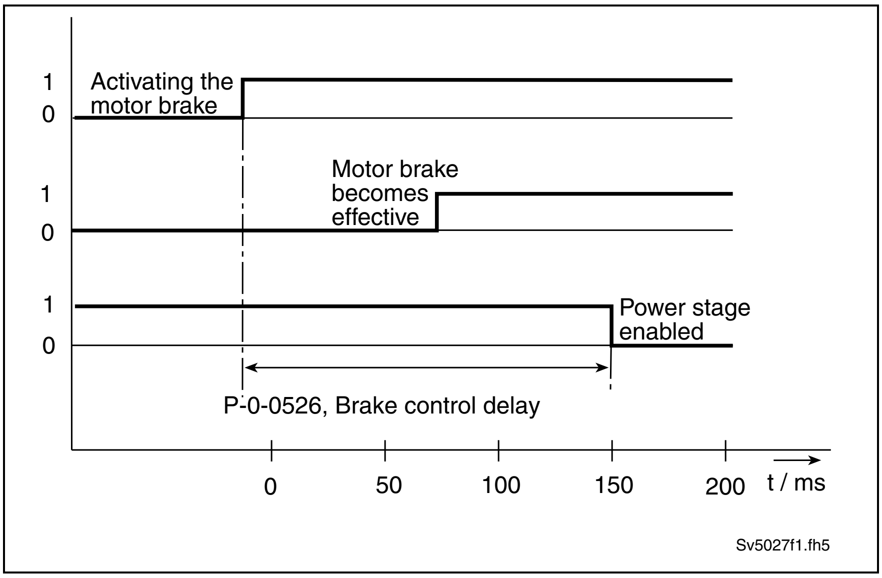


Fig. 7-16: Setting the motor brake control delay

Setting maximum braking time

Parameter **P-0-0126, Maximum braking time** is used to monitor the braking time and activate the motor holding brake, if the theoretical braking time is exceeded due to an error.

The motor holding brake is activated if the time that has passed since the start of the error reaction exceeds the time set in **P-0-0126, Maximum braking time**.

ATTENTION

Brake damage!

If the value in **P-0-0126, Maximum braking time** is too small, then the error reaction is terminated and the motor holding brake activated at a speed greater than 10 rpm.

⇒ The value in **P-0-0126, Maximum braking time** must be set in such a way that the drive can come to a safe standstill out of maximum speed, given the greatest possible moment of inertia and load forces.

Command "Release motor holding brake"

The command **P-0-0542, B100 Command Release motor holding brake** is used to release the holding brake if the drive enable has been switched off.

First, the command must be enabled using bit 9 in the **P-0-0538, Motor function parameter 1**.

The motor holding brake is released upon activation of the command.

Upon completion of the command, the brake is again applied. If, with active command, the drive enable is switched on and off, then the brake is again applied.

DANGER

Fatal injuries and/or property damage!
Releasing the holding brake on a vertical axis leads to axis motion.

Monitoring the motor holding brake

The monitoring of the holding brake can be executed automatically each time the drive enable is switched on or off or by executing command "Brake check". For an automatic check bit 10 must be set in the motor function parameter (**P-0-0538, Motor function parameter 1**).

Automatic checks

Applying drive enable

When applying the drive enable, the release of the brake is checked. This means that the drive is run at maximum nominal brake torque.

If it is possible to move the motor at nominal brake torque, then the brake has been released as it should.

If the motor cannot be moved, then the brake is applied. Error **F269 Error during release of the motor holding brake** is generated.

Removing drive enable

When switching drive enable off, the holding torque of the brake is checked. This means that the nominal brake torque is applied to the motor with the brake closed.

If the motor cannot be moved, then the brake is all right.

If the motor moves during the check, then warning **E269 Brake torque too low** is generated.

The warning persists until the monitor recognizes the brake as being all right.

Command "Brake check"

With the activation of the command **P-0-0541, B200 Brake check command**, it is first checked whether the motor can be moved with a torque that is smaller than the nominal brake torque.

If this is not possible, then the motor holding brake is applied.

Error **F269 Error during release of the motor holding brake** is generated.

If movement is possible, then the nominal brake torque is generated by the motor with the brake applied.

If the motor does not move, then the brake is all right. With movement, the attempt is made to again achieve the holding torque of the brake by looping in the brake. After this procedure, the holding torque is again checked. If nominal torque is again not achieved, then command error **B203 Brake torque too low** is generated.

ATTENTION

Property damage!

⇒ The holding brake check leads to axis motion.

Activation and monitoring of an external brake

With parameter **P-0-0539, Brake status** and the respective parameterization of a digital output (cf. **P-0-0124**) it is possible to activate and monitor an external brake.

Connecting the motor holding brake

See Project Planning Manual ECODRIVE03 respectively DURADRIVE

8 Operating modes

8.1 Setting the operating mode parameters

By means of parameters:

- **S-0-0032, Primary mode of operation**
- **S-0-0033, Secondary operation mode 1**
- **S-0-0034, Secondary operation mode 2**
- **S-0-0035, Secondary operation mode 3**

it is possible to preset four different operating modes at the same time.

In the case of a parallel interface the secondary operating mode 1 must be set to jogging, in order to guarantee the correct function of the jogging inputs. When the input "jogging positive" or "jogging negative" is activated, the drive automatically switches from the primary mode of operation to the secondary operating mode 1.

The parameter descriptions of the above-listed parameters offer an overview of possible input values for the parameters.

8.2 Determining/detecting the active operating mode

Depending on the kind of master communication, parameter **S-0-0134, Master control word** has a different significance.

Bits 8 and 9 in the master control word determine which of the four preselected operating modes will become effective. By configuring the parameter to the signal control word the operating modes can also be switched over with a parallel interface.

Note: When the jogging inputs are activated, the drive switches to the secondary operating mode 1, if the operating mode "jogging" has been preset in this mode. In this case, the configured bits in the master control word have no significance (jogging inputs have priority).

Bits 8 and 9 in master control word	effective operating mode
0 0	Primary mode of operation
0 1	Secondary operating mode 1
1 0	Secondary operating mode 2
1 1	Secondary operating mode 3

Abb. 8-1: Determining/detecting the active operating mode in the master control word

Note: If "0" has been entered in the effective operating mode parameters and this operating mode is activated, error **F207 Switching to uninitialized operation mode** is generated.

8.3 Operating mode: torque control

Note: In the case of the FGP firmware, torque control is only possible in conjunction with analog operation (P-0-4084 = 0xFFFE).

A torque command value is preset for the drive in the operating mode torque control. When the operating mode is activated, the diagnostic message reads **A100 Drive in torque control**.

The command value has two proportions that are added. They are specified in parameter **S-0-0080, Torque/Force command** and in parameter **S-0-0081, Additive Torque/Force command**.

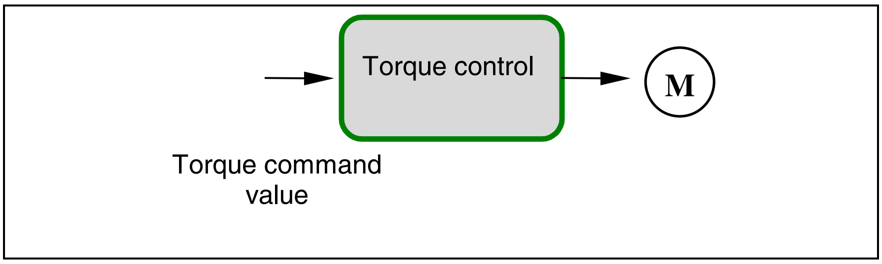


Fig. 8-2: Torque control block diagram

Pertinent parameters

- **S-0-0080, Torque/Force command**
- **S-0-0081, Additive Torque/Force command**
- **P-0-4046, Active peak current**
- **P-0-0176, Torque/Force command smoothing time constant**

Torque controller

The sum of **S-0-0080, Torque/Force Command** and **S-0-0081, Additive Torque/Force command** is limited with the active peak current **P-0-4046, Active peak current**. The active peak current is derived from the current and torque limit.

(See also chapters "Current limit" and "Torque/force limiting")

The limited torque command value is filtered by a 1st order filter. The time constant of the filter is determined by parameter **P-0-0176, Torque/Force command smoothing time constant**.

The limiting and filtering process provides the effective torque-creating command current. It is the command value for the (effective) current controller.

By means of the "Analog output of predefined signals" the effective command current can be output in analog form.

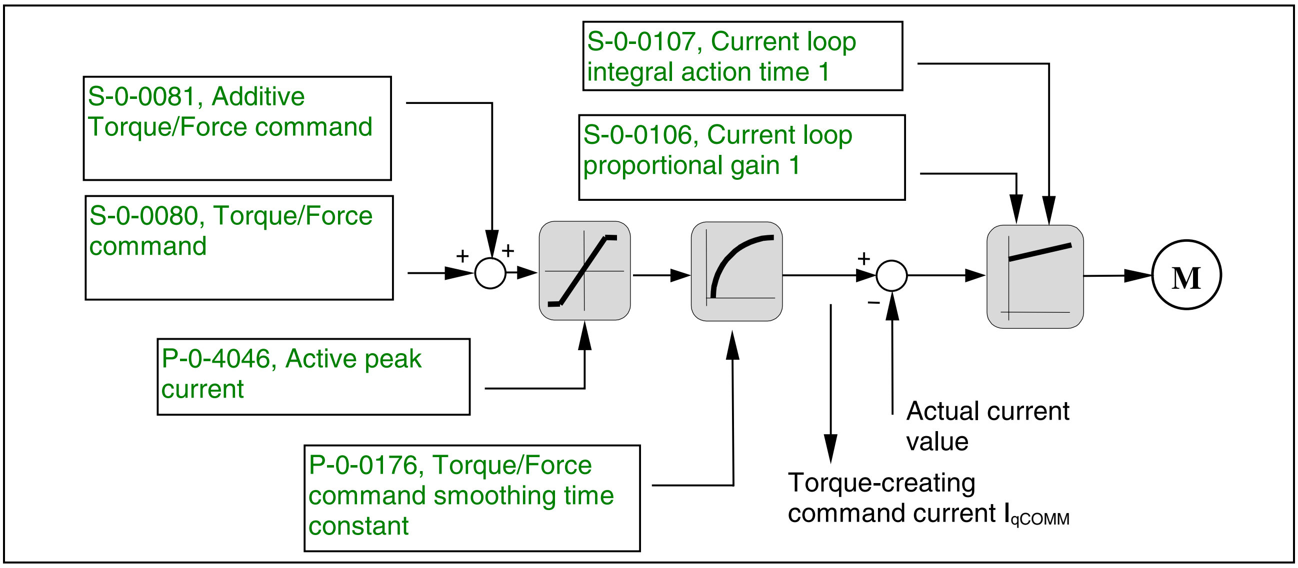


Fig. 8-3: Torque controller

Diagnostic messages

Operating mode-specific monitoring functions:

- Monitoring the actual velocity to the 1.125-fold value of parameter **S-0-0091, Bipolar velocity limit value**.

(see also chapter: "Limiting to bipolar velocity limit value")

If this value is exceeded, error **F879 Velocity limit S-0-0091 exceeded** is generated.

8.4 Operating mode: velocity control

Note: This operating mode is activated with the selection of profile P-0-4084=0x0003 or P-0-4084=0xFF93 or with analog operation with P-0-4084=0xFFFE.

A velocity command value is preset for the drive in the "velocity control" operating mode. The velocity command value is limited with ramps and a filter. The diagnostic message reads **A101 Drive in Velocity Mode** when this operating mode is active.

The command value has two proportions that are added. The proportions have to be specified in the parameters **S-0-0036, Velocity command value** and **S-0-0037, Additive velocity command value**.

The torque/force command value is generated internally by the velocity controller. An additive proportion can be added to this command value by parameter **S-0-0081, Additive Torque/Force command**.

Pertinent parameters

- **S-0-0036, Velocity command value**
- **S-0-0037, Additive velocity command value**
- **S-0-0081, Additive Torque/Force command**
- **S-0-0091, Bipolar velocity limit value**
- **P-0-1201, Ramp 1 pitch**
- **P-0-1202, Final speed of ramp 1**
- **P-0-1203, Ramp 2 pitch**
- **P-0-1211, Deceleration ramp 1**
- **P-0-1213, Deceleration ramp 2**
- **P-0-1222, Velocity command filter**

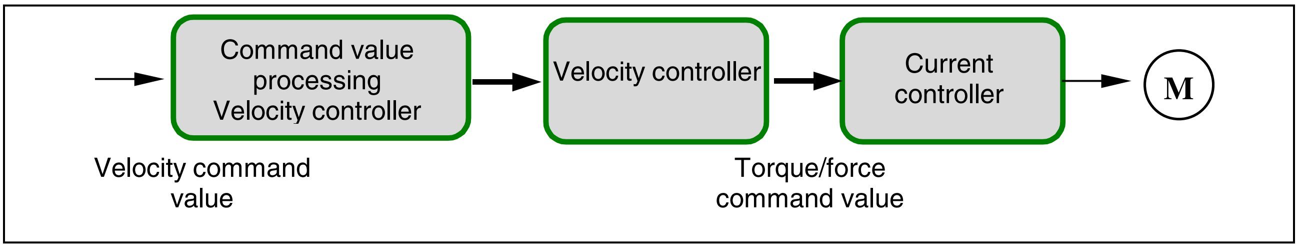


Fig. 8-4: Velocity control block diagram

Command value processing in velocity control

The given **S-0-0036, Velocity command value** is limited to **S-0-0091, Bipolar velocity limit value**. If the command value is higher, the message **E263 Velocity command value > limit S-0-0091** is shown. The command value is then acceleration-limited via **P-0-1201, Ramp 1 pitch**. If command velocity exceeds the velocity in parameter **P-0-1202, Final speed of ramp 1**, then the command value is acceleration-limited in terms of value **P-0-1203, Ramp 2 pitch**. Parameters **P-0-1211, Deceleration ramp 1** or **P-0-1213, Deceleration ramp 2** are used for deceleration. This means that for acceleration and deceleration procedures various ramps can be used. The limited velocity command is jerk limited by means of a filter of the 1st order (**P-0-1222, Velocity command filter**).

If parameters **P-0-1211, Deceleration ramp 1** or **P-0-1213, Deceleration ramp 2** are equal to zero, then parameters **P-0-1201, Ramp 1 pitch** or **P-0-1203, Ramp 2 pitch** used.

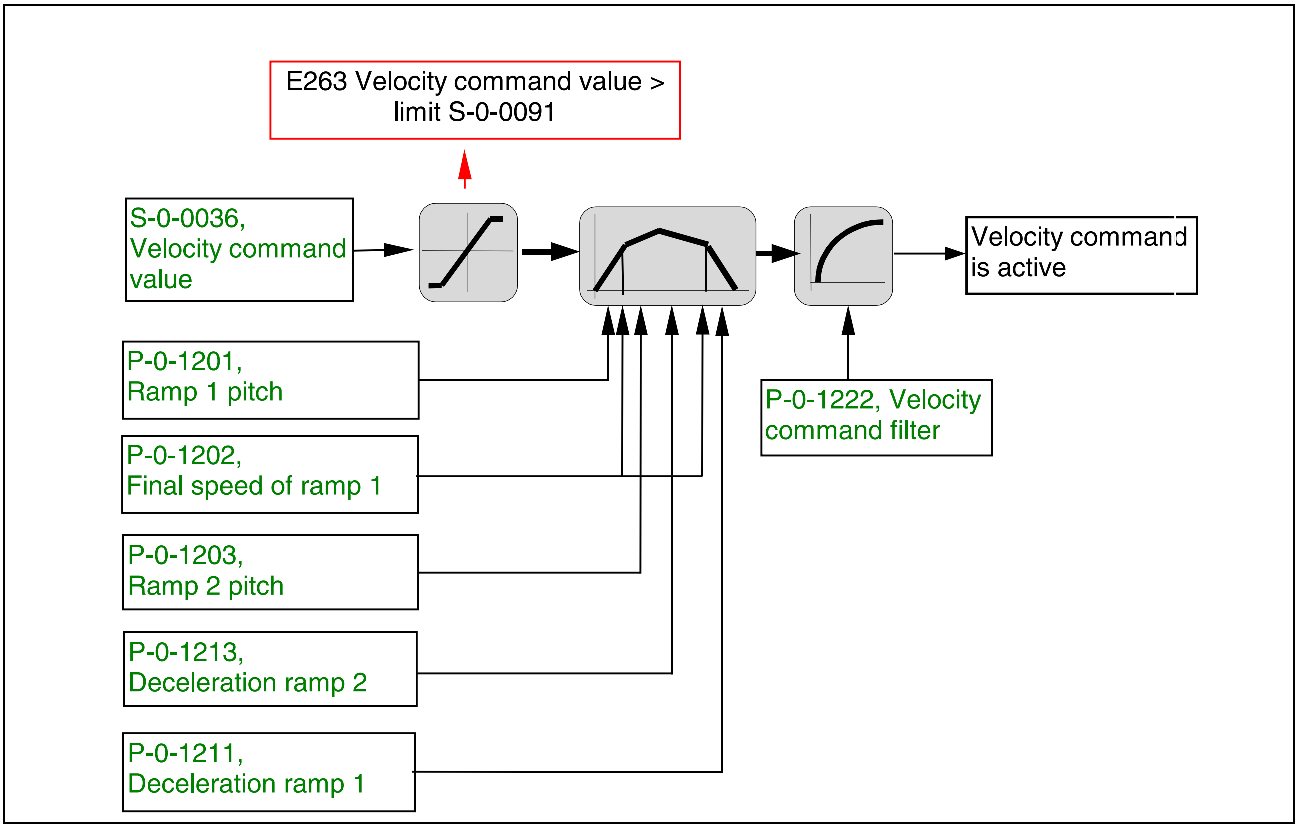


Fig. 8-5: Command value processing: velocity control

See also chapter: "Velocity controller"

See also chapter: "Current controller"

Velocity controller

The value **S-0-0037, Additive velocity command value** is added to the effective velocity command value.

Further it is limited to **S-0-0091, Bipolar velocity limit value**.

(See also chapter: "Limiting to bipolar velocity limit value")

The velocity control difference is produced by subtracting the velocity feedback value that is used for control. In addition, the feedback velocities of the motor and, if available, the external measuring system can be combined into an actual velocity value that is used for control (see also chapter: "Setting the velocity mix factor"). Via **P-0-0004, Velocity loop smoothing time constant** you can set the low-pass filter that filters the control difference for the velocity controller.

This filtered control difference is variable is passed to the velocity controller.

The output of the velocity controller is added to **S-0-0081, Additive Torque/Force command** and then passed to the current and torque/force limit (see also chapters: "Current limit" and "Torque/Force limiting").

To filter mechanical resonance frequencies, a notch filter can be applied to this torque/force command value. Using parameter **P-0-0180, Rejection frequency velocity loop** and **P-0-0181, Rejection bandwidth velocity loop** the frequency range which must be suppressed can be parameterized (see also chapter "Setting the velocity controller").

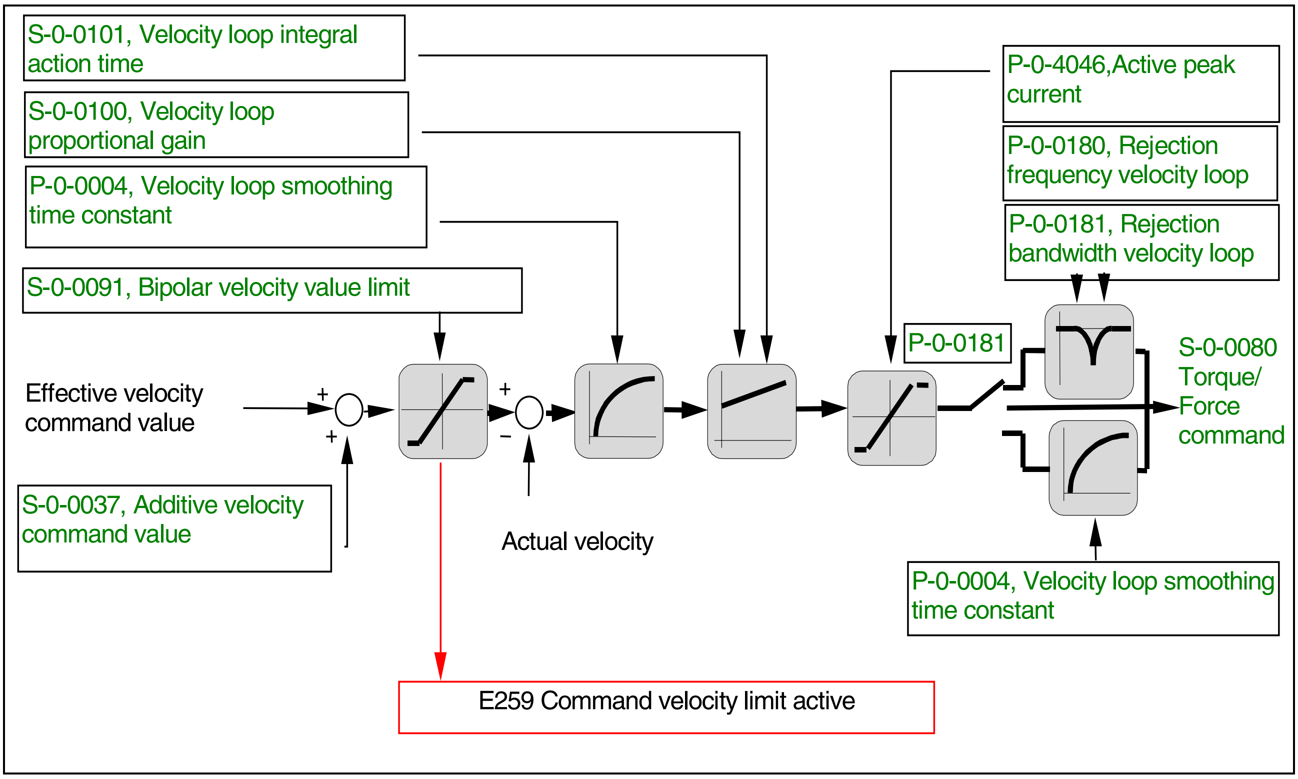


Fig. 8-6: Velocity controller

See also chapter: "Command value processing velocity control"

See also chapter: "Current controller"

Current controller

The current controller is parameterized with **S-0-0106, Current loop proportional gain 1** and **S-0-0107, Current loop integral action time 1** (see also chapter: "Setting the current controller").

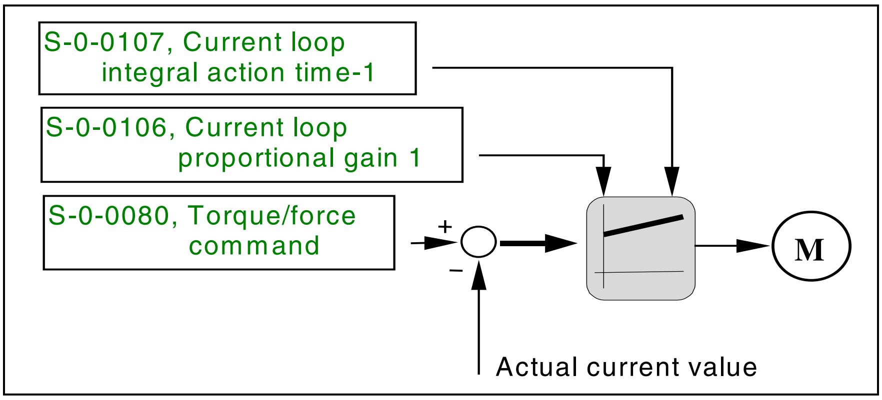


Fig. 8-7: Current controller

Diagnostic messages

Operating mode-specific monitoring functions are:

- **E259 Command velocity limit active**
  If the resulting command value is in the limit, then warning **E259 Command velocity limit active** is displayed.
- **E263 Velocity command value > limit S-0-0091**
  Parameter **S-0-0036, Velocity command value** is set to the value of parameter **S-0-0091, Bipolar velocity limit value**, if the value in S-0-0036 is greater than the value in S-0-0091. In this case, the warning **E263 Velocity command value > limit S-0-0091** is generated.

8.5 Operating mode: Position control

Note: The operating mode "position control" becomes effective in the drive with profile types P-0-4084 = 0xFF92 and possibly P-0-4084 = 0xFFFE.

In the operating mode "Position control", a position command value is preset for the drive every NC cycle time. The timebase is defined by **S-0-0001, NC Cycle time (TNcyc)**.

When this mode is activated, the diagnostic message is one of the following:

- **A102 Position mode with encoder 1**,
- **A103 Position mode with encoder 2**,
- **A104 Position mode lagless, encoder 1**,
- **A105 Position control lagless, feedback 2**

The command value is specified in the parameter **S-0-0047, Position command value**.

Operating mode-specific monitoring functions are:

- Monitoring the command velocity with regard to the value of the parameter **S-0-0091, Bipolar velocity limit value**. (see chapter: "Position Command Value Monitoring")

If this value is exceeded, the error **F237 Excessive position command difference** is generated.

The position command value specified in **S-0-0047, Position command value** passes through an interpolator, to be then specified for the position controller.

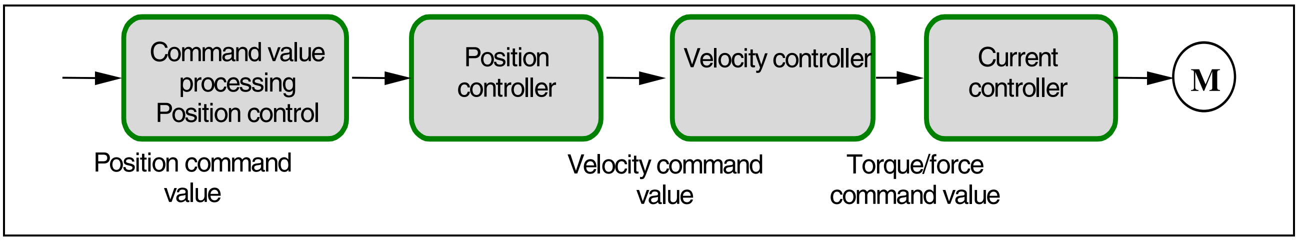


Fig. 8-8: Position control block diagram

Command value processing in position control

A command velocity is formed from two successive position command values. **S-0-0001, NC Cycle Time (TNcyc)** acts as the time basis.

The rule for calculating the command velocity is as follows:

$$V_{comm} = \frac{\text{position command value(k)} - \text{position command value(k}-1)}{S-0-0001}$$

V_{comm}: command velocity

Fig. 8-9: Calculating the command velocity

This velocity is monitored to determine whether it exceeds **S-0-0091, Bipolar velocity limit value** (see also chapter: "Position Command Value Monitoring"). If **S-0-0091** is exceeded, the error **F237 Excessive position command difference** is generated.

The preset position command value profile can be jerk-limited with the parameter **P-0-0099, Position command smoothing time constant**.

The position control loop is closed every 1000 µs. To do this, the position command value in the NC cycle time is fine-interpolated. There is a linear and a cubic interpolator available. Switching between the two is implemented through bit 0 of **P-0-0187, Position command value processing mode**. In general, the cubic interpolator is recommended unless the timing behavior of the linear interpolator is required (see parameter description of P-0-0187). The cubic interpolator is superior to the linear one in particular with lagless position control, because it offers a clearly higher quality of the velocity and acceleration feedforward.

The internal position command value at the position controller is displayed in parameter **P-0-0434, Internal Position command value**.

In this case, the command velocity is calculated as follows:

$$V_{comm} = \frac{\text{position command value(k)} - \text{position command value(k}-1)}{1\text{ms}}$$

V_{comm}: command velocity

Fig. 8-10: Command velocity

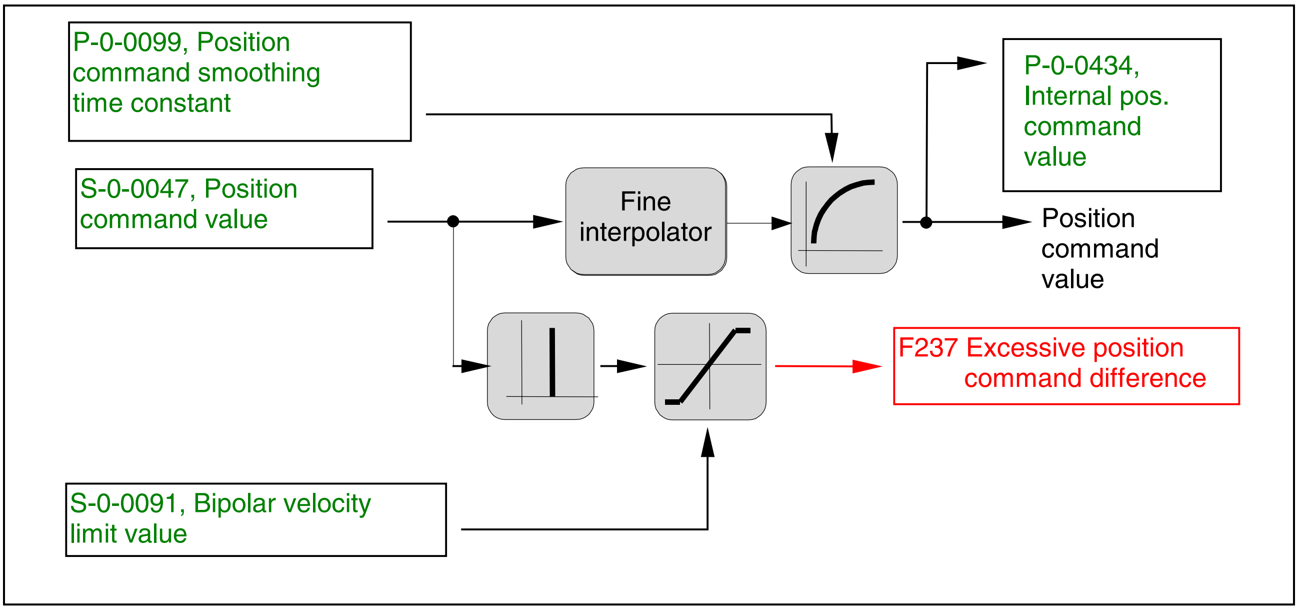


Fig. 8-11: Command value processing: position control

See also chapter: "Position Controller"
See also chapter: "Velocity Controller"
See also chapter: "Current Controller"

Drive-controlled command value processing in position control

The drive-controlled command value processing in position control is a special form of cyclic position control. It has been conceived to operate Gantry axes that are command value-linked via an EcoX bus. When this operating mode is activated, the position difference of the drives is detected, in order to superpose a motion with defined acceleration and velocity to the command value default and therefore equalize the position difference (equalizing motion).

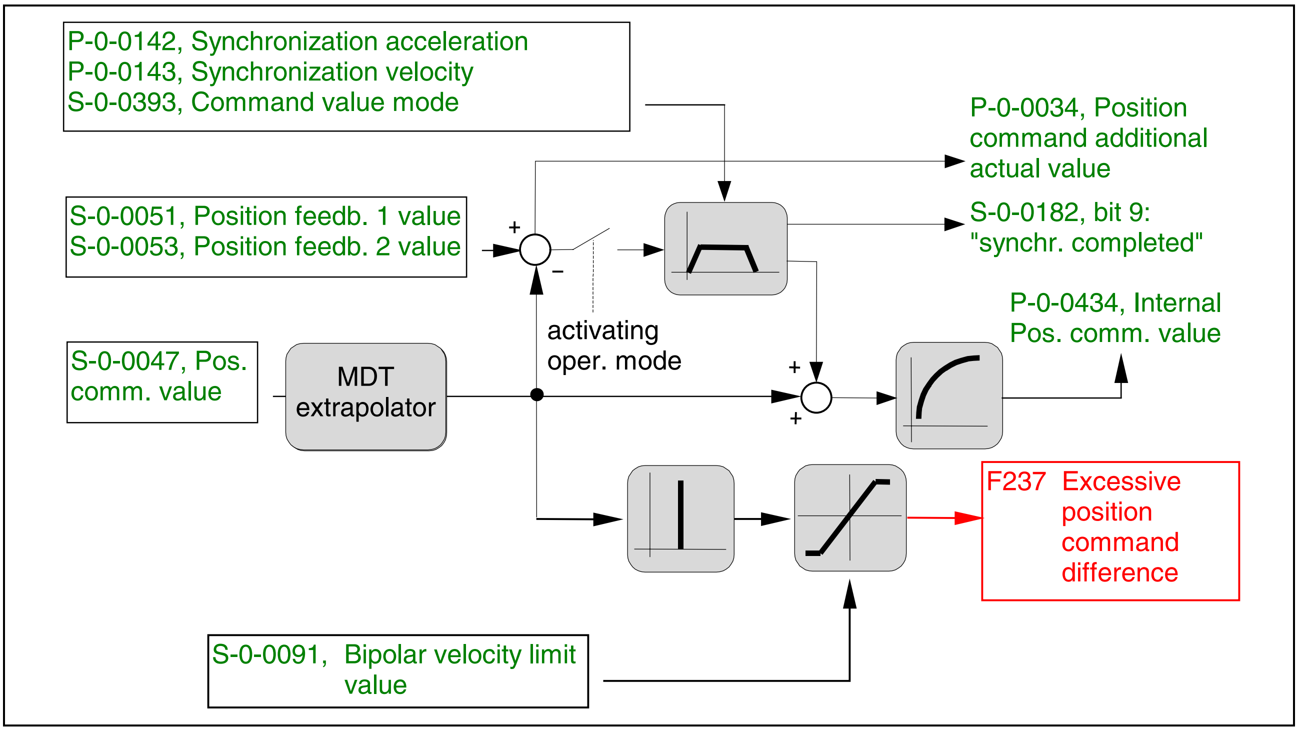


Fig. 8-12: Drive-controlled command value processing in position control

In the case of cyclic position control, the drive-controlled command value processing is activated with bit 8 of the operating mode parameter (e.g. S-0-0032=103 hex).

Parameters for setting the equalizing motion

- **P-0-0142, Synchronization acceleration**
- **P-0-0143, Synchronization velocity**
- **S-0-0393, Command value mode**

A command velocity is formed from two successive position command values. The result of the calculation is transmitted every millisecond.

The command velocity thus is:

$$V_{comm} = \frac{\text{position command value}(k) - \text{position command value}(k-1)}{1\text{ms}}$$

V_{comm}: command velocity

Fig. 8-13: Calculating the command velocity

This velocity is monitored to determine whether it exceeds **S-0-0091, Bipolar velocity limit value** (see also chapter: "Position Command Value Monitoring"). If S-0-0091 is exceeded, the error **F237 Excessive position command difference** is generated.

The preset position command value profile can be jerk-limited with the parameter **P-0-0099, Position command smoothing time constant**.

The position control loop is closed every 1000 µs.

The internal position command value at the position controller is displayed in parameter **P-0-0434, Internal Position command value**.

Status messages

When the equalizing motion is completed, bit 9 "synchronization completed" is set in Parameter **S-0-0182, Manufacturer class 3 diagnostics**.

Diagnostic messages with activated operating mode

- **A154 Position mode with encoder 1, drive-controlled**
- **A155 Position mode lagless with encoder 1, drive-controlled**
- **A156 Position mode with encoder 2, drive-controlled**
- **A157 Position mode lagless with encoder 2, drive-controlled**

Position controller

The position control deviation is generated from the effective position command value and the position feedback value (encoder 1 or encoder 2) that is used for control.

The deviation is transmitted to the position controller. The gain of the position controller is set by means of **S-0-0104, Position loop Kv-factor** (see also chapter: "Setting the position controller").

Bit 3 in the operating mode parameters (S-0-0032..35) indicates whether position control is run with lag distance or lagless.

Meaning of bit 3 of the operating mode parameters (S-0-0032...S-0-0035):

Bit 3 = 1	lagless	(with velocity feedforward)
Bit 3 = 0	with lag distance	(without velocity feedforward)

In the case of lagless position control an acceleration-proportional feedforward proportion can be added via parameter **S-0-0348, Acceleration feedforward gain** (see also chapter: "Setting the Acceleration Feed Forward").

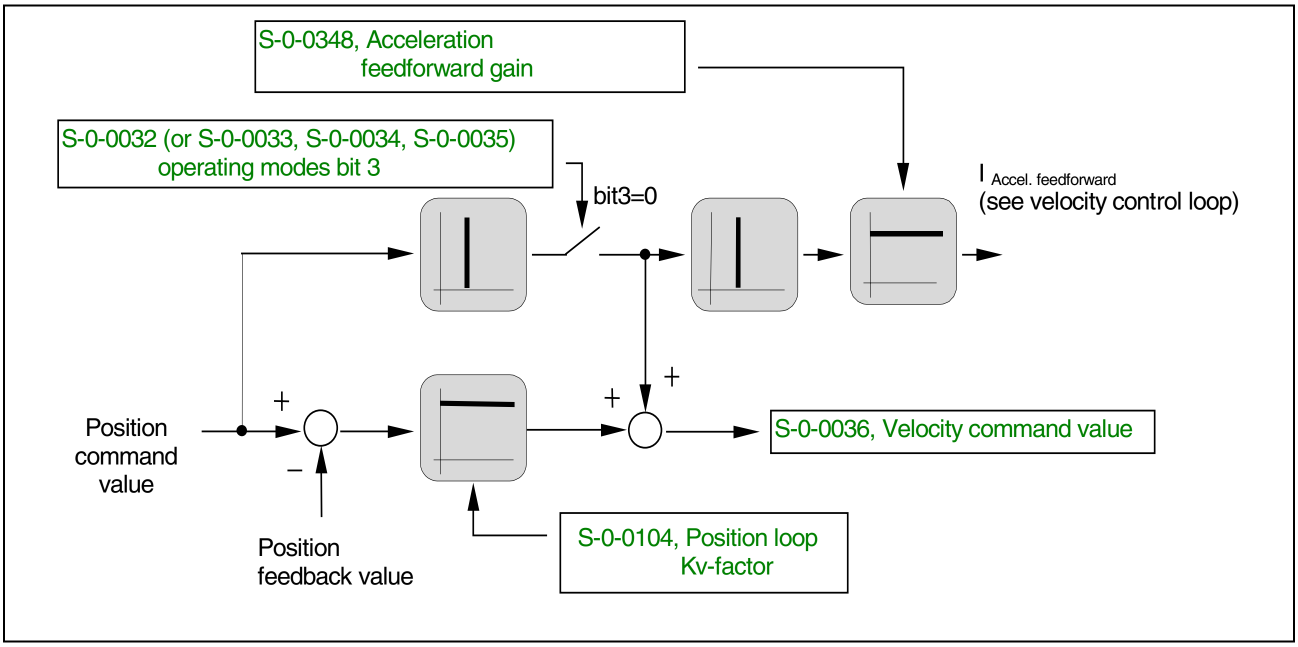


Fig. 8-14: Position controller

See also chapter: "Velocity Controller"
See also chapter: "Current Controller"

Position command value monitoring

If the drive is operated in the position control mode with cyclical position commands, new position command values are transmitted to the drive every NC cycle (**S-0-0001, NC Cycle time (TNcyc)**). The difference between the current and the last position command value is determined and checked for plausibility.

Reasons why the monitoring function is activated:

- Incorrect control system command values
- Command value transmission error

If the "Position control" operating mode is active, the velocity produced by the preset position command values of parameter **S-0-0047, Position command value** is compared to **S-0-0091, Bipolar velocity limit value**. **S-0-0001, NC Cycle Time (TNcyc)** acts as the time base for converting the position command value differences into a velocity.

If the command velocity resulting from the position command value exceeds **S-0-0091, Bipolar velocity limit value**, the error **F237 Excessive position command difference** is generated. For diagnostic purposes, both parameters

- **P-0-0010, Excessive position command value**
- **P-0-0011, Last valid position command value**

will be saved. The velocity produced by the difference of the two values generated the error.

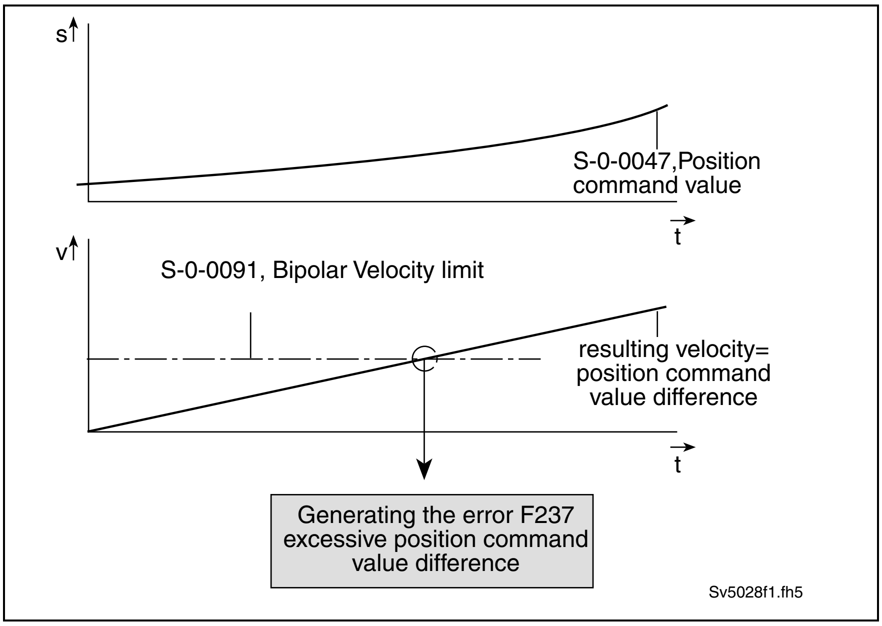


Fig. 8-15: Monitoring the position command value differences and generating the error **F237 Excessive position command difference**

Position command value monitoring - setting

The position command value monitor uses the parameter **S-0-0091, Bipolar velocity limit value**. S-0-0091 should be set to approximately 5 to 10% above the planned maximum velocity of the axis.

8.6 Operating mode: drive internal interpolation

Note: The operating mode "drive internal interpolation" becomes effective in the drive at the time that the profile is selected with P-0-4084=0xFF91. The target position must be programmed via parameter **S-0-0258, Target position**. The target position is then immediately accepted.

The drive is given a target position (asolute) in the operating mode "Drive internal interpolation". The drive now runs to the programmed target position while maintaining positioning velocity, positioning acceleration and the positioning jerk.

Pertinent parameters

For the travel process:

- **S-0-0108, Feedrate override**
- **S-0-0193, Positioning Jerk**
- **S-0-0258, Target position**
- **S-0-0259, Positioning Velocity**
- **S-0-0260, Positioning Acceleration**
- **S-0-0359, Positioning Deceleration**
- **S-0-0393, Command value mode**

For the status display:

- **S-0-0182, Manufacturer class 3 diagnostics**

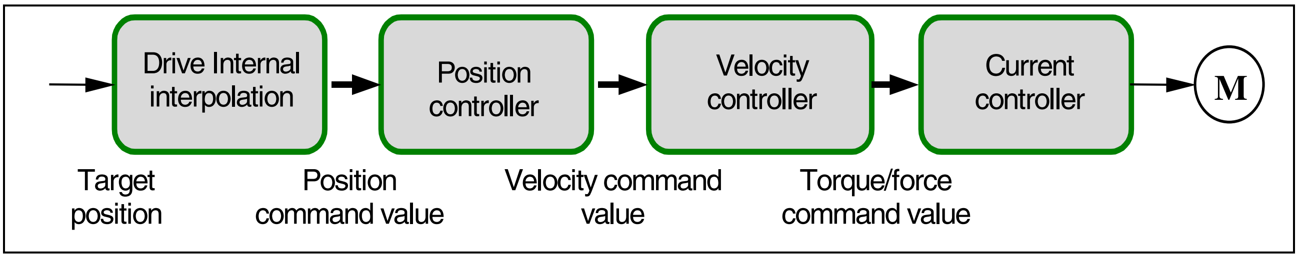


Fig. 8-16: Drive internal interpolation block diagram

Functional principle

The target position can be cyclically programmed via parameter **S-0-0258, Target position**.

Note: The control bits contained in S-0-0393 (bit 3 and bit 4) are meaningless in this operating mode.

The drive generates the position command profile necessary to move to the target position considering the limiting conditions in:

- **S-0-0259, Positioning Velocity**
- **S-0-0260, Positioning Acceleration**
- **S-0-0359, Positioning Deceleration**
- **S-0-0193, Positioning Jerk**
- **S-0-0108, Feedrate override**

Effective positioning velocity

The drive reaches its maximum velocity after an acceleration phase with the value set in **S-0-0260, Positioning Acceleration**.

The maximum velocity during a positioning procedure is the result of:

$$V_{max} = S-0-0259, \text{Positioning velocity} * \frac{S-0-0108, \text{ Feedrate override}}{100\%}$$

Effective accel and decel

The maximum delay is fixed in parameter **S-0-0359, Positioning Deceleration**.

If parameter **S-0-0359, Positioning Deceleration** equals zero, then the drive uses parameter **S-0-0260, Positioning Acceleration** for decel as well.

CAUTION

Damage to property caused by incorrect parameterization!

If the values for positioning decel and accel are zero, then the drive cannot brake. The set target is never reached or is overrun.

⇒ Always enter a value > 0 for positioning accel.

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Smoothing filter (or jerk filter)

Accel and decel are smoothed by using a jerk limit value and PT1 filtering. This means that accel or decel do not become effective until after t= 5*T_R.

The time constant T_R of the smoothing filter (jerk filter) results from:

$$T_R = \frac{S-0-0260,\ \text{Positioning Acceleration}}{S-0-0193,\ \text{Positioning Jerk}}$$

or

$$T_R = \frac{S-0-0359,\ \text{Positioning Deceleration}}{S-0-0193,\ \text{Positioning Jerk}}$$

Note: For the accel or decel procedure only one time constant, namely the biggest one in the above equation, is used.

S-0-0193, Positioning Jerk=0 switches the smoothing filter off, the desired accel or decel is reached directly.

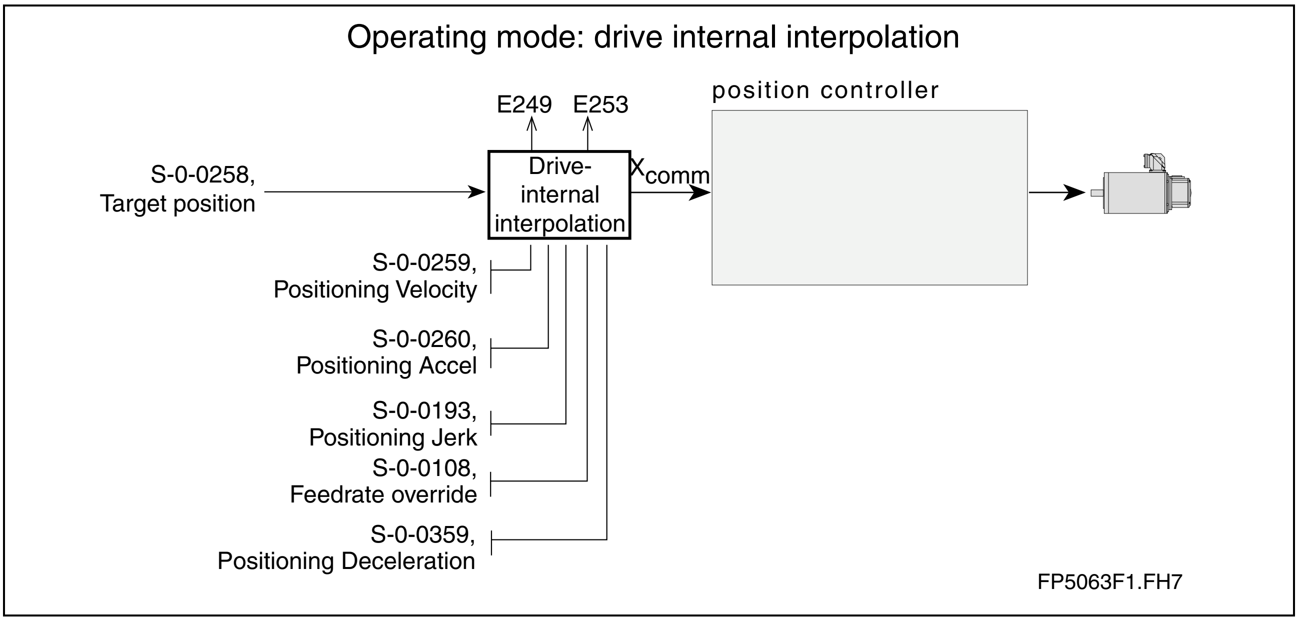


Fig. 8-17: Generating the position command value with drive internal interpolation

S-0-0393, Command value mode

Via bit 0 and bit 1 in parameter **S-0-0393, Command value mode** it is possible to fix both processing and effectiveness of **S-0-0258, Target position** with modulo processing.

Structure of parameter:

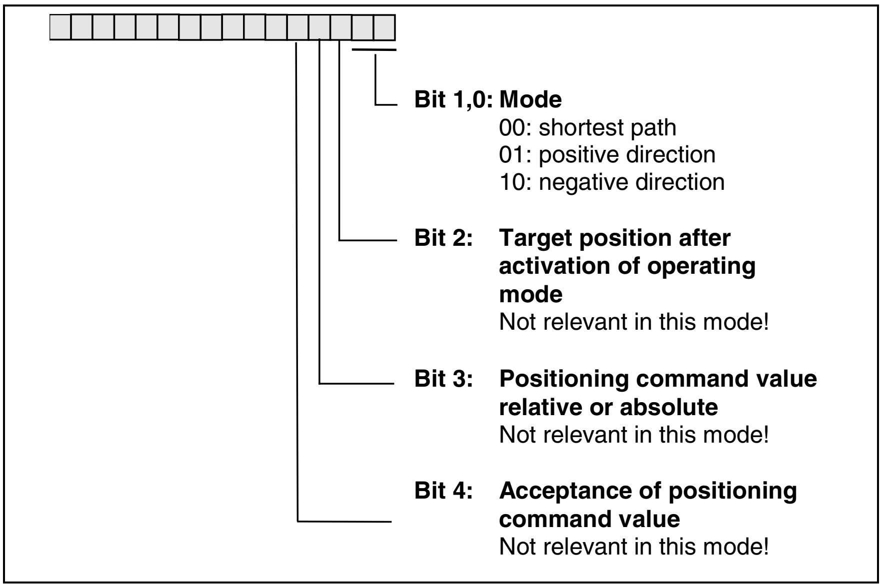


Fig. 8-18: Structure of parameter S-0-0393, Command value mode

For further information, also see parameter description **S-0-0393, Command value mode**.

Monitoring and diagnosing

The diagnosis with activated operating is one of the following:

- **A106 Drive controlled interpolation, encoder 1**
- **A107 Drive controlled interpolation, encoder 2**
- **A108 Drive controlled interpolation, lagless, encoder 1**
- **A109 Drive controlled interpolation, lagless, encoder 2**

The following checks are executed:

E253 Target position out of travel range

- If position limit value monitoring is activated (bit 4 of **S-0-0055, Position Polarity Parameter** is set) and the measurement system used for the operating mode has been homed, the parameter **S-0-0258, Target Position** is monitored for staying within the position limit values (S-0-0049 and S-0-0050). If these values are exceeded, the warning **E253 Target position out of travel zone** is generated.

  The preset target position will not be accepted.

E247 Interpolation velocity = 0

- If the positioning velocity specified in **S-0-0259, Positioning velocity** equals 0, then warning **E247 Interpolation velocity = 0** is generated. This warning is only generated if S-0-0259 is not cyclically transmitted via command communication (SERCOS, Profibus, ...) to the drive.

E248 Interpolation acceleration = 0

- If the positioning acceleration specified in **S-0-0260, Positioning acceleration** equals 0, then warning **E248 Interpolation acceleration = 0** is generated.

E249 Positioning velocity >= S-0-0091

- If the preset positioning velocity **S-0-0259, Positioning velocity** exceeds the maximum allowable limit value (**S-0-0091, Bipolar velocity limit value**), the warning **E249 Positioning velocity S-0-0259 > S-0-0091** will be generated.

  The drive will move at the velocity **S-0-0091, Bipolar velocity limit value** to the new target position.

E255 Feedrate override S-0-0108 = 0

- If the factor of the positioning velocity **S-0-0108, Feedrate override** equals 0, then warning **E255 Feedrate-override S-0-0108 = 0** is generated.

E264 Target position out of num. range

- If the internal numeric range for the position data is exceeded due to continuous relative positioning, then warning **E264 Target position out of num. range** is generated.

Status messages during the operating mode "drive internal interpolation"

In parameters **S-0-0013, Class 3 diagnostics** and **S-0-0182, Manufacturer class 3 diagnostics** there are the following status messages for the operating mode "drive internal interpolation":

- "target position reached", bit 12 of **S-0-0013, Class 3 diagnostics**
- "In target position", bit 10 of **S-0-0182, Manufacturer class 3 diagnostics** (Is mapped to bit 4 of **P-0-4078, Fieldbus status word**)
- "IZP", bit 6 of **S-0-0182, Manufacturer class 3 diagnostics**

The following profile explains how the status messages work:

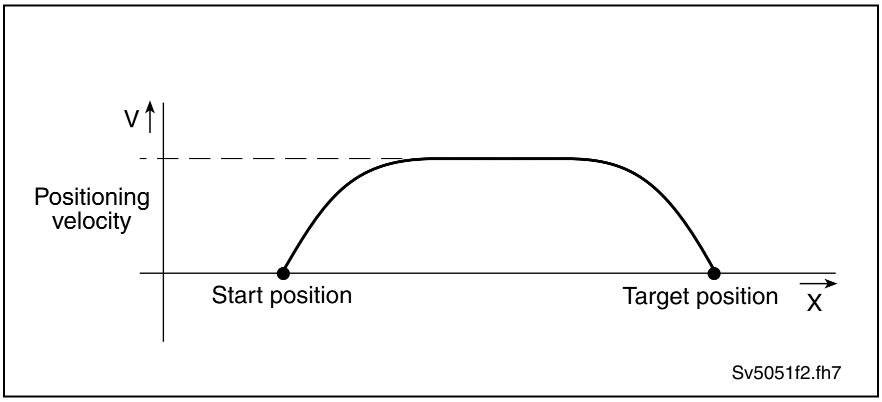


Fig. 8-19: Profile to explain how the interpolation status messages work

In this example, the drive is at the start position, when the new target position is preset.

The following time diagram results:

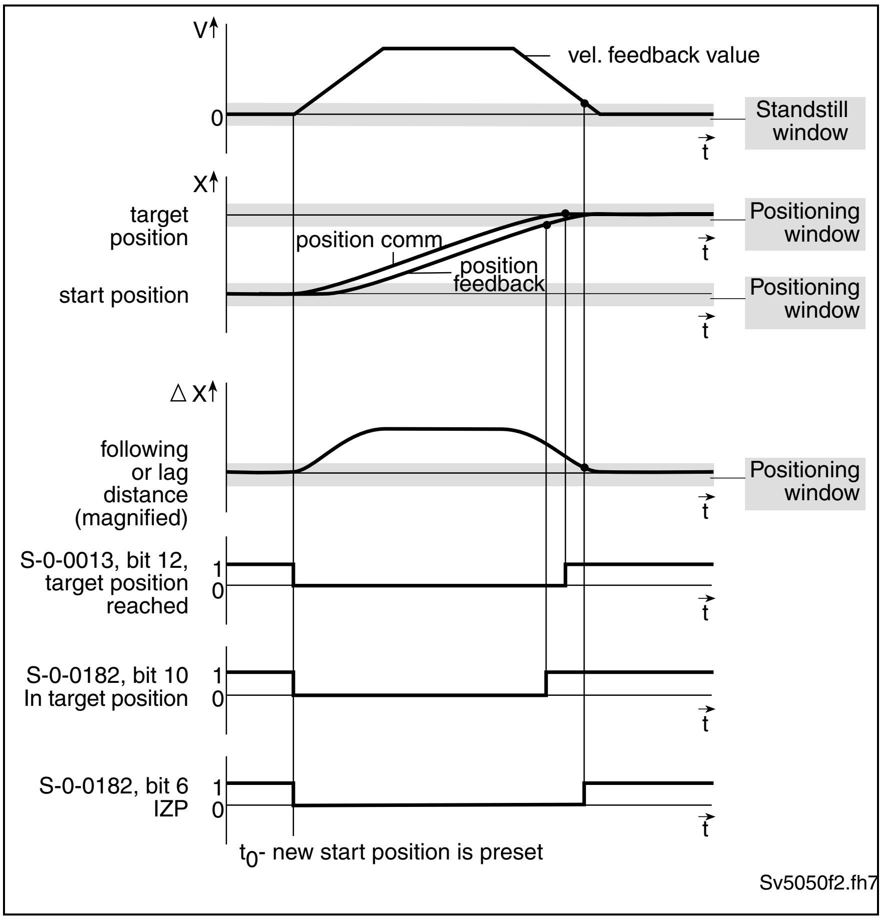


Fig. 8-20: Generating the status bits of the operating modes with drive internal interpolation

8.7 Operating mode: drive controlled positioning

Note: Mode "Drive controlled positioning" can only be used in user-defined mode (profile selection P-0-4084 = 0xFFFE). In this case, parameter **S-0-0282, Positioning command** is to be configured in the real time channel to transmit absolute target position or travel path. The control and status bits needed for the function are contained in the fieldbus control and status words.

In the operating mode "Drive controlled positioning" the drive receives a positioning command value (absolute or relative). The drive runs to the specified target position maintaining positioning velocity, positioning acceleration and positioning jerk.

Pertinent parameters

For the travel process:

- **S-0-0108, Feedrate override**
- **S-0-0193, Positioning Jerk**
- **S-0-0258, Target position**
- **S-0-0259, Positioning Velocity**
- **S-0-0260, Positioning Acceleration**
- **S-0-0282, Positioning command**
- **S-0-0346, Positioning command strobe**
- **S-0-0359, Positioning Deceleration**
- **S-0-0393, Command value mode**

For the status display:

- **S-0-0182, Manufacturer class 3 diagnostics**
- **S-0-0419, Positioning command acknowledge**

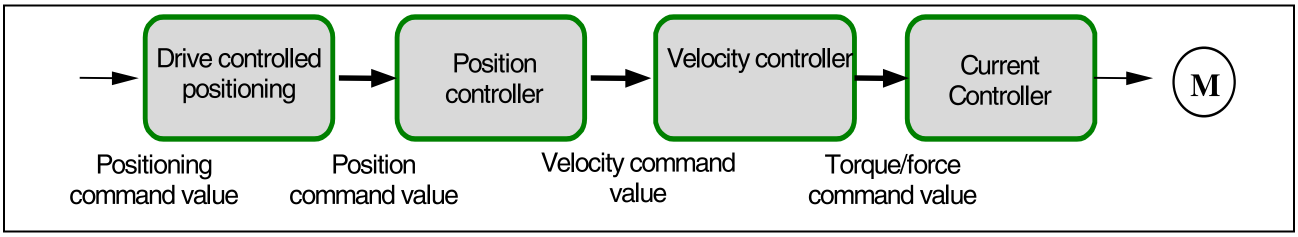


Fig. 8-21: Block diagram "Drive controlled positioning"

Functional principle

Target position or travel path is specified in parameter **S-0-0282, Positioning command**. In bit 3 of parameter **S-0-0393, Command value mode** it is set whether positioning command value is relative or absolute.

Absolute positioning command value
(S-0-0393, bit 3=0)

A status change in parameter **S-0-0346, Positioning command strobe** means positioning command value is directly accepted into parameter **S-0-0258, Target position**.

Relative positioning command value
(S-0-0393, bit 3=1)

A status change in parameter **S-0-0346, Positioning command strobe** means positioning command value is added to parameter **S-0-0258, Target position**.

Note: Bit 0 of parameter **S-0-0346, Positioning command strobe** is cyclically transmitted in the fieldbus control word (bit 0). This means it is not necessary to configure S-0-0346 in the real time channel (compare **P-0-4081, Real-time output object structure**).

Note: The target position can also be directly set in parameter **S-0-0258, Target position**. The specified value is always processed absolutely and is immediately given to the position command value generator, i.e. bits 3 and 4 of parameter **S-0-0393, Command value mode** and parameter **S-0-0346, Positioning command strobe** are not significant in this case.

The drive generates the position command value profile needed to run to the target position while maintaining the marginal conditions set in

- **S-0-0108, Feedrate override**
- **S-0-0193, Positioning Jerk**
- **S-0-0259, Positioning Velocity**
- **S-0-0260, Positioning Acceleration**
- **S-0-0359, Positioning Deceleration**

Effective positioning velocity

The maximum velocity is reached by the drive after an acceleration phase with the value set in **S-0-0260, Positioning Acceleration**.

The maximum velocity during a positioning procedure is the result of:

$$V_{max} = \text{S}-0-0259\text{, Positioning Velocity} * \frac{\text{S}-0-0108\text{, Feedrate override}}{100\%}$$

Effective accel and decel

The maximum delay is fixed in parameter **S-0-0359, Positioning Deceleration**.

If parameter **S-0-0359, Positioning Deceleration** equals zero, then the drive uses parameter **S-0-0260, Positioning Acceleration** for decel as well.

CAUTION

Damage to property caused by incorrect parameterization!

If the values for positioning decel and accel are zero, then the drive cannot brake. The set target is never reached or is overrun.

⇒ Always enter for positioning accel a value > 0.

Smoothing filter (or jerk filter)

Accel and decel are smoothed using a jerk limit value and a PT1 filtering. This means that accel or decel do not become effective until after t= 5*T_R.

The time constant T_R of the smoothing filter (jerk filter) results from:

$$T_R = \frac{\text{S - 0 - 0260, Positioning Acceleration}}{\text{S}-0-0193\text{, Positioning Jerk}}$$

or

$$T_R = \frac{\text{S - 0 - 0359, Positioning Deceleration}}{\text{S}-0-0193\text{, Positioning Jerk}}$$

Note: For the accel or decel procedure only one time constant, namely the biggest one in the above equation, is used.

S-0-0193, Positioning Jerk=0 switches the smoothing filter off, the desired accel or decel is reached directly.

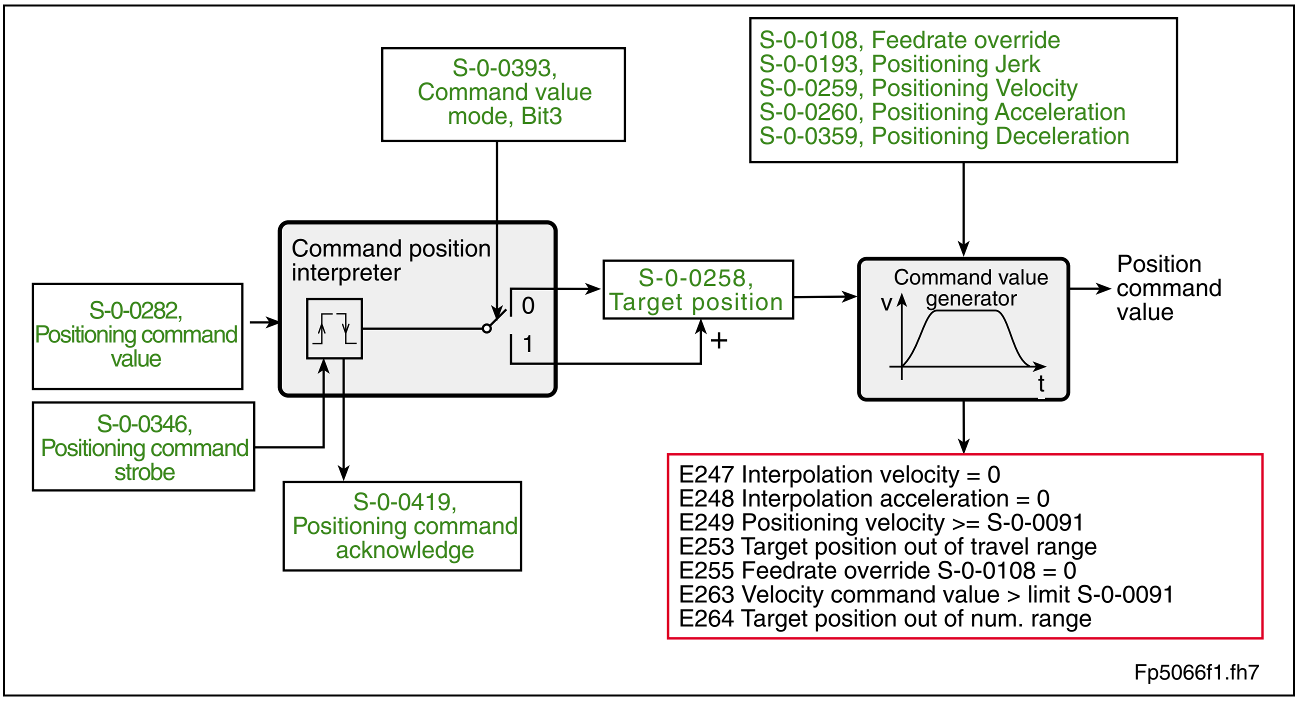


Fig. 8-22: Generating position command value

S-0-0393, Command value mode

Accepting and defining parameter **S-0-0282, Positioning command** depends on what is set in parameter **S-0-0393, Command value mode**.

Structure of the parameter:

- **Bit 1,0: Mode**
  00: shortest path
  01: positive direction
  10: negative direction
- **Bit 2: Target position after activation of mode**
  0: reference for relative positioning is S-0-0258
  1: reference for relative positioning is actual positon value
- **Bit 3: Positioning command value relative or absolute**
  0: Positioning command value is absolute target position
  1: Positioning command value is relative position (travel path)
- **Bit 4: Acceptance of positioning command value**
  0: current target is run to before new target
  1: Positioning command value directly run to, previous target ignored

Fig. 8-23: Structure of parameter S-0-0393, Command value mode

For more information, see parameter description **S-0-0393, Command value mode**.

Acknowledging command value strobe

S-0-0419, Positioning command acknowledge

Acknowledging acceptance of S-0-0282 is used to inform the control unit of whether the preset positioning command value was accepted by the drive or not.

Note: Bit 0 of parameter **S-0-0419, Positioning command acknowledge** is cyclically transmitted in the fieldbus status word bit 10. This means no configuration is needed in the real time channel.

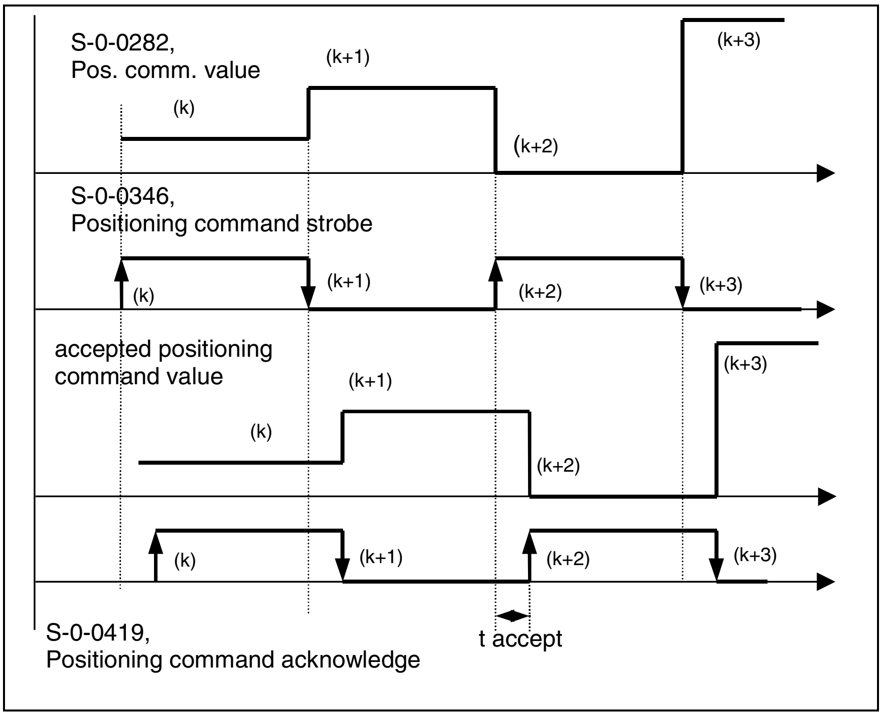


Fig. 8-24: Positioning command value acceptance and acknowledge

Time t_{accept} (see illustration above) defines the time between status change of the acceptance bit by the control and the receipt of acknowledge in the control. The time is made up of effective transmission time of the command and actual values and thus depends on the configuration of the interface to the control (e.g. SERCOS/Fieldbus-Timing-Parameter).

Note: If the operating mode "Drive controlled positioning" is not yet active, then the acknowledgement of acceptance of the new positioning command value does not take place.

Acknowledge if parameter S-0-0393, Command value mode, bit 4 = 0

By setting bit 4 to "0" in parameter **S-0-0393, Command value mode** it is ensured that a positioning command value specified once will always be run to.

The acknowledgement of acceptance takes place when the new positioning command value is accepted into the intermediate memory in parameter **S-0-0258, Target position** and thus in the position command value generator.

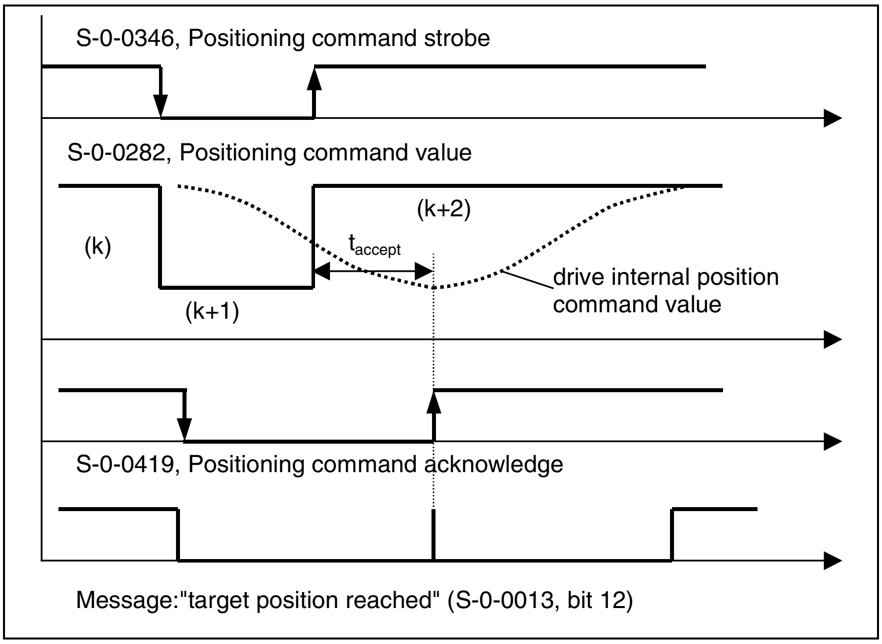


Fig. 8-25: Acknowledge acceptance of positioning command value in mode "running to positioning command value (k+2)"

Acknowledge with error when positioning command value overrun

If in mode "Running to positioning command value" the attempt is made to set a new positioning command value by toggling parameter **S-0-0346, Positioning command strobe**, even though the previous positioning command value (k+1) has not yet been accepted (as the previous positioning command value (k) was not run to yet), then error **F250 Overflow of target position preset memory** is generated.

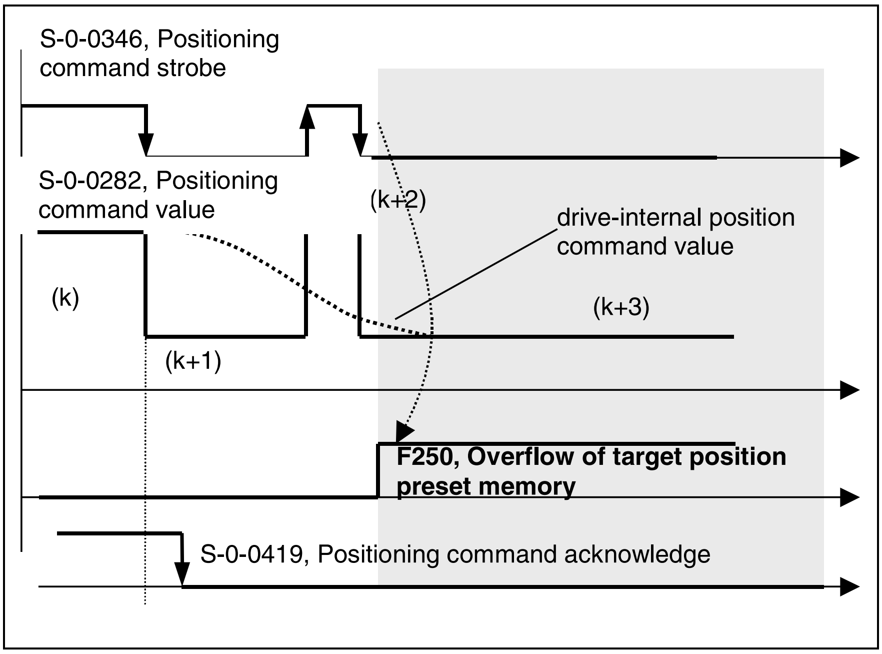


Fig. 8-26: Acknowledge with error overrun in positioning command value

Monitoring and diagnoses

The diagnosis with active mode is one of the following:

- **A106 Drive controlled interpolation, encoder 1**
- **A107 Drive controlled interpolation, encoder 2**
- **A108 Drive controlled interpolation, lagless, encoder 1**
- **A109 Drive controlled interpolation, lagless, encoder 2**

The following checks are conducted:

E253 Target positioning outside of travel range

- If monitoring of position limit values is active (bit 4 of **S-0-0055, Position polarities** is set) and the measuring system of the mode is in reference, then the parameter **S-0-0258, Target position** is checked to maintain position limit values (S-0-0049 or S-0-0050). If it overruns the limit values, then warning **E253 Target position out of travel range** is generated.

  The prescribed target position will not be accepted.

E247 Interpolation velocity = 0

- If specified positioning velocity in **S-0-0259, Positioning Velocity** is "0", then warning **E247 Interpolation velocity = 0** is generated. It is only generated if S-0-0259 is not cyclically transmitted via command communication (SERCOS, Profibus, ...) to the drive.

E248 Interpolation accel = 0

- If specified positioning acceleration in **S-0-0260, Positioning Acceleration** is "0", then warning **E248 Interpolation acceleration = 0** is generated.

E249 Positioning velocity > S-0-0091

- If the specified positioning velocity **S-0-0259, Positioning Velocity** exceeds the maximum limit value (**S-0-0091, Bipolar velocity limit value**) then warning **E249 Positioning velocity >= S-0-0091** is generated.

  The drive runs at velocity **S-0-0091, Bipolar velocity limit value** to the new target position.

E255 Feedrate-Override S-0-0108 = 0

- If the factor of positioning velocity **S-0-0108, Feedrate override** is "0", then warning **E255 Feedrate-override S-0-0108 = 0** is generated.

E264 Target position out of num. range

- If the internal numeric range for the position data is exceeded due to continuous relative positioning, then warning **E264 Target position out of num. range** is generated.

Status messages

In parameters **S-0-0013, Class 3 diagnostics** and **S-0-0182, Manufacturer class 3 diagnostics** there are the following status messages for the operating mode "Drive controlled positioning":

- "Target position reached", bit 12 of **S-0-0013, Class 3 diagnostics**
- "In target position", bit 10 of **S-0-0182, Manufacturer class 3 diagnostics** (Is mapped to bit 4 of **P-0-4078, Fieldbus status word**)
- "IZP", bit 6 of **S-0-0182, Manufacturer class 3 diagnostics**

The following profile explains how the status messages work:

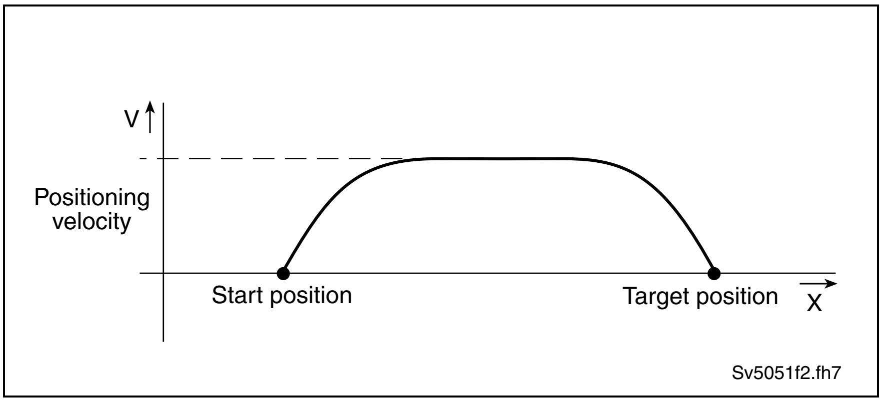


Fig. 8-27: Travel profile to show how interpolation status messages work

In this example, the drive is in start position when the new target position is specified.

This results in the following time diagram:

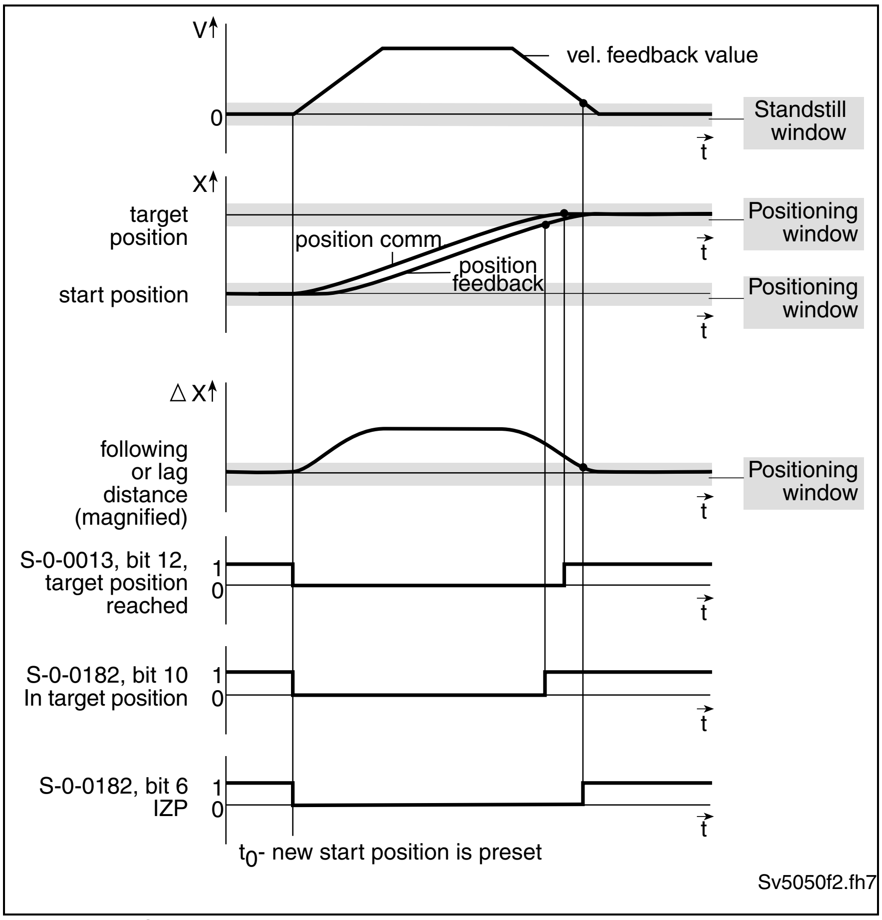


Fig. 8-28: Generating status bits of operating mode with drive controlled positioning

8.8 Positioning block mode

Note: With the profile types:
- **P-0-4084, Profile type** = 0xFF80 or
- **P-0-4084, Profile type** = 0xFF81 or
- **P-0-4084, Profile type** = 0xFF82

the operating mode "positioning block mode" is automatically internally set!

With the operating mode "Positioning block mode" it is possible to run 64 positioning blocks that have been pre-programmed. The drive runs position control to a target position, while maintaining velocity, acceleration, deceleration and jerk limits as defined for each positioning block.

The positioning blocks are actuated by the block selection.

Following block processing permits execution of several positioning blocks processed in direct sequence without having to re-issue a start signal each time.

Typical applications are positioning processes which cover long distances at high speeds (rapid traverse) and then position at end position at low speeds without any intermediate stops. For example:

- Taking up or putting down transport goods by robots
- Execution of joining processes in assembly facilities

A following block chain is made up of a start block and one or more following blocks. The start block is selected and activated in the usual manner. The transition to a following block can vary.

Note: **Following block mode** is possible with absolute and relative positioning blocks with residual path memory. The final block of a chain is not defined as a following block. This identifies the end of the following block chain.

Pertinent parameters

- **P-0-4006, Process block target position**
- **P-0-4007, Process block velocity**
- **P-0-4008, Process block acceleration**
- **P-0-4009, Process block jerk**
- **P-0-4019, Process block mode**
- **P-0-4026, Process block selection**
- **P-0-4051, Process block acquittance**
- **P-0-4052, Positioning block, last accepted**
- **P-0-4057, Positioning block, input linked blocks**
- **P-0-4060, Process block control word**
- **P-0-4063, Process block deceleration**
- **S-0-0346, Set-up flag for relative command values**
- **S-0-0182, Manufacturer class 3 diagnostics**
- **S-0-0259, Positioning Velocity**

Note:	S-0-0259 is used in positioning block mode to reduce positioning velocity (see also **P-4060, Process block control word**).

How it works

Positioning block elements

A positioning block is defined with:

- **P-0-4006, Process block target position**
- **P-0-4007, Process block velocity**
- **P-0-4008, Process block acceleration**
- **P-0-4009, Process block jerk**
- **P-0-4019, Process block mode**
- **P-0-4063, Process block deceleration**

Note:	Each parameter has 64 elements, whereby the elements of the same number write this number into the travel profile of the positioning block.

The drive reaches the relevant positioning block velocity after an acceleration phase with the relevant **P-0-4008, Process block acceleration**.

The effective velocity during a positioning procedure is computed as follows:

$$Vmax = P-0-4007 * S-0-0108 / 100\%$$

Vmax: velocity
P-0-4007, Process block velocity
S-0-0108, Feedrate override

Fig. 8-29: Effective velocity during a positioning procedure

The maximum deceleration is specified by parameter **P-0-4063, Process block deceleration**.

Effective acceleration and deceleration

If parameter **P-0-4063, Process block deceleration** equals zero, then the drive uses parameter **P-0-4008, Process block acceleration** to decelerate.

CAUTION

Property damage!

If the acceleration and deceleration value is equal to zero, then the drive can no longer brake. The specified target is not reached or overrun.

⇒ Set acceleration value > 0

Acceleration and deceleration are smoothed with the specification of a jerk limit value using a PT1 filter. The acceleration or deceleration is thus reached after about five times the time constant.

The time constant of this smoothing filter is computed:

$$T = P-0-4008 / P-0-4009$$
or
$$T = P-0-4063 / P-0-4009$$

P-0-4008, Process block acceleration
P-0-4009, Process block jerk
P-0-4063, Process block deceleration

Fig. 8-30: Determining the time constant

The same time constant is used for both acceleration and deceleration. The greater time constant of the above relationship is used.

If parameter **P-0-4009, Process block jerk** is equal to zero, then the smoothing filter is off, acceleration or deceleration is being reached immediately.

Positioning block control word

With parameter **P-0-4060, Process block control word** the positioning velocity can be limited to the value set in parameter **S-0-0259, Positioning Velocity**.

Position return message

If a positioning block is completed, then bit 12 "End position reached" is set in parameter **S-0-0182, Manufacturer class 3 diagnostics** (→ |target position-actual position value| < positioning window).

Interrupting a positioning block

An interruption can be the result of

- removal of the drive enable
- activation of drive halt.

Activating positioning blocks

"Positioning block mode" must be entered as the primary mode of operation. By activating drive enable and setting drive halt =1 the drive is in primary mode of operation.

A positioning block is started by

- Status change of bit 0 of the parameter **S-0-0346, Positioning command strobe**.
- If the drive is working in the user-defined mode (**P-0-4084, Profile type** = 0xFFFE), then the command value is transmitted in the fieldbus control word (P-0-4077, bit 0 equals S-0-0346 bit 0).
- If profile type I/O mode (**P-0-4084, Profile type** = 0xFF80) has been set in the drive, then a positioning block starts by setting the start signal (**P-0-4077, Fieldbus control word**, bit 1) or the strobe signal (**P-0-4077, Fieldbus control word**, bit 3).

Note: As long as the parameter is not toggled, the drive will remain on the actual position or be brought to a position controlled standstill.

Block selection

In positioning block mode, a positioning block is selected

- by writing data to **P-0-4026, Process block selection**
- or with bit 8...bit 13 in **P-0-4077, Fieldbus control word** in I/O mode

Positioning block modes

Parameter **P-0-4019, Process block mode** is used to set the manner in which the target position is processed in parameter **P-0-4006, Process block target position**.

Possible positioning block modes:

- **Absolute positioning**
- **Relative positioning**
- **Relative positioning with residual path storage**
- **Infinite travel in positive / negative direction**
- **Following block processing**

Note: The control of fieldbus drives does not work via parameter **S-0-0134, Master control word**, but via the profile type-dependent bits in **P-0-4077, Fieldbus control word**.

Absolute positioning

Prerequisite

Parameter **P-0-4019, Process block mode** = 101h

In an absolute positioning block, the target position is a fixed (absolute) position within the machine co-ordinate system.

Prerequisites for the execution of absolute positioning blocks

- The drive must be **homed**.
- The travel range can be limited with position limit values. Absolute positioning blocks are only executed if the target position lies within the allowable travel range.

Example Absolute positioning with target position = 700

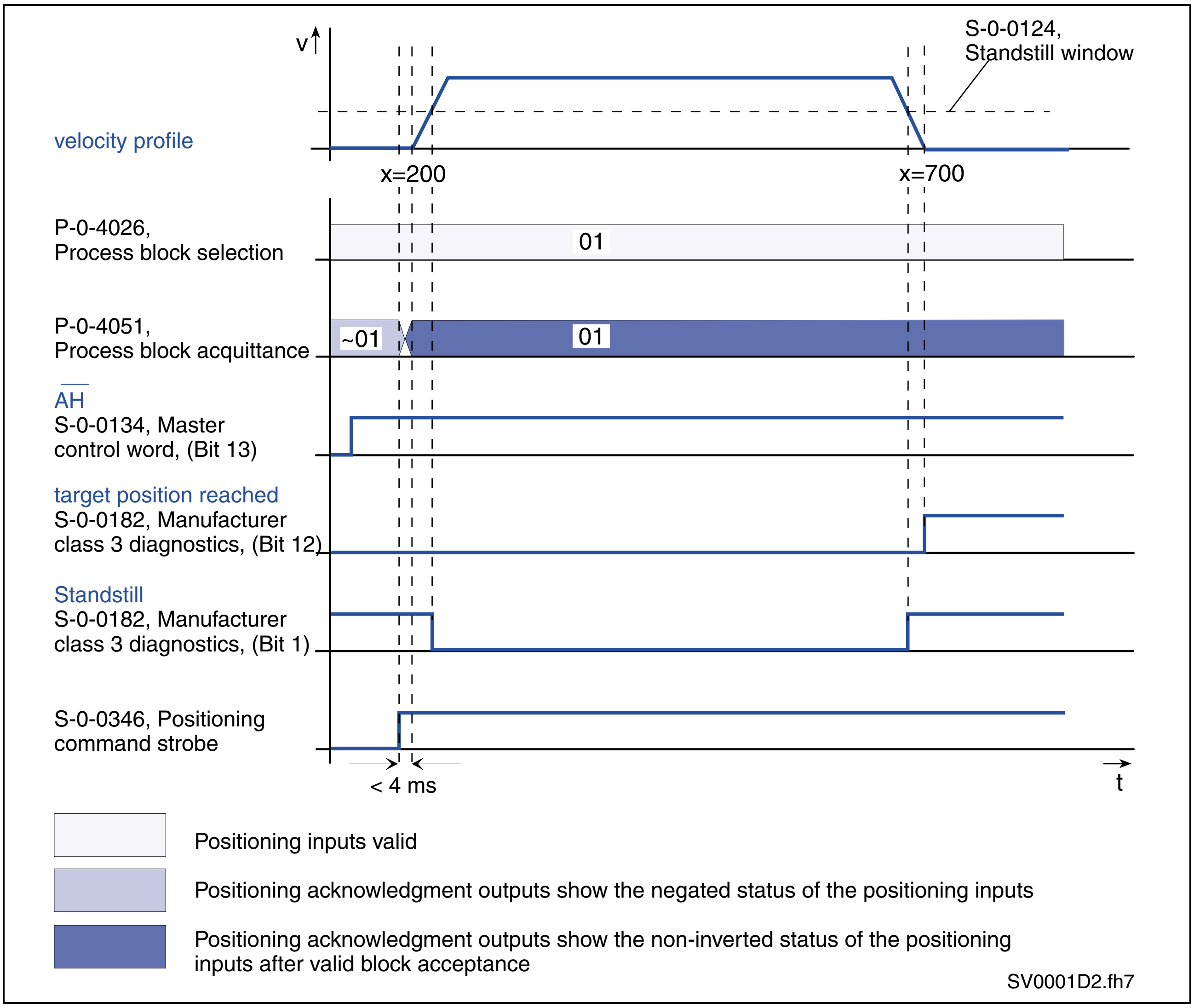


Fig. 8-31: Absolute positioning block

Relative positioning without residual path storage

Prerequisite Parameter **P-0-4019, Process block mode** = 2h

Relative positioning blocks are also executed, if the drive has not been homed.

Reference position In relative positioning blocks without residual path storage, the target position in the positioning blocks is added to the current position.

Residual path If positioning blocks are interrupted, then a part of a path to the target position remains. This remaining distance is the residual path.

Chain dimensional reference By sequencing relative positioning blocks it is possible to position with chain dimensional reference. If a relative block is interrupted without residual path storage, then this chain reference is lost.

If the positioning block is completed (i.e. the drive reaches target position and message "end position reached" is activated) then positioning is possible without the loss of the chain reference.

Note: If infinite positioning in either a forward or backward direction is achieved by sequencing relative positioning blocks (transport belt), then the position data must be scaled in modulo format. (Modulo value = transport belt length or modulo value = 2 times the maximum travel distance.)

Example Relative positioning without residual path storage with target position = 700 (current position = 200).

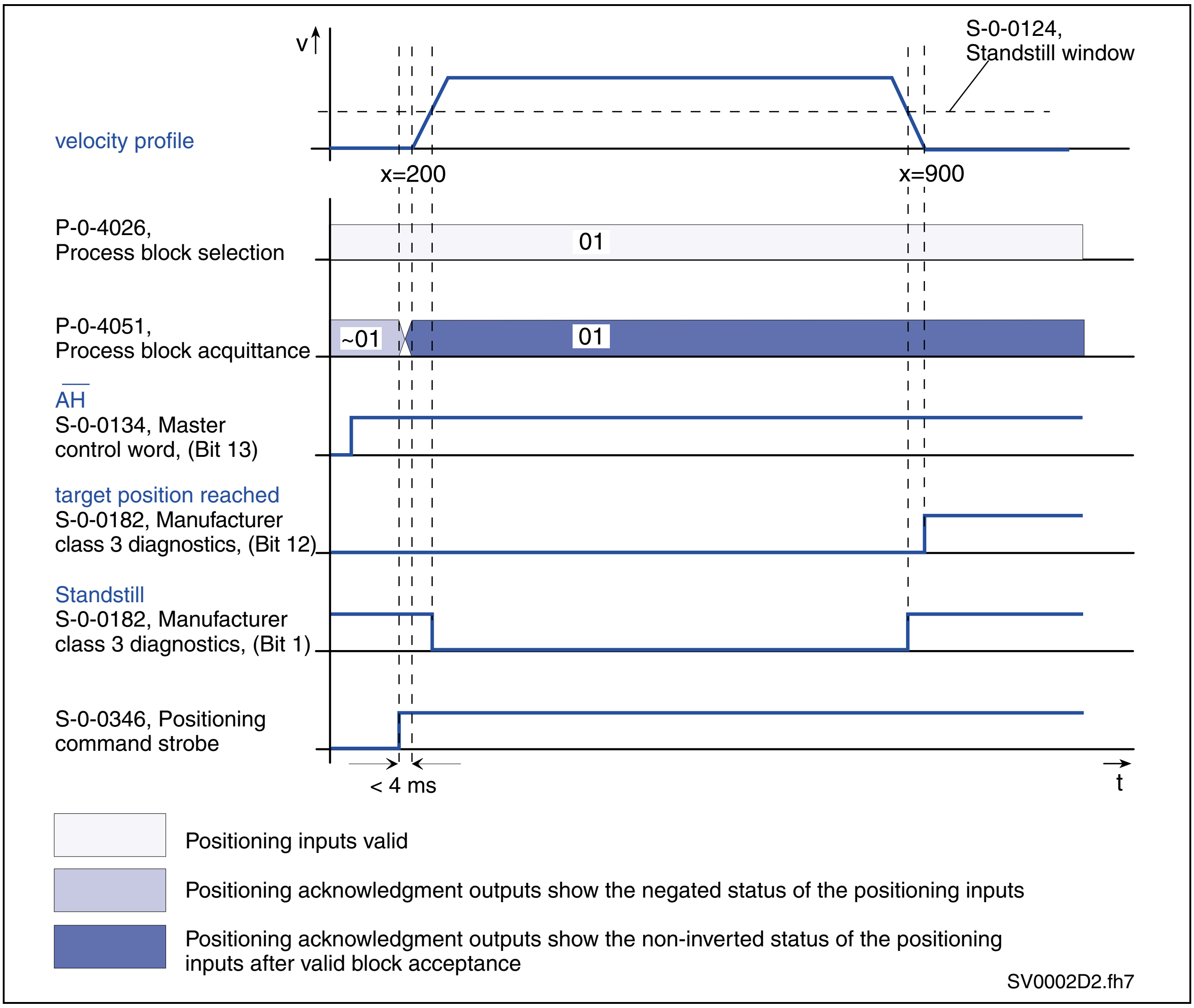


Fig. 8-32: Relative positioning block without residual path storage

Example Relative positioning without residual path storage with target position = 700 (current position = 200). Terminate and restart a relative positioning block without residual path storage.

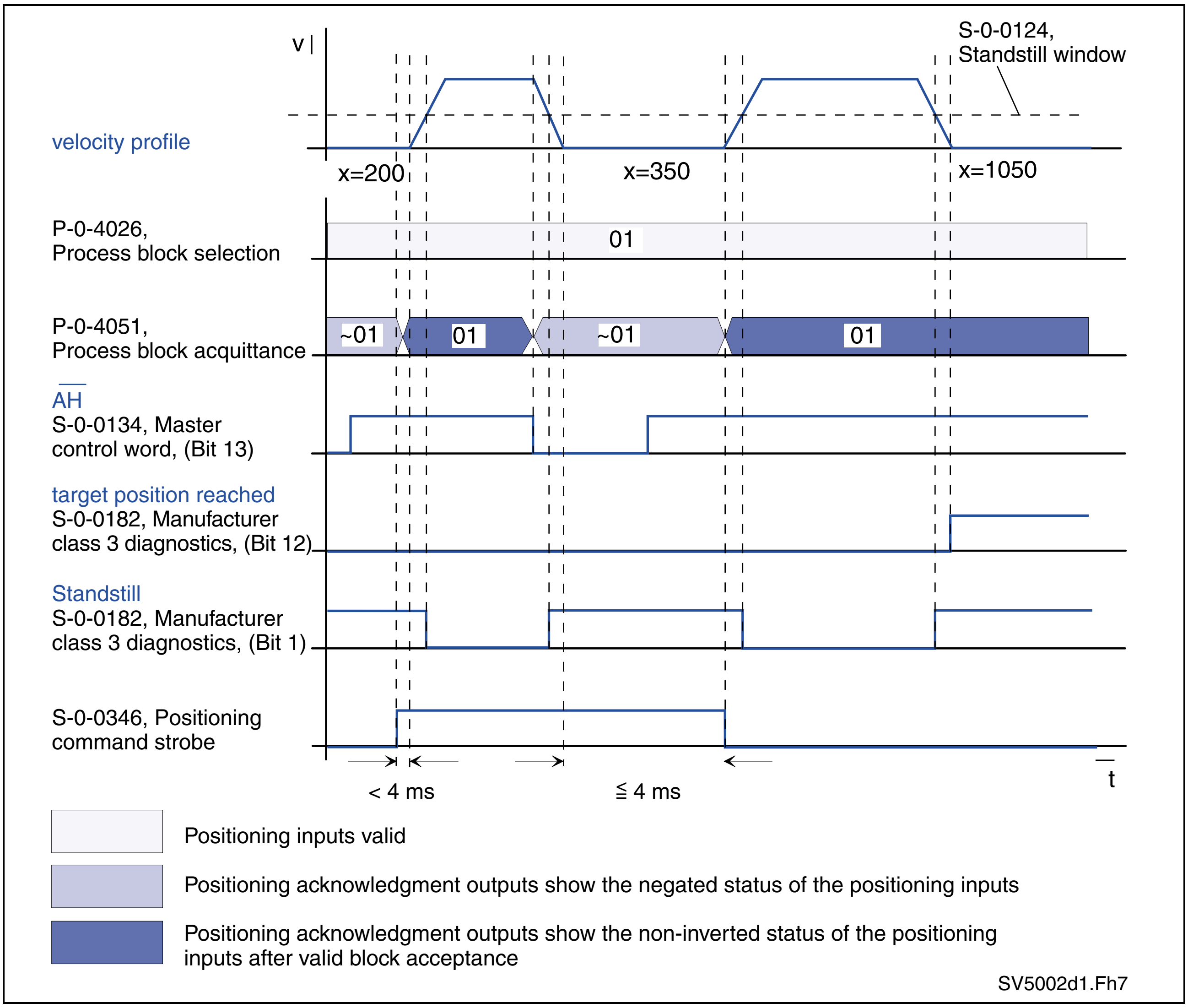


Fig. 8-33: Terminating a relative positioning block without residual path storage

Relative positioning with residual path storage

Prerequisite Parameter **P-0-4019, Process block mode** = 102h

Relative positioning blocks with residual path storage are also executed, if the drive has not been homed.

In a relative positioning block with residual path storage, the target position is a relative path which relates to the target position which last generated the message "end position reached".

Chain dimensional reference By sequencing relative positioning blocks it is possible to position with chain dimensional reference. If a relative positioning block is interrupted with residual path storage, then this chain reference is retained.

Note: If a second positioning block is started while such a positioning block is being executed, then the residual path is discarded. If this new block is also a relative positioning block with residual path storage, then the target position is related **to the current actual position** as if it were a relative path.

Example Relative positioning with residual path storage with target position = 700 without interruption (message: "End position reached" with position = 200).

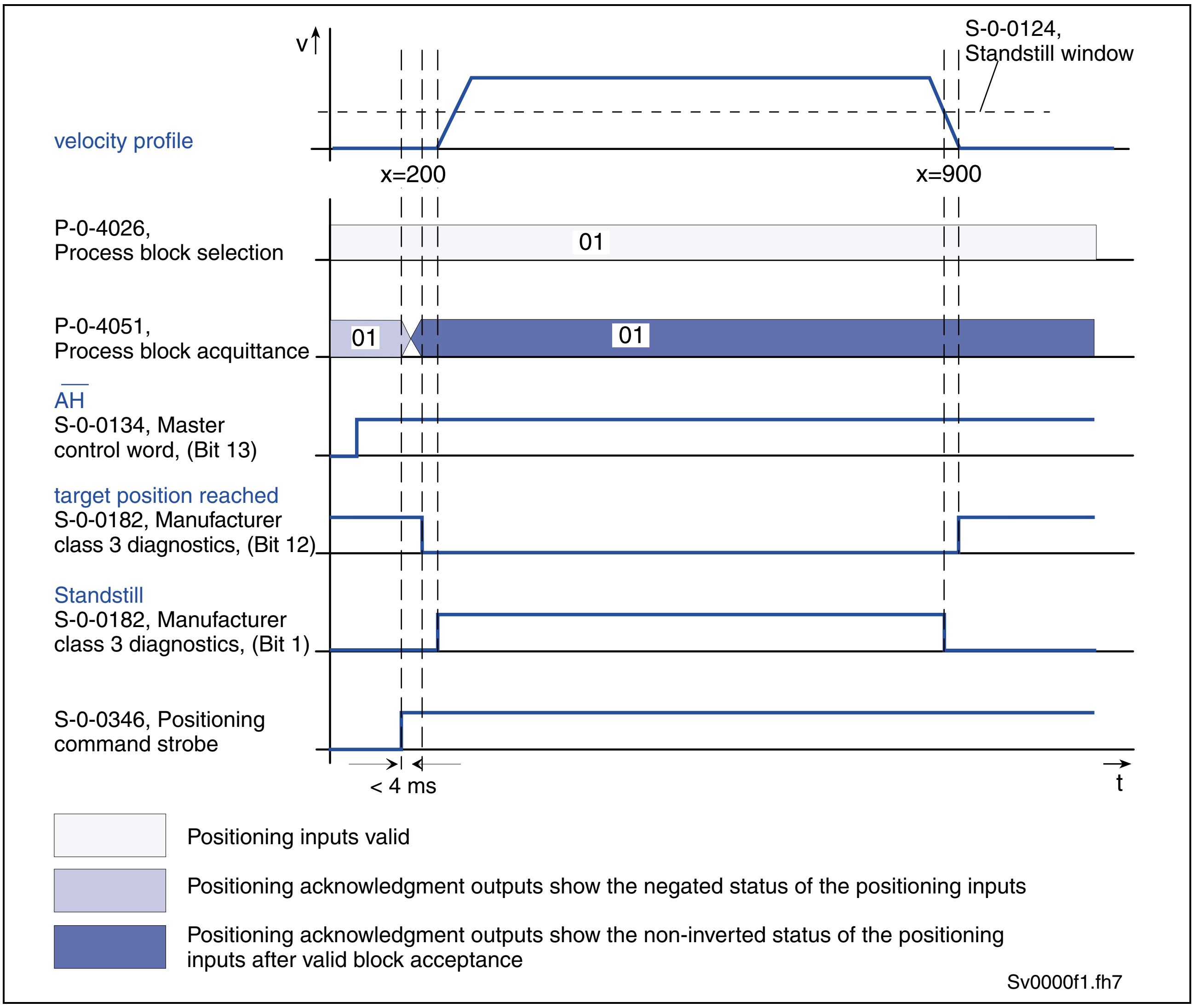


Fig. 8-34: Relative positioning block with residual path storage

Relative positioning block with residual path storage after activating drive enable

Reference position The position command value of the last "End position reached" message is used as reference position.

Note: The chain reference dimension is guaranteed.

Example Interrupted relative positioning block with residual path storage after activating drive enable with target position = 600

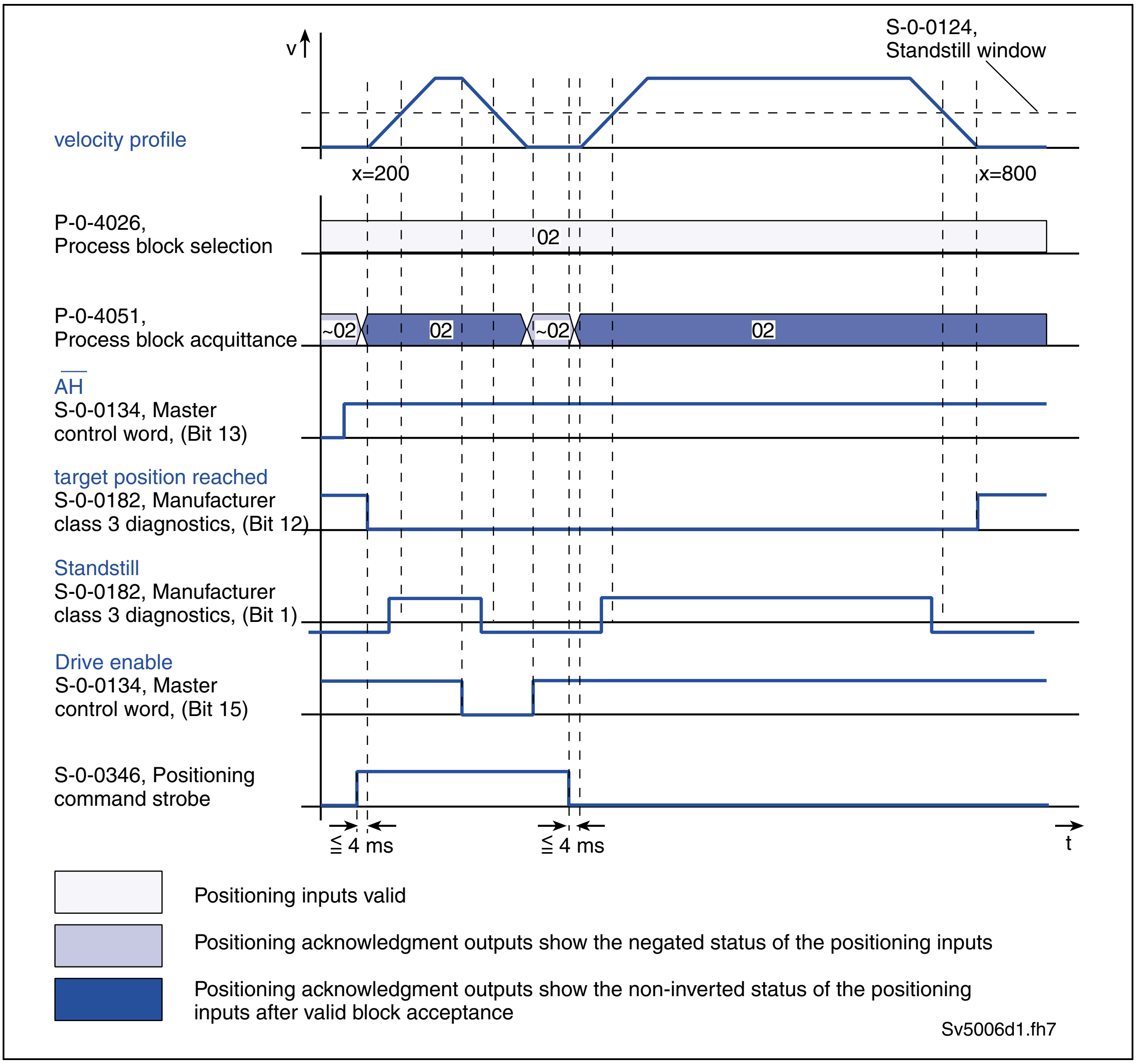


Fig. 8-35: Relative positioning block with residual path storage after activating the drive enable

Relative positioning block with residual path storage after interrupting with jog mode

Example Interrupted relative positioning block **with residual path storage** after jogging with target position = 600 **without overrunning the target position** while jogging.

Reference position The position command value of the last "End position reached" message is used as reference position.

Behavior The distance jogged between the interruption and restart of the positioning block is taken into account. The drive continues to run to the already computed target position.

Note: The chain dimensional reference is guaranteed.

Example Interrupted relative positioning block **with residual path storage** after jogging with target position = 600 **with overrunning the target position** while jogging.

Behavior The drive runs back to the target position set prior to the interruption.

Note: The chain dimensional reference is guaranteed.

Reference position The position command value of the last "End position reached" message is used as reference position.

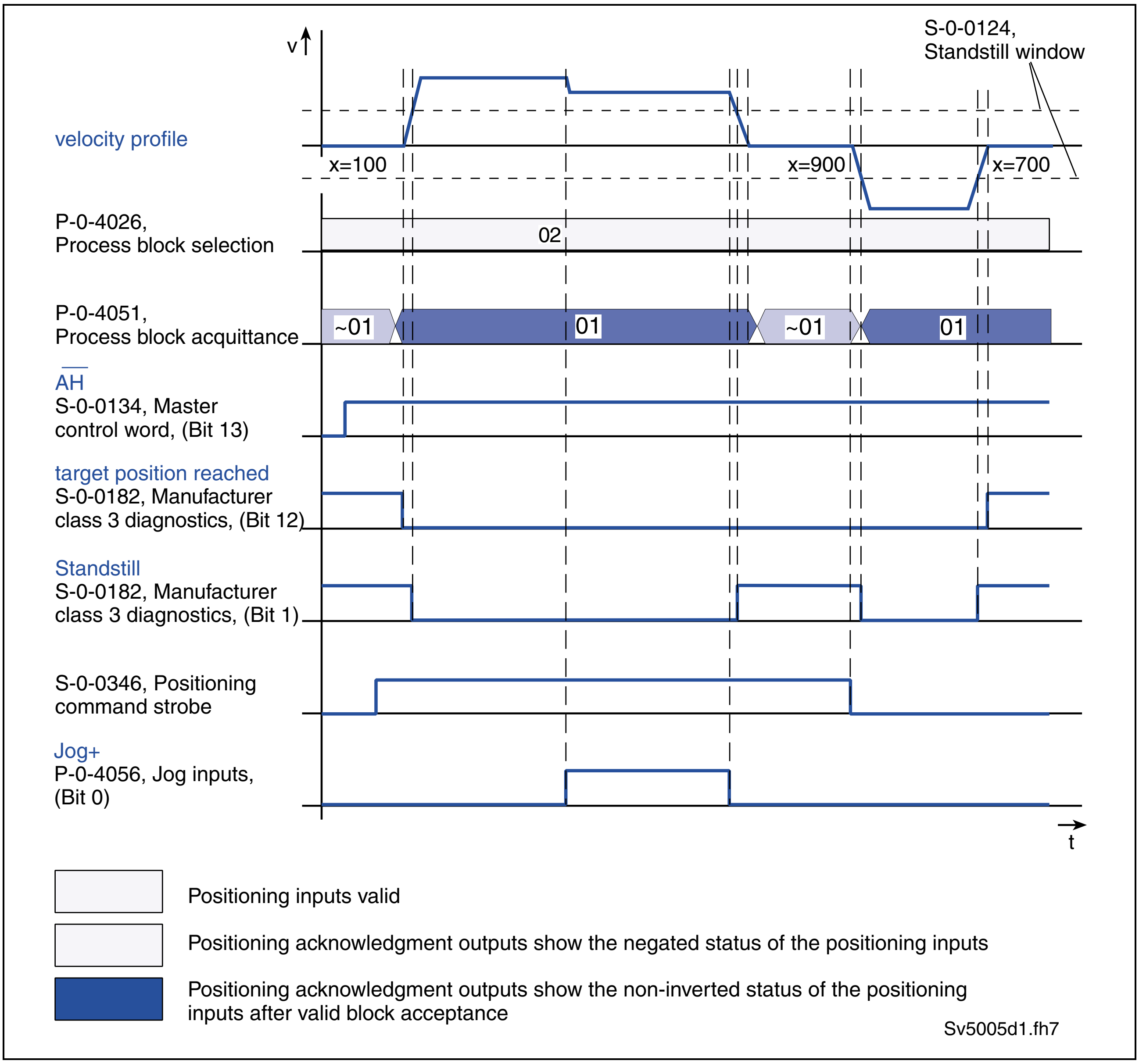


Fig. 8-36: Relative positioning block with residual path storage after jogging

Relative positioning block with residual path storage after switching drive controller control voltage on and off

If an absolute encoder is used then it is possible that the chain reference is retained after switching control voltage on and off. The previously computed target position is stored at power shutdown. The rest of the distance is traveled after the interrupted relative positioning block with residual path storage is activated.

Behavior If a single-turn encoder is used, then the residual path is discarded and added to the actual position.

Reference position

The position command value of the last "End position reached" message is used as reference position.

Note: If a positioning block is not accepted then the drive behaves as if it had never been started.

Infinite running in a positive / negative direction

If an axis is to be run with defined velocity, acceleration and jerk without a specific target position, then the travel block mode "Travelling in a positive direction" or "Travelling in a negative direction" must be specified. The drive runs in the set direction until the start signal is reset or one of the position limit values or the travel range limit switch is reached.

The set target position is irrelevant in this positioning mode.

Parameter **P-0-4019, Process block mode** =

- 104h travel in positive direction
- 108h travel in negative direction

See also section: "Operating mode: jogging"

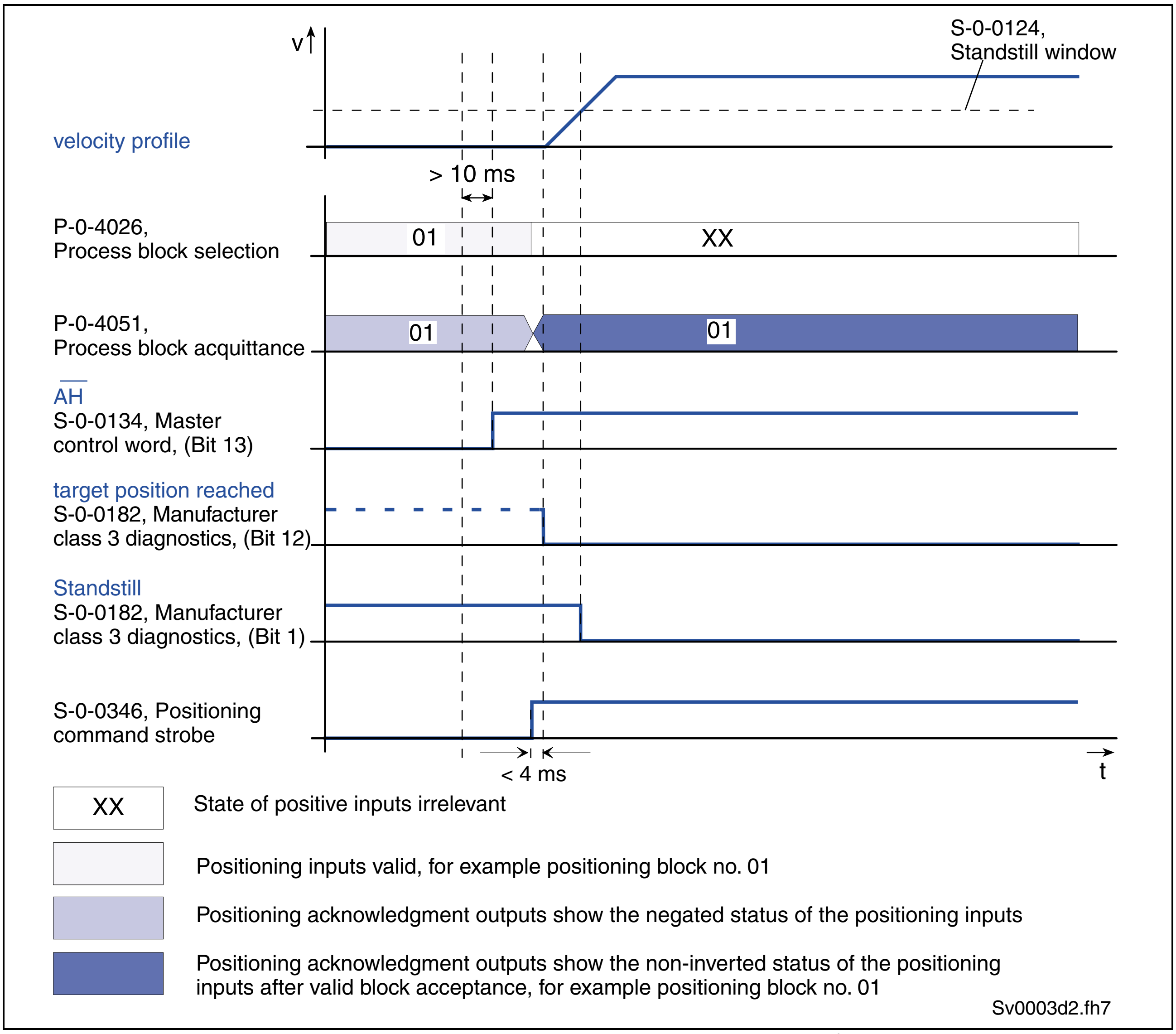


Fig. 8-37: Example: Infinite travel in positive / negative direction

Following block processing

Selecting and activating a following block

Selecting and activating a block with following block is performed in the usual manner. The following block is that block with the next highest block number. A following block can also have a following block so that after a start block up to 63 following blocks can be set.

The potential following block of the block with number 63 is block 0.

Conditions to advance in following block mode

There are two possibilities for block advance. These are also broken down into:

- Block advance mode: **Position-dependent block advance**
  - Block transition with old positioning speed
  - Block transition with new positioning speed
  - Block transition with intermediate halt
- Block advance mode: **Switching signal-dependent block advance**

1) Position-dependent block advance

With position-dependent block advance, the following block is switched into at the target position of the start block.

There are three different types of block transitions:

a) Block transition with old positioning speed (Mode 1)

Parameter setting

- **P-0-4019, Process block mode** = 111h: absolute block with following block
- **P-0-4019, Process block mode** = 112h: relative block with following block
- **P-0-4019, Process block mode** = 114h: infinite block in positive direction with following block
- **P-0-4019, Process block mode** = 118h: infinite block in negative direction with following block

Definition

In this mode, the target position of the start block is run through at the speed of the start block and then switched to the positioning speed of the following block.

With relative and absolute positioning blocks with block advance, the drive runs in the direction of the target position. As soon as the target position is exceeded, it switches to the next block n+1.

With infinite blocks, the drive runs in positive or negative direction. As soon as the target position is exceeded, the drive switches to next positioning block n+1, "n" representing the block currently in process.

Note: If the target position is not in the travel direction, then the target position is nonetheless run to. Thus the drive always reaches the switching position.

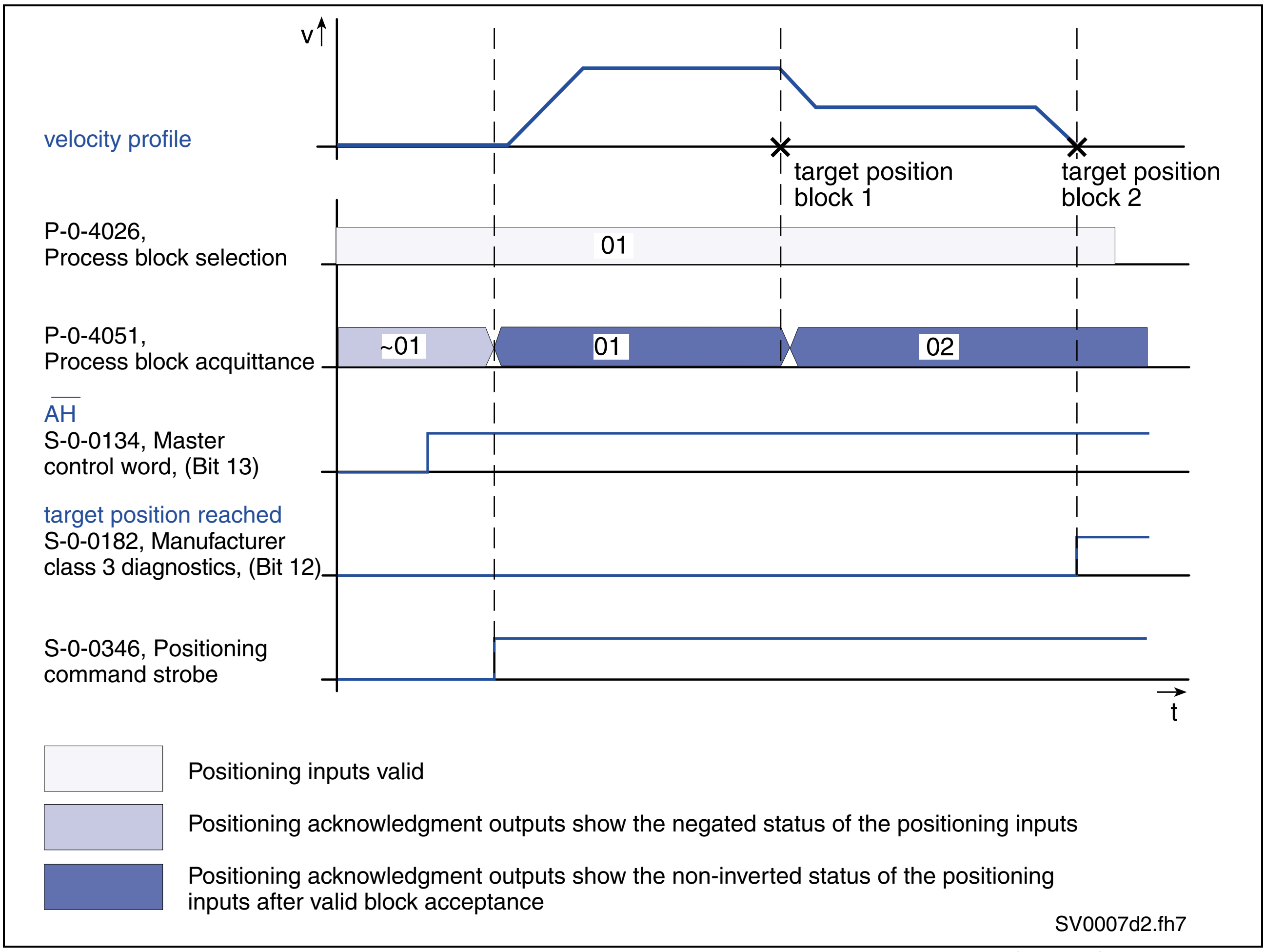


Fig. 8-38: Example: Position-dependent block advance (mode 1)

b) Block transition with new positioning speed (Mode 2)

Parameter setting

- **P-0-4019, Process block mode** =121h: absolute block with following block
- **P-0-4019, Process block mode** =122h: relative block with following block
- **P-0-4019, Process block mode** =124h: infinite block in positive direction with following block
- **P-0-4019, Process block mode** =128h: infinite block in negative direction with following block

Definition

In this mode the target position of the start block is run through at the positioning speed of the following block. The deceleration or acceleration processes required to adjust the velocity are already carried out in the start block.

The drive runs in the direction of the target position $\mathbf{X_n}$ (with infinite blocks in set direction) set in **current** position block **n**. As the drive approaches $\mathbf{X_n}$, acceleration $\mathbf{a_n}$ is used to accelerate or decelerate to the **next** positioning speed $\mathbf{v_{n+1}}$ so that the speed $\mathbf{v_{n+1}}$ can be achieved at target position $\mathbf{X_n}$.

The switch to the next positioning block does not occur until the target position is overrun.

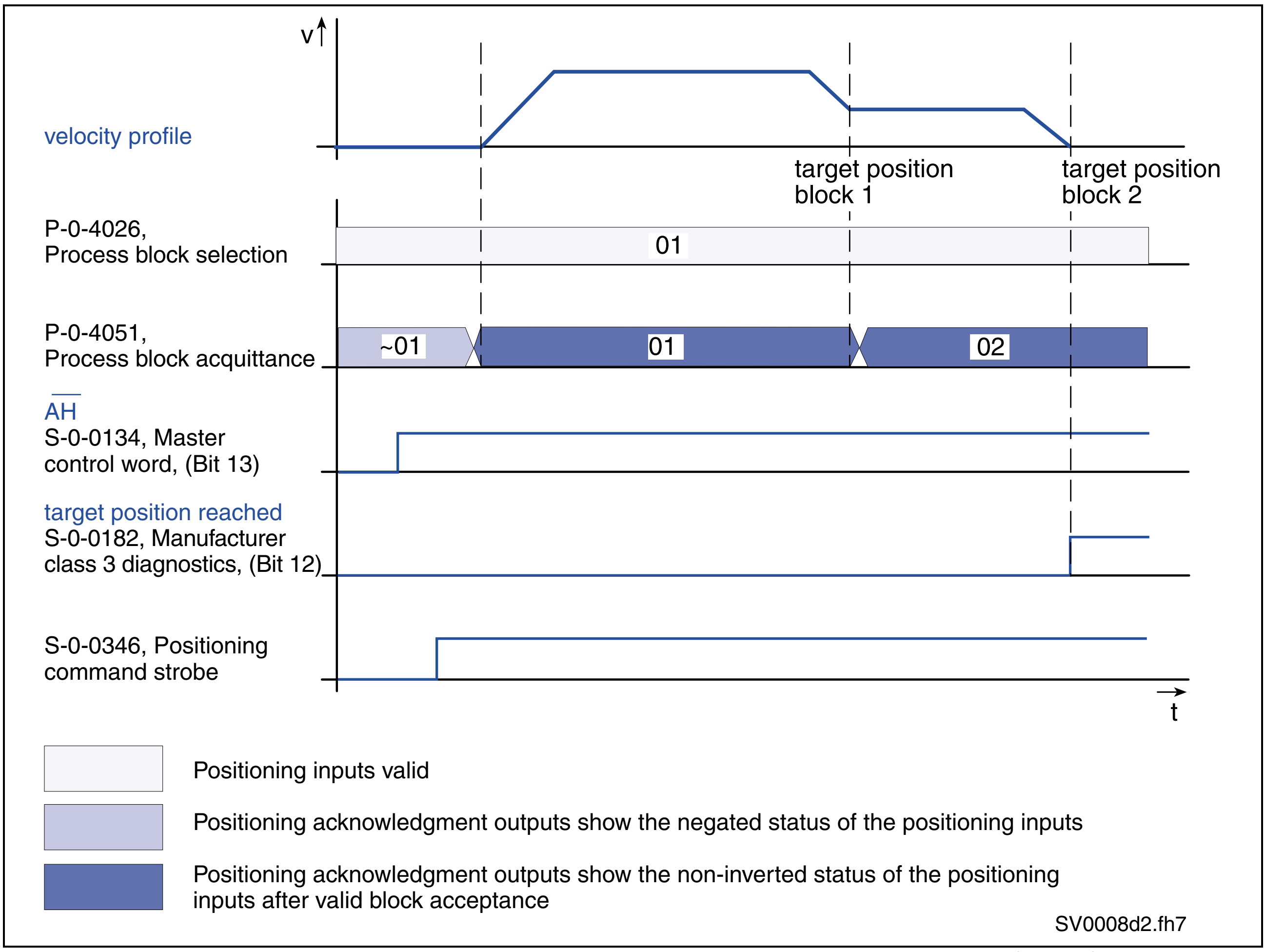


Fig. 8-39: Example: Position-dependent block advance (Mode2)

c) Block transition with intermediate halt

- **P-0-4019, Process block mode** =141h: absolute block with following block
- **P-0-4019, Process block mode** =142h: relative block with following block

Definition

In this mode the drive positions at the target position of the start block. Once the position command is at the target position, the following block is automatically started without a new start signal generated externally.

Another operating mode is switching at overrunning the target position with intermediate halt.

The drive is decelerated to speed 0 at the target position and then accelerated to the new positioning speed.

Note: Advance takes place if the internal command value generator reaches the target position. Very small jerk values result in a creeping to target position which is like a dwell time.

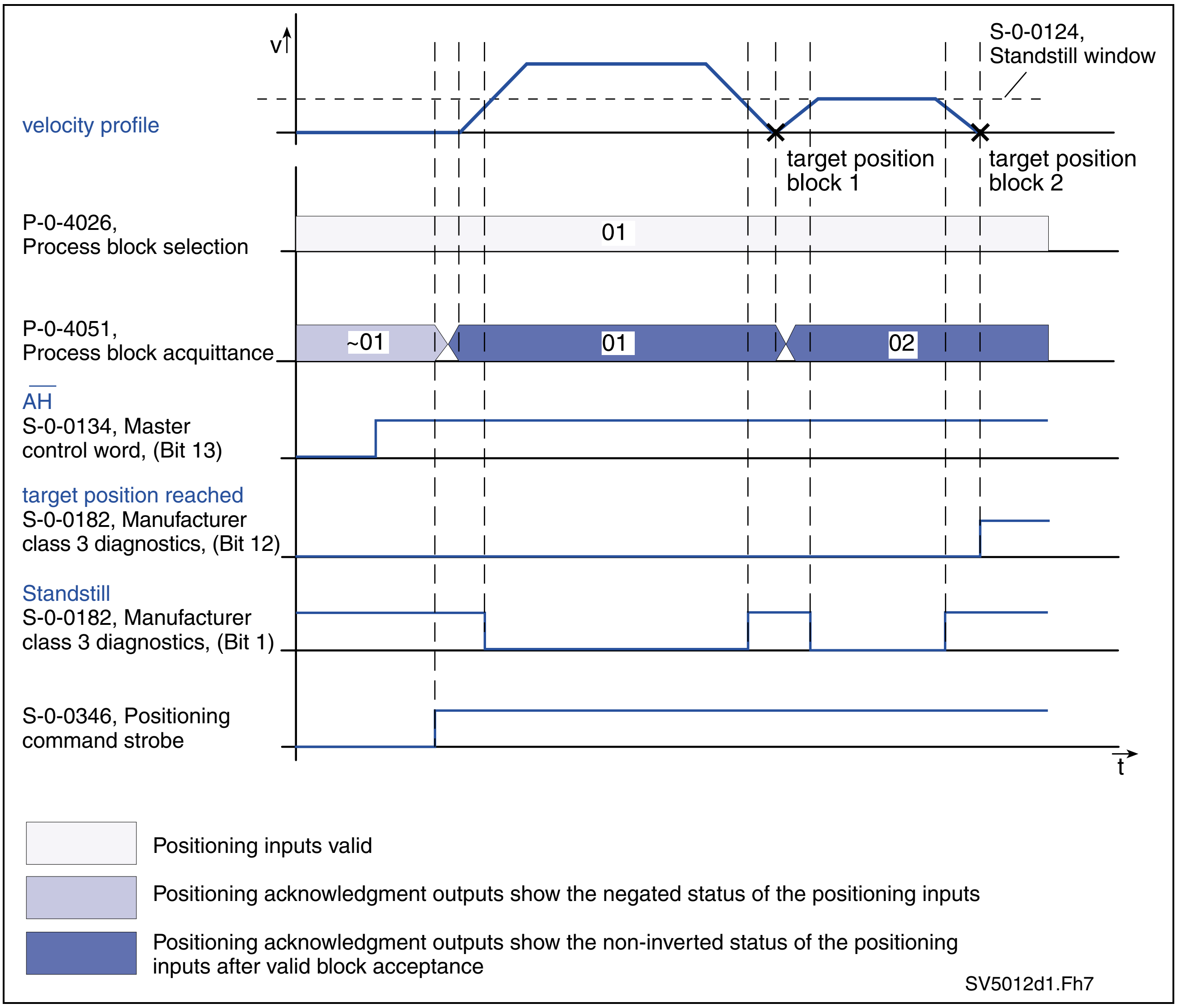


Fig. 8-40: Example: Following block advance with target position with intermediate halt

Note: This mode should be used if there is a change in direction with two sequential following blocks within one following block chain. Otherwise, the position at which the direction is to be changed will be overrun.

2) Switching signal-dependent block advance

Parameter setting

- **P-0-4019, Process block mode** = 181h: absolute block with following block
- **P-0-4019, Process block mode** = 182h: relative block with following block
- **P-0-4019, Process block mode** = 184h: infinite block in positive direction with following block
- **P-0-4019, Process block mode** = 188h infinite block in negative direction with following block

Advance to a block with the next highest block number is triggered with an externally applied switching signal.

Switching with cams

The switching signal-dependent block advance makes a transition to a following block possible based on an external switching signal. As signal inputs the two following block inputs / measuring probe inputs are available.

The state of the hardware signals is shown in parameter **P-0-4057, Positioning block, input linked blocks**.

Definition

The drive switches to the **next travel block** n+1 as soon as the input for the **following block cam 1** goes from "0" to "1". If the target position is not reached then the new positioning block is switched into while travelling.

The drive switches to the **travel block after the next** n+2 as soon as the input for the **following block cam 2** goes from "0" to "1". If a following block cam is actuated during this run, then the drive switches to the positioning block after the next.

Negation of following block cams

In parameter **P-0-4019, Process block mode** it is possible to select the negation of the following block cams with bit 9. If bit 9 equals 1, a positive edge switches to the next block.

Reference position

A following relative positioning block refers to the position at which the following block cam was switched.

Note: The following block cams are checked ever 2 ms. The accuracy of the position detected therefore depends considerably on the velocity at the time of overrun.

Allocation table for cams

Cam 2	Cam 1	Drive reaction
0	0	drive runs to target position of block n
X	0->1	block n+1 started
0->1	X	block n+2 started

X: Don't Care
n: positioning block selected via the parallel inputs or parameter **P-0-4026, Process block selection**

Fig. 8-41: Drive reaction with different switching signal sequences

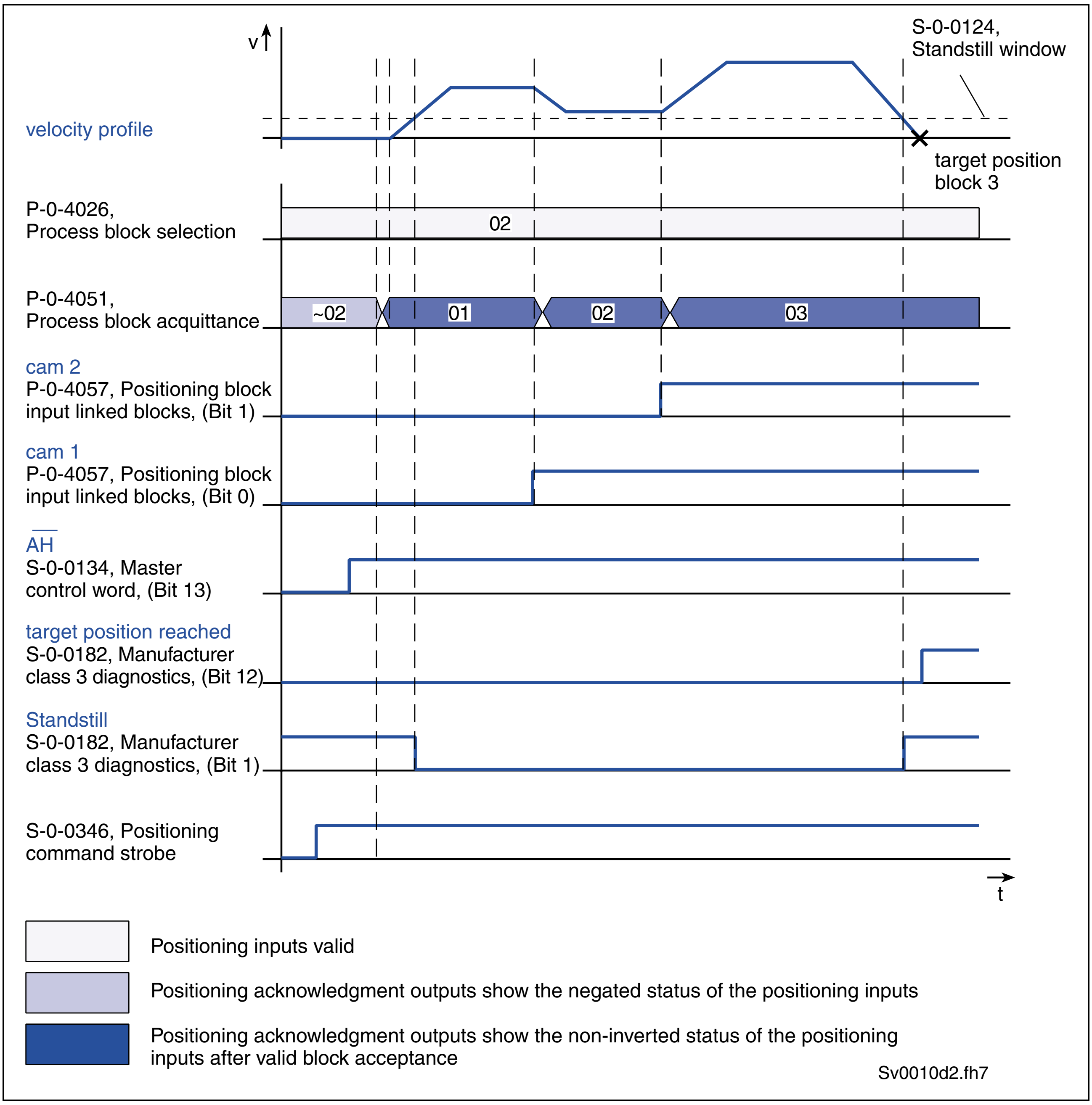


Fig. 8-42: Example: switching signal-dependent block advance

No switching signal for block advance

If the start block of a switching signal-dependent following block is an absolute or relative positioning block, then the drive positions on target position if the switching signal for block advance does not arrive. The drive thus generates the message "End position reached" after the following block chain is completed. If a switching signal is applied during the course of processing, then the drive will execute the following block.

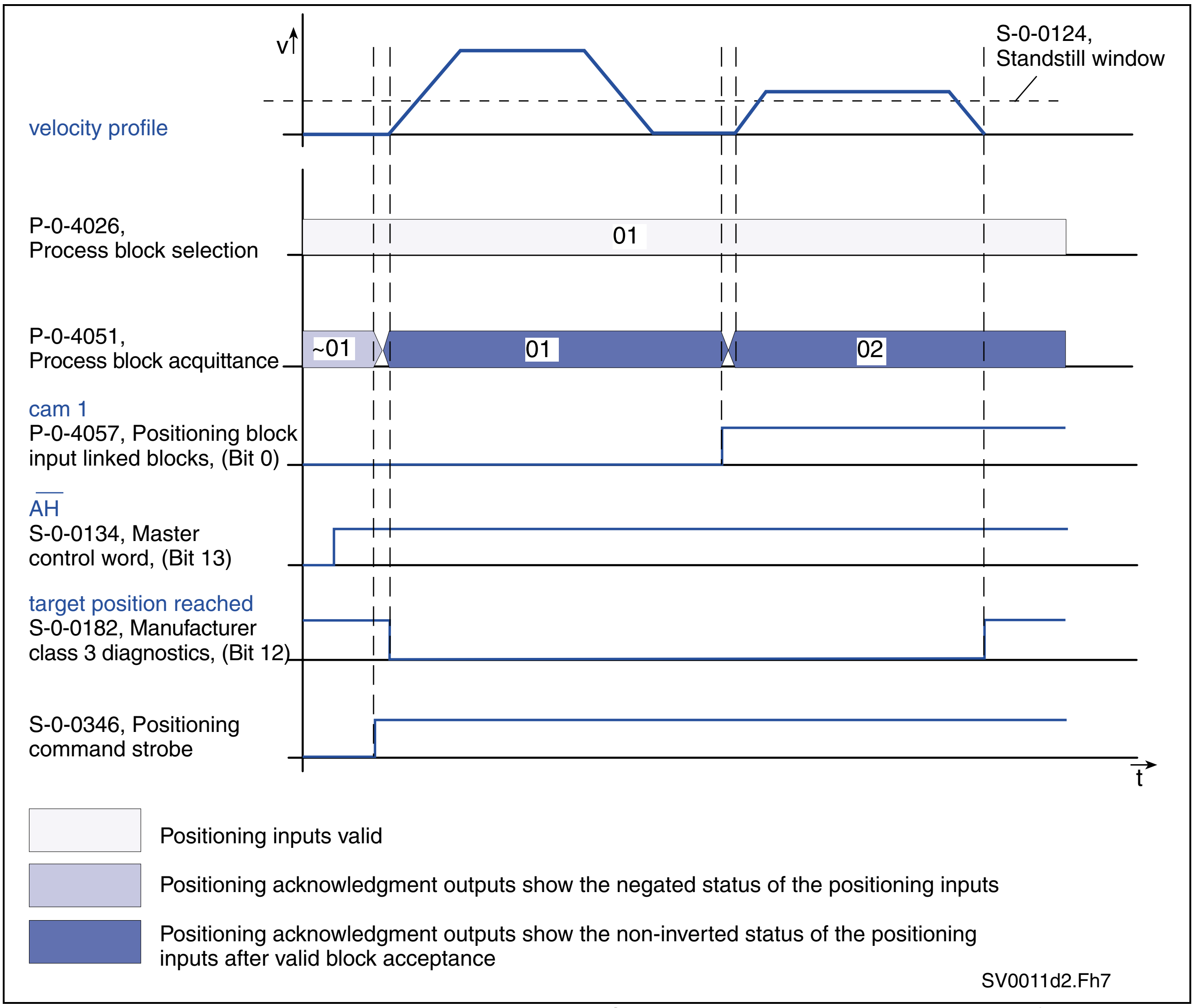


Fig. 8-43: Example: Switching signal-dependent block advance (behavior with no switching signal)

Note: All four conditions for advance are constantly queried and evaluated to be able to switch to the correct following block even after the following block chain is interrupted. Only the first condition for advance occurring during an interruption is recognized however. All others are not taken into account!

Interrupting a following block chain

An interruption can occur with

- a removal of the drive enable
- a removal of the drive start signal.

Depending on the block type of the following block sequence that was interrupted and the events occurring during this interruption, the following block chain is processed differently after a restart.

Note: In following block mode relative positioning blocks **without** residual path storage are not allowed as otherwise the chain dimension reference will be lost.

Interrupting a following block chain by selecting the same block number

Given an interruption, a restart will end the following block chain.

Reference position

The reference position is the original start position of the following block chain.

Note: The chain dimension reference is retained as only absolute and relative positioning blocks with residual path storage are used in following block mode!

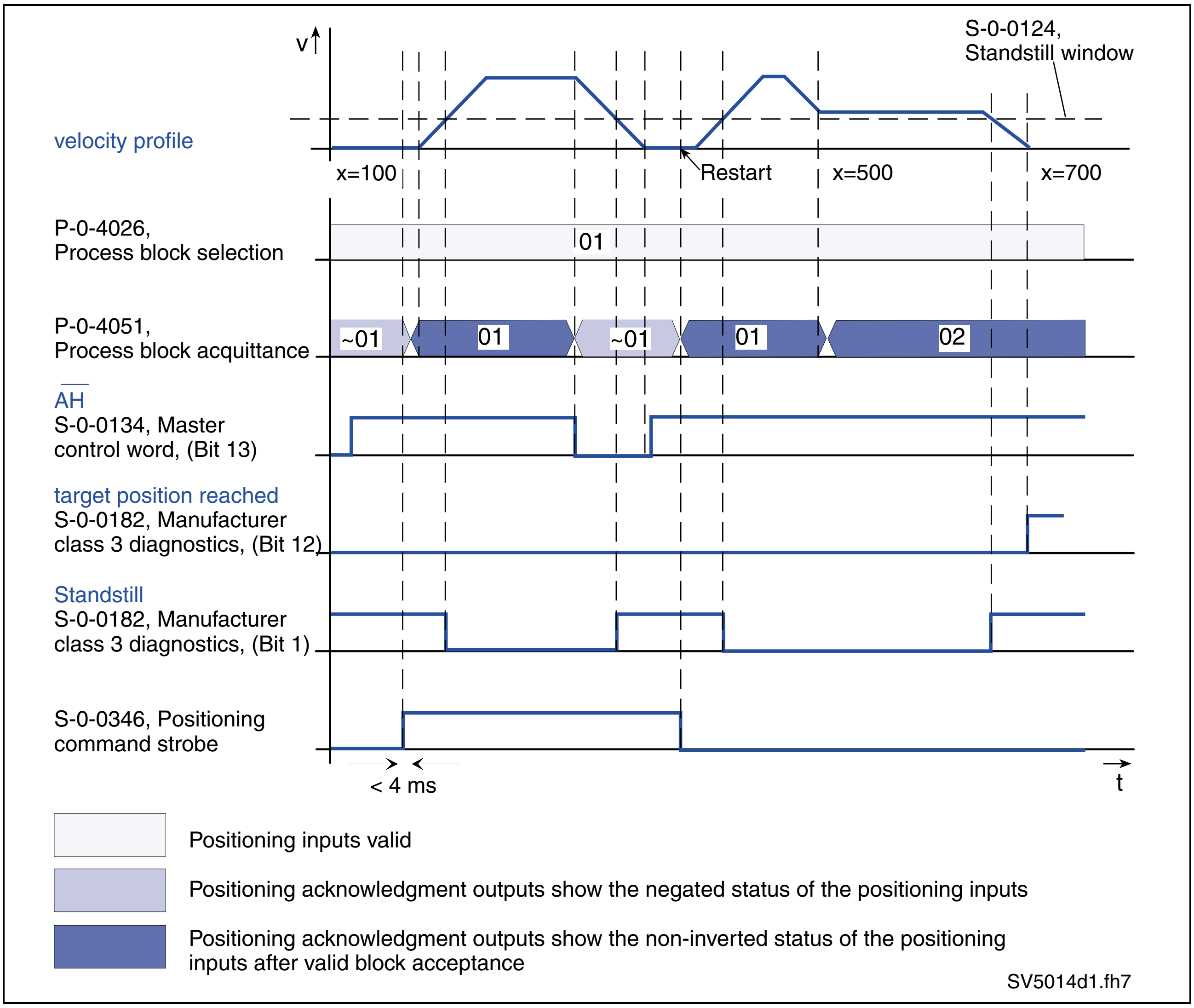


Fig. 8-44: Example: Following block interrupt with same block selected

Changing into jog mode

Note: Given a change into a different mode with an interrupt, the previously interrupted following block chain is completed upon restart unless a new block is selected. Given a following block with advance due to target position means that only the overrunning of the target position of the current position block will be detected. The following block is completed from this position. The advance condition due to switching signals is always detected.

Interrupting a following block chain and selecting a new block number

If a new block number is selected during an interruption (e.g. with drive halt), then the previously interrupted following block chain is not completed after a restart. Instead the current block is executed.

Reference position

Reference position is the current actual position value.

Note: The chain dimension reference is lost if the following block is interrupted.

The conditions for the interruption of following blocks also apply after the control voltage is switched off, if an absolute encoder is used.

Interrupting a following block chain with absolute following blocks

An interruption with absolute positioning blocks represents no problem as the reference dimension is always guaranteed.

If a new block number is selected with an interruption, then the previously interrupted following block is not completed, when **S-0-0346, Positioning command strobe** is toggled. Instead, the current block is executed.

If the same block number is selected with an interruption, then the previously interrupted following block is completed, when **S-0-0346, Positioning command strobe** is toggled.

Parameterization notes for positioning blocks

Taking drive limits into account

When parameterizing following blocks, the maximum values of the drive must be taken into account. These are:

- maximum acceleration capability
- maximum speed (mains voltage independent)

If blocks are parameterized that demand values greater than the maximum values of the drive, then this will generate an excessive lag error. The drive will signal error **F228 Excessive deviation** to indicate that it cannot comply with the position command value.

Minimum values for acceleration and jerk

Acceleration values that are too small can also cause problems which is why the following should be taken into account with fixing the positioning blocks.

Minimum acceleration value

$$\text{acceleration} > \frac{\text{velocity difference}^2}{2\ \text{targetpositiondifference}} = \frac{(v_{n+1} - v_n)^2}{2 \cdot (X_{n+1} - X_n)}$$

X_{n+1} = targetposition of the block n + 1

v_n = block speed n

v_{n+1} = blockspeed n + 1

Fig. 8-45: Minimum acceleration value with following block mode (translatory)

Note: The above relationship applies to an indefinitely large jerk which corresponds to a jerk filter that has been switched off (=0). If such a filter is used, then the computed values have to be doubled in first approximation. The distance to be run with a block and its velocity are generally fixed by the process. If the minimum acceleration value computed with the above formula already causes the maximum value mentioned in the previous section to be exceeded, then a lower positioning block velocity must be selected.

Minimum jerk value

If acceleration values are parameterized too small, then this could mean that the parameterized velocity is not reached. What results is a "Triangular mode".

Directional change within a following block chain

Note: If a directional change takes place when changing from block n to block n+1 of a following block, then mode "Switching at target position with halt" should be used to reverse the direction without overshoot.

Explanation of the figure below

Block n with intermediate halt follows block n-1 with mode 1 (block transition with old positioning speed), because a change in direction occurs when changing from block n to block n+1. At change in direction there is a sign change of the speed for target position n. If the acceleration parameterized in block n is too small to deceleration within the path difference X_n-X_{n-1} from speed v_{n-1} to value 0, then the parameterized target position X_n will be overrun.

This can cause software or hardware limit switches to trigger.

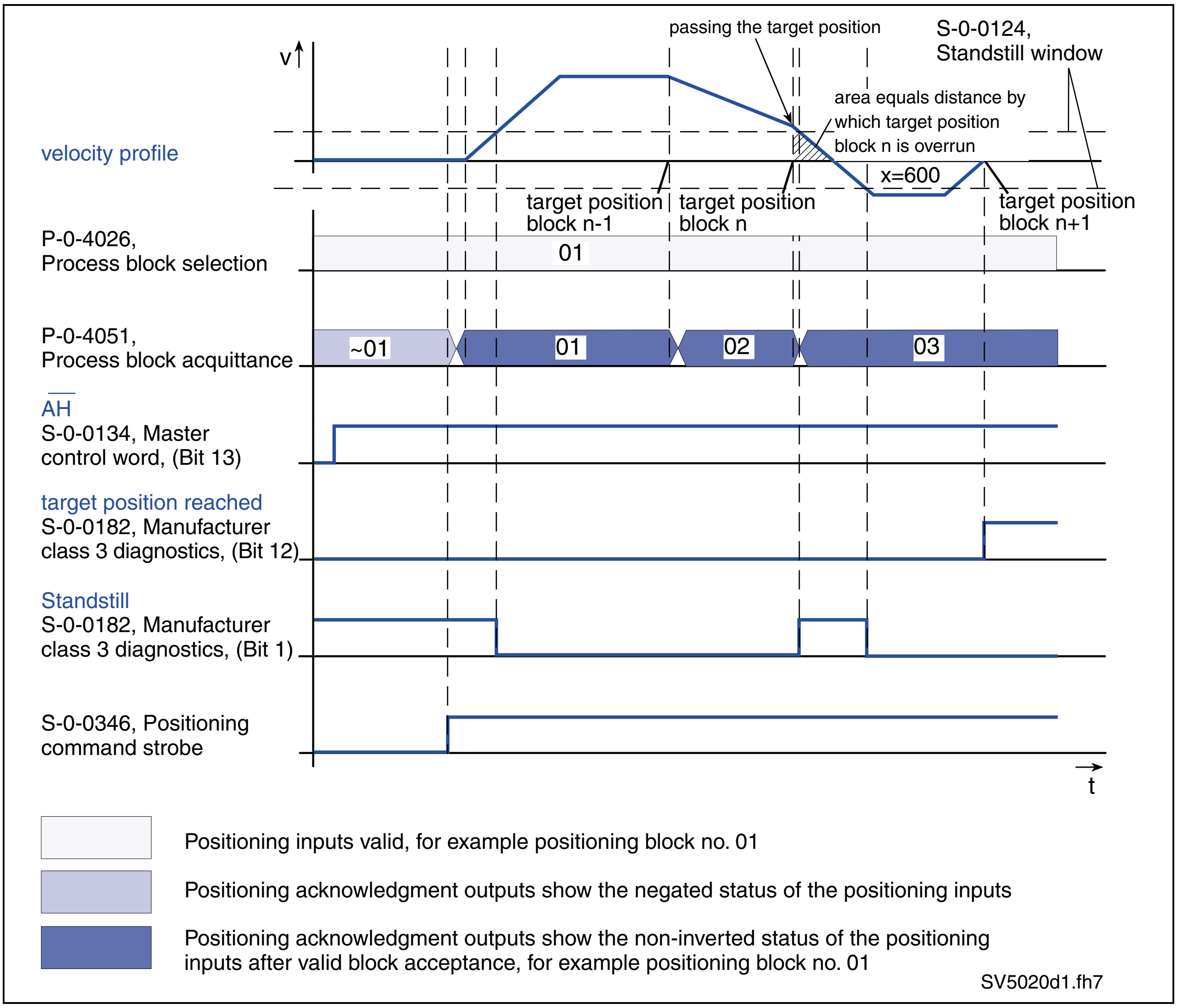


Fig. 8-46: Parameterizing a following block with directional change

Note: In the case of a following block with directional change it is necessary to take the mentioned formula for the minimum acceleration value into account to avoid overshooting of position!

Acknowledging positioning block selected

Acknowledge with active operating mode

After the positioning block mode is activated, the complement of the block number of the selected positioning block is acknowledged until a start signal (condition change **S-0-0346, Positioning command strobe**) is generated. As of the first start signal and if operation is trouble-free, the block number of the positioning block that has started is output. If an error is detected at the start of a positioning block, then the faulty positioning block is acknowledged with the complement of the block number. The drive generates a warning and stops.

Acknowledge with "drive halt"

If "drive halt" is active, then the complement of the block number of the selected positioning block is output in parameter **P-0-4051, Process block acquittance**.

Acknowledge with secondary operating modes, error reaction or command settings

In the case of secondary operating modes, error reaction or command setting, acknowledgment is not effected, i.e. parameter **P-0-4051, Process block acquittance** retains its value.

Acknowledge with drive enable removed

After removing the drive enable the last accepted positioning block is output at the acknowledge outputs. If the drive is at the target position of the last accepted positioning block, then the message "end position reached" is additionally generated.

The example below shows the same absolute positioning block being started once again.

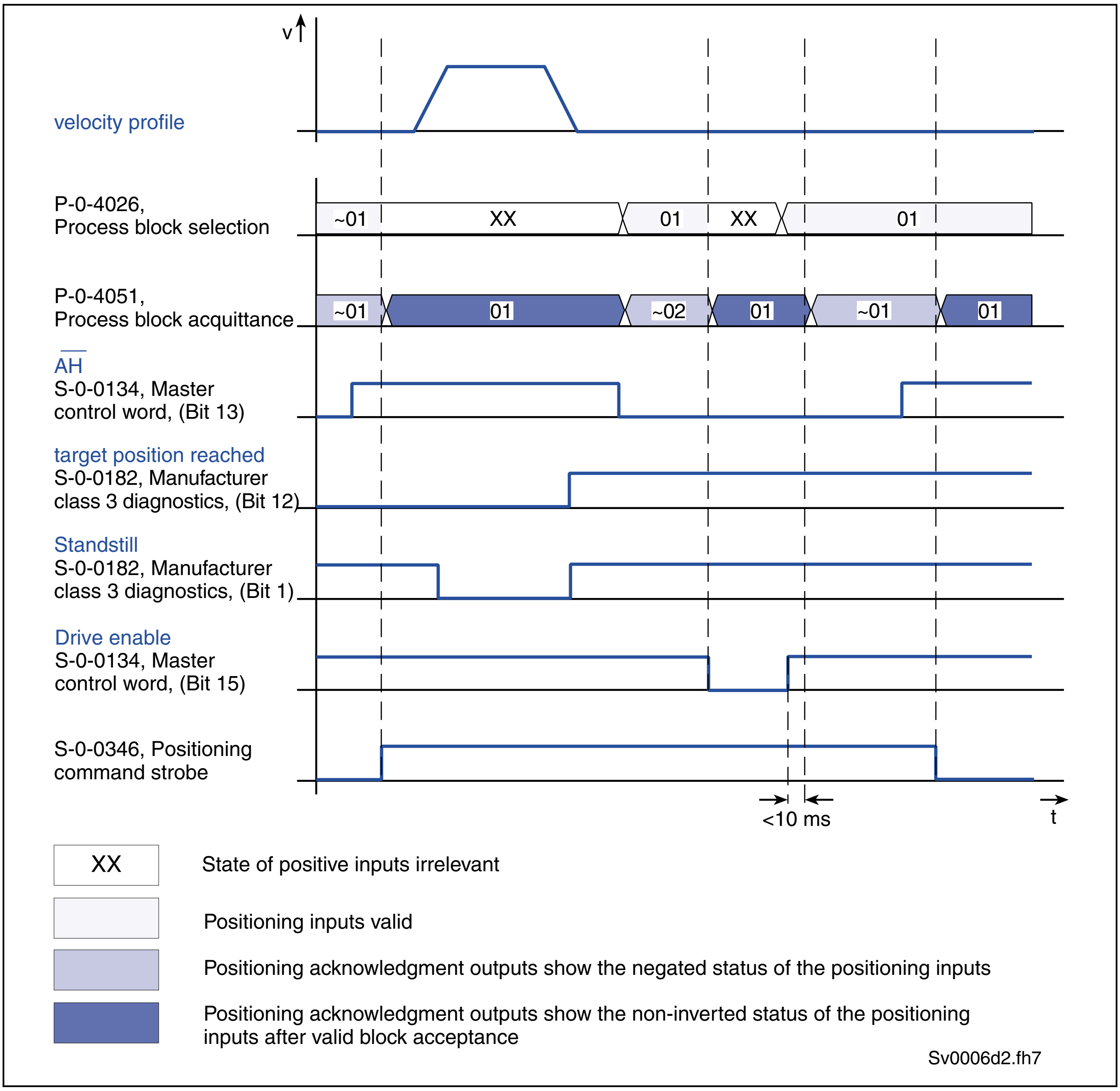


Fig. 8-47: Acknowledging and signaling "End position reached" after drive enable removed

Acknowledge with control voltage interrupt

If the control voltage is switched off, then the last accepted positioning block is stored in parameter **P-0-4052, Positioning block, last accepted**. This means that after powering up the last accepted positioning block is output.

Absolute encoder

If an **absolute encoder** is used, then it can be decided after the control voltage is switched off and on whether the drive is at the target position of the last accepted positioning block (end position reached).

The "End position reached" message is fixed as soon as the drive is ready to operate again (bb contact closed).

Single-turn encoder

If a **single-turn encoder** is used, then the "End position reached" message is not clearly defined after a power interrupt until the first target position has been run to or homed.

Note: The "End position reached" message is only retained if the axis has not been moved during the interruption. If the axis is moved into the positioning window during the interruption, then the "End position reached" message will also be generated. After activating the drive enable, positioning block acknowledge changes as described in "Acknowledge with drive enable removed".

Status messages during the operating mode "positioning block mode"

In addition to the messages during the operating mode "Drive internal interpolation", the following status message is generated in "Positioning block mode":

"End position reached" (bit 12 of **S-0-0182, Manufacturer status class 3** is 1), if the following applies: message "In-target position" (S-0-0182, bit 10) is active and no following block has been selected.

see also: Status messages during operating mode "Drive-internal interpolation"

Diagnostic messages

- **E248 Interpolation acceleration = 0**
- **E249 Positioning velocity S-0-0259 > S-0-0091**
- **E253 Target position out of travel range**
- **E254 Not homed**
- **E255 Feedrate-override S-0-0108 = 0**
- **E258 Selected process block is not programmed**
- **E264 Target position out of num. range**
- **F228 Excessive deviation**

Hardware connections

See Project Planning Manual ECODRIVE03 respectively DURADRIVE

8.9 Operating mode: jogging

The operating mode is used to move an axis in "manual mode".

Pertinent parameters

- **P-0-4030, Jog velocity**
- **P-0-4056, Jog inputs**
- **S-0-0260, Positioning Acceleration**
- **S-0-0359, Positioning Deceleration**
- **S-0-0193, Positioning Jerk**

Note: The parameters for the jogging inputs are available with SERCOS and fieldbus interfaces, even though hardware inputs are not.

Additional parameters

- **S-0-0403, Position feedback value status**
- **S-0-0055, Position polarities**
- **S-0-0049, Positive position limit value**
- **S-0-0050, Negative position limit value**

Note: In the case of a fieldbus interface, it is possible to switch to the secondary operating mode jogging by setting a bit in **P-0-4076, Fieldbus control word**.

How it works

Activating the operating mode jogging

In the case of a fieldbus interface the jogging mode becomes active when being selected via the control word.

The jog direction can be read out of parameter **P-0-4056, Jog inputs**.

Functional sequence of operating mode jogging

Upon activation of the mode, the drive runs position controlled while maintaining the:

- velocity (**P-0-4030, Jog velocity**),
- acceleration (**S-0-0260, Positioning Acceleration**),
- deceleration when braking (**S-0-0359, Positioning Deceleration**) and
- jerk limit value (**S-0-0193, Positioning Jerk**).

The jogging direction is fixed or displayed in parameter **P-0-4056, Jog inputs**.

Jog inputs	Drive	Display
00b	standstill	AF
01b	moving forward	JF
10b	moving backward	Jb
11b	standstill	AH

Fig. 8-48: Relationship of jog input and travel direction

The drive positions itself at the relevant position limit (S-0-0049 or S-0-0050) if:

- position limit monitor is activated (**S-0-0055, Position polarity** bit 4 = 1) and
- the drive has been homed (**S-0-0403, Position feedback value status** bit 0 = 1).

Note If one of the above conditions has not been satisfied, then the drive continues to run infinitely in the set direction.

Note: **The speed at which the drive moves when jogging can be influenced with the help of the Override function**. Function **Positioning at limited speed** also has an immediate effect on the jog velocity.

Diagnostic messages

Warning "**E831 Position limit reached during jog**" is generated if the drive positions at the position limit value.

The warning is cleared:

- once the mode is changed or
- when jogging in the opposite direction.

8.10 Operating mode: velocity synchronization with virtual master axis

Velocity synchronization is used in printing machines in such cases as simple transport rolls. 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 electrical gear. A defined tension can be set with the fine offset of the gear.

The master axis position in this mode is set by the control.

The structure of the mode is illustrated below:

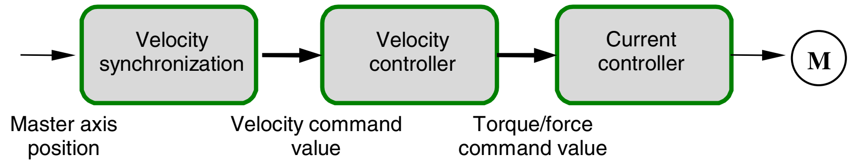


Fig. 8-49: Velocity synchronization with virtual master axis block diagram

Pertinent parameters

- **P-0-0053, Master drive position**
- **P-0-0083, Gear ratio fine adjust**
- **P-0-0108, Master drive polarity**
- **P-0-0142, Synchronization acceleration**
- **P-0-0155, Synchronization mode**
- **P-0-0156, Master drive gear input revolutions**
- **P-0-0157, Master drive gear output revolutions**

Command value preparation for velocity synchronization with virtual master axis

After the slave drive has been synchronized to the master axis position, the drive generates the "synchronous velocity command value" (this is a component of the velocity command value which is transmitted to the velocity controller).

The synchronous velocity command value (dX_{synch}) is calculated in terms of the polarity selected for the master drive (**P-0-0108, Master drive polarity**) and the set scaling type (**S-0-0076, Position data scaling type**) in accordance with the following equation:

$$dX_{Synch} = \pm [(P\text{-}0\text{-}0053_{(n)}) - (P\text{-}0\text{-}0053_{(n-1)}) * \frac{P\text{-}0\text{-}0157}{P\text{-}0\text{-}0156} * (1 + P\text{-}0\text{-}0083)]$$

d_{xSynch}: synchronous velocity command value
n: probe cycle
Fig. 8-50: Generating the synchronous velocity value for rotary scaling

The fine adjustment of the gear ratio that can be configured as cyclical data permits velocity changes at the slave axis at a constant master axis speed. Velocity can also be changed by changing the master axis gear parameters. These can also be cyclically changed.

The following illustrates how the velocity command value is generated in accordance with the above equation:

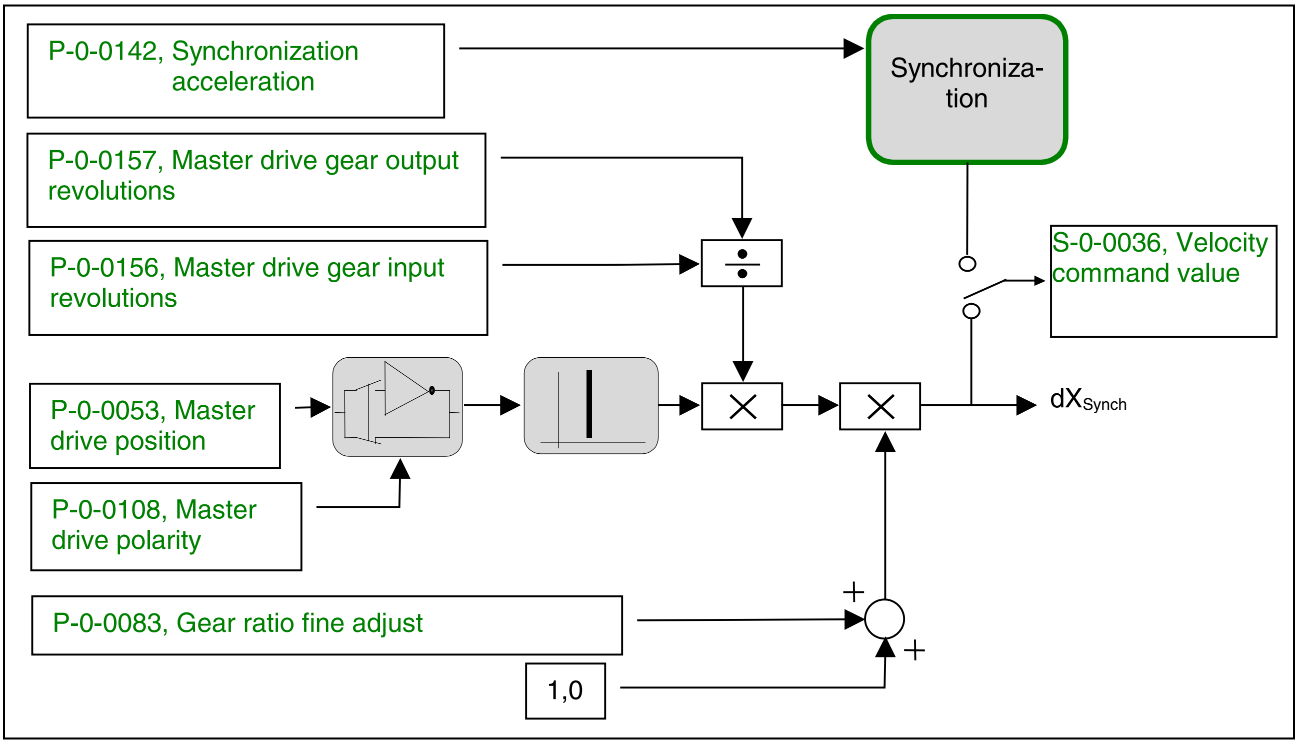


Fig. 8-51: Command value preparation for velocity synchronization

see also "Velocity controller"
see also "Current controller"

Dynamic synchronization in the velocity synchronization operating mode

Pertinent parameters:

- **P-0-0142, Synchronization acceleration**
- **P-0-0155, Synchronization mode**

Dynamic synchronization is included in the "velocity synchronization" operating mode.

By generating velocity command values, the drive accelerates or decelerates during synchronization until the synchronous velocity has been reached. The velocity command values are generated in consideration of the synchronization acceleration.

The settings in parameter **P-0-0155, Synchronization mode** are decisive for synchronization.

Synchronization status message during the velocity synchronization operating mode

Pertinent parameters:

- **S-0-0037, Additive velocity command value**
- **S-0-0040, Velocity feedback value**
- **S-0-0182, Manufacturer class 3 diagnostics**
- **S-0-0183, Velocity synchronization window**

The drive sets bit 8 ("In_Synchronization") in **S-0-0182, Manufacturer class 3 diagnostics** if:

$$\left| dX_{Synch} + S-0-0037 \quad - \quad S-0-0040 \right| < S-0-0183$$

8.11 Operating mode: velocity synchronization with real master axis

The operating mode "Velocity synchronization with real master axis" is used in a way analog to the operating mode "Velocity synchronization with virtual master axis".

The master axis position in the case of velocity synchronization with real master axis, however, is directly preset by means of a master axis encoder.

The structure of the operating mode is illustrated below:

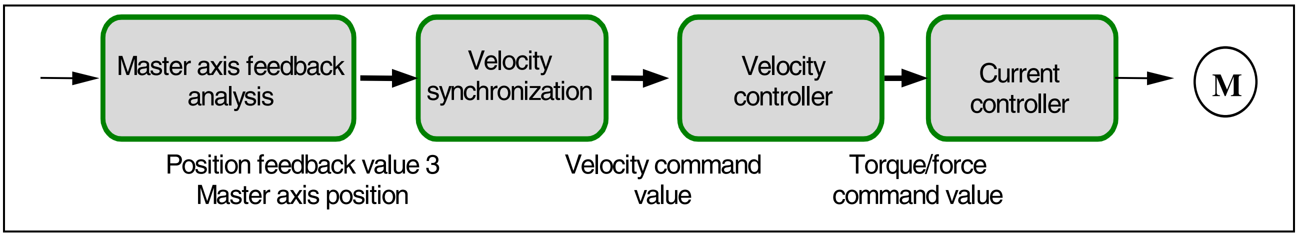


Fig. 8-52: Velocity synchronization with real master axis block diagram

Pertinent parameters

The parameters listed in the chapters "Velocity synchronization with virtual master axis" and "Master axis feedback analysis" are involved in the operating mode "Velocity synchronization with real master axis".

Functional principle

The operating mode "Velocity synchronization with real master axis" combines the function of master axis feedback and velocity synchronization in the drive.

The master axis feedback analysis supplies **P-0-0052, Position feedback value 3** which is copied by the drive to parameter **P-0-0053, Master drive position**.

The function of the individual function blocks is described in the relevant chapters:

see chapter: "Master axis feedback analysis"

see chapter: "Operating mode: velocity synchronization with virtual master axis"

see chapter: "Velocity controller"

see chapter: "Current controller"

Note: If the master axis feedback (incremental encoder) has not been homed, then zero pulse detection is automatically activated. As soon as the zero pulse is detected, there is a position jump to the value **P-0-0087, Offset position feedback value 3**. The resulting velocity jump is suppressed. The automatic detection of the zero pulse can be switched off. To do this, enter the value "5" ("real master axis feedback") in parameter **P-0-0185, Function of encoder 2**.

8.12 Operating mode: phase synchronization with virtual master axis

In machining processes that require absolute phase synchronization, e.g. printing, punching or perforating in printing machines, the position reference to the master axis is established in operating mode "phase synchronization".

In this operating mode, the drive synchronizes to the (virtual) master axis position (P-0-0053) preset by the control.

The structure of the operating mode "phase synchronization with virtual master axis" is illustrated below:

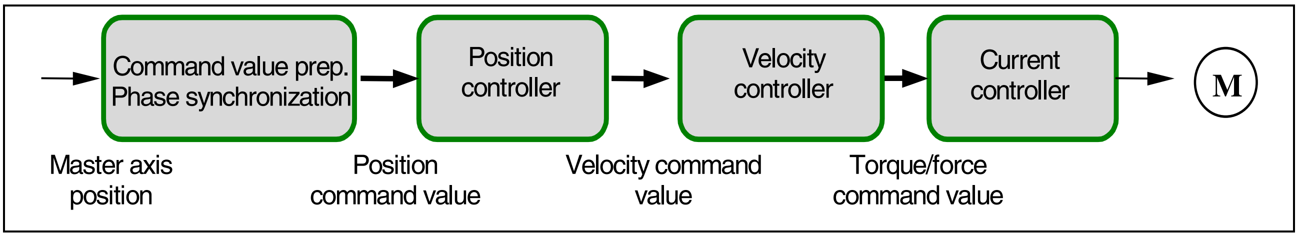


Fig 8-53: Phase synchronization block diagram

Pertinent Parameters

- **S-0-0048, Position command value additional**

S-0-0048 is used to establish a position offset between master axis and slave axis.

- **P-0-0053, Master drive position**

The master axis position is preset cyclically and in equidistant intervals by the control (virtual master axis). Format: 2^{20} increments/master axis revolution.

- **P-0-0083, Gear ratio fine adjust**

The gear ratio of the master drive gear is modified by the percentage parameterized in P-0-0083. For a master drive gear free of drift the value must equal zero.

- **P-0-0108, Master drive polarity**

P-0-0108 is used to invert the master drive gear.

- **P-0-0155, Synchronization mode**

- **P-0-0156, Master drive gear input revolutions**
- **P-0-0157, Master drive gear output revolutions**

Parameters P-0-0156 and P-0-0157 define the master drive gear.

- **P-0-0159, Slave drive feed travel**

With translatory scaling, the slave axis moves by the feed travel, per output revolution of the master drive gear, parameterized in P-0-0159.

- **P-0-0750, Master axis revolutions per master axis cycle**

Parameter P-0-0750 contains the number of master axis revolutions required in order to bring all drives, that are to follow the master axis, back to a defined position with respect to each other.

- **P-0-0752, Load revolutions per actual value cycle slave axis**

Parameter P-0-0752 defines the range in which the actual position value is displayed in absolute form. With modulo scaling, the actual position value is within a range of 360° * number of load revolutions per actual value cycle. The current actual position value within this range can be read from parameter **P-0-0753, Position actual value in actual value cycle**.

Diagnostic parameters

- **P-0-0034, Position command additional actual value**

P-0-0034 indicates the difference between actual position value and synchronous position command value.

- **P-0-0753, Position actual value in actual value cycle**
- **P-0-0754, Command value cycle**

The result of the multiplication of "master drive gear" and number of "master axis revolutions per master axis cycle" defines the command value cycle of the slave axis. This is the range for the calculated synchronous position command values. This calculation is done by the drive.

Command value preparation with phase synchronization with virtual master axis

In the operating mode "phase synchronization with virtual master axis" the position command value is generated by adding the synchronous position command value (X_{Synch}) and **S-0-0048, Position command value additional**.

$$S\text{-}0\text{-}0047 = X_{Synch} + S\text{-}0\text{-}0048$$

S-0-0047, Position command value
X_{Synch}: synchronous position command value
S-0-0048, Position command value additional

Fig. 8-54: Generating the position command value

The synchronous position command value (X_{synch}) is calculated in terms of the selected polarity for the master axis (**P-0-0108, Master drive polarity**) and the scaling type (**S-0-0076, Position data scaling type**) using the following formula:

$$X_{Synch} = \pm P\text{-}0\text{-}0053 * \frac{P\text{-}0\text{-}0157}{P\text{-}0\text{-}0156} * (1 + P - 0 - 0083) * 360°$$

X_{Synch}: synchronous position command value

Fig. 8-55: Generating the synchronous position command value with rotary scaling

$$X_{Synch} = \pm P\text{-}0\text{-}0053 * \frac{P\text{-}0\text{-}0157}{P\text{-}0\text{-}0156} * (1 + P\text{-}0\text{-}0083) * P\text{-}0\text{-}00159$$

X_{Synch}: synchronous position command value

Fig. 8-56: Generating the synchronous position command value with translatory scaling

Note: As a standard, the master axis position is fixed at 2^{20} increments/master axis revolution.

The following figure illustrates how the synchronous position command value is generated using the formulas above.

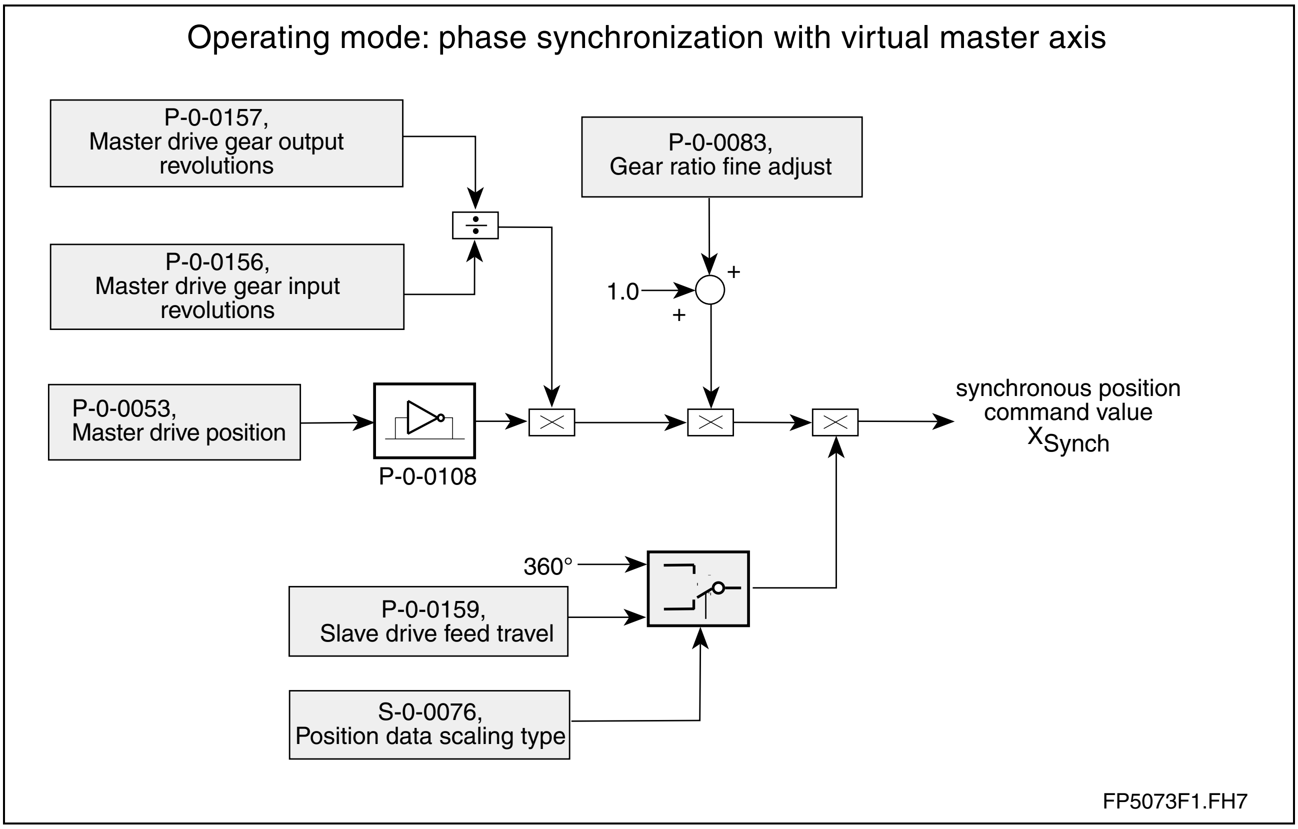


Fig. 8-57: Generation of synchronous position command value

see also "Position controller"

see also "Velocity controller"

see also "Current controller"

Dynamic synchronization in the phase synchronization operating mode

Associated parameters:

- **S-0-0048, Position command value additional**
- **P-0-0060, Filter time constant additional pos. command**
- **P-0-0142, Synchronization acceleration**
- **P-0-0143, Synchronization velocity**
- **P-0-0151, Synchronization init window for modulo format**
- **P-0-0154, Synchronization direction**
- **P-0-0155, Synchronization mode**
- **P-0-0751, Synchronization divisions per command cycle slave axis**

Dynamic synchronization is included in the "phase synchronization" operating mode. It consists of drive-controlled movement which aims at absolute synchronization.

For synchronization operating modes with outer position control loop, synchronization is carried out in two steps:

Step 1 of synchronization

Upon activating the operating mode, a velocity adjustment is first executed.

This means that the drive either accelerates or decelerates from the current feedback velocity at the time of activation to the synchronous velocity.

The drive generates the synchronous velocity by differentiating the synchronous position command values. These synchronous position command values X_{Synch} are generated in terms of the operating mode from **P-0-0053, Master drive position**.

Velocity adjustment already takes place in position control. When accelerating or braking, the drive takes **P-0-0142, Synchronization acceleration** into account.

After velocity adjustment is complete, there is a difference between the active position command value and the sum of the synchronous position command value X_{Synch} and **S-0-0048, Position command value additional**.

Step 2 of synchronization

In the second step of dynamic synchronization the drive moves a distance equal to this difference, taking **P-0-0142, Synchronization acceleration** and **P-0-0143, Synchronization velocity** into consideration. This position adjustment is added to the synchronous movement.

The difference is calculated according to the following equation:

$$\text{Path} = X_{Synch} + \text{S-0-0048} - \text{S-0-0047}$$

X_{synch}: synchronous position command value

Fig. 8-58: Travel path for absolute synchronization

In **P-0-0155, Synchronization mode** synchronization to a position in the modulo range, in the command value cycle or in the division of the command value cycle can be set. The path to be traveled is then limited to this range.

Synchronization in the command value cycle

The range for the command value cycle of the slave axis is defined by the master axis cycle and the master drive gear:

$$\text{Command value cycle} = P-0-0750 * \frac{P-0-0157}{P-0-0156} * 360°$$

Fig. 8-59: Command value cycle

The active value is displayed in parameter **P-0-0754, Command value cycle**.

The path traveled during synchronization is the result of the difference between synchronous position command value (+ **S-0-0048, Position command value additional**) and the actual position value. The synchronous position command value is calculated from the master axis position and the master drive gear. The actual position value in the command value cycle range is derived from the actual position value in the actual value cycle. Prerequisite for this is that the command value cycle is an integral multiple of the actual value cycle. For modulo division the number of command value cycles per actual value cycle is used. The number is calculated with the following formula:

$$\text{Number of command value cycles} = \frac{P-0-0752}{P-0-0750} * \frac{P-0-0156}{P-0-0157}$$

Fig. 8-60: Number of command value cycles per actual values cycle

Synchronization in a division of the command value cycle

The path traveled during synchronization is the result of the difference between synchronous position command value (+ **S-0-0048, Position command value additional**) in the **division** of the command value cycle and the actual position value in the **division** of the command value cycle. The synchronous position command value in the command value cycle is calculated from the master axis position and the master drive gear. By means of parameter **P-0-0751, Synchronization divisions per command cycle slave axis** a command value in the division is determined by modulo division. The actual position value in the division of the command value cycle is derived from **P-0-0753, Position actual value in actual value cycle**. For modulo division the number of divisions per actual value cycle is used. The number is calculated with the following formula:

$$\text{Number of divisions} = P-0-0751 * \frac{P-0-0752}{P-0-0750} * \frac{P-0-0156}{P-0-0157}$$

Fig. 8-61: Number of synchronization divisions per actual value cycle

Synchronization in the modulo range

The path traveled during synchronization is the result of the difference between synchronous position command value (+ **S-0-0048, Position command value additional**) in the **modulo range** and the actual position value in the **modulo range**. The synchronous position command value in the command value cycle is calculated from the master axis position and the master drive gear. By means of the product of the number of master axis revolutions per master axis cycle and the master drive gear a command value in the modulo range is determined by modulo division. The actual position value in the modulo range is derived from the actual position value in the actual value cycle. For this modulo division the number of load revolutions per actual value cycle is used.

Relative synchronization

Absolute synchronization can be switched off. Relative synchronization is carried out instead during which only the adjustment to the synchronous velocity is realized. The bit assignment of parameter P-0-0155 is as follows:

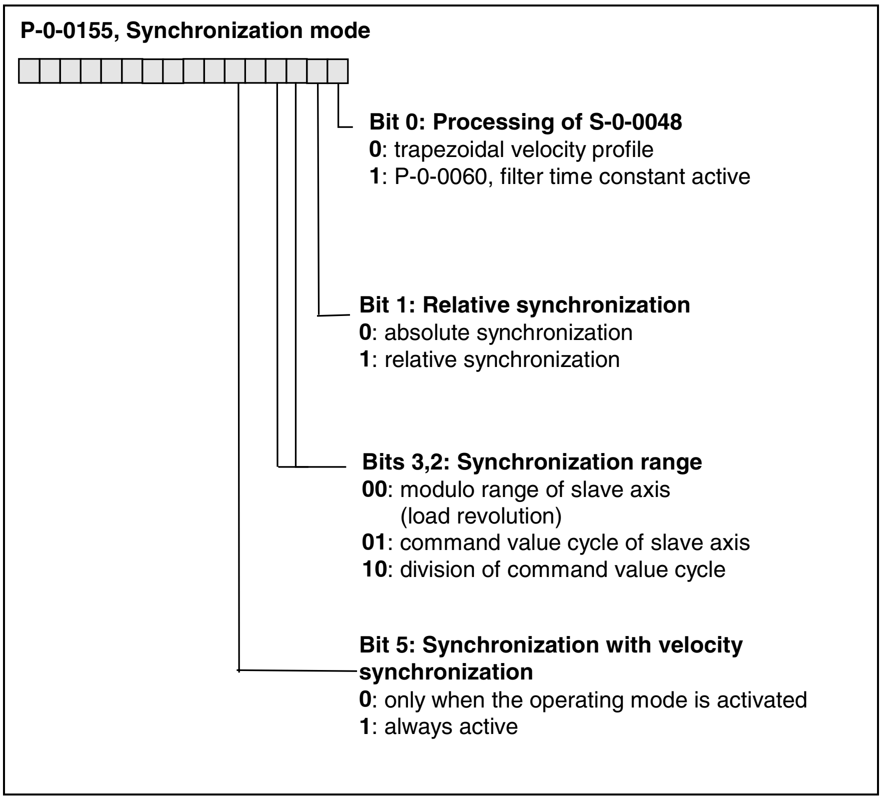


Fig. 8-62: P-0-0155, Synchronization mode

With modulo axes, the path first is limited to +/- **S-0-0103, Modulo value**. Then, parameters **P-0-0154, Synchronization direction** and **P-0-0151, Synchronization init window for modulo format** are taken into consideration.

Note: The synchronization direction parameter will only work, if the shortest path (value ≤ 0.5 * modulo value) is larger than the synchronization window. Then, the synchronization direction will be set with the parameter (positive or negative or shortest path). If the shortest path is smaller than the synchronization window, then the shortest path will always be traveled.

The drive will be in absolute synchronization after the conclusion of the second synchronization phase. The drive sets bit 9 in parameter **S-0-0182, Manufacturer class 3 diagnostics** ("Synchronization concluded“).

The following applies:

$$\text{S-0-0047} = X_{\text{Synch}} + \text{S-0-0048}$$

S-0-0047, Position command value
X_{Synch}: Synchronous position command value
S-0-0048, Position command value additional

Fig. 8-63: Generation of the position command value

Every time the additive position command value (S-0-0048) is changed, a new path will be determined and traveled according to the above equation.

The following figure shows the components of **S-0-0047, Position command value**.

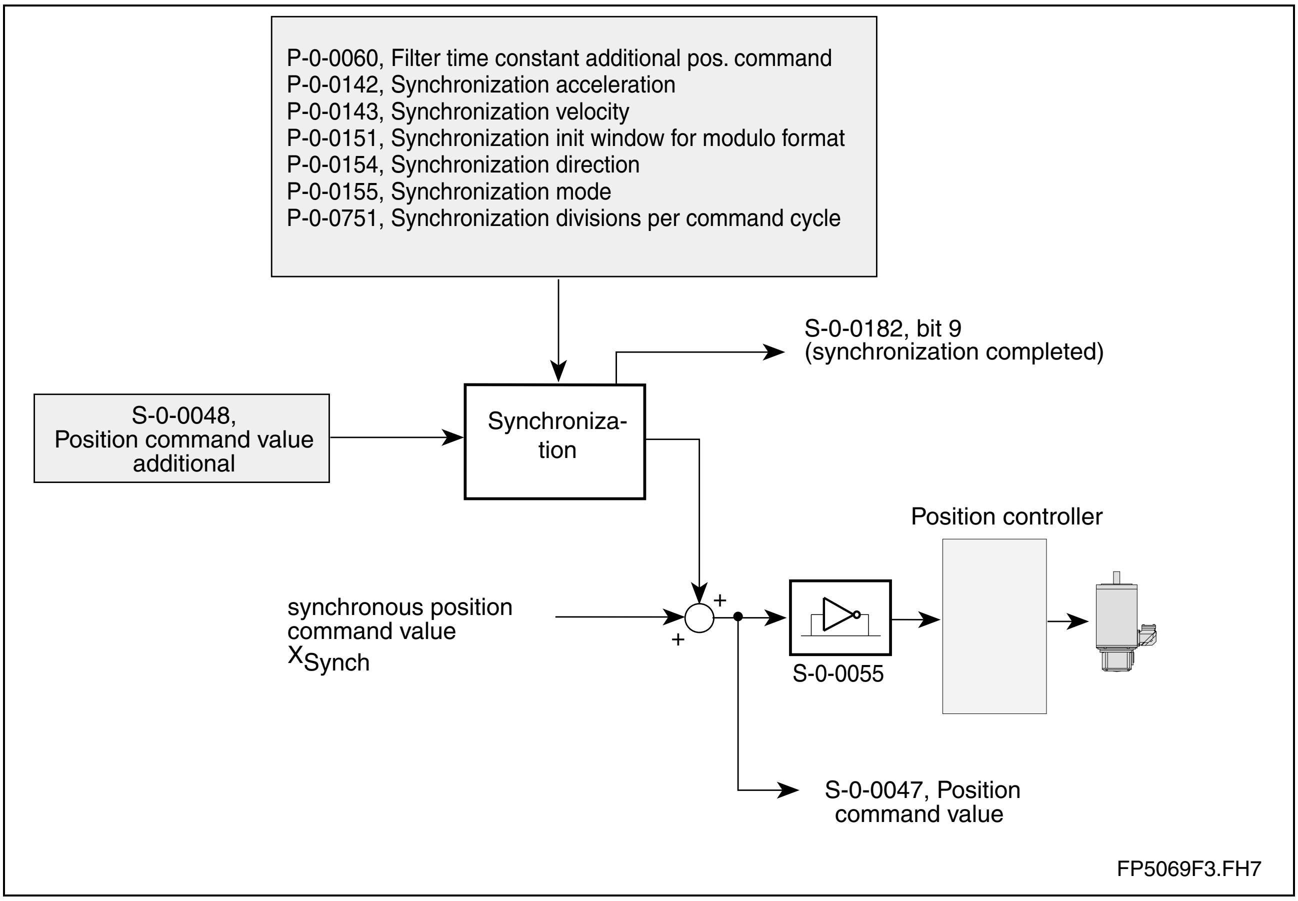


Fig. 8-64: Generation of the position command value

P-0-0155, Synchronization mode

The **P-0-0155, Synchronization mode** parameter can be used to switch off the dynamic synchronization after first reaching absolute synchronization.

To do this, bit is set to 1. In this synchronization mode the following parameters will be inoperative after absolute synchronization is reached:

P-0-0142, Synchronization acceleration

P-0-0143, Synchronization velocity

P-0-0151, Synchronization init window for modulo format

P-0-0154, Synchronization direction

The following changes to the additional position command value will be smoothed with a filter of the first order. The time constant for the filter will be set with the parameter **P-0-0060, Filter time constant additional pos. command**. The status bit "Synchronization completed" is set when reaching absolute synchronization and won't be cleared even with further changes in **S-0-0048, Position command value additional**.

If the dynamic synchronization remains active (**P-0-0155, Synchronization mode** bit 0 = 0), then the bit will be set only if the above equation is satisfied.

The following figures show the time flow of the velocity for the standard and register controller synchronization modes.

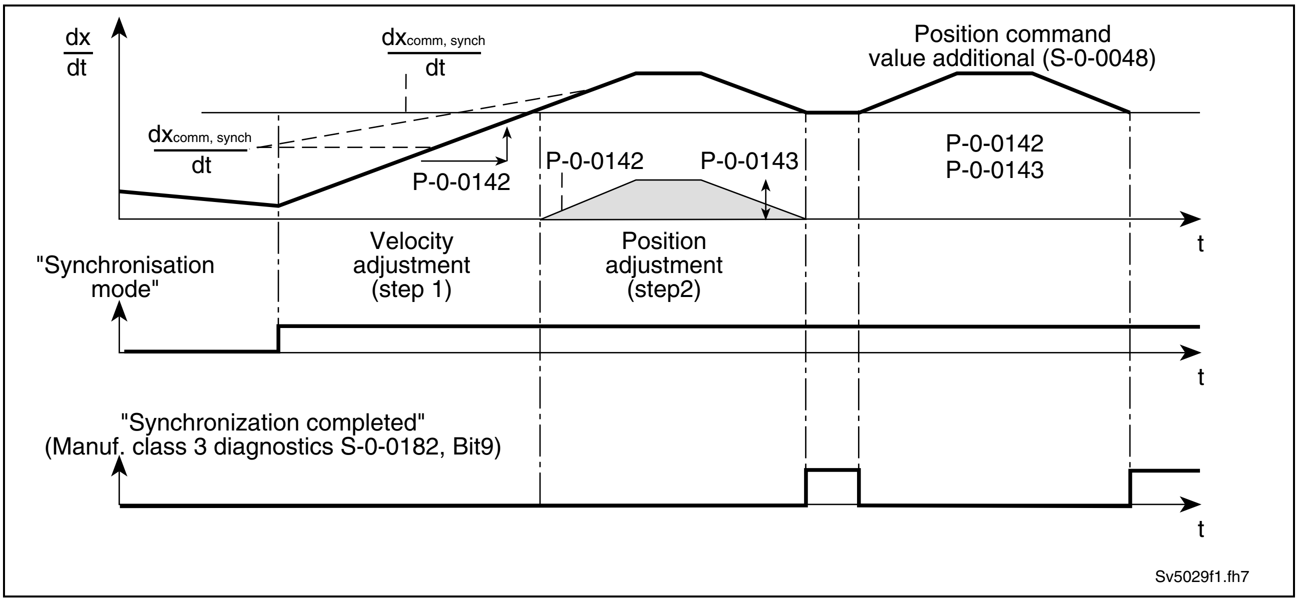


Fig. 8-65: Standard synchronization mode (P-0-0155, bit 0 = 0)

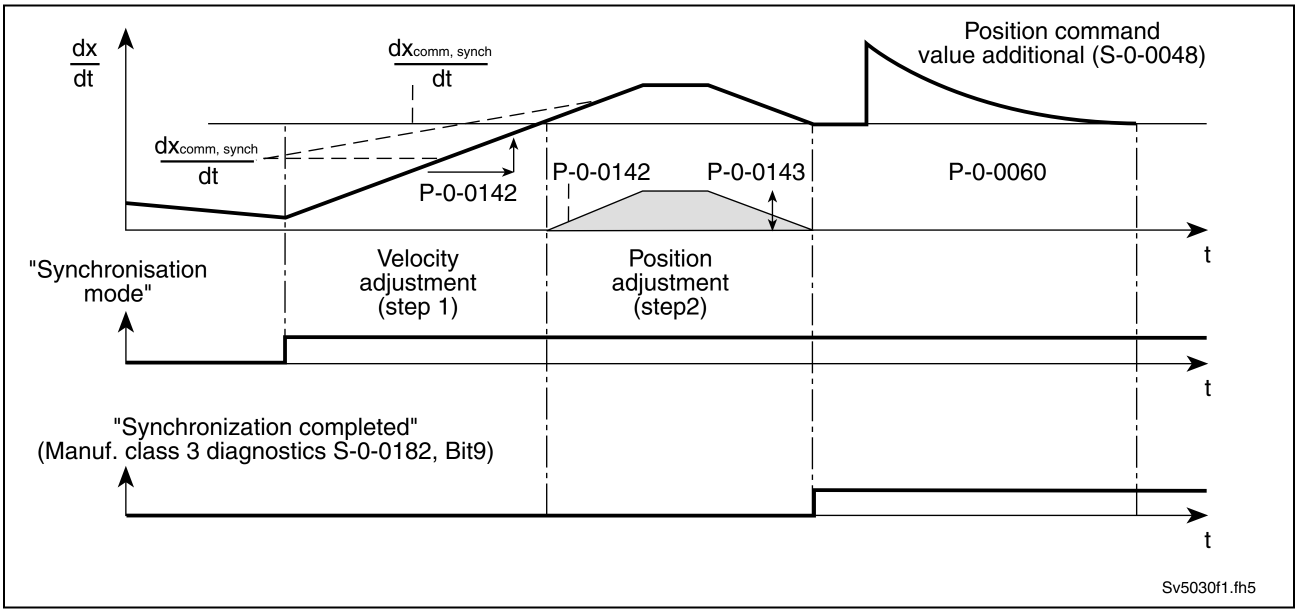


Fig. 8-66: Register controller synchronization mode (P-0-0155, bit 0 = 1)

Relative synchronization (P-0-0155, Synchronization mode, bit 1=1):

After the operating mode is activated, only step 1 of the synchronization procedure is conducted. This realizes a relative position-synchronous slave axis. To do this, parameter **S-0-0048, Position command value additional** is initialized by the drive in such a way that there is no second step to the synchronization process. A phase offset is nonetheless possible by changing parameter **S-0-0048, Position command value additional**. The change is processed in differential form.

Synchronization status message for the phase synchronization operating mode

Associated parameters:

- **S-0-0048, Position command value additional**
- **S-0-0051, Position feedback 1 value**
- **S-0-0053, Position feedback 2 value**
- **S-0-0182, Manufacturer class 3 diagnostics**
- **S-0-0228, Position synchronization window**

The drive sets bit 8 in the Manufacturer Class 3 diagnostics if:

$$\left| X_{Synch} + S-0-0048 \quad - \quad (S-0-0051 \text{ or } S-0-0053) \right| < S-0-0228$$

The bit will be generated only if a synchronization operating mode has been parameterized in the **S-0-0032, Primary mode of operation**.

During the first phase of dynamic synchronization (velocity adjustment), the bit will be set to 0 to avoid being set too early for modulo axes.

8.13 Operating mode: phase synchronization with real master axis

In machining processes that require absolute phase synchronization, such as printing, stamping or perforating in printing machines, the position reference to the master axis is established in the operating mode "Phase synchronization".

In this mode, the drive synchronizes to a (real) master axis position generated from the master axis feedback.

The structure of the operating mode "Phase synchronization with real master axis" is illustrated below:

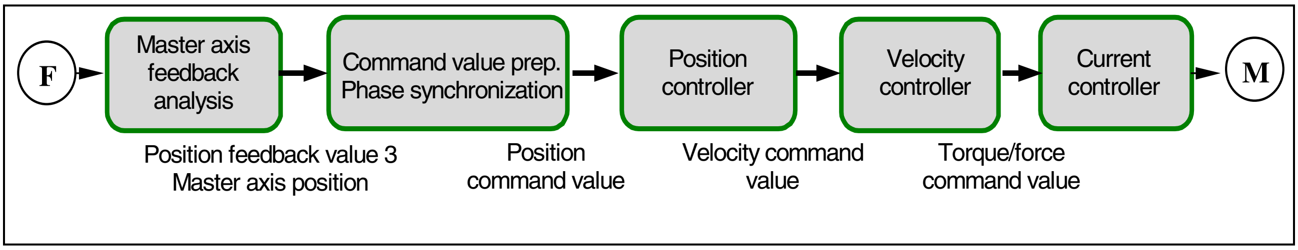


Fig. 8-67: Phase synchronization with real master axis block diagram

Pertinent parameters

The parameters listed in chapters: "Operating mode: phase synchronization with virtual master axis" and "Master axis feedback analysis" are involved in the operating mode "Phase synchronization with real master axis".

Functional principle

The operating mode "Phase synchronization with virtual master axis“ and the master axis feedback analysis are combined in the drive. **P-0-0052, Position feedback value 3** that is obtained by means of the master axis feedback analysis is copied by the drive to parameter **P-0-0053, Master drive position**.

The function of the individual function blocks is described in the relevant chapters.

see chapter: "Master axis feedback analysis"

see chapter: "Operating mode: phase synchronization with virtual master axis"

see chapter: "Position controller"

see chapter: "Velocity controller"

see chapter: "Current controller"

Note: As long as the master axis feedback has not been homed (position status bit 2 = 0), the drive follows the master axis position with synchronous velocity. The dynamic synchronization is begun as soon as the master axis feedback can be analyzed in absolute form (homed) and the synchronous velocity has been reached.

During dynamic synchronization the path is additionally increased by the position jump of the master axis feedback position when detecting the zero pulse.

$$\text{Path} = X_{\text{Synch}} + S-0-0048 \; - \; S-0-0047 + (P-0-0052[n] \; - \; P-0-0052[n-1])$$

X_{Synch}: synchronous position command value

P-0-0052[n]=P-0-0053[n]: Position of master axis feedback immediately **after** detection of zero pulse

P-0-0052[n-1]=P-0-0053[n-1]: Position of master axis feedback immediately **before** detection of zero pulse

Fig. 8-68: Travel path for absolute synchronisation

8.14 Operating mode: electronic cam shaft with virtual master axis

In the operating mode "Electronic cam shaft with virtual master axis" there is a fixed relationship between the master axis position and the slave axis. The (virtual) master axis position is set by the control.

The structure of the operating mode "Electronic cam shaft with virtual master axis" is illustrated below:

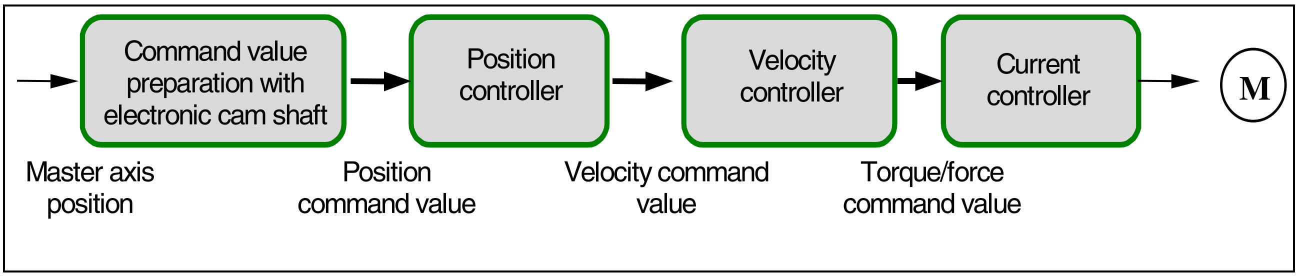


Fig 8-69: Electronic cam shaft block diagram

see also "Position controller"

see also "Velocity controller"

see also "Current controller"

Pertinent parameters

- **S-0-0048, Position command value additional**

S-0-0048 is used to establish a position offset between master axis an slave axis.

- **P-0-0053, Master drive position**

The value in P-0-0053 is preset cyclically and in equidistant intervals by the control (virtual master axis). Format: 2^20 increments/master axis revolution.

- **P-0-0061, Angle offset begin of profile**

With the value in P-0-0061 the access angle for the cam shaft profile is offset with regard to the master axis position. 360° correspond to the total length of the cam shaft profile.

- **P-0-0072, Cam shaft profile 1**

Contains a table with 1024 elements with tab(φ) data points for the cam shaft profile. The first element in the table is the data point for φ = 0. The last element of the table is the data point for φ = 2^20.

- **P-0-0083, Gear ratio fine adjust**

The gear ratio of the master drive gear is modified by the percentage parameterized in P-0-0083. For a master drive gear free of drift the value must equal zero.

- **P-0-0085, Dynamic angle offset**

With the value in P-0-0085 the effective master axis position is shifted according to the following equation:

$$\varphi_{\text{master axis, effective}} = \varphi_{\text{master axis}} + \frac{\text{master axis velocity}}{\text{position controller KV}} * \text{dyn. angle offset}$$

Fig. 8-70: Dynamic angle offset

- **P-0-0088, Control word for synchronous operating modes**

- **P-0-0089, Status word for synchronous operating modes**
- **P-0-0092, Cam shaft profile 2**
- **P-0-0093, Cam shaft distance**

This parameter defines the distance with which the profile of the cam shaft is multiplied.

- **P-0-0094, Cam shaft switch angle**

If the effective master axis position exceeds the angle entered in P-0-0094 in positive or negative direction, switchover is carried out to the cam shaft profile that has been selected by bit 0 of parameter **P-0-0088, Control word for synchronous operating modes**.

- **P-0-0108, Master drive polarity**

P-0-0108 is used to invert the master axis position.

- **P-0-0144, Cam shaft distance switch angle**

A new value for **P-0-0093, Cam shaft distance** will only become active, when the current profile access angle passes the switch angle **P-0-0144, Cam shaft distance switch angle**. In the case of immediate distance switching, the parameter is irrelevant.

- **P-0-0155, Synchronization mode**
- **P-0-0156, Master drive gear input revolutions**
- **P-0-0157, Master drive gear output revolutions**

Parameters P-0-0157 and P-0-0157 define the master drive gear.

- **P-0-0158, Angle offset change rate**
- **P-0-0159, Slave drive feed travel**
- **P-0-0750, Master axis revolutions per master axis cycle**

Parameter P-0-0750 contains the number of master axis revolutions required in order to bring all drives, that are to follow the master axis, back to a defined position with respect to each other. This parameter informs the drive of the range in which the master axis position (P-0-0053) is situated.

- **P-0-0752, Load revolutions per actual value cycle slave axis**

For modulo axes, parameter P-0-0752 defines the range in which the actual position value is displayed in absolute form. With modulo scaling, the actual position value is within a range of 360° * number of load revolutions per actual value cycle. The current value can be read from parameter **P-0-0753, Position actual value in actual value cycle**.

- **P-0-0755, Gear reduction**

P-0-0755 is used to parameterize a motion synchronous to the master axis that is superimposed to the motion determined by cam shaft profile and distance. These command values are not active, when the gear reduction is 0.

Diagnostic parameters

- **P-0-0034, Position command additional actual value**

P-0-0034 indicates the difference between position feedback value and synchronous position command value.

- **P-0-0753, Position actual value in actual value cycle**

Command value preparation for electronic cam shaft

Upon activation of the operating mode "Electronic cam shaft with virtual master axis", the position command value of the drive is initialized in terms of the following relation:

$$X_{F(\varphi L)} = h * tab(\pm\varphi_L * \frac{G_a}{G_e} * (1+F) - \varphi_V) + (\varphi_L * \frac{G_a}{G_e} * (1+F) - \varphi_V)/U + X_V$$

X_F :	Position command value of slave drive (S-0-0047)
+/- :	P-0-0108, Master drive polarity (P-0-0108=1 > -)
φ_L :	Master drive position (P-0-0053)
φ_V :	Angle offset begin of profile (P-0-0061)
h :	Cam shaft distance (P-0-0093)
tab(φ) :	Cam shaft profiles (P-0-0072 or P-0-0092)
X_v :	Position command value additional (S-0-0048)
G_a :	Master drive gear output revolutions (P-0-0157)
G_e :	Master drive gear input revolutions (P-0-0156)
F :	Fine adjust (P-0-0083)
U :	Gear reduction (P-0-0755)

Fig. 8-71: Initializing the position command value

With the operating mode activated, differences, that later on will be added again, are processed in the master drive gear and the cam shaft profiles. Therefore changes in the master drive gear and the cam shaft distance do not cause position command value jumps. Velocity jumps, however, can occur and the absolute position reference, that is established when activating the operating mode, is lost.

In every control cycle, a profile value is taken from the cam shaft profiles, the difference to the last profile value is generated, multiplication with the cam shaft distance is carried out and the result is added to the position command value. If **P-0-0755, Gear reduction** is unequal 0, the master axis position at the output of the master drive gear is additionally divided by the gear reduction, multiplied with the factor $360°/2^{20}$, the product is differentiated and the result is added to the position command value.

If profile limits are exceeded in positive direction, then the profile continues with its first value, the same happens if the limits are exceeded in negative direction.

The position command value generated as per the following relation:

$$X_{F(n)(\varphi L)} = X_{F(n-1)(\varphi L)} + (h * \Delta tab(\pm\varphi_L * \frac{G_a}{G_e} * (1+F) - \varphi_V + \varphi_d) + (\Delta\varphi_L * \frac{G_a}{G_e} * (1+F) - \Delta\varphi_V)/U + X_v)$$

X_F :	Position command value of slave drive (S-0-0047)
+/- :	P-0-0108, Master drive polarity (P-0-0108=1 > -)
φ_L :	Master drive position (P-0-0053)
φ_V :	Angle offset begin of profile (P-0-0061)
φ_d :	Dynamic Angle offset (P-0-0085)
h :	Cam shaft distance (P-0-0093)
tab(φ) :	Cam shaft profiles (P-0-0072 or P-0-0092)
X_v :	Position command value additional (S-0-0048)
G_a :	Master drive gear output revolutions (P-0-0157)
G_e :	Master drive gear input revolutions (P-0-0156)
F :	Fine adjust (P-0-0083)
U :	Gear reduction (P-0-0755)

Fig. 8-72: Generating the position command value for the slave drive

The generation of the synchronous position command value is illustrated in the following figure:

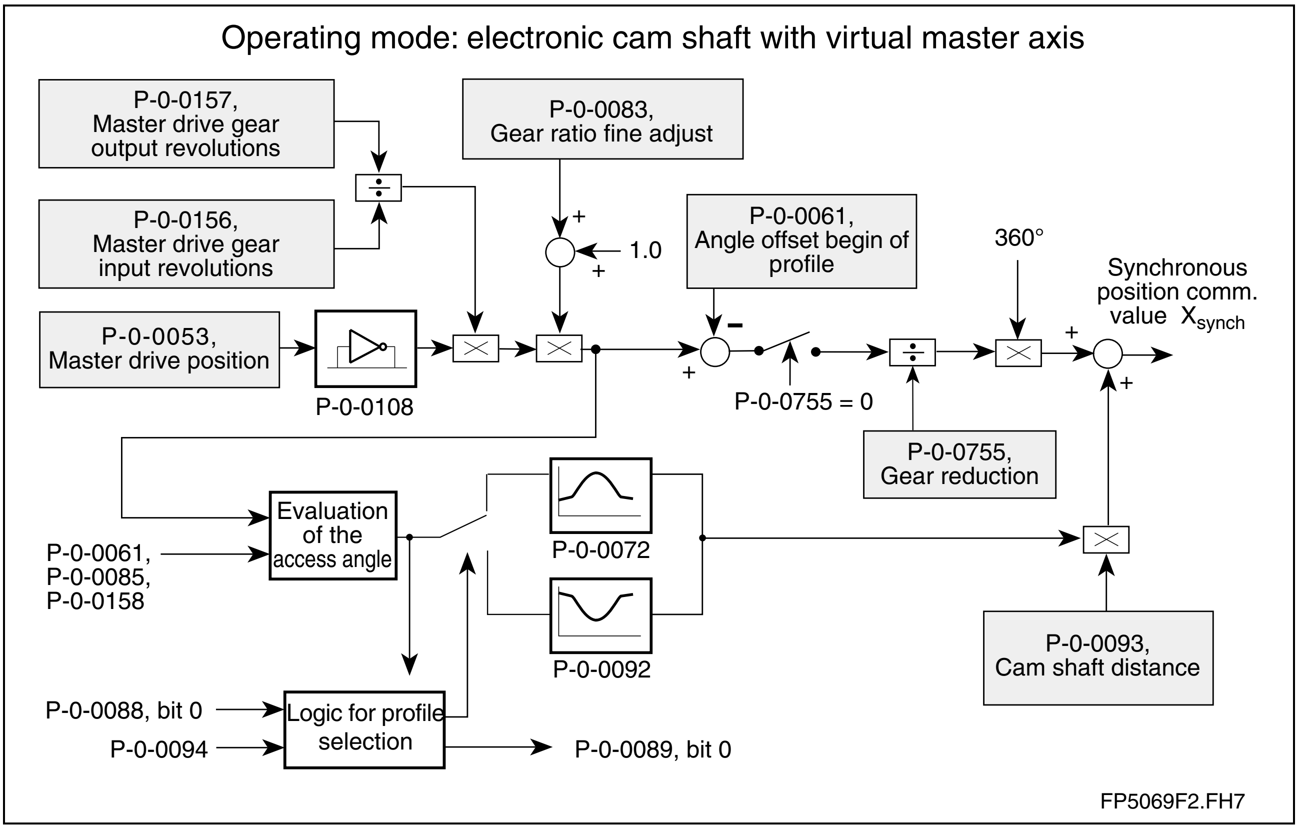


Fig. 8-73: Generating the synchronous position command value

Changes of P-0-0061, Angle offset begin of profile

To avoid jumps of the profile access angle, a new value for parameter **P-0-0061, Angle offset begin of profile** does not immediately become effective. Starting with the current value, a ramp-like approximation of the new value is conducted. The approximation is conducted along the shortest possible path. The gradient of the ramp is set in parameter **P-0-0158, Angle offset change rate**.

P-0-0085, Dynamic angle offset

Parameter **P-0-0085, Dynamic angle offset** is used to compensate a lag error if the position controller has not been set to lagless control. The profile access angle is offset in velocity-dependent form.

$$\varphi d = \frac{P\text{-}0\text{-}0085 * (\varphi L(n) - \varphi L(n-1)) * \frac{Ga}{Ge})}{Kv}$$

φ_L : Master drive position (P-0-0053)
P-0-0085 : Dynamic angle offset
G_a : P-0-0157, Master drive gear output revolutions
G_e : P-0-0156, Master drive gear intput revolutions
K_v : S-0-0104, Position loop Kv-factor

Fig. 8-74: Generating the dynamic angle offset

Modulo axes

With infinitely turning axes, modulo scaling must be set in **S-0-0076, Position data scaling type**.

Note: For constantly fault-free processing of the position data with infinitely turning axes, the values resulting from gear reduction (P-0-0755≠0) must be considered for forward motion. A finite cam shaft profile can be superimposed. When using an infinite cam shaft profile (difference between first and last profile value > 50%), a small error can occur with each profile sequence. With infinite motion in one direction this error multiplies and an unexpected drift can occur.

Selecting the active cam shaft profile 1

The active cam shaft profile (P-0-0072 or P-0-0092) is selected with parameters **P-0-0088, Control word for synchronous operating modes** and **P-0-0094, Cam shaft switch angle**. The active cam shaft is included in **P-0-0089, Status word for synchronous operating modes**. Switching is started by changing the control word. It is conducted and acknowledged by the drive in the status word, when the profile access angle passes **P-0-0094, Cam shaft switch angle**.

Changing the cam shaft distance

Parameter **P-0-0144, Cam shaft distance switch angle** defines at which profile access angle and thus profile element a change in value becomes effective for the cam shaft distance. If the profile values in the switch range are 0, an absolute position reference is maintained in the case of a change.

Activating the distance

With bit 3 of parameter **P-0-0088, Control word for synchronous operating modes** you can select whether a new value for **P-0-0093, Cam shaft distance** becomes effective immediately or only when the profile access angle passes **P-0-0144, Cam shaft distance switch angle**.

Cross cutter

By means of the command values of **P-0-0755, Gear reduction** a cross cutter axis can be operated. A cross cutter (rotating knife) is required to cut a defined piece (format) off some material that is transported with constant velocity. The format is set by the master drive gear. With a master drive gear 1:1 the format corresponds to the circumference of the cutting cylinder (with a number of knives = 1). Smaller formats are realized by a master drive gear [(output/input)>1]. The slave axis (cutting cylinder) then turns faster than the master axis. In this case, the cutting cylinder, in the cutting range (at 180 degrees of profile access angle), has to be decelerated to the transport velocity of the material. After the cutting range the cylinder is accelerated again. This is achieved by superimposing a more or less sinusoidal cam shaft to the constant velocity of the axis that is caused by the linear proportion. With constant cam shaft profile it is then possible to define, by means of the distance, whether the axis decelerates (distance>0) or accelerates (distance<0) in the cutting range.

The number of knives that are distributed at the circumference of the cutting cylinder is entered in parameter **P-0-0755, Gear reduction**. The cutting cylinder will then turn accordingly slower. Per cam shaft profile sequence, the cutting cylinder will move by the distance of two knives at the circumference.

To change the format "on the fly" it is necessary to simultaneously change master drive gear and distance in the cutting range. This function is switched on by setting bit 4 in **P-0-0088, Control word for synchronous operating modes**. A change in the master drive gear will only become effective, when the distance is changed and the new distance value is accepted when **P-0-0144, Cam shaft distance switch angle** is being passed.

Dynamic synchronization in the cam shaft operating mode

Basically, dynamic synchronization is identical with synchronization in the "phase synchronization" operating mode (see also "Dynamic synchronization in the phase synchronization operating mode"). There are the following differences:

In the "cam shaft" operating mode, the number of selectable synchronization ranges depends on the type of position scaling. Modulo axes can synchronize to a position in the command value cycle of the slave axis, in a division of this command value cycle or in the modulo range. The drive controller determines the command value cycle according to the following formula:

$$\text{Command value cycle} = P-0-0750 * \frac{P-0-0157}{P-0-0156 * P\text{-}0\text{-}0755} * 360°$$

Fig.: 8-75: Command value cycle

The active value is displayed in parameter **P-0-0754, Command value cycle**.

With absolute position scaling, absolute synchronization is carried out. Please observe that for initialization of the synchronous position command value, only the master axis position within one master axis revolution (considering master drive gear and fine adjustment) will be taken into account. The synchronous position command value is obtained by multiplying the profile value of this master axis position with the distance.

8.15 Operating mode: electronic cam shaft with real master axis

There is a fixed relationship between master axis position and slave axis in the operating mode electronic cam shaft with real master axis.

The (real) master axis position is determined from the master axis feedback analysis.

The structure of the operating mode "Electronic cam shaft with real master axis" is illustrated below:

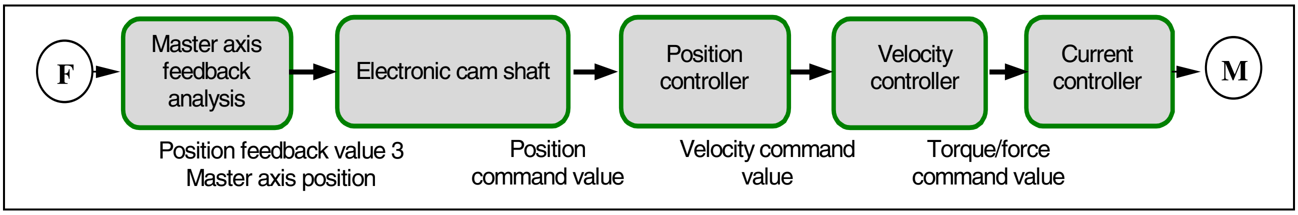


Fig. 8-76: Electronic cam shaft block diagram

Pertinent parameters

The parameters listed in chapters "Operating mode: electronic cam shaft with virtual master axis" and "Master axis feedback analysis" are involved in this operating mode.

Functional principle

The operating mode electronic cam shaft with real master axis combines the operating modes "Electronic cam shaft with virtual master axis" and the master axis feedback analysis in the drive. **P-0-0052, Position feedback value 3** that is obtained by means of the master axis feedback analysis is copied by the drive to parameter **P-0-0053, Master drive position**.

The function of the individual function blocks is described in the relevant chapters.

see chapter: "Master axis feedback analysis"

see chapter: "Operating mode: electronic cam shaft with virtual master axis"

see chapter: "Position controller"

see chapter: "Velocity controller"

see chapter: "Current controller"

Note: As long as the master axis feedback has not been homed (position status bit 2=0), the drive follows the master axis position with synchronous velocity. The dynamic synchronization is begun as soon as the master axis feedback can be analyzed in absolute form (homed) and the synchronous velocity has been reached.

During dynamic synchronization the path is additionally increased by the position jump of the master axis feedback position when detecting the zero pulse.

$$\text{Path} = X_{\text{Synch}} + S-0-0048 \; - \; S-0-0047 + (P-0-0052[n] \; - \; P-0-0052[n-1])$$

X_{Synch}: synchronous position command value
P-0-0052[n]=P-0-0053[n]: Position of master axis feedback immediately **after** detection of zero pulse
P-0-0052[n-1]=P-0-0053[n-1]: Position of master axis feedback immediately **before** detection of zero pulse

Fig. 8-77: Travel path for absolute synchronization

Notes

9 Basic drive functions

9.1 Physical values display format

The data exchange between the controller and the primary control system or user interface occurs by reading and writing controller parameters. Information about the unit and the number of decimal places (see also chapter "Parameter") is necessary for interpreting the operating data of a parameter. The value of the operating data results from these data. The following illustration shows this with an example.

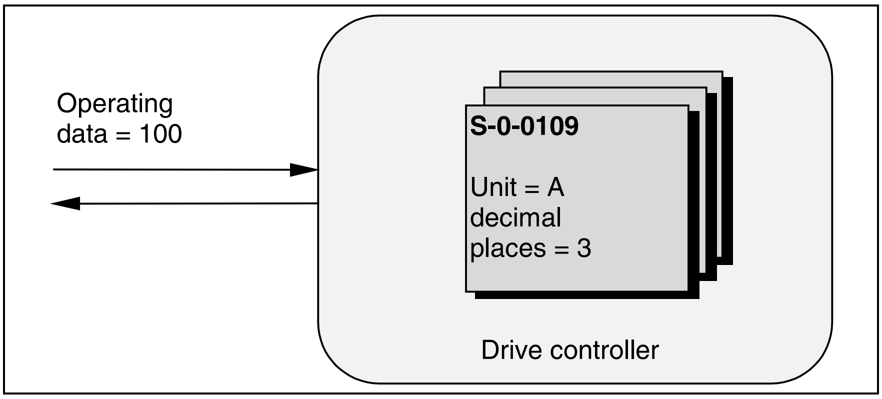


Fig. 9-1: Example for interpreting operating data in the drive

In the above picture, the value 100 is written to the operating data of parameter S-0-0109. When combined, the unit A (Ampere) that belongs to this parameter and the number of decimal places (3) produce the physical value 0.100 A.

Each parameter therefore has a unit and the number of decimal places. The combination of these two criteria is called scaling. When interpreting operating data, these must always be included in the analysis.

Adjustable scaling for position, velocity and acceleration data

The parameter scaling for

- position data,
- velocity data and
- acceleration data

can be adjusted. It can be set by the user with scaling parameters.

It enables

- the value of this data to be made compatible for exchange between control system and drive, in other words, the data can be exchanged in the control system's internal format. The control system will not need to convert this data.
- this data to conform to machine kinematics. Linear movements can be written with linear units, for example, and rotary movements can be written with rotary units.

It is possible to select between linear and rotary scaling, and preferred and parameter scaling, as well as between motor and load reference.

Linear - rotary scaling

Adjustable scaling allows either linear or rotary scaling to be selected. Linear motors normally use linear scaling. Rotary motors use either rotary or linear scaling, if their rotary movement is converted into linear movement (with a ballscrew, for example).

Preferred scaling - parameter scaling

Adjustable scaling allows either preferred scaling or parameter scaling to be selected. If preferred scaling is selected, the appropriate scaling factor parameters and scaling exponent parameters in **S-0-0128, C200 Communication phase 4 transition check** are overwritten with preferred values. This sets a pre-defined scaling. The scaling factor parameters and the scaling exponent parameters are not entered. The preferred scaling depends on whether linear or rotary scaling has been selected.

The following preferred scaling is available:

Physical value	**Rotary preferred scaling**	**Linear preferred scaling (mm)**	**Linear preferred scaling (Inch)**
Position data	0.0001 Degrees	0.0001 mm	0.001 Inches
Velocity data	0.0001 RPM, or 10^-6 Rev/s	10^-6 m/min	10^-5 in/min
Acceleration data	0.001 rad/s²	10^-6 m/s²	--

Fig. 9-2: Preferred scaling

Motor reference - load reference

Either motor reference or load reference can be selected when adjusting the scaling.

Load reference

With rotary load reference, the scaled data are converted from the motor reference format to the gear output format with the gear ratio **S-0-0122, Output revolutions of load gear / S-0-0121, Input revolutions of load gear**.

With linear load reference, the scaled data are converted from the motor reference format to feed format with the gear ratio **S-0-0122, Output revolutions of load gear / S-0-0121, Input revolutions of load gear** and the feed constant **S-0-0123, Feed constant**.

The following restrictions apply in relationship to the motor type being used :

- Rotary motor reference cannot be set with linear motors.
- Linear motor reference cannot be set with rotary motors.

Display format of position data

The scaling of drive controller position data is adjustable. This is done with the parameters

- **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**

This differentiates between linear and rotary scaling. **S-0-0079, Rotational position resolution** sets the rotary position scaling. **S-0-0077, Linear Position Data Scaling Factor** and **S-0-0078, Linear Position Data Scaling Exponent** set the linear position scaling.

The scaling type is set in **S-0-0076, Position Data Scaling Type**.

S-0-0076, Position Data Scaling Type

Bits 2-0: Scaling type
000: not scaled
001: linear scaling
010: rotary scaling

Bit 3:
0: Preferred scaling
1: Parameter scaling

Bit 4: Unit of measure for linear scaling
0: Meter [m]
1: Inch [in]
Unit of measure for rotary scaling
0: Angle degrees
1: reserved

Bit 5: reserved

Bit 6: Data reference
0: to the motor shaft
1: to the load

Bit 7: Processing format
0: Absolute format
1: Modulo format

Bits 15-8: reserved

Fig. 9-3: S-0-0076, Position data scaling type

The scaling type setting is checked for plausibility in **S-0-0128, C200 Communication phase 4 transition check**, and the command error message **C213 Position Data Scaling Error** is generated, if necessary.

Velocity data display format

The scaling of the drive controller's velocity data is adjustable.

This is done with the parameters

- **S-0-0044, Velocity data scaling type**
- **S-0-0045, Velocity data scaling factor**
- **S-0-0046, Velocity data scaling exponent**

The scaling type is set in **S-0-0044, Velocity data scaling type**.

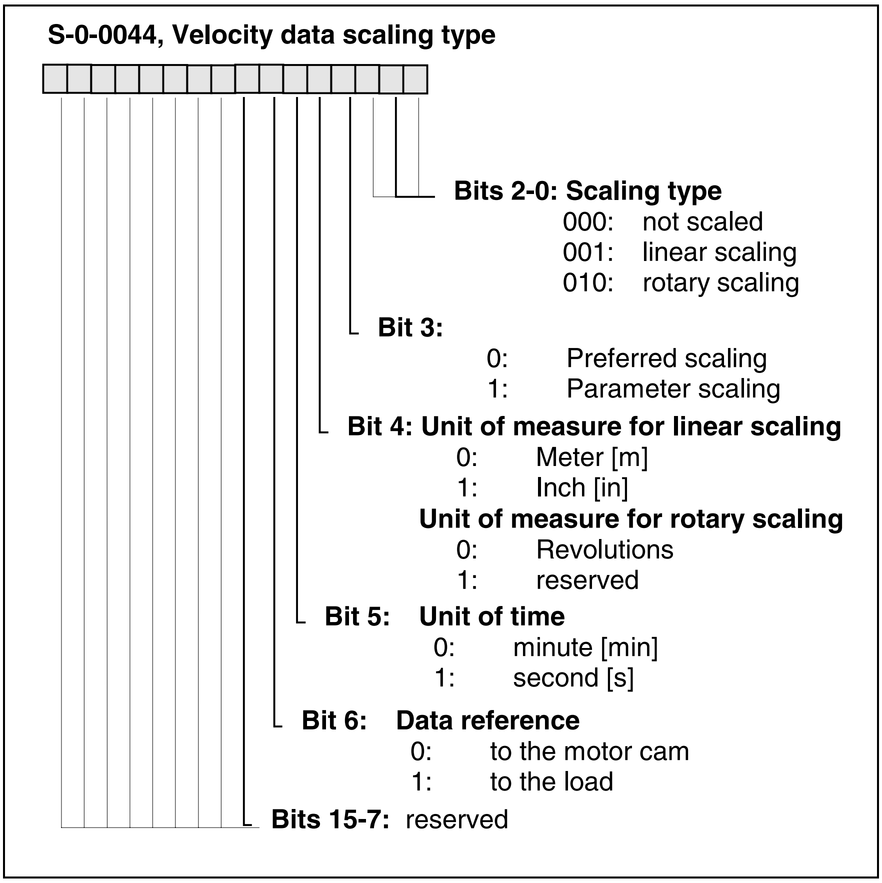


Fig. 9-4: S-0-0044, Velocity data scaling type

The scaling type setting is checked for plausibility in **S-0-0128, C200 Communication phase 4 transition check,** and the command error message **C214 Velocity Data Scaling Error** is generated, if necessary.

Acceleration data display format

The scaling of the drive controller's acceleration data is adjustable.

This is done with the parameters

- **S-0-0160, Acceleration data scaling type**
- **S-0-0161, Acceleration data scaling factor**
- **S-0-0162, Acceleration data scaling exponent**

The scaling type is set in **S-0-0160, Acceleration data scaling type**.

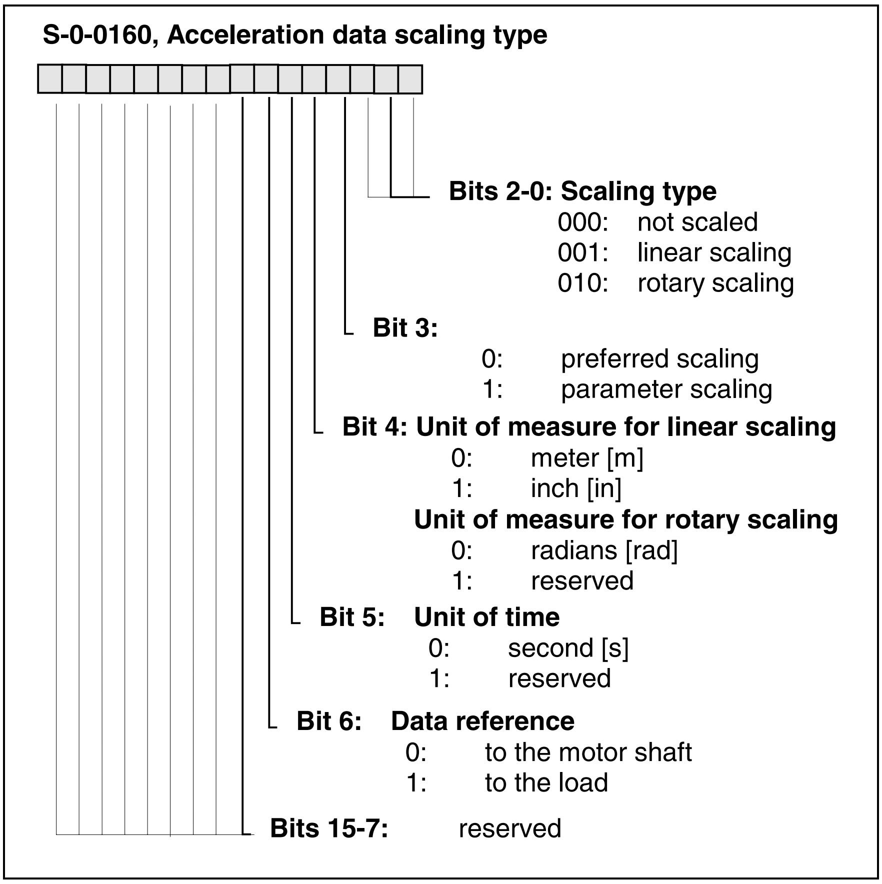


Fig. 9-5: S-0-0160, Acceleration data scaling type

The scaling type setting is checked for plausibility in **S-0-0128, C200 Communication phase 4 transition check,** and the command error message **C215 Acceleration Data Scaling Error** is generated, if necessary.

Command value polarities and actual value polarities

The drive-internal polarities of position, velocity, torque/force and actual values are fixed.

The following applies:

Motor type	Definition of "drive-internal positive direction"
Rotary motors	Clockwise rotation facing the motor shaft
Linear motors	In the direction of the connection of the power cable on the front side of the primary part

Fig. 9-6: Definition of "drive internal positive direction"

The positive direction is specified by the manufacturer for MHD, MKD and MKE motors. For asynchronous motors, linear synchronous motors and MBS motors the positive direction has to be set during commissioning (see chapter: "Other motor encoder characteristics"). The command value polarity and actual value polarity of the drive is thereby fixed.

If the definition of the positive direction of the motor does not conform to the requirements of the machine, the parameters

- **S-0-0055, Position Polarity Parameter**
- **S-0-0043, Velocity polarity parameter**
- **S-0-0085, Torque/Force polarity parameter**

can invert the command value and actual value polarities.

Note: If the polarity needs to be changed, all 3 polarity parameters should always be inverted at the same time, so that the polarities of the position, velocity and torque/force have the same sign.

The following illustration shows the operating characteristics of the polarity parameters.

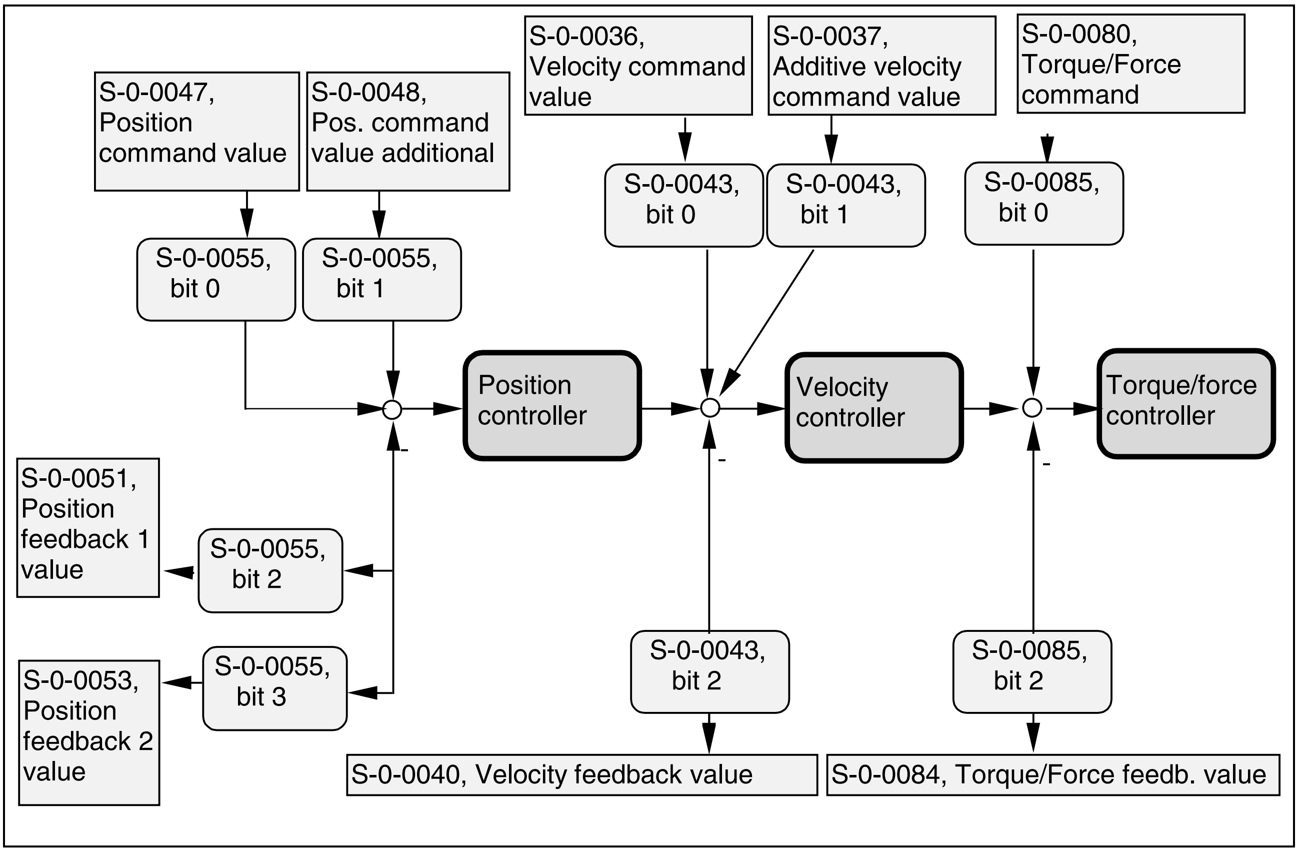


Fig. 9-7: Polarity parameter operating characteristics

The polarity parameters affect only the display values, not the control feedback values.

The drive software only allows all bits within a polarity parameter to be inverted. If bit 0 is inverted, all other bits of the respective parameter are also inverted. This protects against the danger of adding positive feedback into the control loops (command and feedback values with opposing polarities) due to incorrectly set command and feedback value polarities.

Mechanical transmission elements

Mechanical transmission elements are gear and feed mechanisms between the motor shaft and the load. Entering this data is necessary for the load-side conversion of the physical values position, velocity and acceleration, if these are scaled for the load (see also chapter: "Adjustable scaling for position, velocity, and acceleration data"). To see if these parameters have been input correctly, move the shaft and compare the travelled path with the position feedback value and the path actually taken.

Gear ratio

The gear ratio can be set with the parameters

- **S-0-0121, Input revolutions of load gear**
- **S-0-0122, Output revolutions of load gear**

The ratio between gear input and gear output is parameterized in these two parameters.

Example:

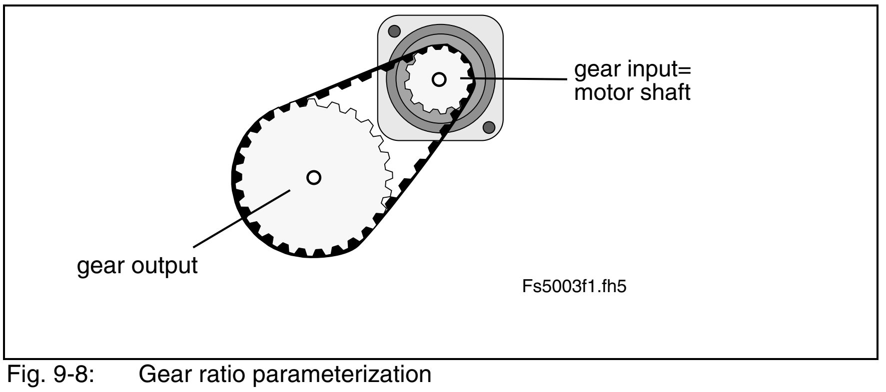


Fig. 9-8: Gear ratio parameterization

Supposing in the illustration above, two gear input revolutions (= motor revolutions) were equivalent to one gear output revolution, the proper parameterization would be:

S-0-0121, Input revolutions of load gear = 2

S-0-0122, Output revolutions of load gear = 1

Feed constant

The feed constant defines how far the load moves linearly per gear output revolution. The feed constant is specified in the parameter **S-0-0123, Feed constant**. The value programmed in this parameter is used along with the gear ratio for converting the position, velocity and acceleration data from motor reference to load reference.

Example:

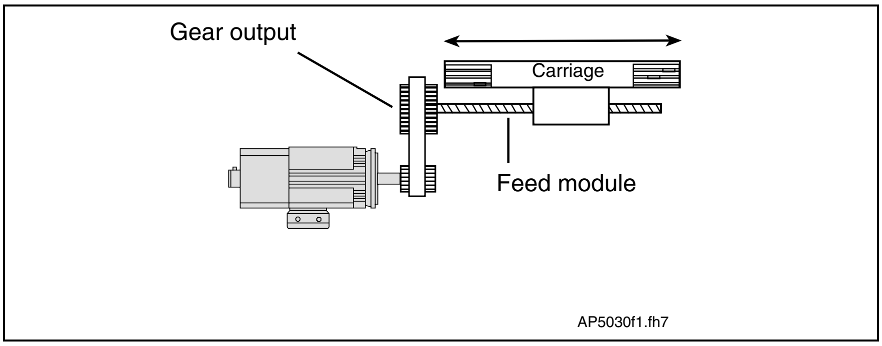


Fig. 9-9: Feed constant parameterization

In the illustration above, the feed module would cover 10 mm per gear output revolution. The proper parameterization for this would be:

S-0-0123, Feed Constant = 10 mm/Rev

Modulo feature

If the modulo feature is activated, all position data in the range of 0 to the modulo value are displayed. It is therefore possible to realize an axis that moves endlessly in one direction. There is no overflow of position data.

The modulo value is set via the parameter **S-0-0103, Modulo Value**.

The modulo feature is activated in the parameter **S-0-0076, Position Data Scaling Type.**

(see also chapter: "Display format of position data")

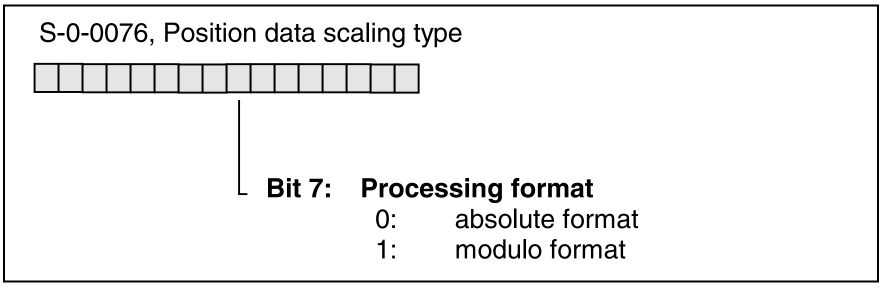


Fig. 9-10: Setting absolute format – modulo format

Note: Processing position data in modulo format is only allowed with rotary motor types. This is checked in **S-0-0128, C200 Communication phase 4 transition check** and acknowledged by command error **C213 Position data scaling error**, if necessary.

The difference, in the display of position data, between absolute format and modulo format is shown in the following figure:

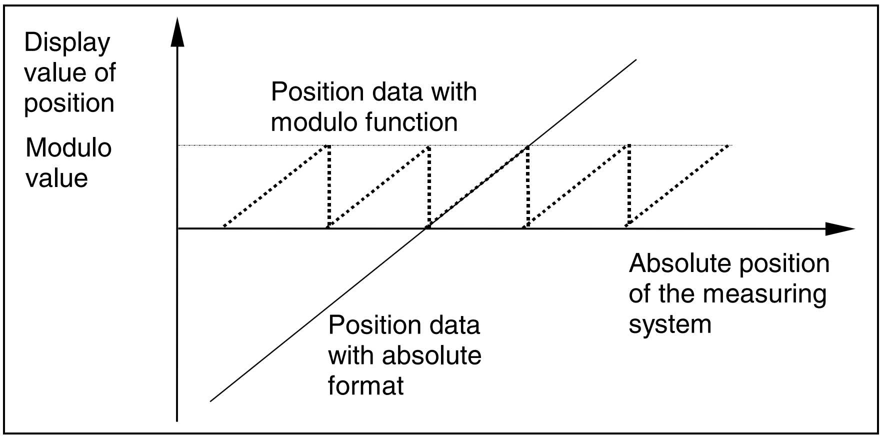


Fig. 9-11: Display value of positions with absolute format and with modulo format

Modulo processing-limiting conditions

If modulo processing of position data is selected, depending on

- the active operating mode and
- the selected position scaling

the following limiting conditions for error-free processing of the position data must be observed:

- The modulo range (**S-0-0103, Modulo Value**) may not be greater than the maximum travel range.
- If rotary or linear position scaling with load reference and no phase synchronization is used as operating mode, then the product of **S-0-0103, Modulo Value**, **S-0-0116, Resolution of motor feedback** and **S-0-0121, Input revolutions of load gear** must be smaller than 2^63.
- If rotary position scaling with load reference is used as operating mode, the modulo value cannot be set. The setting of S-0-0103 is always fixed to one load revolution = 360°. If the operating mode "phase synchronization" is used, linear position scaling mustn't be set.

If, in addition to this, an external measurement system is used, the additional requirements are:

- If rotary position scaling with motor reference and not the operating mode "phase synchronization" is used, then the product of **S-0-0103, Modulo Value**, **S-0-0117**, **Feedback 2 Resolution** and **S-0-0122, Output revolutions of load gear** must be smaller than 2^63.

Compliance with the limiting conditions is checked in **S-0-0128, C200 Communication phase 4 transition check**, and the command is terminated with the error **C227 Modulo Range Error**, if necessary.

Processing command values in modulo format, shortest path - direction selection

The interpretation of position command values, such as **S-0-0047, Position Command Value** and **S-0-0258, Target Position**, with activated modulo feature depends on the mode that has been set.

The following possibilities exist:

- Shortest path
- Positive direction
- Negative direction

The mode is set in parameter **S-0-0393, Command value mode**. This setting is only effective, if the modulo format has been activated in **S-0-0076, Position data scaling type**.

The following settings can be entered:

S-0-0393 = 0

Modulo mode "Shortest path"

The next command value is reached with the shortest path. If the difference between two successive command values is greater than half the modulo value, the drive moves toward the command value in the opposite direction.

S-0-0393 = 1

Modulo mode "Positive direction"

The command value is always approached in a positive direction, regardless of whether or not the difference between two successive command values is greater than half the modulo value.

S-0-0393 = 2

Modulo mode "Negative direction"

The command value is always approached in a negative direction, regardless of whether or not the difference between two successive command values is greater than half the modulo value.

9.2 Setting the measuring systems

The drive controller is equipped with two permanently installed encoder interfaces (X4 and X8).

The encoder interface 1 (X4) is designed so that the following encoder types can be evaluated:

Encoder interface 1

- digital servo feedback (DSF, HSF)
- resolver
- resolver without feedback data memory

Using encoder interface 2 (X8) it is possible to evaluate the following encoder types:

Encoder interface 2

- incremental encoder with sine signals $1V_{pp}$
- incremental encoder with square-wave signals (TTL)
- measuring systems with EnDat interface
- gearwheel encoder with $1V_{pp}$ signals

Both encoder interfaces can be used to connect either a motor encoder or an optional encoder.

At which interface the motor encoder should be connected and what type it is, is set in parameter **P-0-0074, Feedback type 1**.

If an optional encoder is also to be used, the parameter **P-0-0075, Feedback type 2** must be used to define encoder interface and encoder type.

The following table explains the relationship:

Measuring system type:	Interface	Value in P-0-0074/75
digital servo feedback or resolver	1	1
incremental encoder with sine signals from Heidenhain with 1V signals	2	2
incremental encoder with square-wave signals from Heidenhain	2	5
encoder with EnDat-interface	2	8
gearwheel encoder with $1V_{pp}$ signals	2	9
resolver without feedback data memory	1	10
resolver without feedback data memory + incremental encoder with sine signals	1 + 2	11
Hall encoder + square-wave encoder	1 + 2	12
Hall encoder plus sine encoder	1 + 2	14

Fig. 9-12: Measuring systems - connections

The table illustrates that some combinations are not possible, as each encoder interface is physically present only once.

To display the actual position values of the individual measuring systems, use parameters:

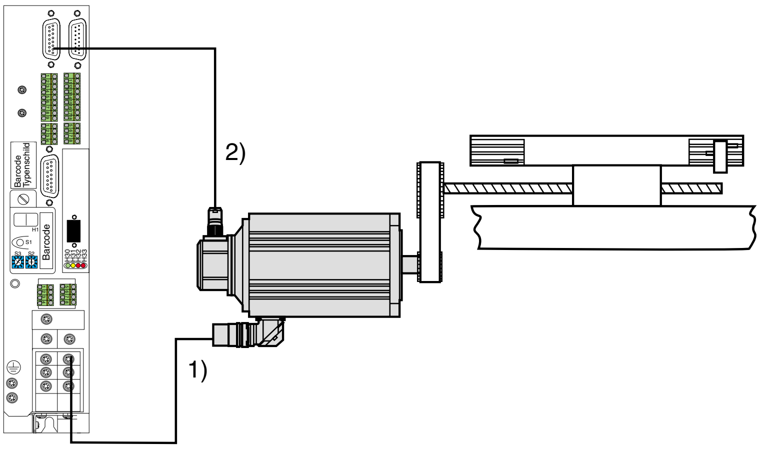
- **S-0-0051, Position feedback 1 value**
- **S-0-0053, Position feedback 2 value**

To set the absolute reference of actual position value 1/2 to the machine zero point, use commands

- **S-0-0148, C600 Drive controlled homing procedure command** or
- **P-0-0012, C300 Command Set absolute measurement**

Motor encoder

The measuring system which is directly coupled with the motor shaft without a gearbox between them is called the motor encoder. As the motor is usually coupled to the load with a mechanical gearbox and possibly a feed unit, this is an indirect measuring system. If a second measuring system is attached directly to the load, than this is a direct measuring system (see chapter: "Optional encoder"). The illustration below shows typical applications of indirect distance measuring.

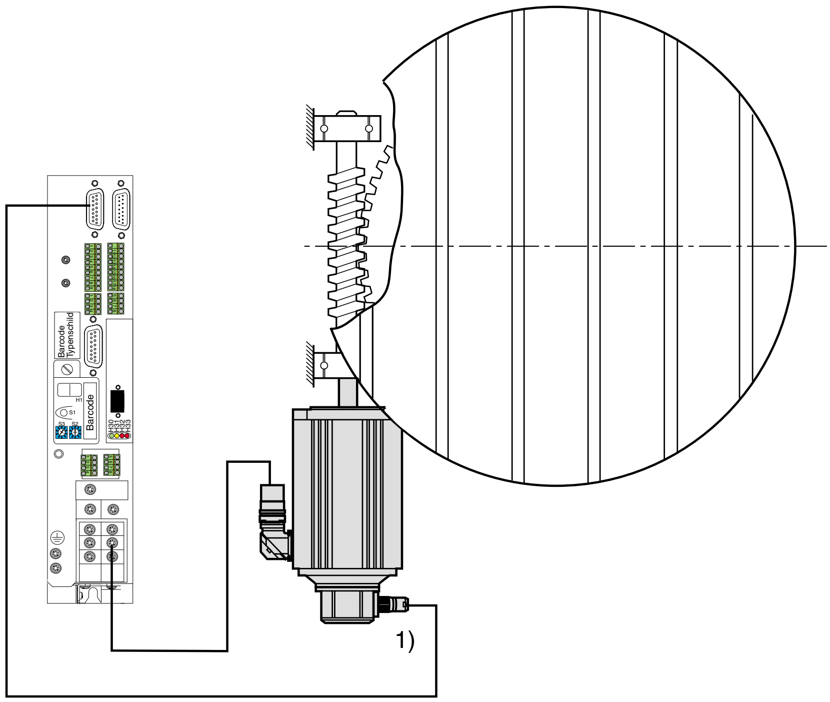


1) Power connection of motor

2) Connection of motor encoder (indirect actual position value acquisition)

Ap5134f1.fh7

Fig. 9-13: Application: Motor encoder with linear servo axis



1) Indirect actual position value acquisition with drive-internal distance measuring system

Ap5135f1.fh7

Fig. 9-14: Application: Motor encoder with rotary servo axis

The following parameters are used to parameterize the motor encoder:

- **P-0-0074, Feedback type 1**
- **S-0-0116, Feedback 1 Resolution**
- **S-0-0277, Position feedback 1 type**

These specify the interface number to which the measuring system is connected, the motor encoder resolution, as well as the direction of movement, etc. The parameter **S-0-0051, Position feedback 1 value** displays the position of the motor encoder.

The reference point relative to the machine zero point is set with

- **S-0-0148, C600 Drive controlled homing procedure command**

or

- **P-0-0012, C300 Command Set absolute Measurement**

Note: For Rexroth Indramat housing motors MHD, MKD and MKE all motor specific data are set automatically. Further settings by the commissioning engineer are not required.

Determining the encoder interface of the motor encoder

The encoder interface of the motor encoder is determined by the parameter **P-0-0074, Feedback type 1**. The number of the motor encoder type must be entered. The motor encoder interface in P-0-0074 is automatically set in some motor types.

(see also chapter: "Characteristics of the different motor types")

The following measuring systems may be used with motors with motor encoder interfaces that can be parameterized:

Measuring system	Encoder interface	Value in P-0-0074	For synchronous motors	For asynchronous motors
not available (only with rotary asynchronous motors)	-	0	no	yes
digital servo feedback (LSF,HSF) or resolver	1	1	yes	yes
incremental encoder with sine signals from Heidenhain (1V signals)	2	2	yes	yes
incremental encoder with square-wave signals from Heidenhain	2	5	yes	yes
encoder with EnDat interface from Heidenhain	2	8	yes	yes
gearwheel encoder with $1V_{pp}$ signals	2	9	no	yes
resolver without feedback data memory	1	10	yes	no
resolver without feedback data memory plus incremental encoder with sine signals	1 + 2	11	yes	no
Hall encoder plus square-wave encoder	1 + 2	12	yes	no
Hall encoder plus sine encoder	1 + 2	14	yes	no

Fig. 9-15: Determining encoder interface for the motor encoder

Note: The motor encoder is only then unnecessary, if you work with a load-side motor encoder. This is only possible with rotary asynchronous motors (**P-0-4014, Motor type**=2 or 6). In this case, the external encoder is the only control encoder (see also "Optional encoder").

Motor encoder resolution

The motor encoder resolution is parameterized in the parameter **S-0-0116, Feedback 1 Resolution**. Enter the line count of the motor encoder. If using a measuring system with intrinsic feedback data memory, the resolution will be taken from this memory and does not need to be entered.

Measuring systems with intrinsic feedback memory:

- DSF, HSF
- Resolver
- EnDat

Depending on whether a rotary or linear motor is used, the unit and the number of decimal places are switched via **S-0-0116, Feedback 1 Resolution**.

(see also chapter: "Linear motor – rotary motor")

Other motor encoder characteristics

To parameterize the other motor encoder characteristics, use **S-0-0277, Position feedback 1 type**.

The structure of this parameter is as follows:

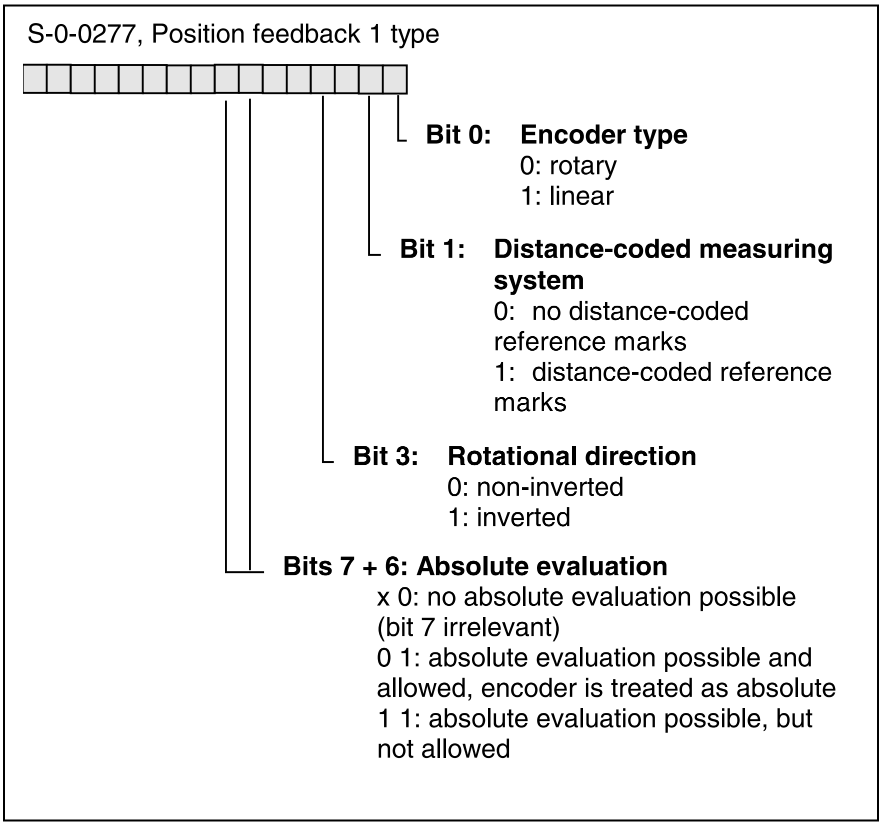


Fig. 9-16: Parameter S-0-0277

Note: The bits in the position encoder type parameter are partially set or cleared by the drive automatically.

There are following criteria:

- If the connected motor has a motor feedback memory (MHD, MKD or MKE), then bits 0, 1 and 3 are cleared.
- If the connected motor is a linear motor, then bit 0 is set to 1.
- Depending on the absolute encoder range and the maximum travel range or modulo value, bit 6 is either set or cleared.

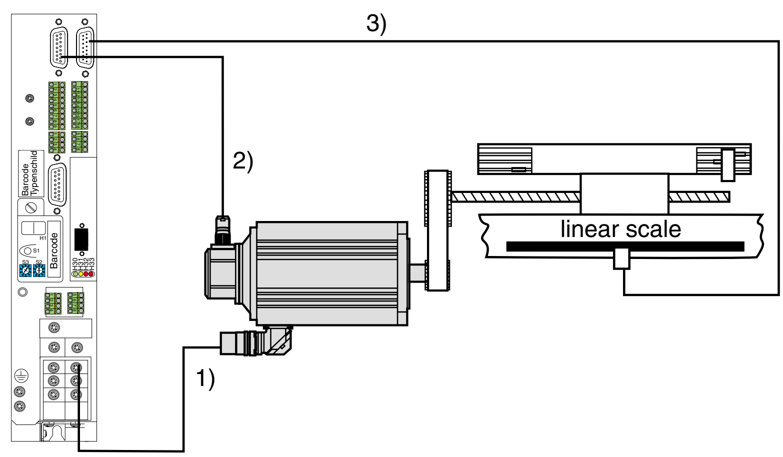
(See also chapter: "Supplementary settings for absolute measuring systems")

Optional encoder

The control with a direct measuring system facilitates higher contour precision of the machined workpieces in terms that it offers higher positioning accuracy. With setting the operating mode, you can determine that the position control in the drive is done with the position feedback value of the optional encoder. Additionally, the velocity control can be completely or partially done with the velocity feedback signal of this measuring system.

see also sections: "Operating modes" and "Setting the velocity mix factor"

Typical application examples:



1) Power connection of motor

2) Connection of motor encoder

3) Connection of optional encoder (direct actual positon value acquisition)

Ap5133f1.fh7

Fig. 9-17: Application: Optional encoder with linear servo axis

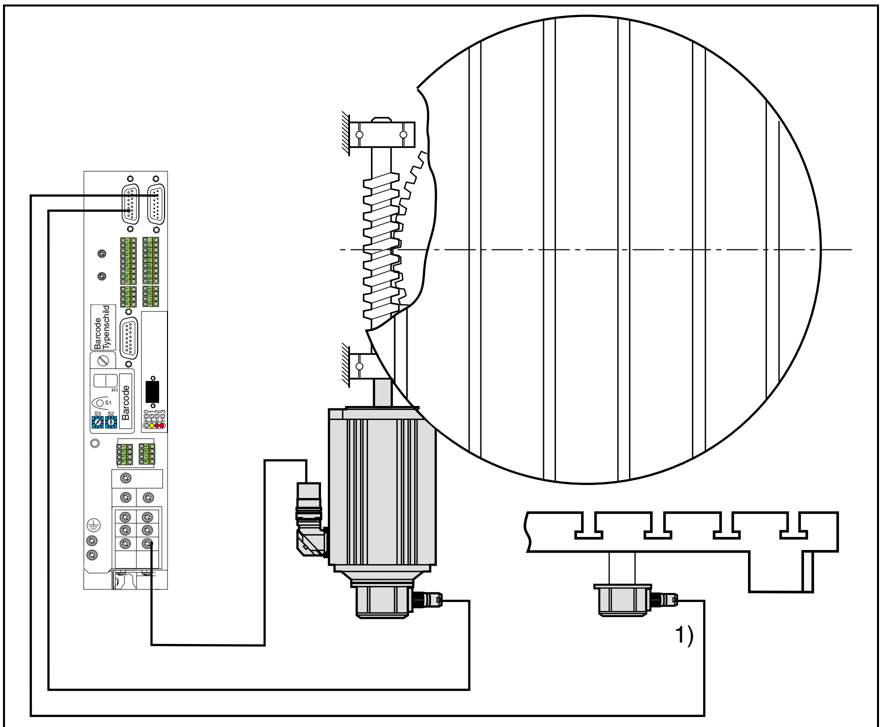


Fig. 9-18: Application: Optional encoder with rotary servo axis

The optional encoder is parameterized with parameters

- **P-0-0075, Feedback 2 type**
- **S-0-0115, Position feedback 2 type**
- **S-0-0117, Feedback 2 Resolution**
- **P-0-0185, Function of encoder 2**

These specify:

- the encoder type which is used,
- the resolution of the optional encoder,
- the direction of movement, etc.

The parameter **S-0-0053, Position feedback 2 value** displays the position of the optional encoder.

The reference point relative to the machine zero point is set with

- **S-0-0148, C600 Drive controlled homing procedure command** or
- **P-0-0012, C300 Command Set absolute measurement**

The optional encoder can be used for different purposes. The evaluation mode is set in parameter **P-0-0185, Function of encoder 2**.

Value in P-0-0185, Function of encoder 2	Meaning
0	Encoder 2 as an additional load-side control encoder for position and/or velocity control loops. Signal frequency monitored for exceeding maximum frequency of the interface. Upon exceeding it, error **F246 Max signal frequency of encoder 2 exceeded** is generated and the position status (S-0-0403) cleared.
1	Optional encoder as master drive encoder.
2	Optional encoder as only load-side control encoder (only with rotary asynchronous motors). In this case, there is no motor encoder (P-0-0074 = "0“). Parameter **P-0-0121, Velocity mix factor Feedback 1 & 2** must be set to 100%.
3	Optional encoder as measuring wheel.

Fig. 9-19: Function of the optional encoder

Determining the encoder interface of the optional encoder

The encoder interface of the optional encoder is determined with parameter **P-0-0075, Feedback 2 type**. The number of the encoder type must be entered in this parameter. The following measuring systems and modules are permitted for the evaluation of the optional encoder.

Measuring system	Interface	Value in P-0-0075
not available	--	0
digital servo feedback	1	1
incremental encoder with sine signals from Heidenhain with 1 V signals	2	2
incremental encoder with square-wave signals from Heidenhain	2	5
encoder with EnDat interface	2	8
gearwheel encoder with 1 V_{pp} signals	2	9

Fig. 9-20: Encoder interface of the optional encoder

If "0" is entered in **P-0-0075, Feedback 2 type** as encoder type, then the encoder evaluation of the optional encoder is switched off.

Optional encoder resolution

To parameterize the resolution of the optional encoder use the parameter **S-0-0117, Feedback 2 Resolution**. Enter the line count of the optional encoder. If using a measuring system with intrinsic feedback data memory, the resolution will be taken from this memory and does not need to be entered.

Measuring systems with intrinsic feedback memory:

- DSF, HSF
- Encoder with EnDat interface

Depending on whether a rotary or linear measuring system was parameterized in bit 0 of **S-0-0115, Position feedback 2 type**, the unit and number of decimal places are switched via **S-0-0117, Feedback 2 Resolution**.

Rotary: dp/rev.

Linear: 0.00001 mm

Position feedback monitor

In applications where an optional measuring system is used, the position feedback monitor can offer an additional margin of safety. The position feedback monitor compares **S-0-0051, Position feedback 1 value** and **S-0-0053, Position feedback 2 value** and is thus capable of diagnosing the following axis errors:

- Slip in the mechanical drive system
- Measuring system errors (as far as these are not recognized by the other measuring system monitors)

To set the monitor function use the parameter

- **S-0-0391, Monitoring window feedback 2**

If an error occurs, the error message **F236 Excessive position feedback difference** is generated.

Basic operating characteristics of the position feedback monitor

The position feedback monitor compares the position feedback values of encoder 1 and encoder 2. If the deviation of both position values is greater than **S-0-0391, Monitoring window feedback 2**, the error **F236 Excessive position feedback difference** is generated. As a result, the motor and optional encoder home mark bits are cleared.

The position feedback monitor is only active, if an optional encoder is available and evaluated and if **S-0-0391, Monitoring window feedback 2** is not parameterized with a 0.

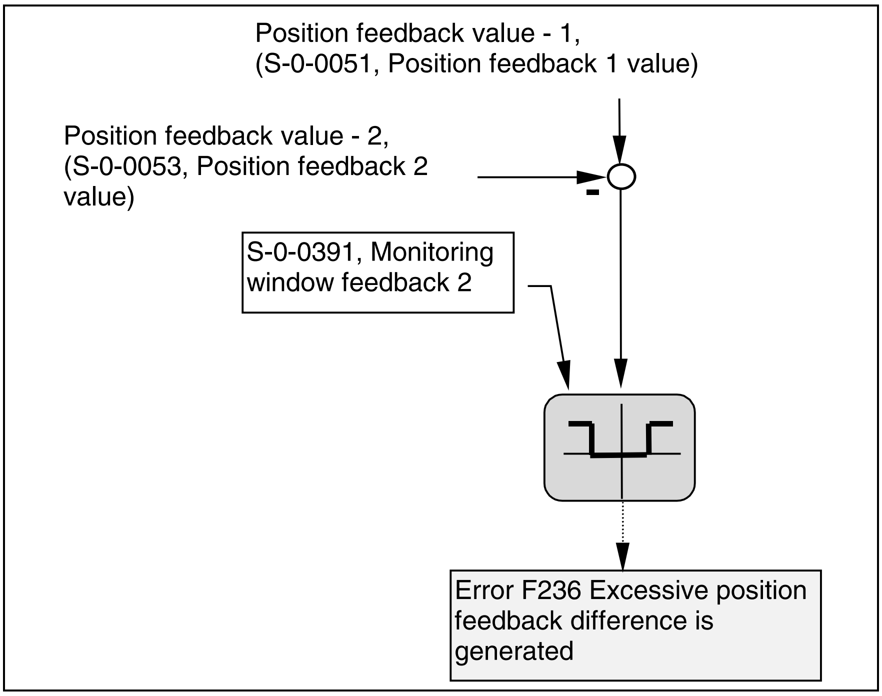


Fig. 9-21: Position feedback monitor schematic

Setting the position feedback monitoring window

The requirements for setting the position feedback monitor are:

- All drive control loops must be set correctly.
- The mechanical axis system must be in its definite status.
- The axis must be homed.

The monitoring window must be determined according to the application. The following basic procedure is recommended for doing this:

- Run a typical operating cycle. To do this, set the planned acceleration and velocity data of the axes.
- Enter progressively smaller values in the parameter **S-0-0391, Monitoring window feedback 2** until the drive generates the error message **F236 Excessive position feedback difference**. Depending on the mechanical system, you should start with 1-2 mm and decrease the window in steps of 0.3 ... 0.5 mm.
- The value at which the monitor is triggered should be multiplied with a tolerance factor of 2 ... 3 and entered in parameter **S-0-0391, Monitoring window feedback 2**.

When determining the monitoring window value, make sure that the position feedback monitor works dynamically. This means that even dynamic deviations of both position feedback values in acceleration and braking phases are registered. This is why it is not enough to use static axis errors as the basis for the setting.

Deactivating the position feedback monitor

It is possible to turn off the position feedback monitor in applications where the optionally connected measuring system does not control the axis position but is used for other measurements. To do this, enter 0 in the parameter **S-0-0391, Monitoring window feedback 2**.

Velocity feedback monitor

If there is no rigid connection between the encoders, position feedback monitoring is generally unsuitable. In these cases it is advantageous to use a velocity feedback monitor that monitors the slip between encoder 1 and encoder2.

The maximum allowed slip is set with parameters

- **S-0-0376, Max. actual velocity difference in percent** and
- **S-0-0377 Maximum actual velocity difference**

Parameter **S-0-0376, Max. actual velocity difference in percent** relates to the actual velocity of encoder 1.

The monitor is switched off with the value "0". If both parameters are unequal zero, the sum of both velocity values is effective.

$$\text{Effective window} = \frac{S-0-0377 + V_{act}\,(\text{encoder 1}) * S-0-0376}{100\%}$$

If the velocity difference between encoder 1 and encoder 2 is greater than the velocity window, the error **F237 Excessive position command difference** is generated.

Other optional encoder characteristics

To parameterize any other characteristics of the optional encoder use **S-0-0115, Position feedback 2 type**.

The structure of this parameter is as follows:

S-0-0115, Position feedback 2 type

Bit 0: Encoder type
0: rotary
1: linear

Bit 1: Distance-coded measuring system
0: no distance-coded reference marks
1: distance-coded reference marks

Bit 3: Rotational direction
0: non-inverted
1: inverted

Bits 7 + 6: Absolute evaluation
x 0: no absolute evaluation possible (bit 7 irrelevant)
0 1: absolute evaluation possible and allowed, encoder is treated as absolute
1 1: absolute evaluation possible, but not allowed

Fig. 9-22: Parameter S-0-0115, Position feedback 2 type

Note: The bits in the position encoder type parameter are partly set or cleared by the drive automatically. There is the following dependency:

- Depending on the absolute encoder range and the maximum travel range or modulo value, bit 6 is either set or cleared.

(See also chapter: "Other settings for absolute measurement systems")

Position feedback values of non-absolute measuring systems after initialization

If there is no absolute measuring system available, then the initialization value can be changed via parameter **P-0-0019, Position start value**.

The following applies:

If the parameter is write accessed in either phase 2 or 3, then this value is accepted as the initialization value:

P-0-0019 write accessed?	Position feedback value 1	Position feedback value 2
no	init. original position of motor encoder	init. original position of motor encoder
yes	position start value	position start value

Fig. 9-23: Position feedback values of non-absolute measuring systems after initialization

WARNING

No valid position feedback values exist before the measuring system is initialized.

Initialization is performed during the transition check for communication phase 4.

Some measuring systems have limitations concerning the maximum velocity during their initialization.

Measuring system	Maximum initialization velocity
DSF/HSF	300 rpm
EnDat	Initialization should occur at standstill
Multiturn resolver	300 rpm

Fig. 9-24: Velocity allowed during initialization

Drive-internal format of position data

There are two different formats in the drive used to display position data. We differentiate between

- display format and
- drive-internal format.

Display format

The display format defines the unit, i.e. the valence with which the position data are exchanged between drive and control/user interface. When a position data parameter is read, it is sent in the display format to the control. The display format is set with parameters

- **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**

The control that is used generally presets the display format.

(See also chapter: "Physical values display format")

Drive-internal format

The drive-internal format determines the valence with which the position command and feedback value editing, as well as the closing of the position control loop in the drive are performed. The drive uses the value of parameter **S-0-0278, Maximum travel range** to calculate the drive-internal format, i.e. the drive-internal position resolution depends on the travel range to be displayed.

Functional principle of the drive-internal position data format

Position data processing in the drive is done with a constant data width. From this fact results the dependence of the resolution of the position data on the travel range of the axis to be covered.

Note: The longer the distance to be displayed, the smaller the drive-internal position resolution.

The values of the following parameters are used to compute the drive-internal resolution:

- **S-0-0116, Feedback 1 Resolution** and
- **S-0-0256, Multiplication 1**.

The parameter for the encoder resolution is to be taken from the data sheet of the measuring system or it is automatically read out of the feedback memory if the respective measuring system is used. The number of division periods per encoder revolution or the grid constant of a linear scale (distance per division period) is to be set in this parameter. The parameter value for the multiplication is calculated by the drive during command **S-0-0128, C200 Communication phase 4 transition check**. It indicates the resolution per division period (dp).

The following applies to the drive-internal resolution of rotary motors:

$$\text{resolution} = \text{multiplication} * \text{encoder resolution}$$

Resolution: drive-internal resolution of position data [Incr/rev]
multiplication: value in S-0-0256 or S-0-0257 [Incr/dp]
encoder resolution: value in S-0-0116 or S-0-0117 [dp/rev]

Fig. 9-25: Drive-internal resolution of rotary motors

The following applies to the drive-internal resolution of linear motors:

$$\text{resolution} = \frac{\text{multiplication}}{\text{encoder resolution}}$$

Resolution: drive-internal resolution of position data [Incr/rev]
multiplication: value in S-0-0256 or S-0-0257 [Incr/dp]
encoder resolution: value in S-0-0116 or S-0-0117 [mm/dp]

Fig. 9-26: Drive-internal resolution of linear motors

Examples

1. MKD motor, S-0-0116 = 4, S-0-0256 = 32768, therefore: drive-internal resolution = 131072 increments/revolution or 0.00275 degrees/increment.
2. Linear scale as optional measuring system, S-0-0117 = 0.02 mm (grid division = 20µm), S-0-0257 = 32768, therefore: drive-internal resolution of approximately 1638400 increments/mm or 0.00061 µm/increment. (How to compute the drive-internal resolution if an optional encoder is used, is described in greater detail below.)

Note: For technical reasons, the value for the multiplication is limited to 4 to 4194304 increments/mm.

Setting the drive-internal position data format

To set the drive-internal resolution, use the parameter **S-0-0278, Maximum travel range**.

Setting the maximum travel range at initial commissioning

At initial commissioning of an axis, this parameter must be set to a value that equals at least the distance that the axis must travel. While executing the command **S-0-0128, C200 Communication phase 4 transition check**, the drive computes the values for **S-0-0256, Multiplication 1** and, if an optional measuring system is available, for **S-0-0257, Multiplication 2**. These parameters thus help to display the resolution.

Note: For technical reasons, the maximum possible resolution of the position feedback value of a position encoder equals 32768 increments per division period of the measuring system. The maximum resolution is reduced, if the travel range is set so large that it can no longer be displayed with the maximum resolution.

To compute the multiplication, one of the following calculations is conducted in the command **S-0-0128, C200 Communication phase 4 transition check**, depending on the measuring system that is used:

for rotary measuring systems:

$$\text{multiplication} = \frac{2^{31}}{\text{travel range} \times \text{encoder resolution}}$$

travel range:	travel range displayed in encoder revolutions
multiplication:	value in S-0-0256 or S-0-0257
encoder resolution:	value in S-0-0116 or S-0-0117

Fig. 9-27: Relationship between maximum travel range and multiplication with rotary measuring systems

Examples

1. MHD motor with S-0-0116 = 512, maximum travel range 2048 motor revolutions, therefore: multiplication of 2^31/(2048*512) = 2048.
2. MHD motor with S-0-0116 = 512, maximum travel range 20 motor revolutions, therefore: multiplication of 2^31/(20*512) = 209715. The highest possible value equals 32768, thus multiplication = 32768.

for linear measuring systems:

$$\text{multiplication} = \frac{2^{31} \times \text{encoder resolution}}{\text{travel range}}$$

travel range:	travel range displayed in mm
multiplication:	value in S-0-0256 or S-0-0257
encoder resolution:	value in S-0-0116 or S-0-0117

Fig. 9-28: Relationship between maximum travel range and multiplication with linear measuring systems

Example

3. Linear scale with 0.02 mm grid division, maximum travel range 5 m, therefore a multiplication of 2^31*0.02/ 5000 = 8589 (→ 8192*).

This results in a resolution of 0.02 mm/8192 = 0.002441 µm.

***Note:** When computing multiplication always use the next lower binary value of the precise result of the calculation.

Drive internal display of position data when an optional encoder is available

Note: If an optional encoder is available (P-0-0185 ≠ "1" or "5"), the multiplication of the motor encoder depends on the one of the optional encoder.

If there is an optional measuring system, then the multiplication of this encoder is computed in terms of the travel range set (see also: "Setting the drive-internal position data format"). The multiplication of the motor encoder is calculated so that it also covers this travel range. This means that values exceeding the greatest reasonable value (32768) for the multiplication of the motor encoder can be generated depending on the mechanical gear elements and encoder resolutions!

Example MKD motor with rotary optional encoder, motor encoder resolution = 4, optional encoder resolution = 1000, travel range = 50 revolutions, gear ratio = 1:1

Calculating the multiplication of the optional encoder:

2^31/(1000*50) = 42949, technically reasonable is a maximum of 32768, thus S-0-0257 = 32768. This results in a resolution of 0.00001098 degrees.

Calculating the multiplication of the motor encoder:

2^31/(4*50) = 10737418, the next smaller binary value = 8388608, thus S-0-0256 = 8388608. However, the technical maximum resolution is 4194304. Therefore, we set the value in S-0-0256 to 4194304. The resolution is 0.00002146 degrees.

Note: The resolution can never exceed 4194304 * S-0-0116!

Example MHD motor with linear optional encoder, resolution of the motor encoder = 256, resolution of the optional encoder = 0.02 mm, travel range = 5 m, feed constant = 10 mm, gear ratio = 3:1

Calculating the multiplication of the optional encoder:

2^31*0.02 mm/5000 mm = 8589, technically reasonable is a maximum of 8192, therefore: S-0-0257 = 8192. This results in a resolution of 0.00244 µm.

Calculating the multiplication of the motor encoder:

5 m of travel range result in 500 gear output revolutions and therefore 1500 gear input revolutions (motor revolutions).

2^31/(256*1500) = 5592, the next smaller binary value = 4096, therefore: S-0-0256 = 4096. This results in a resolution of 0.000343 degrees referred to the motor shaft.

Processing formats of the drive-internal position command value interpolator

In the drive-internal position command value interpolator, the position command value profile for the drive-controlled travel commands "such as "Drive halt", "Drive-controlled homing procedure", operating mode "Drive-internal interpolation",...) are generated. The format of the drive-internal position data affect the maximum acceleration limit which can be preset for the interpolator.

Note: The limits are not valid for presetting cyclic command values (e.g. operating mode "Position control").

The following relationships apply to rotary motors:

$$a_{max} = \frac{51.471.854.040}{\text{encoder resolution} \times \text{multiplication}} \left[\frac{\text{rad}}{\text{s}^2}\right]$$

a_{max}:	max. acceleration of position command interpolator
encoder resolution:	value in S-0-0116 in mm
multiplication:	value in S-0-0256

Fig. 9-29: Maximum acceleration of the position command value interpolator as dependent on the drive-internal position data format

The following relationships apply to linear motors:

$$a_{max} = \frac{8.192.000.000 \times \text{encoderresolution}}{\text{multiplication}} \left[\frac{\text{mm}}{\text{s}^2}\right]$$

a_{max}:	max. acceleration of position command interpolator
encoder resolution:	value in S-0-0116 in mm
multiplication:	value in S-0-0256

Fig. 9-30: Maximum acceleration of the position command value interpolator as dependent on the drive-internal position data format

Example

MHD motor with S-0-0116 = 512, multiplication = 32768, this results in a maximum acceleration of the position command interpolator of 3067 rad/s².

9.3 Supplementary settings for absolute measuring systems

Encoder types and relevant interfaces

The table below shows the absolute measuring systems which can be used as a motor encoder or optional encoder and the range which they can evaluate in absolute form. The relevant encoder interface is also listed.

Measuring system	Absolute encoder range	Interface connector	as motor encoder: P-0-0074=...	as optional encoder: P-0-0075=...
Single-/multi-turn DSF/HSF	1rev./4096rev.	x4	1	1
Single-/multi-turn resolver	1dp/65535dp	x4	1	not possible
Linear scale from Heidenhain with EnDat interface	encoder length-dependent	x8	8	8
Single-/multi-turn rotary encoder from Heidenhain with EnDat interface	1rev./4096rev.	x8	8	8

Fig. 9-31: Absolute measuring systems and their interfaces

Absolute encoder range and absolute encoder evaluation

Measuring systems that supply absolute position information within one or several encoder revolutions (single- or multi-turn encoders) or over a certain distance (absolute linear scales) can be used as motor and/or optional measuring systems. The range (absolute encoder range) in which a measuring system can supply absolute position information is stored in the data memory of the measuring system or the drive software.

Note: The absolute encoder range which the drive can evaluate can be limited with the use of **S-0-0278, Maximum travel range**. In parameters **S-0-0378, Encoder 1, absolute range** or **S-0-0379, Encoder 2, absolute range** the drive displays those absolute encoder ranges which can be evaluated.

Absolute measuring systems do not have to be homed after every initialization of the drive firmware. After initialization, the actual position value is available within the absolute encoder range, machine zero-point related. It is only necessary to conduct a single setup procedure (setting absolute measurement).

Whether a motor or an optional measuring system are to be evaluated as absolute encoders, depends on the following variables:

- the absolute encoder range (**S-0-0378, Encoder 1, absolute range / S-0-0379, Encoder 2, absolute range**) of the relevant encoder.
- the set position scaling (position data represented in absolute or in modulo format) in **S-0-0076, Position data scaling type**
- the travel range set in **S-0-0278, Maximum travel range**
- the modulo value set in parameter **S-0-0103, Modulo value**
- the actual value cycle of the slave axis (**P-0-0752, Load revolutions per actual value cycle slave axis**) in the case of synchronous operating modes.

Note the following relations:

Position scaling (bit 6 of S-0-0076)	S-0-0278, Max. travel range	S-0-0103, Modulo value	Absolute encoder evaluation possible
Absolute format	< S-0-0378 / S-0-0379	not relevant	yes
	> = S-0-0378 / S-0-0379	not relevant	no
Modulo format	S-0-0103	<= S-0-0378/S-0-0379	yes
	S-0-0103	> S-0-0378/S-0-0379	no
Modulo format in conjunction with synchronous operating mode	>= S-0-0103*P-0-0752	S-0-0103*P-0-0752 <= S-0-0378/S-0-0379	yes
	> S-0-0103*P-0-0752	S-0-0103*P-0-0752 > S-0-0378/S-0-0379	no

Fig. 9-32: Absolute encoder evaluation depending on position format, modulo format and maximum travel range

The check whether a measuring system can be evaluated as an absolute system is conducted during command **S-0-0128, C200 Communication phase 4 transition check**. The result is displayed in bit 6 of the relevant position encoder type parameter (S-0-0277 / S-0-0115).

Activating the absolute encoder evaluation

If the absolute evaluation of a measuring system is possible but not wanted, this can be deselected in bit 7 of the respective position encoder type parameter. The measuring system is then treated as if it were a non-absolute encoder.

The position feedback type parameters are structured as follows:

S-0-0277, Position feedback 1 type and
S-0-0115, Position feedback 2 type

Bit 0: Encoder type
0: rotary
1: linear

Bit 1: Distance-coded measuring system
0: no distance-coded reference marks
1: distance-coded reference marks

Bit 3: Rotational direction
0: non-inverted
1: inverted

Bits 7 + 6: Absolute evaluation
x 0: no absolute evaluation possible (bit 7 irrelevant)
0 1: absolute evaluation possible and allowed, encoder is treated as absolute
1 1: absolute evaluation possible, but not allowed

Fig. 9-33: Structure of the position feedback type parameters

Rexroth Indramat

How to correctly generate absolute position information

The correct generation of the machine zero-point related feedback position value is only possible if the conditions do not change. The conditions for correct conversion of the measuring system related position information to the machine zero-point related feedback position value change, if one of the following conditions changes:

Monitoring the conditions for absolute encoder evaluation

- the rotational direction of the measuring system set in parameters **S-0-0277, Position feedback 1 type** or **S-0-0115, Position feedback 2 type** in bit 3
- the position polarity set in **S-0-0055, Position polarities**
- the multiplication calculated using **S-0-0278, Maximum travel range** (**S-0-0256, Multiplication 1** or **S-0-0257, Multiplication 2**).
- the value stored in parameters **S-7-0177, Absolute encoder offset 1** or **S-7-0178 Absolute encoder offset 2**

If one of these four conditions changes, then the position status of the respective measuring system is cleared and error **F276 Absolute encoder exceeds monitoring window** is generated.

Absolute encoder monitor

If the absolute evaluation of a measuring system has been activated (position encoder type parameter S-0-0277 or S-0-0115 = 01xx.xxxxb), then the position feedback value generated in command **S-0-0128, C200 Communication phase 4 transition check** can be monitored. The monitor of the actual position value is only active, if the encoder is in reference.

Functional principle of the absolute encoder monitor

When turning off the drive's power supply, the current feedback position of the axis is loaded into a non-volatile memory. When switching the axis back on, the difference between the stored position and the position newly initialized by the measuring system is generated. If this difference is greater than the parameterized position window in parameter **P-0-0097, Absolute encoder monitoring window**, the error message **F276 Absolute encoder out of allowed window** is generated.

The absolute encoder monitor is appropriate for the following applications:

- The motor is equipped with a holding brake.
- The mechanical drive system is self-locking and cannot be moved manually.

Setting the absolute encoder monitor

The absolute encoder monitoring window must be set by the user. Always select a value greater than the maximum allowed motion of the axis when shutdown. Assuming that the axis has a brake or is self-locking, you can enter 1/10 motor revolutions (36° in reference to the motor shaft) as a standard value for the parameter **P-0-0097, Absolute encoder monitoring window**.

Deactivating the absolute encoder monitor

The absolute encoder monitor cannot be effectively used with axes that **can** or **must** be moved manually in a simple way when switched off. The absolute encoder monitor should be turned off in such situations, in order to prevent unnecessary error conditions.

The absolute encoder monitor can be turned off by writing the value "0" to parameter **P-0-0097, Absolute encoder monitoring window**.

Modulo evaluation of absolute measuring systems

If measuring systems are evaluated in absolute form and modulo evaluation of the position data is activated, then the following restriction applies:

The distance which can be traversed when all is shutdown must be smaller than half the maximum travel range set in parameter **S-0-0278, Maximum travel range** and smaller than the absolute range of the encoder (S-0-0378 or S-0-0379).

Position feedback values of absolute measuring systems after initialization

The condition of the position feedback values of the motor encoder and, if available, of the optional encoder after initializing the position feedback values in the command **S-0-0128, C200 Communication phase 4 transition check** depends on:

- bit 3 in **S-0-0147, Homing parameter**
- availability of an absolute encoder as the motor or optional encoder
- the reference of the relevant absolute encoder

Motor encoder	Optional encoder	Bit 3, S-0-0147	S-0-0051, Position feedback value 1	S-0-0053, Position feedback value 2	Bit 0, S-0-0403
absolute	not absolute	0	absolute value of motor encoder	absolute value of motor encoder	1
absolute	not absolute	1	absolute value of motor encoder	absolute value of motor encoder	0
not absolute	absolute	0	absolute value of optional encoder	absolute value of optional encoder	0
not absolute	absolute	1	absolute value of optional encoder	absolute value of optional encoder	1
absolute	absolute	arbitrary	absolute value of motor encoder	absolute value of optional encoder	1

Fig. 9-34: Position feedback values of absolute measuring systems after initialization

Hinweis: Reference distance can get lost with changes in polarity, scaling, gearbox, ... (see also **S-0-0403, Position feedback value status**).

9.4 Drive limitations

Current limit

Controllers, motors and machines are subject to various limits to protect them against damage from overload. This protection is based on a **dynamic drop of the current** computed for the output stage of the controller and the motor, in addition to parameters that can be set by the user.

The maximum current that may flow for a short period of time or that is available as continuous current is specified in the relevant parameters

- **P-0-4046, Active peak current** and
- **P-0-4045, Active permanent current**.

Pertinent parameters

- **S-0-0110, Amplifier peak current**
- **P-0-4004, Magnetizing current**
- **S-0-0109, Motor peak current**
- **S-0-0111, Motor current at standstill**
- **S-0-0092, Bipolar torque/force limit value**
- **P-0-0109, Torque/force peak limit**
- **P-0-4011, Switching frequency**
- **P-0-4046, Active peak current**
- **P-0-4045, Active permanent current**
- **P-0-0127, Overload warning**
- **P-0-0532, Premagnetization factor**

Functional principle

P-0-4046, Active peak current

Using parameters **S-0-0092, Bipolar torque/force limit value** and **P-0-0109, Torque/force peak limit** the user limits current or torque/force to a fixed maximum value.

The maximum possible currents are fixed by the peak current of the amplifier and the peak current of the motor. These values may not be exceeded. And, as these are the total flowing currents, the magnetization current is deducted from these values for display in parameter **P-0-4046, Active peak current**.

Motor current limitation

The current is dynamically reduced to 2.2-times of the standstill current of the motor to protect the motor against overheating.

Thermal current limit of the controller

To protect the controller from overheating, the current is dynamically reduced to **P-0-4045, Active permanent current**.

Note: At high speeds, the maximum possible motor current is also reduced by the stall current limit.

The smallest value derived from all these limitations is displayed in parameter **P-0-4046, Active peak current**. The controller can supply this maximum current momentarily.

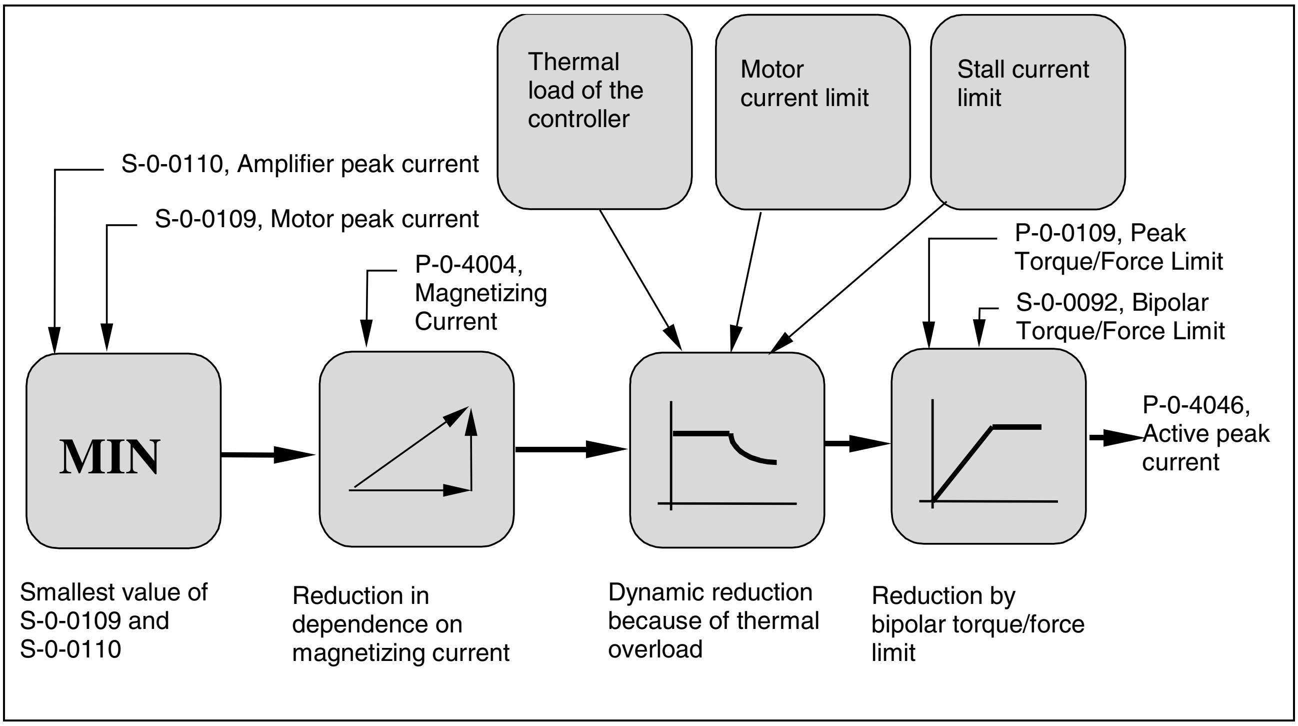


Fig. 9-35: Value displayed in P-0-4046, Active peak current

P-0-4045, Active permanent current

The current displayed in parameter **P-0-4045, Active permanent current** is the continuous current value available from the drive. This current depends largely upon

- the device type and
- the switching frequency of the output stage.

This **device-specific** value is additionally reduced by the magnetizing current as parameter **P-0-4045, Active permanent current** only displays the torque-generating portion of the motor current.

Note: If the effective peak current is smaller than the effective continuous current, then the effective continuous current is set to the value of the effective peak current. This can be the case if the peak motor current is smaller than the continuous current of the controller or the current limit of the motor reduces the current to less than the continuous current of the controller.

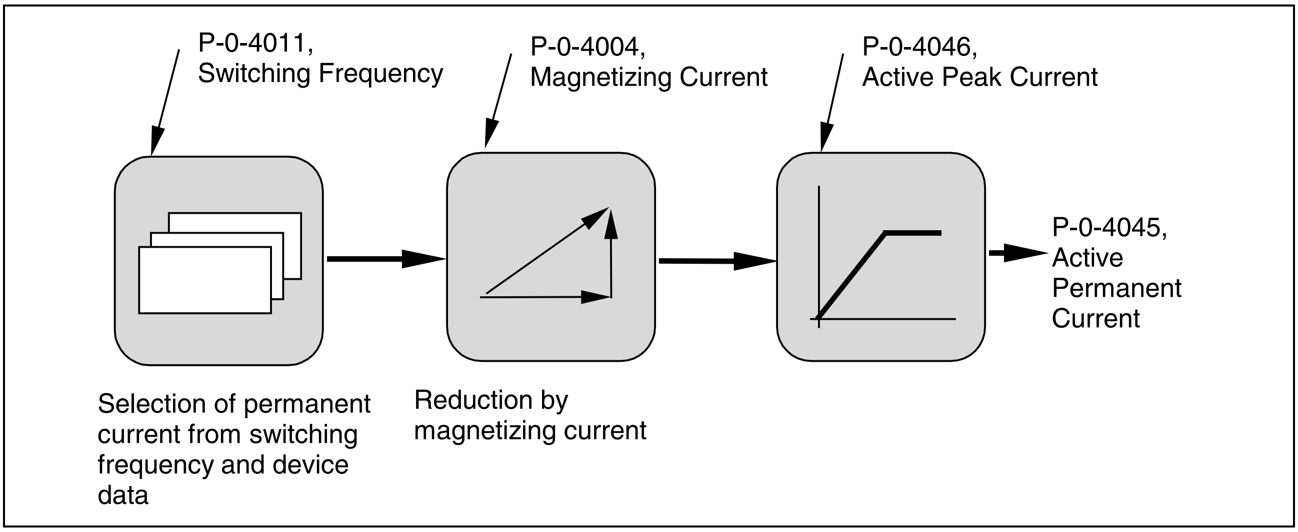


Fig. 9-36: Parameter value of the effective continuous current

Thermal current limit of the controller

It is the task of the thermal current limit of the controller to protect the device against overheating. To do so, the thermal controller load **(P-0-0141**) is computed from

- the controller-specific data,
- the command current profile and
- the selected switching frequency.

If this reaches 100%, then the peak current is reduced.

The maximum current that can be continuously supplied by the controller, is displayed in parameter **P-0-4045, Active permanent current**. This current also leads to a 100% load. To what extent and how quickly the current can be reduced depends on how the actual current supplied exceeds the effective continuous current.

Should the current being supplied once again drop to below the effective continuous current, then the load of the device is reduced and the maximum possible current increases.

To monitor the thermal controller load, two warnings are generated:

- **E257 Continuous current limit active** is generated when the load reaches 100%.
- **E261 Continuous current limit pre-warning** is generated when the load reaches the value set in parameter **P-0-0127, Overload warning**.

This means that a response to any eventual overload is possible even before a peak torque reduction. It makes sense to parameterize a value of 80% for this purpose. This value should not be exceeded when operating the drive correctly.

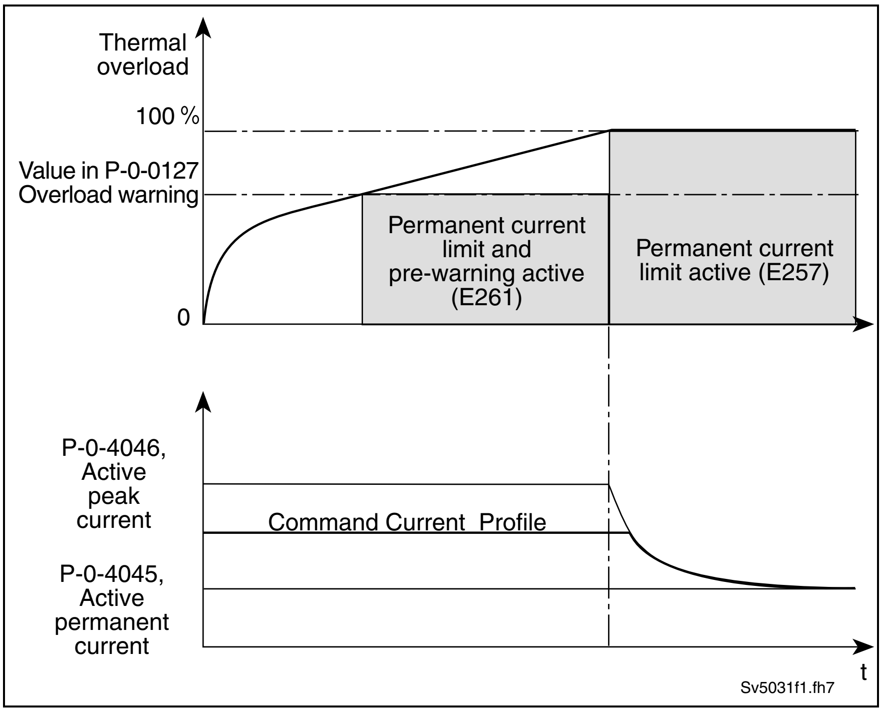


Fig. 9-37: Monitoring the thermal load and continuous current limit

Checking the thermal load of the drive controller

Parameter **P-0-0141, Thermal drive load** can be used to check the extent of the controller load. A correct layout would mean that this would never exceed 80%.

To check the load it is possible to subject the machine to a test run. The time until the load achieves a stationary condition must be greater than 10 minutes.

To check the thermal load of a drive at the time of a start-up without having to run a processing cycle, it is possible to pre-set the controller load to 80 %. To do so, write any value into parameter **P-0-0141, Thermal drive load**. It is necessary to briefly and simultaneously run a typical processing cycle, however. The thermal load should be observed and it must show a falling tendency as otherwise the drive has been incorrectly sized for the application. To check the further increase of the thermal load beyond 80% use

- the overload warning using **P-0-0127, Overload warning** and/ or
- the **P-0-0141, Thermal drive load** output

using the analog output.

A typical curve of the thermal load as can be observed with analog output, is displayed below.

Note:	By writing data to **P-0-0141, Thermal drive load** the load is preset to 80 % during the execution of a processing cycle.

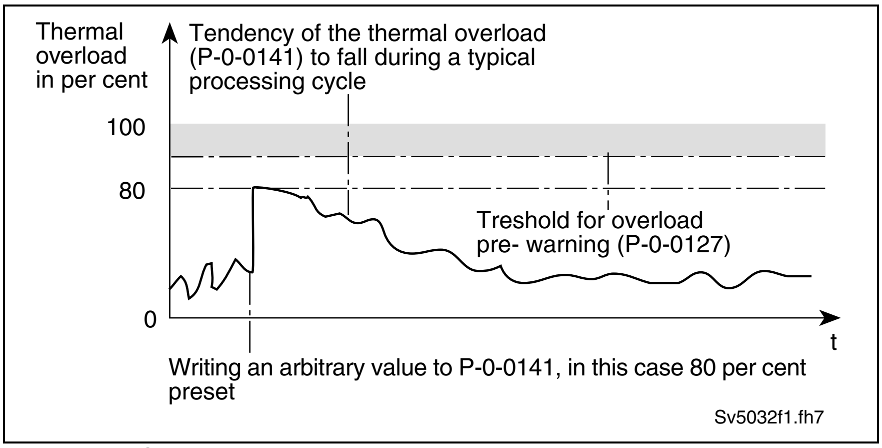


Fig. 9-38: Checking the thermal load

Motor current limit

The motor may be loaded for a maximum of 400 ms with the 4-fold value of **S-0-0111, Motor current at standstill**. During continuous operation, a 2.2-fold value is permitted. If the maximum value is exceeded for an extended period, however, then the motor current limit reduces the maximum motor current to 2.2-times the motor standstill current.

For the maximum motor current to increase again, it is necessary to first reduce the load on the motor, i.e. the current must drop below the 2.2-fold motor standstill current.

If the motor overload limit is active then

- warning **E225 Motor overload** is generated and
- Bit 0 (overload warning) in **S-0-0012**, **Class 2 diagnostics** is set.

Stall current limit

For physical reasons it is necessary to limit the maximum actual current of the motor, if a specific speed is exceeded. The stall current limit is used for this purpose. This limit is determined purely by the technical structure of the motor and cannot be influenced. Parameter **P-0-0532, Premagnetization factor** is used to set this in asynchronous motors. (See chapter: "Asynchronous motors")

Torque/force limit

Parameters

- **S-0-0092, Bipolar torque/force limit value** and
- **P-0-0109, Torque/force peak limit**

specify the per cent value of **S-0-0111, Motor current at standstill *** "Factor cooling type" that can be maximally made available. The factor of the cooling type is derived from that cooling type of the motor which has been programmed in parameter **P-0-0640, Cooling type**:

Cooling type	Parameter value of P-0-0640, Cooling type	Factor
uncooled	0	100 %
cooled	1	150 %
water cooled	2	190 %

Fig. 9-39: Factor cooling type

For each drive controller there is a certain peak torque that is determined by the maximum allowed current of the respective motor/controller combination. This peak torque is used for acceleration processes of many applications.

Variable torque limit

Parameter **S-0-0092, Bipolar torque/force limit value** is used to vary the torque/force limit value during operation. This makes sense, for example, for temporary approach to an end limit. In this parameter, torque/force limit values can be preset by the control unit in each program cycle.

Peak torque limit

Parameter **P-0-0109, Torque/force peak limit** can be used to limit the maximum peak torque, during the commissioning of a drive, to the maximum allowed torque of an axis, for example. This parameter ensures that the allowed maximum peak torque of an application is not exceeded, even if **S-0-0092, Bipolar torque/force limit value** is set to any value.

The following illustrates the interaction of current limit and torque/force limit for determining the maximum output current.

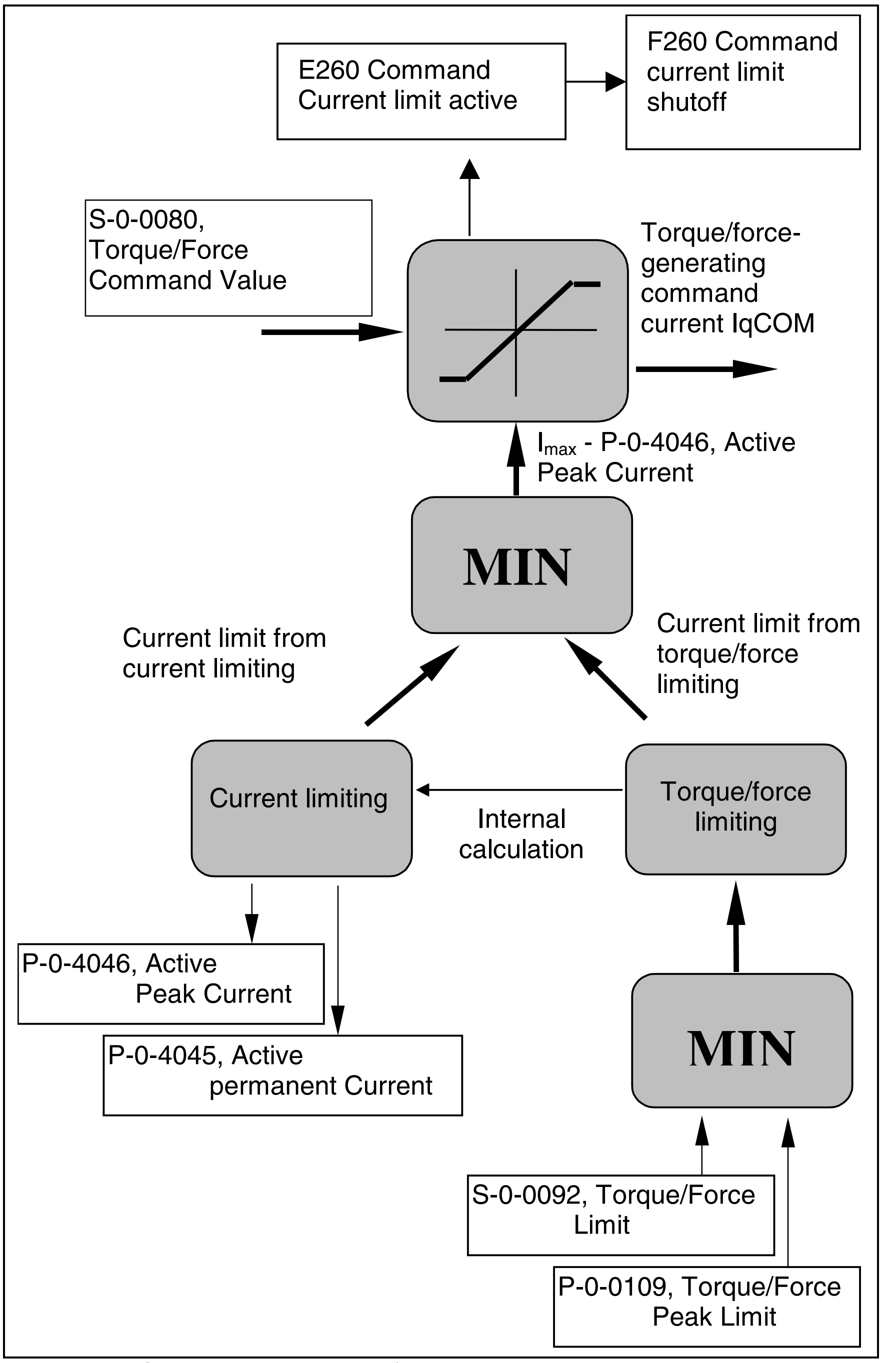


Fig. 9-40: Current limit and torque/force limit

The current and torque limits both effect the limit of the torque-generating command current displayed in parameter **P-0-4046, Active peak current**.

Note: The smaller of the two limit values is effective in this case!

Warning and errors

If the peak current limit is active, then the drive generates warning **E260 Command Current limit active**. If the drive remains in peak current limitation for more than 1.5 s, then it shuts itself off with error message **F260 Command current limit shutoff**.

This function can be switched on via **P-0-0538, Motor function parameter 1** bit 11=1. (Load base parameters switches the function off.) With main spindle axes, the drives are generally accelerated at the current limit which is the reason why this function does not make sense in this case.

Acceleration dependent current command value limit

The function of acceleration dependent torque limitation is switched on with bit 12 of parameter **P-0-0538, Motor function parameter 1**.

The required acceleration torque is computed based on load moment of inertia, torque constant and specified command acceleration. Parameter **S-0-0092, Bipolar torque/force limit value** can then be set to the required machining torque. Parameter **P-0-0109, Torque/force peak limit** always limits the maximum available torque and is set to the maximum value allowed for the machine.

Generating the acceleration command value with position-controlled drives:

$$a_{comm} = \frac{dv_{comm}}{dt} = \frac{d^2x_{comm}}{dt^2}$$

x_{comm}: Command position at position controller
v_{comm}: Command velocity at speed controller
a_{comm}: Command acceleration

Fig. 9-41: Acceleration command values with position-controlled drives

Generating the acceleration command value with speed-controlled drives:

$$a_{comm} = \frac{dv_{comm}}{dt}$$

v_{comm}: Command velocity at speed controller
a_{comm}: Command acceleration

Fig. 9-42: Acceleration command value with speed-controlled drives

Required torque equals:

$$M_B = a_{comm} * J_{ges} = a_{comm} *(J_{Mot} + J_{Last})$$

a_{comm}: Command acceleration
J_{Mot}: Motor moment of inertia
J_{Last}: Load inertia

Fig. 9-43: Required torque

Required torque-generating motor current:

$$i_B = \frac{(a_{comm} * J_{ges})}{Km}$$

Km: Torque constant of motor
i_B: Acceleration current

Fig. 9-44: Motor current

The allowed maximum current thus equals

$$I_{max} = \frac{S-0-0092 * I_{DauerMotor}}{100\% + |I_B|} \text{ or } I_{max} = \frac{P-0-0109 * I_{DauerMotor}}{100\%}$$

$I_{DauerMotor}$: S-0-0111, Motor current at standstill
I_{max}: maximum current
I_B: acceleration current

Fig. 9-45: Maximum current

Determining the torque constant and load moment of inertia

The torque constant in Rexroth Indramat synchronous motors is in the motor data memory. The tolerance (especially via temperature) equals about - 5%...+20%.

The load moment of inertia can be set with the automatic controller setting. The tolerance error of the torque constant is automatically allowed for when determining the load moment of inertia by means of the automatic controller setting!

Note: In the case of error reactions causing the velocity to be switched to zero (**P-0-0119, Best possible deceleration** =0) and fatal warnings, the torque is limited to the value set in **P-0-0109, Torque/force peak limit**.

Velocity limit

The following parameters limit the velocity of the drive:

- **S-0-0113, Maximum Motor Speed (nmax)**
- **S-0-0091, Bipolar Velocity Limit Value**

The parameter **S-0-0091, Bipolar Velocity Limit Value** is designed to allow variable limits of the maximum velocity to values smaller than the maximum allowed velocity during operation.

The parameter **S-0-0113, Maximum Motor Speed (nmax)** designates the maximum possible motor velocity. It is contained in the motor encoder data memory of MHD, MKD and MKE motors and does not need to be entered. With other types of motors this value must be taken from the motor data sheet.

Limiting to maximum motor velocity

The maximum motor velocity defines the maximum velocity of the drive on the drive-side. It is included in the calculation of the maximum value entered in the parameter **S-0-0091, Bipolar Velocity Limit Value**.

Limiting to bipolar velocity limit value

The bipolar velocity limit value (S-0-0091) defines the maximum velocity of the drive for the user. It becomes active as

- the monitor of the feedback velocity in the "Torque control" operating mode
- the limit for the resulting command value in the velocity controller
- the monitor of the position command value differences in the "Position control" operating mode (see also chapter: "Position command value monitoring")
- the limit of **S-0-0036, Velocity Command Value** in the "Velocity control" operating mode

Monitoring the feedback velocity in the "Torque control" operating mode

Monitoring the feedback velocity in the "Torque control" operating mode occurs with regard to 1.125 times the value of **S-0-0091, Bipolar Velocity Limit Value**. If this value is exceeded, the fatal error **F879 Velocity limit S-0-0091 exceeded** is generated. The drive switches to torque-free operation afterwards.

Limiting the resulting command value in the velocity controller

In all operating modes in which the velocity controller is active (all operating modes except for "Torque control"), the given velocity command value is limited to the value of **S-0-0091, Bipolar Velocity Limit Value**. If this condition is reached, the warning **E259 Command Velocity Limit active** is generated.

Limiting S-0-0036, Velocity Command Value in the Velocity Control Operating Mode

Limiting S-0-0036, Velocity command value in the "Velocity control" operating mode

In the "Velocity control" operating mode, the input of **S-0-0036, Velocity Command Value** is limited to **S-0-0091, Bipolar Velocity Limit Value**. If the value entered in S-0-0036 exceeds this limit, the warning **E263 Velocity command value > limit S-0-0091** is generated.

Travel range limits

To avoid accidents and damages to the machine, many safety precautions are provided. A part of these safety measures refers to limiting the allowed working range. These limits can be introduced by the following measures:

- Software limits in the control (only active with axis in reference)
- Position limit values in the drive (only active with axis in reference)
- Travel limit switches in the drive
- Safety limit switches (in the E-Stop circuit)

Relevant Parameters

- **S-0-0049, Positive position limit value**
- **S-0-0050, Negative position limit value**
- **S-0-0055, Position polarities**
- **S-0-0403, Position feedback value status**
- **P-0-0090, Travel limit parameter**
- **P-0-0222, Status Inputs travel range limits**

Functional principle of travel range limits

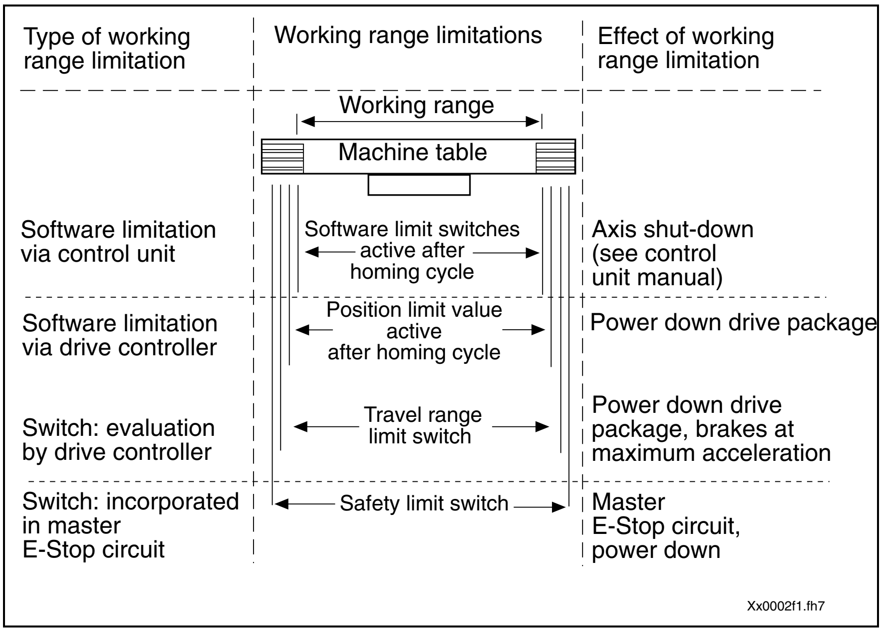


Fig. 9-46: Effect and ways of limiting the working range

In the drive, there are two methods for limiting the travel range:

- entering position limit values (only active, if the axis has been homed) and
- installing travel range limit switches.

If the travel range is limited by the drive, the drive's reaction to exceeding the travel range can be set. There are the following possibilities:

- **Error** with a "Set velocity command value to zero" reaction and automatic drive enable shutoff.
- **Warning** with a "Set velocity command value to zero" reaction and automatic reset when the error conditions are no longer present.

The reaction is set in bit 2 of **P-0-0090, Travel limit parameter**:

P-0-0090, Travel limit parameter

Bit 0: Negation
- 0: Limit switch input =24V, => travel range exceeded
- 1: Limit switch input =0V, => travel range exceeded

Bit 1: Activation
- 0: Travel range switch is not active
- 1: Travel range switch is active

Bit 2: Reaction
- 0: Exceeded travel range is handled as an error
- 1: Exceeded travel range is handled as a warning

Fig. 9-47: Setting the drive reaction with exceeded travel range (bit 2)

Note: Decelerating the axis with the use of a velocity command value ramp is not possible! Braking always occurs at maximum allowable torque/force (see **P-0-4046, Active peak current**).

Exceeding the travel range as an error

If a 0 is entered in bit 2 of P-0-0090, then exceeding the travel range is handled as an error with the reaction "set velocity command value to zero". (See also chapter: "Velocity command value reset".)

After the velocity command value has been set to zero, the drive turns off the internal drive enable and becomes torque-free. The ready-to-operate contact opens.

For re-commissioning the following steps are required:

⇒ Clear the error with the command **S-0-0099, C500 Reset class 1 diagnostic** or press the S1 button.

⇒ Reactivate the drive with the positive edge of the drive enable signal.

If the error condition is still present, that is, if the limit switch is still activated or if the axis limit values are still exceeded, only command values that go back into the allowed range will be accepted. Monitoring the command values is dependent on the active operating mode.

The following applies:

Operating Mode	Command Value Check
Torque control	Polarity of **S-0-0080, Torque/Force command**
All operating modes with drive-internal velocity control	Polarity of the internal velocity command value
All operating modes with drive-internal position control	Polarity of the velocity resulting from the given position command value

Fig. 9-48: Monitoring the command values in the case of error

If command values are given that would lead out of the allowed travel range, the travel range error will be generated again.

Exceeding the travel range as a warning

If a "1" is entered in bit 2 of **P-0-0090, Travel limit parameter**, then exceeding the travel range is handled as a warning with the reaction "set velocity command value to zero".

The drive does not switch off its internal drive enable.

If the error condition is still present, that is, if the limit switch is still activated or if the axis limit values are still exceeded, only command values that go back into the allowed range will be accepted. Monitoring the command values is dependent on the active operating mode (see "Exceeding the travel range as an error")

Travel range limit switch - monitor

The state of the travel range limit switch is displayed in parameter **P-0-0222, Status Inputs travel range limits**. The status of the positive limit switch is mapped to bit 0, the status of the negative limit switch is mapped to bit 1.

The monitor for exceeding the travel range limit switches is only activated if the monitor is switched on in bit 1 of **P-0-0090, Travel limit parameter**.

Exceeding the travel zone limit switches is recognized when these are activated. The diagnostic message depends on the type of handling:

How handled	SS display	Diagnostic message
as an error	F643	F643 Positive travel limit switch detected
as an error	F644	F644 Negative travel limit switch detected
as a warning	E843	E843 Positive limit switch activated
as a warning	E844	E844 Negative limit switch activated

Fig. 9-49: Diagnostic message when travel range limit switch is exceeded

Note: When both travel limit switches are being actuated simultaneously, e.g. if one of the switches does not work correctly, this is handled as an error. The drive in this case reacts as if exceeding the travel range had been parameterized as an error. The error messages **F643 Positive travel limit switch detected** or **F644 Negative travel limit switch detected** are generated.

Travel range limit switches - activation and polarity

The travel range limit switches are activated with the parameter **P-0-0090, Travel limit parameter**.

Additionally, the inputs can be inverted in this parameter.

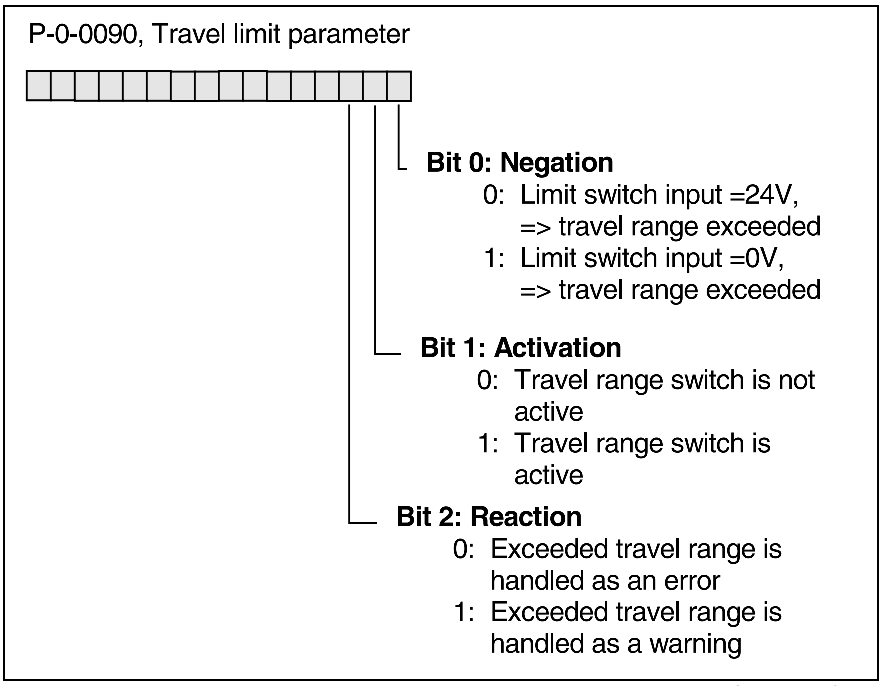


Fig. 9-50: Activation and polarity of the travel range limit switches (bit 0 or 1)

Position limit values

The monitoring for exceeding the position limit parameters:

- **S-0-0049, Positive position limit value**
- **S-0-0050, Negative position limit value**

is executed only if

⇒ one of the encoder systems is homed, that is, when at least one position feedback value refers to the machine's zero point.

- and -

⇒ the monitor of the position limit values in **S-0-0055, Position polarities** (bit 4) has been activated.

The monitoring is done, as a default, with the position feedback value of the encoder defined with **S-0-0147, Homing parameter** (bit 3). If this encoder is not homed, the monitoring is performed with the second encoder, as long as it is present and homed.

Exceeding the position limits is recognized, when the monitored position feedback value exceeds the travel range defined by the position limit values.

If "Drive-internal interpolation", "Drive-controlled positioning" or "Positioning block mode" is used as the active operating mode, the drive checks to see if the target position is outside of the position limit values. If it is, the drive will not move and the warning **E253 Target position out of travel range** is generated, and bit 13 in parameter **S-0-0012, Class 2 diagnostics** is also set.

The diagnostic message in the case that the position limit values have been exceeded depends on the type of handling:

How handled	SS display	Diagnostic message
as an error	F629	F629 Positive travel limit exceeded
as an error	F630	F630 Negative travel limit exceeded
as a warning	E829	E829 Positive position limit exceeded
as a warning	E830	E830 Negative position limit exceeded

Fig. 9-51: Diagnostic message when position limits have been exceeded

Position limit values - activation

The position limit value monitor is activated in bit 4 of **S-0-0055, Position polarities**.

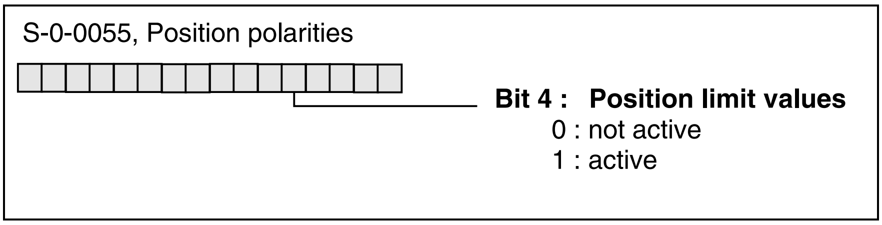


Fig. 9-52: Activating the position limit values

Travel range limit switches - connection

see project planning manual ECODRIVE03 respectively DURADRIVE

9.5 Master axis feedback analysis

Functional principle of master axis feedback analysis

The "master axis feedback analysis" feature is used to analyze a master axis feedback in the drive. The master axis feedback can be analyzed parallel to the motor encoder as an optional measuring system and supports detection of the position of a mechanical shaft. From the position values, velocity or position command values are computed in the drive or in the control.

Activating the function

The master axis feedback analysis is activated with **P-0-0185, Function of encoder 2** (P-0-0185=1 or 5).

Transmitting the master axis position and computing the command values

The position feedback value of the master axis feedback is made available in parameter **P-0-0052, Position feedback value 3**. There are three ways of transmitting the master axis position:

The position of the master axis is either transmitted directly to the drive and then used to compute the velocity or position command values in the drive.

The feature can be used, if the drive is operated in one of the following modes:

- "velocity synchronization with **real** master axis"
- "phase synchronization with **real** master axis"
- "electronic cam shaft with **real** master axis"

- or -

the position feedback value of the master axis feedback (**P-0-0052, Position feedback value 3**) is cyclically transmitted to the control. From this information, the control generates the master axis position (P-0-0053). The master axis position is then cyclically transmitted to one or several (slave) drives. The drive then computes the velocity or position command values from the master axis position.

It is then possible to operate the slave drives in one of the following modes:

- "velocity synchronization with **virtual** master axis"
- "phase synchronization with **virtual** master axis"
- "electronic cam shaft with **virtual** master axis"

- or -

the position feedback value of the master axis feedback (**P-0-0052, Position feedback value 3**) is processed by the master axis generator (in order to compensate the transmission time via the EcoX bus) and then transmitted cyclically, via the EcoX bus, to the slave drives as **P-0-0761, Master axis position for slave axis**. From the master axis position, the drives then compute the velocity or position command values.

The slave drives can then be operated in one of the following modes:

- "velocity synchronization with **virtual** master axis"
- "phase synchronization with **virtual** master axis"
- "electronic cam shaft with **virtual** master axis"

Parameterizing the master axis feedback

For the master axis feedback it is possible to use either cyclical absolute measuring systems or incremental encoders with sine or square-wave signals. The encoders must have a binary resolution.

Note: For position-synchronous axes it is preferable to use absolute measuring systems.

In an ECODRIVE03 the encoder interface not needed by the motor encoder can be used to analyze the master axis feedback.

The encoder interface of the master axis feedback is defined with parameter **P-0-0075, Feedback 2 type**. The number of the encoder has to be entered in this parameter.

Measuring system	Function	P-0-0074/ P-0-0075	Interface	Note
HSF	absolute cyclical	1	X4	in MKD and MHD motors the X4 interface is assigned to the motor encoder and cannot, therefore, be used for the master axis feedback
EnDat	absolute cyclical	8	X8	typical number of lines 2048
incremental with 1Vpp sine signals	incremental	2	X8	maximum input frequency: 200 kHz!
incremental with TTL signals	incremental	5	X8	maximum input frequency: 200 kHz!

Fig. 9-53: Measuring systems and parameterization with master axis feedback

In addition, the following parameters can be used to parameterize the master axis feedback:

- **P-0-0052, Position feedback value 3**

The parameter **P-0-0052, Position feedback value 3** displays the position of the master axis feedback. The format of the position feedback value 3 is 2^{20} increments per revolution, the format cannot be changed.

- **P-0-0087, Offset position feedback value 3**

The position feedback value 3 can be given an offset. Use the parameter **P-0-0087, Offset position feedback value 3** to do this.

- **S-0-0115, Position feedback 2 type**

To parameterize the rotational direction of the master axis feedback use bit 3 of **S-0-0115, Position feedback 2 type**. To invert the rotational direction, set bit 3.

- **S-0-0117, Feedback 2 Resolution**

Note: Parameterization of the resolution of the master axis feedback is only needed, if a feedback without feedback data memory is used.

The resolution must be entered in parameter **S-0-0117, Feedback 2 Resolution**.

- **P-0-0185, Function of encoder 2**

To use the optional encoder as a master axis feedback, a 1 or 5 must be entered in parameter **P-0-0185, Function of encoder 2**.

If a 5 is entered in parameter **P-0-0185, Function of encoder 2** in the case of incremental encoders, the encoder does not establish the reference to the zero pulse. Therefore, the master axis position can only be evaluated in relative form.

- **P-0-0186, Position feedback value 3, smoothing time**

The original position value can be smoothed using a low-pass filter. The time constant is fixed with parameter **P-0-0186, Actual Position value 3, smoothing time**.

Time constants of 0, 2, 4 and 8 ms can be set. The phase lag of the filter is compensated.

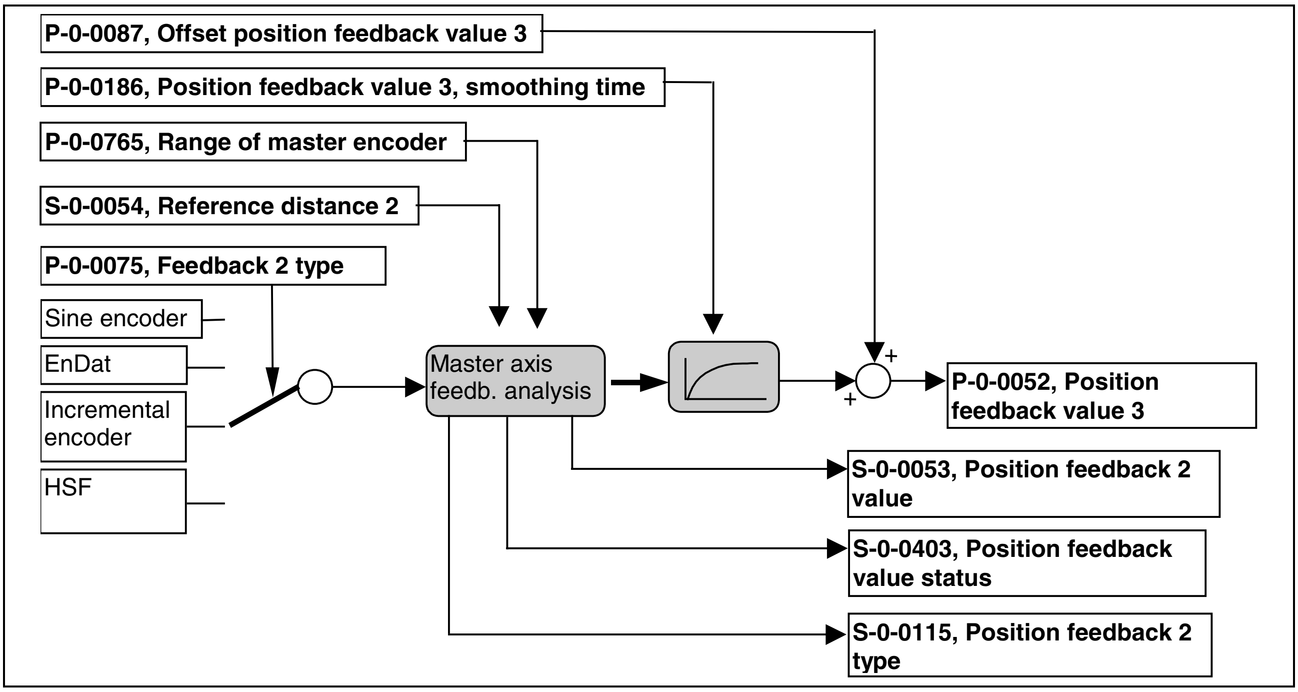


Fig. 9-54: Principle of master axis feedback analysis

- **P-0-0765, Range of master encoder**

Parameter **P-0-0765, Range of master encoder** defines the absolute range of the master axis feedback. The input is a factor of 2^{20}, the following applies:

$$\text{Modulo range of master axis feedback} = \text{master axis feedback range} * 2^{20}$$

The master axis feedback is analyzed/displayed within this range; i.e. **P-0-0052, Position feedback value 3** represents the position of the master axis feedback in the format "master axis feedback range * 2^{20}".

If the modulo range of the master axis feedback is smaller than the absolute display range of the master axis feedback (is automatically determined by the selected encoder), bit 6 is set in parameter **S-0-0115, Position feedback 2 type** ("absolute analysis possible").

Setting absolute measurement of the master axis feedback

The absolute master axis feedback is set up by starting the command **P-0-0012, C300 Command Set absolute measurement**.

Other parameters used to set up absolute master axis feedbacks:

- **S-0-0054, Reference distance 2** (unit/scaling of S-0-0054 is switched depending on P-0-0185)
- **S-0-0147, Homing parameter** (bit 3 determines which encoder the command "Set absolute measurement" will affect).

Homing the master axis feedback

Absolute measuring systems supply, after being powered up, absolute position and therefore do not have to be homed. A single setting of absolute measurement can set the desired position. In addition, the position can be offset by means of parameter **P-0-0087, Offset position feedback value 3**.

Incremental measuring systems cannot supply an absolute position until their zero pulse has been detected.

- In addition to the position status of the motor encoder (bit 1), parameter **S-0-0403, Position feedback value status** also contains the position status of the optional encoder (bit 2). This means that in bit 2 the position status of the master axis feedback is available.
- If an incremental measuring system is used as a master axis feedback, then its position status is "0" once it is turned on. The detection of the zero pulse is active if the position status of the master axis feedback equals "0". To detect the zero pulse it is necessary to "overrun" it.
- After detecting the zero pulse, the position feedback value 3 jumps to its absolute value. The position of the zero pulse equals parameter **P-0-0087, Offset position feedback value 3**.
- If the procedure of detecting the zero pulse is to be repeated, then by using command **S-0-0191, D600 Cancel reference point procedure command** it is possible to clear the position status of the master axis feedback. The zero pulse can then be detected again.

9.6 Drive error reaction

If an error is recognized in the drive controller, the controller reacts with a preset error reaction.

This drive error reaction depends on the error class of the current error and the setting of the parameters

- **P-0-0117, NC Reaction on Error**
- **P-0-0118, Power off on Error**
- **P-0-0119, Best Possible Deceleration**

Note: The error class determines whether the drive reaction parameterized as above can be carried out in the case of error or not.

There are 4 error classes, which have different priorities.

(see also "Error classes")

Error class	Diagnostic message	Drive reaction
Fatal	F8xx	The error reaction parameter settings in **P-0-0117, NC reaction on error** and **P-0-0119, Best Possible Deceleration** will be ignored, since a drive reaction is impossible. Torque/force is instantly cut off.
Travel range	F6xx	Independently of the settings in parameters **P-0-0117, NC reaction on Error** and **P-0-0119, Best possible deceleration**, the velocity command value is immediately set to zero. This reaction corresponds to the setting P-0-0117 bits 0 and 1 = 00 (no NC Reaction) P-0-0119 bits 0 and 1 = 00 (velocity command value reset). This setting provides the fastest possible deceleration of the axis if the travel range is exceeded.
Interface	F4xx	An NC reaction is impossible, since the communication with the NC became inoperative. The drive proceeds instantly with the deceleration procedure parameterized by **P-0-0119, Best possible deceleration** -or- if bit 1 has been set to the value "1" in **P-0-0117, NC reaction on error**, an error reaction is carried out via DISC macro (see also: "DISC – Drive macros").
Non-fatal	F2xx	The drive carries out the deceleration procedure set in **P-0-0117, NC reaction on error** and **P-0-0119, Best possible deceleration**. If NC reaction on error has been activated, then the drive continues to operate for 30 seconds after detecting an error, as if no error had been detected. The NC has this time to bring the axis to an NC-controlled standstill. The drive then carries out the reaction set in P-0-0119.

Fig. 9-55: Error reaction of the drive

Best possible deceleration

The drive reaction **P-0-0119, Best possible deceleration** is carried out automatically with

- interface errors F4xx
- non-fatal errors F2xx

At the end of each error reaction, the drive's torque is cut off.

With

- fatal errors F8xx
- travel range errors F6xx

P-0-0119, Best possible deceleration is ignored.

The following settings are possible:

Value of P-0-0119	Reaction
0	velocity command value reset
1	torque command value reset
2	velocity command value reset with command value ramp and filter

Fig. 9-56: Parameterization options for "Best possible deceleration"

The drive reaction, which is defined by "Best possible deceleration," determines the reaction of the drive if

- the drive enable signal changes from 1 to 0 (disable the drive enable) and
- the operating mode is switched to parameter mode while the drive is enabled (reset of the communication phase)

Velocity command value reset

P-0-0119, Best possible deceleration = 0

Given an error, the drive in velocity control will stop with command value = 0. The drive stops with its maximum permissible torque (see also chapter: "Current limit").

Failure reaction sequence with spindle brake present

The sequence for the motor brake activation (if available) and the power stage release with velocity command value reset (with spindle brake) are displayed below.

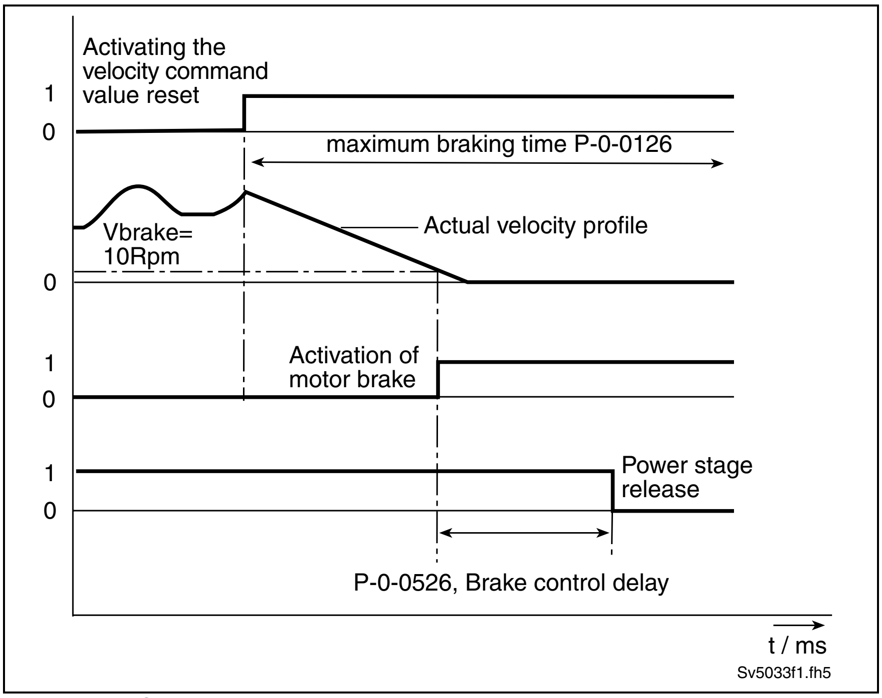


Fig. 9-57: Sequence of the velocity command value reset

Note: Activation of the motor holding brake depends on P-0-0525, bit 1.
see also chapter: "Motor holding brake"

Note: If the value entered in P-0-0126 is too small, then the error reaction could be terminated without axis standstill.

WARNING

Danger of damaging the motor brake if P-0-0126, Maximum braking time is set too low

⇒ The value for **P-0-0126, Maximum braking time** must always be set higher than the time needed to decelerate the axis with the velocity command value reset, taking maximum possible velocity into account.

Disable torque

P-0-0119, Best possible standstill = 1 or fatal error

In the event of an error, the drive goes torque-free and is braked only by the frictional force, i.e. it "coasts". The actual time to standstill can be considerable especially with spindles.

Note: The error reaction "Torque disable" is absolutely necessary with fatal errors (F8xx), because braking, e.g. with a defective power stage or feedback, is no longer possible!

DANGER

Drive continues to move unbraked in the case of error!

Danger to life from parts in motion if the machine safety doors are open.

⇒ Check drive for motion (e.g., using **S-0-0040**, **Velocity feedback value**, if possible) and await standstill!

Note: Activation of the motor holding brake depends on P-0-0525, bit 1

(see also chapter: "Motor holding brake").

The temporal behavior of the brake in conjunction with an error reaction depends on the brake type. Please note the instruction under "Torque disable with brake type: Servo brake".

Torque disable with brake type: Spindle brake

The motor holding brake is not activated until the motor speed drops below 10 min^{-1}.

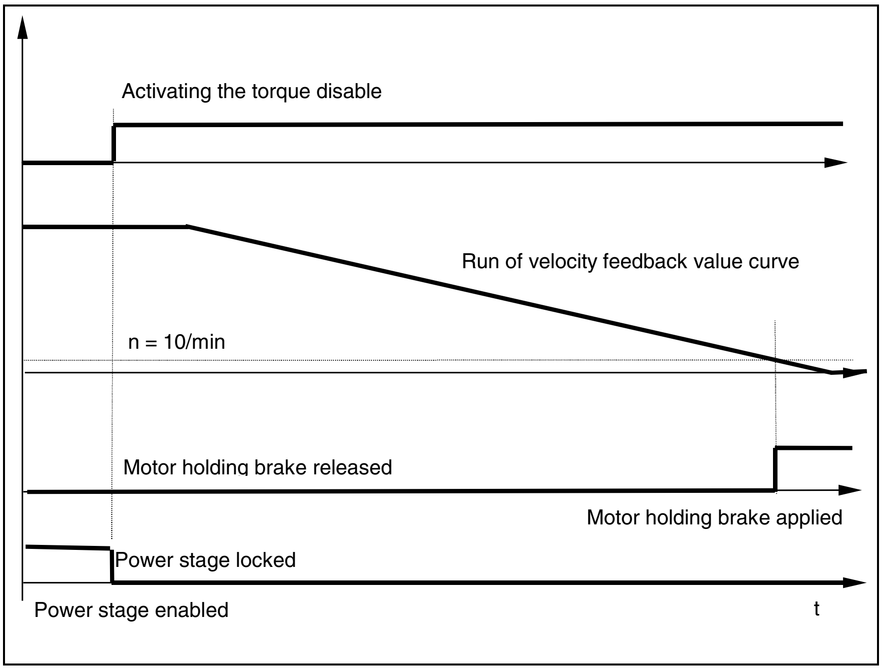


Fig. 9-58: Time diagram with torque disable and **P-0-0525, Type of motor brake**, bit 1 = 1

Torque disable with brake type: Servo brake

The motor holding brake is immediately activated!

Note: It is not sensible to set the best possible standstill to torque disable when using a motor holding brake of the servo-brake type at the same time. When performing the best possible standstill, the drive does not brake actively, but only with the holding brake. After 20000 turns, the brake is worn.

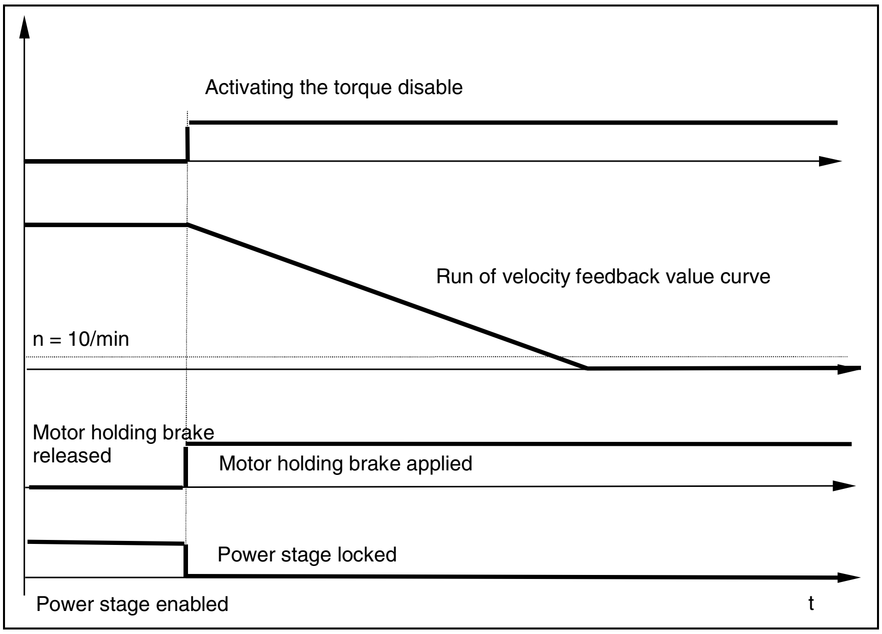


Fig. 9-59: Time diagram with torque disable and **P-0-0525, Type of motor brake**, bit 1 = 0

See also chapter: "Motor holding brake".

Velocity command value to zero with filter and ramp

P-0-0119, Best possible standstill = 2

In the event of an error the drive in velocity control is brought to a standstill with a command value ramp with end value zero. The velocity command value passes through a jerk-limiting command value smoothing filter.

The parameters used in this case are:

- **P-0-1201, Ramp 1 pitch**
- **P-0-1202, Final speed of ramp 1**
- **P-0-1203, Ramp 2 pitch**
- **P-0-1211, Deceleration ramp 1**
- **P-0-1213, Deceleration ramp 2**
- **P-0-1222, Velocity command filter**

These parameters work as described in section: "Operating mode: Velocity control".

If parameters **P-0-1211, Deceleration ramp 1** or **P-0-1213, Deceleration ramp 1** are equal to zero, then parameters **P-0-1201, Ramp 1 pitch** or **P-0-1203, Ramp 2 pitch** are used.

If parameters **P-0-1201, Ramp 1 pitch** or **P-0-1203, Ramp 2 pitch** are equal to zero, then the drive brakes without a ramp.

Note: Activation of the motor holding brake depends on P-0-0525, bit 1.

See also functional description: "Motor holding brake".

Power off on error

Bb contact

The project planning manual prescribes that power must be turned on via the Bb contact. This means that power can only be switched on, if the Bb relay is closed. On the other hand, switching power off requires the Bb contact to open.

The signaling of a drive error to the drive package or the power supply module can be activated via parameter **P-0-0118, Power off on error**. Communication utilizes the signal **BBdrive** (X11/5 and X11/14).

Note: Devices of the DURADRIVE family have been designed as stand-alone devices. They do not have any signal lines leading to other drive controllers. Therefore package reaction settings are ineffective for devices of the DURADRIVE family.

Structure of the parameter:

P-0-0118, Power off on error

Bit 0: Package reaction or power off on error
0: no package reaction on error and therefore no power off on error (exception: bleeder overload always cuts power off)
1: package reaction and power off on error

Bit 1: Condition for power on
0: power on possible, if no error **and** operating mode (comm. phase 4)
1: power on possible, if no error ("passive axis“)

Bit 2: Point of time of power off on error (only if bit 0 =1)
0: message output immediately when error occurs (package reaction of all controllers on same power supply module, preferred setting)
1: message not output until error reaction completed This means that power will not be cut off until the end of the error reaction

Bit 3: Reaction to DC bus undervoltage
0: undervoltage is treated as an error or a non-fatal warning
1: undervoltage is treated as a fatal warning with suppression of motoring operation

Bit 4: Automatic clearing of the undervoltage error
0 : undervoltage error is stored
1 : undervoltage error is cleared by drive upon removal of drive enable

Bit 5: Undervoltage as non-fatal warning
0 : undervoltage as error or fatal warning
1 : undervoltage is treated as non-fatal warning

Fig. 9-60: P-0-0118, Power off on error

Power off and package reaction on error

Signal line "BBdrive"

In the case of drive packages (several drives that have a power supply common to all and which can execute errors commonly), it is possible to inform, via signal line "BBdrive" (x11/5 and X11/14), the individual controllers and any power supply module which may be present as to whether the drive has detected an error as a result of which the power source must be shutdown.

If the controllers without error detect the error state on the signal line "Bbdrive", then they will, in turn, also conduct the error reaction and shut power off.

The point of time at which the message is output to the drive package (at start or end of the error reaction) is set in bit 2 of P-0-0118. In units that cannot release energy generated during the braking process (by means of bleeders or a mains-regenerated power supply) bit 2 should be set to 1 to prevent the drive coasting.

Note:	Devices of the DURADRIVE family have been designed as stand-alone devices. They do not have any signal lines leading to other drive controllers. Therefore package reaction settings are ineffective for devices of the DURADRIVE family.

Condition for power on

Using bit 1 of **P-0-0118, Power off on error** it is possible to set that point of time at which the drive signals its readiness to operate and therefore at which power can be switched on.

Passive axis

If bit1=1, then power can be switched on immediately after basic initialization of the drive, in other words, in communication phase 0 ("passive axis”).

If bit1=0, then the drive must be in communication phase 4 and without error before the power can be switched on for the first time.

Reaction to undervoltage (DC bus voltage too small)

Bits 3, 4 and 5 of **P-0-0118, Power off on error** offer various options on how to react to undervoltage.

Undervoltage is present if the drive has been enabled (subject to torque) and the DC bus voltage drops below the minimum value (about 75% of the rectifier value of the connected supply voltage).

Undervoltage as fatal warning

Using bit 3=1 treats undervoltage as a "fatal warning".

This makes sense if the energy in the DC bus must be retained for that period of time which a control needs to start a synchronized deceleration of several drives.

The drive does not signal a class 1 diagnostics error and the reaction parameterized in **P-0-0119, Best possible deceleration** is also not conducted.

Switching motoring operation off leads to a slower drop in the DC bus voltage. This means that asynchronous motors can still have a magnetic field when the control starts the synchronized deceleration of the drives. Braking then takes place in generator mode.

Automatic clearing of the undervoltage

If undervoltage is treated as an error (bit 3, 5 = 0), then bit 4 can be used to set an automatic clearing of the error once the control removes the drive enable signal.

This makes sense if the error occurs even with normal shutdowns and the cause is simply that the drive does not remove the enable fast enough.

Undervoltage as warning

Using bit 5 = 1 it is possible to switch off every reaction to undervoltage in the DC bus, mains errors or mains section errors (with separate mains section). Only one warning is generated.

Mains error

If either the mains section or controller detect undervoltage in the supply network (mains error), then a softstart of the mains section for the power supply is initiated (mains coupled via the braking resistor). If the control does not react by bringing the machine to a standstill, then error **F220 Braking resistor overload shutdown** can be generated.

NC response in error situation

Note: NC response in error situation is only possible with non-fatal errors, otherwise the drive reacts immediately with an error response.

If the drive controller recognizes an error, it sends a message to the control. The control can then decelerate the servo axes of the machine in a co-ordinated way with a "travel procedure in the case of error", thus preventing damage.

If this is desired, you have to delay the drive error response. This guarantees that the axis that sends an error message can continue following the command values set by the control. This is achieved by setting the time delay between the recognition of the error and the drive's error response. This can be set in parameter **P-0-0117, NC reaction on error**.

The following applies:

Value of P-0-0117	Function
0	Drive conducts the error response immediately after recognition of an error.
1	Drive continues following the command values of the control for 30 s, then reacts with "best possible deceleration".
2	The drive-internal control "DISC" conducts the error response (see also: "DISC – Drive macros").

Fig. 9-61: NC response in error situation

Note: Activating the "NC response in error situation" (bit 0 = 1) is only recommended for controls that have a corresponding error response procedure in the case of error.

E-Stop function

The E-Stop function supports the deceleration of the drive via a hardware input on the drive controller. It thus represents the option of shutting down the drive parallel to master communication, in an emergency.

Activation and kind of deceleration can be parameterized.

The following parameters are available for this function:

- **P-0-0008, Activation E-Stop function**
- **P-0-0223, Status Input E-Stop**

Activation and selection of a reaction

For the activation of the E-Stop input and the selection of a reaction for shutdown of the drive, use parameter **P-0-0008, Activation E-Stop function**.

The following applies:

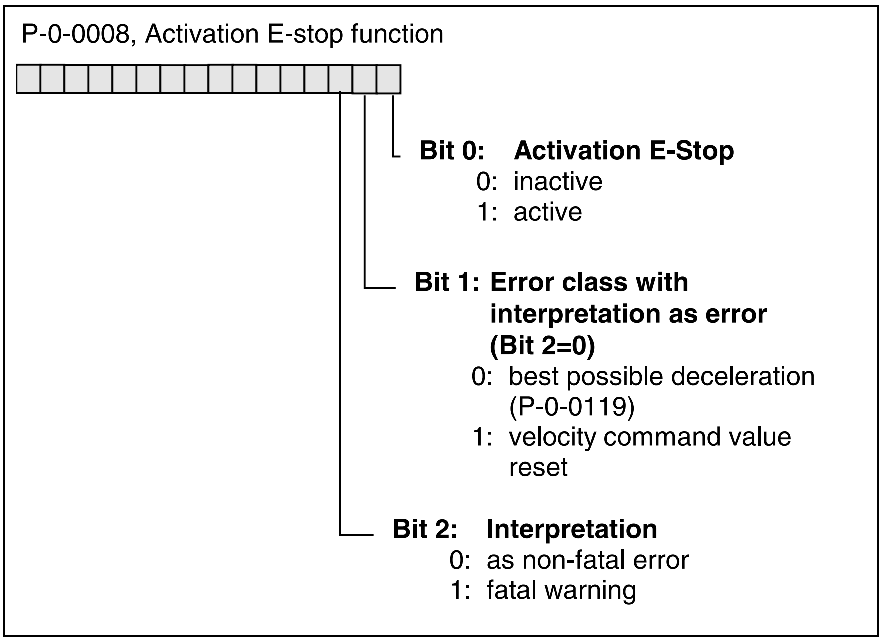


Fig. 9-62: P-0-0008, Activation E-Stop-Function

Functional principle of the E-Stop function

By activating the E-Stop function (bit 0 = 1) the drive executes, upon actuation of the E-Stop input, the selected reaction for deceleration. This reaction depends on bit 2 of **P-0-0008, Activation E-Stop function**.

Interpretation as warning E834 E-Stop activated

If the interpretation "fatal warning" has been parameterized in P-0-0008 (bit 2=1), then the drive responds, as if the external drive enable were switched off, with the reaction parameterized in **P-0-0119, Best possible deceleration**. The warning diagnosis **E834 Emergency-Stop** appears. Bit 15 is set in **S-0-0012, Class 2 diagnostics** (manufacturer-specific warning). Simultaneously, the bit "change bit class 2 diagnostics“ is set in the drive status word. This change bit is cleared again by reading **S-0-0012, Class 2 diagnostics**.

Using parameter **S-0-0097, Mask class 2 diagnostic,** warnings can be masked in terms of their effects on the change bit.

The functional principle at work when actuating the E-Stop input is that of a series connection to an external drive enable. When activating the E-Stop input, the drive responds as if the external drive enable were switched off. To re-activate the drive, the E-Stop input must become inactive, and another positive edge must be applied to the external drive enable.

Interpretation as error with adjustable reaction

If the interpretation as an error has been set in bit 2, then the reaction selected in bit 1 is performed. When the E-Stop input is activated, the error diagnosis **F434 Emergency-Stop** (or **F634 Emergency-Stop**) appears. Bit 15 is set in parameter **S-0-0011, Class 1 diagnostics**. Bit 13 ("drive interlock, error with class 1 diagnostics") is set in the drive status word of the drive telegram.

The error can be cleared via command **S-0-0099, C500 Reset class 1 diagnostic** or the S1 button on the drive controller if the E-Stop input is no longer activated.

This function basically works as if an error had occurred in the drive. The drive reaction is immediate, independent of p**arameter** P-0-0117, **NC reaction on error.**

If bit 1 = 0 in parameter P-0-0008, the drive shuts down according to the error reaction parameterized in **P-0-0119, Best possible deceleration**.

F434 Emergency-Stop

The diagnosis upon activating the E-Stop input then reads **F434 Emergency-Stop**.

Interpretation as error with "Velocity command value reset"

If bit 1 =1 in parameter P-0-0008, then the drive is braked at maximum torque, if the E-Stop of the drive is activated, until standstill. This is done regardless of the error reaction set in parameter P-0-0119. It corresponds to the best possible standstill "Velocity command value reset".

F634 Emergency-Stop

The diagnosis with the activation of the E-Stop input then reads **F634 Emergency-Stop**.

Status of the E-Stop input

The status of the E-Stop input can be controlled via parameter **P-0-0223, Status Input E-Stop**. The status of the E-Stop input is stored there in bit 0.

Connection of the E-Stop input

see Project Planning Manual ECODRIVE03 respectively DURADRIVE

9.7 Control loop settings

General information for control loop settings

The control loop settings in a digital drive controller are important for the characteristics of the servo axis.

Determining the control loop settings requires expert knowledge. For this reason, application-specific controller parameters are available for all digital Rexroth Indramat drives. These parameters are either contained in the motor feedback data memory and can be activated through the command **S-0-0262, C700 Command basic load** (with MHD, MKD and MKE motors) or they must be input via the parameterization interface.

(see also chapter "Load default")

Note: "Optimizing" the controller settings is generally not necessary!

In some exceptions, however, it may be necessary to adjust the control loop settings for a specific application. The following section gives a few simple but important basic rules for setting the control loop parameters in such cases.

In every case, the given methods should only be seen as guidelines that lead to a robust control loop setting. Specific aspects of some applications may require settings that deviate from these guidelines.

The control loop structure is made up of a cascaded position, velocity and torque/force controller. Depending on the operating mode, only the torque control loop or the torque and velocity control loops become operative. The control loop is structured as depicted below:

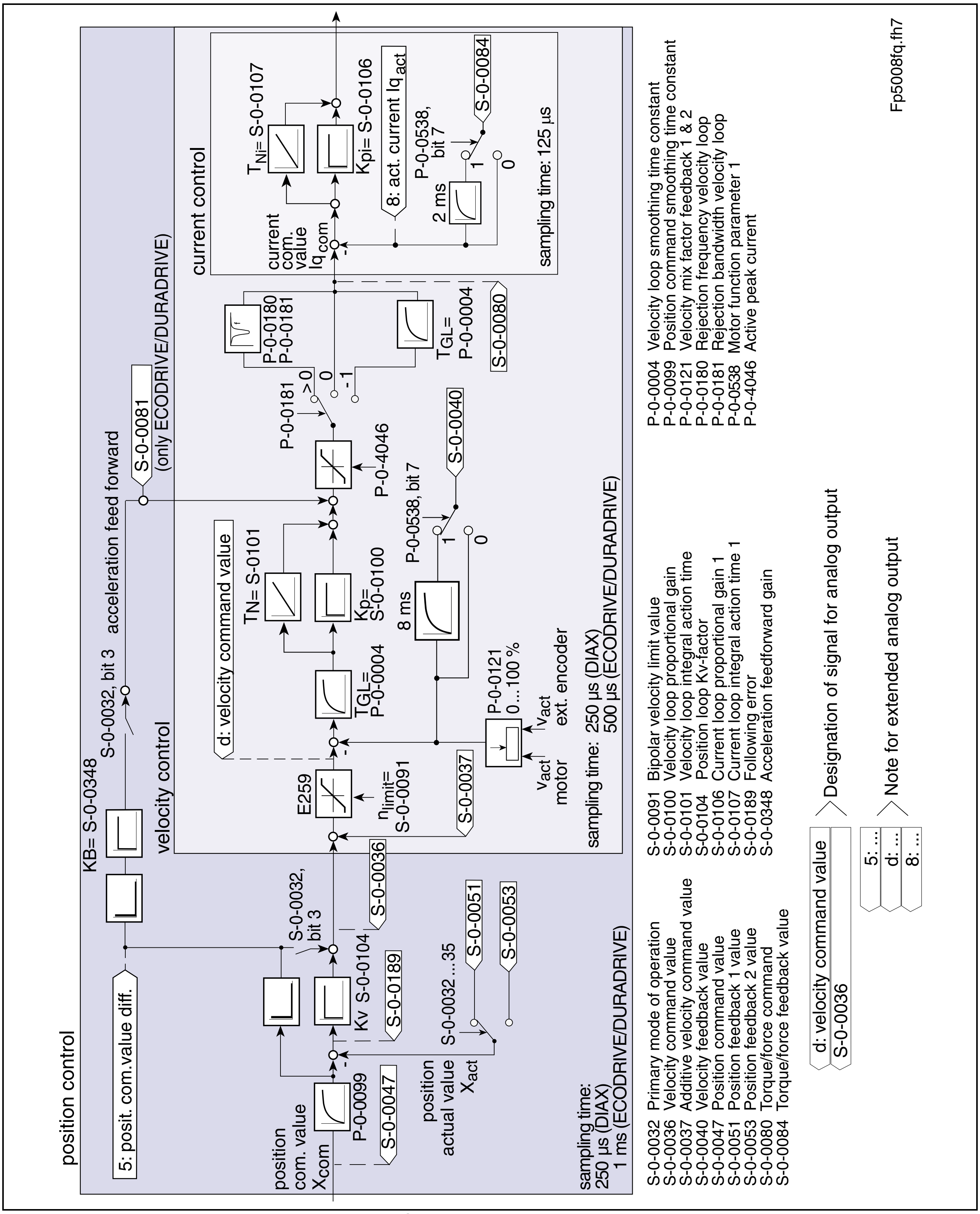


Fig. 9-63: Control loop structure

Load default

With the "load default" feature, you can activate the default control parameters for motor types with motor feedback data memory, such as

- MHD,
- MKD and
- MKE

With these parameters, the relevant controller parameters can be set for the motor type used.

Note: The parameters are pre-defined by the manufacturer for the moment of inertia relationship of $J_{motor} = J_{load}$.

Most applications can work with these values.

There are default values for the following parameters:

- **S-0-0100, Velocity loop proportional gain**
- **S-0-0101, Velocity loop integral action time**
- **S-0-0104, Position loop Kv-factor**
- **S-0-0106, Current loop proportional gain 1**
- **S-0-0107, Current loop integral action time 1**
- **S-0-0348, Acceleration feedforward gain**
- **P-0-0004, Smoothing Time Constant**
- **P-0-0181, Rejection bandwidth velocity loop**

The "Load default" feature can be activated in 2 different ways:

- Automatic activation during execution of command **S-0-0128, C200 Communication phase 4 transition check** for the first operation of this motor type with this drive.
- With execution of command **S-0-0262, C700 Basic Load**

Automatic execution of the load default feature

If a controller is operated with a specific type of motor for the first time, then the controller will detect this. During the execution of command **S-0-0128, C200 Communication phase 4 transition check** it compares parameter **S-7-141, Motor type**, which is read out of the motor feedback data memory, with the value of parameter **S-0-0141, Motor type** which is backed up in the parameter memory of the controller. If these two parameters are different, then error **F208 UL The motor type has changed** is generated. "UL" appears in the 7-segment display.

Note: Before you clear error F208 and thus start the "load default" feature, you have the option of saving the specific controller parameters.

Error **F208 UL The motor type has changed** can be cleared in 3 different ways:

1. Executing the command **S-0-0099, C500 Reset class 1 diagnostic**
2. Actuating key S1
3. Applying 24 V at the "Clear error" input

In all 3 cases, the "Load default" feature is activated.

If the execution of load default is impossible, then the respective command error of command **S-0-0262, C700 Command basic load** will appear.

(see also chapter: "Error conditions of the load default settings procedure")

Execution of the load default feature as a command

With parameter **S-0-0262, C700 Command basic load**, the feature can be executed as a command. This might be useful if manually changed controller parameters are to be set back to their default values.

Error conditions when executing the load default feature

If the feature started by executing the command **S-0-0262, C700 Command basic load** is not successfully processed, then the reason for this error is displayed either on the 7-segment display or with the diagnostic parameter **S-0-0095, Diagnostic message**.

The following could cause an error during load default:

SS Display	Diagnostic Message	Cause
C702	default parameters not available	load default is impossible for the motor type selected, load default is only possible for MHD, MKD and MKE
C703	default parameters invalid	connection of drive to motor feedback data memory is interrupted or feedback is defective
C704	default parameters incorrect	The existing default value cannot be processed since, for example, the extreme value limit was exceeded in the default value
C705	Locked with password	The customer password has been activated, therefore it is impossible to change the control loop parameters

Fig. 9-64: Possible errors during basic load command

Note: If a parameter can not be set to its default value, the parameter is set invalid in its data status. This serves safety purposes and helps in diagnosing errors.

Setting the current controller

The parameters for the current control loop are set by Rexroth Indramat and cannot be adjusted for specific applications. The parameter values set at the factory are activated with the command **S-0-0262, C700 Command basic load** for motors with feedback data memory or must be taken from the motor data sheet.

The values for the parameterization of the current controller are to be found in the parameters

- **S-0-0106, Current loop proportional gain**
- **S-0-0107, Current Loop Integral Action Time**

WARNING

Damage to the motor and the drive controller caused by change of values defined by Rexroth Indramat!

⇒ Changes to the current controller parameters are not permitted.

Setting the velocity controller

In order to be able to set the velocity controller, the current controller must have been correctly set.

The velocity controller is set via the parameters

- **S-0-0100, Velocity Loop Proportional Gain**
- **S-0-0101, Velocity Loop Integral Action Time**
- **P-0-0004, Smoothing Time Constant**
- **P-0-0180, Rejection frequency velocity loop**
- **P-0-0181, Rejection bandwidth velocity loop**

The setting can be made by:

- one-time execution of the "Load default" feature
- start of the command "automatic control loop settings"
- the procedure described below

Preparations for setting the velocity controller

A number of preparations must be made in order to be able to set the velocity controller:

- The mechanical system must be set up in its final form in order to have actual conditions while setting the parameters.
- The drive controller must be properly connected.
- The safety limit switches (if available) must be checked for correct operation.
- The "Operating mode: velocity control" must be selected in the drive.

Start settings

The controller setting must be selected for the start of parameterization as follows:

- **S-0-0100, Velocity Loop Proportional Gain** = default value of the connected motor.
- **S-0-0101, Velocity Loop Integral Action Time** = 0 ms (no integral gain)
- **P-0-0004, Smoothing Time Constant** = minimum value (500 µs) ➔ filter is switched off
- **P-0-0181, Rejection bandwidth velocity loop** = 0 Hz (deactivated)

Note: When determining the velocity controller parameters, the functions for torque and backlash compensation must not be active.

Definition of the critical proportional gain and smoothing time constant

1. After turning on the controller enable, let the drive move at a low velocity. rotary motors: 10...20 RPM, linear motors: 1...2 m/min)
2. Increase **S-0-0100, Velocity loop-proportional gain** until unstable behavior (continuous oscillation) begins.
3. Determine the frequency of the oscillation by oscilloscoping the actual velocity (see also chapter: "Analog output"). If the frequency of the oscillation is much higher than 500 Hz, increase the parameter **P-0-0004, Smoothing Time Constant** until the oscillation stops. After this, increase the **S-0-0100, Velocity Control Proportional Gain** until instability occurs again.
4. Reduce **S-0-0100, Velocity loop proportional gain** until the oscillation stops by itself.

The value found using this process is called the "critical velocity loop proportional gain".

Note: By inputting **P-0-0181, Rejection bandwidth velocity loop** = -1 a PT_2 filtering function can be activated. (see also block diagram with control loop structure in chapter: "General information for control loop settings").

Determining the critical integral action time

1. Set **S-0-0100, Velocity loop proportional gain** = 0.5 x "critical proportional gain"
2. Reduce **S-0-0101, Velocity loop integral action time** until unstable behavior results.
3. Increase **S-0-0101, Velocity loop integral action time** until continuous oscillation stops.

The value determined through this process is called the "critical integral action time."

Determining the velocity controller setting

The critical values determined before (see "Determining the critical integral action time" and "Definition of the critical proportional gain and smoothing time constant") can be used to derive a control setting with the following features:

- Independent from changes to the axis since there is a large enough safety margin to the stability boundaries.
- Safe reproduction of the characteristics in series production machines.

The following table shows some of the most frequently used application types and the corresponding control loop settings.

Application Type	Velocity controller proportional gain	Velocity loop Integral Action Time	Comments
Feed axis on standard tool machine	$K_p = 0.5 \times K_{pcrit}$	$T_n = 2 \times T_{ncrit}$	Good stiffness and good command response
Feed axis on perforating press or chip-cutter machines	$K_p = 0.8 \times K_{pcrit}$	$T_n = 0$	High proportional gain; no I-part, to achieve shorter transient recovery times.
Feed drive for flying cutting devices	$K_p = 0.5 \times K_{pcrit}$	$T_n = 0$	Relatively non-dynamic control setting without I-part, to avoid structural tension between the part to cut off and the cutting device.

Fig. 9-65: Identification of velocity controller settings

Filtering oscillations from mechanical resonance

The drives are able to suppress oscillations caused by the drive train between the motor and the axis or spindle mechanics over a narrow frequency band. Thus, increased drive dynamics with good stability can be achieved.

With distortion-resistant drive mechanics, the mechanical system of rotor-drive train-load is induced to generate mechanical oscillations as a result of position/velocity feedback in a closed control loop. This behavior identified as a "two mass oscillator" is generally within the 400-800 Hz range, depending on the rigidity and spatial volume of the mechanical system.

This "two mass oscillation" usually has a clear resonance frequency which can be specifically suppressed by a rejection filter installed in the drive.

When suppressing the mechanical resonance frequency, the dynamics of the velocity and position control loops in terms of control can be significantly improved compared to without a rejection filter.

This results in greater contour accuracy and smaller cycle times for positioning processes, leaving sufficient stability margin.

The filter can be set in rejection frequency and bandwidth. The rejection frequency is the one with highest attenuation, the bandwidth determines the frequency range with which the attenuation is less than -3 dB. Greater bandwidth leads to smaller band attenuation of the rejection frequency! The following parameters can be used to set both values:

- **P-0-0180, Rejection frequency velocity loop**
- **P-0-0181, Rejection bandwidth velocity loop**

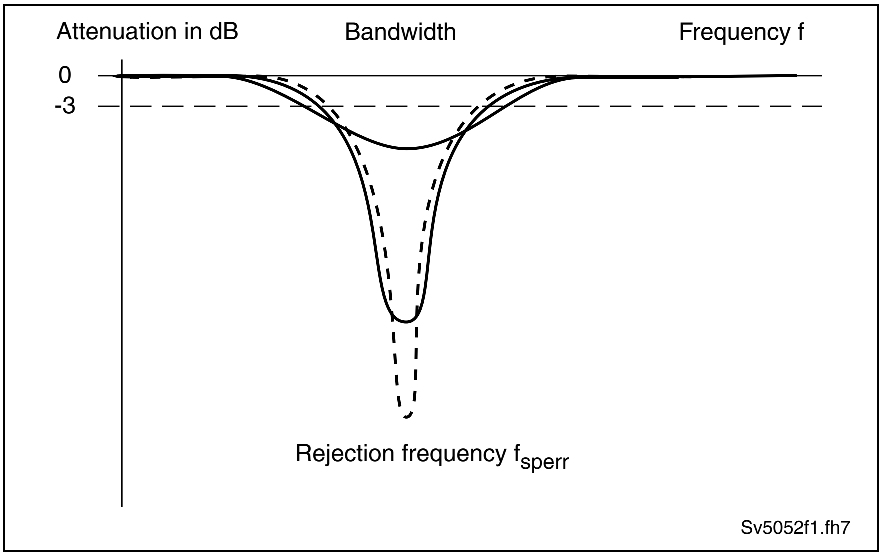


Fig. 9-66: Amplitude response of the rejection filter in terms of bandwidth, qualitative

To set the band filter, we recommend the following procedure:

Presetting

Set rejection filter inactive.

Enter the value "0" in parameter **P-0-0181 Rejection bandwidth velocity loop**.

Determine resonance frequency

Connect oscilloscope to analog output channels, assign velocity feedback value to analog output 1 (enter "S-0-0040" in **P-0-0420, Analog output 1, signal selection** and enter the desired scaling, e.g. 100 rpm/10 V in **P-0-0422, Analog output 1 scaling**).

- or -

Use the oscilloscope function of the drive to display velocity feedback value. This can be read out directly by an FFT of the frequency response.

Excite the drive mechanics, e.g. tap lightly and tangentially with a rubber hammer.

Record the time of the velocity oscillations with an oscilloscope or oscilloscope function and analyze for clearly salient frequencies. If the oscilloscope function is used, then the resonance frequency can be directly read out of the frequency readout.

Determining the initial state of the loop

Set the drive enable signal and optimize the velocity loop with inactive rejection filter (see "Setting the velocity controller").

Record step response of the velocity feedback value and the torque/force generating command current with a small velocity command step (the torque-generating command current is not allowed to reach the limit during this process).

Turn rejection filter on and check the effect

Enter the most salient frequency in Hz in parameter **P-0-0180, Rejection frequency velocity loop**.

Enter a minimum bandwidth in parameter **P-0-0181, Rejection bandwidth velocity loop** (e. g. 25 Hz).

Record the previous step response again.

If the step response features less overshoot and shorter periods of oscillation, then:

Check whether increasing the value of **P-0-0181, Rejection bandwidth velocity loop** causes an improvement.

- or -

Check whether a change in the value of **P-0-0180, Rejection frequency velocity loop** causes an improvement.

If the step response results in the same behavior, then:

Check the resonance frequency analysis

- or -

Clearly increase the value in **P-0-0181, Rejection bandwidth velocity loop**.

Optimize rejection filter or velocity loop

With the pre-optimized values of **P-0-0180, Rejection frequency velocity loop** and **P-0-0181, Rejection bandwidth velocity loop**, optimize the velocity controller again (see above).

The step response defined above must have a similar appearance with higher values for **S-0-0100, Velocity loop proportional gain** and / or smaller values for **S-0-0101, Velocity loop integral action time**.

An additional optimizing run may be necessary for **P-0-0180, Rejection frequency velocity loop** and **P-0-0181, Rejection bandwidth velocity loop** using the step response.

Filtering with double smoothing filter

Optimization of the control loop with a rejection filter does not always make the regulation good enough. This happens for example when the closed loop does not have significant resonance frequencies. Activation of a second smoothing filter (with PT1 characteristics) can, depending on the case, improve the regulation quality as desired.

To do this, set the parameter **P-0-0181, Rejection bandwidth velocity loop** to -1. The rejection filter as well as the assigned parameter **P-0-0180, Rejection frequency velocity loop** are deactivated. Instead of the rejection filter, a smoothing filter is activated in the control loop. This uses the same smoothing time constant (T_{gl}) as the smoothing filter **P-0-0004, Velocity loop smoothing time constant**. Together with the smoothing filter at the input of the velocity controller, you obtain a filter with PT2 characteristics. Frequencies greater than the cut-off frequency ($f_g = 1/2\pi T_{gl}$) are much more suppressed and cannot excite oscillations in the control loop any more.

The parameter for the filter is **P-0-0004, Velocity loop smoothing time constant**.

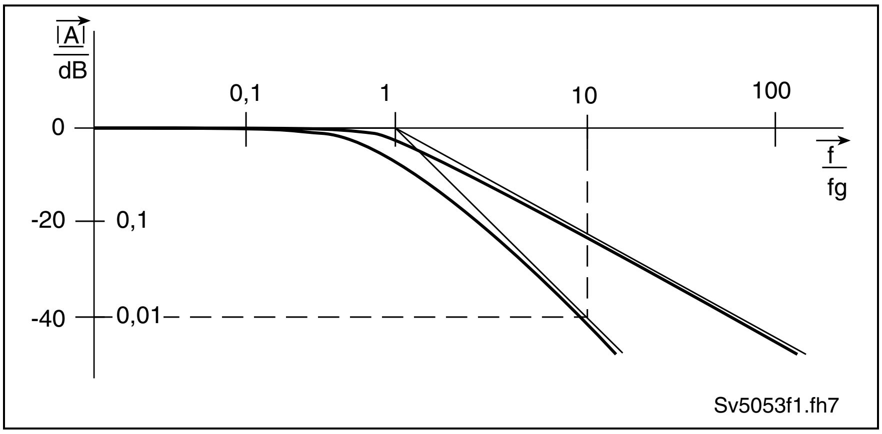


Fig. 9-67: Frequency response of a PT1 and PT2 filter

Note: The setting is the same as described under "Definition of the critical proportional gain and smoothing time constant".

Velocity control loop monitoring

If the velocity control loop monitor detects a fault in the velocity control loop, then error

- **F878 Error in velocity control loop**

is generated.

Note: The velocity control loop monitor is only active with operating modes with which the velocity control loop in the drive is closed (i.e. always except with torque control) and monitoring activated.

Activating the monitor

The velocity control loop monitor is activated with parameter **P-0-0538, Motor function parameter 1**.

The structure of the parameter:

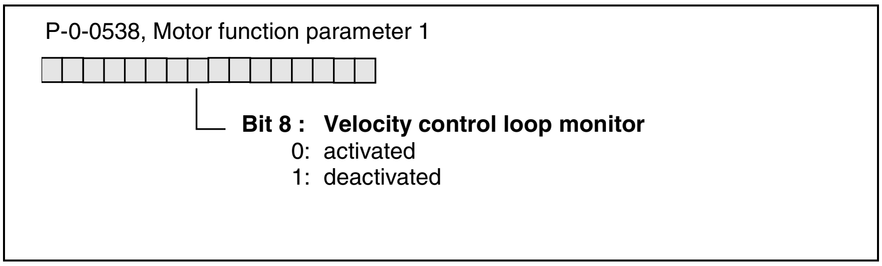


Fig. 9-68: P-0-0538, Motor function parameter 1

Note: It is highly recommended not to deactivate the velocity control loop monitor activated at the factory, as it represents a basic safety function of the drive!

Causes of a monitor trigger

The velocity control loop monitor is designed to be triggered in the case of those faults that lead to the wrong direction of rotation of the motor torque. The following options are basically possible:

- incorrect polarity with motor connection
- wrong commutation angle
- faults in the velocity encoder

Note: This prevents the "runaway effect" of the motor.

Criteria for triggering the monitor

One of the following criteria must be met for the velocity control loop monitor to be triggered:

- current command value limited to **P-0-4046, Active peak current**
- motor accelerating in the wrong direction
- actual velocity value is greater than 0.0125-times the maximum motor velocity.

Position controller

The position deviation is generated from the effective position command value, that is generated from the respective generator function of the active operating mode, and the position feedback value (encoder 1 or encoder 2) used for control.

The position deviation is transmitted to the position controller the gain of which is set via **S-0-0104, Position loop Kv-factor** (see chapter: "Setting the position controller").

Meaning of bit 3 of the operating mode parameters (S-0-0032...S-0-0035)

Bit 3 of the operating mode parameters (S-0-0032..35) indicates whether a path is to be traveled with lag distance or laglessly:

Bit 3 = 1	lagless	(with velocity feedforward)
Bit 3 = 0	with lag distance	(without velocity feedforward)

The following figure shows how the velocity feedforward works: By means of differentiation, a velocity value is calculated from the position command values. This value is a velocity command value with which the new position command value can be reached within one position controller cycle. One position controller cycle after this feedforward value has been transmitted to the velocity controller, the position command value is entered for the position controller. This means that the drive has already reached the new position command value, when it is entered for the position controller, and the lag is clearly reduced ("lagless").

With lagless position control, an acceleration-related feedforward proportion can be added by means of parameter **S-0-0348, Acceleration feedforward gain**. The feedforward proportion is generated with another differentiation according to the velocity feedforward.

(see also chapter: "Setting the acceleration feed forward")

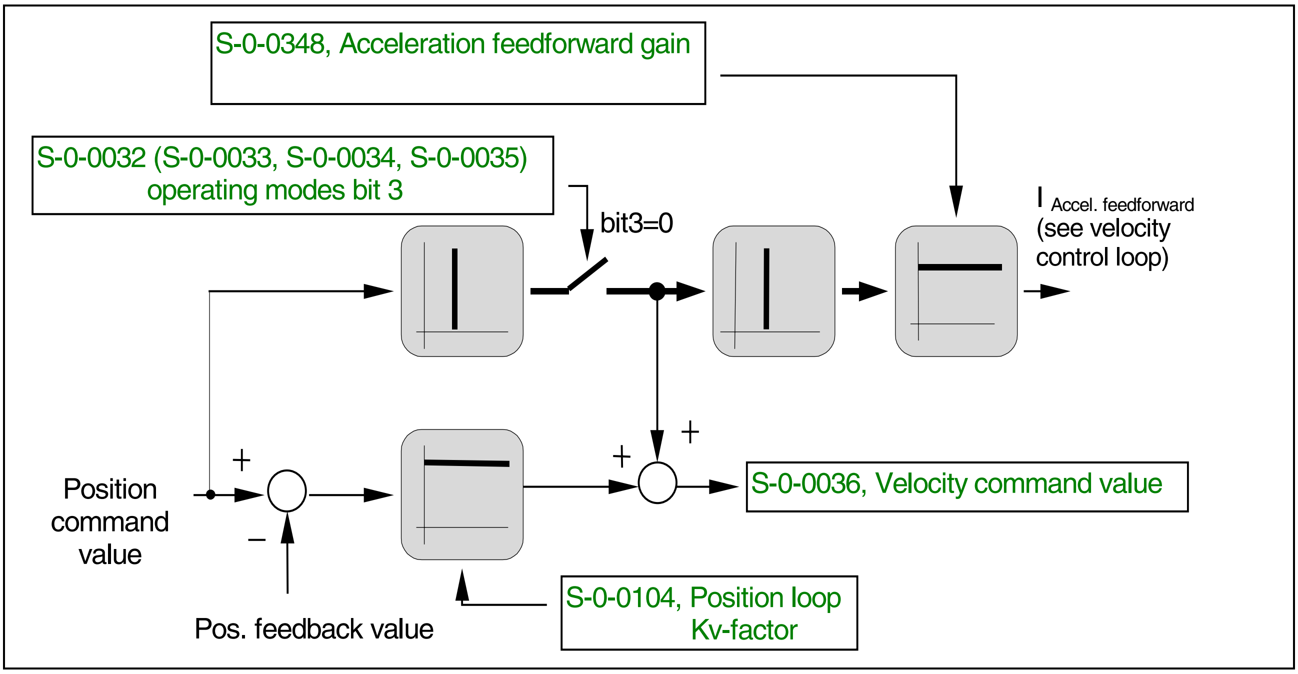


Fig. 9-69: Position controller

see also chapter: "Velocity controller"

see also chapter: "Current controller"

Setting the position controller

Pre-requisite

In order to set the position controller correctly, current and velocity controller must be correctly set.

The position controller can be set with the parameter

- **S-0-0104, Position loop Kv-factor**

This can be set by either executing the "load default" feature once or by following the process below.

Preparations for setting the position control loop

A number of preparations must be made in order to be able to set the position controller properly:

- The mechanical system of the machine must be definitely assembled, in order to have original conditions for parameter definition.
- The drive controller must be properly connected.
- The safety limit switches (if available) must be checked for correct operation.
- Operate the drive in a mode that closes the position loop in the drive ("Operating mode: Position control").
- The outer velocity controller must be properly tuned. The start value chosen for the K_v factor should be relatively small (K_v = 1).
- For the determination of the position controller parameter, no compensation function should be activated.

Determining the critical position controller gain

- Move axis at a slow velocity, e. g. with a jog function at the connected NC Control (rotary motors: 10...20 Rpm, linear motors: 1...2 m/min).
- Raise the K_v factor until instability occurs.
- Reduce the K_v factor until the continuous oscillation stops by itself.

The K_v factor determined through this process is called the "Critical position control loop gain (K_{vcrit})**".**

Determining the position controller setting

In most applications, an appropriate position controller setting will lie between 50% ... 80% of the critical position controller loop gain.

This means:

S-0-0104, Position loop Kv-factor = 0.5...0.8 x K_{vcrit}

Position control loop monitoring

The position control loop monitor is used to diagnose errors in the position control loop.

Reasons for triggering the position control loop monitor can be:

- Exceeding the torque or acceleration capability of the drive.
- Blocking of the axis’ mechanical system
- Failures in the position encoder

The position control loop monitor is only active when an operation mode with closed position loop in the drive is active.

To set and diagnose the monitoring function, two parameters are used:

- **S-0-0159, Monitoring Window**
- **P-0-0098, Max. Model Deviation**

If the position control loop monitor detects an error in the position control loop, the error message

- **F228 Excessive deviation**

is generated.

General operating characteristics of the position control loop monitor

To monitor the position control loop, a model position feedback value is computed in the drive while the position control loop is closed, which depends only on the preset position command value profile and the set control loop parameters. This model position feedback value is compared continuously to the position feedback value that is used for control. If the deviation exceeds **S-0-0159, Monitoring Window** during 8 ms error **F228 Excessive deviation** will be generated.

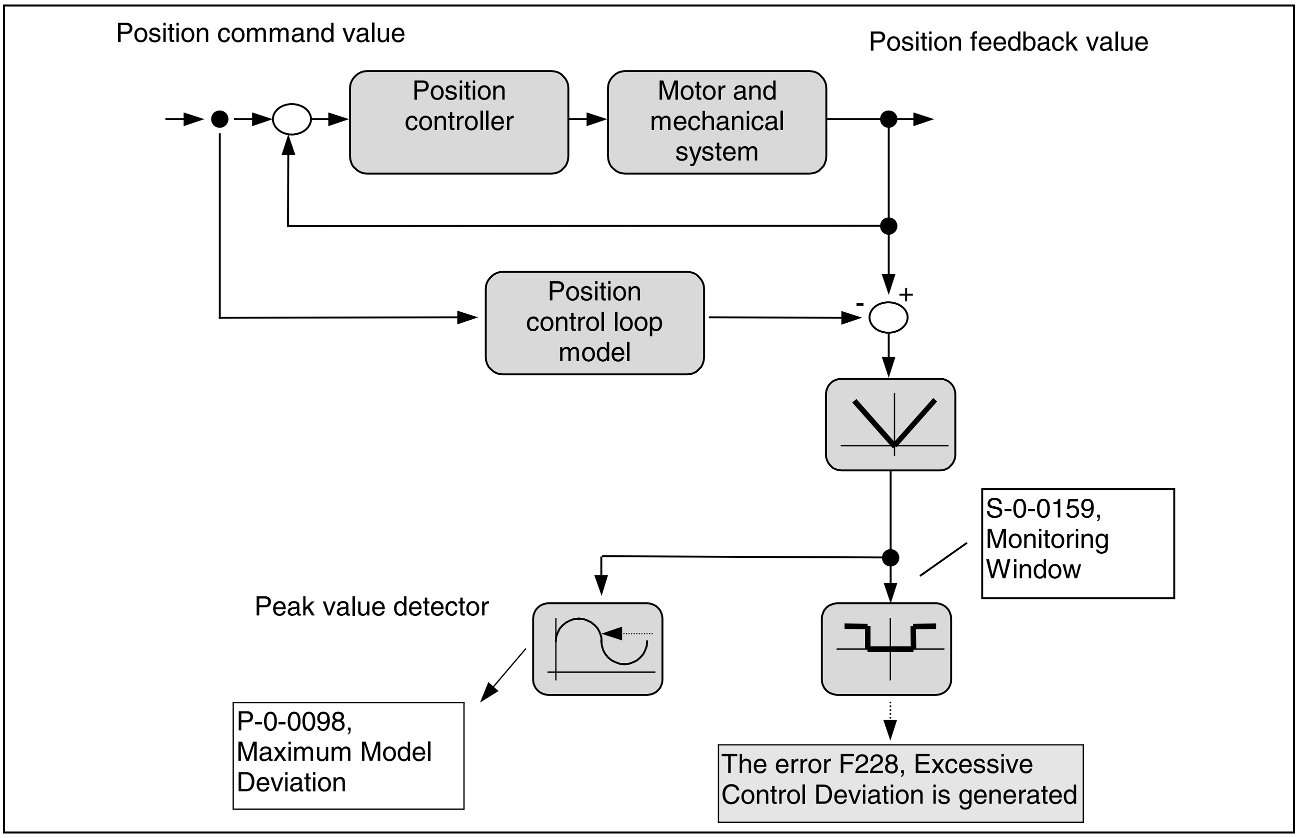


Fig. 9-70: Schematic of position control loop monitor

Note: For monitoring, the feedback value used for position control is always used, this means that for position control with the motor encoder, position feedback value 1 is used, and for position control with the external encoder, the position feedback value 2 is used.

Setting the position control loop monitor

Requirements

Requirements for the setup of the position loop monitoring are

- Check the velocity and position control loops for their appropriate settings before setting the position control loop.
- The respective axis should be checked mechanically.

Setting

The position control loop monitor setting should be carried out as follows:

- Through the connected control, you should proceed in a typical operation cycle. In this mode, move at the maximum projected velocity.
- Parameter **P-0-0098, Max. Model Deviation** always displays the maximum deviation between the position feedback value and the expected position feedback value.

Note:	The contents of parameter P-0-0098 is saved in the volatile memory, i.e. after switching the drive on, the contents of this parameter equals zero.

- This value can be used to help set the monitoring window. Parameter **S-0-0159, Monitoring Window** is to be set to **P-0-0098, Max. Model Deviation** multiplied by a safety factor. A safety factor between 1.5 and 2.0 is recommended.

Example:

P-0-0098, Maximum Model Deviation = 0.1 °

⇒ S-0-159, Monitoring Window = 0.2 ° (= 2 x 0.1 °)

Deactivation of the position control loop monitor

It is strongly recommended to activate the position control loop monitor.

However, there are exceptions for which the position control loop monitor must be deactivated. You can do this by entering very high values for parameter **S-0-0159, Monitoring Window**.

Note:	By default, the position control loop monitor is active.

Setting the acceleration feed forward

For Servo applications, where high precision at high speeds counts, you have the option to greatly improve the precision of an axis during acceleration and braking phases through activation of the acceleration feedforward.

Typical applications for the use of the acceleration feedforward:

- Free form surface milling
- Grinding

To set the acceleration feedforward, use the parameter

- **S-0-0348, Acceleration feedforward gain**

Requirements for a correct setting of the acceleration feedforward

- Velocity and position control loop have to be set appropriately.
- For the position controller, lagless operation mode must be selected.

Setting the acceleration feed forward

Setting the correct acceleration feedforward can only be done by the user since it depends on inertia.

Note: With automatic control loop settings it is not only possible to determine inertia but also the value for S-0-0348.

The setting is done in two steps:

Calculation of a guide value for acceleration feedforward

1. For the calculation of the guide value for the acceleration feedforward you need the value of the total inertia momentum translated to the motor shaft ($J_{Motor}+J_{Load}$) of the axis. This value is known approximately from the sizing of the axis. Additionally, you need the torque constant of the used motor. This data can be retrieved from the motor data sheet or the parameter **P-0-0051, Torque/force constant**. The guide value is calculated as:

$$\text{Acceleration feedforward} = \frac{J_{Motor} + J_{Load}}{Kt} \times 1000$$

Acceleration feedforward [mA\rad\s²]

J_{Motor}:	Inertia of the motor [kg m²]	(P-0-0510)
J_{Load}:	Inertia of the load [kg m²]	(P-0-4010)
Kt:	Torque constant of the motor [Nm/A]	(P-0-0051)

Fig.9-71: Guide value for the acceleration feedforward

The determined guide value is to be entered in parameter **S-0-0348, Acceleration feedforward gain**.

Checking the effect of the acceleration feedforward and, if necessary, fine tuning of parameter S-0-0348

2. The deviation of the position feedback value from the position command value can be displayed through the analog diagnostic outputs of the drive controller or the oscilloscope function. To check the effect of the acceleration feedforward, you must oscilloscope this signal during movement of the axis along the desired operation cycle. In acceleration and braking phases, the feedforward must reduce the dynamic control deviation drastically.

Setting the velocity mix factor

With the help of the velocity mix factor, you can combine the values of motor measuring system and external measuring system to obtain the velocity feedback value used for velocity control. This might be an advantage, when there is play or torsion between motor and load.

To set the mixing ratio, use the parameter

- **P-0-0121, Velocity mix factor feedback1 & 2**

Note: This function is only applicable when there is an external measuring system. If there is no external measuring system available, **P-0-0121** is automatically set to 0 %.

The mixture of the velocity feedback value can be continuously varied between:

100 % velocity feedback value of the motor encoder ... 0 % feedback value of the external encoder (P-0-0121 = 0)

AND

0 % velocity feedback value of the motor encoder ... 100 % feedback value of the external encoder (P-0-0121 = 100)

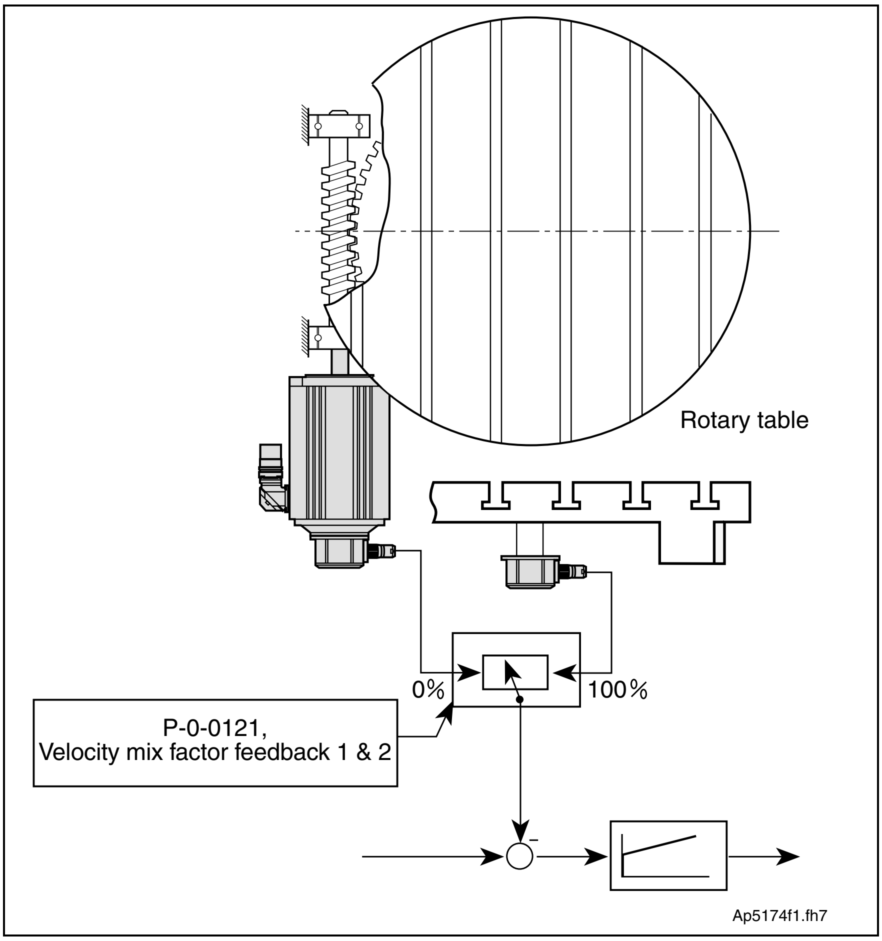


Fig. 9-72: Functional principle velocity mixing

9.8 Automatic control loop settings

General comments

To facilitate drive parameterization for the user, the firmware offers automatic control loop setting.

Using parameters **P-0-0163**, **Damping factor for automatic control loop adjust** and **P-0-0164, Application for automatic control loop adjust**, the user can have an influence on the result of the automatic control loop settings (obtained control loop dynamics).

Note: It is necessary to move the drive in order to conduct the automatic control loop settings. The velocity and position control loops are optimized!

Prerequisites for starting the automatic control loop settings

CAUTION

Property damage and/or damage to persons caused by drive motion!

During the command **D900 Command automatic loop tuning**, the drive moves automatically, i. e. without external command value setting.

⇒ Check and make sure that the emergency stop sequence and the travel range limit switch are working.

See also chapter: "Safety instructions for electric servo drives and controls"

Definition of travel range

Since the axis must be moved in order to identify and set the control loop, it is necessary to define an allowed travel range. There are two options:

- Define a travel range by inputting the limits **P-0-0166, Lower position limit for automatic control loop adjust** and **P-0-0167, Upper position limit for automatic control loop adjust** (a downwardly-compatible function)
- Define a travel range by inputting **P-0-0169**, **Travel distance for automatic control loop adjust** (needed with modulo axes!)

Note: The mode is selected with the use of parameter **P-0-0165, Selection for automatic control loop adjust**, bit 15.

Inputting the limits P-0-0166, P-0-0167

If bit 15 of P-0-0165 has **not** been set, then the range in which the axis may move with an automatic control loop setting is defined with

- a lower limit position (**P-0-0166**) and
- an upper limit position (**P-0-0167**)

This results in the value of **P-0-0169, Travel distance for automatic control loop adjust**.

Inputting P-0-0169

If Bit 15 of P-0-0165 is set, then the range in which the axis may move with an automatic control loop setting is defined with

- **P-0-0169, Travel distance for automatic control loop adjust** and
- **Start position** (actual position) at the start of the command

This results in the value of P-0-0166 (start position - travel range) and of P-0-0167 (start position + travel range) in which the axis may move to execute the command.

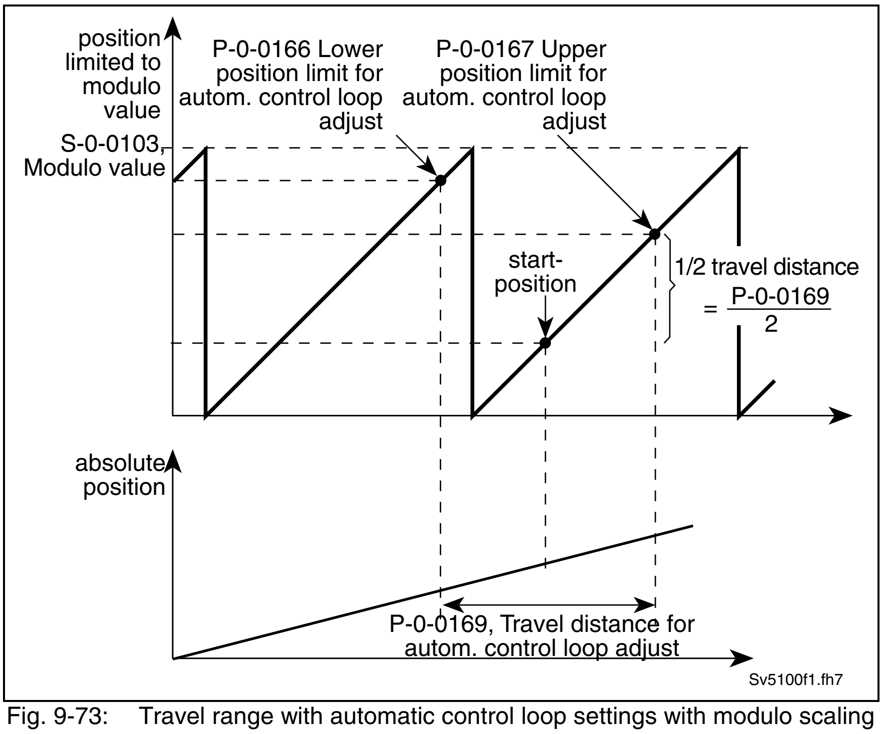


Fig. 9-73: Travel range with automatic control loop settings with modulo scaling

Note: The travel range defined here is only monitored during the execution of the command "Automatic control loop settings".

Possible diagnostic messages when determining the travel range:

D905 Travel range invalid, P-0-0166 & P-0-0167

If the defined travel path equals less than two motor revolutions, then command error **D905 Travel range invalid, P-0-0166 & P-0-0167** is generated.

D906 Travel range exceeded

If the axis is not within the defined travel range at the start of the command, then command error **D906 Travel range exceeded** is generated.

Loading the default control parameters

Before executing the command for setting the control loop, the default control parameters stored in the motor feedback should be loaded or the data of the motor data sheet should be entered in the respective parameters.

Drive enable or drive start

The oscillations and thus the automatic control loop settings are only conducted if

- the **drive enable** is present

- and -

- **drive start** is set.

Note: In field bus drives with DRIVECOM profile, this is the "Operation enable" equivalent, i.e. the status machine must be booted up!

Note: If there is no drive enable at command start, then command error **D901 Start requires drive enable** is generated.

Command settings

All parameters used in the execution of the command must be programmed before command start so that they are effective in the automatic control loop settings.

- **P-0-0163, Damping factor for autom. control loop adjust**. Use this parameter to select the desired control loop dynamics.
- **P-0-0164, Application for autom. control loop adjust** is used to take the mechanical conditions with controller optimization into account.
- **P-0-0165, Selection for autom. control loop adjust** is used to select functionalities (modes) of the automatic control loop settings.

Possible causes for command error D903

If the value set for the following parameters is too low, this can cause command error **D903 Inertia detection failed** to be generated.

- **S-0-0092, Bipolar torque/force limit value**
  The maximum torque effective during the automatic control loop settings can be programmed with parameter S-0-0092. This can help limit the torque to prevent mechanical wear and tear.
- **S-0-0108, Feedrate override**
  By means of the feedrate override the velocity can be programmed via the analog channel (potentiometer) during the automatic control loop settings.
- **S-0-0259, Positioning Velocity**
  This parameter sets the velocity effective during the automatic control loop settings.
- **S-0-0260, Positioning Acceleration**
  This parameter sets the acceleration effective for the automatic control loop settings.

Note: The reasons that command error D903 is generated can either be excessive inertia, but also too slow speed, acceleration or torque.

Executing automatic control loop settings

Note: **1)** The execution of the control loop settings is connected with a drive motion, i.e. the drive moves in terms of the travel range fixed in parameters P-0-0166 and P-0-0167 or P-0-0169.
2) The parameter settings needed to execute the command must be realized prior to command start.

Starting the command

The automatic control loop settings are started by writing the binary numeric value "3" (11b) (=command start) to parameter **P-0-0162, D900 Command Automatic control loop adjust**.

Triggering a motion

An axis motion and thus the execution of the automatic control loop settings is only possible if the signal "Drive halt" has not been set. If the signal "Drive has" has been set, the drive will acknowledge the start of command **P-0-0162, D900 Command Automatic control loop adjust**, but the axis won't move.

Triggering the motion by starting command D900

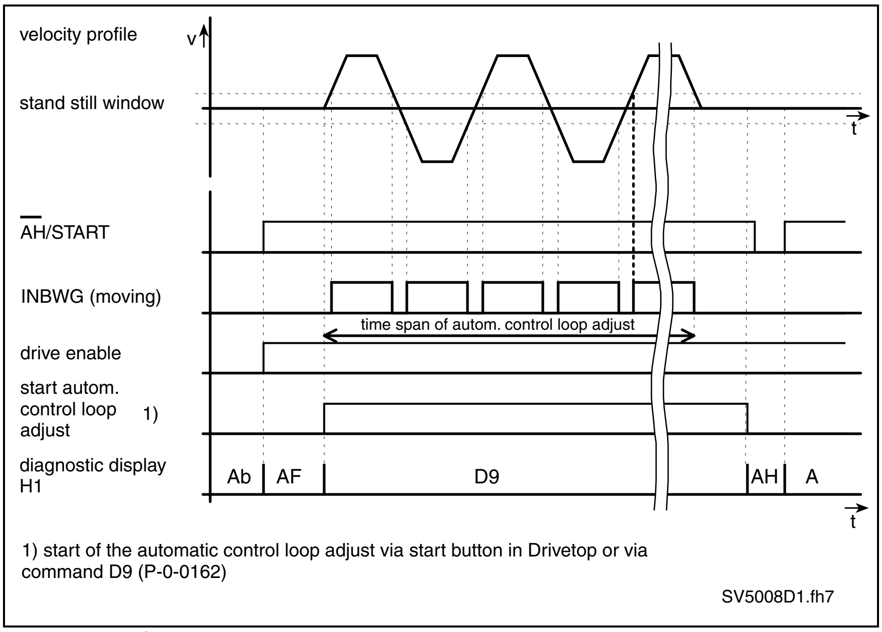


Fig. 9-74: Signal flow chart

Triggering the motion with drive start

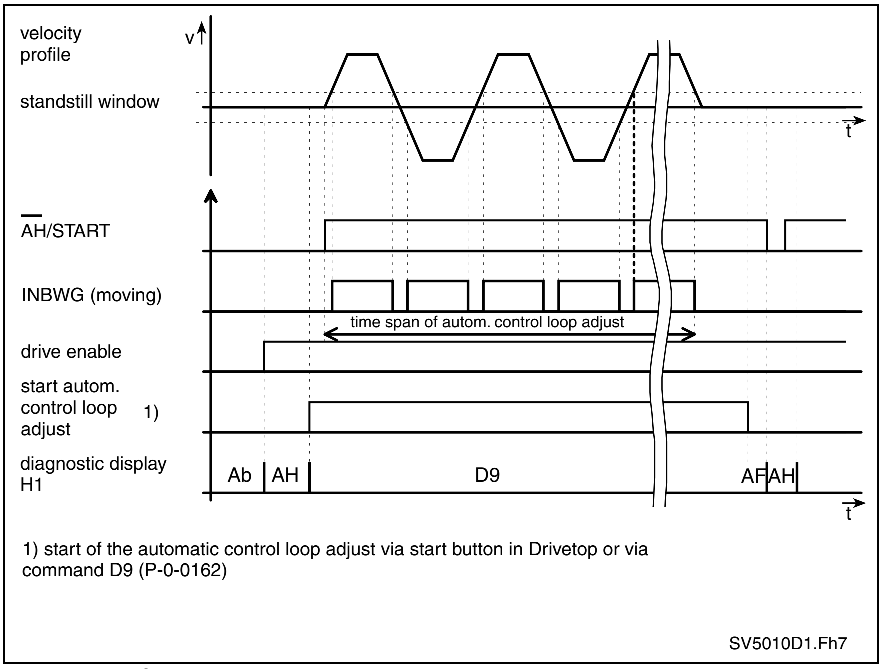


Fig. 9-75: Signal flow chart

Interrupting the command with "Drive halt"

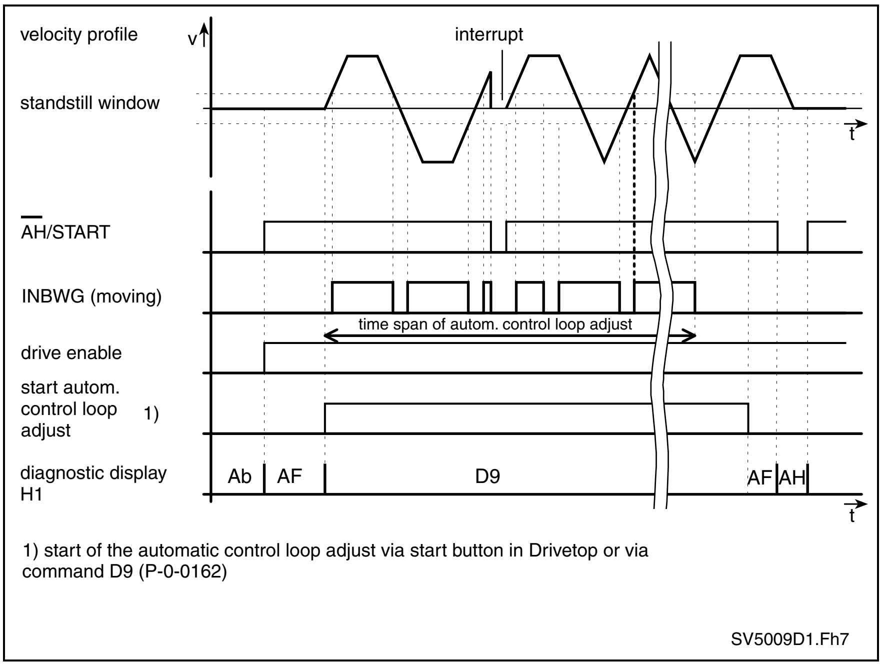


Fig. 9-76: Signal flow chart

Note: A repeated run with possibly changed settings can be conducted either:
1) by removing and then applying the drive enable or start signal (drive start)
2) or by ending and then restarting command D900.

Chronological sequence of automatic control loop settings

Description of the steps:

1st step Check for possible command errors at command start.

2nd step Determine total and extrinsic inertia by evaluating acceleration and deceleration procedures.

3rd step Calculate and use controller parameters in drive.

The parameters **P-0-0163, Damping factor for autom. control loop adjust** and **P-0-0164, Application for autom. control loop adjust** will be checked.

4th step Check velocity control loop and correct controller parameters, if need be, until desired behavior appears (depends on dynamics programmed).

5th step Check position control loop and correct controller parameters, if need be, until aperiodic behavior in control loop appears.

6th step END Wait for possible new start or end of command.

During this step the drive is idle (velocity = 0) and the display reads D900.

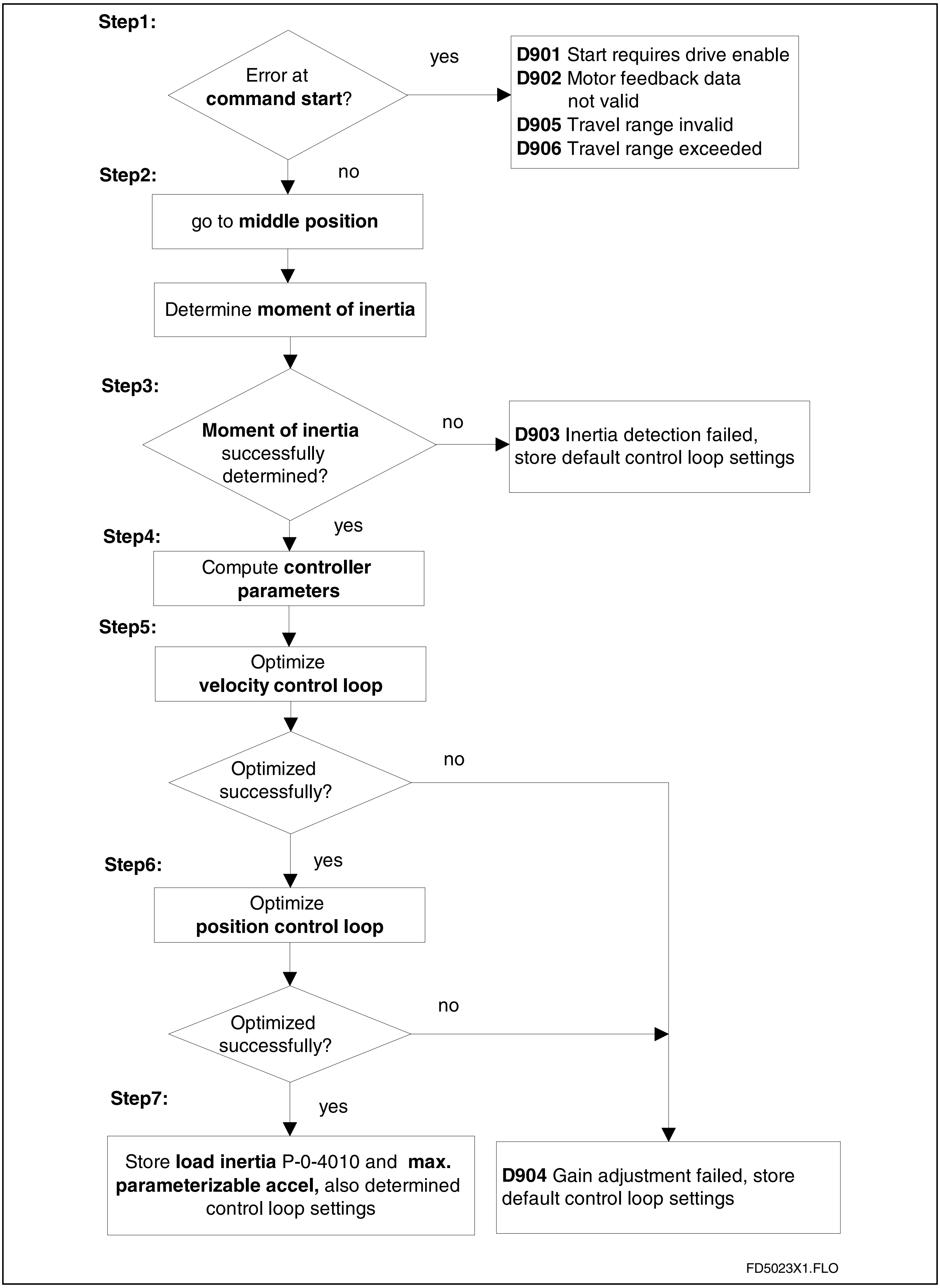


Fig. 9-77: Automatic control loop setting sequence

Results of automatic control loop settings

Note: The current control loop is not affected by the automatic control loop settings, as its setting is load-independent and the default values have been set to optimum current controller parameters at the factory.

The results of automatic control loop settings depends on the selection in **P-0-0165**.

Parameter structure P-0-0165:

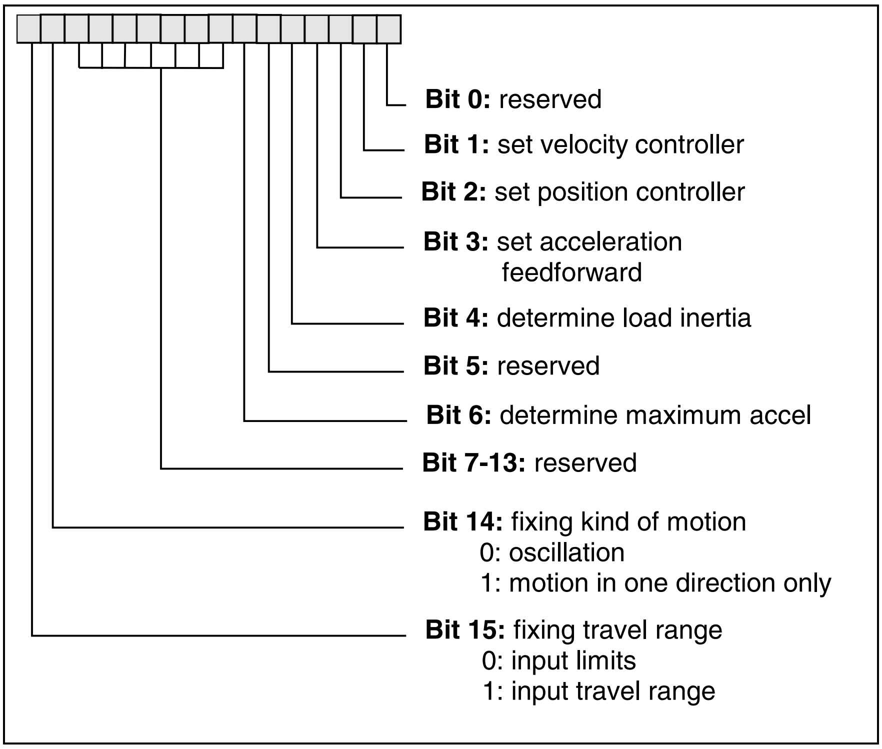


Fig. 9-78: Selection parameter for automatic control loop settings

Possible results of the automatic control loop settings are:

- Setting of velocity control loop
- Setting of position control loop
- Determination of **P-0-4010, Load inertia** (reduced to motor shaft)
  The load inertia determined during automatic control loop settings is stored in parameter P-0-4010.
- Determination of **P-0-0168, Maximum acceleration**
  The maximum drive acceleration determined during automatic control loop settings is stored in parameter P-0-0168.
- **S-0-0348, Acceleration feed forward gain**
  As the result of the automatic control loop settings, the value for acceleration feed forward is calculated in accordance with the following formula:

$$S-0-0348=\frac{P-0-4010+P-0-0051}{S-0-0051}$$

Fig. 9-79: Calculating the acceleration feed forward

9.9 Drive halt

The "drive halt" function is used to bring an axis to a standstill with a defined acceleration and defined jerk.

The function is activated:

- by setting the drive halt bit to zero in the field bus control word. The structure of the field bus control word depends on the set profile type. For profile types I/O mode (profile type = FF80, FF81 or FF82) in bit 1, for Rexroth Indramat profile types in bit 13 of field bus control word.
- by interrupting a drive control command (e.g. "Drive-controlled homing").

Pertinent parameters

Which parameters are active depends upon which operating mode was interrupted by the "drive halt" command.

Standstill for operating mode "Drive internal interpolation":

- **S-0-0359, Positioning Deceleration** (or **S-0-0260, Positioning Acceleration**, if S-0-0359 = "0")
- **S-0-0193, Positioning Jerk**

Standstill for operating mode "Positioning block mode":

- **P-0-4063, Process block deceleration** (or **P-0-4008, Process block acceleration**, if P-0-4063 = "0")
- **P-0-4009, Process block jerk**

Standstill for operating mode "Jogging":

- **S-0-0260, Positioning Acceleration**
- **S-0-0193, Positioning Jerk**

Standstill for operating modes without drive-internal position command value generation:

- **S-0-0138, Bipolar acceleration limit value**
- **S-0-0349, Jerk limit bipolar**

Standstill for operating modes "Velocity control" or "Torque control":

- **P-0-1211, Deceleration ramp 1** (or **P-0-1201, Ramp 1 pitch**, if P-0-1211 = "0")
- **P-0-1202, Final speed of ramp 1**
- **P-0-1213, Deceleration ramp 2** (or **P-0-1203, Ramp 2 pitch**, if P-0-1213 = "0")

The following parameters are used for diagnostic purposes:

- **S-0-0124, Standstill window**
- **S-0-0182, Manufacturer class 3 diagnostics**

Functional principle of drive halt

If the "drive halt" function is activated, then the drive does not follow the command values of the active operating mode but brings the drive to a halt automatically while maintaining the parameterized acceleration.

The manner in which the standstill takes place depends on the previously activated operating mode.

Standstill in position control with previously active deceleration and jerk limits values

Standstill takes place in position control with the use of previously active deceleration and jerk limit values, if an operating mode with drive-internal position command value generation was previously active.

Operating modes with drive-internal position command value generation are:

- drive-internal interpolation
- positioning block mode
- jog mode

Note: If the deceleration parameter of the operating mode is zero, then the relevant acceleration parameter of the operating mode is used.

Standstill in position control with S-0-0138 and S-0-0349

If previously a position control mode without drive-internal position command value generation was active, then standstill in position control takes place with the use of the acceleration in **S-0-0138, Bipolar acceleration limit value** and the jerk in **S-0-0349, Jerk limit bipolar**.

Operating modes without drive-internal position command value generation are:

- position control
- phase synchronization
- electronic cam shaft

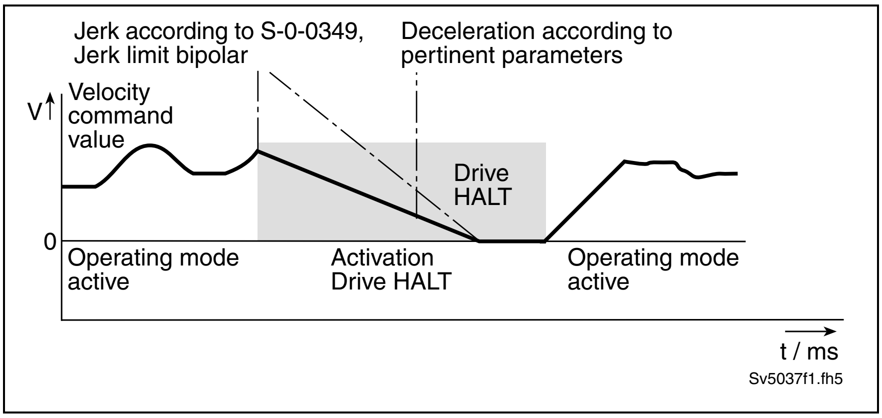


Fig. 9-80: Principle of "drive halt" with previously active position control without drive-internal position command value generation

Note: If an operating mode with position control with lag distance was previously activated, then the position-controlled standstill is conducted with position control with lag distance. Otherwise, the function is conducted with lagless position control.

Standstill in velocity control

If either the "Velocity control" or "Torque/force control" or "Velocity synchronization" operating mode was previously active, then standstill in velocity control uses parameters

- **P-0-1211, Deceleration ramp 1**
- **P-0-1202, Final speed of ramp 1**
- **P-0-1213, Deceleration ramp 2**

If the value of parameter **P-0-1211, Deceleration ramp 1** is zero, then parameter **P-0-1201, Ramp 1 pitch** is used.

If the value of parameter **P-0-1213, Deceleration ramp 2** is zero, then parameter **P-0-1203, Ramp 2 pitch** is used.

If parameters **P-0-1201, Ramp 1 pitch** or **P-0-1203, Ramp 2 pitch** are also equal to zero, then standstill takes place without ramp and at full torque.

Note: In all cases, the 7-segment display reads **AH** and the diagnosis in S-0-0095 reads **A010 Drive HALT**!

Drive halt acknowledgment

If the feedback velocity falls below the value of parameter **S-0-0124, Standstill window**, the bit 11 "Drive halt acknowledgment (AHQ)" will be set in **S-0-0182, Manufacturer class 3 diagnostics**.

Activating the operating mode

The selected operating mode becomes active again if the drive halt bit is set in the field bus control word (the structure of the field bus control word depends on the set profile type. For profile types I/O mode (profile type = FF80, FF81 or FF82) in bit 1, for Rexroth Indramat profile types in bit 13 of the field bus control word).

Connecting the drive halt input

If command communication does not use a field bus, e.g. SERCOS interface or Profibus, then the hardware controls the "drive halt" function.

For more information on this see the Project Planning Manuals:

ECODRIVE03 respectively DURADRIVE in chapter: "Drive halt (AH) and Drive enable (RF)".

9.10 Drive-controlled homing

The position feedback value of the measuring system to be homed forms a coordinate system referring to the machine axis. If absolute encoders are not used, the system does not correspond to the machine coordinate system after the drive has been initialized.

The command **S-0-0148, C600 Drive controlled homing procedure command** thus supports

- establishing the correspondence between the measuring system of the drive and the machine coordinate system in non-absolute measuring systems,
- drive-controlled running to the reference point in absolute measuring systems.

Drive-controlled homing means that the drive, in compliance with the parameterized homing velocity and homing acceleration, independently generates position command values, in order to carry out the drive motions necessary for the homing procedure.

Note: It is possible to perform this feature for either the motor encoder or the optional encoder.

Pertinent parameters

To run this feature, use the following parameters:

- **S-0-0041, Homing velocity**
- **S-0-0042, Homing acceleration**
- **S-0-0052, Reference distance 1**
- **S-0-0054, Reference distance 2**
- **S-0-0147, Homing parameter**
- **S-0-0148, C600 Drive controlled homing procedure command**
- **S-0-0150, Reference offset 1**
- **S-0-0151, Reference offset 2**
- **P-0-0153, Optimal distance home switch - reference mark**
- **S-0-0165, Distance coded reference offset 1**
- **S-0-0166, Distance coded reference offset 2**
- **S-0-0177, Absolute distance 1**
- **S-0-0178, Absolute distance 2**
- **S-0-0298, Reference cam shift**
- **S-0-0299, Home switch offset**

In addition, the following parameters

- **S-0-0108, Feedrate override**
- **S-0-0057, Position window**
- **S-0-0349, Jerk limit bipolar**
- **S-0-0403, Position feedback value status**

are used.

Setting the homing parameter

The basic sequence is dependent, among other things, on how parameter **S-0-0147, Homing parameter** has been parameterized.

The following settings must be performed in S-0-0147:

- homing direction positive / negative
- homing with motor encoder / optional encoder
- evaluation of the home switch yes / no
- evaluation of the reference mark yes / no
- go to reference point yes / no

The parameter is structured as follows:

S-0-0147, Homing parameter

Bit 0: Start direction
0: positive = clockwise with view towards motor shaft
1: negative = counter-clockwise with view towards motor shaft

Bit 3: Feedback selection
0: with motor feedback (feedback 1)
1: with external feedback (feedback 2)

Bit 5: Home switch evaluation
0: home switch is detected
1: home switch is not detected

Bit 6: Reference mark evaluation
0: reference mark is detected
1: reference mark is not detected

Bit 8, 7: Stop/positioning/run path
0 0: once the home switch or reference mark have been overrun, the drive stops and switches over the coordinate system
0 1: once the home switch or reference mark have been overrun, the drive positions at the reference point and switches over the coordinate system
1 0: drive always runs path that is needed to overrun two sequential reference marks and then switches over the coordinate system **(only with distance-coded reference marks!)**
1 1: Not allowed!

Fig. 9-81: Structure of parameter S-0-0147, Homing parameter

Note: Apart from the parameterization of parameter S-0-0147, the sequence of the drive-controlled homing procedure also depends on the type and allocation of the reference marks of the encoder to be homed.
(see "Overview of the type and allocation of reference marks of non-absolute measuring systems")

Overview of the type and allocation of reference marks of non-absolute measuring systems

For better understanding, you can divide the measuring systems into 4 groups according to the type and allocation of their reference marks:

- **Type 1**: Measuring systems with absolute single-turn range, such as the Single-turn DSF or resolver. These measuring systems have an absolute range of 1 encoder revolution or fractions of an encoder revolution (resolver).
  Typical applications are
  - the encoders for the MHD, MKD and MKE motors,
  - the GDS measuring system.
  - single-turn encoder with EnDat interface from Heidenhain
- **Type 2**: Incremental rotary measuring systems with a reference mark for each encoder revolution, such as the ROD or RON types from Heidenhain.
- **Type 3**: Incremental linear measuring systems with one or several reference marks, such as the LS linear scales from Heidenhain.
- **Type 4**: Incremental measuring systems with distance-coded reference marks, e. g. the LSxxxC linear scales from Heidenhain.

The drive-internal detection of the allocation of the reference marks is done with the settings of the corresponding position encoder type parameter **S-0-0277, Position feedback 1 type** (for motor encoder) or **S-0-0115, Position feedback 2 type** (for optional encoder).

In these parameters, you set with bit 0 whether it is a rotary or a linear measuring system, and bit 1 decides whether the measuring system has distance-coded reference marks.

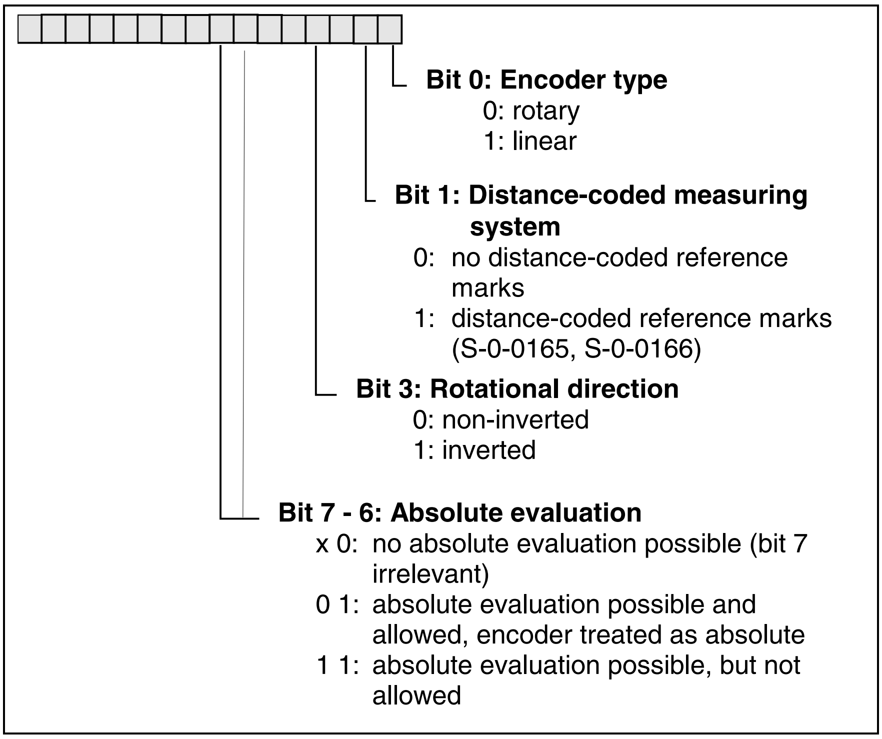


Fig. 9-82: Structure of the position feedback type parameters S-0-0115 / S-0-0277

Note: For measuring systems with their own data memory (type 1), this setting is done automatically.

See also chapter: "Setting the measurement system".

Functional principle of drive-controlled referencing in non-absolute measuring systems

To establish congruency between drive (measuring system) and machine coordinate system it is necessary that the drive has precise information about its relative position within the machine coordinate system. The drive receives this information by detecting the home switch edge and/or the reference mark.

Note: To evaluate only the home switch is not recommended as the detection position of the home switch edge is less precise compared to the detection of the reference mark!

Coordinate system alignment is achieved by comparing the desired feedback position at a specific point within the machine coordinate system with the actual feedback position ("old" drive coordinate system). A differentiation is made between the following cases:

- "Evaluation of a reference mark/home switch edge" (type 1..3) and
- "Evaluation of distance-coded reference marks"

Definition of the reference point

- With "Evaluation of a reference mark/home switch edge" the "specific" point within the coordinate system is the so-called reference point. The desired feedback position is set at this point via parameter **S-0-0052, Reference distance 1** (for motor encoders) or **S-0-0054, Reference distance 2** (for optional encoders). The physical position of the reference point derives from the position of the reference mark plus the value in **S-0-0150, Reference offset 1** or **S-0-0151, Reference offset 2**. Once the reference mark is detected, the drive knows the position of this mark and therefore also that of the reference point in the "old" drive coordinate system. The desired position in the new coordinate system referring to the machine’s zero point is in parameter **S-0-0052, Reference distance 1** and **S-0-0054, Reference distance 2** (machine coordinate system).
- With "Evaluation of distance-coded reference marks" the "specific" point is the zero point (position of the first reference mark) of the distance-coded measuring system. By detecting the position difference between two adjacent reference marks the position of the first reference mark in the "old" drive coordinate system can be determined. The desired feedback position at this point is defined by the position of the first reference mark in the machine coordinate system at this point plus the value in **S-0-0177, Absolute distance 1** (for motor encoders) or **S-0-0178, Absolute distance 2** (for optional encoders).

In both cases, the difference between both coordinate systems is added to the "old" drive coordinate system. The coordinate systems will then correspond to one another.

By switching the position command and feedback value, **S-0-0403, Position feedback value status** is set to 1. This means that the feedback position value now refers to the machine zero point.

Note: If the drive, once the "homing" command has been conducted, is in parameter mode again, then parameter **S-0-0403, Position feedback value status** is set to 0, because the feedback values in command **S-0-0128, C200 Communication phase 4 transition check** are re-initialized.

See also: "Commissioning with evaluation of reference mark/home switch edge"

See also: "Commissioning with evaluation of distance-coded reference mark"

Functional principle of drive-guided referencing with absolute measuring systems

If the measuring system to be homed (as per bit 3 of S-0-0147) is evaluated as an absolute measuring system, then command **S-0-0148, C600 Drive controlled homing procedure command** supports two different purposes:

- drive-controlled travelling to the reference point and
- triggering the switch of the position feedback value, if setting the absolute measurement is conducted with drive enable applied.

Drive-controlled travelling to reference point

If the absolute encoder is homed, i.e. parameter **S-0-0403, Position feedback value status** is set to "1", then the drive, after the start of command **S-0-0148, C600 Drive controlled homing procedure command**, automatically runs to the reference point, if "1" is set in bit 7 of parameter **S-0-0147, Homing parameter** for "Drive on reference point after drive-controlled homing". The reference point is defined in parameters **S-0-0052, Reference distance 1** or **S-0-0054, Reference distance 2**.

Triggering position feedback value switch with setting absolute dimension

If command **P-0-0012, C300 Command Set absolute measurement** is conducted with drive enable applied, then the switching of the position feedback value register **S-0-0051, Position feedback 1 value** or **S-0-0053, Position feedback 2 value** is not conducted until:

- command **S-0-0148, C600 Drive controlled homing procedure command** is also conducted after the start of P-0-0012

- or -

- drive enable is switched off.

(See chapter: "Set absolute measuring")

Functional sequence "drive-controlled homing"

The command value profile depends on the parameters:

- **S-0-0041, Homing velocity**
- **S-0-0108, Feedrate override**
- **S-0-0042, Homing acceleration**

To limit the acceleration changes, you can additionally activate a jerk limit. You can do this by entering the parameter **S-0-0349, Jerk limit bipolar**.

The following diagram explains this:

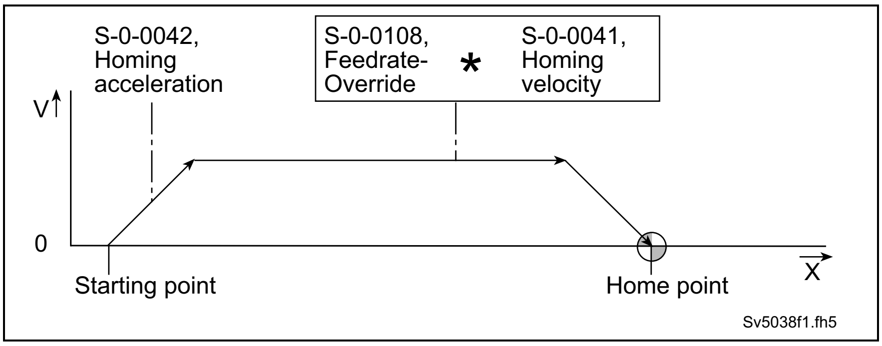


Fig. 9-83: Position command profile with homing velocity and homing acceleration

Maximum velocity

The maximum velocity is influenced, as with all drive-controlled functions, by the feedrate. The effective maximum velocity is the result of the product of **S-0-0041, Homing velocity** and **S-0-0108, Feedrate override**.

Note: If the parameter **S-0-0108, Feedrate override** starts with zero, then warning **E255 Feedrate override S-0-0108 = 0** will be generated.

Motional process

The motional process during drive-controlled homing of non-absolute encoders can be made up of up to 3 processes:

- If the home switch evaluation process has been activated and there are no distance-coded reference marks, then the drive accelerates to the homing velocity and continues with this velocity in the selected homing direction until the positive home switch edge is detected. If the drive is already on the home switch at the start of drive-controlled homing (**S-0-0400, Home switch** = "1"), the drive at first accelerates in the opposite homing direction until the negative home switch edge is detected, and then reverses the direction. If a distance-coded measuring system is homed, the drive, with the home switch not being actuated, runs in the selected homing direction. If the home switch is actuated at the start of the command, the drive runs in the opposite direction.

WARNING

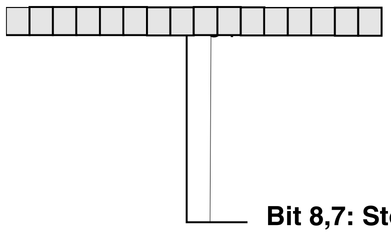
Property damage caused by incorrectly parameterized home switch edge!

⇒ Make sure that the home switch edge lies within the reachable travel range.

- If reference marks are available (type 2...4), and if the reference mark evaluation is activated, then the drive runs in homing direction until it detects a reference mark. In distance-coded measuring systems (type 4), two adjacent reference marks must be passed. The reference marks are always evaluated (independent of bit 6 in S-0-0147).

Motion profile prior to coordinate system switching

The motion profile prior to coordinate system switching depends on bits 7 and 8 in **S-0-0147, Homing Parameter**. There are three options:



Bit 8,7: Stop/positioning/run path
0 0: once the reference switch or reference mark have been overrun, the drive stops and switches over the coordinate system
0 1: once the reference switch or reference mark have been overrun, the drive positions at the reference point and switches over the coordinate system
1 0: drive always runs path that is needed to overrun two sequential reference marks and then switches over the coordinate system **(only with distance-coded reference marks!)**
1 1: Not allowed!

Fig. 9-84: Bit 7 and 8 of **S-0-0147, Homing parameter**

Explanation of the 3 different possibilities of setting the motion profile prior to coordinate system switching:

- Stopping: After the necessary motions to detect the reference switch or mark have been executed, the drive stops with the programmed homing acceleration. Once a velocity is reached that is less than the value set in **S-0-0124, Standstill window**, the switch to the coordinate system (position feedback value switching) is performed and the successful completion of the command is signaled.
- Positioning: After the necessary movements to detect the reference switch or mark have been executed, the drive positions at the reference point.
  This reference point for non-distance-coded measuring systems is the sum of the position of the relevant reference mark/reference switch edge plus the reference dimension offset. The reference point for distance-coded encoders is the position of the 2nd over-traveled reference mark.
- Running path: This mode is only possible with distance-coded measuring systems! During the homing procedure, the drive runs a specific path. The path is fixed by what has been set in parameter **S-0-0165, Distance-coded reference 1**. By running the path that has been programmed here, it is assured that the drive will always overrun two adjacent marks. This function makes sense, for example, in Gantry axes (parallel, mechanically coupled axes) equipped with distance-coded measuring systems. By activating this mode in all of the coupled axes it is ensured that at the simultaneous start of command **S-0-0148, C600 Drive controlled homing procedure command** every drive will run the same profile.

Note: If the "Run path" mode is used with Gantry axes, then the Gantry axes are not automatically run in parallel by the homing procedure. The mechanically coupled axes only run a relative path. Their mutual position reference does not change. (In contrast to the "Positioning" mode that is only possible with non-distance-coded encoders. In this case the axes are automatically run in parallel by the drive-side homing procedure.)

Position feedback values after the "Drive-controlled homing" command

The position feedback values from the motor and optional encoders, after the command **S-0-0148, C600 Drive controlled homing procedure command** is executed, depend on bit 3 in **S-0-0147, Homing parameter** and on **S-0-0403, Position feedback value status**.

Motor encoder	Opt. encoder	S-0-0147, bit 3	Position feedback value 1	Position feedback value 2
as desired	reference	0	reference distance 1	unchanged
as desired	no reference	0	reference distance 1	reference distance 1
no reference	as desired	1	reference distance 2	reference distance 2
reference	as desired	1	unchanged	reference distance 2

Fig. 9-85: Position feedback values after command **S-0-0148, C600 Drive controlled homing procedure command**

Commissioning with "Evaluation of reference mark/home switch edge"

If the encoder does not have distance-coded reference marks (type 1..3), then select in **S-0-0147, Homing parameter** whether

- home switch evaluation is desired or not and/or
- reference mark evaluation is desired.

Additionally it must be defined

- in which direction the drive should move with the start of the command **S-0-0148, C600 Drive controlled homing procedure command** as well as whether
- the drive should go to the reference point or not.

If a home switch evaluation becomes necessary, then the necessary settings must first be made. (see chapter "Evaluation of the home switch"). All additional steps can then be conducted as follows:

1. Check the relevant position encoder type parameter (S-0-0277/S-0-0115) to make sure it has been correctly set.
2. parameterize the following parameters with "0"

- **S-0-0052, Reference distance 1** or
- **S-0-0054, Reference distance 2**
- **S-0-0150, Reference offset 1** or
- **S-0-0151, Reference offset 2**

3. Set parameters **S-0-0041, Homing velocity** and **S-0-0042, Homing acceleration** to small values (e.g. S-0-0041 = 10 Rpm, S-0-0042 = 10 rad/s²).
4. Conduct the command **S-0-0148, C600 Drive controlled homing procedure command**.

Note: If the command is cleared, then the original operating mode becomes active again. If drive-internal interpolation is set, then the drive immediately runs to the value set in **S-0-0258, Target position**. This value now relates to the new (machine zero point-related) coordinate system!

Result of the drive-controlled homing command

The command should be completed without error. The machine zero point is at the position of the home switch or the reference point, as the reference distance (S-0-0052/54) has been parameterized with "0". The position feedback value in **S-0-0051, Position feedback 1 value** or **S-0-0053, Position feedback 2 value** should now have absolute reference to this preliminary machine zero point. To set the correct machine zero point, you can now conduct the following steps:

- Run the axis to the desired machine zero point and enter the position feedback value displayed there with opposite sign in **S-0-0052, Reference distance 1** or **S-0-0054, Reference distance 2**.

- or -

- Run the axis to position feedback value = 0 and measure the distance between the current position and the desired machine zero point. Enter the distance in **S-0-0052, Reference distance 1** or **S-0-0054, Reference distance 2**.

Once the command **S-0-0148, C600 Drive controlled homing procedure command** is again completed, the position feedback value should refer to the desired machine zero point.

The reference point can be shifted relatively to the reference mark (see "Consideration of the reference offset").

Parameter **S-0-0041, Homing velocity** and **S-0-0042, Homing acceleration** can now be set to their final values.

Consideration of the reference offset

If the evaluation of the reference mark is activated in **S-0-0147, Homing parameter**, then the reference point is always set on the position of the selected reference mark. If a measuring system of type 1..3 is present (not distance-coded), you can shift the position of the reference point relatively to the position of the reference mark. Doing so, you can select any position after homing.

The offset is set with the parameters

- **S-0-0150, Reference Offset 1** (for motor encoder)
- **S-0-0151, Reference Offset 2** (for optional encoder)

Positive reference offset

If the reference offset is positive, then its drive-internal direction is positive (see "Command polarities and actual value polarities"); in other words, the reference point is shifted, in terms of the reference mark, in a clockwise direction when looking towards the motor shaft.

If the homing direction is also positive, then the drive does not reverse the direction after passing the reference mark.

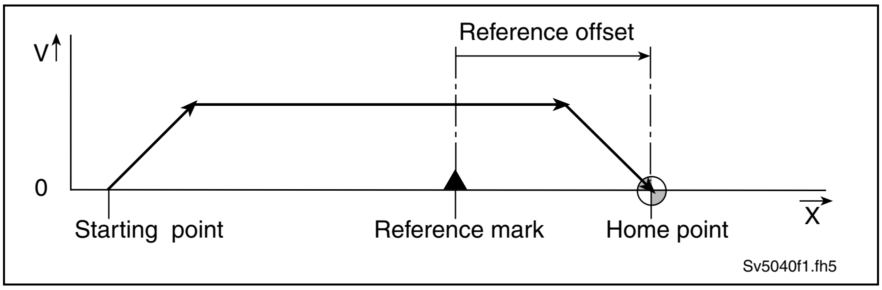


Fig. 9-86: Command value profile for **positive** reference offset and **positive** homing direction

If the homing direction is negative, then the drive must reverse the travel direction (with types 2 and 3) after passing the reference mark.

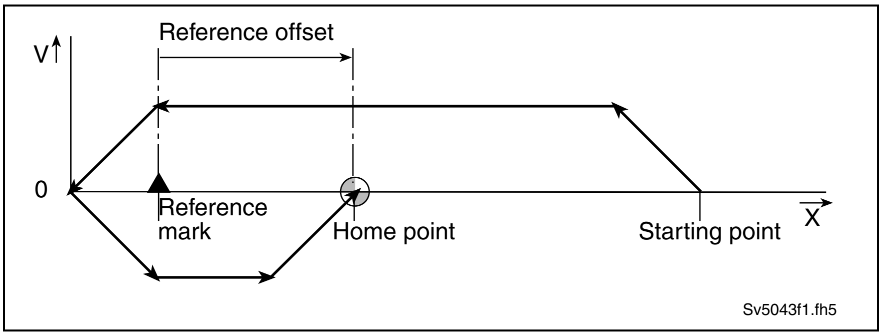


Fig. 9-87: Command value profile for **positive** reference offset and **negative** homing direction

Negative reference offset

If the **reference offset is negative**, then its drive-internal direction is negative (see chapter: "Command polarities and actual value polarities"); in other words, the reference point is shifted, in terms of the reference mark, counterclockwise looking towards the motor shaft.

If the homing direction is negative, then the drive does not reverse the travel direction after passing the reference mark.

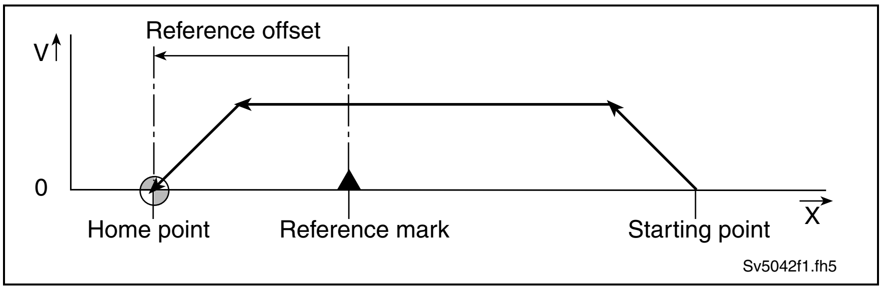


Fig. 9-88: Command profile with negative reference offset and negative homing direction

If the homing direction is positive, then the drive must reverse the travel direction (with types 2 and 3) after passing the reference mark.

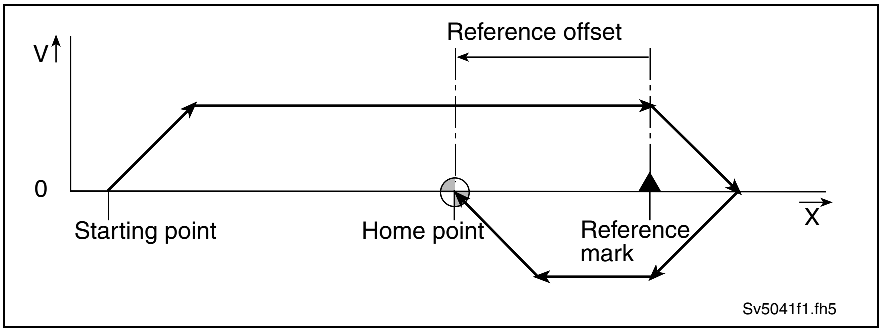


Fig. 9-89: Command value profile with negative reference offset and positive homing direction

Evaluation of the home switch

With the help of a home switch it is possible to identify a certain reference mark in the case where an unspecific arrangement of reference marks of the measuring system to be homed is used.

Home switch evaluation

If bit 5 in S-0-0147 = 0, then the reference mark, that follows the positive edge of the home switch in homing direction, will be evaluated.

Note: The home switch input is mapped to parameter **S-0-0400, Home switch**.

Example

Homing of a motor encoder with one reference mark per revolution.

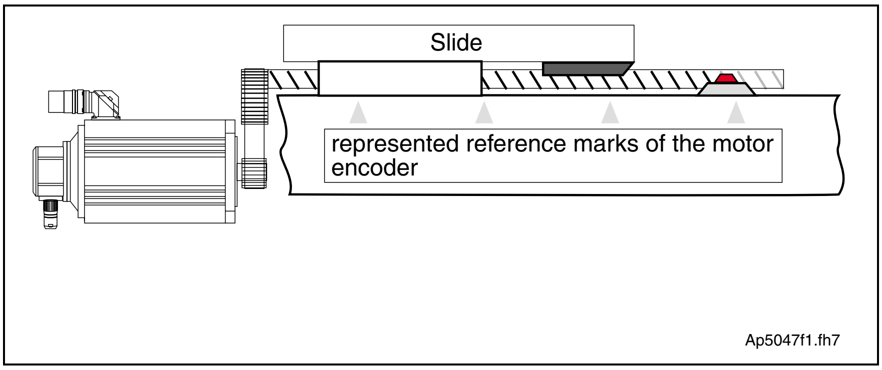


Fig. 9-90: Selection of a reference mark depending on the homing direction

If home switch evaluation is activated, the drive searches at first for the positive edge of the home switch. If the home switch is not actuated at the beginning of the command, the drive moves in the preset homing direction.

WARNING

Damage to the installation caused by the drive reaching the travel range limits!

⇒ The homing direction must be set in such a way that the positive edge can be found.

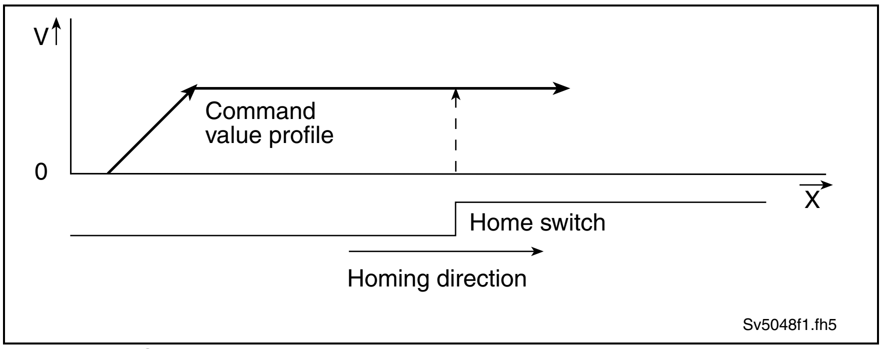


Fig. 9-91: Correct setting of homing direction

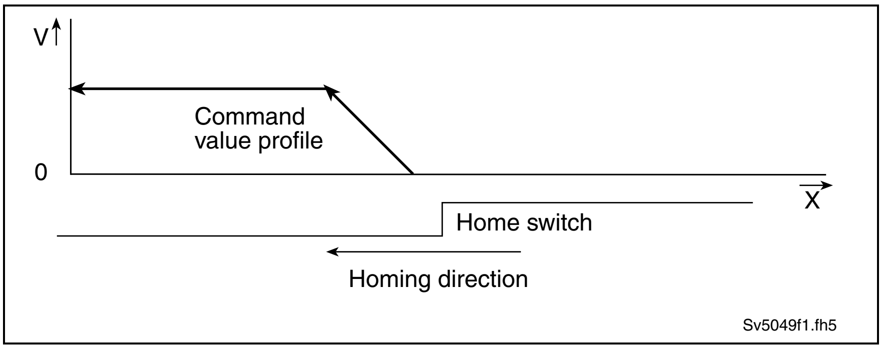


Fig. 9-92: Incorrectly set homing direction

Command value profile with actuated home switch at the start of the command

If the home switch is actuated when the command is started, the drive generates command values in the opposite direction to move away from the home switch. As soon as a 1-0 edge of the home switch signal is detected, the drive reverses its direction and continues as if started outside the home switch range.

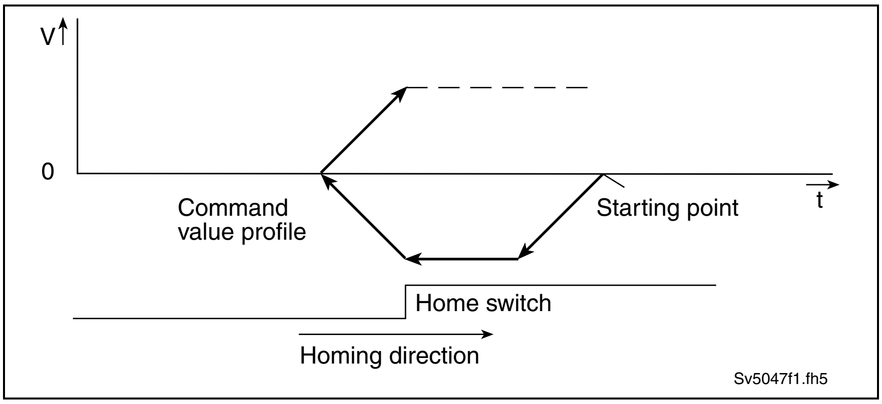


Fig. 9-93: Command profile with start position on the home switch

Monitoring the distance between home switch and reference mark

If the distance becomes too small between the home switch edge and the reference mark to be evaluated, then it is possible that the home switch edge will only be detected after the reference mark has already passed. The result is that only the following reference mark is evaluated. The reference mark detection becomes ambiguous.

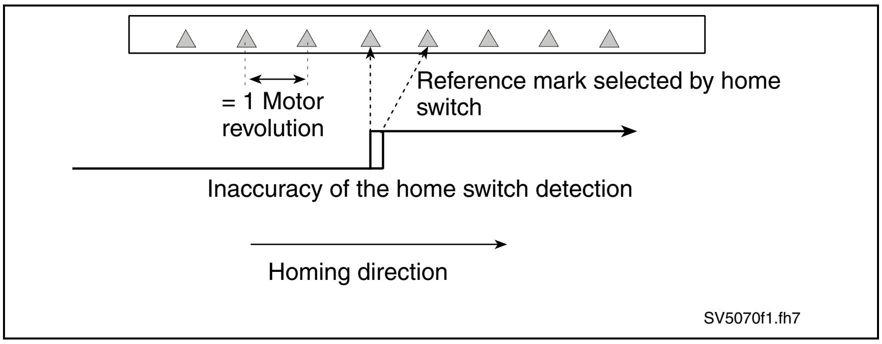


Fig. 9-94: Ambiguous detection of reference marks at too small distance between home switch edge and reference mark

The distance between the home switch edge and the reference mark is monitored for this reason.

If the distance between the home switch edge and the reference mark becomes smaller than a certain value, the command error **C602 Distance home switch - reference mark erroneous** will be generated.

The **critical range** for the distance between home switch edge and reference mark is:

0.25 * Distance between reference marks

The **optimal distance** between home switch edge and reference mark is:

0.5 * Distance between reference marks

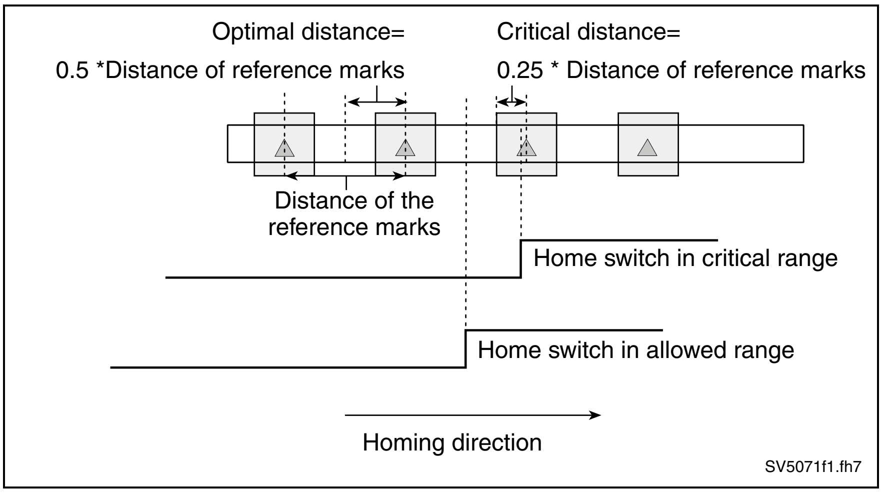


Fig. 9-95: Critical and optimal distance between home switch and reference mark

To monitor the distance between the home switch and the reference mark, the optimal distance is entered in **P-0-0153, Optimal distance home switch - reference mark**.

The following requirements apply:

Encoder type	P-0-0153	Function
Rotary	0	The distance between the home switch and the reference mark will be monitored. The optimal distance will be calculated internally and amounts to a 1/2 encoder revolution for DSF or incr. rotary encoders, or 1/2 encoder revolution / **S-0-0116, Feedback 1 Resolution** for resolvers.
Rotary	x	The distance between the home switch and the reference mark will be monitored. Half the reference mark distance must be entered in **P-0-0153, Optimal distance home switch - reference mark**.
Linear	0	The distance between the home switch and the reference mark will not be monitored. The linear encoder does not have reference marks with constant distances. The real distance between the home switch and the reference mark must be big enough to achieve detection of the home switch edge when considering the maximum homing velocity and the cycle time for the home switch input polling.
Linear	x	The distance between the home switch and the reference mark will be monitored. Half the reference mark distance must be entered in **P-0-0153, Optimal distance home switch - reference mark**.

Fig. 9-96: Monitoring the distance home switch-reference mark

For every homing with home switch evaluation, the difference between actual distance and optimal distance is monitored. The difference is saved in parameter **S-0-0298, Reference cam shift**. The home switch edge can then be shifted mechanically by this value.

To avoid a mechanical shifting of the home switch edge, this can be done by the software in parameter **S-0-0299, Home switch offset**. The value in parameter **S-0-0298, Reference cam shift** is to be transferred to parameter **S-0-0299, Home switch offset**.

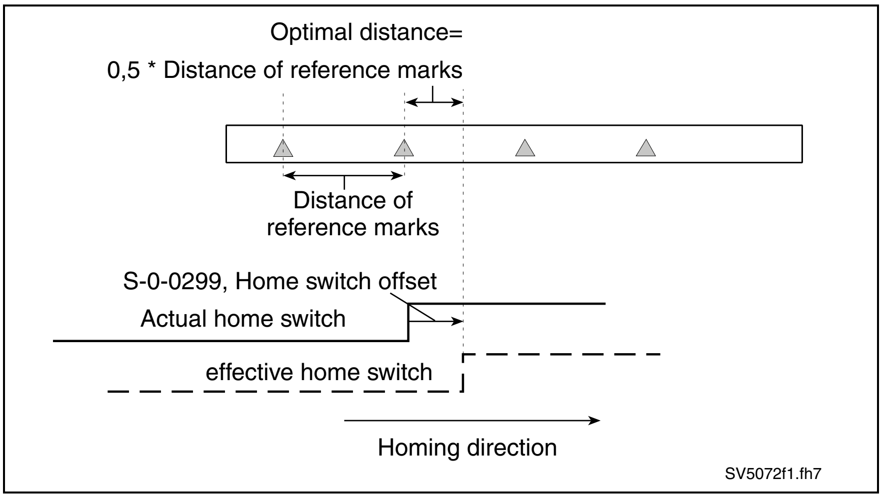


Fig. 9-97: Function of parameter S-0-0299, Home Switch Offset

The parameter **S-0-0299, Home switch offset** can be set as follows:

- Running the homing command with **S-0-0299, Home switch offset** = 0.
- If the distance is not in the range between 0.5..1.5 * **P-0-0153, Optimal distance home switch - reference mark**, the error message **C602 Distance home switch - reference mark erroneous** will be generated.
  In this case, you have to enter the value from **S-0-0298, Reference cam shift** in **S-0-0299, Home switch offset**.
- Check: You should see a 0 displayed in **S-0-0298, Reference cam shift** when homing is restarted.

Commissioning with "Evaluation of distance-coded reference mark"

If the encoder has distance-coded reference marks (type 4), then it must be set in **S-0-0147, Homing parameter**

- whether the home switch should be evaluated and/or
- in which direction the drive should move at the start of the command "Drive-controlled homing", and
- whether the drive should position at the position of the 2nd overrun reference mark, whether it should stop after the 2nd reference mark is overrun, or whether a specific path is to be run (especially in the case of Gantry axes).

Determining the travel path in "Run path" mode

If in bits 7 and 8 of **S-0-0147, Homing parameter** the "Run path" mode has been programmed (see function sequence of "Drive-controlled homing"), then the drive always runs a path defined by parameter **S-0-0165, Distance coded reference offset 1**.

Homing of a translatory motor encoder

For the homing of a translatory motor encoder (encoder 1) the following applies:

$$S_{Refen} = S\text{-}0\text{-}0165 * S\text{-}0\text{-}0116$$

S-0-0165: Value in parameter S-0-0165, Distance coded reference offset 1
S-0-0116: Value in parameter S-0-0116, Feedback 1 Resolution
S_{Refen}: Travel path

Fig. 9-98: Travel path when homing with distance-coded reference marks and in "Run path" mode for translatory measuring systems (linear scales)

Homing of a translatory optional encoder

For the homing of a translatory optional encoder (encoder 2) the following applies:

$$S_{Refen} = S\text{-}0\text{-}0165 * S\text{-}0\text{-}0117$$

S-0-0165: Value in parameter S-0-0165, Distance coded reference offset 1
S-0-0117: Value in parameter S-0-0117, Feedback 2 Resolution
S_{Refen}: Travel path

Fig. 9-99: Travel path when homing with distance-coded reference marks and in "Run path" mode for translatory measuring systems (linear scales)

Homing of a rotary motor encoder

For the homing of a rotary motor encoder (encoder 1) the following applies:

$$S_{Refen} = \frac{360Degrees * S-0-0165}{S-0-0116}$$

S-0-0165: Value in parameter S-0-0165, Distance coded reference offset 1
S-0-0116: Value in parameter S-0-0116, Feedback 1 Resolution
S_{Refen} Travel path

Fig. 9-100: Travel path when homing with distance-coded reference marks and in "Run path" mode for rotary measuring systems

Homing of a rotary optional encoder

For the homing of a rotary optional encoder (encoder 2) the following applies:

$$S_{Refen} = \frac{360Degrees * S-0-0165}{S-0-0117}$$

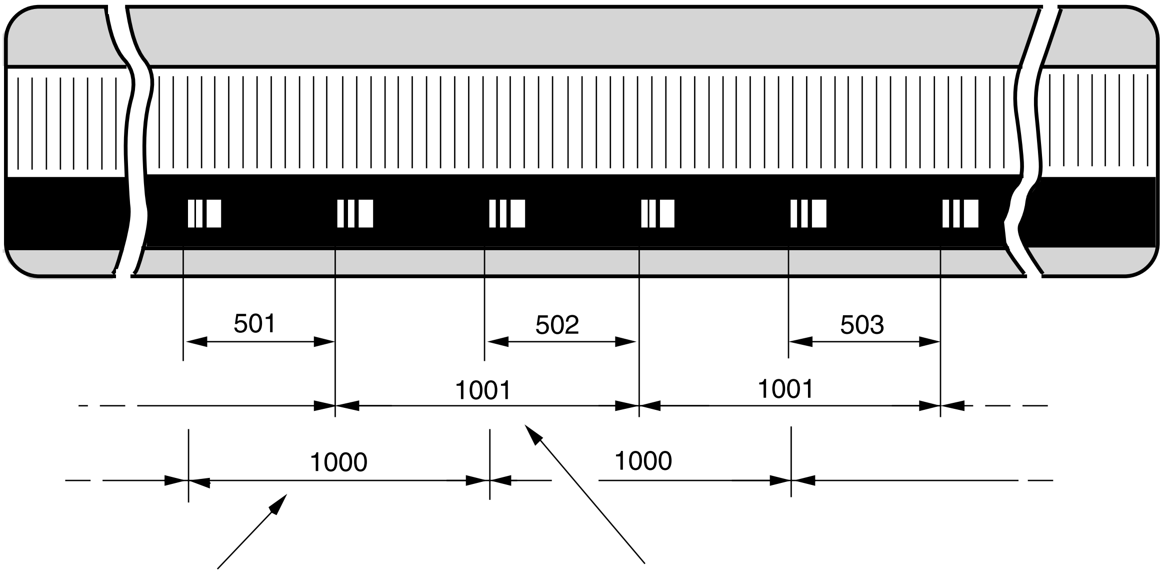
S-0-0165: Value in parameter S-0-0165, Distance coded reference offset 1
S-0-0117: Value in parameter S-0-0117, Feedback 2 Resolution
S_{Refen} Travel path

Fig. 9-101: Travel path when homing with distance-coded reference marks and in "Run path" mode for rotary measuring systems

In parameters

- **S-0-0165, Distance coded reference offset 1** and
- **S-0-0166, Distance coded reference offset 2**

the greater and smaller distance of the reference mark must be entered. These values can be retrieved from the encoder specification.



„Distance-coded reference dimension 2“
(smaller value) SERCOS-ID No.:S-0-0166;
Input unit: pitch

The manufacturer of the length measuring system indicates:
distance travelled up to the absolute position value: 20 mm
pitch unit: 20 µm (0-02 mm)

20 mm: 0.02 mm = 1000 pitch units

This value (1000 pitch units) is to be entered in parameter ID No. S-0-0166.

„Distance-coded reference dimension 1“
(greater value) SERCOS ID No. S-0-0165.
Input unit: pitch unit

For Heidenhain length measuring system the greater value is the product of:
(distance travelled + pitch unit):
pitch unit, therefore:
20.02 mm: 0.02 mm = 1001 pitch units

This value (1001 pitch units) is to be entered in parameter ID No. S-0-0165.

Setting up of distance-coded Heidenhain length measuring systems (taken from: Catalog for NC length measuring systems, September 1993):				
Length measuring system Type	Distance travelled: in mm	Pitch unit: in µm	Input in: ID No.: S-0-0166	Input in: ID No.: S-0-0165
LS 403C LS 406C LS 323C LS 623C LS 106C ULS 300C	20	20	1000	1001
LS 103C LS 405C ULS 300C	10	10	1000	1001
LID 311C LID351C	20	10	2000	2001

Pi5005f1.fh7

Fig. 9-102: Distance-coded measuring systems specified with greater and smaller distance

The greater distance is entered in **S-0-0165, Distance coded reference offset 1**, in **S-0-0166, Distance coded reference offset 2** the smaller distance. The unit of these two parameters is division periods. Typical values for a linear scale with distance-coded reference marks are 20.02 mm for the greater distance and 20.00 mm for the smaller distance with a resolution of 0.02 mm. In parameter S-0-0165/166 enter the values 1001 or 1000.

The further steps are outlined below.

5. Check the relevant position encoder type parameter (S-0-0277/S-0-0115) for the correct setting.
6. The parameters **S-0-0177, Absolute distance 1** or **S-0-0178, Absolute distance 2** must be parameterized with 0.
7. The parameters **S-0-0041, Homing velocity** and **S-0-0042, Homing acceleration** must be set to small values (e.g. S-0-0041 = 10 rpm, S-0-0042 = 10 rad/s²).
8. Execute command **S-0-0148, C600 Drive controlled homing procedure command**.

WARNING

If the command is cleared, then the original operating mode becomes active again. If drive-internal interpolation is set, then the drive immediately goes to the value set in **S-0-0258, Target position**. This value now relates to the new (machine zero point related) coordinate system!

Result of the homing command

The command should be completed without error. The machine zero point is at the position of the first reference mark of the distance-coded measuring system, as the absolute offset (S-0-0177/0178) was parameterized with 0. The relevant position feedback value in **S-0-0051, Position feedback 1 value** or **S-0-0053, Position feedback 2 value** should now have the absolute reference to this preliminary machine zero point. To set the correct machine zero point, the following steps can be conducted:

- Run the axis to the desired machine zero point and enter the position feedback value displayed there with the opposite sign in **S-0-0177, Absolute distance 1** or **S-0-0178, Absolute distance 2**.

- or -

- Run the axis to position feedback value = 0 and measure the distance between the current position and the desired machine zero point. Enter the distance in **S-0-0177, Absolute distance 1** or **S-0-0178, Absolute distance 2**.

Once the command **S-0-0148, C600 Drive controlled homing procedure command** is again executed, the position feedback value should refer to the desired machine zero point.

Parameters **S-0-0041, Homing velocity** and **S-0-0042, Homing acceleration** can now be set to their final values.

Home switch evaluation with distance-coded reference marks

To evaluate a home switch together with homing of a distance-coded measuring system serves only the purpose of staying within the allowed travel range.

Higher security with a home switch

If the home switch is not evaluated, the drive always covers the distance in the selected homing direction which is necessary to capture 2 adjacent reference marks.

This distance is

$$s_{Refmax} = (S\text{-}0\text{-}0165 * \text{Feedback Resolution}) + \frac{v^2}{2 * a}$$

S-0-0165:	value in parameter S-0-0165, Distance coded reference offset 1
v:	value in S-0-0041, Homing velocity
a:	value in S-0-0042, Homing acceleration
s_{Refmax} :	maximum travel distance for homing with distance-coded reference marks
S-0-0116:	Feedback 1 Resolution
S-0-0117:	Feedback 2 Resolution

Fig. 9-103: Travel distance for homing with distance-coded reference marks

ATTENTION

Damage to the machine caused by leaving the allowed travel range, because the drive is closer to the travel range limit in homing direction than the necessary travel distance S_{Refmax}!

⇒ Make sure that the distance of the axis to the travel range limit at start of the command **S-0-0148, C600 Drive controlled homing procedure command** is greater than the max. necessary travel distance S_{Refmax}

- or-

⇒ evaluate the home switch.

Home switch evaluation

When the home switch is evaluated, the drive automatically starts in the opposite homing direction, if at the command start the home switch is activated (**S-0-0400, Home switch** = 1).

Therefore, the home switch must be mounted in such a way that it covers at least the maximum necessary travel distance S_{Refmax} until reaching the travel range limit in the homing direction.

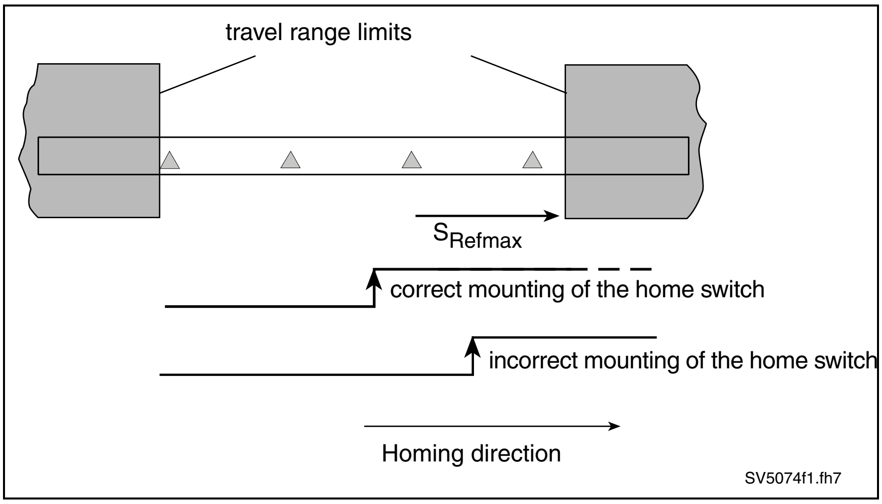


Fig. 9-104: Mounting the home switch with distance-coded reference marks

Functions of the control during "Drive-controlled homing"

During drive-controlled homing, the drive independently generates its position command values. Preset command values of the control will be ignored. If the command is confirmed by the drive as completed, the position command value, now related to the machine zero point, will be made available in parameter **S-0-0047, Position command value**. This value must be read by the control via the service channel before ending the command, and the control-side interpolator must be set to this value. If this command is completed by the control and if the command values of the control become active again in the drive, these values should be added to the value read out of the drive.

Starting, interrupting and completing the command "Drive-controlled homing"

This feature is implemented as a command.

To start the feature, you must set and release the command by writing data to the parameter **S-0-0148, C600 Drive controlled homing procedure command** (input = 3). The drive acknowledgement has to be retrieved from the data status out of the same parameter. The command is completed, when the command change bit in the drive status word is set and the acknowledgement changes from "in process" (7) to "command executed" (3) or to "command error" (0xF).

If the command is interrupted (input = 1) during processing (acknowledgment = 7), the drive reacts by activating the "drive halt" feature. The execution of the command continues, if the interruption is cancelled.

(See also chapter: "Drive Halt")

Possible error messages during "Drive-controlled homing"

During the execution of the command, the following command errors can occur:

- **C601 Homing only possible with drive enable**
  At start of the command the controller enable was not set
- **C602 Distance home switch - reference mark erroneous**
  The distance between home switch and reference mark is too small (see chapter: "Monitoring the distance between home switch and homing mark")
- **C604 Homing of absolute encoder not possible**
  The encoder to be homed is an absolute encoder. The command "Drive-controlled homing" was started without first starting the command "Set absolute measuring" (see also chapter "Set absolute measuring")
- **C606 Reference mark not detected**
  For incremental encoders, the detection of the reference mark captures the actual position. While searching the reference mark during the homing procedure, the traveled distance is monitored. If the traveled distance is greater than the calculated maximum distance necessary to detect a reference mark, the error message **C606 Reference mark not detected** is generated. The monitoring is done as follows:

- **Rotary incremental encoders**: Maximum travel path equals 1 encoder revolution, if “0” has been entered in **P-0-0153, Optimal distance home switch - reference mark**. If P-0-0153 has not been parameterized with "0", then twice the value of P-0-0153 is used as the maximum travel path.
- **Linear incremental encoders**: Maximum travel path equals twice the value of P-0-0153; if P-0-0153 = "0" then there is **no** monitoring!
- **Distance-coded measuring systems**: Maximum travel path defined with **S-0-0165, Distance coded reference offset 1**.

The cause for this error message can be:

- Detection of the reference marks impossible (because of cable break, defective encoder, etc.)
- **S-0-0165, Distance coded reference offset 1** incorrectly parameterized

Mounting of the home switch

CAUTION

Property damage to the installation caused by overrunning the allowed travel range!

⇒ The home switch should be set up in such a way that its "activated" range exceeds the allowed travel range. Otherwise, the allowed travel range may be overrun at command start, if the start position is unfavorable.

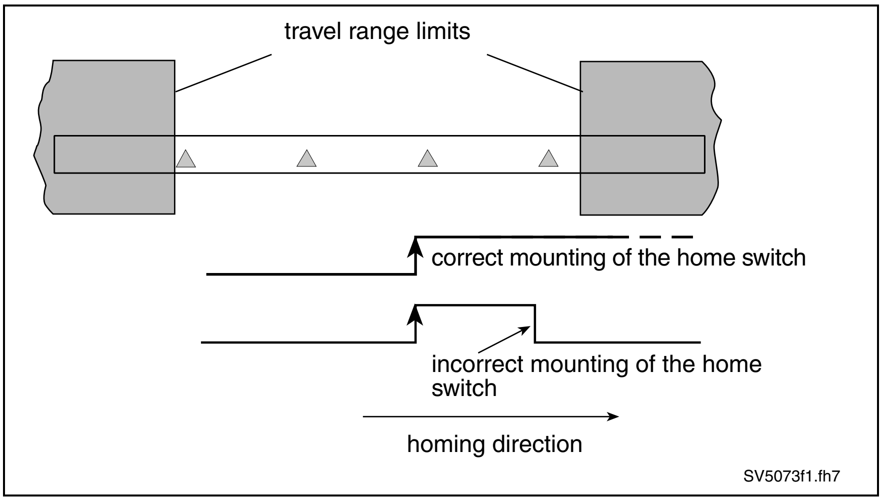


Fig. 9-105: Mounting of the home switch in reference to the travel range

Connection of the home switch

see Project Planning Manual ECODRIVE03 respectively DURADRIVE.

Homing of Gantry axes

Gantry-type machines are used to process workpieces with large surfaces. To allow Gantries to be traversed without the danger of skewing, the digital AC servo drive with SERCOS interface is equipped with the feature "Gantry Axis".

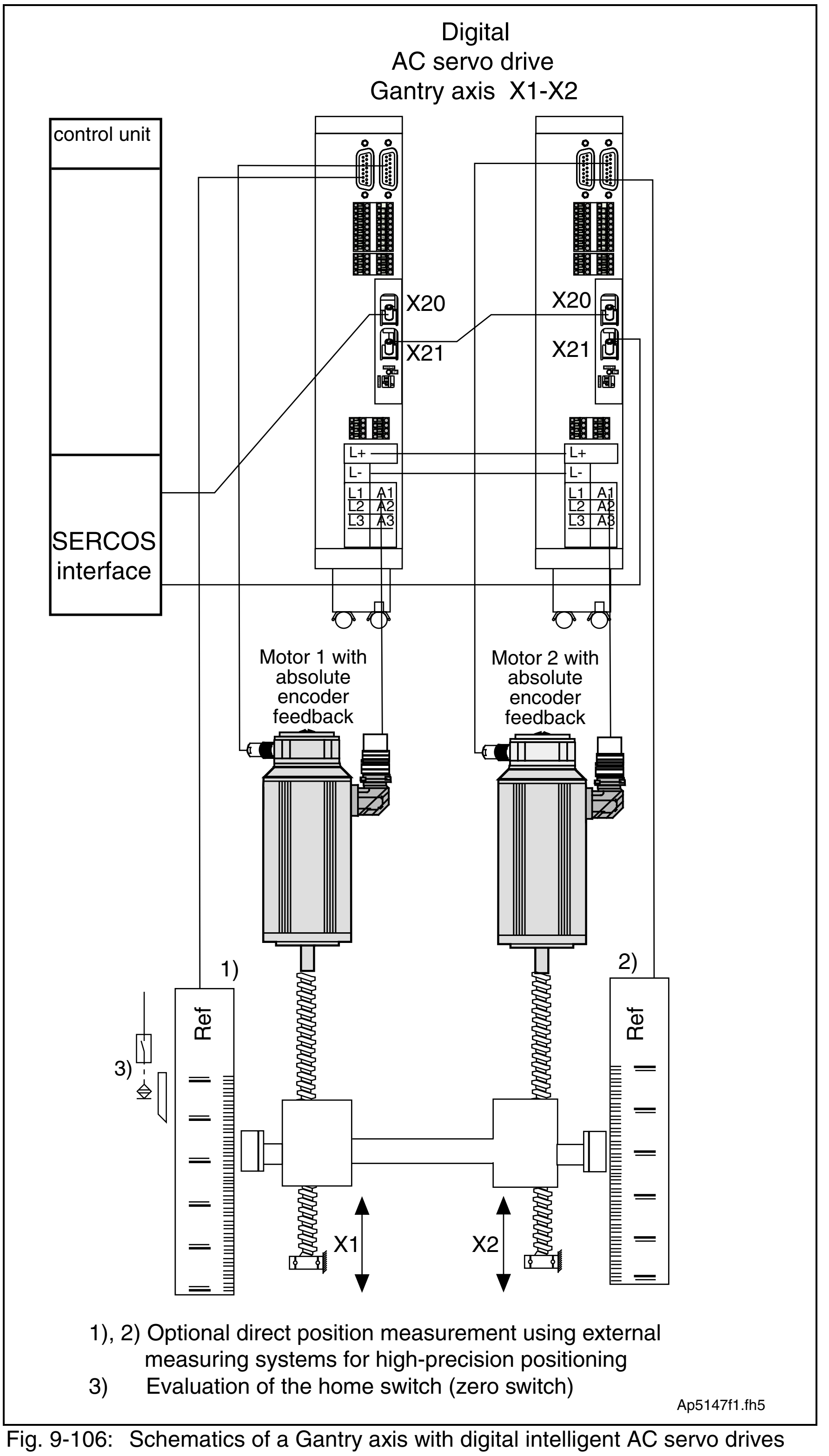


Fig. 9-106: Schematics of a Gantry axis with digital intelligent AC servo drives

CAUTION

Property damage caused by skewing of the Gantry axes!

⇒ The possibility of skewing must always be compensated by the mechanical structure in such a way that the machine will never under any circumstances be damaged.

Prerequisites for operating Gantry axes

- Both Gantry axes are registered as a single axis in the control unit.
- The axes are identically parameterized.
- The Gantry drives are equipped with absolute encoders.
- The parallel guideways of the Gantry axes (X1; X2) are guaranteed.

Setting up Gantry axes

1. Align the Gantry axis at right angles to the traversing direction.

⇒ Move the axis in jog mode or manually.

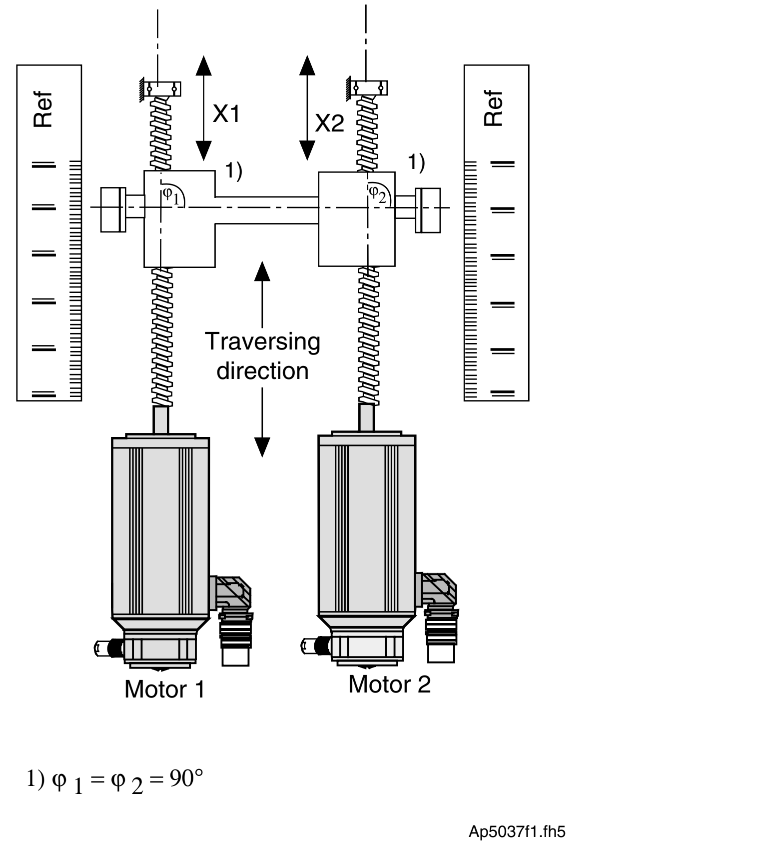


Fig. 9-107: Rectangular aligning of Gantry axis

2. Set absolute reference dimension

⇒ Determine the distance from the Gantry axis to the machine zero point.

⇒ Enter distance A to machine zero point in parameter **S-0-0052, Reference distance 1**.

⇒ Trigger command **P-0-0012, C300 Command Set absolute measurement**.

⇒ Cancel the drive enable signal:
The value entered in parameter "Reference distance 1" is transferred to parameter **S-0-0051, Position feedback 1 value**.

⇒ Reset the command.

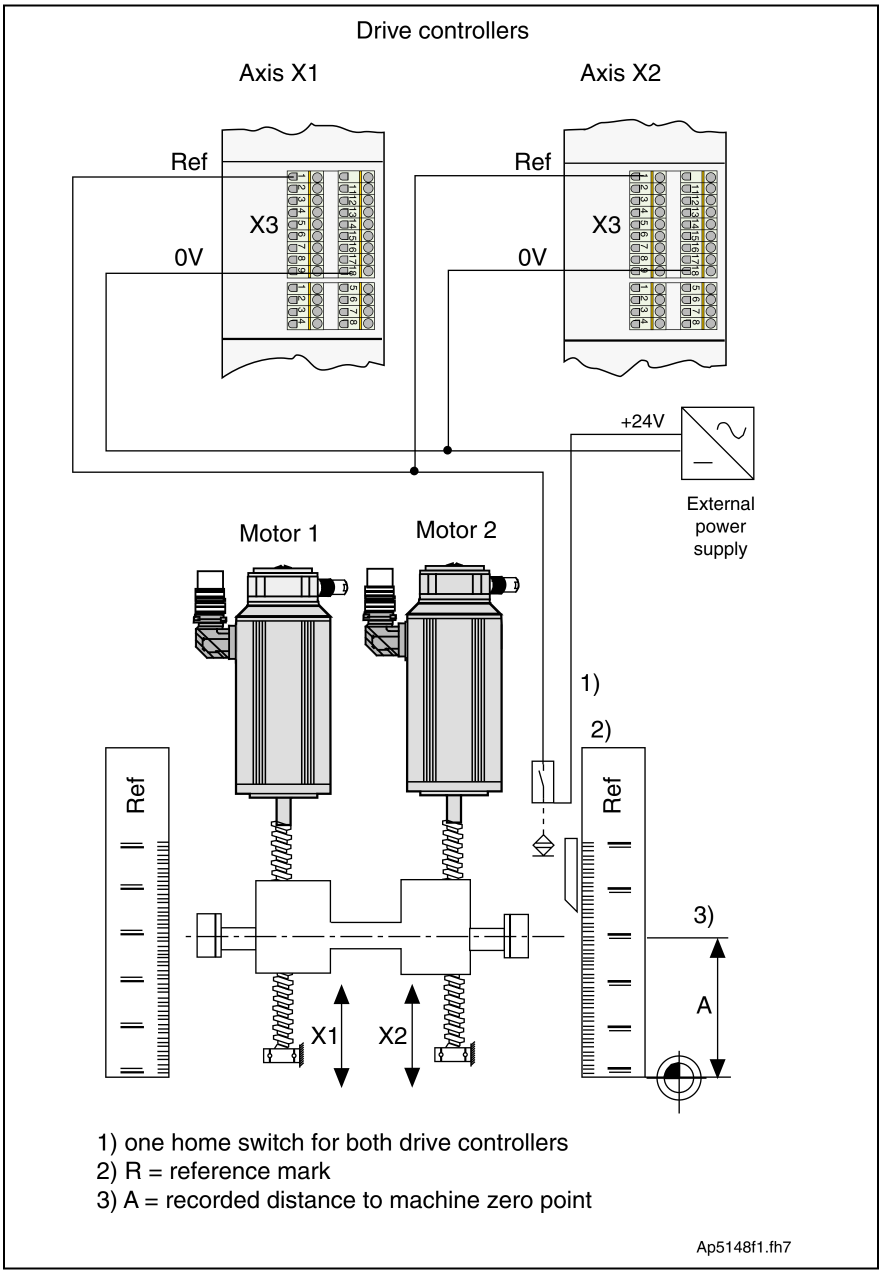


Fig. 9-108: Connecting the home switch to the drive controllers of Gantry axis X1/X2

3. Setting the reference distance of the direct position measuring system (if installed).

⇒ Set the following homing procedure parameters in both axis to the same values:

- **S-0-0041, Homing velocity**
- **S-0-0042, Homing acceleration**
- **S-0-0108, Feedrate override**
- **S-0-0147, Homing parameter**

4. Check the connection/function of the home switch:

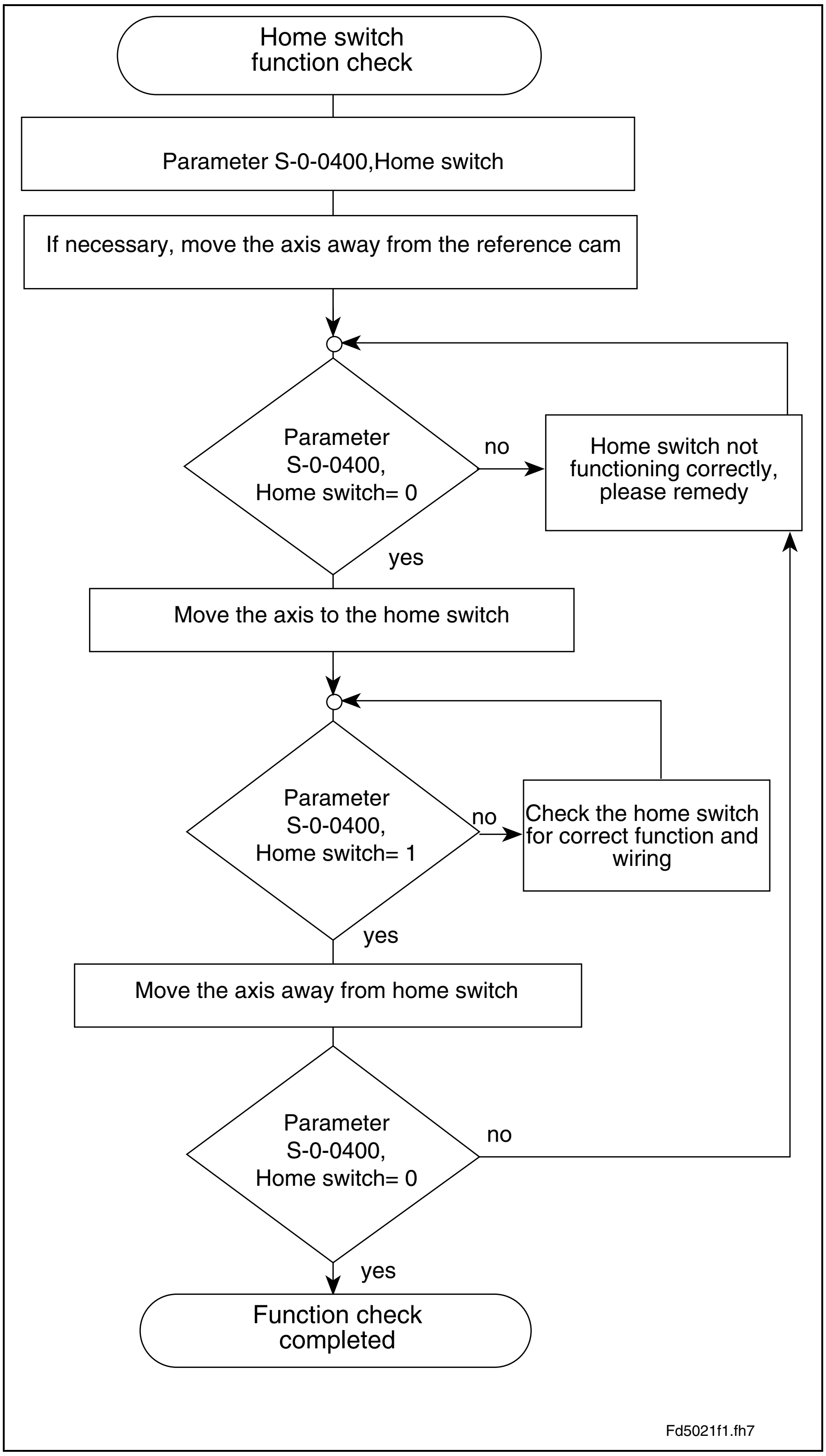


Fig. 9-109: Checking the function of the home switch

5. Detecting the reference mark positions of external feedback systems

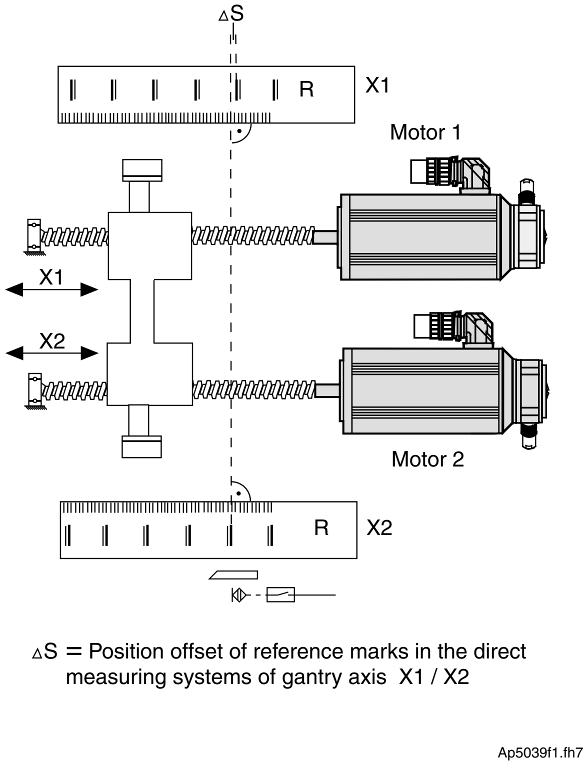


Fig. 9-110: Position offset of reference marks in the direct measuring systems of Gantry axes X1/X2

⇒ Activate command **P-0-0014, D500 Command determine marker position** in both axis (see control manual).

⇒ Move both axes towards the reference marks by presetting the same position command values through the control.

Note: The direction of travel must be the same as the subsequent homing direction (bit 0, **S-0-0147, Homing parameter**).

On reaching the relevant reference mark of the linear scale, each of the two drives stores the actual position feedback value 2 in the corresponding mark position (**S-0-0173, Marker position A**). Once the reference mark has been detected, the respective drive acknowledges the command "Get mark position". When both Gantry axes have acknowledged the command, the NC control must decelerate the drives to a standstill.

⇒ Determine the reference mark offset (ΔS):

$$\Delta S = S-0-0173, \text{ Marker position A (axis X1)} - S-0-0173, \text{ Marker position A (axis X2)}$$

Fig. 9-111: Calculating the reference mark offset (ΔS)

6. Compute and enter reference offset 2 of each axis.

For the axis the reference mark of which occurs first, the following applies:

$$S\text{-}0\text{-}0151, \text{ Reference offset 2} \geq \frac{Vref^2}{2 \times aref} + \Delta S$$

ΔS: Reference mark offset
V_{ref}: Homing velocity
a_{ref}: Homing acceleration

Fig. 9-112: Computing S-0-0151, Reference offset 2 for the axis the reference mark of which occurs first

For the axis the reference mark of which occurs last, the following applies:

$$S\text{-}0\text{-}0151, \text{ Reference offset 2} \geq \frac{Vref^2}{2 \times aref}$$

V_{ref}: Homing velocity
a_{ref}: Homing acceleration

Fig. 9-113: Computing S-0-0151, Reference offset 2 for the axis the reference mark of which occurs last

CAUTION

Property damage caused by reversal of direction of one of the two axes!

⇒ For **S-0-0151, Reference offset 2**, do not enter values lower than the computed ones.

⇒ The polarity of parameter **S-0-0151, Reference offset 2** must be selected so that the reference point shifts in the homing direction, i.e. with negative homing direction in one or both axes, also the reference offset must be input with negative sign. This avoids a reversal of direction after passing the reference mark (see "Consideration of the reference offset").

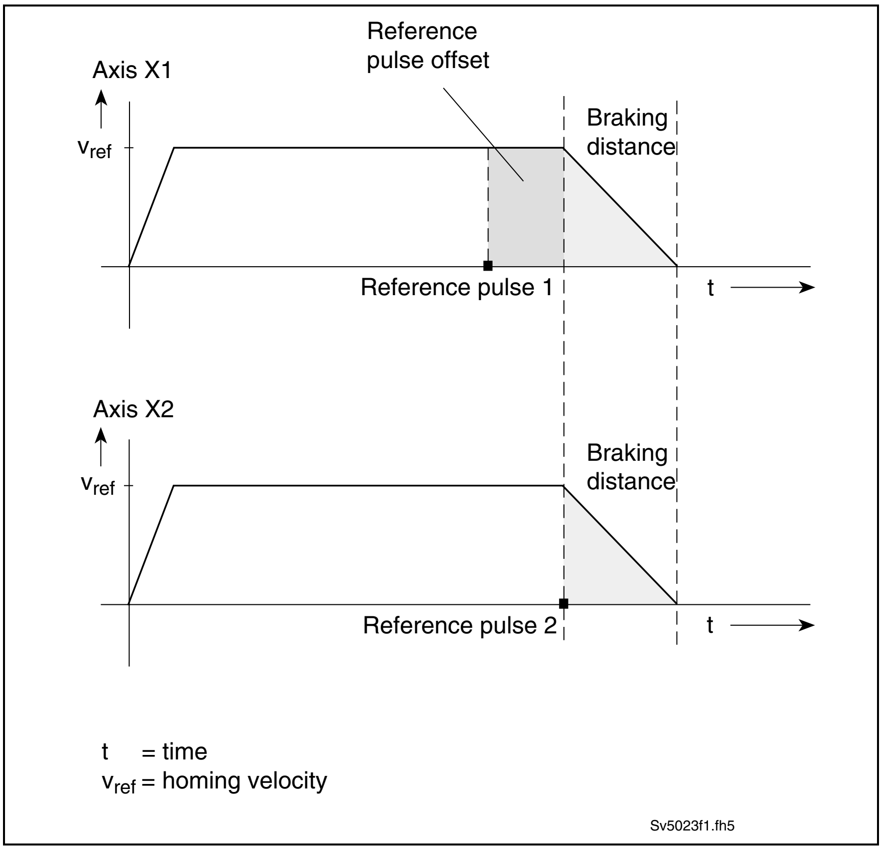


Fig. 9-114: Velocity curves of Gantry axes during homing

9.11 Set absolute measuring

When commissioning an absolute measuring system, the initial position feedback value represents an arbitrary value which does not refer to the machine zero point.

Note: The value of **S-0-0403, Position feedback value status** is "0".

Establishing the absolute reference

In contrast to non-absolute measuring systems, establishing the absolute reference of an absolute measuring system only has to be done once, at the time that the axis is commissioned.

With the use of command **P-0-0012, C300 Command Set absolute measurement** the position feedback value of this measuring system can be set to the desired value. After the "Set absolute measurement" procedure has been completed, the position feedback value of the relevant encoder has a defined reference to the machine zero point.

Activating the feature

The command can be triggered by writing data to parameter **P-0-0012, C300 Command Set absolute measurement** or with a zero switch input edge.

Command reference point

If there is only one absolute measuring system, then the command automatically references this measuring system. Given two absolute systems, however, then the selection must be set in bit 3 of **S-0-0147, Homing parameter**.

Saving the data

By means of a backup of all required data of the absolute measuring system in a feedback data memory or a parameter memory, all information is retained every time the machine is switched off and on again. The actual position value retains its reference to the machine zero point.

Pertinent parameters

The following parameters are relevant to the execution of the command "Set absolute measurement":

- **P-0-0012, C300 Command Set absolute measurement**
- **P-0-0612, Setting absolute measurement, control word**
- **S-0-0147, Homing parameter**
- **S-0-0052, Reference distance 1**
- **S-0-0054, Reference distance 2**
- **S-0-0403, Position feedback value status**
- **S-7-0177, Absolute distance 1**
- **S-7-0178, Absolute distance 2**

Functional principle

When setting absolute measurement, the motor has to be brought to a precise position. The desired position feedback value of the measuring system is entered in parameters **S-0-0052, Reference distance 1** (for motor encoders) or **S-0-0054, Reference distance 2** (for optional encoders).

Upon successful completion of command **P-0-0012, C300 Command Set absolute measurement**, the position feedback value is set to the value entered in the relevant **Reference distance** and the corresponding bit is set in **S-0-0403, Position feedback value status**.

Setting absolute measurement of master axis feedback

If the optional encoder has been defined as a master axis feedback, the scaling and the unit of parameter **S-0-0054, Reference distance 2** are switched. In parameter **S-0-0403**, **Position feedback value status** only bit 2 is set to "1".

Control word for setting absolute measurement

The execution of the command depends on **P-0-0612, Setting absolute measurement, control word**. Bit 0 determines whether the current coordinate system is retained even after the control voltage is switched off and on, i.e. whether the current absolute distance (S-7-0177 or S-7-0178) is stored in the non-volatile feedback data memory.

Note: Given frequent setting of absolute measurement, bit 0 of P-0-0612 should be set to "1" as the feedback data memory is only suited for a limited number of write accessing procedures.

For bits 1 and 2 the difference as to whether drive enable is given or not must be made.

Parameter structure:

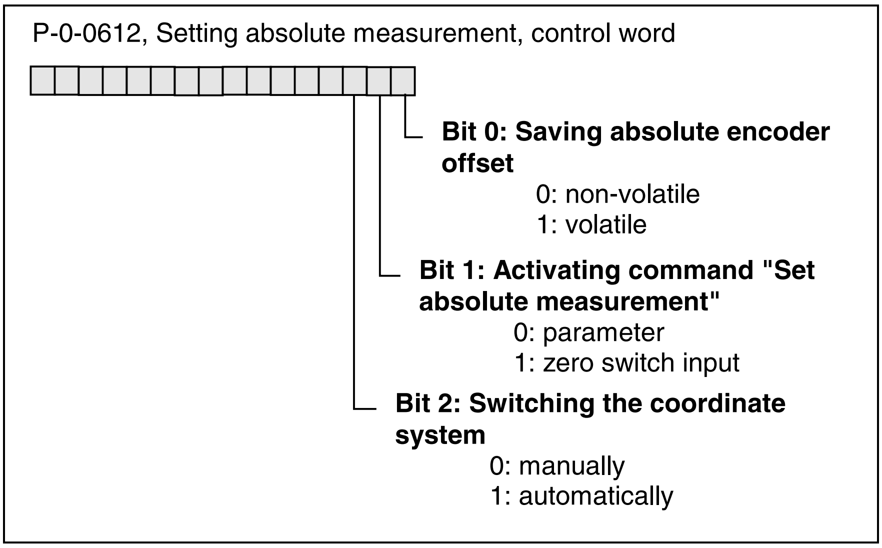


Fig. 9-115: P-0-0612, Setting absolute measurement, control word

"Set absolute measurement" without drive enable

Activating the command

Bit 1 of P-0-0612 is used to select whether the command "Set absolute measurement" is started by

- writing "11b" to parameter P-0-0012 with (if bit 1 of P-0-0612 equals "0") or
- a positive edge at the zero switch input (if bit 1 of P-0-0612 equals "1").

Switching the coordinate system

Note: **If the drive enable is not applied and command** "Set absolute measurement" is started, then drive-internally the coordinate system is always immediately switched (bit 2 is irrelevant in this case!).

Case	P-0-0612	Behavior when executing the command
A1	Bit1 = 0 Bit2 = x	Setting the absolute measurement by conducting **P-0-0012, C300 Command Set absolute measurement** • by writing "11b" to P-0-0012, in addition to the start of command "Set absolute measurement", the coordinate system is also immediately switched
B1	Bit1 = 1 Bit2 = x	Setting absolute measurement with a positive edge at the zero switch input • a positive edge at zero switch input stores the actual position • and the coordinate system is also immediately switched

Fig. 9-116: Overview, setting absolute measurement without drive enable

Case A1

When activating the command by writing data to the parameter, proceed as follows:

- The axis must be brought to the precisely measured position.
- The desired position feedback value at this position has to be written to the respective reference distance.
- The command can then be started by writing "11b" to **P-0-0012, C300 Command Set absolute measurement**.

- The command immediately sets the position feedback value of the measuring system to the reference dimension and the position status becomes "1". The drive has completed the command which can now be cleared (P-0-0012 ="0").

Case B1

Basically same procedure as with case A1, but the command is activated by an edge at the zero switch input.

Note: Bit 1 of P-0-0612 and the command itself are cleared automatically and drive-internally upon completion of the command "Set absolute measurement"!

"Set absolute measurement" with drive enable

If the application uses a so-called "vertical axis" or the position approached without drive enable cannot, for whatever reason, be held, then the command can also be executed with drive enable.

Activating the command

Use bit 1 of P-0-0612 to select whether the command is started by

- writing "11b" to parameter P-0-0012 (bit 1 ="0") or
- a positive edge at the zero switch input (bit 1 ="1").

Note: For safety reasons, edge evaluation is automatically deactivated after the command "Set absolute measurement" has been completed. This means that when being used in systems with slip, bit 1 in P-0-0612 must be cyclically used.

Switching the coordinate system

Use bit 2 of **P-0-0612** to select whether, when executing command **P-0-0012, C300 Command Set absolute measurement**,

- there is also an immediate drive-internal switch of the coordinate system (bit 2 ="1") or
- **S-0-0148, C600 Drive controlled homing procedure command** is started or the drive enable is removed by the control, in order to switch the coordinate system (bit 2 ="0").

Case	P-0-0612	Behavior when executing the command
C1	Bit1 = 0 Bit2 = 0	• By writing "11b" to P-0-0012, the command "Set absolute measurement" is started but the coordinate system not switched. • By starting the command S-0-0148 or removing drive enable, the coordinate system is switched.
C2	Bit1 = 0 Bit2 = 1	• By writing "11b" to P-0-0012, in addition to the start of command "Set absolute measurement", the coordinate system is also immediately switched
D1	Bit1 = 1 Bit2 = 0	• a positive edge at the zero switch input stores the actual position • and the control starts command S-0-0148 to switch the coordinate system!
D2	Bit1 = 1 Bit2 = 1	• a positive edge at the zero switch input stores the actual position • and immediately switches the coordinate system

Fig. 9-117: Overview, setting absolute measurement with drive enable

CAUTION

Property damage caused by incorrect parameterization!

⇒ Make sure that the encoder to be set has been selected in bit 3 of **S-0-0147, Homing parameter**.

Case C1

In the event that the coordinate system switch is not to take place automatically and drive-internally (P-0-0612, bit 2 ="0"), proceed as follows:

- Take the axis to the measured position.
- Enter the desired position feedback value in the respective reference distance parameter.
- Start command **P-0-0012, C300 Command Set absolute measurement** (by writing "11b" to P-0-0012). There is no switching of position data as yet.
- Start command **S-0-0148, C600 Drive controlled homing procedure command** or remove drive enable. This feature recognizes that it is dealing with an absolute measuring system and conducts the command "Set absolute measurement", in other words, the position feedback value is set to the reference dimension. The position command value (**S-0-0047, Position command value**) is simultaneously set to the same value. If the drive is in "Position control" mode, then the position command value must be read via the acyclic parameter channel (e.g. service channel with SERCOS) and the position command value of the control set to this value before the homing command is cleared.
- Clear command **P-0-0012, C300 Command Set absolute measurement**.

Case C2

In the event that the coordinate system is to be automatically and drive-internally switched at the start of command "Set absolute measurement" (P-0-0612, bit 2 ="1"), proceed as follows:

- Take the axis to the measured position.
- Enter the desired position feedback value in the respective reference distance parameter.
- Start command **P-0-0012, C300 Command Set absolute measurement** (by writing "11b" to P-0-0012) and position data are also automatically switched.
- Drive-internally and automatically command **S-0-0148, C600 Drive controlled homing procedure command** is started. With command execution, the drive recognizes that it is dealing with an absolute measuring system and conducts the command "Set absolute measurement", in other words, the position feedback value is set to the reference dimension. The position command value (**S-0-0047, Position command value**) is simultaneously set to the same value. If the drive is in "Position control" mode and the coordinate system is automatically switched, the control cannot bring its command value immediately up to the new actual value and there is an abrupt transition.
- Clear command **P-0-0012, C300 Command Set absolute measurement**.

Case D1 In the event that the coordinate system switch is not to be automatic and drive-internal (P-0-0612, bit 2 ="0"), then basically the same procedure as with case C1 should be followed, but the command is activated by a positive edge at the zero switch input.

- Activate the zero switch input by setting P-0-0612, bit1="1".
- Run the axis to the measured position (e.g. jog it there).
- etc.

Note: Both bit 1 of P-0-0612 and the command itself are automatically, drive-internally cleared after completion of the command "Set absolute measurement"!

Case D2 If the coordinate system is to be switched drive-internally and automatically at the start of the command "Set absolute measurement" (P-0-0612, bit 2 ="1"), then basically the same procedure as with case C2 should be followed, but the command is activated by a positive edge at the zero switch input.

- Activate the zero switch input by setting P-0-0612, bit1="1"
- Run the axis to the measured position (e.g. jog it there).
- etc.

Note: Both bit 1 of P-0-0612 and the command itself are automatically, drive-internally cleared after completion of the command "Set absolute measurement"!

Position feedback values after setting the absolute measurement

The state of the position feedback values of the motor encoder and, if available, of the optional encoder after the execution of the command "Set absolute measurement", depends on bit 3 in **S-0-0147, Homing parameter** and the availability of an absolute encoder in the form of a motor or optional encoder.

Motor encoder	optional encoder	non-absolute encoder homed?	S-0-0147, bit 3	Position feedback value 1	Position feedback value 2
absolute	non-absolute or not available	no	any	reference distance 1	reference distance 1
absolute	non-absolute or not available	yes	any	reference distance 1	unchanged
non-absolute	absolute	no	any	reference distance 1	reference distance 2
non-absolute	absolute	yes	any	reference distance 1	unchanged
absolute	absolute	-	0	reference distance 2	unchanged
absolute	absolute	-	1	unchanged	reference distance 2

Fig. 9-118: Position feedback values after setting the absolute measurement

Position feedback values of absolute encoders after power on

(see chapter: "Actual position values of absolute measuring systems after initialization")

Diagnostic messages

While executing the command, it is possible that command error "**C302 Absolute measuring system not installed**" is generated once the command **P-0-0012, C300 Command Set absolute measurement** is started without an absolute measuring system having been installed.

Hardware connections

See Project Planning Manual ECODRIVE03 respectively DURADRIVE.

10 Optional drive functions

10.1 Configurable signal status word

The configurable signal status word is used to accept a maximum of 16 copies of bits from other drive parameters. This makes it possible for the user to put a bit list together which contains all status information of the drive that is important to the control.

It is only possible to use the signal status word in the

- freely configurable operating mode
- freely expandable I/O mode

Note: The bits in the signal status word are put together in every command communication cycle at the point of time T4 **S-0-0007, Feedback acquisition starting time (T4)**.

Pertinent parameters

The following parameters are used with this function:

- **S-0-0026, Configuration list signal status word**
  ID number list with variable length to configure the bit list
- **S-0-0144, Signal status word**
  configurable bit list
- **S-0-0328, Assign list signal status word**
  bit number list with variable length to configure the bit list
- **S-0-0398, IDN list of configurable data in the signal status word**

Configuration of the signal status words

Configuration of the IDNs

In parameter **S-0-0026, Configuration list signal status word** the IDNs of those parameters are indicated that contain the original bits (sources). The parameters that can be entered in the configuration list are listed in parameter **S-0-0398, IDN list of configurable data in the signal status word**. The position of an IDN in the list determines the bit in the signal status word to which the IDN applies. For example, the 1st list element determines from which parameter bit 0 of the signal status word is taken.

Bit number configuration

Which bit of the parameters selected in **S-0-0026, Configuration list signal status word** is to be copied into the signal status word is determined in **S-0-0328, Assign list signal status word**.

Note: If this list remains empty, then bit 0 of the mentioned parameters is automatically copied. Otherwise, the bit taken out of the source parameter is specified here.

Bit numbers from 0 (LSB) to 31 (MSB) can be specified. For each bit number of this list there must be an IDN in the same list position in list S-0-0026. Otherwise, when writing the bit number list, the drive will issue the error message "0x1001, ID number not available". This is why data must be written to list **S-0-0026, Configuration list signal status word** before they are written to **S-0-0328, Assign list signal status word**.

Example A signal status word with the following configuration is to be configured:

Bit no. in S-0-0144,Signal status word	S-0-0026 IDN of original parameter	S-0-0328 Bit no. of original parameter	Definition
0	S-0-0013	1	Vist = 0
1	S-0-0182	6	IZP
2	S-0-0403	0	position status
3	P-0-0016	4	P-0-0015 specifying memory address of a drive-internal counter. Bit 4 of the counter is transmitted.

Fig. 10-1: Example of a configurable signal status word

Output of the signal status word

With DKC01.3 bits 0-9 of parameter **S-0-0144, Signal status word** are copied to the digital outputs (X15.14-23), with DKC21.3 they are copied to the digital outputs (X210.17-28).

Note: A maximum of 16 bits can be configured. Configuration is performed from the least-significant to the most-significant bit. In other words, the position of the bit copy in the signal status word is the result of the continuous configuration in S-0-0026.

Diagnostic messages / error messages

The following checks are run when inputting parameters **S-0-0328, Assign list signal status word** or **S-0-0026, Configuration list signal status word**:

- If more elements are programmed in **S-0-0328, Assign list signal status word** than in **S-0-0026, Configuration list signal status word**, then error message "0x1001, ID number not available" is generated.
- If an IDN specified in **S-0-0026, Configuration list signal status word** does not exist, then error message "0x1001, ID number not available" is generated.
- Check whether the IDN specified in **S-0-0026, Configuration list signal status word** has variable data length (list parameters) or a so-called online read function. Parameters with online read function are generally parameters with physical units (position, speed, acceleration and currents) as well as parameters **S-0-0135, Drive status word** and **S-0-0011, Class 1 diagnostics**. If yes, then service channel error message "0x7008, Data not correct" is generated.

Note: In each of these cases, only those inputs up to the faulty element are accepted!

10.2 Configurable signal control word

With the signal control word it is possible to write access single control bits in the various parameters by using a freely-configurable collective parameter.

The configurable signal control word supports acceptance of a maximum of16 copies of bits from other drive parameters.

Accessing signal control word

Depending on the command communication, parameter **S-0-0145, Signal control word** is write accessed in various ways:

- With SERCOS and fieldbus interface, parameter **S-0-0145, Signal control word** must be configured in accordance with the cyclical data so that the configured control bits are evaluated.

This function can only be used in freely-configurable operating mode.

Note: The bits in the signal control word are evaluated in each interface cycle at the point of time T3 **S-0-0008, Command valid time (T3)**.

Pertinent parameters

The following parameters are used for the function

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

Configuring the signal control word

Selection list

Only those parameters contained in list **S-0-0399, IDN list of configurable data in the signal control word** can be allocated to configuration list **S-0-0027, Configuration list signal control word**.

Configuration of the IDNs

The IDNs of the parameters which are to be configured with the help of the signal control word (=targets) are specified in parameter **S-0-0027, Configuration list signal control word**.

The position of an IDN in this list determines which bit in the signal control word is allocated to which IDN (targets). For example, the 1st list element determines which parameter bit 0 of the signal control word is allocated to.

Configuration of the bit numbers

Which bit of the selected parameters (=targets in **S-0-0027, Configuration list signal control word**) is set (or cleared) by the signal control word is determined in **S-0-0329, Assign list signal control word**.

Note: If this list remains empty, then bit 0 is automatically set in the specified parameters. Otherwise, the bit which is allocated to the target parameter is specified here.

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

Exceptions

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

If the allocated parameter is parameter **S-0-0346, Positioning command strobe**, then a positive edge in the relevant bit of the control word effects a toggling of the parameter **S-0-0346, Positioning command strobe**.

ID number not available

For every bit number in list **S-0-0329, Assign list signal control word** there must be an IDN at the same list position in the list **S-0-0027, Configuration list signal control word**. Otherwise, when writing the bit number list, the drive will generate the error message "0x1001 ID number not available".

Note: This is why list S-0-0027 must be written prior to list S-0-0329.

Example

Bit no. in S-0-0145	S-0-0027 ID number of the target parameter	S-0-0329 Bit no. of the target parameter	Definition
0	P-0-4026	0	select positioning block
1	P-0-4026	1	select positioning block
2	P-0-4026	2	select positioning block
3	P-0-4026	3	select positioning block
4	P-0-4026	4	select positioning block
5	P-0-4026	5	select positioning block
6	S-0-0346	0	start (strobe)
7	S-0-0148	0	start homing command
8	P-0-4056	0	jog positive
9	P-0-4056	1	jog negative

Fig. 10-2: Example for configuration signal control word (=default setting for parallel interface)

Note: A maximum of 16 bits can be configured. Configuration is performed from the least-significant to the most-significant bit. In other words, the position of the bit copy in the signal control word is the result of the continuous configuration in S-0-0027.

Diagnostic messages / error messages

When inputting one of the parameters (S-0-0027 or S-0-0329) the following checks are run:

- If more elements are programmed in **S-0-0329, Assign list signal control word** than in **S-0-0027, Configuration list signal control word**, then error message "0x1001, ID number not available" is generated.
- If an IDN specified in **S-0-0027, Configuration list signal control word** is not available, then error message "0x1001, ID number not available" is generated.
- If an IDN specified in **S-0-0027, Configuration list signal control word** is not contained in parameter **S-0-0399, IDN list of configurable data in the signal control word**, then error message "0x7008, Data not correct" is generated.

Note: In each of these cases, only those inputs up to the faulty element are accepted!

10.3 Analog output

With the help of the function "Analog output" drive-internal signals and state variables can be generated as analog voltage signals. These can be examined with an oscilloscope connected to the analog outputs.

The conversion of the digital values from the drive is done via two 8-bit digital/analog converters. The maximum output voltage equals +/- 10 volts. There is an output every 500 µs.

Possible output functions

1. Writing data directly to the analog output
2. Assigning IDNs to analog outputs
3. Output of pre-set signals
4. Byte output of RAM memory cells
5. Bit output of RAM memory cells

To parameterize the function, the following parameters are available:

- **P-0-0139, Analog output 1**
- **P-0-0140, Analog output 2**
- **P-0-0420, Analog output 1, signal selection**
- **P-0-0421, Analog output 1, expanded signal selection**
- **P-0-0422, Analog output 1, scaling per 10V full scale**
- **P-0-0423, Analog output 2, signal selection**
- **P-0-0424, Analog output 2, expanded signal selection**
- **P-0-0425, Analog output 2, scaling per 10V full scale**
- **P-0-0426, Analog outputs, IDN list of assignable parameters**

Direct analog output

With the parameters **P-0-0139, Analog output 1** and **P-0-0140, Analog output 2** it is possible for the control to use the two 8-bit digital/analog converters of the drive. Voltage values written to these parameters, ranging between -10.000 volts and +10.000 volts, are output by the drive at the analog outputs. The quantization equals 78 mV.

A precondition for this use of an analog output is that the signal selection (P-0-0420 or P-0-0423) and the expanded signal selection (P-0-0421 or P-0-0424) were deactivated for the used channel by inputting 0.

Analog output of existing parameters

Selection list

All parameters contained in the list **P-0-0426, Analog output, IDN list of assignable parameters** can be output as analog values.

Configuration

This first requires that their IDN be input in the signal select for channel 1 (P-0-0420) or 2 (P-0-0423). The unit and the attribute (number of decimal places) of the relevant scaling (P-0-0422 or P-0-0425) is set as per the selected parameter. If the selected parameter depends on a scaling type, then the settings made in the parameter apply to the scaling as well.

Scaling

With **P-0-0422, Analog output 1, scaling per 10V full scale** or **P-0-0425, Analog output 2, scaling per 10V full scale** is it then fixed at what value 10 volts are output.

For example, with rotary preferred position scaling and signal select position command value (S-0-0047), the unit of the scaling factor is set to degrees and the number of decimal places is set to 4. The input of 90.0000 degrees in the scaling factor will then result in 10 volts being output per 90 degrees at the load.

If signals with a binary format are selected (e. g. **S-0-0134, Master control word**), then the display format of the scaling is set to decimal without decimal places. There is no unit.

With this scaling, a bit number between 0 and 15 is selected. The state of this bit of the set parameter is then output in such a way that for logical "0" at the analog output -10 volts are output and for logical "1" +10 volts (bit output).

Outputting pre-set signals

To be able to display such signals in an analog manner, which do not exist as a parameter, there is a way to select these via predefined signal numbers and to output them via the expanded analog output.

The following parameters are used for selection:

- **P-0-0421, Analog output 1, expanded signal selection** and
- **P-0-0424, Analog output 2, expanded signal selection**

Activation of the expanded analog output

The expanded output only functions if the signal select for the channel used (P-0-0420 or P-0-0423) is deactivated by inputting the ID number 0 (S-0-0000).

The following list shows which signal is output with which signal number.

Signal number P-0-0421/424	Output signal	Reference unit: Scaling factor 1.0000
0x00000001	motor encoder sine signal	0.5V/10V
0x00000002	motor encoder cosine signal	0.5V/10V
0x00000003	Opt. encoder sine signal	0.5V/10V
0x00000004	Opt. encoder cosine signal	0.5V/10V
0x00000005	Position command difference on the pos. controller	rot. ⇒ 1000rpm/10V lin. ⇒ 100m/min/10V
0x00000006	DC bus power	1kW/10V
0x00000007	absolute DC bus power amount	1kW/10V
0x00000008	effective current (Iq)	S-0-0110/10V
0x00000009	wattless current (Id)	S-0-0110/10V
0x0000000a	thermal load	100 % / 10V
0x0000000b	motor temperature	150°C/10V
0x0000000c	magnetizing current	S-0-0110/10V
0x0000000d	velocity command at the velocity controller	rot. ⇒ 1000rpm/10V lin. ⇒ 100m/min/10V
FREE		
FREE		
...		
0x00000014	synchronous position command value	rot. => 360°/10V lin. => 1mm/10V
0x00000015	synchronous velocity	rot. => 1000rpm/10V lin. => 100m/min/10V
0x00000016	fine interpolated master axis position	2^20/10V
0x00000017	master axis velocity in NC-cycle	rot. => 1000rpm/10V

Fig. 10-3: Signal selection list with pre-defined signal selection

See also control loop block diagram in chapter "General information for control loop settings"

These outputs are scaling independent and always relate to the motor shaft. The scaling of the signals is possible via the parameters

- **P-0-0422, Analog output 1, scaling per 10V full scale** and
- **P-0-0425, Analog output 2, scaling per 10V full scale**

These have been set as factors with 4 decimal places in the expanded signal selection. If these scaling factors are 1.0000, then the standards specified in the table apply.

Note: Velocity and position data always refer to the motor shaft! The scaleable output signals can reach overload if the scale is selected such that the current signal value exceeds the +/-10 V limit. The exceeded value is emulated in the displayable (+/-10 V) range and makes it possible to examine signals with a higher resulution.

Example

Output of the position command difference with a scaling of 150rpm/10V on channel 1

Input:

P-0-0420, Analog output 1, signal selection = S-0-0000

P-0-0421, Analog output 1, expanded signal selection = 0x00000005

P-0-0422, Analog output 1, scaling per 10V full scale = 0.1500

Bit and byte outputs of the data memory

Note: Use of this function makes sense only with information about the structure of the internal data memory; therefore, this function can be used effectively only by the respective developer.

Activation of the bit and byte output

The bit and byte output is only possible, if the signal selection for the used channel (P-0-0420 or P-0-0423) is deactivated by inputting the ID number 0 (S-0-0000).

Configuration

The selection of the function and the storage address takes place in the parameters:

- **P-0-0421, Analog output 1, expanded signal selection** and
- **P-0-0424, Analog output 2, expanded signal selection**

In the high nibble (bits 28..31), byte output (5 byte output from coprocessor) is activated with a 1 and bit output (6 bit output from coprocessor) with a 2. The storage address is input in the least significant 24 bits of the parameters.

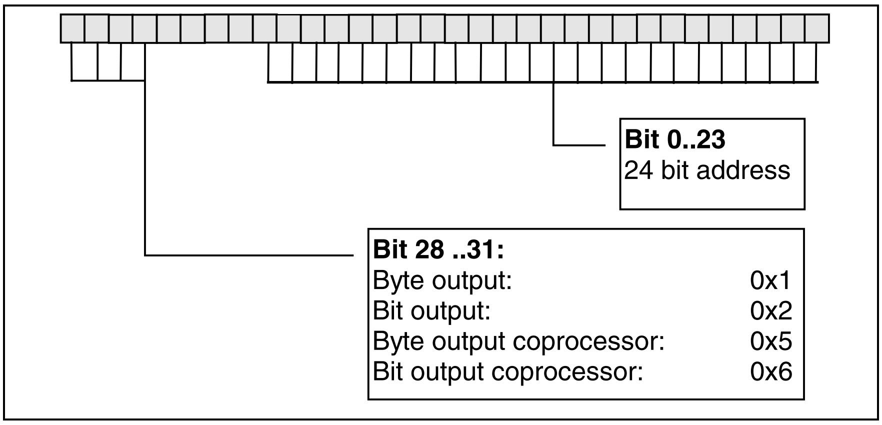


Fig. 10-4: Parameterizing bit or byte output

Scaling The parameters

P-0-0422, Analog output 1, scaling per 10V full scale and

P-0-0425, Analog output 2, scaling per 10V full scale

either select the bit to be output or determine from which bit (least significant) onward the byte to be output will begin.

When selecting the bit number, only values between 0 and 15 make sense. If greater values are entered, then only bits 0..3 are used.

When outputting bits, -10 volts (bit = 0) or +10 volts (bit = 1) are output.

Byte output When outputting bytes, the MSB of the byte to be output is interpreted as sign bit. Voltages ranging from -10 to +10 volts are output.

Terminal assignment of analog output

see Project Planning Manual ECODRIVE03 respectively DURADRIVE

10.4 Analog inputs

Using the function "Analog inputs", **2 analog inputs** can be mapped to one parameter each via an analog/digital converter. The analog voltage in the form these two parameters can then either be

- transmitted to the control and serves the control as an analog input function or
- assigned in the drive to a different parameter taking a settable scaling and a settable offset into account.

Note: With the help of analog inputs it is also possible to set command values for velocity control mode.

Pertinent parameters

The following parameters are available for the function:

- **P-0-0210, Analog input 1**
- **P-0-0211, Analog input 2**
- **P-0-0212, Analog inputs, IDN list of assignable parameters**
- **P-0-0213, Analog input 1, Assignment**
- **P-0-0214, Analog input 1, scaling per 10V full scale**
- **P-0-0215, Analog input 2, Assignment**
- **P-0-0216, Analog input 2, scaling per 10V full scale**
- **P-0-0217, Analog input 1, Offset**
- **P-0-0218, Analog input 2, Offset**

Functional principle of the analog inputs

The two analog inputs are connected via the two **differential inputs** E1+ / E1- and E2+ / E2-.

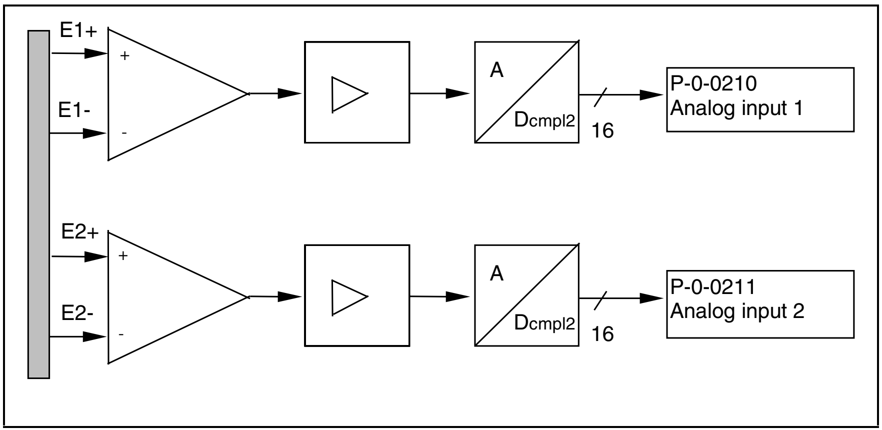


Fig. 10-5: Functional principle of the analog inputs

The digitized voltages of both differential inputs are displayed in the parameters **P-0-0210, Analog input 1** and **P-0-0211 Analog input 2**.

Assignment of analog inputs to parameters

Both parameters **P-0-0210, Analog input 1** and **P-0-0211 Analog input 2**, which depict the analog-to-digital converted voltages, can be assigned to other drive parameters, i.e. they can be cyclically copied while taking

- an offset and
- a selectable scaling

into account.

Processing of analog inputs

- Analog channel 1 **is processed every 1 ms**.
- Analog channel 2 **is processed every 8 ms**.

Exception: In modes "velocity control" or "torque/force control", the command values are scanned every 500 µs.

For assignment, the following principle is used:

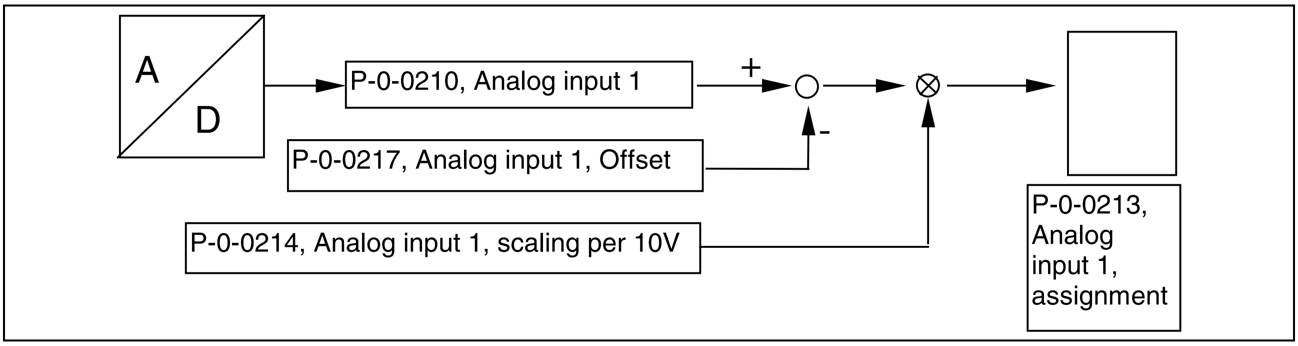


Fig. 10-6: Functional principle of the assignment of analog input 1 to a parameter

Displaying analog value 1

The digitized input voltage is stored in parameter **P-0-0210, Analog input 1**.

Configuring analog input 1

An assignment of an analog input to a parameter is activated, if in parameter **P-0-0213, Analog input 1, assignment** a value unequal S-0-0000 has been parameterized.

The contents of **P-0-0210, Analog input 1** minus the contents of **P-0-0217, Analog input 1, Offset** is scaled with the scaling factor set in **P-0-0214, Analog input 1, scaling per 10V full scale** and then copied to the parameter with the ID number set in **P-0-0213, Analog input 1, Assignment**.

Evaluation parameter unit

The unit of the parameter **P-0-0214, Analog input 1, Scaling per 10V full scale** complies with the unit of the assigned parameter.

Selection list

Only those parameters can be assigned that are listed in **P-0-0212, Analog inputs, IDN list of assignable parameters**.

Configuring analog input 2

Note: The configuration or assignment of analog input 2 can be conducted accordingly.

Example

Assignment of analog input 1 to

S-0-0036, Velocity command value with 10 V corresponds to 1000 rpm

Parameter setting:

- **P-0-0213, Analog input 1, assignment** = S-0-0036
- **P-0-0214, Analog input 1, evaluation per 10V** = 1000.0000 rpm

Terminal assignment of analog inputs

see Project Planning Manual ECODRIVE03 respectively DURADRIVE

10.5 Digital inputs/outputs

Each drive controller has two digital outputs available with the basic device, independent of command communication.

When connecting EMD modules (a maximum of two), further digital outputs and digital inputs are available.

With the feature "digital inputs/outputs" it is possible to output the operating data of any parameter on digital outputs or to map digital inputs to the operating data of any parameter.

Pertinent parameters

- **P-0-0110, Parallel output 2**
- **P-0-0111, Parallel input 2**
- **P-0-0112, Parallel output 3**
- **P-0-0113, Parallel input 3**
- **P-0-0124, Assignment IDN -> Digital output**
- **P-0-0125, Assignment digital input-> IDN**
- **S-0-0097, Mask class 2 diagnostic**

Assignment of digital outputs

Functional principle

With parameter **P-0-0124, Assignment IDN -> Digital output** it is possible to assign any parameter to digital outputs.

Parameter structure P-0-0124

Parameter P-0-0124 is a 4-byte parameter. The low word of the parameter contains the IDN of the parameter that is to be assigned to a digital interface. The high word contains the number of the digital interface.

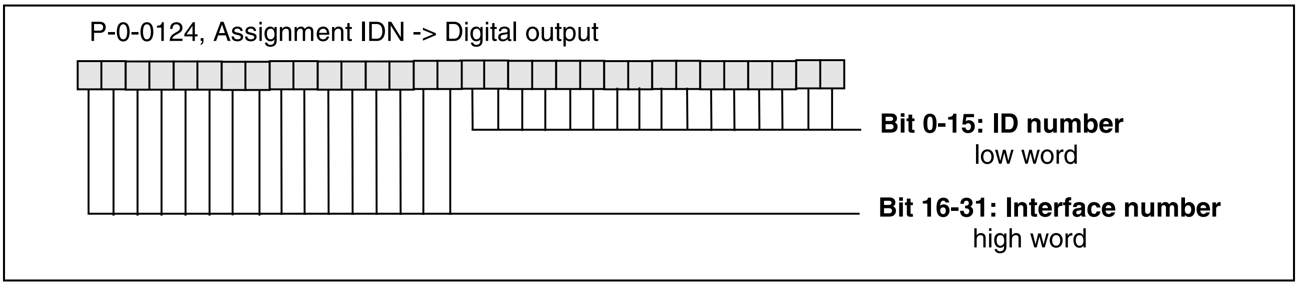


Fig. 10-7: P-0-0124, Assignment IDN -> Digital output

Example:

Parameter S-0-0144 is to be assigned to a digital interface.

1. interface number = 0 -> high word =0
2. ID number = S-0-0144 –> low word = 0x90

⇒ The value 0x00090 must therefore be written to P-0-0124.

If the value 0 is written to the low word of P-0-0124 or the values 2 or 3 are written to the interface number, then the drive automatically puts the signals READY (power section ready and no error) and WARNING (one bit of class 2 diagnostics is set and masked with S-0-0097) on the outputs X3/8 and X3/10.

Note: If an EMD module is available and the value 0 has been written to the low word of P-0-0124, the value of parameter **P-0-0110, Parallel output 2** is given to the outputs of the EMD module.

If two EMD modules are available, the value of parameter **P-0-0110, Parallel output 2** is given to the outputs of the first EMD module and the value of parameter **P-0-0112, Parallel output 3** is given to the outputs of the second EMD module.

Bit 0 of the parameter corresponds to output 0, bit 1 of the parameter to output 1,...

Interface number in the high word of P-0-0124	Outputs on basic device / module
0	outputs X3/8 and X3/10
2	outputs of EMD module 1, 16 bit
3	outputs of EMD module 2, 16 bit

Fig. 10-8: Interface number indicated in parameter <-> outputs on basic device / module

Note: Independent of parameter P-0-0124, the freely-configurable signal status word is assigned to the digital outputs X210/17 to X210/20 of the DKC21.3.

Assignment of digital inputs

With parameter **P-0-0125, Assignment digital input -> IDN** it is possible to assign any parameter to digital inputs.

Parameter structure P-0-0125

Parameter P-0-0125 is a 4-byte parameter. The low word of the parameter contains the IDN of the parameter that is to be assigned to a digital interface. The high word contains the number of digital interface.

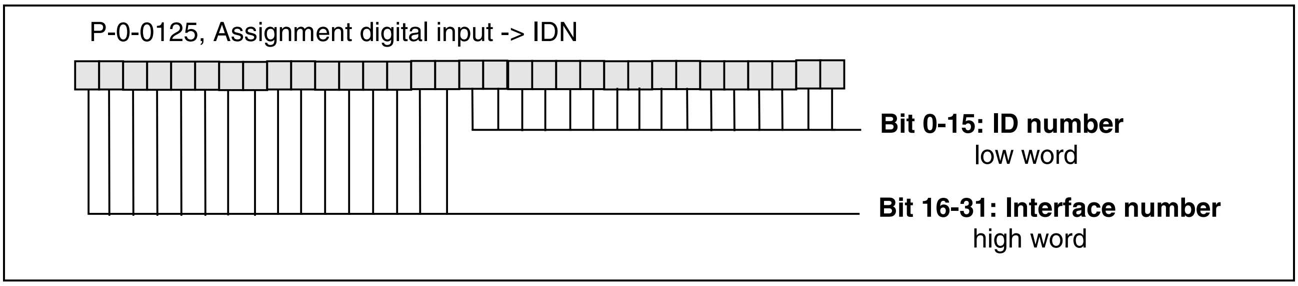


Fig. 10-9: P-0-0125, Assignment digital input -> IDN

Example:

The values of the digital inputs of the EMD module 1 are to be stored in parameter **S-0-0145, Signal control word**.

1. interface number = 2 -> high word = 2
2. ID number = S-0-0145 –> low word = 0x91

⇒ The value 0x20091 must be written to P-0-0125.

Note: If an EMD module is available and the value 0 has been written to the low word of P-0-0125, the inputs of the EMD module 1 are mapped to parameter **P-0-0111, Parallel input 2**.

If two EMD modules are available, the inputs of the EMD module 1 in parameter **P-0-0111, Parallel input 2** and the inputs of the EMD module 2 in parameter **P-0-0113, Parallel input 3** are given to the outputs of the second EMD module.

Input 0 corresponds to bit 0 of the parameter, input 1 to bit 1 of the parameter,...

Interface number	**Inputs on basic device / module**
2	inputs of EMD module 1, 16 bit
3	inputs of EMD module 2, 16 bit

Fig. 10-10: Interface number indicated in parameter <-> inputs on basic device / module

Rexroth Indramat

10.6 Oscilloscope feature

The oscilloscope feature is used to record internal and external signals and state variables. Its function can be compared to a 2-channel oscilloscope. The following parameters are available to set the oscilloscope feature:

- **P-0-0021, List of Scope Data 1**
- **P-0-0022, List of Scope Data 2**
- **P-0-0023, Signal Select Scope Channel 1**
- **P-0-0024, Signal Select Scope Channel 2**
- **P-0-0025, Trigger Source**
- **P-0-0026, Trigger Signal Selection**
- **P-0-0027, Trigger Level for Position Data**
- **P-0-0028, Trigger Level for Velocity Data**
- **P-0-0029, Trigger Level for Torque/Force Data**
- **P-0-0030, Trigger Edge**
- **P-0-0031, Timebase**
- **P-0-0032, Size of Memory**
- **P-0-0033, Number of Samples after Trigger**
- **P-0-0035, Delay from Trigger to Start**
- **P-0-0036, Trigger Control Word**
- **P-0-0037, Trigger Status Word**
- **P-0-0145, Expanded Trigger Level**
- **P-0-0146, Expanded Trigger Address**
- **P-0-0147, Expanded Signal K1 Address**
- **P-0-0148, Expanded Signal K2 Address**
- **P-0-0149, List of selectable signals for oscilloscope function**
- **P-0-0150, Number of valid Samples for Oscilloscope Function**

Functional principle of the oscilloscope feature

Activating the oscilloscope feature

The oscilloscope feature can be activated with the parameter **P-0-0036, Trigger Control Word** by setting bit 2. From then on, all data will be recorded that were selected through the parameters **P-0-0023, Signal Selection Channel 1** and **P-0-0024, Signal Selection Channel 2**. The selection will be defined with numbers that are assigned to various signals.

Triggering

The triggering is activated by setting bit 1 in parameter **P-0-0036, Trigger Control Word**. The trigger conditions can be set with the parameters **P-0-0025, Trigger Source**, **P-0-0026, Trigger Signal Selection** and **P-0-0030, Trigger Edge**. The signal amplitude that releases the trigger can be set with the parameters P-0-0027 to P-0-0029.

If a trigger event is recognized, then the number of values in the parameter **P-0-0033, Number of Samples after Trigger** will be recorded and the feature will be completed. Parameters **P-0-0031, Timebase** and **P-0-0032, Size of Memory** can define the recording duration and the time intervals of the measured values.

The measured values are stored in parameters **P-0-0021** and **P-0-0022** and can be read by the control.

Parameterizing the oscilloscope feature

Oscilloscope feature with defined recording signals

Preset signals and state variables can be selected through parameters **P-0-0023, Signal Select Scope Channel 1** and **P-0-0024, Signal Select Scope Channel 2**. The selection can be made by entering the signal number (hex format) in the corresponding signal selection parameter. The selected signal number defines the unit of data stored in the list of scope data. The following signals are predefined with numbers.

Number	Signal selection	Unit of the measured value list
0x00	Channel not activated	--
0x01	Position feedback value dependent on operating mode S-0-0051 or S-0-0053	dependent on position scaling
0x02	Velocity feedback value parameter (S-0-0040)	velocity scaling dependent
0x03	Velocity control deviation (S-0-0347)	velocity scaling dependent
0x04	Following error parameter (S-0-0189)	dependent on position scaling
0x05	Torque/force command value parameter S-0-0080	Percent
0x06	Position feedback 1 value S-0-0051	dependent on position scaling
0x07	Position feedback 2 value S-0-0053	dependent on position scaling
0x08	Position command value S-0-0047	dependent on position scaling
0x09	Velocity command value parameter (S-0-0036)	velocity scaling dependent
0x0A	Master drive position P-0-0053	increments [2^20/rev.]
0x0B	Position feedback value 3 P-0-0052	increments [2^20/rev.]

Fig. 10-11: Selection of predefined signals

Note: Parameter **P-0-0149, List of selectable signals for oscilloscope function** was introduced so that the control can detect the number of preset numbers. This parameter has the structure of a list parameter and transmits the ID numbers of the possible signals.

Expanded oscilloscope recording feature

In addition to the oscilloscope feature with preset signals, the drive also allows for recording of any desired internal signals. Use of this feature makes sense only with information about the structure of the internal data memory; therefore, this feature can be used effectively only by the respective developer. The feature can be activated with parameters P-0-0023 and P-0-0024 by setting bit 12.

The format for the data to be saved can be defined with bit 13.

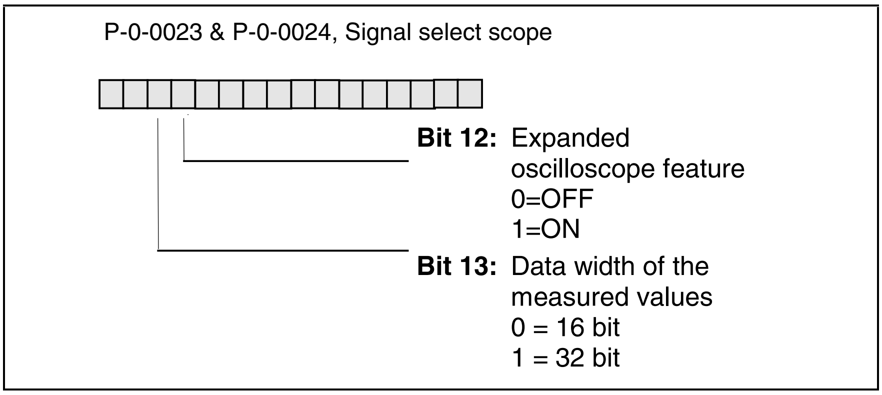


Fig. 10-12: Structure of parameters P-0-0023 and P-0-0024

If the expanded signal selection is parameterized, then the desired signal address can be defined in parameters **P-0-0147, Expanded signal K1 address** and **P-0-0148, Expanded signal K2 address**. During the recording process, the contents of the selected addresses are saved in the lists of scope data.

Note: If a 16-bit data width is selected, then the signal data will be stored as sign-extended 32-bit values.

Oscilloscope feature trigger source

The **P-0-0025, Trigger Source** parameter makes it possible to choose between two trigger types.

External trigger (P-0-0025=0x01)

The trigger is activated by the control through bit 0 in **P-0-0036, Trigger Control Word**. This makes it possible to transmit a trigger event to several drives. This parameterization supports parameter **P-0-0035, Delay from trigger to start** which is needed to visualize the recording data.

Internal trigger (P-0-0025 = 0x02)

Triggering occurs through the monitoring of the parameterized trigger signal. If the selected edge is recognized, then the trigger will be released. Parameter **P-0-0035, Delay from trigger to start** will be set to zero.

Selection of trigger edges

Various trigger edges can be selected with the parameter **P-0-0030, Trigger Edge**. The following options are available:

Number	Trigger edge
1	Triggering on the positive edge of the trigger signal
2	Triggering on the negative edge of the trigger signal
3	Triggering on both the positive and negative edge of the trigger signal
4	Triggering when the trigger signal equals the trigger level

Fig. 10-13: Trigger edge selection

Selection of fixed trigger signals

The parameter **P-0-0026, Trigger Signal Selection** determines the signal that is monitored for the parameterized edge reversal. Just as for the signal selection, there are drive-internal fixed trigger signals for the trigger signal selection. These are activated by entering the corresponding number.

The following signal numbers are possible:

Trigger signal number	Trigger signal	Associated trigger level
0x00	no trigger signal	not defined
0x01	Position feedback value according to active operating mode	Position data (P-0-0027)
0x02	Velocity feedback value Parameter S-0-0040	Velocity data (P-0-0028)
0x03	Velocity deviation Parameter S-0-0347	Velocity data (P-0-0028)
0x04	Following error Parameter S-0-0189	Position data (P-0-0027)
0x05	Torque command value Parameter S-0-0080	Torque data (P-0-0029)
0x06	Position feedback 1 value S-0-0051	Position data (P-0-0027)
0x07	Position feedback 2 value S-0-0053	Position data (P-0-0027)
0x08	Position command value S-0-0047	Position data (P-0-0027)
0x09	Velocity command value Parameter (S-0-0036)	Velocity data (P-0-0028)

Fig. 10-14: Selection of fixed trigger signals

Selection of expanded trigger signals

In addition to a trigger signal selection with preset signals, the drive also allows for triggering on any internal signal. Use of this feature makes sense only with information about the structure of the internal data memory; therefore, this feature can be used effectively only by the respective developer. This feature can be activated with the parameter **P-0-0026, Trigger Signal Selection** by setting bit 12.

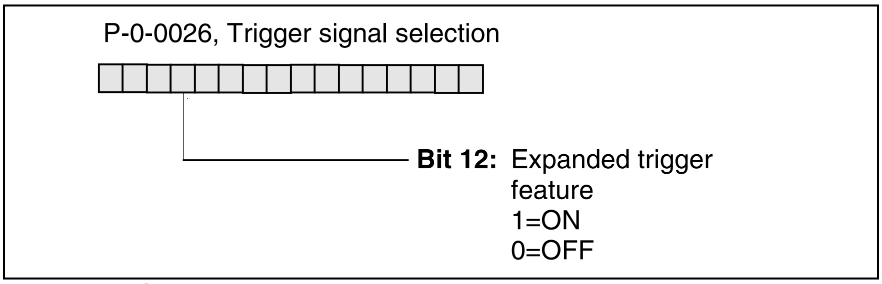


Fig. 10-15: Structure of parameter P-0-0026

If the expanded trigger feature is activated, then the trigger signal address must be defined via the parameter **P-0-0146, Expanded Trigger Address**. The associated trigger level is entered in the parameter **P-0-0145, Expanded Trigger Level**. This parameter is defined as follows:

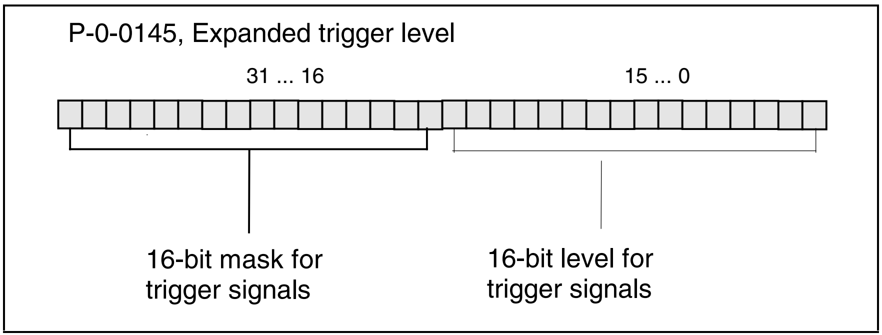


Fig. 10-16: Structure of parameter P-0-0145

The 16-bit value of the trigger level is monitored the trigger signal being ANDed before by means of the trigger signal mask.

Parameterizing time resolution and size of memory

The recording ranges for the oscilloscope feature can be defined with parameters **P-0-0031, Timebase** and **P-0-0032, Size of Memory**. The maximum size of memory defined is 512 measured values. If you need fewer measured values, you can change the value in the memory size parameter.

The time resolution can be set from 500 µs to 100 ms in steps of 500 µs. This determines the time intervals in which the measured values are recorded. The minimum recording duration is 256 ms, the maximum recording duration is 51.2 s.

In general:

$$\text{Recording duration} = \text{Time resolution} \times \text{Size of Memory}\,[\mu s]$$

Fig. 10-17: Determining the recording duration

Setting the trigger delay

By setting the parameter **P-0-0033, Number of Samples after Trigger**, it is possible to record measured values before the trigger event occurs (trigger delay function of an oscilloscope). The setting is made in units of the parameterized time resolution. The input value determines the number of probe values still recorded after a trigger event. By entering 0 [time resolution], only data available before a trigger event will be recorded. If the value of parameter **P-0-0032, Size of Memory** is entered, then only the measured values occurring after the trigger event will be recorded.

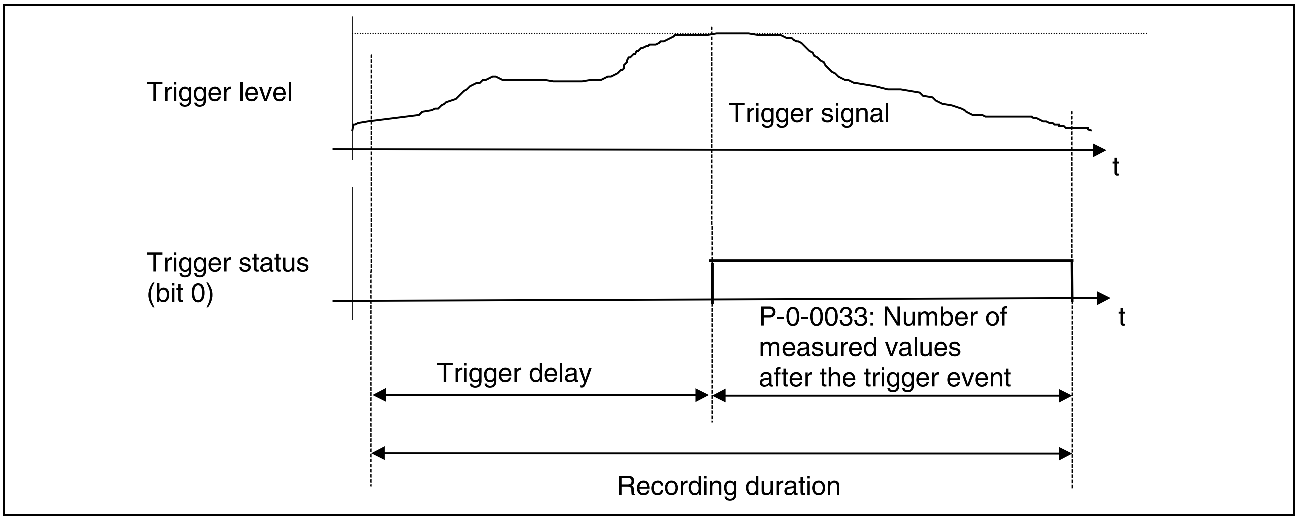


Fig. 10-18: Trigger delay - Number of measured values after trigger event

Activating the oscilloscope feature

The oscilloscope feature can be activated with the parameter **P-0-0036, Trigger Control Word**. The parameter is defined as follows:

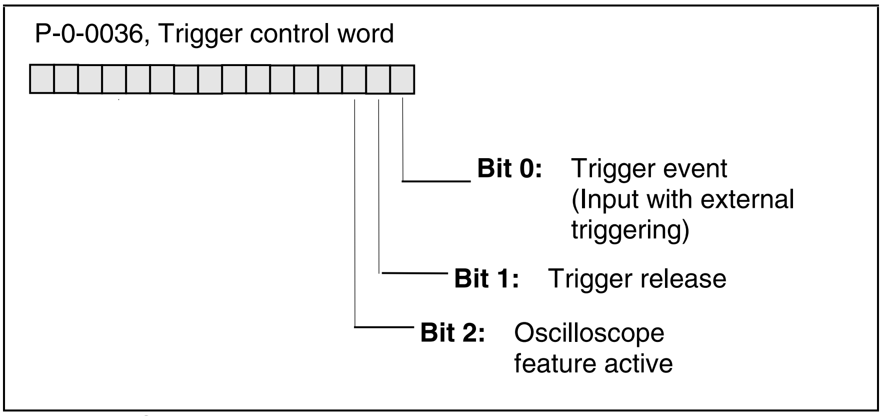


Fig. 10-19: Structure of parameter P-0-0036

The oscilloscope feature is activated by writing "1" to bit 2, i.e. the selected measurement signals are continuously written to the internal probe value memory. If bit 1 is set, then the trigger monitor is activated and the oscilloscope feature waits for the selected edge to occur. If a valid edge is recognized, then the probe value memory will be completed as set in parameter P-0-0033, and the oscilloscope feature will be deactivated by resetting bits 1 and 2 in the trigger control word.

Oscilloscope feature with external trigger and internal trigger condition

If triggering is selected in parameter **P-0-0025, Trigger Source** with the control bit of the trigger control word, then the trigger will only be released with the 0→1 (rising) edge of bit 0 in the trigger control word.

With this drive, it is also possible to monitor a trigger signal for the trigger condition. If the trigger condition is recognized, then bit 0 will be set in the trigger status, but the trigger will not be released. In this way, it is possible to signal the trigger event for several drives simultaneously using the real-time status and control bits via the control, and to release the trigger.

Since there is a delay between the recognition of the trigger event and the release of the trigger, caused by the transmission of the trigger event via the control, the delay is measured by the drive and stored in the parameter **P-0-0035, Delay from Trigger to Start**. A time-correct display of the signals can be guaranteed by using this parameter for the visualization of the measured values.

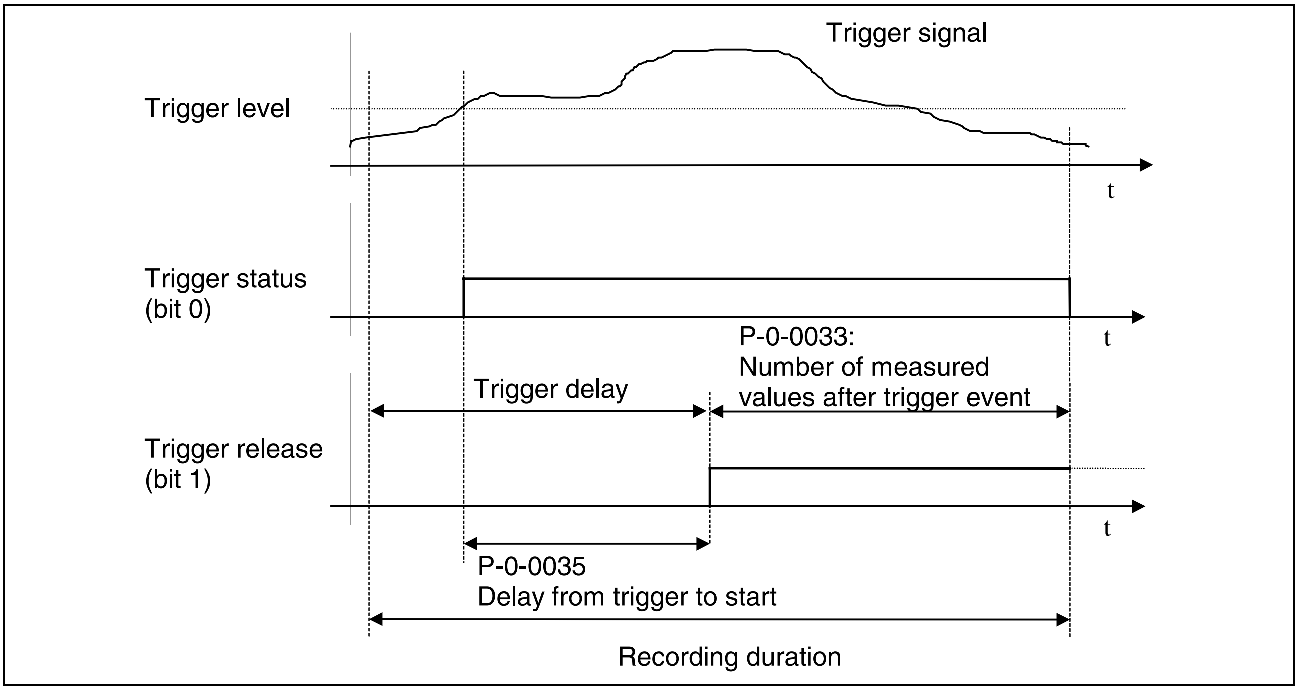


Fig. 10-20: Delay from trigger to start

Status messages for the oscilloscope feature

Information about the status of the oscilloscope feature is shared with the control by means of parameter **P-0-0037, Trigger Status Word**.

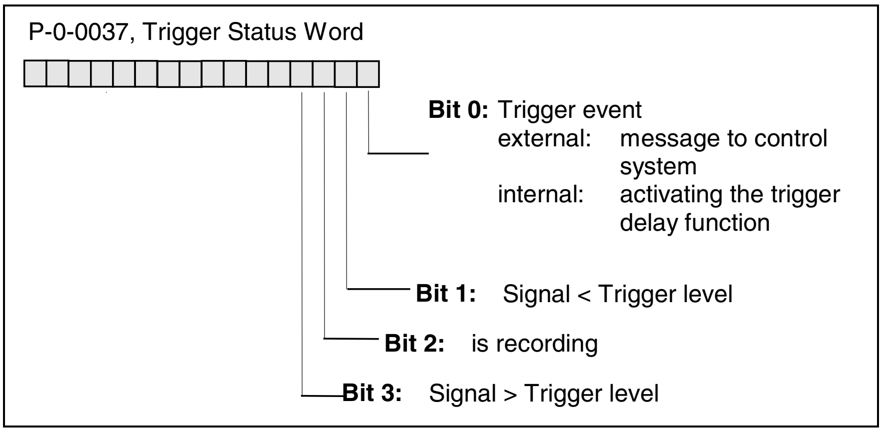


Fig. 10-21: Structure of parameter P-0-0037

Number of valid measured values

As soon as bit 2 is set by the **P-0-0036, Trigger Control Word**, the drive starts recording measured values.

If the trigger event is recognized after the bit is set, the oscilloscope feature records the number of measured values after the trigger event and then stops recording.

The total probe value memory for the current measurement will not always be written, dependent on the memory size setting, the time resolution, the number of measured values after the trigger event and the time when the trigger event occurs; this means that the memory contains measured values which are not valid for this measurement.

The parameter P-0-0150, Number of valid Samples indicates the number of valid measured values for the current recording.

10.7 Probe input feature

There are two digital inputs available for measuring positions and times. The measurands are fixed at the time of the positive and negative edges.

The following measured values can be determined:

- position feedback value 1
- position feedback value 2
- relative internal time in [µs]
- master axis position
- position feedback value 3

Note: The probe inputs are scanned every 1 µs. The measured signals are only generated every 500 µs. Linear interim interpolation takes place between these two scanning steps with an accuracy of 1 µs.

Both the absolute values at the time the positive or negative edges occur as well as their difference can be read via parameters.

Pertinent parameters probe analysis

- **S-0-0170, Probing cycle procedure command**
- **S-0-0169, Probe control parameter**
- **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-0-0179, Measurement value 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**

- **P-0-0200, Signal select probe 1**
- **P-0-0201, Signal select probe 2**
- **P-0-0202, Difference probe values 1**
- **P-0-0203, Difference probe values 2**
- **P-0-0204, Start position for active probe**
- **P-0-0205, End position for active probe**
- **P-0-0224, Probe, number of marker failures**
- **P-0-0225, Probe, IDN list signal selection**
- **P-0-0226, Probe, extended control word**

Main function of the probe analysis

The feature is activated by **S-0-0170, Probing Cycle Procedure Command**. The command change bit is never set, because neither positive nor negative command acknowledgment has been provided for.

To activate the feature, "3" must be written to parameter **S-0-0170, Probing Cycle Procedure Command**. Doing this,

- the data status of **S-0-0170, Probing Cycle Procedure Command** is set to "7", i.e. command being processed.
- all measured values and measured value differences are set to "0".
- all "probe latched" parameters are cleared.
- the monitor of the external voltage is activated (if it has not been activated before).

From this point on, the status of the probe signals will be displayed in the parameters

- **S-0-0401, Probe 1**
- **S-0-0402, Probe 2**

A probe input is enabled with parameters

- **S-0-0405, Probe 1 Enable** or
- **S-0-0406, Probe 2 Enable**

With a 0-1 switch of the signal, the trigger mechanism is activated to evaluate the positive and/or negative edge of the probe signal.

In parameter **S-0-0169, Probe control parameter** you have to set which probe inputs are evaluated and whether positive and/or negative edges are evaluated.

From this point on, when a probe signal edge is recognized, the selected signal will be stored in the positive or negative probe value parameter and, at the same time, the difference between the positive probe value and the negative probe value will be computed and saved in the probe value difference parameter.

The status messages

- **S-0-0409, Probe 1 Positive Latched** and
- **S-0-0410, Probe 1 Negative Latched**, or
- **S-0-0411, Probe 2 Positive Latched** and
- **S-0-0412, Probe 2 Negative Latched**

will be incremented accordingly.

When the probe enable is cleared, the status messages

- **S-0-0409, Probe 1 Positive Latched** and
- **S-0-0410, Probe 1 Negative Latched**, or
- **S-0-0411, Probe 2 Positive Latched** and
- **S-0-0412, Probe 2 Negative Latched**

will be cleared.

Note: Only the first positive and the first negative signal edge of the input will be evaluated after the positive edge of the probe enable. For each new measurement, the probe enable must be reset to 0 and then to 1. When the probe enable is cleared, the corresponding "probe latched" parameters are also cleared.

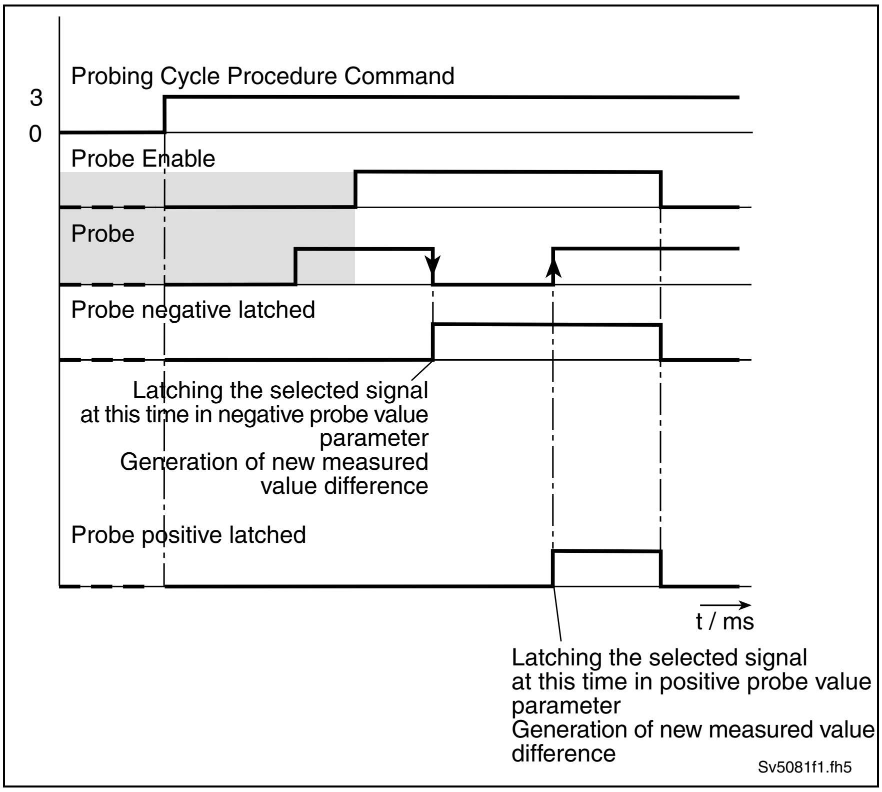


Fig. 10-22: Evaluation of probe signal edges, when positive and negative signal edge evaluation are set in the probe control parameter

Signal edge selection for the probe inputs

A positive probe value and a negative probe value are available for every probe input. The positive probe value is assigned to the 0→1 (positive) edge of the probe signal, and the negative probe value is assigned to the 1→0 (negative) edge. The **S-0-0169, Probe Control Parameter** determines whether both occurring edges will be evaluated and will lead to the measured value being saved in the positive/negative probe value parameter.

Before activating this feature, data should be written to the parameter.

Structure of the parameter:

S-0-0169, Probe Control Parameter

Bit 0: Activating Positive Edge Probe 1
0: positive edge is not analyzed
1: positive edge is analyzed

Bit 1: Activating Negative Edge Probe 1
0: negative edge is not analyzed
1: negative edge is analyzed

Bit 2: Activating Positive Edge Probe 2
0: positive edge is not analyzed
1: positive edge is analyzed

Bit 3: Activating Negative Edge Probe 2
0: negative edge is not analyzed
1: negative edge is analyzed

Bit 5: Enable Mode Probe 1
0: **Single measurement**, after each measurement, another measurement must be released with a 0-1 edge of the enable.
1:**Continuous measurement**, the measurement is done as long as the enable stays 1.

Bit 6: Enable Mode Probe 2
0: **Single measurement**, after each measurement, another measurement must be released with a 0-1 edge of the enable.
1: **Continuous measurement**, the measurement is done as long as the enable stays 1.

Fig. 10-23: Structure of Parameter S-0-0169, Probe control parameter

Signal selection for the probe inputs

Parameter **P-0-0225, Probe, IDN list signal selection** contains the IDNs of the parameters that are available as measuring signals.

- position feedback value 1 (motor encoder)
- position feedback value 2 (optional encoder, if available)

The selection is made via parameters **P-0-0200, Signal select probe 1** and **P-0-0201, Signal select probe 2**.

Value of P-0-0200/P-0-0201	Signal
0	for time
S-0-0051	position feedback value 1
S-0-0053	position feedback value 2

Fig. 10-24: Probe function determining signals for probe 1

Depending on this choice, the units and decimal places of the parameters positive probe value, negative probe value, measured value difference, start position for active probe and end position for active probe of the relevant probe are switched.

Time measurement

For time measurement, bit 2 must be set in parameter **P-0-0226, Probe, extended control word**. Signal selection is irrelevant in this mode. Time intervals between 2 ms and approx. 200 s can be measured with microsecond-precision.

Continuous measurement

Enable mode is activated with bits 5 and 6 in **S-0-0169, Probe control parameter**.

If a probe edge is detected, then the value of the relevant "probe latched" parameter is incremented (see following list).

- **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**

By configuring this or these parameters in the cyclical feedback value telegram of the drive together with the relevant measured value itself, the information as to whether a new measured value is latched or not is available in the next interface cycle of the control. If a probe edge was detected, then the next measurement of this edge is automatically enabled in the drive as long as the relevant probe enable parameter

- **S-0-0405, Probe 1 enable** or
- **S-0-0406, Probe 2 enable**

has not been cleared.

Note:	Only one probe event can be latched per millisecond!

Measurement with expectation window

In parameter **P-0-0226, Probe, extended control word** it is possible to activate the measurement with expectation window.

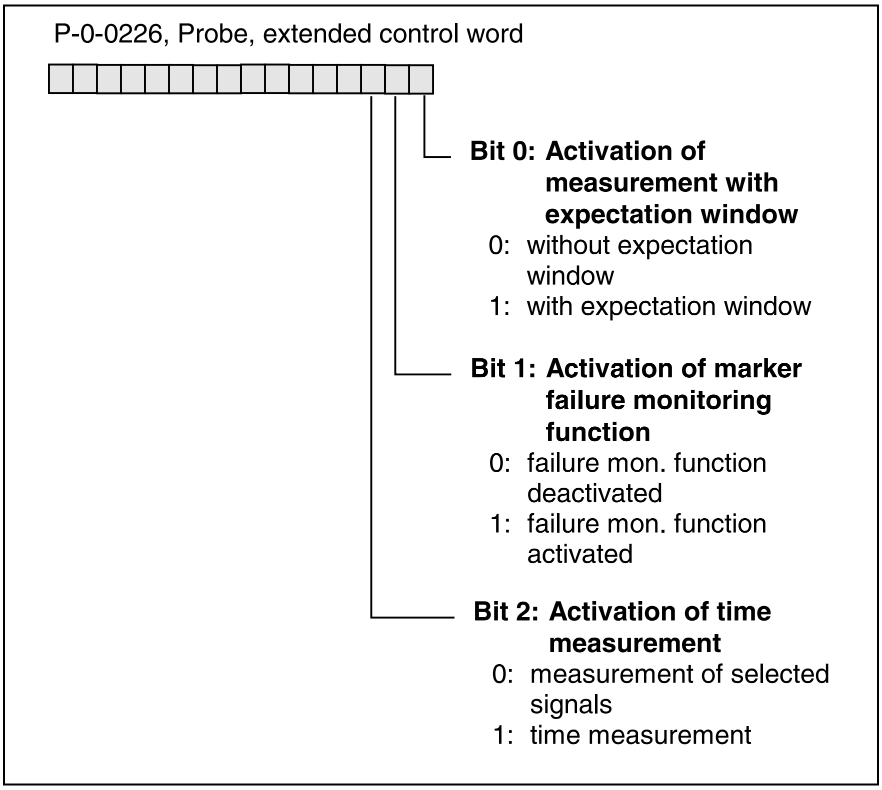


Fig. 10-25: P-0-0226, Probe, extended control word

Expectation window

For probe 1 there is the possibility to define that the measuring signal is only detected, if it is within a defined range. This range (expectation window) is defined by parameters

- **P-0-0204, Start position for active probe** and
- **P-0-0205, End position for active probe**.

Marker failure monitoring function

In conjunction with the expectation window a marker failure monitoring function can be activated for probe 1. If the selected signal passes through the complete expectation window without the probe event occurring, parameter **P-0-0224 Probe, number of marker failures** is incremented.

The monitoring function requires a minimum width for the expectation window of:

$$X_{min} = \frac{V_{max}}{60 * 500e^{-6} 360°}$$

X_{min}: minimum angle of the signal to be measured
V_{max}: maximum velocity of the measuring signal

The monitoring function requires a maximum width for the expectation window of:

$$X_{max} = \text{modulo value} - X_{min}$$

X_{min}: minimum angle of the signal to be measured
X_{max}: maximum angle of the signal to be measured

As soon as a probe event occurs within the expectation window, the failure counter is cleared. Probe events that occur outside the expectation window do not clear the failure counter.

When the probe enable is cleared, the failure counter is also cleared.

Connecting the probe inputs

see Project Planning Manual ECODRIVE03 respectively DURADRIVE.

10.8 Positive stop drive procedure

The command **S-0-0149, D400 Positive stop drive procedure** turns off all controller monitors that would lead to an error message in Class 1 Diagnostics during the blocking of a drive during a fixed limit stop.

If the command is started, the drive generates the diagnostic message **D400 Positive stop drive procedure command**.

The controller monitors are switched off in all drive operating modes.

If there is a Class 1 Diagnostics error message at the start of the command, the error **D401 ZKL1-Error at command start** will be generated.

The drive will acknowledge the command as properly executed when:

- the controller monitors are switched off
- $|Md|$ (S-0-0084) >= $|Md_{Limit}|$ (S-0-0092) and
- $n_{feedback} = 0$

Note: The message ‘$n_{feedback} = 0$’ is influenced by the parameter **S-0-0124, Standstill Window**.

If the command is cancelled by the control after execution, then all regular controller monitors are reactivated.

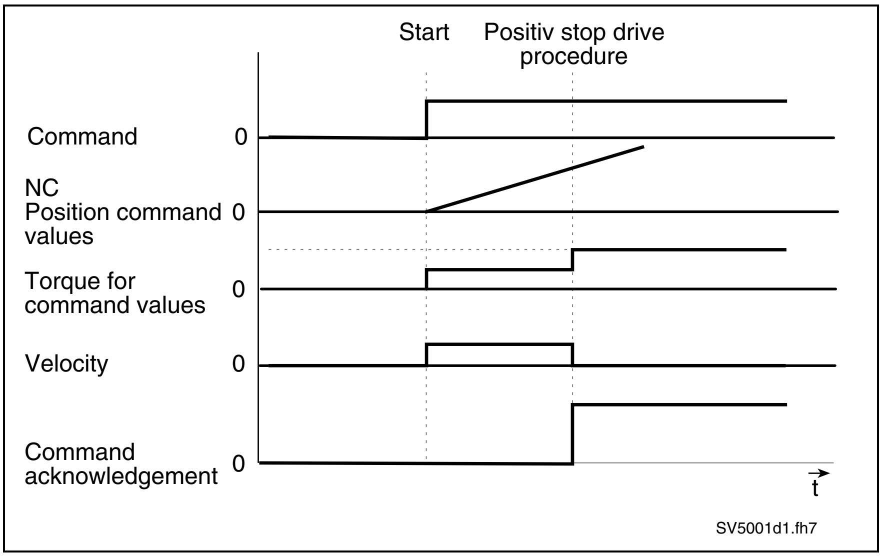


Fig. 10-26: Time sequence when activating the command: Positive stop drive procedure

10.9 Command - Detect marker position

The command "Detect marker position" supports

- the control of an error free detection of the reference marker in an incremental measuring system or
- the determination of the position of the reference marker, if the homing procedure is conducted by the control. In this case, this information is used to switch the coordinate system in the control.

A home switch evaluation is not run with this command.

The following parameters are provided for this function:

- **S-0-0173, Marker position A**
- **P-0-0014, D500 Command determine marker position**

Functional principle of command detect marker position

Once the command **P-0-0014, D500 Command determine marker position** is started, the following is done:

- The diagnosis **D500 Command Get mark position** is generated.
- If an incremental measuring system is selected, then the detection of a reference marker is activated, and the drive waits for the next reference marker.
- If a reference marker is detected, i.e. the position of a reference marker has been run over, then its position feedback value is stored in parameter **S-0-0173, Marker position A**. This command is now signaled as completed.

Note: The drive generates no command values. The mode active at command start remains unchanged. To overrun the reference marker, the control must generate command values (e. g. by jogging) that cause a motion in the direction in which the reference marker is to be detected.

Additional uses of parameter S-0-0173, Marker position A

In parameter **S-0-0173, Marker position A**, the position of the reference marker is also stored during the command **S-0-0148, C600 Drive controlled homing procedure command**. It relates, however, to the "old" coordinate system (before the coordinate system was switched while performing a homing function).

10.10 Command parking axis

The command "Parking axis" is used to uncouple an axis. This may, for example, be necessary if an axis is temporarily brought to a standstill. The start of the command switches off all monitoring functions of the measuring system and the control loops.

Pertinent parameters

- **S-0-0139, D700 Command parking axis**

Functional principle

The command may only be started without drive enable.

If the command is activated with drive enable applied, then the drive generates command error **D701 Park axis only without drive enable**.

After starting command **S-0-0139, D700 Command parking axis**:

- the measuring system monitors,
- the control loop monitors and
- the temperature monitors

are deactivated.

The measuring system initializations are conducted at the end of the command. This means all initializations as with command **S-0-0128, C200 Communication phase 4 transition check** are conducted. The 7-segment display reads "**PA**“.

This drive no longer accepts the drive enable.

10.11 Programmable limit switch

The "Programmable limit switch" feature allows realizing 16 dynamic position switch points.

An individual switch-on and switch-off position and a lead time are available for each position switch point.

Reference signal for the limit switch

The reference signal for the limit switch can be selected:

- **S-0-0047, Position command value**,
- **S-0-0051, Position feedback 1 value**,
- **S-0-0053, Position feedback 2 value**,
- **P-0-0052, Position feedback value 3** or
- **P-0-0053, Master drive position**.

The corresponding limit switch bit can be inverted depending on how the switch-on and switch-off threshold is set.

Note: A switch cam is generated every 1 ms. The total cycle time is the result of: $T_{total\ cycle}$ = number of cams*1 ms. When parameterizing all 16 cams, the total cycle time is 16 ms.

Pertinent parameters

- **P-0-0131, Signal select position switch**
- **P-0-0132, Switch on threshold position switch**
- **P-0-0133, Switch off threshold position switch**
- **P-0-0134, Position switch lead times**
- **P-0-0135, Status position switch**
- **P-0-0603, Position switch, control word**

Function diagram for the programmable limit switch

This feature shows whether the selected reference signal lies within the range between the switch-on and switch-off position.

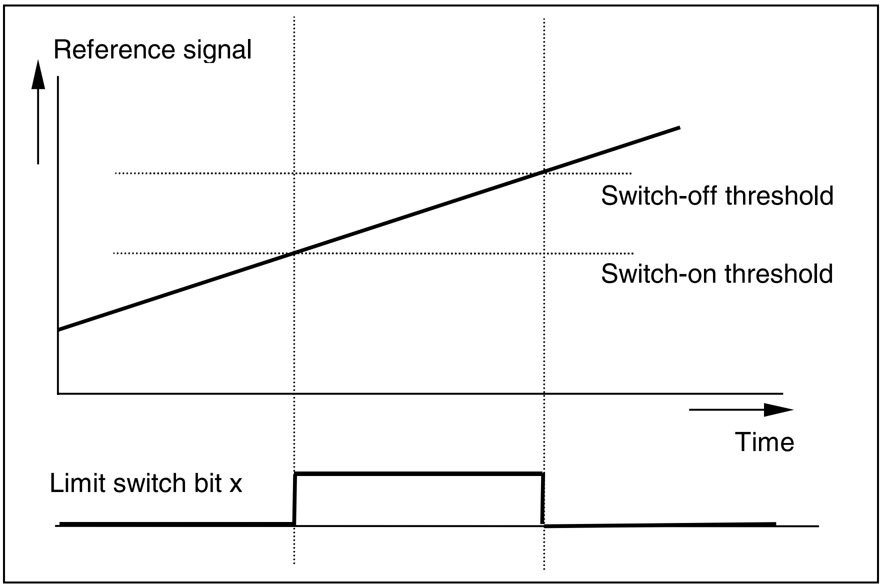


Fig. 10-27: General function diagram for the programmable limit switch

The corresponding bit in the limit switch status word can be inverted by setting the switch-on and switch-off threshold.

There are two different situations that apply.

Switch-on threshold smaller than switch-off threshold

If the switch-on threshold has been programmed with a value smaller than the switch-off threshold, then the following applies:

The limit switch bit is "1" if:

- Reference signal > X_{on}

AND

- Reference signal < X_{off}

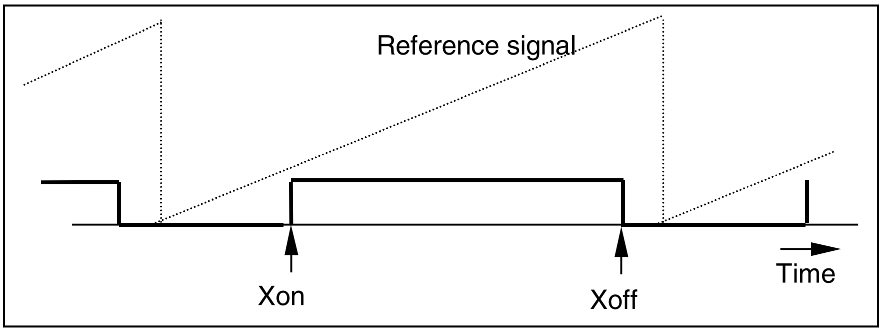


Fig. 10-28: Limit switch bit with $X_{on} < X_{off}$

Switch-on threshold greater than switch-off threshold

The limit switch bit is "1" if:

- Reference signal > X_{on}

OR

- Reference signal < X_{off}

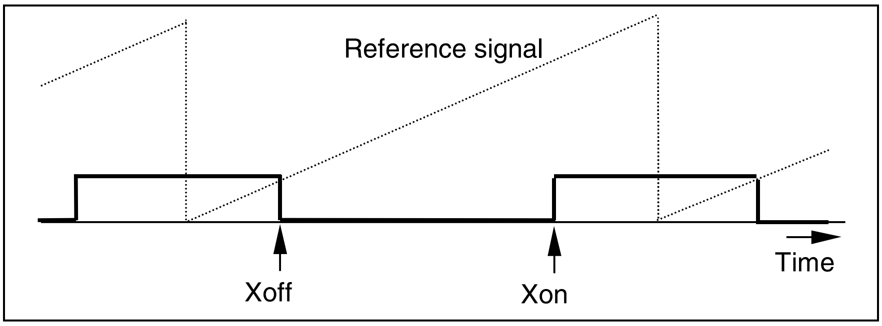


Fig. 10-29: Limit switch bit with $X_{on} > X_{off}$

A switch hysteresis is available to avoid limit switch bit flickering when the switch-on or switch-off threshold is reached.

Limit switch lead time

By setting a lead time, compensation can be made for the delay of an external switch element that is controlled by a limit switch bit. In that way, a theoretical adjustment value for the respective switch-on and switch-off thresholds is calculated from the programmed lead time and the current drive velocity. The limit switch bit switches by the lead time before reaching the corresponding threshold.

Note: When using a lead time, the velocity of the drive should be constant in the range between the theoretical and actual switch-on or switch-off threshold.

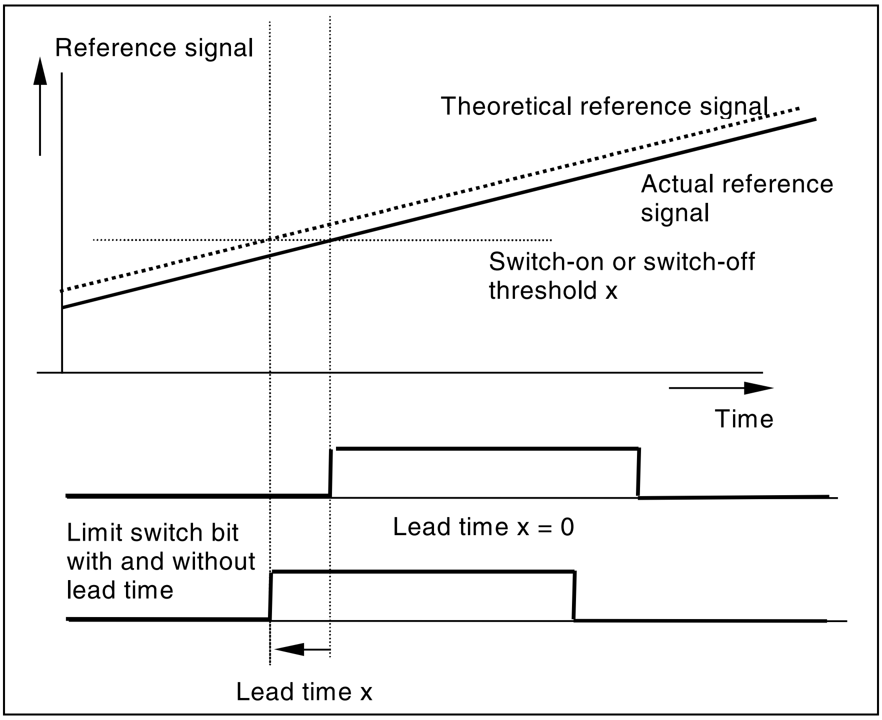


Fig. 10-30: Function diagram for the limit switch lead time

Direction-dependent cam

Every cam can take effect depending on the direction of travelling. When bit 0 = 1 has been parameterized in parameter **P-0-0603, Position switch, control word**, the cam only takes effect, if the velocity of the reference position is greater than zero. With bit 1=1 in parameter **P-0-0603, Position switch, control word**, the cam only takes effect, if the velocity of the reference position is smaller than zero. With bit 0 and bit 1=0, the cam is active in both directions. If the velocity is opposed to the selected effective direction, the cam status is cleared. If the reference position equals the cam position, the cam status is maintained.

Note: If the reference position is the position feedback value, the cam status is not unequivocal, if the reference position equals the cam position (feedback value noise).

Parameterizing the limit switch

The **P-0-0131, Signal select position switch** parameter is used to activate the limit switch and to select a signal. The following values can be entered:

P-0-0131	Feature
0	The limit switch is not activated
1	The limit switch is activated, the reference signal is **S-0-0051, Position feedback 1 value**
2	The limit switch is activated, the reference signal is **S-0-0053, Position feedback 2 value**
3	The limit switch is activated, the reference signal is **S-0-0047, Position command value**
4	The limit switch is activated, the reference signal is **P-0-0052, Position feedback value 3**
5	The limit switch is activated, the reference signal is **P-0-0053, Master drive position**

Fig. 10-31: Limit switch: activating and setting the reference signal

The list parameters **P-0-0132, Switch on threshold position switch**, **P-0-0133, Switch off threshold position switch** and **P-0-0134, Position switch lead times** can be used to set the switch-on and switch-off thresholds, as well as the lead times.

Each of these parameters contains 16 elements. Element 1 is provided for limit switch bit 1, element 2 for bit 2, and so forth.

Note: Parameter **P-0-0134, Position switch lead times** always should be parameterized completely, i. e. with all 16 elements, even if not using the lead time.

Note: Depending on the resolution of the measuring system, there must be a minimum distance between the switch-on and switch-off thresholds of the switch cams, because an internal switch hysteresis is available. For an MKD025 with resolver, for example, this distance is at least 0.4°.

The status of each limit switch bit is displayed in parameter **P-0-0135, Status position switch**.

10.12 Encoder emulation

By means of encoder emulation it is possible to output positions in the following standard formats

- **TTL format** with incremental encoder emulation
- **SSI format** with absolute encoder emulation.

This allows closing the position control loop with an external control.

Incremental encoder emulation

Incremental encoder emulation is the simulation of a real incremental encoder by the drive controller.

By means of the incremental encoder signals, a higher-level numeric control (NC) receives information about the velocity of the motor mounted to the controller. By integrating these signals, the control generates information about position and is thus able to close a higher-level position control loop.

Absolute encoder emulation

Absolute encoder emulation means that the drive controller has the option of simulating a real absolute encoder in SSI data format. The drive controller thus offers the possibility of transmitting the position in SSI data format to the connected control (NC). Thus the control is able to close the position control loop.

Pertinent parameters

- **P-0-4020, Encoder emulation type**
- **P-0-0502, Encoder emulation, resolution**
- **P-0-0012, C300 Command Set absolute measurement**

For **incremental encoder emulation**, parameter

- **P-0-0503, Marker pulse offset**

is used additionally.

For **absolute encoder emulation** parameters

- **S-0-0076, Position data scaling type**
- **S-0-0052, Reference distance 1**
- **S-0-0051, Position feedback 1 value**
- **S-0-0053, Position feedback 2 value**
- **S-0-0047, Position command value**
- **P-0-0053, Master drive position**
- **P-0-0052, Position feedback value 3**
- **S-0-0121, Input revolutions of load gear**
- **S-0-0122, Output revolutions of load gear**
- **S-0-0123, Feed constant**

are used additionally.

Activating encoder emulation

It is possible to define the behavior of the function with the help of parameter **P-0-4020, Encoder emulation type**.

P-0-4020, Encoder emulation type

Bit 1-0: Selecting the emulation type
0 0: no output
0 1: incremental encoder emulation
1 0: absolute encoder emulation

Bit 4: Dead time compensation
0: dead time compensation is switched off
1: dead time compensation is active

Bit 10-8: Selecting the emulated position
0 0 0: output of the position of the motor encoder
0 0 1: output of the position of the optional encoder
0 1 0: output of the position command value (S-0-0047)

All other bit positions are always 0.

Fig. 10-32: Parameter P-0-4020, Encoder emulation type

Functional principle: incremental encoder emulation

Number of lines

The number of lines of the emulated incremental encoder is fixed in parameter **P-0-0502, Encoder emulation, resolution**:

- 1 to 65536 (=2^16) lines / revolution

Note: If a motor with resolver feedback is mounted, then the emulator outputs as many zero pulses per mechanical revolution as the resolver has pairs of poles. It must therefore be noted that the input for **P-0-0502**, **Encoder emulation, resolution** must be divisible by the number of resolver pole pairs without a remainder, otherwise the zero pulse will "run away".

Unit

The parameter unit depends on the motor type

- rotary motors: **lines / revolution**
- linear motors: **lines / mm** or **lines / inch**

Position of the zero pulse as relates to motor position

Absolute encoder

With motor encoders that achieve an absolute, unequivocal position within one motor revolution after initialization, or within one electrical revolution with resolvers, the zero pulse is always output at the same motor position each time the drive controller is switched on.

Relative encoder

Since with relative encoders there is no unequivocal position after powering up, it is necessary to home. Homing uses the incremental encoder emulator zero pulse.

With relative encoders (e.g. sine encoders, gearwheel encoders) the following occurs automatically with each progression of phases 2 to 4 (this means also after powering up the drive controller):

- The detection of the motor encoder internal reference point is activated.
- The zero pulse output of the incremental encoder emulator is locked.
- The increment output is activated.

It is assumed that the motor is now run via the position control loop of the control (referencing, going to zero or homing).

Drive-controlled homing

The drive can also conduct drive-controlled homing, if the control permits it.

As soon as the motor encoder internal reference point is detected, the following is conducted:

- general release of zero pulse output.
- immediate output of a zero pulse by the emulator.
- initialization of zero pulse so that it is always output at this absolute motor position.

Note: The output of the zero pulse occurs after homing is successfully completed. It is then output at always the same position (reference mark).

Zero pulse offset

With rotary motors it is possible to offset the zero pulse using **P-0-0503, Marker pulse offset** within an electrical or mechanical revolution in a clockwise direction.

The unit of P-0-0503 is degrees. The input range for motor encoders that, after their initialization, have an absolute, unequivocal position within a motor revolution, is 0..359.9999 degrees.

The input range for **resolvers** with an absolute, unequivocal position within an electrical revolution is 0..359.9999 degrees / number of pole pairs.

Restrictions with incremental encoder emulation

In contrast to the conventional incremental encoder with which the pulse output frequency is practically infinitely separated into very fine increments (i.e. the pulse edges are always allocated to fixed positions), emulated incremental encoder signals are subject to certain restrictions. These are primarily the result of how the digital process of the drive controller works.

Maximum output frequency

The maximum pulse frequency is 1024 kHz. If this frequency is exceeded, then pulses can be missing. The error **F253 Incr. encoder emulator: pulse frequency too high** is generated. A position offset of the emulated position in contrast to the real position takes place.

$$I_{max} = \frac{f_{max} * 60}{n_{max}}$$

I_{max}: maximum number of lines
n_{max}: allowed maximum speed in 1/min

Fig. 10-33: Computing the maximum number of lines

Compensation of delay (dead time) between real and emulated positions

Between position measurement and pulse output, there is a dead time of about 1 ms. If in parameter **P-0-4020, Encoder emulation type** bit 4 is set to 1, then this time is compensated in the drive.

Pulse breaks at the end of the pulse output cycle

At the end of each time interval the signal levels for a specific period can remain constant. The output frequency cannot be changed during the time interval of T_A. This effect can be observed especially with high frequencies, i. e. with high numbers of lines and/or at high speeds.

Diagnostic messages with incremental encoder emulation

The following diagnoses are generated with incremental encoder emulation:

- **F253 Incr. encoder emulator: pulse frequency too high**

Cause:

The output frequency at the chosen number of lines exceeds the value of 1024 kHz.

Remedy:

- Reduce input for **P-0-0502, Encoder emulation, resolution**
- Reduce travel velocity

Cause:

The output of all lines in the interval is monitored and was faulty in this case so that a position offset occurred. The error occurs only with extremely long interrupt running times.

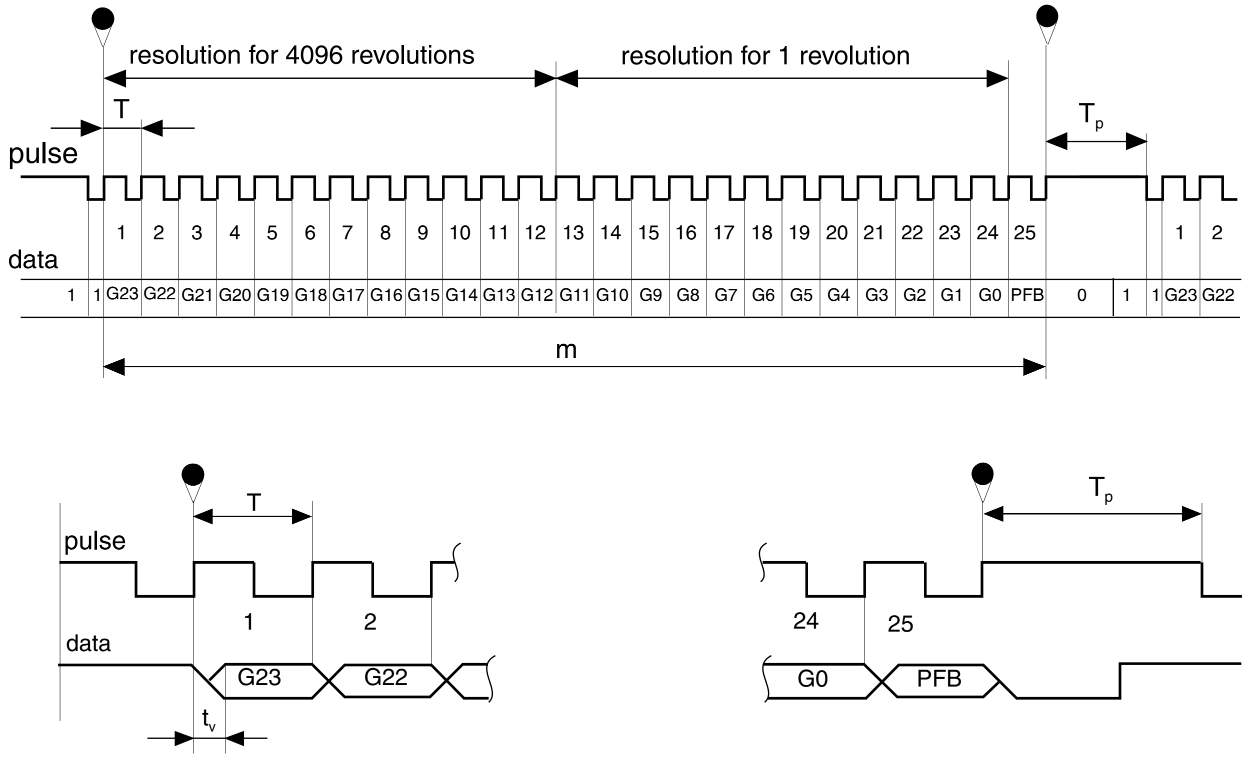
Remedy:

All software options that are not absolutely necessary should be switched off, e. g. the processing of the 2nd analog input, signal output via both analog outputs and so on.

Functional principle: absolute encoder emulation

SSI format

The following figure illustrates the format of SSI data transmission:



G0 = least significant bit in gray code
G23 = most significant bit in gray code
m = stored parallel information
T = pulse time
T_p = pulse break ≥ 20 µs
t_v = delay time max. 650 ns
PFB = power failure bit (not used and always logically LOW)

SV0202F1.FH7

Fig. 10-34: SSI format as pulse diagram

Note: The power failure bit is not generated by the drive!

Emulated position reference

The emulation of the signals "Position feedback 1 value", "Position feedback 2 value" and "Position command value" depends on **S-0-0076, Position data scaling type** and is scaling-dependent.

The values of emulator and parameters **S-0-0051, Position feedback 1 value**, **S-0-0053, Position feedback 2 value** or **S-0-0047, Position command value** are synchronous. This simplifies, among other things, emulation control, e.g. with the DriveTop program.

If **S-0-0076, Position data scaling type** is used to parameterize "motor reference", then an encoder-related emulation is possible.

If the data reference is load-related, then the feed constants and gear ratios must be entered application-specifically.

The values for position feedback value 3 and master axis position are always emulated in encoder-related form. In this case, S-0-0076 is irrelevant.

Resolution with absolute encoder emulation

The output data format (number of bits/revolution) for the emulated SSI position is fixed in parameter **P-0-0502**, **Encoder emulation, resolution**.

The input range and unit depend on **S-0-0076, Position data scaling type**. The following combinations are possible:

- **10 .. 24** bit / revolution
- **4 .. 24** bit / mm
- **8 .. 24** bit / inch

Note: The unit of the parameter is switched accordingly when selecting SSI emulation via parameter **P-0-4020, Encoder emulation type**.

Homing with absolute encoder emulation

Using parameter **P-0-0012, C300 Command Set absolute measurement** it is possible to home the absolute position output by the absolute encoder emulator.

When setting absolute measurement, the value of parameter **S-0-0052, Reference distance 1** is processed.

Position jumps at the display limit of absolute encoder emulation

Using SSI emulation, it is possible to display 4096 revolutions in absolute form. If the display limit has been reached when using SSI emulation, then small fluctuations of the actual position lead to large jumps in the emulated SSI position.

This is the case, for example, with position 0 and 4096 revolutions after.

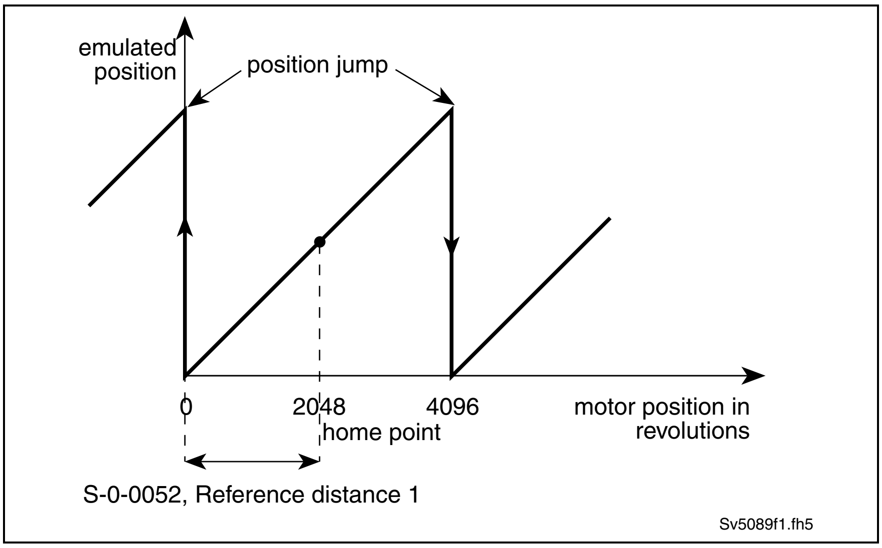


Fig. 10-35: SSI display limit

To avoid this effect, use command **P-0-0012, C300 Command Set absolute measurement** to shift the SSI position value.

It is recommended to move the position to the center of the SSI display range by means of **S-0-0052, Reference distance 1**. This offers the option of running 2048 revolutions to the left and to the right.

10.13 Measuring wheel mode

The measuring wheel mode feature is used with material feed axes (e.g. in sheet-metal machining). By means of a measuring wheel encoder mounted to the material, highly precise material machining is ensured even if some slip occurs between the driving motor and the material itself.

The measuring wheel encoder is only used if material is being machined. See the illustration below.

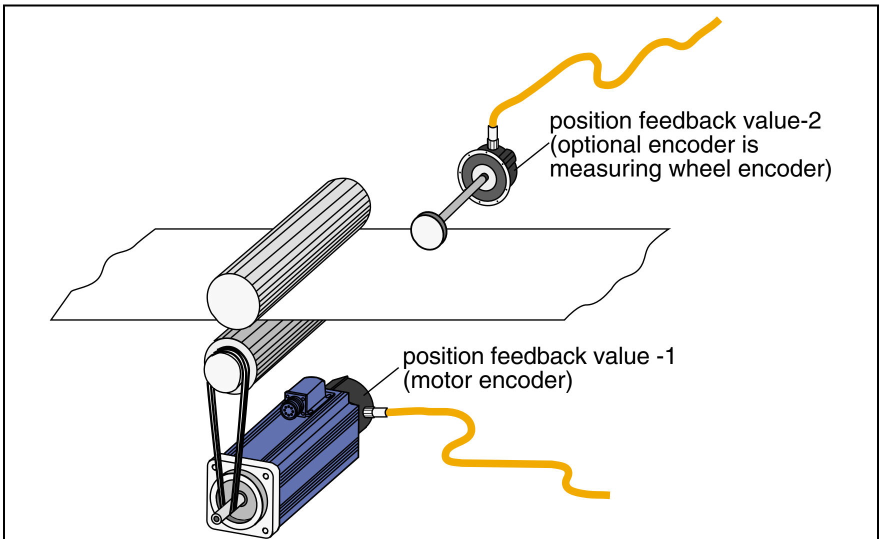


Fig. 10-36: A typical arrangement of drive with measuring wheel encoder

Pertinent parameters

The following parameters are used to parameterize this feature:

- **P-0-0185, Function of encoder 2**
- **P-0-0220, D800 Command Measuring wheel mode**
- **P-0-0221, Actual position filter time const. for measuring wheel mode**
- **S-0-0386, Active Position value**
- **S-0-0391, Monitoring window feedback 2**

Functional principle

The activation of the measuring wheel operation triggers a switching within the drive from control with encoder 1 (motor encoder) to hybrid position control (using the measuring wheel encoder).

The functional principle is illustrated below.

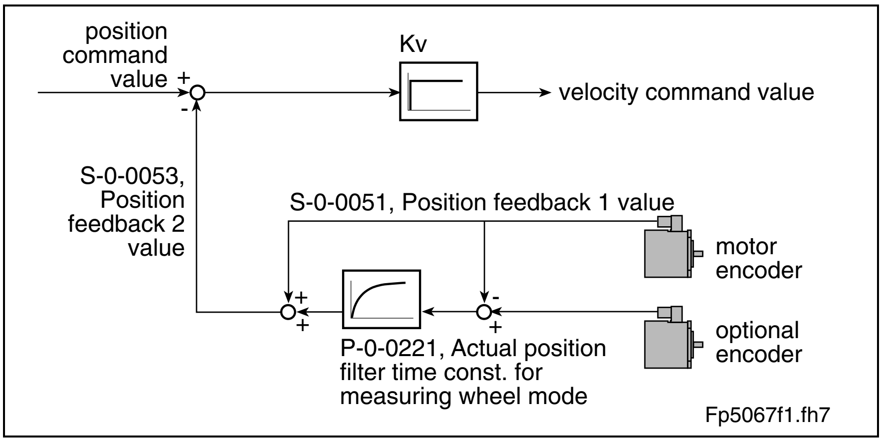


Fig. 10-37: Functional principle of the measuring wheel mode

Any negative effect caused by the poor coupling of encoder 2 to the motor shaft (due to material only) is to be mitigated by attenuating the actual position value differences. The smoothing of this difference is set by means of parameter **P-0-0221, Actual position filter time const. for measuring wheel mode**.

Note: If parameter **P-0-0221, Actual position filter time const. for measuring wheel mode** is parameterized with zero, then only the position feedback value 2 of the optional encoder is used as actual position control value.

Note: The absolute position of both encoders is irrelevant.

Pre-requisites

- The optional encoder must be registered as a measuring wheel encoder in parameter **P-0-0185, Function of encoder 2**.
- There is material in the feed rolls and under the measuring wheel.
- The feed rolls are closed.
- The measuring wheel encoder is pressed up against the material.

DANGER

Uncontrolled motions of the drive if measuring wheel encoder or feed rolls have no contact to the material. The position control loop is then open via encoder 2.

⇒ Only start the measuring wheel mode command, if the encoder 2 has contact to the material.

Activation

The feature is activated with command **P-0-0220, D800 Command Measuring wheel mode**.

The active operating mode determines further drive behavior:

Drive in position control

The drive switches to position control with encoders 1 and 2.

At the start of the command, the drive sets position feedback value 2 (measuring wheel encoder) to position feedback value 1.

Note: If the command is active, the position feedback value of encoder 1 is set to the value of encoder 2 when switching to an operating mode that is not position-controlled (velocity control, error reaction,...).

Drive not in position control

The position of the measuring wheel encoder is correctly detected. Control, however, uses encoder 1.

Note: If the command is active, the position feedback value of encoder 2 is set to the value of encoder 1 when switching to an operating mode that is position-controlled (e.g. "Drive-controlled positioning").

In certain operating modes, such as velocity control, the feed rolls can be lifted off the material (discharging the feed rolls).

Clearing the command

Position control with the measuring wheel encoder remains active as long as the command is set.

When the command is cleared, the drive sets position feedback value 1 to position feedback value 2 and then switches back to position control with encoder 1.

Note: In parameter **S-0-0386, Active Position value** it is always the active position feedback value that is displayed; i.e. when the "Measuring wheel mode" command is active and the drive is in a position-controlled operating mode, position feedback value 2 is provided in S-0-0386, otherwise position feedback value 1 is provided.

Parameterizing the measuring wheel encoder

A measuring wheel encoder is parameterized with parameters:

- **S-0-0123, Feed constant**
- **S-0-0115, Position feedback 2 type**
- **S-0-0117, Feedback 2 Resolution**

The measuring wheel encoder can only be parameterized as a rotary encoder, if the distance that is covered per encoder revolution corresponds to the feed constant S-0-0123. That means the measuring wheel circumference should correspond to the circumference of the feed rolls.

Measuring wheel encoder parameterized as linear encoder

If this is impossible, the measuring wheel encoder has to be parameterized as a linear encoder.

In this case, enter the encoder resolution as per the following formula:

$$\text{encoder resolution} = \frac{\text{measuring wheel circumference}}{\text{(encoder cycles/revolution)}}$$

Encoder resolution: **S-0-0117, Feedback 2 Resolution**

Fig. 10-38: Encoder resolution if measuring wheel encoder parameterized as linear encoder

In this case, linear encoder (bit 0=1) must be set in parameter **S-0-0115, Position feedback 2 type**.

Diagnostic messages

In conjunction with the measuring wheel mode command the following error message could be generated:

- **D801 Measuring wheel operation not possible**

Position feedback value monitor

As with the measuring wheel operation there is slip between motor encoder and measuring wheel encoder, the position difference between encoder 1 and encoder 2 adds up.

If the position difference monitor has been activated (**S-0-0391, Monitoring window feedback 2** unequal zero), the position difference is cleared after every measuring wheel revolution (or after 500 mm in the case of linear scaling).

When using a measuring wheel encoder, the monitoring window is to be set to the slip that is allowed per measuring wheel revolution. In the case of rotary scaling, the parameter **S-0-0391, Monitoring window feedback 2** refers to the measuring wheel circumference, in the case of linear scaling it refers to 500 mm.

10.14 Master axis generator

Master axis of master axis feedback

Functional principle

In the drive, a synchronous operating mode with "real master axis feedback" must be activated in the drive. The master axis generator is not required. The synchronous operating modes with real master axis feedback directly use position feedback value 3 as a command value.

If several drives, which realize the master axis connection via EcoX, follow a real master axis feedback, the master axis generator has to be activated in the master drive.

Pertinent parameters

- **P-0-0052, Position feedback value 3**
- **P-0-0761, Master axis position for slave axis**
- **P-0-0762, Master axis generator, signal selection list**
- **P-0-0763, Master axis generator, signal selection list**
- **P-0-0768, Master axis generator, status**

Parameter **P-0-0052, Position feedback value 3** has to be configured in parameter **P-0-0763, Master axis generator, signal selection**.

The master axis generator generates **P-0-0761, Master axis position for slave axis** from the position feedback value 3, plus a linear set-up time to compensate the EcoX transmission time.

P-0-0761, Master axis position for slave axis has a fixed resolution of 2^20 increments per revolution. The modulo value is determined by the useable range of the master axis feedback. Therefore, the following applies:

$$0 \leq P-0-0761 \leq P-0-0765 * 2\text{^}20$$

Fig. 10-39: P-0-0761, Master axis position for slave axis

The position status of the master axis feedback is stored in parameter **P-0-0768, Master axis generator, status** and transmitted via EcoX.

Setting the master axis position for slave axis is only possible by means of homing or "Setting absolute measurement" of the master axis feedback.

Master axis of master drive

Functional principle

The master axis position of the slave axis is generated from the position command value, position feedback value 1, position feedback value 2 or position feedback value 3.

The master axis position of the slave axis (P-0-0761) is transmitted to the slave drives via the EcoX bus (for parameterization see command value linkage EcoX master) With the slave drives (EcoX slave), the value is written to parameter **P-0-0053, Master drive position** (for parameterization see EcoX slave). If the slave drives are in a synchronous operating mode with "virtual master axis", these drives follow the master drive.

Pertinent parameters

- **S-0-0051, Position feedback 1 value**
- **S-0-0053, Position feedback 2 value**
- **P-0-0434, Internal Position command value**
- **P-0-0761, Master axis position for slave axis**
- **P-0-0762, Master axis generator, signal selection list**
- **P-0-0763, Master axis generator, signal selection**
- **P-0-0768, Master axis generator, status**

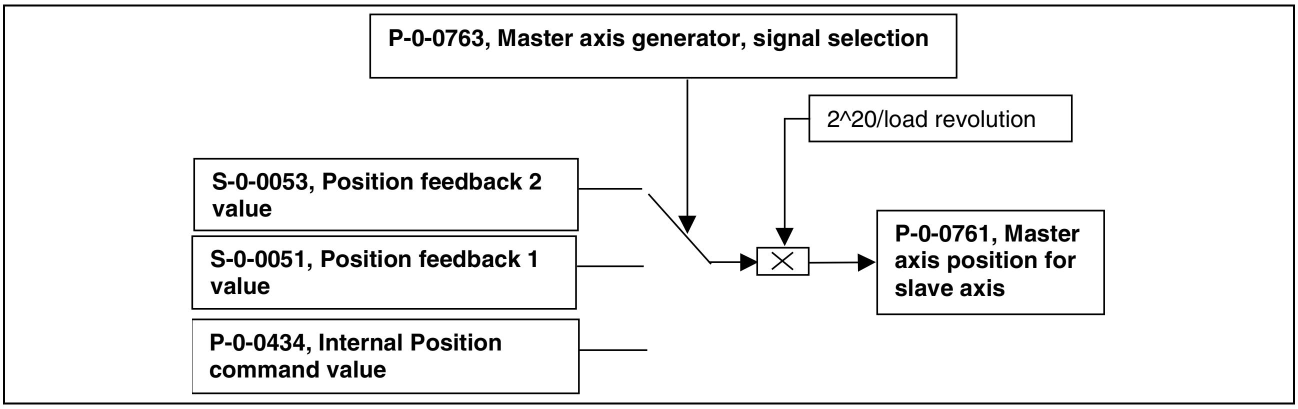


Fig. 10-40: Functional principle

The list of assignable parameters contains the parameters that can serve as the input values for the master axis generator. The parameter number that generates the input value for the master axis has to be entered in parameter **P-0-0763, Master axis generator, signal selection**. The value S-0-0000 switches the master axis generator off.

Data format

The input value is converted to the format of parameter **P-0-0761, Master axis position for slave axis**. **P-0-0761, Master axis position for slave axis** has a fixed resolution of 2^20 increments per load revolution of the master axis.

For rotary axes the following applies:

P-0-0761 = 2^20* /360° * S-0-0051.

Translatory axis:

P-0-0761 = 2^20* /feed constant [mm/rev] * S-0-0051

Display range

In the case of absolute display of the position data (not in the case of position feedback value 3) the range from –2048 revolutions to +2048 revolutions can be displayed unambiguously.

In the case of modulo axes, the master axis position of the salve axis is also displayed within the range of the modulo value.

Setting the master axis position of the slave axis

Setting the master axis position of the slave axis is only possible by means of homing or "Setting absolute measurement" of the respective encoder. The position status of the master drive or the master axis feedback is stored in the master axis generator status parameter bit 0 and transmitted via EcoX.

The transmission time is compensated by a velocity-dependent, linear set-up time in the master axis generator.

Virtual master axis generator

Functional principle

In the case of a virtual master axis generator, the master axis position is not derived from the position of an encoder or real drive, but determined by means of calculation. The virtual master axis generator is a quite simple one. When the enable signal is set, the virtual master axis generator integrates the acceleration limit value until the velocity limit value has been reached. The current velocity is integrated, the result is the master axis position for the slave axis (P-0-0761). When the enable signal is cleared, the velocity is decelerated to zero with **P-0-0772, Master axis generator, deceleration**.

$$P-0-0761=\iint \text{master axis acceleration dt}$$

Fig. 10-41: Virtual master axis generator

Pertinent parameters

- **P-0-0760, Master axis generator, command word**
- **P-0-0761, Master axis position for slave axis**
- **P-0-0765 Range of master encoder**
- **P-0-0768, Master axis generator, status**
- **P-0-0770 Master axis generator, velocity limit**
- **P-0-0771 Master axis generator, acceleration limit**
- **P-0-0772 Master axis generator, deceleration**
- **P-0-0773, Master axis generator, preset position**

Structure of P-0-0760, Master axis generator, command word

With bit 0=1 of parameter **P-0-0760, Master axis generator, command word** the virtual master axis generator is activated, parameter **P-0-0762, Master axis generator, signal selection list** then is irrelevant.

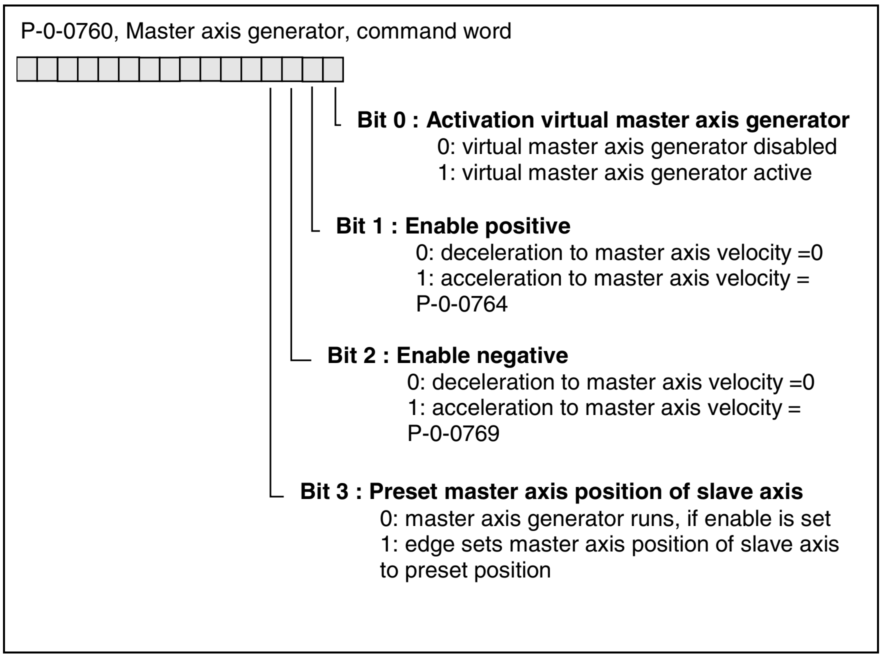


Fig. 10-42: P-0-0760, Master axis generator, command word

P-0-0761, Master axis position for slave axis is limited to the range of the master axis feedback modulo.

Status word

Bit 2 of parameter **P-0-0768, Master axis generator, status** indicates when the master axis generator has reached the command velocity.

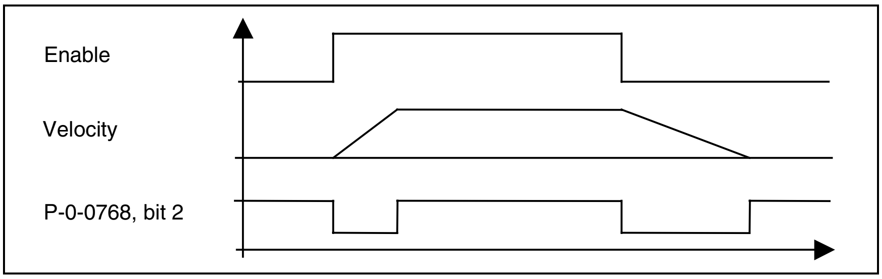


Fig. 10-43: P-0-0768, Master axis generator, status

10.15 DISC - Drive macros

DISC is a function that allows integrating special drive functions, that are not "hard wired" in the drive firmware, in the drive controller in the form of drive macros.

The drive macros can be loaded to the drive controller via PC by means of commissioning tools (e. g. DriveTop), or by means of program libraries available in the higher-level control unit.

They are executed by means of a **logic task** (only parameter/data linking), **drive task** (also allows drive-controlled motion control) or **event task** (is activated depending on events; is also allowed to carry out drive-controlled motion control).

Possible use of the drive macros:

- more variable error reactions (relative and absolute return motion)
- quick stop when signal at measuring probe input
- extension of existing operating mode (positioning block mode with delay time, ...)
- automatic drive reactions when an event occurs (interruption of the active operating mode, e. g. interruption of cam shaft mode or phase synchronization)
- higher-level process controllers (register controllers, ...)

The drive macros are programmed by Rexroth Indramat and made available in a "library".

10.16 EcoX – Expansion interface for digital drives

Overview

EcoX is the name of an expansion interface. It is a serial, cyclic bus that allows the following functions:

- The synchronization of drives and I/O modules.
- The connection of up to 2 modules, with 16 digital inputs and outputs each, per drive controller.
- The transmission of a command value from one to a maximum of 19 other bus nodes.

 Rexroth Indramat

Pertinent parameters

- **P-0-0110, Parallel output 2**
- **P-0-0111, Parallel input 2**
- **P-0-0112, Parallel output 3**
- **P-0-0113, Parallel input 3**
- **P-0-0430, EcoX configuration**
- **P-0-0431, EcoX command, IDN list of configurable parameters in master**
- **P-0-0432, EcoX command value, configuration**
- **P-0-0433, EcoX command IDN list of configurable parameters in slave**
- **P-0-0435, List of configurable data dig. Input**
- **P-0-0436, List of configurable data dig. Output**
- **P-0-0437, List of EcoX slave drives**

Function

Synchronization and structure of an EcoX bus

The following figure shows a possible stage of expansion of an EcoX bus.

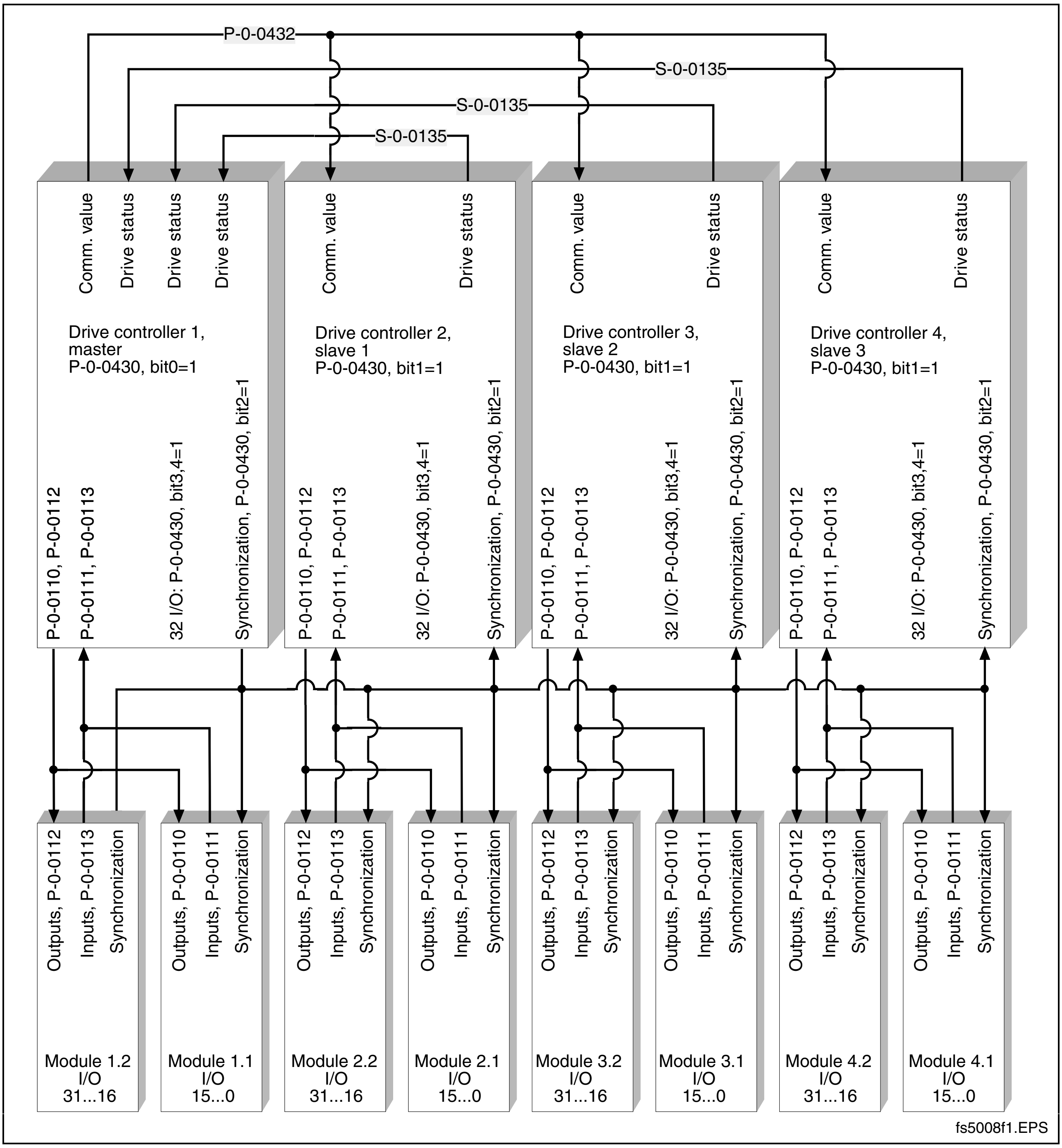


Fig. 10-44: Schematic structure of an EcoX bus (maximum stage of expansion with I/O modules, another 8 slave drives possible)

Note: The maximum number of I/O modules is 8. They can be connected to a maximum of 4 drive controllers. A minimum of 1, a maximum of 2 I/O modules must be connected to the master. The distribution to the other drives is arbitrary.

The settings in parameter **P-0-0430, EcoX configuration** are necessary for data consistency and for precise timing. The following definitions have to be made:

- In all EcoX nodes:
  - Is the node the master or the slave?
  - Are there 0, 1 or 2 I/O modules connected to the respective node?
- In the master: How many slave drive controllers are connected to the EcoX bus?
- In the slaves: Should the drive be synchronized to the EcoX master or to the higher-level communication controller (e. g. SERCOS)?

Synchronization of the EcoX bus

As far as synchronization is concerned, the I/O modules differ from the drives:

- The I/O modules always synchronize to the EcoX master.
- Drive controllers synchronize either to the EcoX master or the higher-level communication controller (e. g. SERCOS).

Note: All EcoX nodes have to be synchronous.

If the drive controller is a slave, it has to be synchronized (either via the master communication or by EcoX).

Note: Only one drive controller of an EcoX bus may be parameterized as a master!

Assignment drive controller ↔ I/O module

An I/O module is assigned to a drive controller by setting the same address at both address switches (I/O module and drive controller). The distinction between I/O modules 1 and 2 is realized by a bridge in the EcoX connector at the EMD module.

Before the I/O modules can be operated, they have to be activated via parameter P-0-0430, bits 3 and 4.

Inputs and outputs

Allocation If all conditions have been fulfilled, parameters P-0-0110 and P-0-0112 are sent to the I/O modules and the inputs in parameters P-0-0111 and P-0-0113 are returned.

Update The inputs and outputs are updated from phase 2 on. From phase 4 on, the I/Os are deterministic and synchronous to the drive controller. Before, the I/O modules are polled.

Cycle time The cycle time of the synchronous I/O modules depends on the number of drive controllers at the bus, but is independent of whether 1 or 2 I/O modules (16 or 32 I/Os) have been connected. As a matter of principle, the following applies:

$$\text{cycle time} = 1\,\text{ms} * (\text{master} + \text{number of slaves})$$

Fig. 10-45: Calculation of the cycle time of the synchronous I/O modules

Examples:

1. There is one drive controller at the EcoX bus (1 master + 0 slaves with I/O modules) ⇒ The cycle time of the synchronous I/O modules is 1 ms.
2. There are three drive controllers at the EcoX bus (1 master + 2 slaves with I/O modules) ⇒ The cycle time if the synchronous I/O modules is 3 ms.

Dead time of the I/Os The dead time of the inputs is 1 ms.

Command value linkage

Via the expansion interface a command value can be transmitted from the master drive controller to the slave drive controllers. This allows linking up to 20 drives (1 master and 19 slaves without I/O modules). If you use I/O modules, the number of slaves is reduced by the number of I/O modules. To do this, please proceed as follows:

- In the drive controller that has been parameterized as the **master**, enter the command value parameter to be transmitted in parameter **P-0-0432, EcoX command value, configuration**. This parameter must be contained in the list **P-0-0431, EcoX command IDN list of configurable parameters in master**.
- In the drive controller that has been parameterized as the **slave**, enter the parameter, to which the transmitted command value parameter is to be assigned, in parameter **P-0-0432, EcoX command value, configuration**. This parameter must be contained in the list **P-0-0433, EcoX command IDN list of configurable parameters in slave**.

The transmission of the command value from the master to the slaves requires 1 ms. This dead time is compensated in the master.

Diagnostic messages

- **E267 Hardware synchronization defective**
- **E288 Firmware update of EMD module active**
- **E289 Waiting for scan by EcoX master**
- **E291 Timeout in EMD module**
- **E296 Number of EcoX slaves incorrect**
- **E411 Double SST failure**
- **F288 Error during firmware update of EMD module**
- **F291 Timeout in EMD module**
- **F292 Overtemperature in EMD module**
- **F294 Timeout in EcoX slave**
- **F296 Number of EcoX slaves incorrect**
- **F297 Error in EcoX slave**
- **F411 Double SST failure shutdown**

Hardware dependence

Connecting I/O modules is only possible with the expansion interface.

see also: "DURADRIVE Project Planning Manual" or "ECODRIVE03 Project Planning Manual"

11 Serial communication

11.1 Overview

The drive controller is equipped with a serial interface. It is used to parameterize the drive. By means of this interface, it is possible to transmit:

- Parameters
- Commands
- Diagnoses

Interface mode

The interface can be operated in either

- RS232 mode or
- RS485 mode

Interface protocol

Two different protocols are supported:

- Indramat SIS protocol
  The user data are transmitted in INTEL format.
- **ASCII protocol**

Their precise structure is outlined in one of the following sections.

Note:	If an ASCII protocol is used, then the number of bytes to be transmitted differs from the data length in the parameter description (internal number format).

11.2 Pertinent parameters

The data exchange via the serial interface is controlled by means of the following parameters:

- **P-0-4021, Baud rate RS-232/485**
- **P-0-4022, Drive address**
- **P-0-4050, Delay answer RS-232/485**

General information on the parameter structure

All parameters of the drive controller are stored in a consistent parameter structure. Each parameter consists of 7 elements. The table below describes the individual elements and the possibilities of access. The following sections refer to the parameter structure described below.

Element no.	Data block element	Access
1	ID number	read
2	Name	read
3	Attribute	read
4	Unit	read
5	min. input value	read
6	max. input value	read
7	Operating data	read/ write

Fig. 11-1: Parameter structure

11.3 Functional principle independent of protocol

Basic state after switching control voltage on

After the control voltage is switched on, serial communication in the drive is in "Passive mode“. Communication is not possible in passive mode.

Selecting a protocol

To be able to take up serial communication with the drive it is necessary to set the communication mode (protocol)

- with a CHANGE DRIVE command (with ASCII protocol)
- or a valid start telegram (with SIS protocol).

Setting the drive address

The drive address is set via the serial interface by write accessing communication parameter **P-0-4022, Drive address**.

DriveTop or a PLC, for example, can be used for this purpose.

Exception:

If value "256“ is entered in communication parameter **P-0-4022, Drive address**, then the unit address set via the address switch will be used for serial communication and not the value set in **P-0-4022, Drive address**.

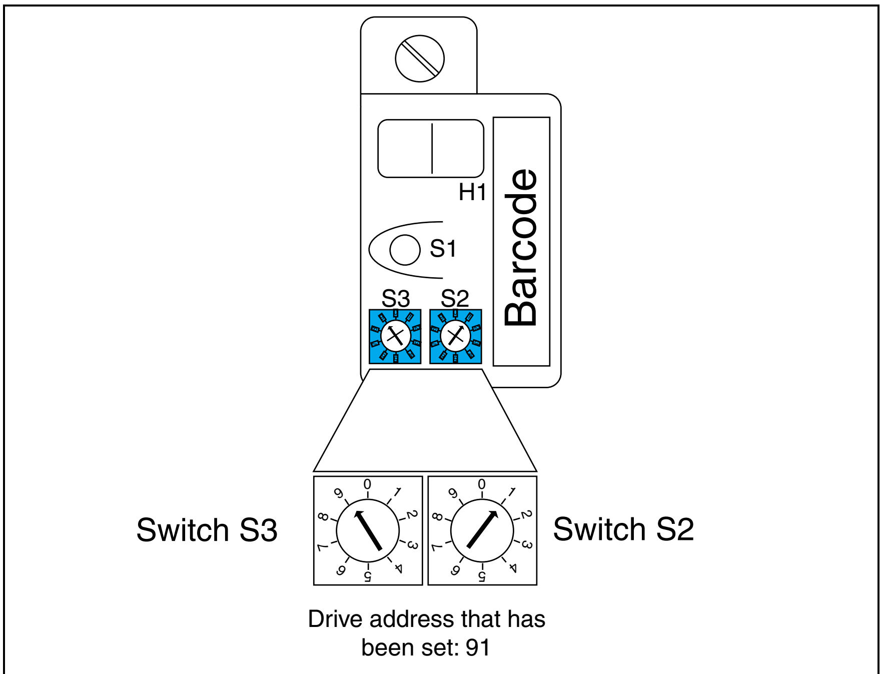


Fig. 11-2: Setting the address via the address switch on the programming module

RS485 mode

It is only absolutely necessary to set the drive address if communication uses the RS485 bus, because each bus node will be addressed at a specific bus address.

Note: To avoid accessing conflicts, assign each drive address only once.

RS232 mode

This mode does not necessitate the setting of drive address, because only one node is connected (peer-to-peer connection).

Communication via RS232 interface

Features

The RS232 interface is intended for use when connecting a PC with the DriveTop commissioning program.

- Transmission rates: 9600 and 19200 baud
- Maximum transmission path: 15 m
- 8-bit ASCII protocol or 8-bit SIS protocol
- no parity bit
- a stop bit

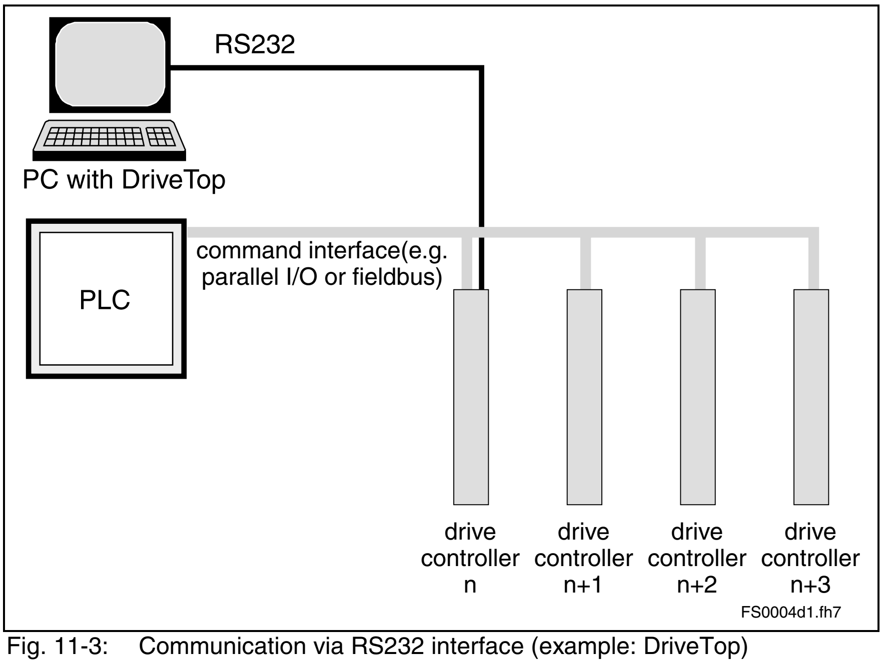


Fig. 11-3: Communication via RS232 interface (example: DriveTop)

Communication via RS485 interface

Features

Communications via RS485 interface allows implementing a serial bus with the following data:

- Up to 31 drives can be connected to one bus master.
- Transmission rates of: 9600 and 19200 baud
- Maximum transmission path: 500 m
- Half duplex mode over a 2-wire line
- 8-bit ASCII protocol or 8-bit SIS protocol
- no parity bit
- a stop bit

Operating several drives with DriveTop

Application advantages:

- Commissioning several drives without replugging an interface cable (central parameterization and diagnostics connection).
- Implementing a central PC-supported visualization unit.

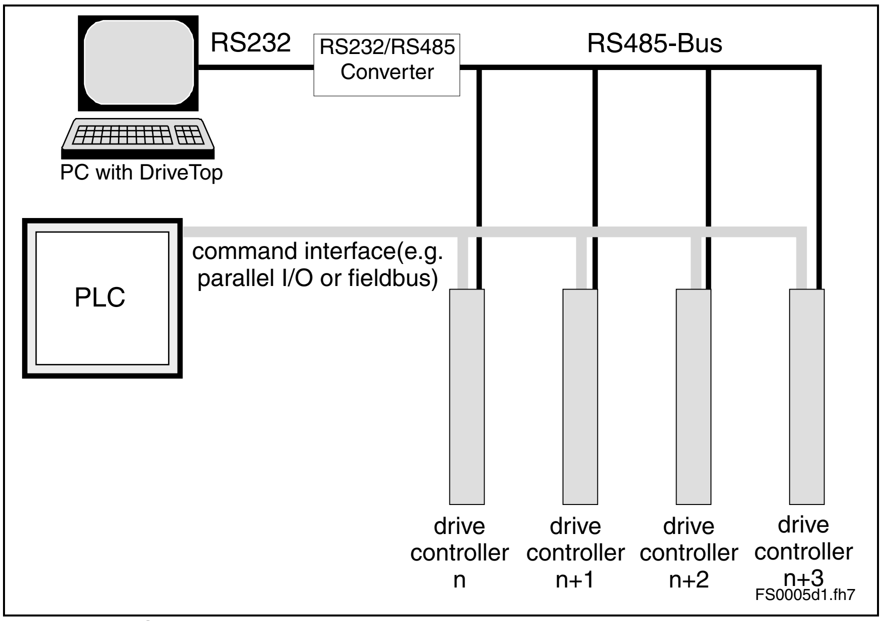


Fig. 11-4: Operating several drives with DriveTop

Parameterization and diagnosing with a PLC

Application advantages:

- Parameters can be changed with a PLC (e.g. adjusting positioning blocks).
- Expanded diagnostics options for the PLC by reading in error codes.

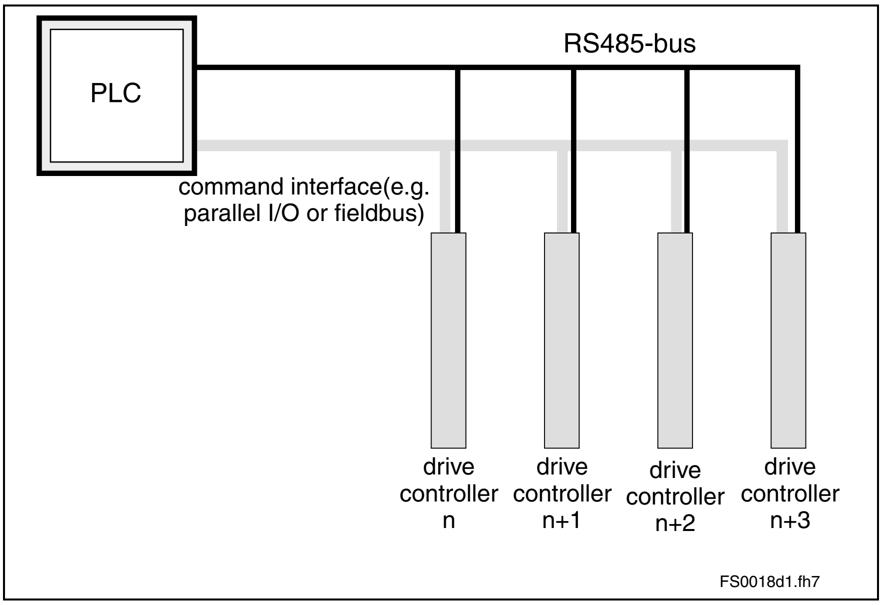


Fig. 11-5: Parameterizing and diagnosing with a PLC

Parameterizing and diagnosing drive groups using a communication unit

Application advantages:

- Realization of a central visualization unit

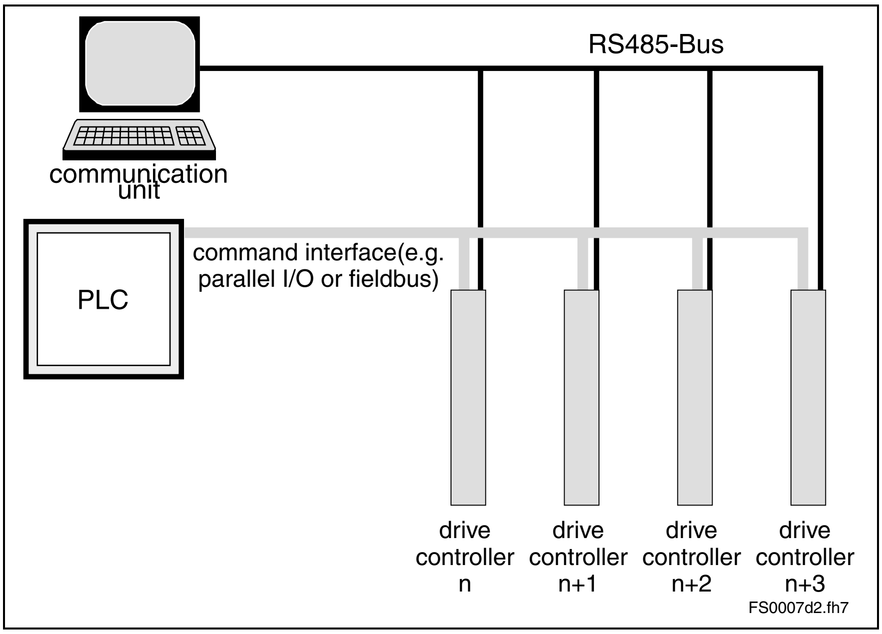


Fig. 11-6: Parameterizing and diagnosing drive groups using a communication unit

Error messages

The error codes defined in the SERCOS interface specification (see SERCOS interface specification, chapter 4.3.2.3 "Error messages in the service channel") are used for the respective errors. These codes are also used in the case of incorrect access to control and system parameters.

Error code	Explanation
0x1001	No IDN
0x1009	Invalid access to Element 1
0x2001	No name
0x2002	Name transmission too short
0x2003	Name transmission too long
0x2004	Name cannot be changed
0x2005	Name is write-protected at this time
0x3002	Attribute transmission too short
0x3003	Attribute transmission too long
0x3004	Attribute cannot be changed
0x3005	Attribute is write-protected at this time
0x4001	No units
0x4002	Unit transmission too short
0x4003	Unit transmission too long
0x4004	Unit cannot be changed
0x4005	Unit is write-protected at this time
0x5001	No minimum value
0x5002	Minimum value transmission too short
0x5003	Minimum value transmission too long
0x5004	Minimum value cannot be changed
0x5005	Minimum value is write-protected at this time
0x6001	No maximum value
0x6002	Maximum value transmission too short
0x6003	Maximum value transmission too long
0x6004	Maximum value cannot be changed
0x6005	Maximum value is write-protected at this time
0x7002	Operation data transmission too short
0x7003	Operation data transmission too long
0x7004	Operation data cannot be changed
0x7005	Operation data is write-protected at this time
0x7006	Operation data is smaller than the minimum value
0x7007	Operation data is greater than the maximum value
0x7008	Invalid data
0x7009	Operation data is password write-protected
0x700A	Operation data is write protected, it is configured cyclically
0x700B	Invalid indirect addressing: (e.g., data container, list handling)
0x700C	Operation data is write protected, due to other settings. (e.g., parameter, operation mode, drive enable, drive on etc.)

Fig. 11-7: Error specifications in accordance with SERCOS

Transmission protocols

When switching on the 24 V supply voltage, an automatic protocol detection is activated upon receipt of a symbol from the serial interface.

As soon as either:

- a valid SIS start telegram

- or -

- a valid ASCII start sequence ("bcd:address")

has been received, there is an internal switching to the relevant protocol type and baud rate.

The drive supports two different protocols:

- ASCII protocol
- SIS protocol

These are explained below in greater detail.

11.4 ASCII protocol

Features

- Transmission rates of: 9600 and 19200 baud
- 8-bit ASCII protocol
- no parity bit
- a stop bit

Structure, telegram frame

In this case, no telegram frame is used, but instead the transmitted ASCII symbol is converted and interpreted. It is only necessary to maintain a specified order.

Communicating with an ASCII protocol

Actuating a specific bus node

To communicate with a bus node it must be directly addressed with a CHANGE DRIVE command (CD command), specifying the drive address. With each CD command, the drive specified by the address is activated. All other drives are switched into passive mode. The addressed drive signals with a prompt. As of this point, all further communication takes place with this drive until another CHANGE DRIVE command switches to another drive.

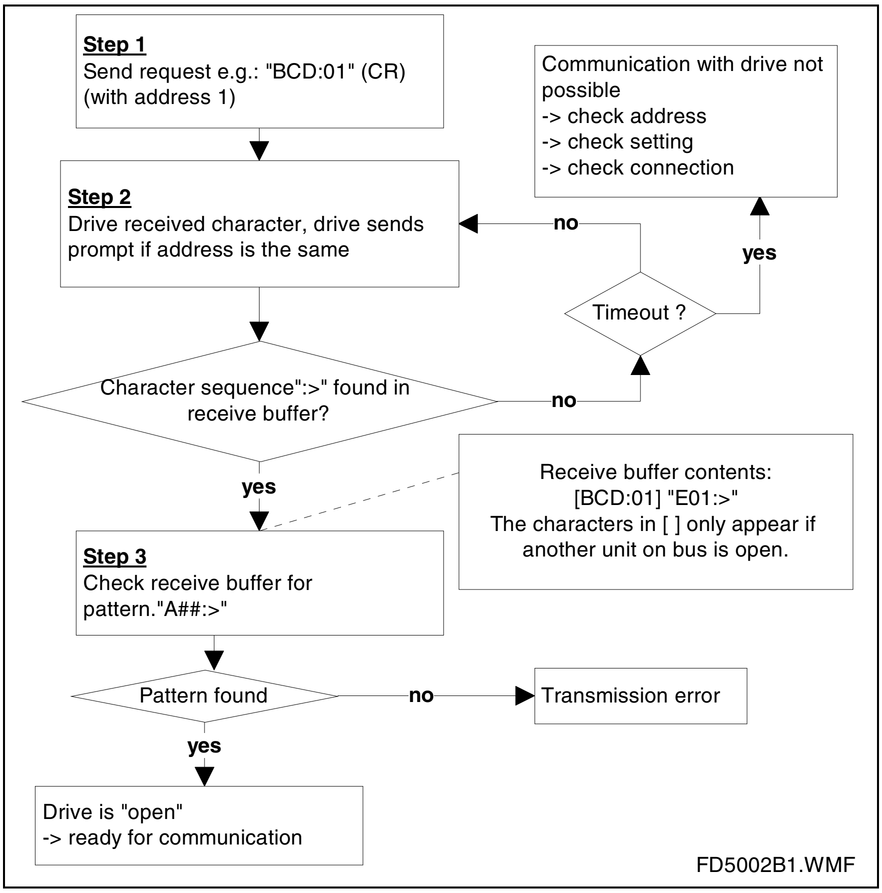


Fig. 11-8: Actuating a bus node

Write accessing a parameter

The write accessing of a parameter generally takes place as follows:

ID number of parameter, data block element number, w, operating data (Carriage Return)

Once a write operation is completed, the drive signals with a prompt.

To access the parameter value of parameter P-0-4037, for example, the following must be input:

Note: All data entered must correspond to the data type set in the attribute (HEX, BIN, DEZ).

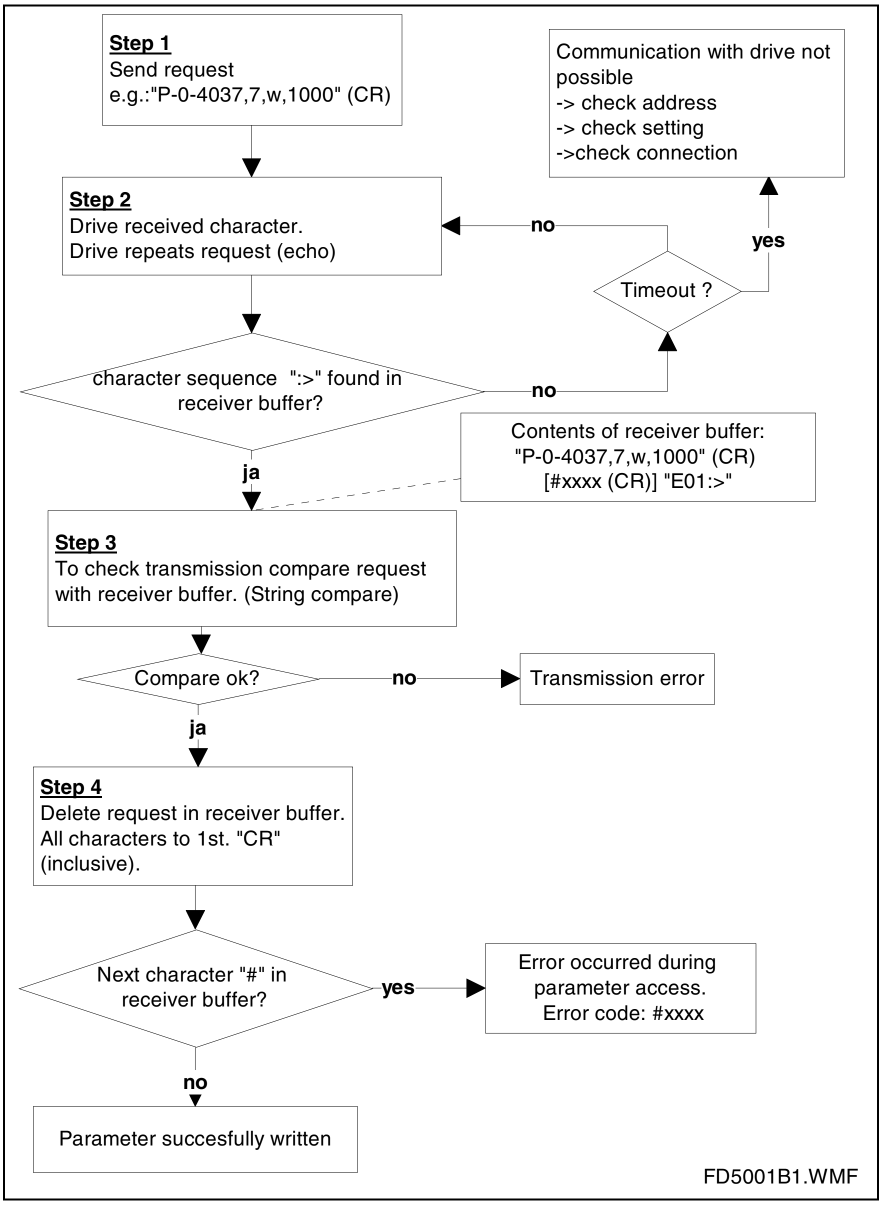


Fig. 11-9: Write accessing a parameter

see also: "Error messages"

Read accessing a parameter

The read accessing of a parameter generally takes place as follows:

ID number of parameter, data block element number,r (Carriage Return)

The drive plays back the contents of the addressed data block element.

To access the operating data of parameter P-0-4040, for example, the following must be input:

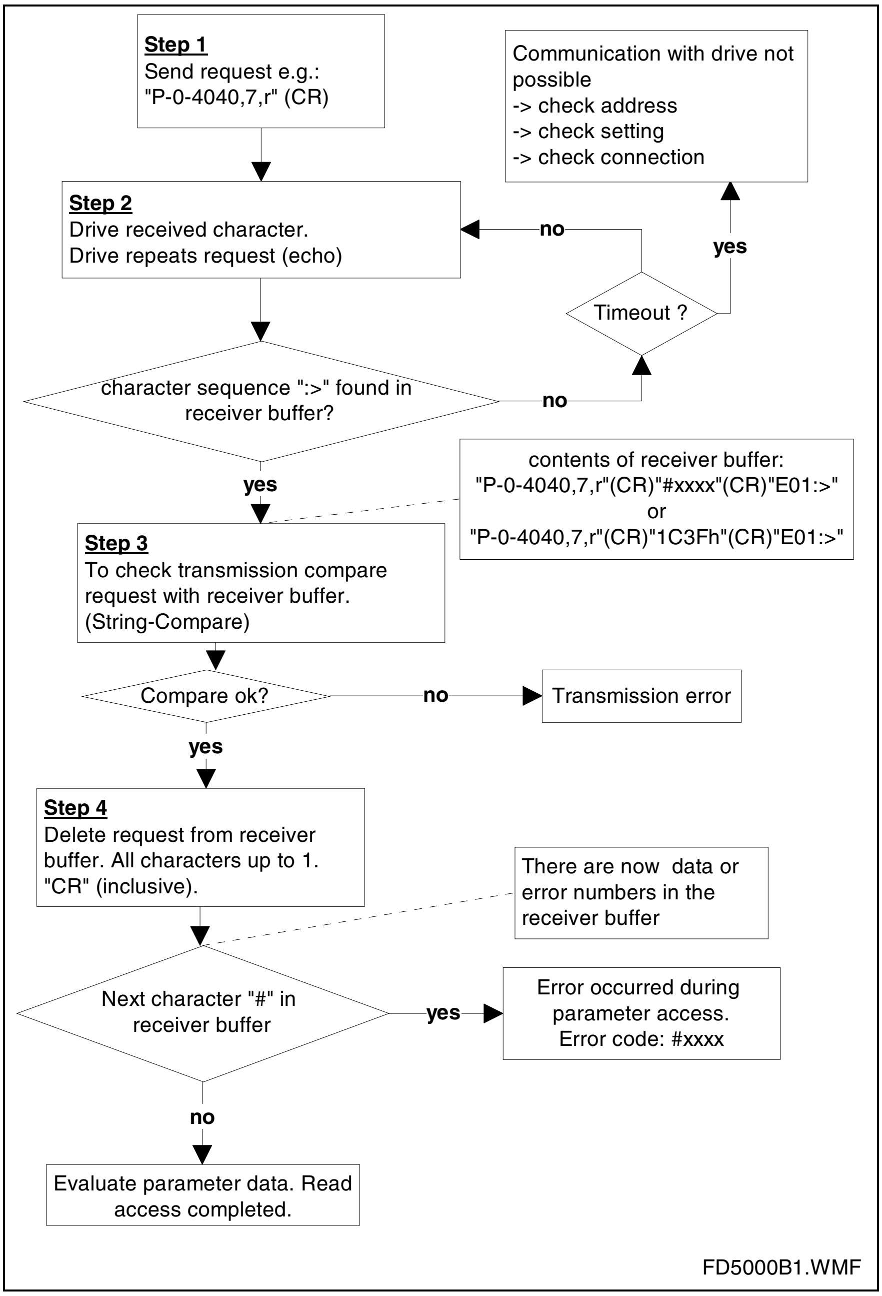


Fig. 11-10: Read accessing a parameter

Write accessing list parameters

There is a number of lists in the drive. These can be addressed when writing in a modified way.

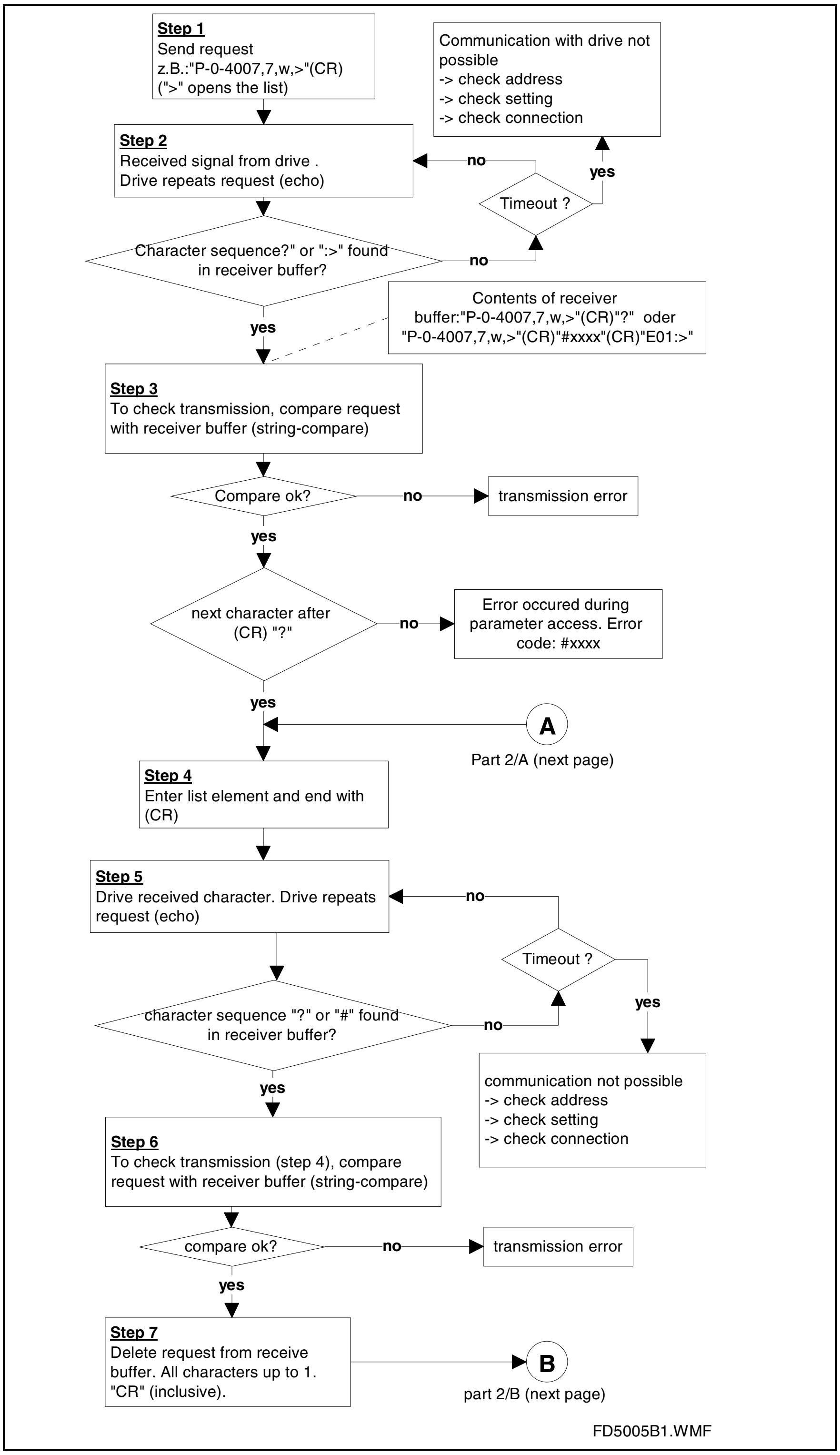


Fig. 11-11: Write accessing list parameters (part 1)

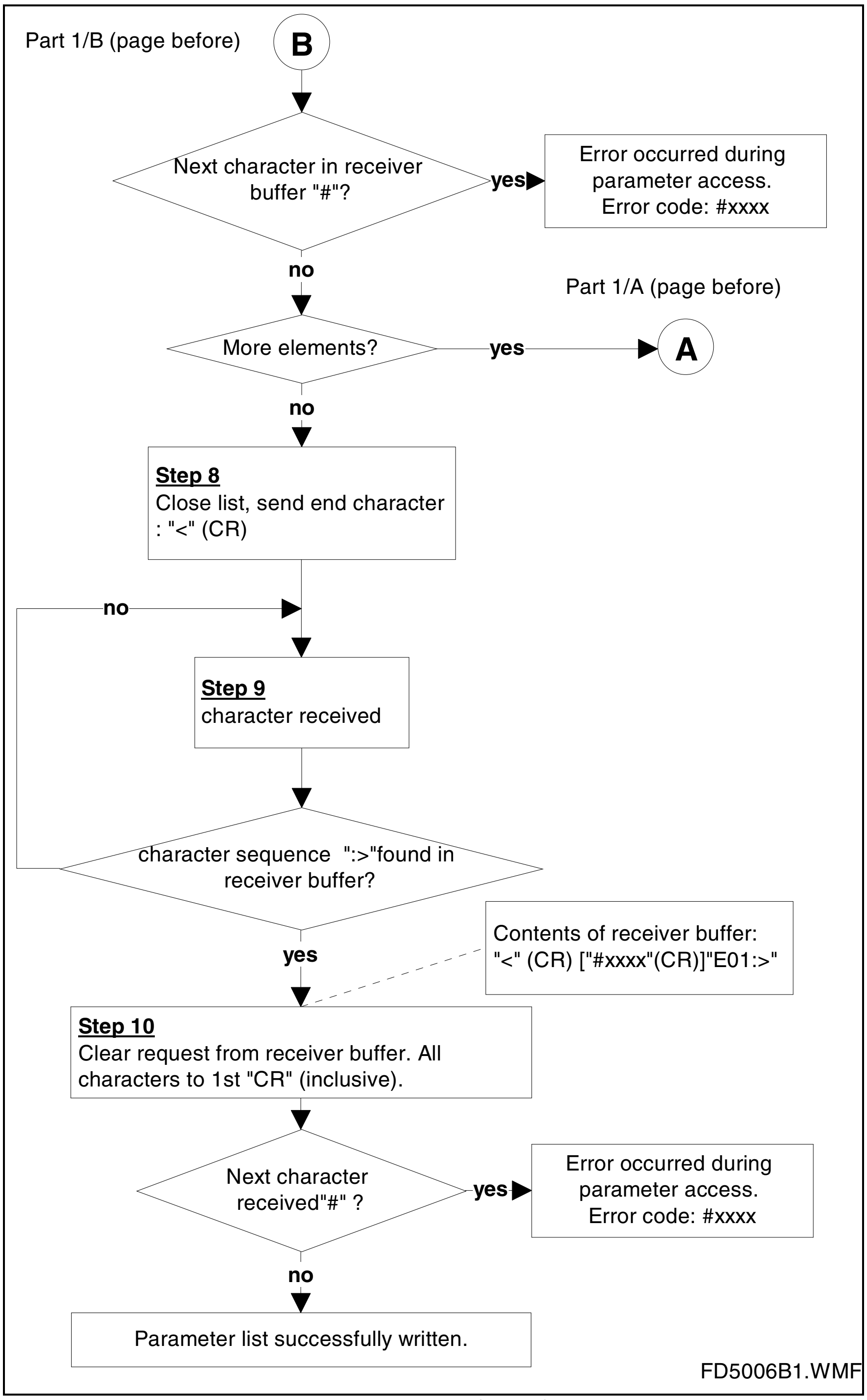


Fig. 11-12: Write accessing list parameters (part 2)

It is important to conclude the input with a "<" symbol as only then will the data be accepted in the drive.

Read accessing list parameters

List parameters are read accessed in the same way as normal parameters. The drive supplies all list elements as response, however.

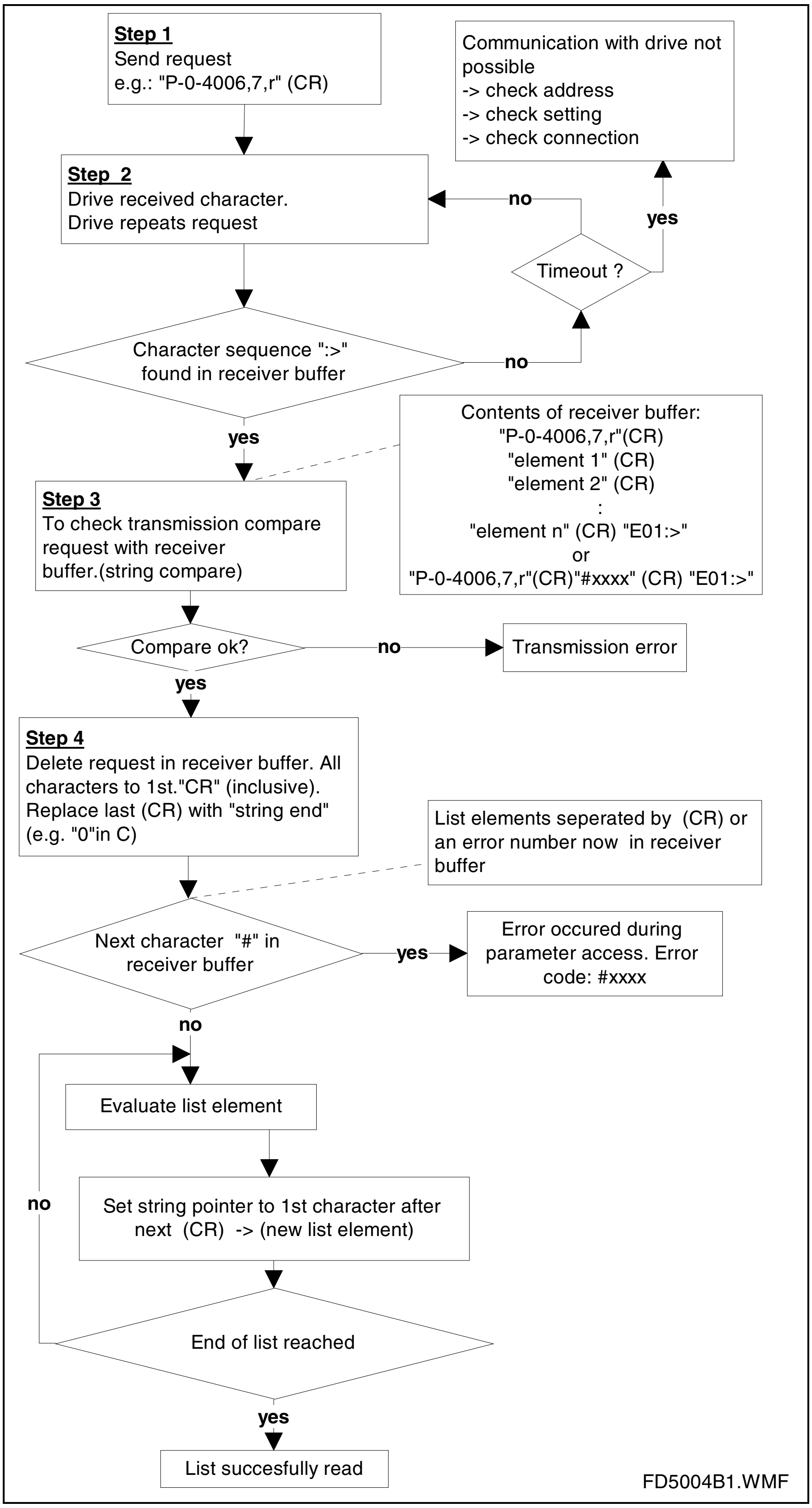


Fig. 11-13: Read accessing list parameters

Starting a command

Numerous commands can be conducted in the drive controller . Command execution takes place automatically in the drive.

There are commands for:

- Switching between operating and parameterization modes
  - **S-0-0127, C100 Communication phase 3 transition check**
  - **S-0-0128, C200 Communication phase 4 transition check**
  - **P-0-4023, C400 Communication phase 2 transition**
- **S-0-0262, C700 Command basic load**
- **S-0-0099, C500 Reset class 1 diagnostic**
- **S-0-0148, C600 Drive controlled homing procedure command**
- **P-0-0012, C300 Command Set absolute measurement**

A command can be started, terminated and completed via the serial interface. The status of command execution can also be read.

A command is started as follows:

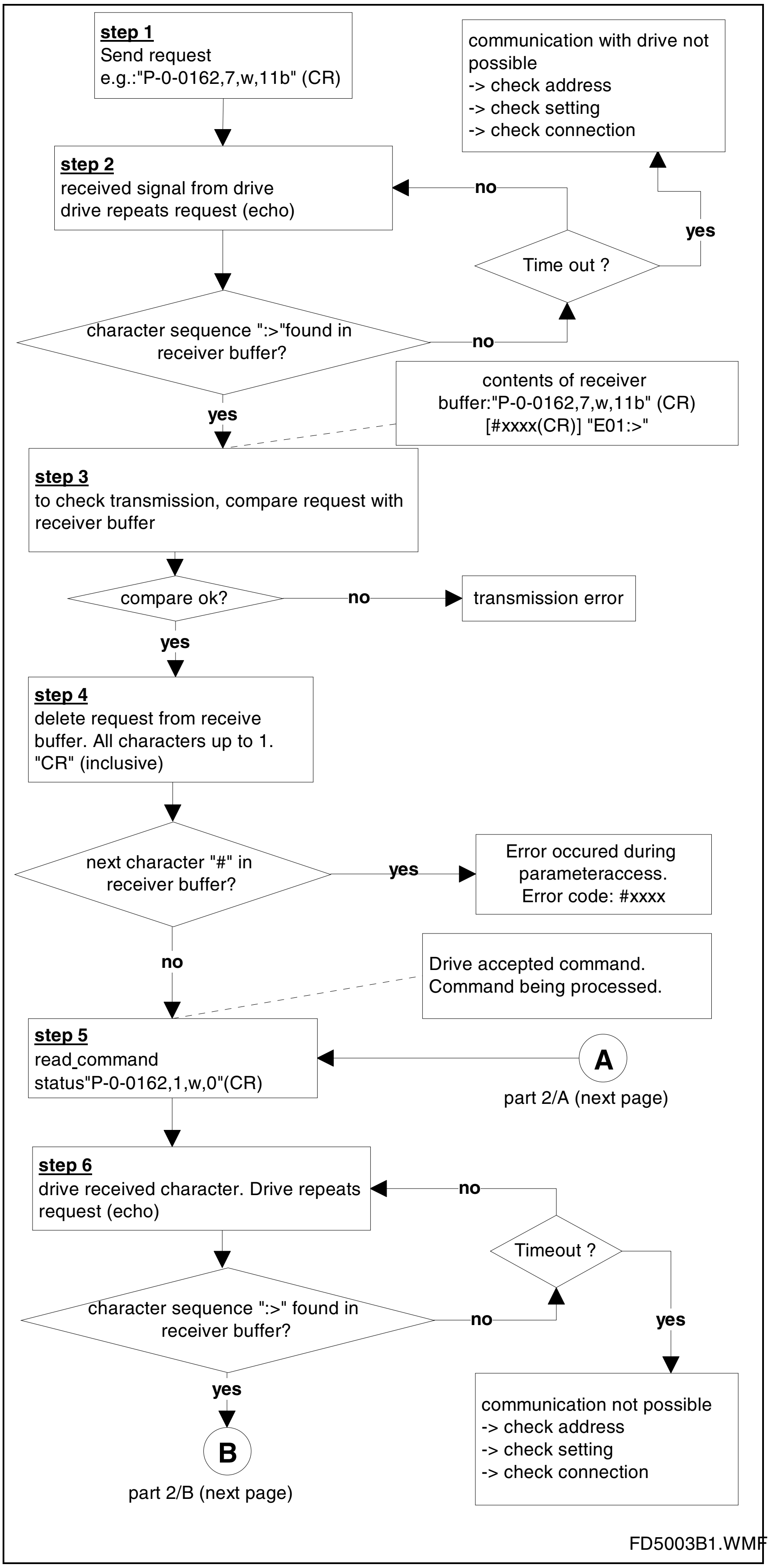


Fig. 11-14: Starting a command, part 1

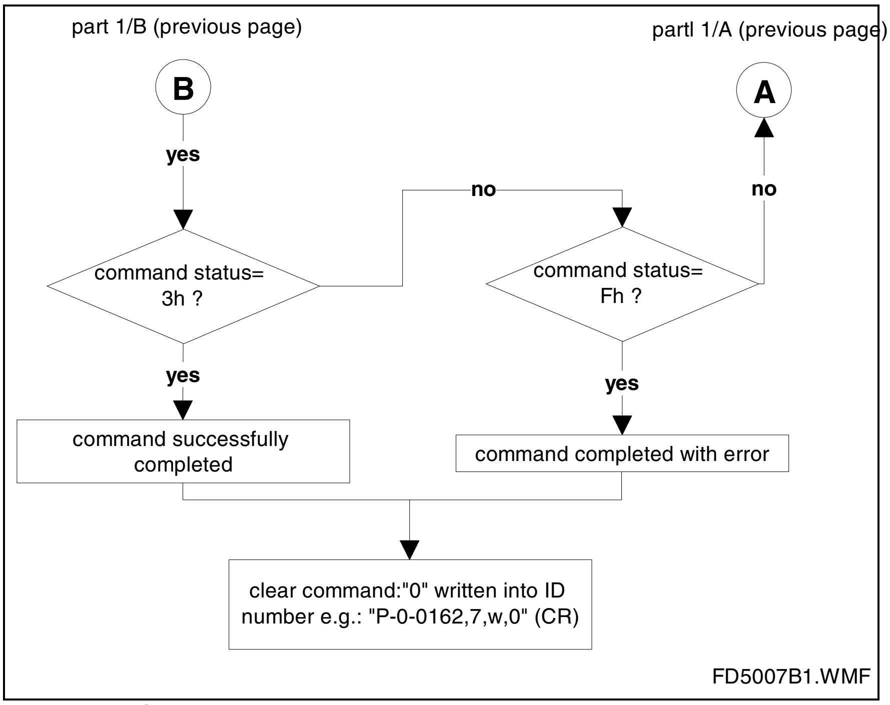


Fig. 11-15: Starting a command, part 2

Querying command status

The current status of a command can be queried. By doing so, it can be ascertained that the drive has concluded command execution before the control (or PC) has ended the command.

The command status is queried as follows:

ID number of command,1,w,0 (Carriage Return)

The drive signals the current command status after the ID number of the command parameter is written.

Possible status messages

0 h	command not set in drive
1 h	command set in drive
3 h	command set, released and properly executed
5 h	command set in drive and enabled
7 h	command set and enabled, but not executed
F h	command set and enabled, but not executed, as error present

Fig. 11-16: Status messages

The command status is transmitted in bit list form. The definition of the individual bits is illustrated below.

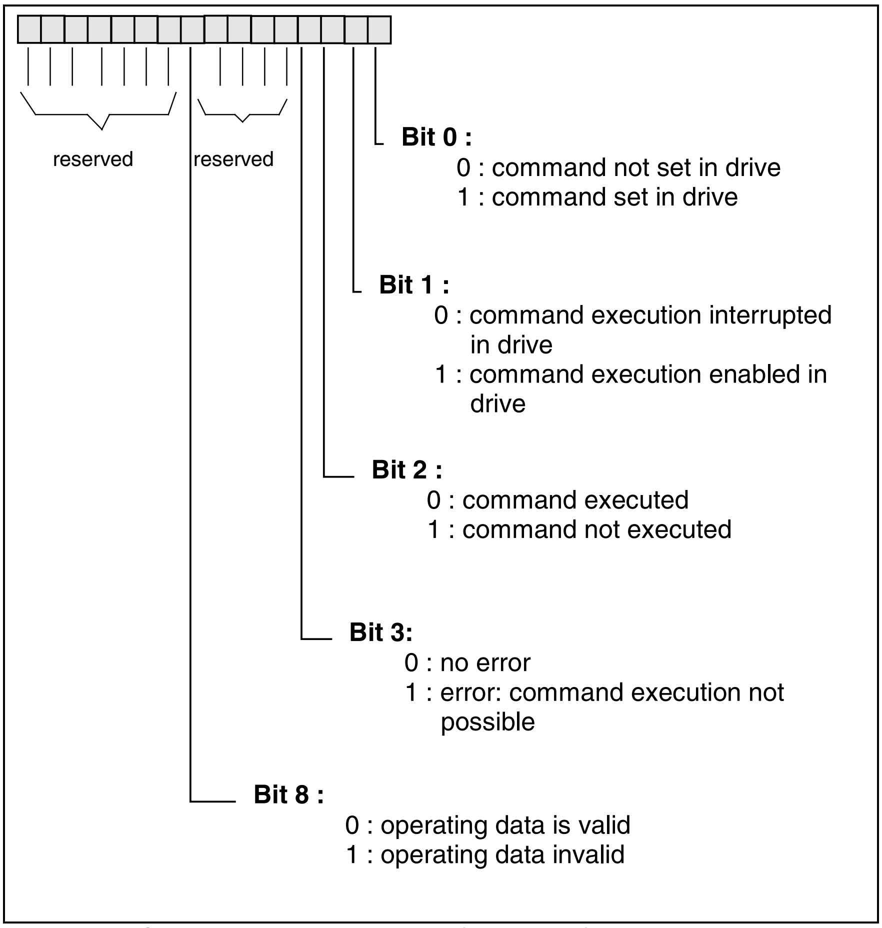


Fig. 11-17: Command acknowledgement (data status)

Ending a command

A command is ended as follows:

ID number of command,7,w,0 (Carriage Return)

Application example (changing position block data)

Suppositions:

- Several drives are connected with a PLC via an RS485 interface. The drive address is 1.
- Drive working in positioning mode. Four positioning blocks are used.
- The target positions of the positioning blocks are to be changed via RS485 interface.

Taking up communication with the relevant axis

BCD:01 (CR) Command to switch to drive **A01:>**
Echo of connected drives.
All other drives remain passive.

Note: There is no echo by symbol. Not until after the receipt of the CR does the drive send the entire input sequence back.

Write list of target positions into drive

The target positions of all axes are stored in the form of a list in parameter **P-0-4006, Process block target position**. To change one or more values in this list, it is necessary to write all relevant values of this list. If, therefore, four target positions are used, then all four positions must be written even if only one position is changed.

Drive reaction:		Input:
P-0-4006,7,w,>(CR)		
?	*100.0 (CR)*	target position block0
?	*200.0 (CR)*	target position block1
	etc.	
?	*<(CR)*	
E01:>		

Error with ASCII communication

The following error messages specifically occur when communicating with an ASCII protocol:

Error code	Explanation
0x9001	fatal error (symbol cannot be identified)
0x9002	parameter type error
0x9003	invalid data block number
0x9004	Input cannot be identified
0x9005	data element number not defined
0x9006	error in write/read (r/w)
0x9007	nonsense symbol in data

Fig. 11-18: Error messages during ASCII communication

11.5 SIS protocol

Features

The SIS protocol

- is a binary protocol.
- A checksum test is conducted (higher Hamming distance D).
- All telegrams are identified by an unequivocal start symbol ("0x02").
- There is a defined telegram frame structure.
- It is possible to trigger movements (e.g. jogging) via an SIS telegram.

Structure, telegram frame

An SIS telegram is basically broken down into three blocks:

- telegram head
- user data head
- user data

Telegram head	Net data head	Net data

Fig. 11-19: The structure of an SIS telegram

Telegram head structure

Byte	Name	Definition of the individual telegram bytes
1	StZ	Start symbol: STX (0x02)
2	CS	This is the checksum byte. It is generated by adding all subsequential telegram symbols as well as the start symbol StZ and concluding negation. In other words, the sum of all telegram symbols always equals 0 if the transmission was successful.
3	DatL	The length of the subsequential user data and the variable part are in the frame protocol. Up to **247 bytes** (255 - 7 {subaddresses} - 1 {current telegram number}) user data can be transmitted in one telegram.
4	DatLW	The repetition of DatL takes place here. The telegram length is generated from the DatLW and the fixed part of the frame protocol (byte 1 - 8), i.e. telegram length = DatLW + 8.
5	Cntrl	Bit 0 - 2: Number of subaddresses in the address block (0 - 7), Bit 3: 'current telegram number' : 0 => not supported, 1 => additional byte Bit 4: 0 => command telegram, 1 => reaction telegram Bit 5 - 7: Status data for the reaction telegram: 000 no error, request was processed 001 transmission request being processed 010 transmission cannot presently be processed 100 warning 110 error
6	Service	This specifies the service that the sender is requesting of the receiver or which the receiver is conducting. 0x00 ... 0x0F general services 0x00 participant ID 0x01 terminate a data transmission 0x02 Flash operation 0x03 Initialization of SIS communication 0x0F Token Passing 0x10 ... 0x7F presently reserved 0x80 ... 0x8F special services for ECODRIVE 0x90 ... 0x9F special services for SYNAX 0xA0 ... 0xAF special services for MT-CNC or MTC200 0xB0 ... 0xBF special services for ISP200 0xC0 ... 0xCF special services for CLC-GPS 0xD0 ... 0xDF special services for HMI system 0xE0 ... 0xFF presently reserved
7	AdrS	Address of the sender: station number (0 - 127)
8	AdrE	Address of the receiver: AdrE = 0 - 127 ==> specifies a single station, AdrE = 128 - 254 ==> addresses logical groups, AdrE = 255 ==> fixes a broadcast Telegrams with AdrE = 128 - 255 are **not** answered with a reaction telegram.
9	AdrES1	Subaddress 1 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 000**
10	AdrES2	Subaddress 2 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 001**
11	AdrES3	Subaddress 3 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 010**
12	AdrES4	Subaddress 4 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 011**
13	AdrES5	Subaddress 5 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 100**
14	AdrES6	Subaddress 6 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 101**
15	AdrES7	Subaddress 7 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 110**
16	PaketN	current telegram number (package number), **if bit 3 in byte cntrl has been set**

Fig. 11-20: SIS telegram head

Structure of the user data head

Note: The structure of the user data head depends on the transmission direction. Also the user data headers, described here are only used for the services 8x80 … 0x8F.

It is differentiated between command and reaction telegram:

- **Command telegram** (Master --> Slave):

This is the telegram that the master (drive) sends to the slave!

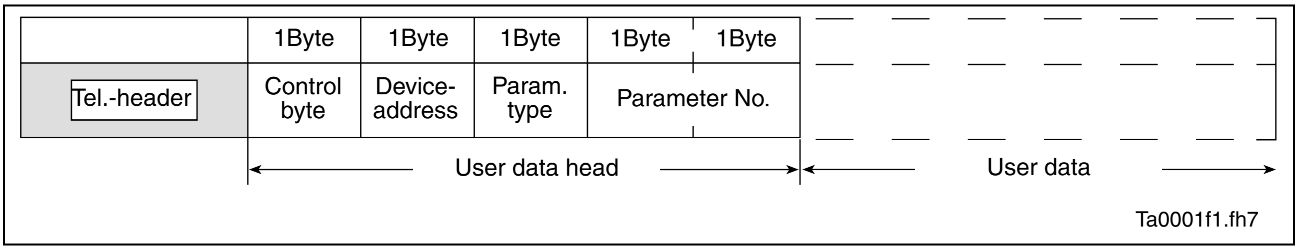


Fig. 11-21: User data head structure in the command telegram

Control byte

The control byte indicates the parameter element (data, name,...) that is be be read or written. It also indicates whether further telegrams (following telegrams) are required for reading or writing.

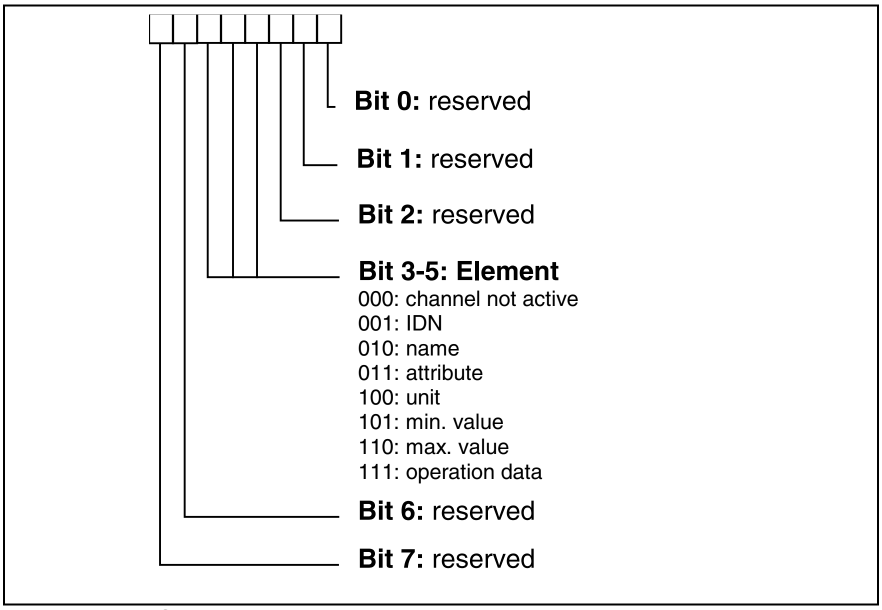


Fig. 11-22: Structure of the control byte

- **Reaction telegram** (Slave--> Master):

This is the telegram that the slave (drive) sends to the master!

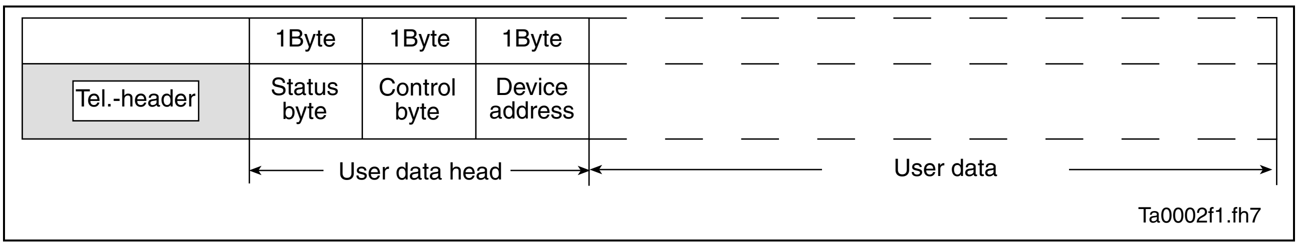


Fig. 11-23: User data head structure in reaction telegram

Definition of the user data head The user data head describes the mode of transmission in the command telegram.

Status byte In the status byte an error code is returned, if necessary. In case the transmission is error-free, 0x00 is returned in the status byte.

Control byte The data block element of a parameter which is being accessed is specified in the control byte. Bit 2 is used to control the transmission of following telegrams (the writing of lists in several increments).

Unit address The unit address set at the address switch must be entered here.

Parameter number and type The parameter number has the format set in the SERCOS interface specification. To be able to address control parameters as well, 1 byte is set in front of the address to identify the parameter type.

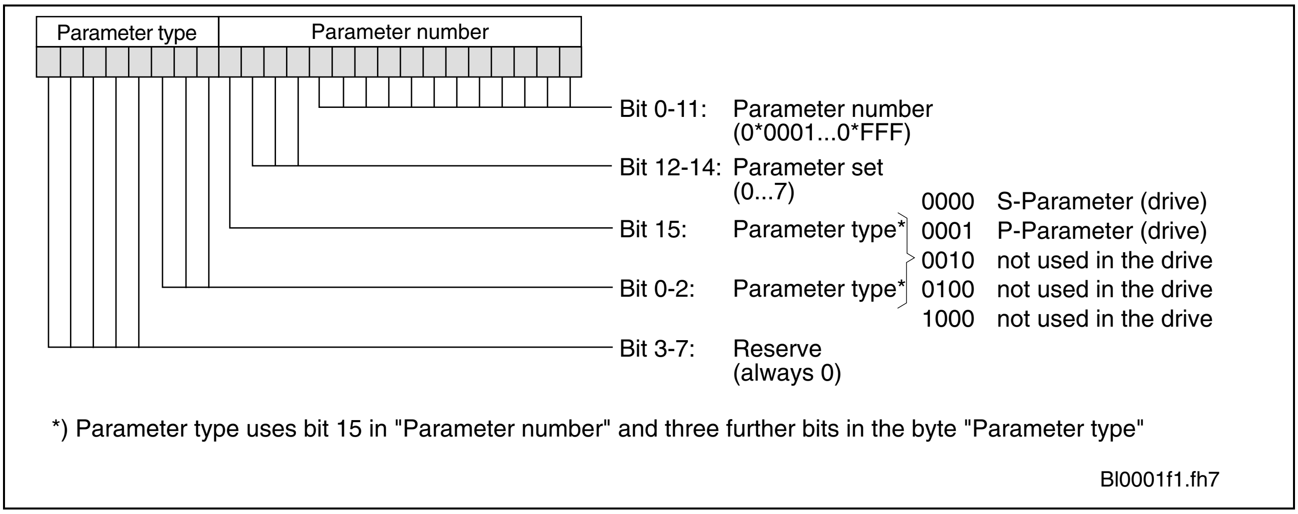


Fig. 11-24: Parameter number and type in user data head

Structure of the user data field

Values of any kind can be entered in the user data bytes. These can be interpreted as needed by a specific service. For example, binary symbols are entered into the user data during flash programming and the decimal value when writing a parameter.

The number of bytes in the user data field and of the user data head is entered in the DatL and DatLW bytes.

Communicating with the SIS protocol

Actuating a drive via an SIS protocol

When communicating with SIS protocols, a difference is made between command telegrams and reaction telegrams depending on transmission direction. A node can only be addressed, if a specific telegram format (frame) is maintained at his address (see programming module).

Note: Only after the drive has received at least one valid SIS telegram is the SIS channel enabled for further communications.

The individual access modes are described briefly below before the individual services are explained.

Read accessing

If a command telegram is used to start the reading of a parameter, then the drive checks whether a following telegram is needed. In this case, bit 2 (current / final transmission) in the reaction telegram of the control byte is maintained at "0" until the final reaction telegram is sent. In the final reaction telegram bit 2 is set to "1".

The transmission of a following reaction telegram is triggered by the renewed transmission of an unchanged command telegram.

Following telegram accessing

If write or read of a parameter is started in the drive with a following telegram, then this procedure must be concluded or interrupted before a different service can be started. If a different service was started anyway, then error code "0x800C unallowed access" is sent in the reaction telegram. The previously started service with following telegram can then be processed as usual in the next command telegram, or interrupted.

The following services are supported in the drive:

- Service 0x01 terminating a data transmission
- Service 0x81 read a list segment
- Service 0x8E write a list segment
- Service 0x8F write a parameter
- Service 0x80 read a parameter
- Service 0x01 read access with following telegrams
- Service 0x8F write access with following telegrams

Service 0x01 terminating a data transmission

Command telegram

- Enter 0x01 in the service of the telegram head.
- Enter the service to be interrupted in the user data.

Reaction telegram

If there is no error, then the reaction telegram has the following structure:

Telegram head	User data head

Fig. 11-25: Structure of the reaction telegram

If there is an error, then user data containing the error codes are sent. The user data head corresponds to the SIS specification.

Telegram head	User data head	User data

Fig. 11-26: Structure of the reaction telegram

Note: If no following telegrams are processed but this service is sent anyway, then no error reaction telegram will be sent!

Service 0x80 read a parameter

A one-time read access is completed with one transmission step. The master enters the following information in the command telegram:

- In the control byte the desired element is selected in bits 3-5 "Element". Bit 2 is set to "1" (final transmission).
- The device address is entered.
- Parameter type and number are entered.
- There are no user data transmitted.

The answer to a read access is composed as follows:

- In the Cntrl byte of the telegram head, bit 4 is set to "1", in order to show that it is a reaction telegram.
- The status byte of the user data head shows whether an error has occurred during the processing of the command telegram.
- The control byte is read from the command telegram and copied to the reaction telegram.
- The device address is read from the command telegram and copied to the reaction telegram.
- The required data is written to the user data.

Example:

Reading parameter S-0-0044 (type of scaling for velocity data) from the drive with the address "3". The parameter has the value 0x0042.

Command telegram:

	3C	03	00	2C	00
Tel. header	Control byte	Device address	Param. type	Parameter No. (LSB)	(MSB)

← User data head →

Ta0005f1.fh7

Fig. 11-27: Reading S-0-0044 (command telegram)

Reaction telegram:

	00	3C	03	42	00
Tel. header	Status byte	Control byte	Device address	User data (LSB)	(MSB)

← User data head →

Ta0006f1.fh7

Fig. 11-28: Reading S-0-0044 (reaction telegram)

Service 0x8F write a parameter

Command telegram

- Enter 0x8F in the service of the telegram head.
- Enter the parameter to be written in bytes "parameter type" and "parameter number" of the user data head.
- Enter the value to be written in the user data.

Reaction telegram

Note: This service can be used to start all commands in the drive.

A one-time write access is completed with 1 transmission step.

The master enters the following information in the command telegram:

- The device address is entered.
- In bits 3-5 "Element" of the control byte the operating data is selected. Bit 2 is set to "1" (final transmission).
- The IDN of the parameter to be written is written in the parameter number.
- The value of the operating data is loaded in the user data.

The answer to a write access is composed as follows:

- In the Cntrl byte of the telegram head, bit 4 is set to "1", in order to show that it is a reaction telegram.
- The status byte of the user data head shows whether an error has occurred during the processing of the command telegram.
- The control byte is read from the command telegram and copied to the reaction telegram.
- The device address is read from the command telegram and copied to the reaction telegram.
- There are no the user data transmitted.

Example:

Tranmission of parameter S-0-0044 (type of scaling for velocity data) to the drive with the address "3". The value 0x0042 is written to the parameter.

Command telegram:

	3C	03	00	2C	00	42	00
Tel. header	Control byte	Device address	Param. type	Parameter No. (LSB)	(MSB)	User data	
	User data head						

Ta0009f1.fh7

Fig. 11-29: Writing parameter S-0-0044 (command telegram)

Reaction telegram:

	00	3C	03
Tel. header	Status byte	Control byte	Device address
	User data head		

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Fig. 11-30: Writing parameter S-0-0044 (reaction telegram)

Service 0x81 read a list segment

Command telegram

- Enter 0x81 in the service of the telegram head.
- Parameter type and parameter no. of the parameter to be read must be entered in the user data head.
- In the user data bytes 0 and 1 enter the offset within the list as a word (=16 bit).
- In user data bytes 2 and 3 enter the number of the words to be read.

Reaction telegram

- Bit 2 identifies the current / final transmission in the control byte of the reaction telegram.

Note: The output of a following telegram is started by a renewed transmission of the unchanged command telegram.

Service 0x8E write a list segment

Command telegram

- Enter 0x8E in the service of the telegram head.
- Enter parameter type and number of the parameter to be read in the user data head.
- In user data bytes 0 and 1 enter the offset within the list as a word (=16 bit).
- In user data bytes 2 and 3 enter the number of the words to be written.

Reaction telegram

- Any occurring errors are entered in the user data of the reaction telegram.

Note: Only list segments can be processed with this service that are contained in the present list. If the actual list length is to be changed, then this must be specified. It is not possible to operate in following telegram mode.

Starting a command

Via the SIS interface all commands in the drive can be started with service 0x8F write a parameter.

Telegram head	User data head	2 byte user data

Fig. 11-31: Structure of the command telegram

- Enter 0x8F in the service of the telegram head.
- Enter the actuating command in bytes "parameter type" and "parameter number" of the user data head.
- Enter the default of the command in the user data byte.

Application examples (following telegrams)

Write access with following telegrams (service 0x8F)

Parameters or elements with a length exceeding 243 byte are read in several steps. The transmission of lists of this kind is performed in several steps. Bit 2 in the control byte identifies the current transmission step as either current or final transmission.

The control word for a transmission in several steps is described below.

1st step:

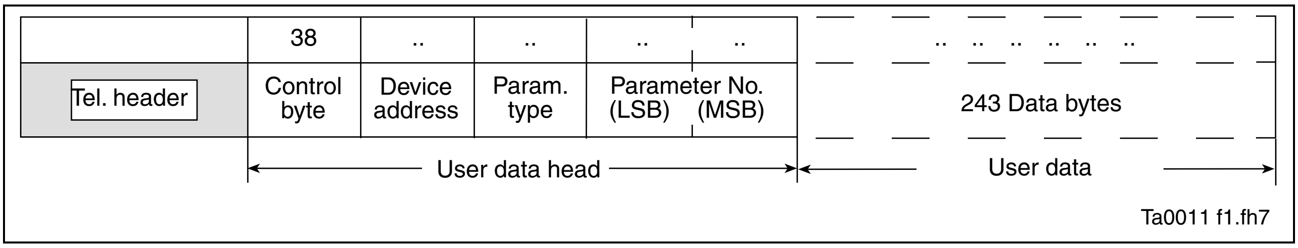

Fig. 11-32: Writing with following **command** telegram (step 1)

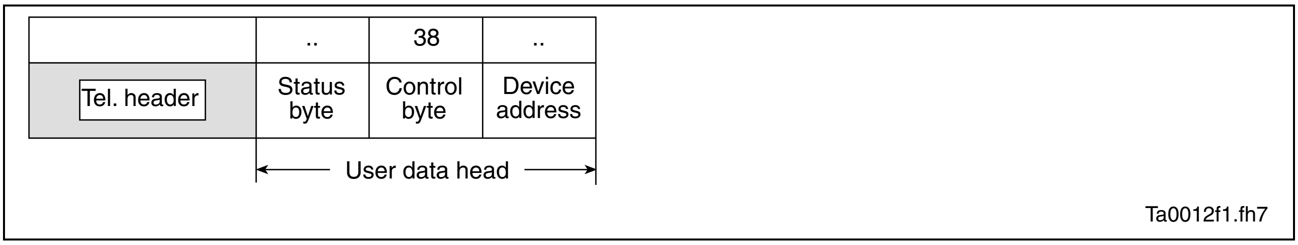

Fig. 11-33: Writing with following **reaction** telegram (step 1)

2nd step:

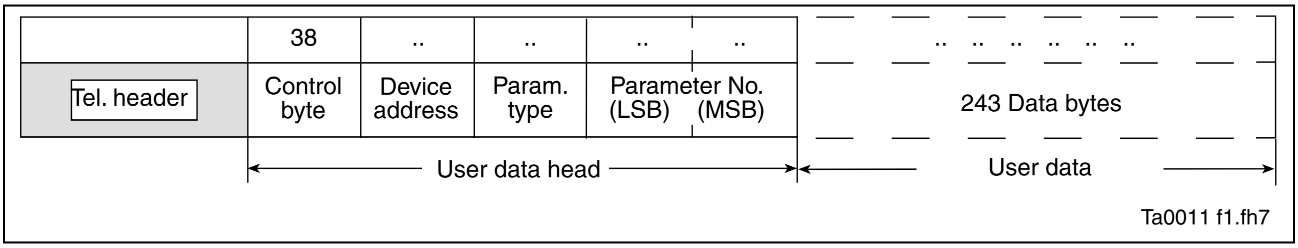

Fig. 11-34: Writing with following **command** telegram (step 2)

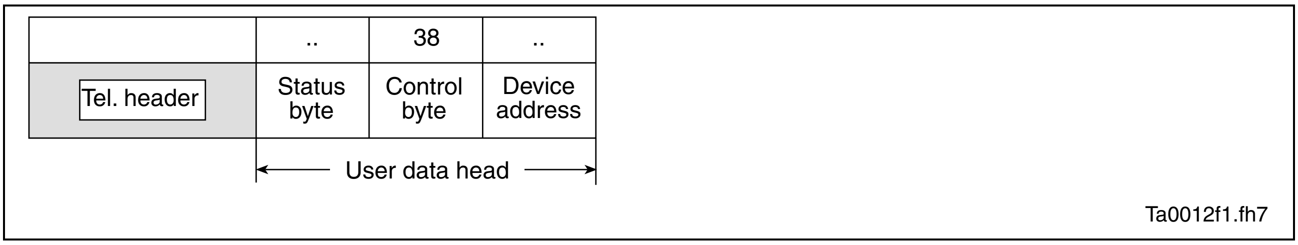

Fig. 11-35: Writing with following **reaction** telegram (step 2)

Final step:

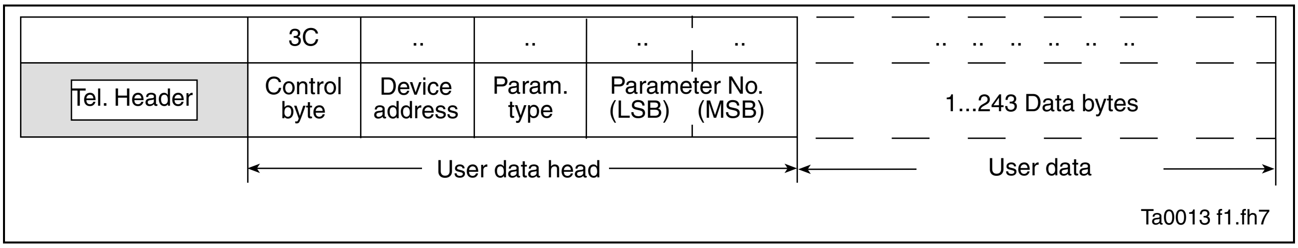

Fig. 11-36: Writing with following **command** telegram (step 3)

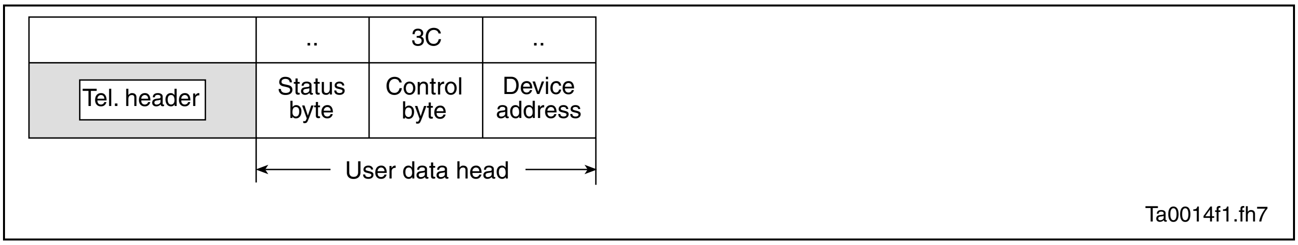

Fig. 11-37: Writing with following **reaction** telegram (step 3)

Read acces with following telegrams (service 0x01)

Parameters or elements with a length exceeding maximum data field length of 245 byte are read in several steps. Bit 2 in the control byte of the reaction telegram designates the current transmission step as either current or final transmission.

The following is the control word for a transmission in several steps.

1st step:

	3C	..	..	..	..
Tel. header	Control byte	Device address	Param. type	Parameter No. (LSB)	(MSB)
	User data head				

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Fig. 11-38: Following **command** telegram 1

	..	38	..	.. ..
Tel. header	Status byte	Control byte	Device address	245 Data bytes
	User data head			User data

Ta0008f1.fh7

Fig. 11-39: Following **reaction** telegram 1

2nd step:

	3C	..	..	..	..
Tel. header	Control byte	Device address	Param. type	Parameter No. (LSB)	(MSB)
	User data head				

Ta0007f1.fh7

Fig. 11-40: Following **command** telegram 2

	..	38	..	.. ..
Tel. header	Status byte	Control byte	Device address	245 Data bytes
	User data head			User data

Ta0008f1.fh7

Fig. 11-41: Following **reaction** telegram 2

Last step

	3C	..	..	..	..
Tel. header	Control byte	Device address	Param. type	Parameter No. (LSB)	(MSB)
	User data head				

Ta0007f1.fh7

Fig. 11-42: Following **command** telegram 3

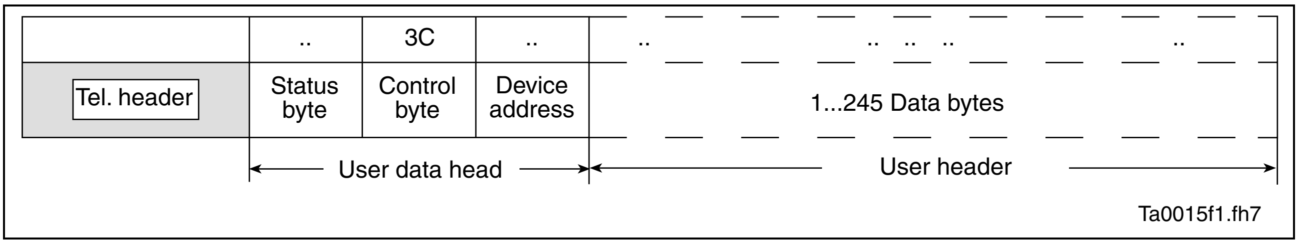

Fig. 11-43: Following **reaction** telegram 3

Error with SIS communication

Error during parameter transmission

Status byte

If an error occurs during parameter transmission, then "error during parameter transmission" is signalled in the status byte.

Error code

An error code is transmitted in the first two bytes of the user data. It describes the type of error.

The following errors can occur during parameter transmission:

Error code	Explanation
0x0000	no error
0x0001	service channel not open
0x0009	element 0 incorrectly accessed
0x8001	"Service channel presently occupied (BUSY)" The desired acces presently not possible as service channel is busy.
0x8002	"problem in service channel" The requested drive cannot presently be accessed.
0x800B	"Transmission terminated (higher priority)"
0x800C	"Unallowed access (service channel still active)" A new request is started before the last transmission is completed.

Fig. 11-44: Error messages in serial protocol

Execution and protocol acknowledgement

One status byte is transmitted with each reaction telegram. The status byte supplies the results of a transmission in the form of a code number.

Generally, the following applies:

Status byte results	Code number
transmission no error	0x00
protocol error	0xF0 ... 0xFF
execution error	0x01 ... 0xEF

Fig. 11-45: Definition of the status byte

Protocol error	Code number	Error description
"Invalid service“	0xF0	The requested service is not specified or is not supported by the addressed node.

Fig. 11-46: Definition of protocol error

Execution error	Code Number	Error description
"Error during parameter transmission“	0x01	An error occurred during read/write of a parmeter

Fig. 11-47: Definition of execution error

Example:

Write accessing the write-protected parameter **S-0-0106, Current loop proportional gain 1**.

The master is trying to write the value "0" to the parameter. The drive acknowledges with error message 0x7004 ("data cannot be changed").

Command telegram:

	3C	00	04	0B	00	00	00
Tel.-header	Control byte	Device address	Param. type	Parameter No. (LSB)	(MSB)	User data	

← User data head →

Ta0003f1.fh7

Fig. 11-48: Writing S-0-0106 (command telegram)

Reaction telegram:

	01	3C	00	04	70
Tel. header	Status byte	Control byte	Device address	User data	

← User data head →

Ta0004f1.fh7

Fig. 11-49: Reading S-0-0106 (reaction telegram)

11.6 Connection technique

See Project Planning Manuals ECODRIVE03 respectively DURADRIVE

Notes

12 Glossary

1MB
Rotary liquid-cooled asynchronous frameless motors.

2AD
Rotary asynchronous motors for main spindle applications.

Acceleration feedforward
In applications that require highest precision at high velocity it is possible to activate the acceleration precontrol and thereby significantly increase the precision of the axis in the acceleration and deceleration phases.

ADF
Rotary liquid-cooled asynchronous motor.

Analog inputs
By means of this function, two analog command values are mapped to one parameter via an analog/digital converter. The analog voltage can then be assigned to a parameter. This allows, for example, preselecting torque limit values or speed command values via analog inputs for the operating mode "Velocity control".

Analog outputs
The analog output function allows to output drive-internal signals and status variables in the form of analog voltage signals. In addition, the control unit can output cyclically transferred values.

AT
Abbreviation of "Antriebstelegramm" (German word for "drive telegram"). The drive telegram is sent from the slave to the master via the real time data channel.

Automatic control loop setting
In order to facilitate parameterization of an axis, the firmware types of the ECODRIVE03 and DURADRIVE product families include automatic control loop setting. After the user has specified the required axis dynamics, the drive controller automatically defines the control loop parameters for this kind of control loop setting.

Base parameters
Standard values for all drive parameters are stored in the drive controller. These values can be loaded anytime.

Basic load
Default control loop parameters are available for all digital drive controllers. These parameters are either contained in the motor feedback data memory (if available) and can be activated by executing the command "basic load", or can be read from a data base via the parameterization user interface of DriveTop.

Box set
If you order a box set from Rexroth Indramat, you get several books with related topics that are collected in a box.

CAN

Controller Area Network (CAN) is a serial bus system. This international standard network is particularly suitable for interconnecting units that are controlled by a micro controller. CAN is realtime-capable and highly reliable in data transfer.

CANopen

CANopen, a profile family for industrial automation, is based upon CAN and the CAN Application Layer (CAL). The CANopen specifications developed by the research groups of the international association of users and manufacturers *CAN in Automation (CiA)* allow installing cost-efficient decentralized control systems and input/output systems, as well as interconnected sensor/actuator systems.

Command "Drive-controlled homing procedure"

With this function the drive controller automatically carries out the homing procedure, i. e. it establishes a reference for the measurement system, in compliance with preset parameters.

Command "Get mark position"

The command "Get mark position" is used to check whether the reference marks of an incremental measuring system are recognized correctly.

Command "Parking axis"

The command "Parking axis" is used to uncouple an axis. This can be necessary, for example, for stopping an axis temporarily . The start of this command causes all monitoring functions of the measuring system and of the control loops to be switched off.

Command "Positive stop drive procedure"

The "Positive stop drive procedure" causes all controller monitoring functions to be switched off. When the drive is blocked by the positive stop, no error message is generated.

Command "Set absolute measurement"

By means of this function the actual position value of an absolute measuring system can be set to any value. The actual position value thereby gets a defined reference to the machine zero point.

Current limit

By internal monitoring of the thermal load of the drive controller and the motor it is possible to activate the reduction of the allowed output current.

Customer password

All important axis-specific parameters are stored in the programming module. In order to protect these parameters against accidental or unauthorized change, they can be write-protected by a customer password.

Diagnosis

Every status of the drive controller is identified by means of a diagnosis. The diagnosis is displayed on the drive controller as a combination of letters and numbers, as well as stored in parameters. In addition, the commissioning software DriveTop illustrates the diagnosis in the form of a short text. There are different diagnoses for error, warning, command and status (diagnoses that display the operating status).

DISC

This function allows integrating special drive functions, that are not "hard wired" in the drive firmware, in the drive controller in the form of drive macros.

DKC

Name of a drive controller developed by Rexroth Indramat. This drive controller belongs to the ECODRIVE03 product family.

DKCxx.3-016-7-FW

The devices of the DKCxx.3-016-7-FW type still were in their development phase at the time this documentation was compiled, i. e. the data in the documentation are preliminary. For further information on the availability and the definite functionality, please contact our service department.

Document typecode

The document typecode helps identify documents. It can be found at several places on a document: on the left bottom of the title page, on the reverse of the title page (marginal note: "Document Typecode") and in each footing.

Drive Halt

When the Drive Halt function is activated, the drive does not follow the command values of the active operating mode any longer. The values that are used for stopping depend on the operating mode that had been active before.

DSF

Abbreviation for the position encoder type "digital servo feedback".

Dynamic position switch

The function "dynamic position switch" allows realizing dynamic position switching points. For each position switching point there is an individual switch-on and switch-off position, as well as an individual rate time.

EcoX

EcoX is the name of an expansion interface. This expansion interface is a serial, cyclic bus.

Encoder emulation

The encoder emulation allows outputting the actual position value of the motor encoder or an external encoder, or the position command value in the TTL format (incremental encoder emulation) or in the SSI format (absolute encoder emulation).

Error memory and hours-run meter

Errors that occur during operation are stored in an error memory. This memory contains the last 19 errors that occurred and the time when they occurred. There are also hours-run meters for the control section and power section of the drive controller.

Error reaction to be parameterized

If an error status is recognized in the drive controller, a drive error reaction is automatically started. In the case of a non- fatal error status the kind of error reaction (best possible deceleration) can be predetermined. (There are up to four different possibilities available.)

E-Stop function

The E-Stop function is used to stop the drive via a hardware input at the drive controller. It is thereby possible to switch off the drive in parallel with the master communication in case of emergency. It is possible to select how to activate the E-Stop function and how to stop the drive.

Evaluation of absolute measuring systems

Measuring systems that provide absolute position information over one or several encoder revolutions (single or multi-turn encoder) or over a certain distance (absolute linear measuring systems) can be used as motor measuring systems and/or optional measuring systems. The information on the absolute encoder range within which the measuring system can provide position data, is stored in the data memory of the measuring system or in the drive software. After the initialization procedure (setting of the absolute position), the actual position value is available within the absolute encoder range, with reference to the machine zero point.

Evaluation of optional encoders for position and/or velocity control

Optional (load-side) encoders can be evaluated, in order to use their values for position and/or velocity control. The optional encoder can be used as a load-side motor encoder.

FGP

Part of a firmware name. This firmware is used for general automation and supports master communication via field bus interfaces.

GDS

Name of a digital single-turn encoder supplied by Rexroth Indramat.

IBS

Abbreviation of the German term "Inbetriebnahmeschritt(e)" ("commissioning step[s]").

Jerk

Jerk is the change in acceleration per time.

LAF

Asynchronous linear frameless motors with encapsulated standard construction.

LAR

Asynchronous linear housing motors for high acceleration and short travel distances.

LSB valence

Valence of the "least significant bit".

LSF

Synchronous linear frameless motors with encapsulated standard construction for automation.

- and -

Synchronous linear frameless motors with encapsulated thermo construction for precision processing.

MBS

Synchronous rotary frameless spindle motors.

MBW

Synchronous rotary frameless motor with stator and rotor.

MDT

Abbreviation for master data telegram. The master data telegram is sent from the master to the slave via the real time data channel.

Measuring probe function

The measuring probe function is used to measure positions (actual position value or master axis position) and times (relative internal time) by means of binary input signals.

MHD

High-performance synchronous rotary motors.

MKD

Synchronous rotary motors for standard applications.

MKE

Synchronous rotary motors for areas subject to explosion hazard.

Modulo function

The modulo function allows representing all position data within the range from 0 to the modulo value that has been parameterized. It is therefore possible to realize axes that move endlessly in one direction.

Multi-turn encoder

Position encoder that provides absolute position over several revolutions.

Oscilloscope function

The oscilloscope function is used to record internal and external signals and status variables. Its functional scope corresponds approximately to that of a 2-channel oscilloscope.

PDO

Process data objects. Objects that are transferred via the acyclic channel (real time data channel), in the case of master communication via CANopen interface.

Position control loop monitoring

The position control loop monitoring function is used to diagnose malfunction within the position control loop. This monitoring function can recognize, for example, transgression of the torque or acceleration capacity of the drive, blockage of the axis mechanism or failures in the position encoder.

RCD

Abbreviation for residual current-operated protective devices.

Scaling

Combination of the unit and the number of decimal places.

SDO

Service data objects. Objects that are transferred via the cyclic channel (process data channel), in the case of master communication via CANopen interface.

SGP

Part of a firmware name. This firmware is used for general automation.

Single-turn encoder

Position encoder, an absolute value is assigned to every angular position between 0° and 360°.

SMT

Part of a firmware name. This firmware is used for machine tool applications.

Torque/force limit to be parameterized

The torque/force limit value can be parameterized to values below the maximum possible value. This is useful, for example, when the drive moves to the end position of its travel range.

Travel range limit

In order to limit the working range, the firmware provides the following functions:

- position limit values and
- travel range limit switches

Typecode

see document typecode

Velocity control loop monitoring

The drive controller monitors the velocity control loop for correct function and causes immediate stop (torque disable) in case of error. This monitoring function allows recognizing, for example, incorrect polarity of the motor connection, incorrect commutation angle or failures in the velocity encoder.

The monitoring function avoids the "runaway effect".

Velocity limit

The parameterization of the drive controller can limit the velocity of a motor to values lower than the maximum possible velocity. The maximum velocity can therefore be variably limited as required by specific applications.

Velocity mix factor

By means of the velocity mix factor the actual velocity value used for velocity control can be calculated from a combination of motor measuring system and external measuring system. This can be advantageous if the coupling between motor and load has play or torsion.

Notes

13 Index

7

A

B

C

E

F

N

O

P

Q

R

S

W

Z

Notes

14 Service & Support

14.1 Helpdesk

Unser Kundendienst-Helpdesk im Hauptwerk Lohr am Main steht Ihnen mit Rat und Tat zur Seite. Sie erreichen uns

- telefonisch: **+49 (0) 9352 40 50 60**
  über Service Call Entry Center Mo-Fr 07:00-18:00
- per Fax: **+49 (0) 9352 40 49 41**
- per e-Mail: **service@indramat.de**

Our service helpdesk at our headquarters in Lohr am Main, Germany can assist you in all kinds of inquiries. Contact us

- by phone: **+49 (0) 9352 40 50 60**
  via Service Call Entry Center Mo-Fr 7:00 am - 6:00 pm
- by fax: **+49 (0) 9352 40 49 41**
- by e-mail: **service@indramat.de**

14.2 Service-Hotline

Außerhalb der Helpdesk-Zeiten ist der Service direkt ansprechbar unter

+49 (0) 171 333 88 26
oder **+49 (0) 172 660 04 06**

After helpdesk hours, contact our service department directly at

+49 (0) 171 333 88 26
or **+49 (0) 172 660 04 06**

14.3 Internet

Unter **www.indramat.de** finden Sie ergänzende Hinweise zu Service, Reparatur und Training sowie die **aktuellen** Adressen *) unserer auf den folgenden Seiten aufgeführten Vertriebs- und Servicebüros.

☐ Verkaufsniederlassungen
☐ Niederlassungen mit Kundendienst

Außerhalb Deutschlands nehmen Sie bitte zuerst Kontakt mit unserem für Sie nächstgelegenen Ansprechpartner auf.

*) http://www.indramat.de/de/kontakt/adressen
Die Angaben in der vorliegenden Dokumentation können seit Drucklegung überholt sein.

At **www.indramat.de** you may find additional notes about service, repairs and training in the Internet, as well as the **actual** addresses *) of our sales- and service facilities figuring on the following pages.

☐ sales agencies
☐ offices providing service

Please contact our sales / service office in your area first.

*) http://www.indramat.de/en/kontakt/adressen
Data in the present documentation may have become obsolete since printing.

14.4 Vor der Kontaktaufnahme... - Before contacting us...

Wir können Ihnen schnell und effizient helfen wenn Sie folgende Informationen bereithalten:

1. detaillierte Beschreibung der Störung und der Umstände.
2. Angaben auf dem Typenschild der betreffenden Produkte, insbesondere Typenschlüssel und Seriennummern.
3. Tel.-/Faxnummern und e-Mail-Adresse, unter denen Sie für Rückfragen zu erreichen sind.

For quick and efficient help, please have the following information ready:

1. Detailed description of the failure and circumstances.
2. Information on the type plate of the affected products, especially type codes and serial numbers.
3. Your phone/fax numbers and e-mail address, so we can contact you in case of questions.

14.5 Kundenbetreuungsstellen - Sales & Service Facilities

Deutschland – Germany

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