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ECODRIVE03
Drive for Machine Tool Applications
With SERCOS-, Analog- and Parallelinterface

Functional Description: SMT-02VRS

SYSTEM200

DOK-ECODR3-SMT-02VRS**-FK01-EN-P

Rexroth
Indramat

Title ECODRIVE03 Drive for Machine Tool Applications With SERCOS-, Analog- and Parallelinterface

Type of Documentation Functional Description: SMT-02VRS

Document Typecode DOK-ECODR3-SMT-02VRS**-FK01-EN-P

Internal File Reference

- Box 71-02V-EN
- Based on: SMT 02V
- 120-1000-B308-01/EN

Purpose of Documentation The following documentation describes the functions of the firmware FWA-ECODR3-SMT-02VRS.

This documentation serves:

- for Description of all functional features

Record of Revisions

Description	Release Date	Notes
DOK-ECODR3-SMT-02VRS**-FK01-EN-P	12.99	first release

Published by Rexroth Indramat GmbH
Bgm.-Dr.-Nebel-Str. 2 • D-97816 Lohr a. Main

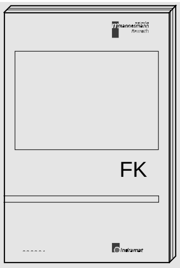
Telephone 09352/40-0 • Tx 689421 • Fax 09352/40-4885

http://www.rexroth.com/indramat

Dept. ECD (MK/JR)

Note This document has been printed on chlorine-free bleached paper..

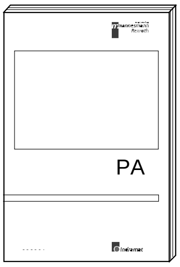
Summary of Documentation - Box



Functional Description:

Description of all implemented Function based on SERCOS Parameters

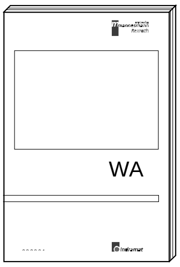
Order designation:
DOK-ECODR3-SMT-02VRS**-FK01-EN-P



Parameter Description:

A description of all parameters used in the firmware

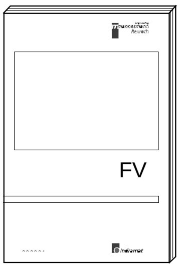
Order designation:
DOK-ECODR3-SMT-02VRS**-PA01-EN-P



Troubleshooting Guide:

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

Order designation:
DOK-ECODR3-SMT-02VRS**-WA01-EN-P

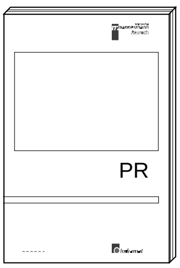


Firmware Version Notes:

Description of new and changed functions in terms of the derivatives:

-FWA-ECODR3-SMT01VRS-MS

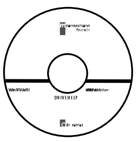
Order designation:
DOK-ECODR3-SMT-02VRS**-FV01-EN-P



Project Planning Manual:

-Planning control cabinet construction
-Planning the electric layout in the control cabinet

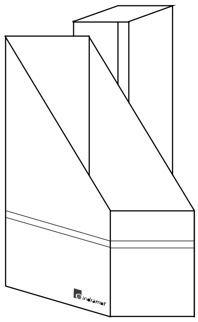
Order designation:
DOK-ECODR3-DKC**.3****-PR01-EN-P



CD: DRIVEHELP

Collection of Windows help systems which contain documents on firmware derivatives

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



Order designation
DOK-ECODR3-SMT-02VRS**-7101-EN-P

Notes

Contents

Supplement A: Serial Communication

1 System Overview

1.1 ECODRIVE03 - the Universal Drive Solution for Automation

The universal automation system **ECODRIVE03** is an especially cost-effective solution for drive and control tasks.

Exceptional power data, extensive functions and an excellent price-performance ratio are characteristic of this system.

Further features of **ECODRIVE03** are its easy assembly and installation, extreme machine accessing and the elimination of system components.

ECODRIVE03 can be used to implement numerous drive tasks in the most varying of applications. Typical applications are:

- machine tools
- printing and paper processing machines
- handling systems
- packaging and food processing machines
- handling and assembly systems

1.2 ECODRIVE03 - a Drive Family

There are three application-related firmware variants available for the **ECODRIVE03 family**:

FWA-ECODR3-SMT-0xVRS-MS
- Drive for Machine Tool Applications With SERCOS-, Analog- and Parallelinterface

FWA-ECODR3-SGP-0xVRS-MS
- Drive for General Automation With SERCOS-, Analog- and Parallelinterface

FWA-ECODR3-FGP-0xVRS-MS
- Drive for General Automation With Fieldbus-Interfaces

The following function description relates to the firmware variant:

FWA-ECODR3-SMT-02VRS-MS
- Drive for Machine Tool Applications With SERCOS-, Analog- and Parallelinterface

For each listed variant, there is individual documentation.

1.3 Drive Controllers and Motors

Available controllers

The drive controller family of the **ECODRIVE03** generation is at present made up of eight different units. These differentiate primarily in terms of which interface is used command communications.

- DKC01.3 Parallel interface
- DKC11.3 Analog interface
- DKC21.3 Parallel interface 2
- DKC02.3 SERCOS interface
- DKC03.3 Profibus-DP interface
- DKC04.3 InterBus interface
- DKC05.3 CANopen interface
- DKC06.3 DeviceNet interface

Each of these drive controllers is, in turn, available in a 40 A, 100 A or a 200 A version.

Supported motor types

With **ECODRIVE03** firmware it is possible to operate

- synchronous motors for standard applications up to 48 Nm.
- synchronous motors for increased demands of up to 64 Nm.
- asynchronous motors for main spindle applications
- asynchronous kit motors
- linear synchronous and asynchronous motors

1.4 Function Overview: FWA-ECODR3-SMT-02VRS-MS

Command Communications Interface

- SERCOS interface
- Parallel interface
- Analog interface.

Possible Operating Modes

- torque control
- velocity control
- position control
- drive-internal interpolation
- relative drive-internal interpolation
- jogging
- positioning block mode
- Stepper motor mode

Supported Types of Motors

- MKD
- 2AD
- 1MB
- LAF
- MKE
- Rotary synchronous kit motor
- MHD
- ADF
- MBW
- LAR
- Linear synchronous kit motor

Supported Measuring Systems

- HSF/LSF
- resolver
- sine encoder with 1Vss signals
- encoder with EnDat-Interface
- resolver without feedback data memory
- resolver without feedback data memory with incremental sine encoder
- gearwheel encoder with 1Vss signals
- Hall encoder + square-wave encoder
- Hall encoder + sine encoder
- ECI encoder

Which combination is possible, is outlined in section: "Setting the Measurement System"

General Functions

- Extensive diagnostics options
- Basic parameter block that can be activated for a defined setting of the drive parameters to default values.
- Customer passwords
- Error memory and operating hour counter
- Configurable signal status word
- Supports five (5) languages for parameter names and units and diagnoses (S-0-0095)
  - German
  - English
  - French
  - Spanish
  - Italian
- Settable drive-internal position resolution
- Evaluation of option (load-side) encoder for position and/or velocity control
- Evaluates absolute measuring system with setting of absolute dimension
- Modulo function

- Parametrizable torque limit
- Current limit
- Velocity limit
- Travel range limit:
  - via travel range limit switch and/or
  - position limit values
- Drive-side error reactions:
  - error reaction "return limit"
  - best possible standstill "velocity command to zero"
  - best possible standstill "Torque free"
  - best possible standstill "velocity command to zero with ramp and filter
  - power shutdown with fault
  - NC reaction with fault
  - E-Stop function
- Control loop settings
  - base load function
  - acceleration precontrol
  - velocity mix factor
  - velocity precontrol
  - automatic control loop settings
- Velocity control loop monitor
- Position control loop monitor
- Drive halt
- Command Drive-controlled homing
- Command Set Absolute Measuring
- Analog output
- Analog input
- Oscilloscope function
- Probe function
- Command Detect marker position
- Dynamic cam switch group
- Encoder emulation
  - absolute encoder emulation (SSI format)
  - incremental encoder emulation
- Command Positive Stop Drive Procedure
- Command Parking Axis
- Command Spindle Positioning
- Frictional compensation
- Corrective functions
  - reverse backlash correction

2 Safety Instructions for Electric Servo Drives and Controls

2.1 Introduction

Read these instructions before the equipment is used and eliminate the risk of personal injury or property damage. Follow these safety instructions at all times.

Do not attempt to install, use or service 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 product is resold, rented or transferred or passed on to others, then these safety instructions must be delivered with the product.

WARNING

Inappropriate 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 product damage, personal injury, severe electrical shock or death !

2.2 Explanations

The safety warnings in this documentation describe individual degrees of hazard seriousness in compliance with ANSI:

Warning symbol with signal word	**Degree of hazard seriousness** The degree of hazard seriousness describes the consequences resulting from non-compliance with the safety guidelines.
DANGER	Bodily harm or product damage will occur.
WARNING	Death or severe bodily harm may occur.
CAUTION	Death or severe bodily harm may occur.

Fig. 2-1: Classes of danger with ANSI

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2.3 Hazards by inappropriate use

DANGER

High voltage and high discharge current ! Danger to life, risk of severe electrical shock and risk of injury !

DANGER

Dangerous movements ! Danger to life and risk of injury or equipment damage by unintentional motor movements !

WARNING

High electrical voltage due to wrong connections ! Danger to life, severe electrical shock and severe bodily injury !

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 inappropriate handling ! Bodily injury caused by crushing, shearing, cutting and mechanical shock !

CAUTION

Risk of injury due to inappropriate handling of batteries !

2.4 General Information

- Rexroth Indramat GmbH is not liable for damages resulting from failure to observe the warnings given in these documentation.
- Order operating, maintenance and safety instructions in your language before starting up the machine. If you find that due to a translation error you can not 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.
- Trained and qualified personnel in electrical equipment :
  Only trained and qualified personnel may work on this equipment or within its proximity. Personnel are qualified if they have sufficient knowledge of the assembly, installation and operation of the product as well as an understanding of all warnings and precautionary measures noted in these instructions.
  Furthermore, they should be trained, instructed and qualified to switch electrical circuits and equipment on and off, to ground them and to mark them according to the requirements of safe work practices and common sense. 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 on commercial machinery.

European countries: see directive 89/392/EEC (machine guideline).

- The ambient conditions given in the product documentation must be observed.
- Use only safety features that are clearly and explicitly approved in the Project Planning manual.
  For example, the following areas of use are not allowed: Construction cranes, Elevators used for people or freight, Devices and vehicles to transport people, Medical applications, Refinery plants, the transport of hazardous goods, Radioactive or nuclear applications, Applications sensitive to high frequency, mining, food processing, Control of protection equipment (also in a machine).
- Start-up is only permitted once it is sure that the machine, in which the product is installed, complies with the requirements of national safety regulations and safety specifications 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 INDRAMAT document "EMC in Drive and Control Systems”.
  The machine builder is responsible for compliance with the limiting values as prescribed in the national regulations and specific EMC regulations for the application.

European countries: see Directive 89/336/EEC (EMC Guideline).

U.S.A.: See National Electrical Codes (NEC), National Electrical Manufacturers Association (NEMA), and local building codes. The user of this equipment must consult the above noted items at all times.

- Technical data, connections and operational conditions are specified in the product documentation and must be followed at all times.

2.5 Protection against contact with electrical parts

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

Making contact with parts conducting voltages above 50 volts could be dangerous to personnel and cause an electrical shock. When operating electrical equipment, it is unavoidable that some parts of the unit conduct dangerous voltages.

DANGER

High electrical voltage ! Danger to life, severe electrical shock and severe bodily injury !

⇒ 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 electrical 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 if the ground wire is not permanently connected, even for brief measurements or tests.

⇒ Before working with electrical parts with voltage potentials higher than 50 V, the equipment must be disconnected from the mains voltage or power supply.

⇒ The following should be observed with electrical drives, power supplies, and filter components:

Wait five (5) minutes after switching off power to allow capacitors to discharge before beginning work. Measure the voltage on the capacitors before beginning 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 (r.c.d.) must not be used on an electric drive ! Indirect contact must be prevented by other means, for example, by an overcurrent protective device.

⇒ Equipment that is built into machines must be secured against direct contact. Use appropriate housings, for example a control cabinet.

European countries: according to EN 50178/1998, section 5.3.2.3.

U.S.A: See National Electrical Codes (NEC), National Electrical Manufacturers Association (NEMA) and local building codes. The user of this equipment must observe the above noted instructions at all times.

To be observed with electrical drives, power supplies, and filter components:

DANGER

High electrical voltage ! High leakage current ! Danger to life, danger of injury and bodily harm from electrical shock !

⇒ Before switching on power for electrical units, all housings and motors must be permanently grounded according to the connection diagram. This applies even for brief tests.

⇒ Leakage current exceeds 3.5 mA. Therefore the electrical equipment and units must always be firmly connected to the supply network.

⇒ Use a copper conductor with at least 10 mm² cross section over its entire course for this protective connection !

⇒ Prior to startups, even for brief tests, always connect the protective conductor or connect with ground wire. High voltage levels can occur on the housing that could lead to severe electrical shock and personal injury.

European countries: EN 50178/1998, section 5.3.2.1.

USA: See National Electrical Codes (NEC), National Electrical Manufacturers Association (NEMA), and local building codes. The user of this equipment must maintain the above noted instructions at all times.

2.6 Protection by protective low voltage (PELV) against electrical shock

All connections and terminals with voltages between 5 and 50 Volts on INDRAMAT products are protective low voltages designed in accordance with the following standards on contact safety :

- International: IEC 364-4-411.1.5
- EU countries: see EN 50178/1998, section 5.2.8.1.

WARNING

High electrical voltage due to wrong connections ! Danger to life, severe electrical shock and severe bodily injury !

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

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

2.7 Protection against dangerous movements

Dangerous movements can be caused by faulty control or the connected motors. These causes are be various such as:

- unclean or wrong wiring of cable connections
- inappropriate or wrong operation of equipment
- malfunction of sensors, encoders and monitoring circuits
- defective components
- software errors

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

The monitors in the drive components make faulty operation almost impossible. Regarding personnel safety, especially the danger of bodily harm and property damage, this alone should not be relied upon to ensure complete safety. Until the built-in monitors become active and effective, it must be assumed in any case that some faulty drive movements will occur. The extent of these faulty drive movements depends upon the type of control and the state of operation.

DANGER

Dangerous movements ! Danger to life and risk of injury or equipment damage !

⇒ Personnel protection must be secured for the above listed reason by means of superordinate monitors or measures.

These are instituted in accordance with the specific situation of the facility and a danger and fault analysis conducted by the manufacturer of the facility. All the safety regulations that apply to this facility are included therein. By switching off, circumventing or if safety devices have simply not been activated, then random machine movements or other types of faults can occur.

Avoiding accidents, injury or property damage :

⇒ Keep free and clear of the machine's range of motion and moving parts. Prevent people from accidentally entering the machine's range of movement:

- use protective fences
- use protective railings
- install protective coverings
- install light curtains or light barriers

⇒ Fences must be strong enough to withstand maximum possible momentum.

⇒ Mount the emergency stop switch (E-stop) 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 start-inhibit system to prevent unintentional start-up.

⇒ Make sure that the drives are brought to standstill before accessing or entering the danger zone.

⇒ 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

⇒ Avoid operating high-frequency, remote control and radio equipment near electronics circuits and supply leads. If use of such equipment cannot be avoided, verify the system and the plant for possible malfunctions at all possible positions of normal use before the first start-up. If necessary, perform a special electromagnetic compatibility (EMC) test on the plant.

2.8 Protection against magnetic and electromagnetic fields during operations and mounting

Magnetic and electromagnetic fields generated by 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 pacemakers, metal implants and hearing aids are not permitted to enter 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 pacemaker to enter such an area, then a physician must be consulted prior to doing so. Pacemaker, that are already implanted or will be implanted in the future, have a considerable deviation in their resistance to interference. Due to the unpredictable behavior 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.

2.9 Protection against contact with hot parts

CAUTION

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

⇒ Do not touch surfaces near the source of heat ! Danger of burns !

⇒ Wait ten (10) minutes before you access any hot unit. Allow the unit to cool down.

⇒ Do not touch hot parts of the equipment, such as housings, heatsinks or resistors. Danger of burns !

2.10 Protection during handling and installation

Under certain conditions unappropriate handling and installation of parts and components may cause injuries.

CAUTION

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

⇒ Observe general instructions and safety regulations during handling installation.

⇒ Use only appropriate lifting or moving 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.

⇒ Wear appropriate protective clothing, e.g. safety glasses, safety shoes and safety gloves.

⇒ Never stay under suspended loads.

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

2.11 Battery safety

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

CAUTION

Risk of injury through incorrect handling !

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

⇒ Never charge batteries (danger from leakage and explosion).

⇒ Never throw batteries into a fire.

⇒ Do not dismantle batteries.

⇒ Handle with care. Incorrect extraction or installation of a battery can damage equipment.

Note: 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 refuse. Observe the legal requirements given in the country of installation.

2.12 Protection against pressurized Systems

Certain Motors (ADS, ADM, 1MB etc.) and drives, corresponding to the information in the Project Planning manual, must be provided with and remain under a forced load such as compressed air, hydraulic oil, cooling fluid or coolant. In these cases, improper handling of the supply of the pressurized systems or connections of the fluid or air under pressure can lead to injuries or accidents.

CAUTION

Danger of injury when pressurized systems are handled by untrained personnel!

⇒ Do not attempt to disassemble, to open or to cut a pressurized system.

⇒ Observe the operation restrictions of the respective manufacturer.

⇒ Before the disassembly of pressurized systems, lower pressure and drain off the fluid or gas.

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

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

Note: Environmental protection and disposal! The fluids used in the operation of the pressurized system equipment is not environmentally compatible. Fluid that is damaging to the environment must be disposed of separate from normal waste. Observe the national specifications of the country of installation.

3 General Instructions for Installation

3.1 Definition of Terms, Introduction

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

Parameter

Communication with the drive occurs (with a few exceptions) with the help of parameters. They can be used for

- Setting the configuration
- Parameterizing the control/drive settings
- Accessing control/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 ID numbers.

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 Commands)

Paramter 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 parametrization surface.

Element No.:	Designation:	Remarks:
1	ID Number	Parameter identification
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. 3-1: Data blocks or parameter structure

Write Accessibility Only the operating data can be changed; 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 communications phase.

Possible Error Messages when Reading and Writing Operating Data

Error:	Reason:
0x7002, data transmitted too short	
0x7003, data transmitted too long	
0x7004, Data not changeable	The operating data is write-protected
0x7005, Data currently write-protected	The operating data cannot be written to in this communication phase (see Supplement A:Parameterdescription)
0x7006, Data smaller than minimum value	The operating data is smaller than its minimal input value
0x7007, Data larger than maximum value	The operating data is larger than its maximum input value
0x7008, Data is not correct	The value could not be accepted as written because internal tests lead to a negative result
0x7009, data write protected with password	The parameter cannot be write accessed as the customer password was activated in parameter **S-0-0267, Password**. All parameters listed in S-0-0192, IDN-list of backup operation data are therefore locked.

Fig. 3-2: Error messages while reading/writing operating data

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 or
- parameterizing the control drive settings

Each time operating data is written to it is stored.

The following modules contain non-volatile memory:

- Control drive
- Motor feedback (optional)
- Programming module

Parameters Stored in the Digital Drive

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

This consists of 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-0-4015, Intermediate DC bus voltage**
- **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, Braking resistor data**
- **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 with MHD, MKD and MKE motors.

Additionally, parameters for the "Load Default" function and the position encoder are stored here.

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

In parameter block 7 (e.g., S-7-0100) the original data without write access are stored in the motor feedback data memory. These are copied after powering up into the parameters of parameter block 0 (e.g., S-0-0100).

Note: The parameters of parameter block 0 take effect.

Parameters Stored in DSM Programming Module

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

All ID numbers 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 before hand so that they can be written into the new module after the exchange.

Note:	By switching the programming module when devices are exchanged, the characteristics of the device that has been exchanged can be easily transferred to the new device.

Data Saving

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 parametrization surface, you can obtain a complete data backup of this axis after the first setup (Backup&Restore-function).

Parameter Buffer Mode

The drive controller is capable of storing data that is transmitted via the user data channel (e.g., service channel) either temporarily or permanently.

Note:	Parameter **S-0-0269, Parameter buffer mode** is insignificant as of version FGP-02VRS as all the parameters are backed up from that point on in a NOVRAM.

Basic parameter block

The drive parameters are fixed at delivery 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 basic parameter block is constructed so 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 lower values

Velocity control is the mode set.

Note:	The basic parameter block does not guarantee a matching of the drive to the machine as well as, in some cases, to the motor connected and the measuring systems. The relevant settings must be made when first starting up the axis.

(See also: "Basic Drive Functions" and "Commissioning Guidelines".)

Running the "load basic parameter block" function automatically

The drive firmware is on the programming module. In the event of a firmware exchange, the drive controller will detect this the next time the machine 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 replacement of the firmware followed by "load base parameter block". If this is to be prevented, then the parameters must be stored prior to an exchange and must be reloaded after exchange and load base parameter block.

Note: As long as the drive displays "PL" and the command is active, then communications via the serial interface (with DriveTop) is not possible.

Password

All important axis-specific parameters are stored in the programming module. If, e.g., a controller is replaced because of a defect then the features can be transferred to the new controller by simply using the old module.

S-0-0279, IDN-list of password-protected operation data

The affected parameters are stored in **S-0-0279, IDN-list of password-protected operation data.** To secure these parameters against unwanted or non-authorized changes, the customer password can be activated.

By editing **S-0-0279, IDN-list of password-protected operation data** the user can select the parameter which are to be 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 symbols and length

The password has to have:

- at least 3 symbols
- no more than ten symbols
- can only use the letters a - z and A - Z
- and the numbers 0 to 9.

3 different password states are possible

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

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

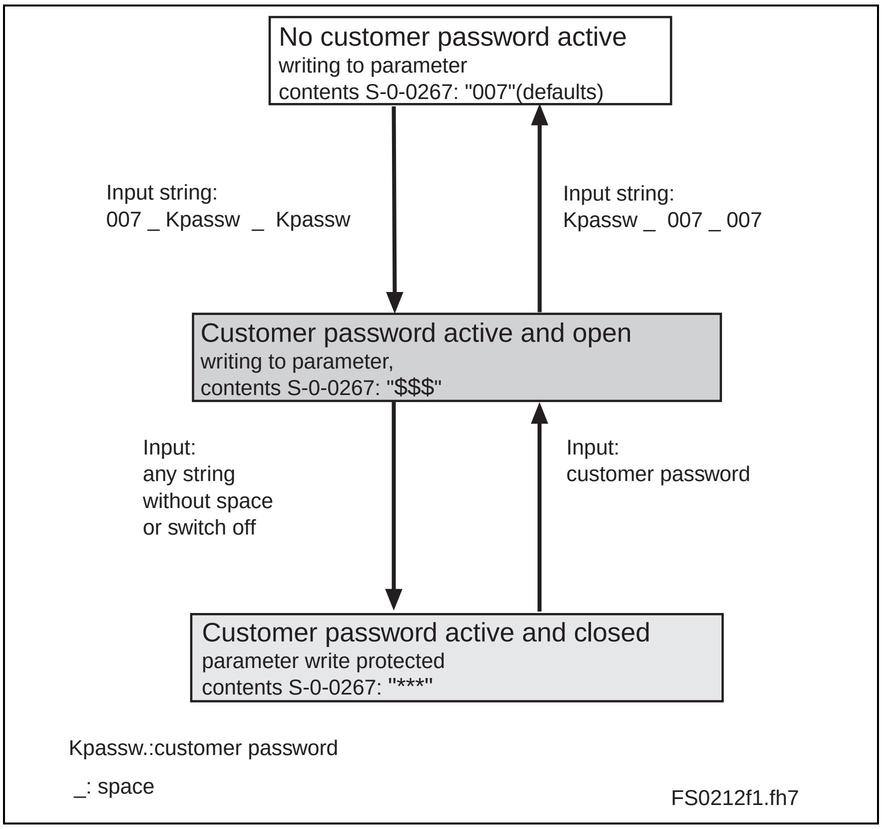

Fig. 3-3: Possible password states

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

Note: As long as the drive displays "PL" and the command is active, then communications via the serial interface (with DriveTop) is not possible.

Master password Rexroth Indramat retains the rights to the 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.

Each command that is started must also be cleared.

A primary control can start, interrupt or erase 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 H1 display, where x is the number of the command.

list of all procedure commands

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

Command Types

There are 3 command types.

- **Drive-Controlled Command**
  - Eventually leads to an automatic drive operation or motion
  - Can be started only when controller enable is set
  - Deactivates the active operating mode during its operation
- **Monitor Command**
  - Activates or deactivates monitors or features in the control drive
- **Management Command**
  - executes management tasks; is not interruptable

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 commanded value 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.

Also see: "Data block structure".

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

data status

The condition can be:

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

Change Bit Command

The Change Bit Command 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 command. It can read the corresponding data status of the command or the command itself, which was set sometime but has not been cleared. The control system will recognize from this if the command ended with or without an error in the drive. Afterwards this command should be cleared by the control.

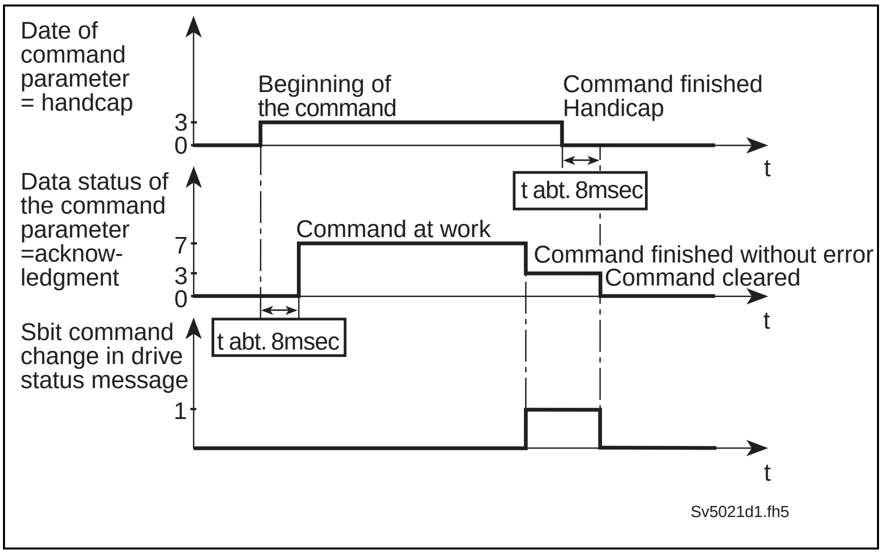

Fig. 3-4: Input, acknowledgement and Command Change Bit during proper execution

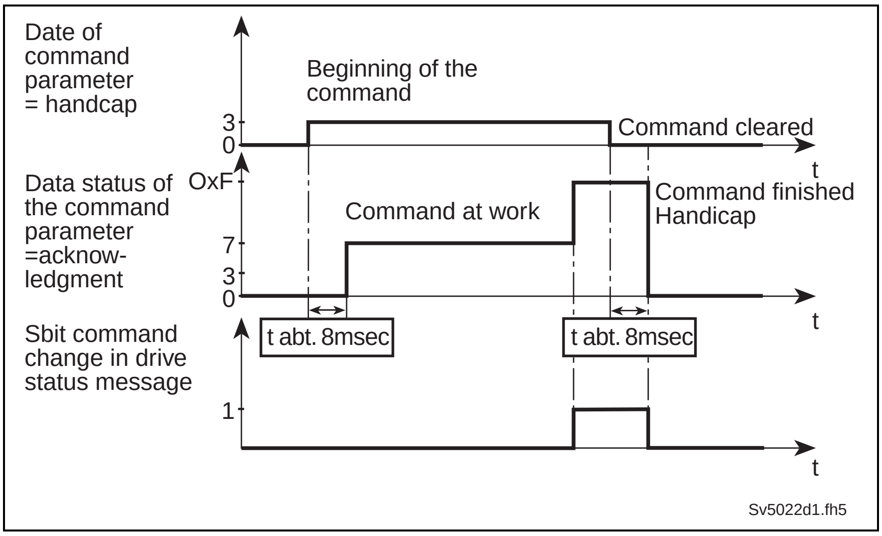

Fig. 3-5: Input, acknowledgement and Command Change Bit during erroneous execution

A delay time of up to 8ms 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, leading 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 is ready for operation and the controller enable signal is positive.
- The drive displays **"AF"** in the H1 display.

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

See also: "Operating Modes"

Warnings

Warnings do not cause automatic shutdowns

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 a shutdown of the drive if this state continues.

Warning Classes

The warning class is evident from the diagnostic message

Warnings can be separated into 2 classes. They are differentiated by whether the drive executes an automatic reaction when the warning appears.

Warning Class:	Diagnostic Message:	Drive Response:
With drive response	E8xx	reacts on its own specifically in terms of any occurring warnings
Without drive response	E2xx	--

Fig. 3-6: Breakdown of the Warning Classes

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

Error

Many areas are monitored in connection with operating modes and parameter settings. An error message is generated if a condition is encountered which no longer allows proper operation

Error Classes

The error class is evident from the diagnostic message.

Errors are separated into four different drive's error response:

Error Class:	Diagnostic Message:	Drive Response:
Fatal	F8xx	Torque free switching
Travel range	F6xx	Velocity command value switched to zero
Interface	F4xx	In accordance with best possible deceleration
Non-fatal	F2xx	In accordance with best possible deceleration

Fig. 3-7: Error class divisions

Drive's Error Response

If an error state is detected in the drive, the drive's error response will automatically be executed as long as the drive is in control. The H1 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 must be externally cleared.

Errors are not automatically cleared; they are cleared externally by:

- Initiating the command S-0-0099, C500 Reset class 1 diagnostic or
- Pressing the "S1" key.

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 set controller enable, the drive will execute an error response. The drive automatically deactivates itself at the end of each error response; 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

- enter a 0-1 edge bit into the controller enable

Error memory

Error memory and operating hour counter

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 hour

Simultaneously, there is an operating hour counter for control and power sections of the drive controller. This function has the following parameters:

- **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 List 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 parametrization programs (e.g., DriveTop).

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

The ID numbers of all parameters in the drive are in this parameter. This list supports, for example, the parametrization program in the menu of which "All drive parameters" the information as to which ID number is in this drive firmware is stored.

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

In parameter **S-0-0192, IDN-list of backup operation data** the ID numbers 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 parametrization program uses this ID number list to secure a copy of the drive parameters.

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

In the data of these ID lists, the drive enters the ID numbers out of parameter **S-0-0018, IDN-list of operation data for CP2** 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 resident memory (programming module, amplifier or motor feedback data memory), do not fit to 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 upon negative acknowledgement of command **S-0-0127, C100 Communication phase 3 transition check** in **S-0-0021, IDN-list of invalid op. data for comm. Ph. 2** must be corrected.

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

The drive enters the ID numbers out of parameter **S-0-0019, IDN-list of operation data for CP3** into the data of this ID list, which were detected in command **S-0-0128, C200 Communication phase 4 transition check** as invalid. Parameters are detected as invalid if:

- their checksum, stored together with the operating data in a resident 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 limits or
- their operating data has violated the plausibility rules.

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

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

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

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

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

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

The ID numbers of all the commands in the drive are stored in this parameter.

3.2 Parametrization Mode - Operating Mode

Command communication sets the communications phase and therefore the parametrization or operating modes

Given drive controllers without command communications interface or if the command communications is not active (command communications = could be SERCOS), then the drive switches automatically into operating mode after the control voltage is switched on.

If the command communications is active, then the drive controller does not automatically switch into operating mode after the control voltage is switched on. Only the command communications master can switch between parametrization modes and operating modes.

Parametrization surfaces that communicate with the drive controller vua the RS232/485 can switch from parametrization and operating mode as long as the drive is not in control mode and command communications is not active.

The switch from parametrization to operating mode is controlled by starting and ending 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**

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

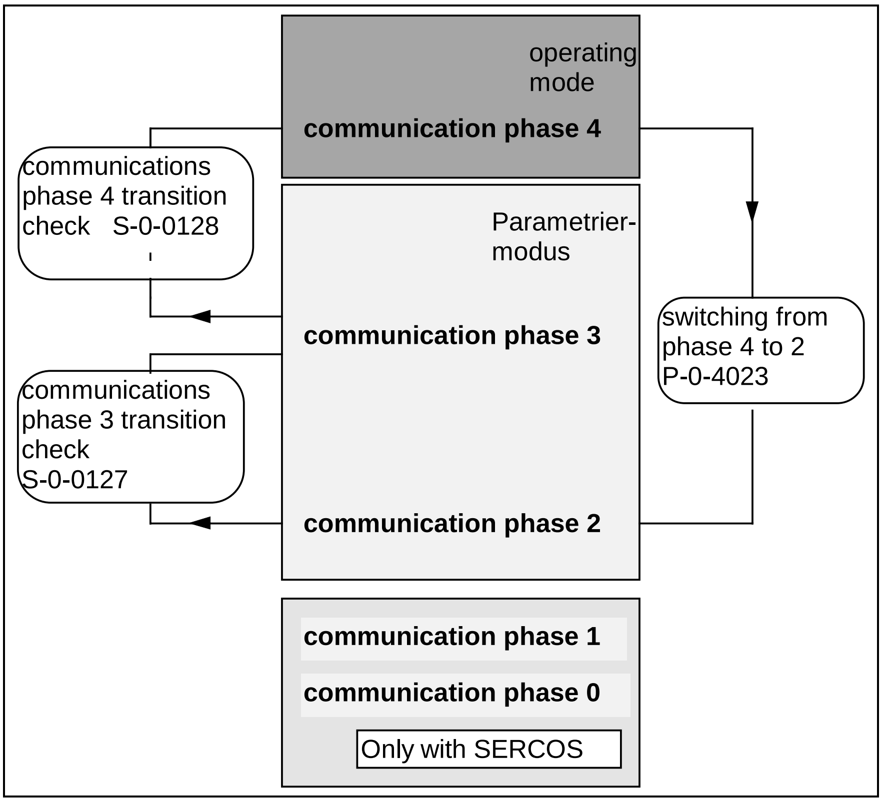

Fig. 3-8: The communications phases

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 communications phase 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.

The causes and help with transition command errors are specified in the diagnostics description.

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

In transition command C1 checks command communications timing. For units without command communications, these checks are irrelevant. (Command communications can include, e.g. SERCOS and so on).

The following checks are conducted in command C1.

Checking telegram configurations of the command communications

This checks whether the parameters selected for the configurable data block in the master data telegram or drive data telegram can be configured. It is also checked whether the allowable lenth of the configurable data block has been maintained.

Command errors :

- **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**

can occur in this case.

Checking validity of communications parameters

If a parameter needed for transition to phase 3 has never been written into or the backup 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. Ph. 2**

They are made valid by writing into them.

Extreme value check of communications parameters

If during the extreme value check of the parameters relevant to command communications an error is generated, 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. Ph. 2**

and must be corrected.

Checking plausibility and maintaining marginal conditions of command communications

Check timing parameters of command communications in phases 3 and 4 for plausibility and maintaining marginal conditions.

Command errors

- **C108 Time slot parameter > Sercos cycle time** (only with Sercos)
- **C109 Position of data record in MDT (S-0-0009) even** (only with Sercos)
- **C110 Length of MDT (S-0-0010) odd** (only with Sercos)
- **C111 ID9 + Record length - 1 > length MDT (S-0-0010)** (only with Sercos)
- **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)**
- **C115 T2 too small** (only with Sercos)

can occur.

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 a parameter needed for transition to phase 4 has never been written into, and its backup 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. Ph. 3**

and are made valid by writing into.

Reading the controller memory

The drive controller reads the EEPROM memory 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. Ph. 3.**

Checking whether optional encoder is needed

Checking, as per operating mode parameters **S-0-0032..35** or referencing parameter **S-0-0147**, whether a second encoder is needed but there isn't one, as 0 is entered in parameter **P-0-0075, Feedback type 2**. The faulty operating parameters or referencing parameters are listed in:

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

Command error

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

Checking whether motor encoder is availablet

Check whether no motor encoder is available (**P-0-0074, Feedback type 1** = 0) and a value of 2 has not been 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**

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

- **C218 Feedback 2 data reading error**

is generated. If "load side motor encoder" has been selected in parameter **P-0-0185, Function of encoder 2** but no rotary asynchronous motor is available, then error message

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

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 can 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. Ph. 3**

and must be corrected.

Checking modulo range

Checking whether an activated modulo scaling of the position of parameter **S-0-0103, Modulo value** can be processed. If so, 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. Ph. 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 errors

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

are generated.

Checking controller type

Depending on controller type, various internal settings are performed. if parameter **S-0-0140, Controller type** cannot be read, then command error

- **C228 Controller type S-0-0140 wrong**

is generated.

Absolute encoder monitoring

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

- **F276 Absolute encoder out of allowed window**

is generated. The transition command is wrongly acknowledged, but instead the error must be cleared with the execution of command **S-0-0099, C500 Reset class 1 diagnostic**.

(Also see section: "Clearing Error").

3.3 Commissioning Guidelines

For commissioning drive controllers, the parametrization interface DriveTop can be used.

The procedures for commissioning a drive controller with DriveTop entail 11 steps (IBS-1..11).

The sequence is illustrated below.

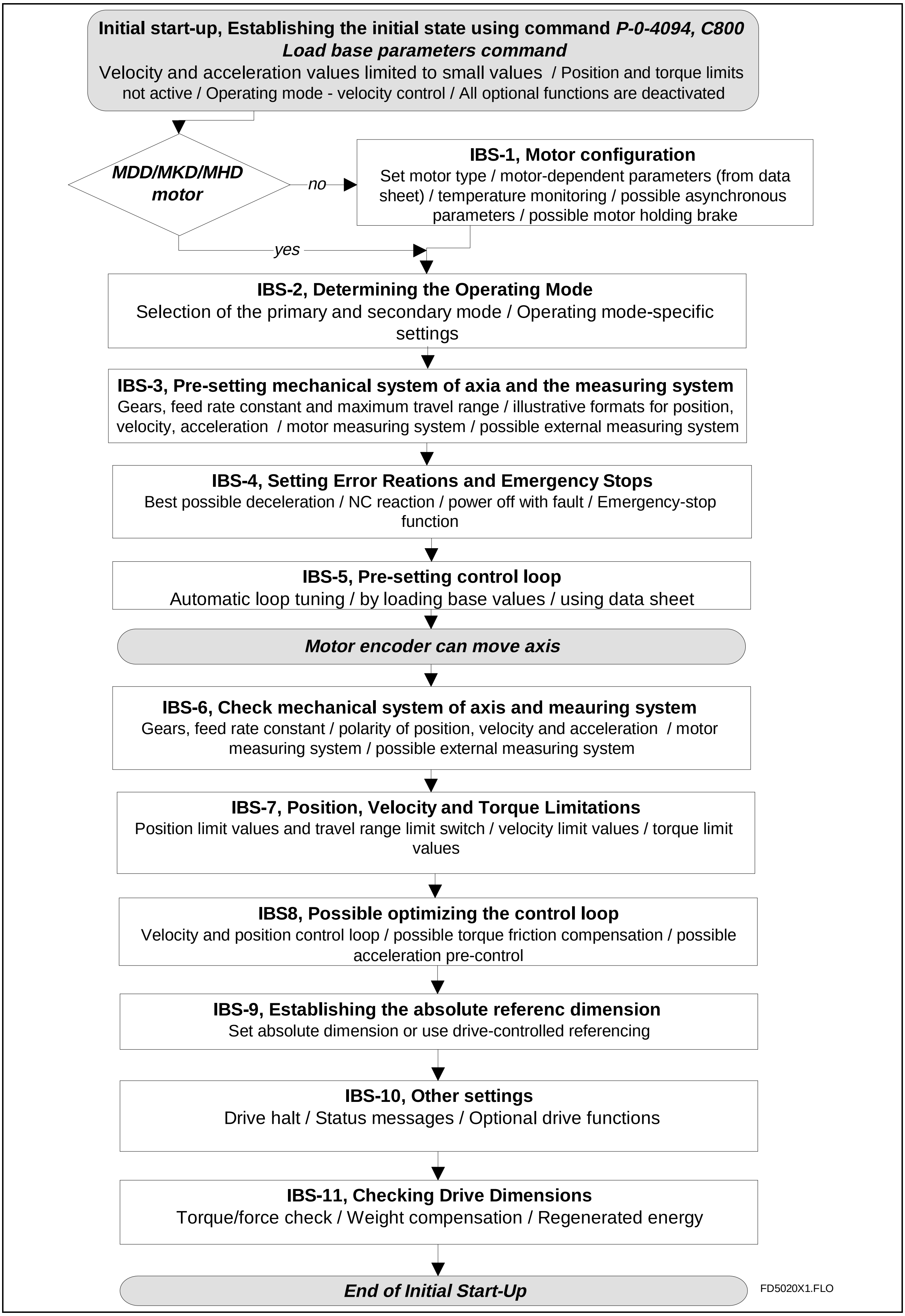

Fig. 3-9:Commissioning guidelines

IBS-1, Motor configuration

motor without data memory

These guidelines are 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 with DriveTop using data from the motor data bank.
- the parameters for the motor temperature warning and off thresholds must be parametrized as well
- and given a motor holding brake, these parameters must be properly set also.

motor with data memory

Those motors with data memory such as

- MHD, MKD,MKE-motors

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

(See also chapter: "Setting the Motor Type“.)

IBS-2, Determining the Operating Mode

In this step, the main and auxiliary operating modes are selected.

Operating-mode specific settings must be made.

In particular, necessary limit values, optionally usable filters and the available operating modes must be defined.

Note: The initialization of the operating mode in drives with SERCOS interface is set automatically by the control.

(Also see section: "Operating Modes")

IBS-3, 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 the drive of linear slides
- scaling settings for showing position, velocity and acceleration parameters of the drive. This sets, for example, whether the data is motor shaft or load related and which LSB valence these have, e.g., position data with 0.001 degrees or 0.0001 inches and so on.
- Interfaces, rotational directions and the resoluton of the motor encoder, and where available, optional encoders.

(See also chapter : -"Physical Values Display Format"
-"Mechanical Transmission Elements" and
-"Setting the Measurement System").

IBS-4, Setting the error reactions and E-stop

In this step, the reaction of the drive in the event of an error is set as well as the triggering of the drive's own E-stop input. The following parametrizations must be performed:

- type and mode of error reactions in drive
- selection whether NC reaction in error case should happen
- selection whether and if so when, the power supply is switched off and whether a package reaction is to be conducted
- Configuration of the E-stop input

(See also chapter: "Drive Error Reaction“)

IBS-5, Pre-setting Control Loop

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

- Execute 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

- Execute command S-0-0262, C700 Command basic load or
- by 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 become necessary (velocity and position control loop parameters, compensation functions and precontrol), then use commissioning step no. 8.

(See also chapter: "Control Loop Settings".)

IBS-6, Checking axis mechanics and measuring system

The presettings made in IBS 3 are checked here and modified, if necessary. This means that the axis must be moved by jogging. The following checks must be made:

- check 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. (This check need not be performed in MHD and MKD motors. If this is not the case, then bit 2 in **S-0-0277, Position feedback 1 type** must 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 can be checked whether a distance is correctly displayed in this process. 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 external encoder in parameter **S-0-0053, Position feedback 2 value** it can be checked whether a distance is correctly displayed in this process. **S-0-0051, Position feedback 1 value** and **S-0-0053, Position feedback 2 value** should run parallel when jogging a specific path. 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 chapter : -"Physical Values Display Format"
-"Mechanical Transmission Elements" and
-"Setting the Measurement System").

IBS-7, Limits for position, velocity and torque

The limits for the travel range are conducted by setting

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

as well as the limit values for the axis velocity and maximum drive torque/force are parametrized also.

(See also chapter: -"Torque Limit",
-"Travel Range Limits" and
-"Limiting Velocity".)

IBS-8, Optimizing the control loop

This step is only necessary if the settings for velocity and position control loops in IBS 4 did not achieve the needed quality. As such, optimize the control behavior as follows:

- modify the parameter for velocity and position control loops
- possibly activate the acceleration pre-control
- possibly activate the friction torque compensation
- possibly activate the velocity mixture and
- possibly activate the notch filter.

(See also chapter: "Control Loop Settings").

IBS-9, Establishing absolute reference measuring

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

- setting absolute measuring (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" and
-"Setting the Absolute Dimension")

IBS-10, Other settings

Here

- drive halt function is parametrized,
- the language selected,
- general status message settings and
- the optional drive function settings are conducted.

(See also chapter: -"Drive Halt"
-"S-0-0013, Class 3 diagnostics"
-"S-0-0182, Manufacturer class 3 diagnostics"
-"Optional Drive Functions"
-"Language Selection"

IBS-11,Controlling drive dimensions

The power-related drive checks are conducted here. 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 axis, the weight compensation must be set so that the current consumption with upwards and downwards motions of the axes have the same minimum value.

Check the regenerated peak power and regenerated continuous power.

3.4 Diagnostic Configurations

Overview of Diagnostic Configurations

The diagnostics are configured into 2 groups:

- options for recognizing the current operating states of the priority-dependent, drive-internal generation of diagnoses
- collective messages for diverse status messages

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

Drive-Internal Diagnostics

The current operating condition of the drive is evident by which errors, warnings, commands and drive stop signals are available and which operating mode is active. Whether the drive is in preparation for operation or in parameter mode also is displayed.

The current operating condition 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 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).

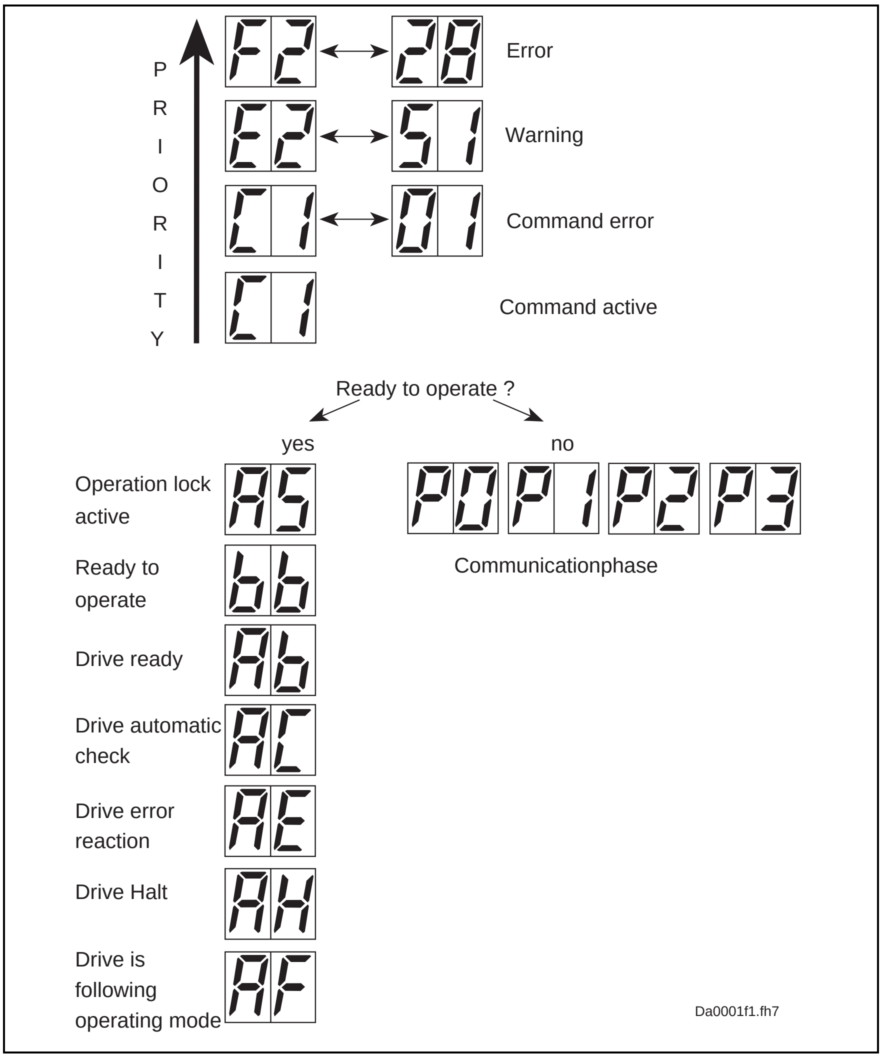

Fig. 3-10: Priority-dependent diagnostic formation on the H1 display

Diagnostic Message Composition

Each operating condition 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.

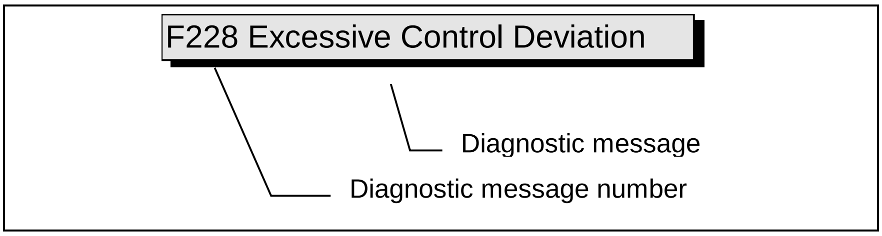

Fig. 3-11: Diagnostic message composition with a diagnostic message number and text

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. The form of the display emerges from the graphic "Priority-Dependent Display of the Diagnostic Message".

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

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

The diagnostic message language 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** .

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 can indicate an error condition without a language barrier. This parameter 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.

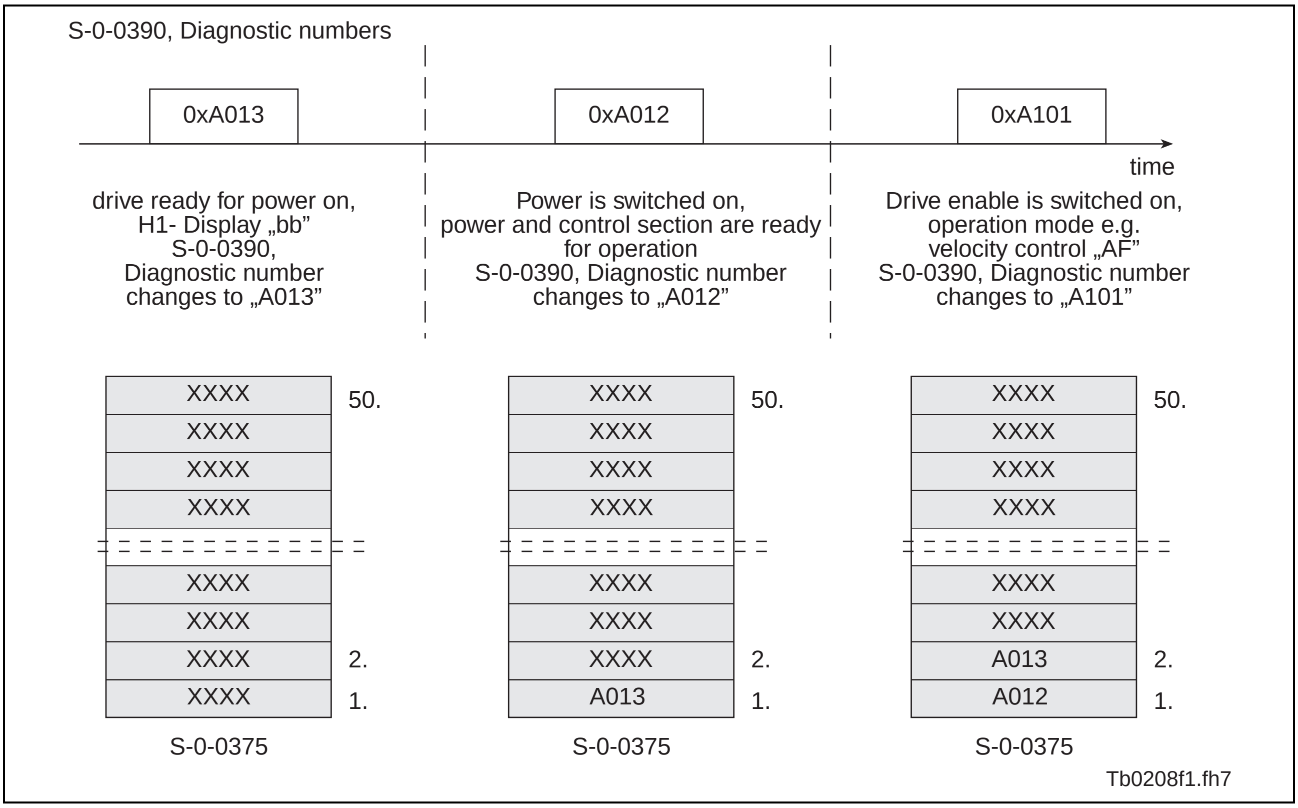

Fig. 3-12: Example for generating **S-0-0375, List of diagnostic numbers**

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 Error")

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. 3-13: S-0-0011, Class 1 diagnostics

S-0-0012, Class 2 diagnostics

Toggeling a bit is signalled with a change bit in the drive status word

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.

S-0-0012, Class 2 Diagnostics

- **Bit 0** : Overload warning **S-0-0310**
- **Bit 1** : Excess amplifier temperature warning **S-0-0311**
- **Bit 2** : Excess motor temperature warning **S-0-0312**
- **Bit 3** : Cooling error warning **S-0-0313**
- **Bit 4** : reserved
- **Bit 5** : Positioning speed > n_{limit} **S-0-0315**
- **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 exceeds position limits **S-0-0323**
- **Bit 14** : reserved
- **Bit 15** : Manufacturer error

Fig. 3-14: Structure of parameter 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.

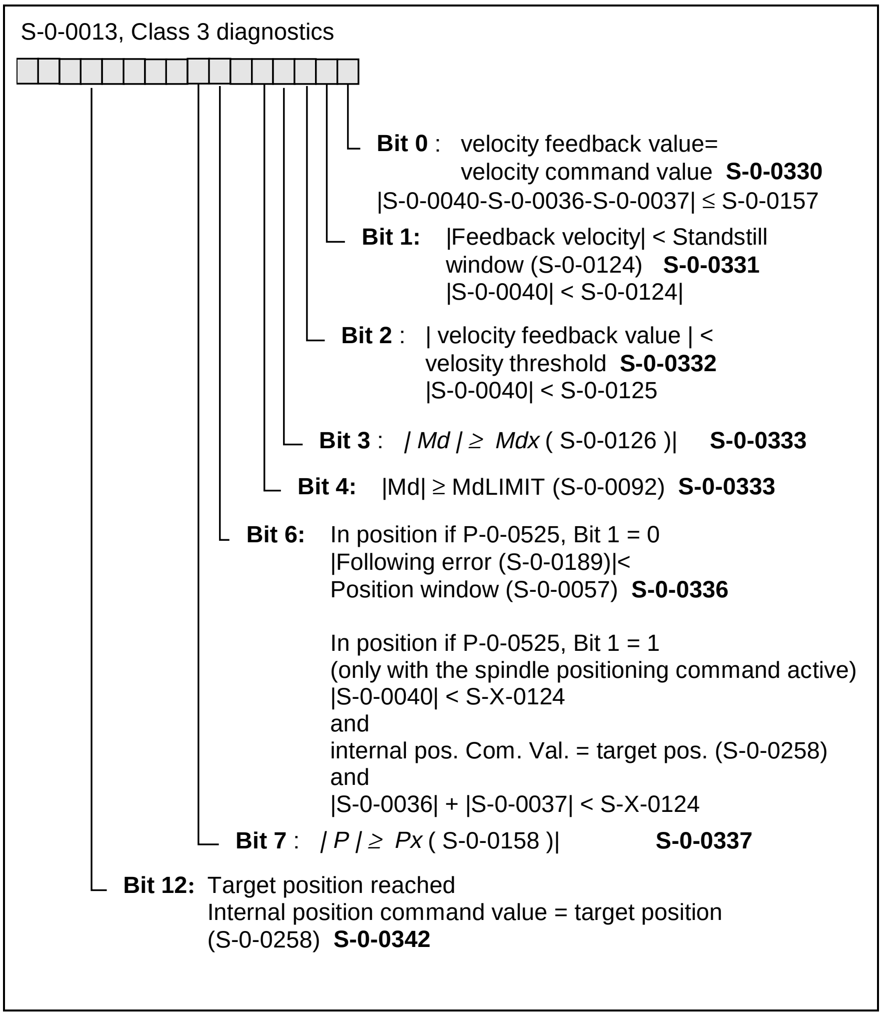

Fig. 3-15: Structure of S-0-0013, Class 3 diagnostics

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**.

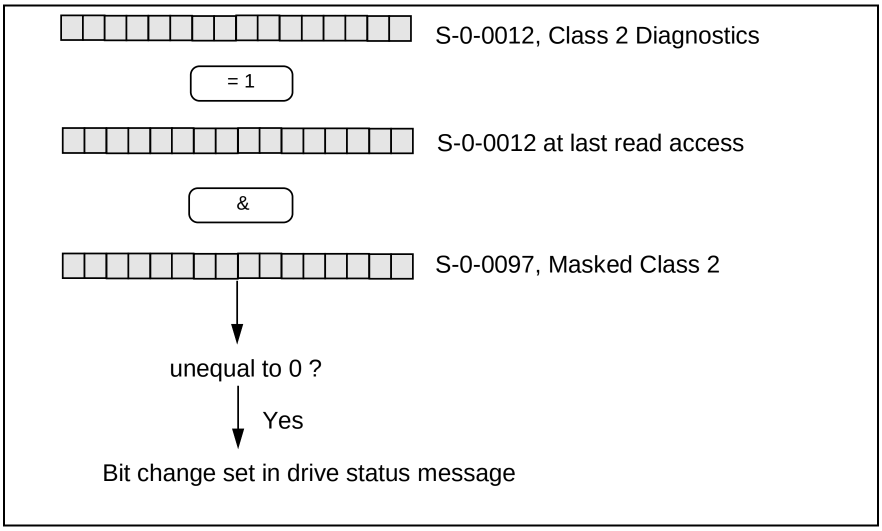

Fig. 3-16: Generating the change bit of class 2 diagnostics

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.

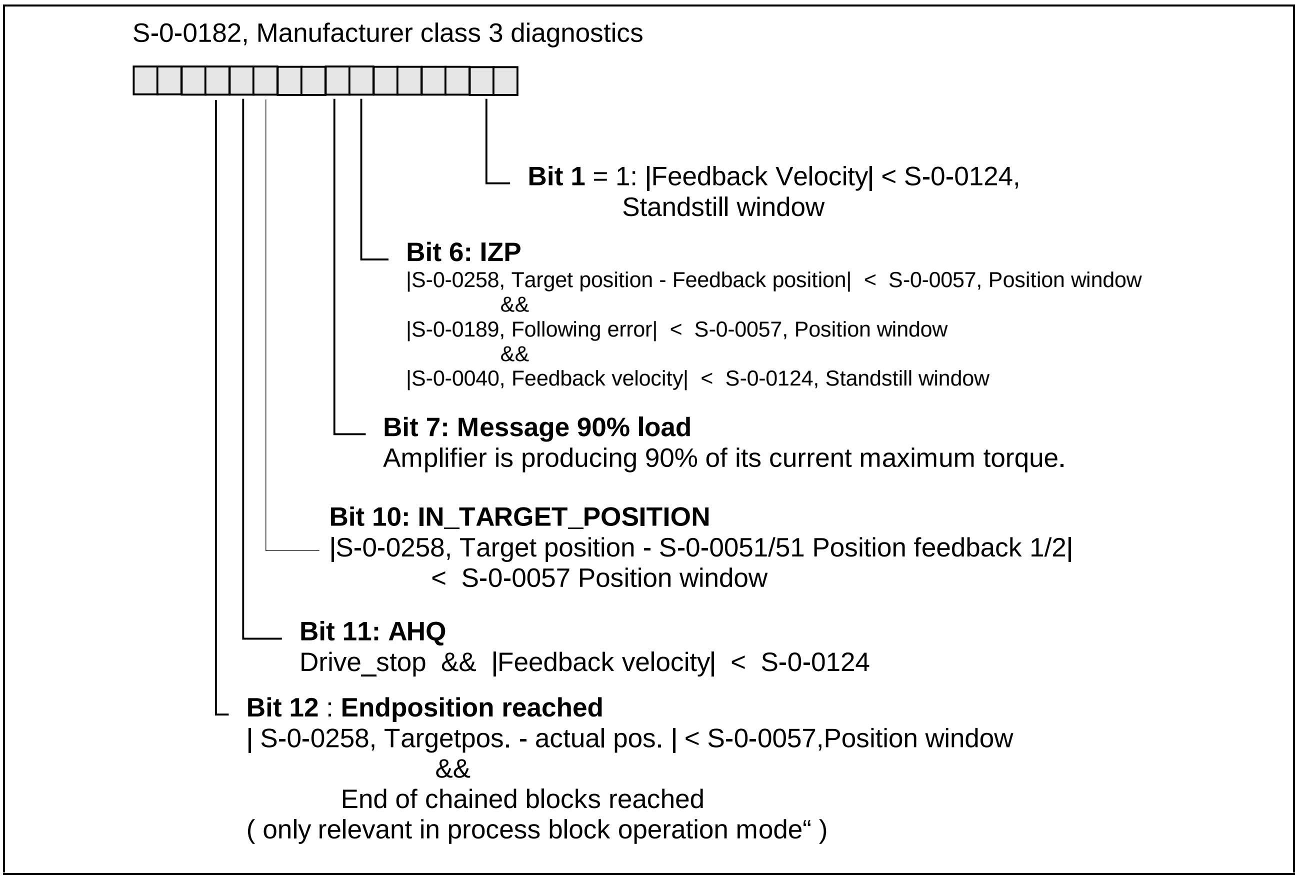

Fig. 3-17: Structure of S-0-0182, Manufacturer class 3 diagnostics

3.5 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. 3-18: Language Selection

3.6 Firmware Update with the Dolfi Program

With the help of the Dolfi program it has become possible to conduct firmware updates for a drive controler via the serial interface.

The program can be ordered from Indramat with item number:

-SWA-DOL*PC-INB-01VRS-MS-C1,44-COPY

or material number 279804.

This includes an extensive description of the program as well.

Error Message in the Firmware Loader

If a firmware update is conducted with a serial interface (using the SIS protocol), then the drive can generate error messages.

Dolfi and the display on the drive read as follows:

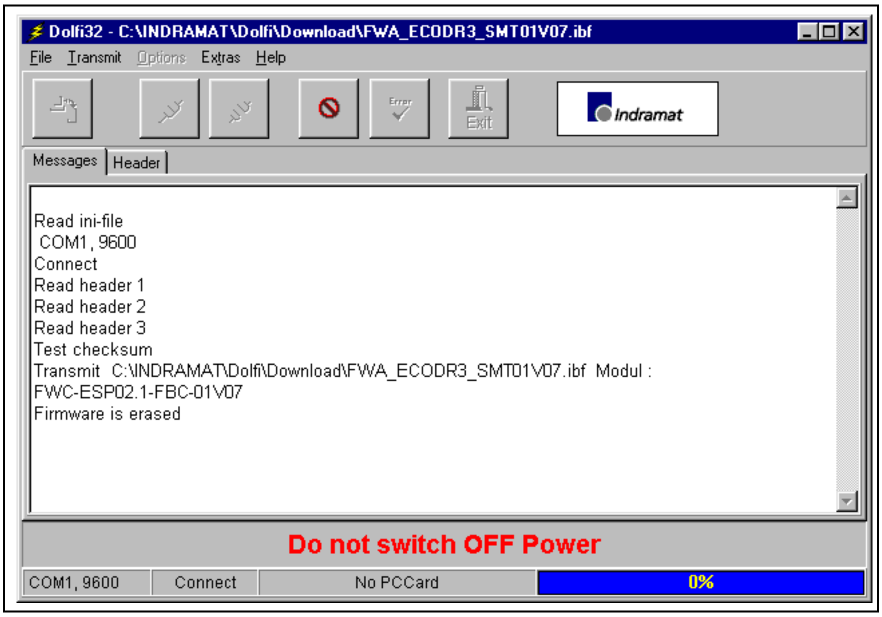

Fig. 3-19: Example: An illustration of how an error firmware was cleared

The table below lists the error messages:

SIS error message	7 segment display	Error message:
0x9002	dL / 00	Firmware was cleared
0x9003	-	Loading into phase 3 not allowed
0x9004	-	Loading into phase 4 not allowed
0x9102	dL / 03	Firmware was cleared
0x9103	-	Restart in phase 3 not allowed
0x9104	-	Restart in phase 4 not allowed
0x9200	dL / 06	Read error
0x9400	dL / 07	Timeout during reset
0x9402	dL / 0F	Address range not within flash storage
0x940A	dL / 08	Reset only in loader possible
0x960A	-	Programming only possible in loader
0x96E0	dL / 0b	Error during flash verification
0x96E1	dL / 0C	Timeout when programming flash
0x96FF	dL / 09	Error when writing into RAM
0x9701	dL / 0d	Addition checksum faulty
0x9702	dL / 0E	CRC32 checksum faulty

Fig. 3-20: SIS error of firmware loader

Note: While the firmware is being updated, the display of the drive reads "**dL**".

0x9002 (dL / 00) Firmware was cleared

Description: a) Programming the module FBC bootkernel or FIL firmware loader.

Firmware FIL is running, or the bootkernel must be replaced. To do so, the command "Drive firmware shutdown“ must be sent, i.e., the control must go from the FIL module to the FGP, SGP or SMT module. During the transition it is checked whether the checksum of the FGP, SGP or SMT is correct to ensure that the module was correctly programmed and can be called up. This checksum check went wrong.

b) Modules FGP, SGP or SMT must be programmed.

Firmware FGP, SGP or SMT must be replaced. To do so, the command "Shutdown, Loader“ must be sent. This means that the control must change from module FGP, SGP or SMT into module FIL: During the transition it is checked whether the addition checksum of the FIL module is correct or not to ensure that the module was correctly programmed and can be conducted. This checksum check went wrong.

Clearing the errors: On a)

Prior to programming the FIL it is necessary to program modules FGP, SGP or SMT.

On b)

Prior to programming FGP, SGP or SMT it is necessary to program FIL.

0x9003 Loading into phase 3 not allowed

Description: The drive is in phase 3. A change to the firmware loader is necessary because the firmware is to be replaced. This can only be done in phase 2.

Clearing errors: Switch the drive into phase 2.

0x9004 Loading into phase 4 not allowed

Description: The drive is in phase 4. A change to the firmware loader is necessary because the firmware is to be replaced. This can only be done in phase 2.

Clearing errors: Switch the drive into phase 2.

0x9102 (dL / 03) Firmware was cleared

Description: The drive firmware is to be restarted after the firmware was replaced. The programming of modules FGP, SGP or SMT was incomplete (addition checksum check went wrong).

Clearing errors: Modules FGP, SGP or SMT must be reprogrammed.

0x9103 Restart in phase 3 not allowed

Description: The drive is in phase 3 and the drive firmware must be restarted. This can only be done in phase 2.

Clearing errors: Switch the drive into phase 2.

0x9104 Restart in phase 4 not allowed

Description: The drive is in phase 4 and the drive firmware must be restarted. This can only be done in phase 2.

Clearing errors: Switch the drive into phase 2.

0x9200 (dL / 06) Read error

Description: A memory module is to be read. An error occurred while making the attempt.

Clearing errors: Check address range in the *.ibf file. If it is alright, i.e., a memory module is actually at that address, then the error can only be cleared by replacing the firmware module ESF02.1.

0x9400 (dL / 07) Timeout during reset

Description: An error occurred while trying to reset a flash.

Clearing errors: Repeat the reset command. If the error continues to appear, then it can only be cleared by replacing firmware module ESF02.1.

0x9402 (dL / 0F) Address range not in flash

Description: An address range not in the flash must be cleared.

Clearing errors: Correct address range in the SIS or check the range in the *.ibf file.

0x940A Reset only possible in loader

Description: Drive firmware is running and the flash is to be cleared.

Clearing errors: Change into firmware loader.

0x96E0 (dL / 0b) Error when verifying the flash

Description: An error occurred during the programming process. A memory cell in the flash could not be write accessed.

Clearing errors: The flash must be cleared prior to the programming command. If the error continues, then the firmware module ESF02.1 must be replaced.

0x96E1 (dL / 0C) Timeout when programming the flash

Description: An error occurred during programming. A memory cell in the flash could not be write accessed.

Clearing errors: Programming command repeated. If the error continues, then the firmware module ESF02.1 must be replaced.

0x96FF (dL / 09) Error when write accessing the RAM

Description: An error occurred during programming. A memory cell in the flash could not be write accessed.

Clearing errors: Check whether the target address is actually in the RAM. If the error continues, then the firmware module ESF02.1 must be replaced.

0x9701 (dL / 0d) Wrong checksum

Description: The programmed checksum is checked at the end of the updating of the firmware module. This check went wrong.

Clearing errors: Reprogram the module, check the checksum of the source file (*.ibf).

0x9702 (dL / 0e) CRC32 checksum faulty

Description: The programmed CRC32 checksum is checked at the end of the updating of the firmware module. This check went wrong.

Clearing errors: Reprogram the module, check the checksum of the source file (*.ibf).

Additional Problems when Loading Firmware

The programming of a module was terminated

Problems on the serial interface can lead to the termination of a transmission.

In the event that the loading procedure of the FBC module was terminated, then do not switch the unit off. This module is responsible for starting the firmware and therefore absolutely necessary.

A module that has not been completely programmed can simply be reprogrammed (open ibf file, press transmit button, in the "Send" window, select *Module single* and by *skipping,* find the right module. Now press the send button).

After the unit is switched on, the display reads dL

The last programming procedure with Dolfi was not correctly completed.

To leave the firmware loader on one or all of the modules of an *.ibf file must be programmed with Dolfi. The drive firmware is started by pressing the separate button.

Dolfi can be used to establish a connection

a) A baud rate other than Dolfi was set in parameter P-0-4021.

P-0-4021, Baud Rate RS-232/485:

Baud rate [Baud]	Setting in parameter P-0-4021
9600	0
19200	1

It is advisable to set parameter P-0-4021 to 0 for "Connecting process“ (=9600 Baud). The baud rate for the download can be set to a different value in Dolfi.

If the programming of a module was terminated, e.g., due to interference at a serial interface, then the baud rate for the download is still set in a DKC. For Dolfi to be able to re-establish a connection, it is necessary to set the connect rate to the same value with which the most recent download occurred.

If the unit was switched back on and if the display reads dL, then a baud rate of 9,600 is always set.

b) The receiver and unit address is not identical with the address set at the controller via switches S2 and S3.

Dolfi can not open the ibf file

Dolfi signals "Wrong ibf format“ when opening the ibf file.

The ibf file was generated with a different release and the ibf format has changed.

To open the file the correct Dolfi version must be used. This can be obtained from the manufacturer.

Dolfi signals timeout

Timeout messages appear while the ibf files are being transmitted. Interference at the serial connections could be the problem or the deactivated COM interface FIFO.

This can be activated as follows:

Windows 95:

Start → Settings → System control → System → Unit manager → Connections (COM and LPT) → COM connections (COMx) → Connection settings → Expanded

→ Activate FIFO, Use standard setting

Windows NT:

Start → Settings → System control → Connections → COMx → Settings → Expanded

→ Activate FIFO

Select the download baud rate

Depending on the length of serial interface cable there is a physical limit for the maximum baud rate at which serial communications runs without a fault.

The factory sets the maximum download baud rate at 19.2 kBd. The baud rate can be increased considerably in some applications which helps achieve a reduction in the time needed for a firmware update.

The following baud rates can be implemented at the specified cable lengths.

Cable length / m	max. baud rate / kBd
2	115.2
5	57.6
10	57.6
15	38.4

Fig. 3-21: Maximum baud rate as dependent on the cable length

Notes

4 Communication Through the SERCOS-interface

4.1 Overview of SERCOS Communication

The basic features of the SERCOS interface are:

- **Cyclicyl data exchange command and feedback values with exact time intervals**
- **Synchronization of measurement point and command value input**
- **Overall synchronization of all drives connected to the control**
- **Minimum cycle time 0.5 ms / maximum cycle time 65 ms**
- **Baud rate selectable, either 2 or 4 MBaud**
- **Service channel for settings and diagnostics**
- **Data transfer through fiber optic ring**
- **Configuration of the telegram contents**
- **SERCOS compatibility class C, Granularity 1, i.e., a multiple of 1000 µsec can be programmed as cycle time.**

The features of the interface are mentioned here briefly. More detailed information is included in the SERCOS interface specification.

4.2 Data Transfer Cycle through SERCOS

To synchronize the drives in a ring, the **Master Synchronization Telegram** (MST) is sent at the beginning of every SERCOS cycle. The MST contains only the preset communication phase information from the master.

You can configure the master data and drive telegram.

Once during every Sercos cycle, a **Master Data Telegram** (MDT) is sent from the control to every drive. The master control word, the service channel and a configurable data block are included here. In this data block, the command and limit values are contained, which are sent by the control according to the operation mode of the drive. The contents of this data block can be configured through the telegram settings.

The master data telegram is received by all drives in the ring at the same time.

In addition, a **Drive Telegram** (AT) is sent during each Sercos cycle time from every drive to the control. The drive status word, the service channel and a configurable data block are contained here. This data block contains mainly feedback and status values, which are needed to operate the corresponding drives by the control.

Master Control Word

The master control word is part of the Master Data Telegram. The most important control information for the drives is contained here, such as

- **Drive ON and Drive enable**
- **Drive Stop**
- **Interpolator cycle**
- **Set operation mode**
- **Real-time control bit 1 and 2**
- **Control information for the service channel**

The master control word is structured as follows:

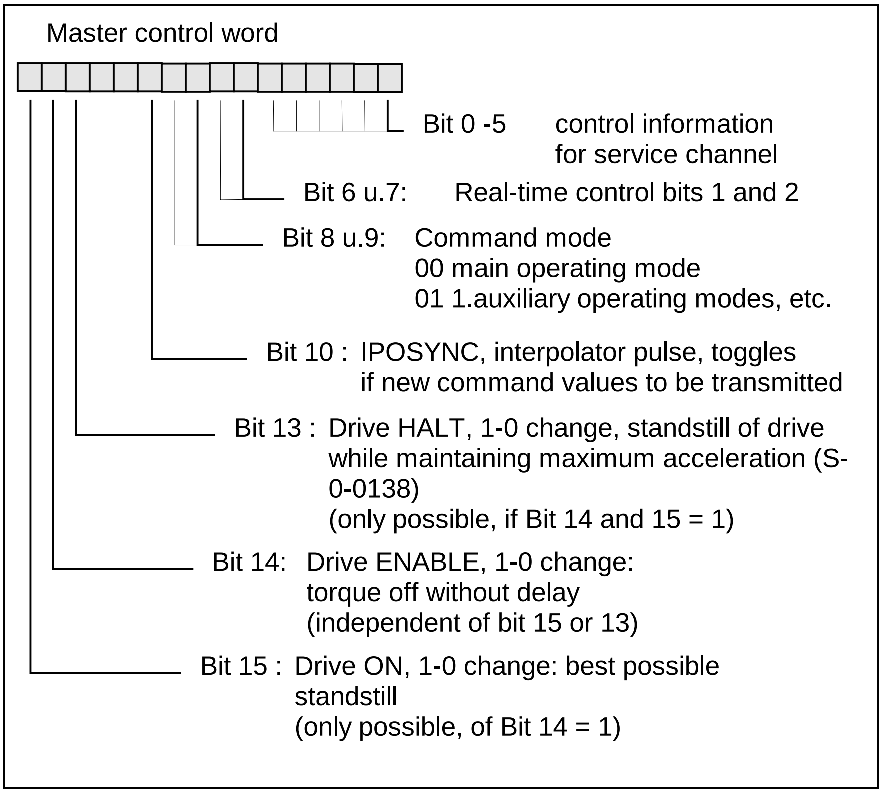

Fig. 4-1: Structure of the master control word

The Master Control Word is transferred to the drive cyclically with every Master Data Telegram, synchronously to the SERCOS cycle (see **S-0-0002, SERCOS cycle time TScyc**). For diagnostic purposes, the Master Control Word can be read back via the parameter **S-0-0134, Master Control Word**.

Drive enable

The activation of the drive is done through a 0-1 edge of the drive enable signal. For drive controllers with a SERCOS Interface, the drive enable signal corresponds to bit 15 in the master control word of the master data telegram.

To have the drive enable signal accepted (meaning that the drive is ready to accept commands from the control), the following requirements must be fulfilled:

- SERCOS Interface in operating mode (Communication phase 4)
- No drive error
- Power section enabled

In this condition, the drive displays **Ab** on the seven-segment display, and the drive diagnostic from the parameter **S-0-0095, Diagnostic message** is **A012 Control and power sections ready for operation**.

If the drive enable is set, the seven-segment display changes to **AF**. After that it displays the drive diagnostic for the activated operation mode (i.e., **A101 Drive in VELOCITY control**).

If the drive enable is activated without a DC bus voltage (**Ab** doesn't appear on the H1 display), the error message **F226 Undervoltage in power section** will be displayed.

Drive Status Word

The drive status word is part of the drive telegram. All important status information from the drive is contained here.

- **Readiness for use of the control and power sections**
- **Drive error**
- **Change bits for diagnostics class 2 and 3**
- **Current operation mode**
- **Real-time status bits 1 and 2**
- **Status information for the service channel**

The drive status word is structured as follows:

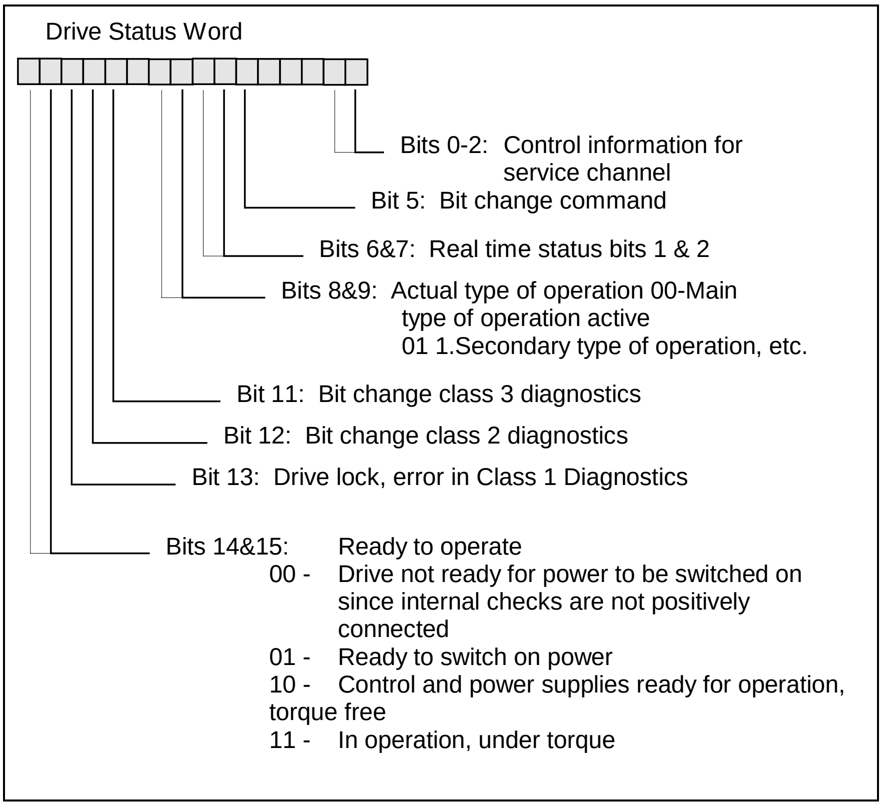

Fig. 4-2: Structure of the drive status word

The Drive Status Word is transferred to the control cyclically with every Drive Telegram, synchronously to the SERCOS cycle (see **S-0-0002, SERCOS cycle time TScyc**). For diagnostic purposes, the Drive Status Word can be read back via the parameter **S-0-0135, Drive status word**.

Acknowledge of the Drive Enable

The drive confirms the drive enable setting in the drive status word of the drive telegram. Bits 14 and 15 of "10" (control and power section enabled, temporarily) changes to "11" (in operation, temporarily enabled) after the drive enable is activated and has been accepted.

The confirmation of the drive enable setting in the status word is acknowledged after the drive has sufficient time to prepare for its operation mode. For example, the asynchronous motor uses this time to magnetize itself.

If the drive enable is disabled, the drive performs its reaction through parameter **P-0-0119, Best possible deceleration**. Here, time passes between resetting and confirming the reset. This time depends on

- the setting of the parameter P-0-0119, Best possible deceleration
- the existence of a motor brake and its parameterization.
- the velocity of the axis before the reset of the drive enable

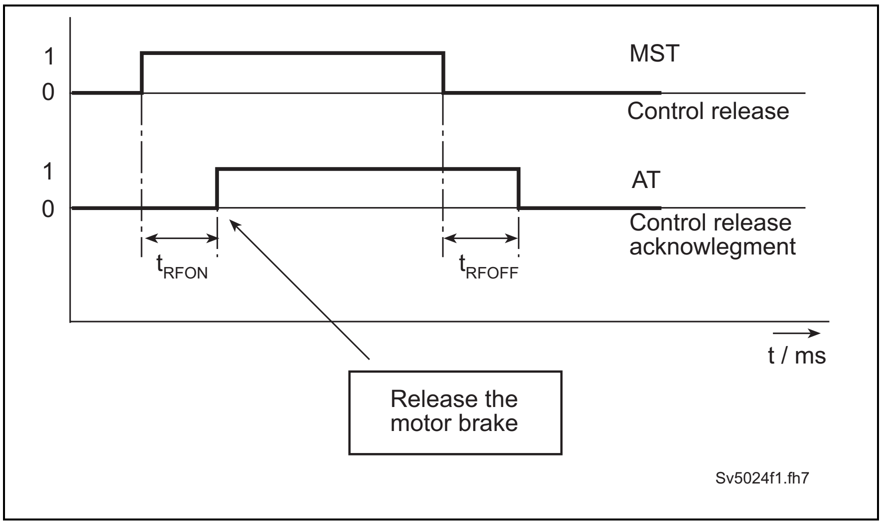

Fig. 4-3: Confirmation of the drive enable

Typical values for t_{RFON} are about 8 ms for synchronous motors or 300ms for asynchronous motors.

Note: During the time t_{RFEIN}, the control should set its command values to reach a set velocity of 0. The activation of the optional motor brake takes place after the drive enable confirmation time (0-1 edge from confirmation of drive enable).

4.3 Real-Time Control and Status Bits

In the master control and drive status words, there are 2 configurable real-time bits. The configuration of these binary signals is achieved through parameters

- **S-0-0301, Allocation of real-time control Bit 1**
- **S-0-0303, Allocation of real-time control Bit 2**
- **S-0-0305, Allocation of real-time status Bit 1**
- **S-0-0307, Allocation of real-time status Bit 2**

The parameter number that will be assigned to the corresponding real-time status bit is set here. Bit 0 of this parameter will be sent cyclically to the master or the drive via the real-time status or control bit.

4.4 Transmission of non-cyclical Data through SERCOS

The non-cyclical data (data that is not time-critical) is transmitted via the **service channel**.

The transmission via the service channel is done in several steps for the MDT and AT, and the transmission of an element could last over several Sercos cycles.

The service channel is used for

- **Parameterization** and
- **Diagnostic**

4.5 Startup for the SERCOS Interface

To start the interface you have to:

- **connect the fiber optic cable**
- **set the drive address**
- **check the distortion indicator**
- **set the transmission rate**
- **set the transmission power**

Adjustments of the SERCOS Interface

All settings can be done with switches on the front plate of the interface

The settings should be complete before connecting communication to the fiber optic ring.

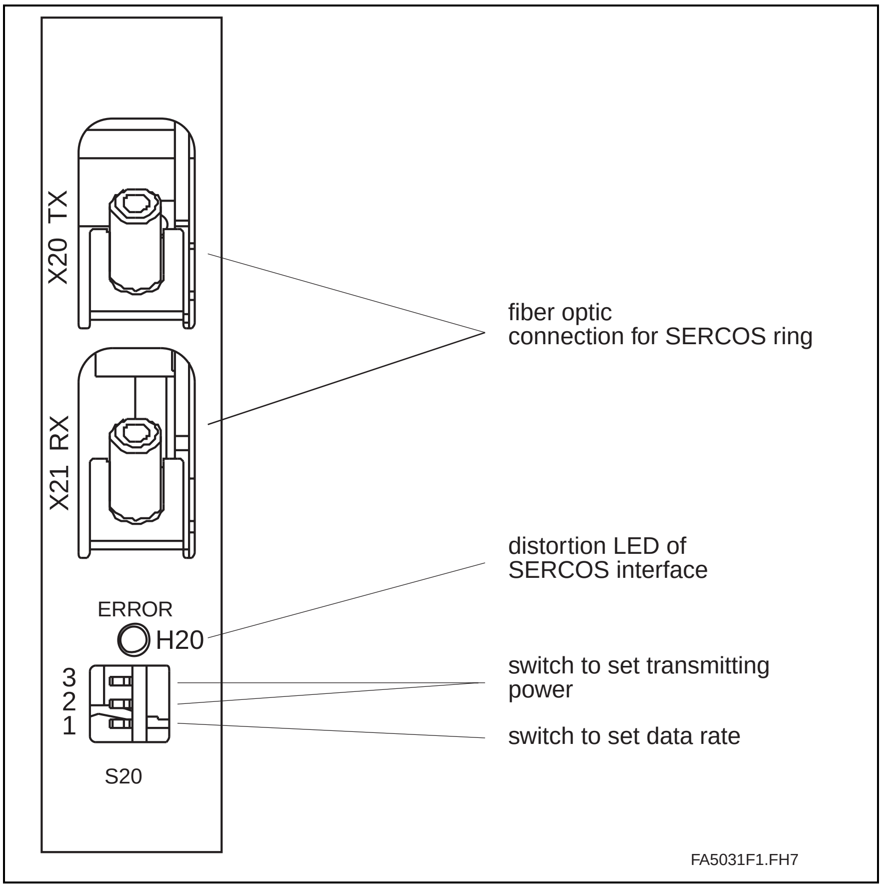

Fig. 4-4: View of interface to command communication

See also Troubleshooting Guide: **E410 Slave not scanned or adress 0**.

Connecting the Fiber Optic Cables of the SERCOS Interface

The connection between the control and the digital drives is done with fiber optic cables.

SERCOS interface (IEC 1491) The used topology is a ring structure according to SERCOS interface (IEC 1491).

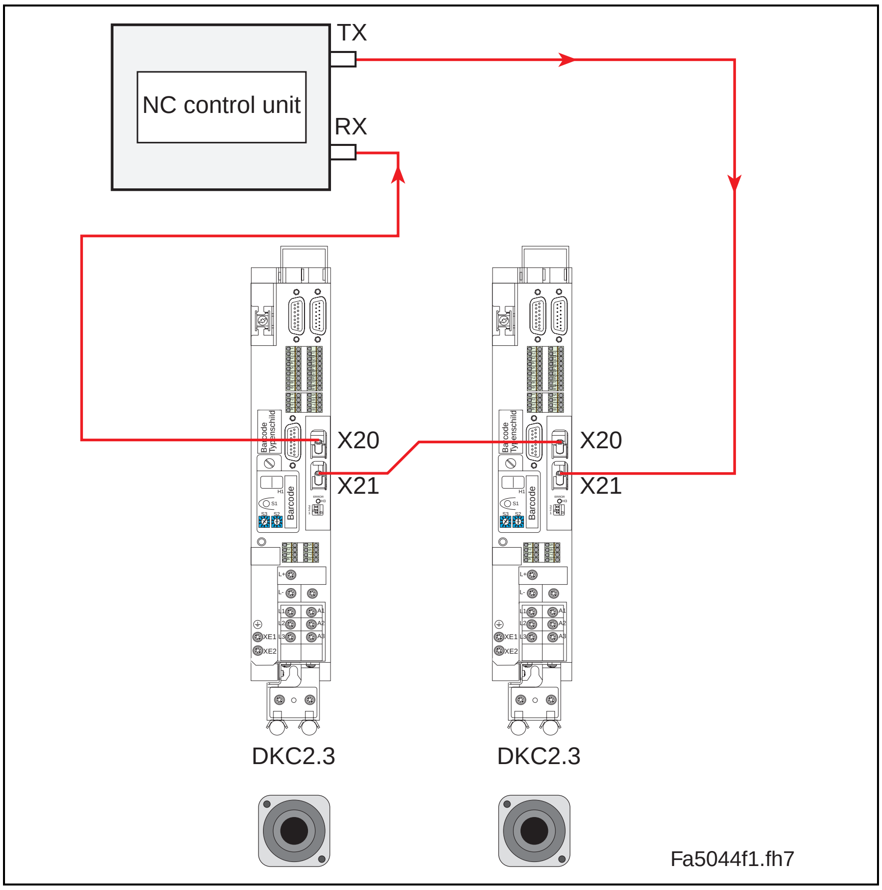

Fig. 4-5: Ring topology

The ring starts and ends at the control.

The optical output of the control is connected with the optical input of the first drive (X21). The output of the latter (X20) is connected with the input of the next drive, and so on. The output of the last drive is connected with the input of the control.

Setting the Drive Address of the SERCOS Interface

The drive address is set via switches S2 and S3 on the programming module. Addresses ranging from 0 to 99 can be programmed.

The drive address is not dependent on the sequence of drive connections through the fiber optic ring.

After setting all the addresses, you can switch on the arrangement.

Checking the Distortion Indicator of the SERCOS Interface

The next step is to check whether every station gets a sufficient optical signal level , in other words whether the receiver is not under- or overloaded.

Distortion indicator may not be lit nor glow (flicker)!

For normal operation, the distortion indicator LED H20 stays dark.

If it’s lit, examine the transmission path in front of that station.

To do so, the distortion display of the drives are checked in signal flow direction starting from the sender output of the master (control). (See Fig. 4-4: View of interface to command communication).

The distortion display of the drives is the LED "H20”.

Check distortion indicator in "direction of the light”

At first, check the 1st drive in the ring. If its distortion indicator is dark, go to the next drive. Do this up to the last drive and then at the master’s input (control).

If one of the indicators is lit, check the following:

- Is the transmission (baud) rate set correctly?
- Is the transmission power of the predecessor in the ring correct? (too high or too low)
- Is the fiber optic cable to the predecessor defective?

Using the Distortion Indicator

A distortion indicator H20 lights in the following cases:

- wrong transmission (baud) rate
- wrong transmission power
- fiber optic connection defective

Therefore, in the case of a lit distortion indicator lamp, check the following:

Checking the transmission rate

Check the transmission rate at the control and at the effected drive.

Checking the transmission power

Check the transmission power at the control and at the physical predecessor of the effected drive. (See Setting the optical Transmission Power).

Checking the fiber optics

Check the fiber optic cable and its connectors from the physical predecessor to the effected drive.

Transmission Rate of the SERCOS interface

The baud rate is set at factory to 2Mbaud. It can be programmed via switch S20,1 on the interface module .

Baud rate:	Switch S20,1:	Comment
2 Mbaud	OFF	state at delivery
4 Mbaud	ON	

Fig. 4-6: Programming the transmission rate

Setting the optical Transmission Power

Transmission power is set via switches S20,2 and S20,3 on the interface module.

cable length	0 .. 15 m	15 m ..30 m	30 m .. 50 m
	S20,2 = OFF S20,3 = OFF	S20,2 = ON S20,3 = OFF	S20,2= ON S20,3 = ON

Fig. 4-7: Setting transmission power with plastic fiber optic cables

cable length	0 .. 500 m
	S20,2 = ON / S20,3 = ON

Fig. 4-8: Setting the transmission power with glass fiber optic cables

Checking the Fiber Optics

When the transmission rate and power are correctly set, and there is still no communication, the fiber optic connection can be defective. In this case, the distortion indicator lamp will light, too.

Reason for a faulty connection can be damage or bad manufacturing (connector mounting, ...).

Sometimes it is possible to recognize a defective cable when hardly any light comes out at its end, or that, for example, the optical fiber has been torn back into the connector (check the face of the connector). Further examinations cannot be done with simple means.

The only remedy is an exchange of the defective fiber optic cable.

4.6 SERCOS Telegram Configuration

To operate the drive properly, the settings of the telegram send and receive times, their lengths, and content have to be transmitted from the SERCOS master to the drive.

Configuration of the Telegram Send and Receive Times

The requirements to calculate the time slot parameter (telegram send and receive times) are stored in the following parameters within the drive:

- **S-0-0003, Minimum AT transmit starting time (T1min)**
- **S-0-0004, Transmit/receive transition time (TATMT)**
- **S-0-0005, Minimum feedback acquisition time(T4min)**
- **S-0-0088, Receive to receive recovery time (TMTSG)**
- **S-0-0090, Command value transmit time (TMTSG)**

The SERCOS Master calculates from the information received from all drives the time slot parameters for the operation of the communication phase 3. Those values are transferred to the drive in communication phase 2 through the parameters

- **S-0-0002, SERCOS Cycle time (Tscyc)**
- **S-0-0006, AT Transmission starting time (T1)**
- **S-0-0007, Feedback acquisition starting time (T4)**
- **S-0-0008, Command valid time (T3)**
- **S-0-0009, Beginning address in master data telegram**
- **S-0-0010, Length of master data telegram**
- **S-0-0089, MDT Transmit starting time (T2)**

The drive checks these settings while processing the command **S-0-0127, C100 Communication phase 3 transition check**. The following error messages may appear:

- **C101 Invalid communication parameter (S-0-0021)**
- **C108 Time slot parameter > Sercos cycle time**
- **C109 Position of data record in MDT (S-0-0009) even**
- **C110 Length of MDT (S-0-0010) odd**
- **C111 ID9 + Record length - 1 > length MDT (S-0-0010)**
- **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)**
- **C115 T2 too small**

Configuration of Telegram Contents

The telegram contents are set through these parameters:

- **S-0-0015, Telegram Type Parameter**
- **S-0-0016, Custom Amplifier Telegram Configuration List**
- **S-0-0024, Config. List of the Master Data Telegram**

However, the drive-directed conditions for the type and number of configured data must be in the set range. Those are provided by the drive in

- **S-0-0185, Length of the configurable data record in the AT**
- **S-0-0186, Length of the configurable data record in the MDT**
- **S-0-0187, List of configurable data in the AT**
- **S-0-0188, List of configurable data in the MDT**

The drive checks these settings while processing the command **S-0-0127, C100 Communication phase 3 transition check**. The following error messages may appear:

- **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**

Note: Parameter **S-0-0188, List of configurable data in the MDT** is also used for the configuration of the multiplex channel. There are therefore parameters in S-0-0188 that have a variable data length (list parameters). These can, however, only be used as multiplex data. Such IDNs may not be entered in **S-0-0024, Config. list of the master data telegram**. If such are entered, then **C104 Config. IDN for MDT not configurable** is generated.

4.7 SERCOS Interface Error

If conditions are detected in the drive that prevent the correct operation of the interface, or if error values are recognized during the initialization phase, the drive responds by resetting to communication phase 0. This means that no drive telegrams will be sent. The drive proceeds with the programmed error reaction (see **P-0-0119, Best possible deceleration**) and waits for the reinitialization of the SERCOS ring through the master.

Possible errors could be:

- **F401 Double MST failure shutdown**
- **F402 Double MDT failure shutdown**
- **F403 Invalid communication phase shutdown**
- **F404 Error during phase progression**
- **F405 Error during phase regression**
- **F406 Phase switching without ready signal**

Diagnostic of the interface Status

The parameter **S-0-0014, Interface status** is used to analyze the existing initialization error and the current communication phase.

Error Count for Telegram Interrupts

The drive checks every received master synchronization and master data telegram for

- **the correct receive time set point,**
- **the assigned telegram length and**
- **the correct CRC check sum**

A telegram interrupt is registered with an incrementation in the error counter. For this purpose, these two parameters are used: **S-0-0028, MST error counter** and **S-0-0029, MDT error counter**.

These parameters are cancelled by switching the communication phase from 2 to 3 (S-0-0028) or from 3 to 4 (S-0-0029).

4.8 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 communications via SERCOS or Profibus and configure the multiplex parameter in the cyclical telegrams.

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 structure 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 are used:

- **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

The IDNs are entered in parameter **S-0-0370, Configuration list for the MDT data container** which are dependent on the index in **S-0-0368, Addressing for data container A,** low byte, and transmitted to **S-0-0360, MDT Data container A**. Write accessing S-0-0370 is only possible in communications phase 2.

S-0-0371, Configuration list for the AT data container

The IDNs are entered in parameter **S-0-0371, Configuration list for the AT data container A** that are dependent on indices in **S-0-0368, Addressing for data container A**, (high byte), and transmitted to **S-0-0364, AT Data container A**. Write accessing S-0-0371 is only possible in communications phase 2.

Note: A maximum of 32 IDNs can be configured in S-0-0371.

Addressing the Data Container

S-0-0368, Addressing data container A

Parameter **S-0-0368, Addressing for data container A** contains indices for the selection of the parameters transmitted in the data container.

The graph below illustrates the configuration lists with the maximum number of elements (32).

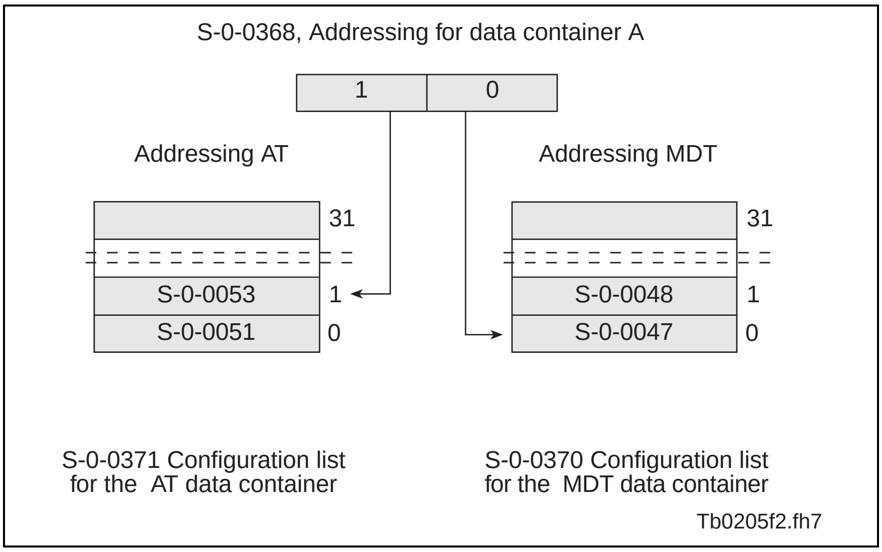

Fig. 4-9: Functional principle of addressing data container A

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 required data channel or some other interface.

Using the Data Container

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 that parameter addressed via S-0-0368 in the configuration list (S-0-0370).

Note: Parameter S-0-0360 is **not write accessible via the requried data channel.** The display format is hexidecimal 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 that parameter addressed via S-0-0368 in the configuration list (S-0-0370).

Note: Parameter S-0-0364 is **not write accessible via the required 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 cyclically and by element write into list parameters. The element to be written into or read of a list parameter is written into both parameters.

Note: The parameters become effective if in **S-0-0368, Addressing for data container A** a list parameter is 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.

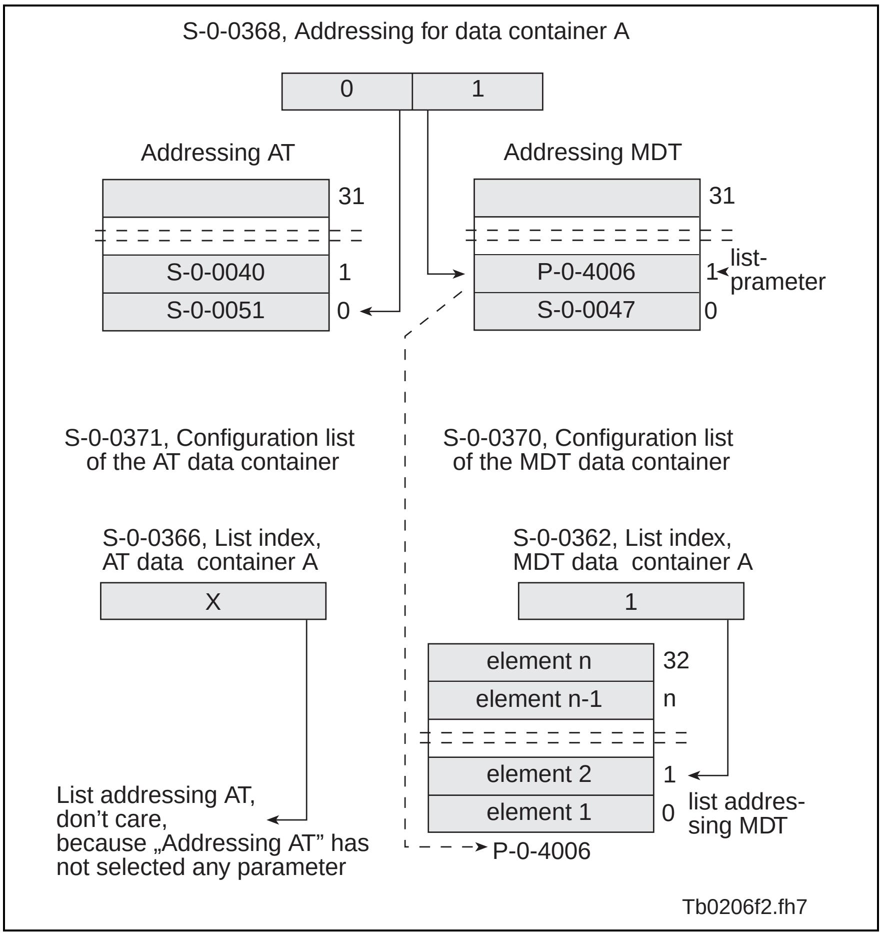

Fig. 4-10: Processing list elements with the multiplex channel, here for the MDT container

Diagnostic Messages

In conjunction with the multiplex channel, various checks are conducted:

Checking the Configured IDN Order

Checks in transition command

The temporal sequence of the processing of cyclical MDT data in the drive has an order specified with which the configured IDNs are entered in parameter **S-0-0024, Config. list of the master data telegram**.

If both the parameter **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 a command error message.

- **C118, MDT order for configuration faulty**

Checking the Configuration Lists

It must be ensured that the ID numbers 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 ID numbers in **S-0-0187, List of configurable data in the AT** or **S-0-0188, List of configurable data in the MDT** are contained in the list.

The following errors are possible:

If list **S-0-0370, Configuration list for the MDT data container** has one or more IDNs which are not available are not 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 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 ID Numbers

Checking the input

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 data channel error message "0x1001, ID number not available" is generated.
- It is checked whether the entered IDN in parameter **S-0-0188, List of configurable data in the MDT** is available. If not, then the data channel error message "0x7008, Data not correct" is generated.

Checking the Indices

Checking while running

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 warnings:

- **E408 Invalid addressing of MDT data container A**
- **E409 Invalid addressing of AT data container A**

is generated.

Note: The warnings can only occur if the lists has fewer ID number entries than is maximumly possible.

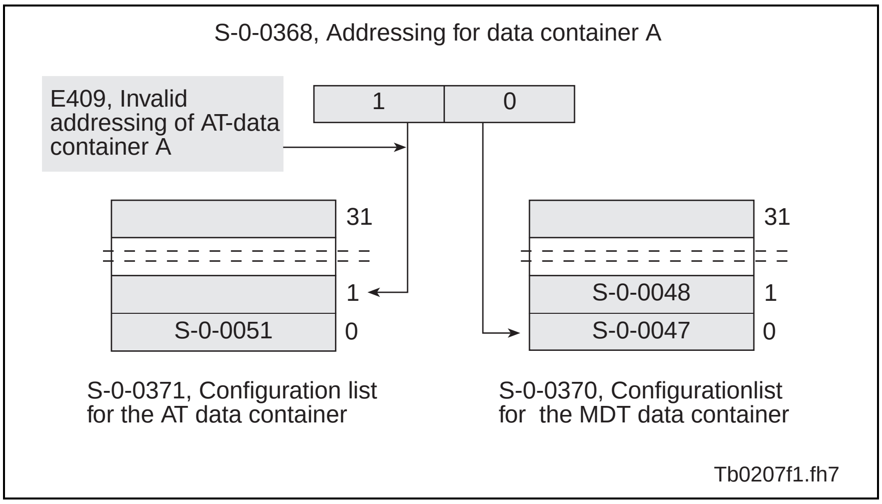

Fig. 4-11: Invalid addressing of MDT data container A

5 Command Communications with Analog Interface

5.1 Overview

In DKC01.3 or DKC11.3 the drive enable, drive halt and clear errors are specified via a digital input. Diagnoses such as drive errors and warnings are output via digital outputs.

Note: If the SERCOS interface is not active with a DKC02.3 or the fieldbus interface with the DKC03.3, DKC04.3, DKC05.3 or DKC06.3, then the analog interface can be used in both of these units as well.

5.2 Pertinent Parameters

- **S-0-0134, Master control word**
- **S-0-0135, Drive status word**
- **S-0-0099, C500 Reset class 1 diagnostic**

5.3 How it works

Digital inputs

Digital inputs are read in every 500us and filtered with a digital filter so that the drive can detect a signal change within 2ms. Due to the digital processing, the signals are active in the drive within 10ms.

The digital input signals are stored in parameter **S-0-0134, Master control word**.

See section: "Master Control Word"

Drive enable

The drive is activated via a 0-1 edge of the drive enable signal which is displayed in bit 15 of the master control word.

For the drive enable signal to be accepted, i.e., for the drive to switch from an off to an on state, the following conditions must be met:

- no drive error
- power section must be on

The drive displays **Ab** in this state. The diagnosis via parameter **S-0-0095, Diagnostic message** reads **A012 Control and power sections ready for operation**.

Once the drive enable is set, then the 7-segment display reads **AF**. The diagnosis then shows the activated state, e.g., **A101 Drive in VELOCITY control**.

Drive Halt

The signal is dependent on the state and zero active which means that if the signal = 0V , then the drive is in "Drive halt". The input signal is illustrated in the master control word bit 13.

See Section: "Drive Halt".

Clear error An 0-1 edge at the error input starts the reset error command. Activating the error clear command resets all drive errors.

LIMIT+/LIMIT- The inputs LIMIT+ and LIMIT- are in parameter **P-0-0222, Status Travel Range Limit Switch**.

See Section: "Travel Range Limits".

E-Stop This input is on parameter **P-0-0223, Status E-stop input**.

See section: "Emergency stop feature".

Digital Outputs

An Errors If the drive is ready to activate the drive enable then this means that no drive error is pending and the power section is on, then this output is set.

If there is a drive error or if the power section is not ready, then the output (**Ab**) is cleared.

A Warning If there is a warning diagnosis which generates a change in the status bit as set in status class 2 mask or status class 3 mask, then the digital output "A warning" is set. If there is no masked warning, then the output is cleared.

See section: "Permanently-Configured Collective Indication".

Acknowledge of the Drive Enable

The drive acknowledges the drive enable in the drive status word Bits 14 and 15 change from "10" (control and power sections ready to operate, torque free) to "11" (in operation, with torque), if drive enable is activated and accepted.

The duration between setting and acknowledging the setting of the drive enable equals that time that the drive needs to establish complete operational readiness. For example, an asynchronous motor uses this time to magnetize.

When removing the drive enable, the drive conducts the reaction parameterized in **P-0-0119, Best possible deceleration**. Here as well, this takes a certain length of time between resetting and acknowledging the reset. This depends on

- Setting in parameter **P-0-0119, Best possible deceleration**
- whether there is a motor brake and its parameterization
- the velocity of the axis at the time of drive enable reset

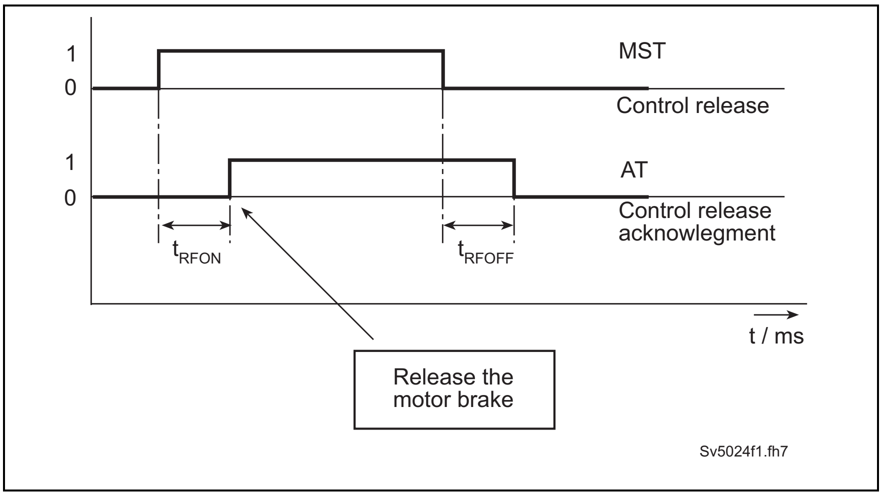

Fig. 5-12: Acknowledge drive enable

Typical values for t_{RFEIN} are about 10msec in synchronous and 300msec in asynchronous motors.

Note: **During time** t_{RFEIN} the drive should set the command value so that a command speed of 0 results. Any cooling of an existing motor brake does not occur until after the point in time when drive enable is acknowledged (t_{RFEIN} + brake delay time).

5.4 Connecting Signals to DKCxx.3

See Project Planning Manual.

Section: Electrical connections unit type dependent.

Notes

6 Command Communication Using Parallel Interface

6.1 Overview

The DKC01.3 is outfitted with freely-configurable inputs and outputs in addition to the digital inputs of its basic unit (drive enable, drive halt/start, delete error).

The outputs are allocated by configuring the signal status word. Bits 0 through 9 are, in this case, the digital outputs of the parallel interface (X15/14 to X15/23).

The inputs are allocated by configuring the signal control word. Bits 0 through 9, in this case, are the digital inputs of the parallel interface (X15/1 to X15/10).

6.2 Pertinent Parameters

- **S-0-0144, Signal status word**
- **S-0-0145, Signal control word**
- **S-0-0026, Configuration list signal status word**
- **S-0-0027, Configuration list signal control word**
- **S-0-0328, Assign list signal status word**
- **S-0-0399, IDN list of configurable data in the signal control word**

6.3 How it works

Configurable outputs

The signal status word in a DKC01.3 is generated every 2ms. Bits 0 - 9 are mapped on the parallel interface.

Allocation of signal status word to digital outputs:

Bit number in the signal status word	Digital output of the parallel interface
0	X15/14
1	X15/15
2	X15/16
3	X15/17
4	X15/18
5	X15/19
6	X15/20
7	X15/21
8	X15/22
9	X15/23

Fig. 6-13: Allocation of signal status word to digital outputs

See also section: "Configurable Signal Status Word"

Configurable Inputs

All inputs are digitally filtered. The read-in cycle takes 2ms. In other words, the filtering and probing results in a reaction time equal to a minimum of 1.5 and a maximum of 4ms.

The digital inputs of the parallel interface are mapped on bits 0-9 of the signal control word.

Allocation of signal control word to digital inputs

Bit number in the signal status word	Digital input of the parallel interface
0	X15/1
1	X15/2
2	X15/3
3	X15/4
4	X15/5
5	X15/6
6	X15/7
7	X15/8
8	X15/9
9	X15/10

Fig. 6-14: Allocation of signal control word to digital inputs

See also section: "Configurable Signal Control Word"

Application: Stepper Motor Mode with Parallel Interface

(See also section: "Operating Mode: Stepper Motor Operations")

The parallel interface is needed to operate the drive as if it were a stepper motor. The inputs for the stepper motor signals are permanently allocated to the function. The inputs for jogging and referencing must be allocated accordingly.

Note: **The command** "Load base parameters" configures the inputs as specified in the terminal diagrams.

Application: Positioning Block Mode with Parallel Interface

(See also section: "Positioning Block Mode")

The parallel interface is needed to operate the drive in positioning block mode. Positioning block select, jogging inputs, referencing input, the start input and outputs are configured with command "Load base parameters" as per the terminal diagrams.

Positioning block select, start signal:

A positive edge at the start signal effects a toggling of parameter **S-0-0346, Setup flag for relative command values**. The inputs for the position block select are mapped on the parameter positioning block selection. By toggling parameter **S-0-0346, Setup flag for relative command values** the relevant positioning block is started.

Block select acknowledgment, In-Pos message:

The acknowledgement of the block selection ensues as soon as the positioning block is set. The in-pos message is simultaneously updated.

Jogging input:

Selecting the jogging inputs effects an internal switch to jogging mode. The switch can only be made every 8 ms which means that the reaction time to a jog input can equal up to 12 ms.

Application: Analog Main Spindle with Parallelinterface

(See also section:: "Spindle Positioning")

To operate as an analog unit with main spindle functions, the spindle positioning command can be allocated to an input. The main spindle messages must be allocated to the digital outputs.

Notes

7 Motor Configuration

7.1 Characteristics of the Different Motor Types

You can use the following motor types.

MKD	MHD
2AD	ADF
1MB	MBW
MKE	LAR
MBS	LSF
	LAF

The individual motor types differ in the following points:

- Availability of data memory in the motor feedback for all motorspecific parameters
- Synchronous motor - Asynchronous motor
- Linear motor - rotational motor
- Temperature check can be changed or not.
- Basic load (load default) is possible when a Feedback-Data Memory is present.
- Motor encoder interface setting can be changed or one setting only
- Start of commutation offset setting command possible or not
- Motor temperature sensor with PTC or NTC features

The individual motor types have the following characteristics

Motor type	Motor feedback data memory	Sync./Async.	Temp. check	Motor-encoder interface	Load default	Temp. Sensor
MHD/MKD/MKE	yes	synchronous	fixed	fixed (1)	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

Fig. 7-15: Characteristics of the Motor Types part 1

see also parameter description: **P-0-4014, Motor type**

Motor Feedback-Data Memory

The motor feedback data memory contains all motor-related parameters

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 with 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: Motor types without motor feedback memory necessitate that these parameters are input at the initial start-up using the data sheet.

Linear-Rotational

Units are

motordependent

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:	Rotational:	Linear:
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. 7-16: Scaling in Linear or 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-Asynchronous

Specific parameters are used only for synchronous motors, others only for asynchronous motors.

There are differences in the use and review of the parameters in the command **S-0-0128, C200 Communication phase 4 transition check**.

They are:

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 switch-off limit for the motor temperature check is fixed at one point for MHD-, MKD, MKE motors.

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 parameter default values are:

S-0-0201, Motor warning temperature = 145,0°C

S-0-0204, Motor shutdown temperature = 155,0°C

Those default values can be used to help set the parameters for all other motor types. 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 message **E251 Motor overtemp. prewarning** is generated.

If the temperature rises to the motor switch-off temperature, the error message **F219 Motor overtemp. shutdown** is displayed.

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. The data memory contains a set of default control parameters in addition to all motor-dependent parameters.

These parameters are activated with the load default feature.

(See also "Load Default Feature")

7.2 Setting the Motor Type

The setting of the motor type is done either:

- it depends on the used motor type.
- automatically by reading the motor feedback memory or
- through the input of the parameter **P-0-4014, Motor type.**

The motor type should be set before start up 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 Memory

MHD, MKD and MKE motors have a motor feedback data memory, in which the motor type is stored (along with other information). The drive controller recognizes these motor types automatically and the following is executed:

- the value of the parameter **P-0-4014, Motor type** is set to its proper value and will be write-protected.
- 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 storage (see "Motor Feedback-Data Memory"). The parameter in the motor feedback memory are set with parameter block number 7. These are retrieved 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.

This procedure is followed right after switching on as in the command **S-0-0128, C200 Communication phase 4 transition check**. The command error message, **C204 Motor type P-0-4014 incorrect**, will be generated in case an MHD, MKD and MKE motor is selected in **P-0-4014, Motor type** but the corresponding character sequence cannot be found in the motor feedback data 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: "Characteristics of the Different Motor Types"

7.3 Asynchronous Motors

With the Firmware, you can use asynchronous motors in the entire rpm range, including constant power range.

In addition to the general motor parameters, you have to set the following asynchronous motor parameters for specific motors according to the Indramat default:

- **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 parameters to adjust the drive to his requirements.
- **P-0-0532, Premagnetization factor**

Basics for the Asynchronous Motor

Asynchronous motors are divided in three working ranges.

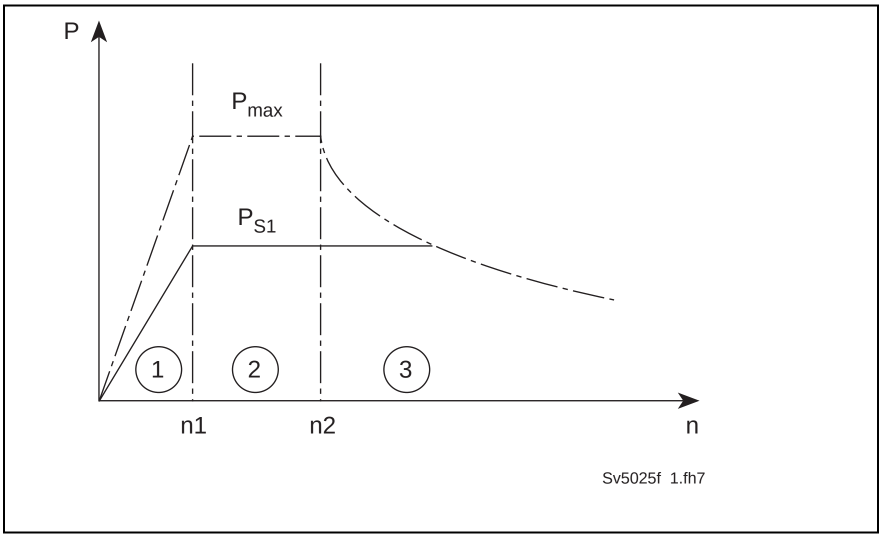

Fig. 7-17: Subsections of Work Ranges

Range 1:

The Basic RPM Range is defined by a constant torque and a fixed torque/force constant (parameter P-0-0051). In idle, the programmed magnetization current flows. The motor voltage is less than the maximum control output voltage. The corner RPM 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 velocity. The slip is increased correspondingly.

The adjustment of magnetization current and slip is executed automatically by the vector control. The voltage is decreased during idle to the motor idle voltage (P-0-0535), and when fully in use it is increased to the maximum motor voltage (P-0-0536).

Range 3:

Range of decreasing Peak Power. The motor works at the stability limit; through the vector control, the current is maintained at an efficient and stable level. According to the parameter "current stability limit," the peak current will be decreased enough so that the maximum power cannot be exceeded. An 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 always is reached for each DC bus voltage without parameter adjustment.

The power in range 3 cannot be extended through the use of more powerful controllers.

Torque Evaluation

100% torque refers to the motor's nominal torque according to the ID plate. Since the peak torque of asynchronous motors is limited to 2.5 times of 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 picture:

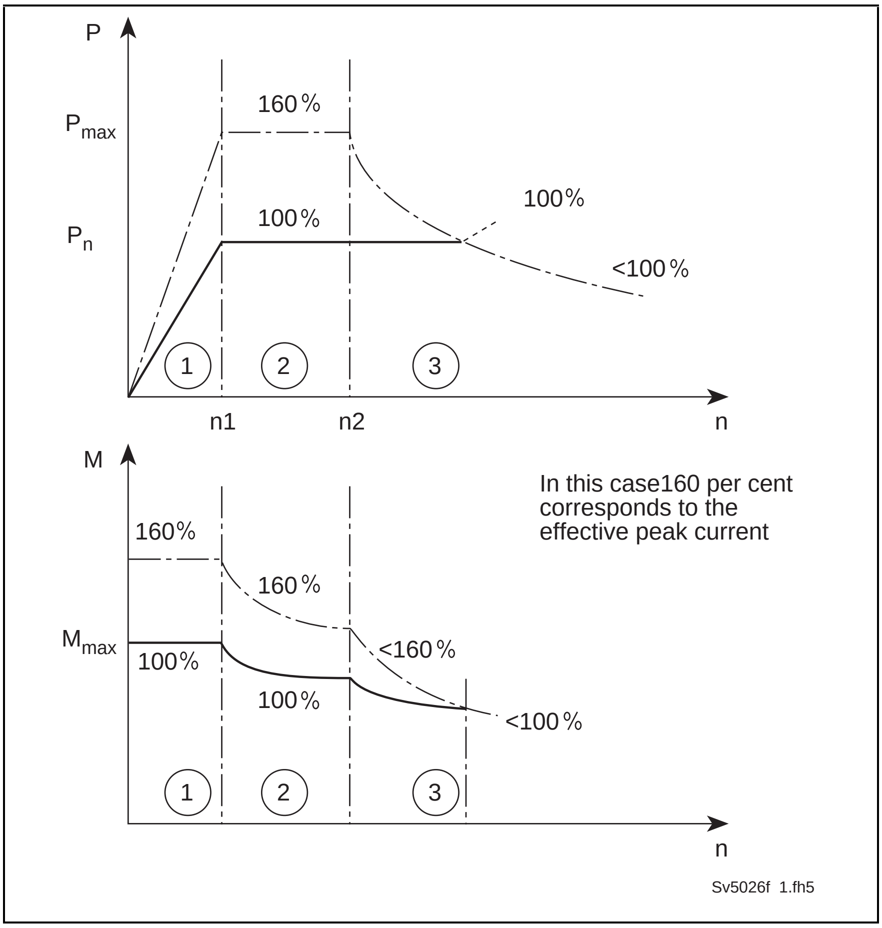

Fig. 7-18: Torque assignment

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 rating plate is not relevant here since it could relate to another DC bus voltage.)

Range 3 is similar to the evaluation of range 2, except that the preset torque decreases in correspondence to the increasing velocity of the peak power. For high velocity, 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 Settings for 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 Parameterstorage and are therefore transferable to another controller.

Note: Motor-specific parameters are used by all controls in the same manner. The resulting power characteristics curve depends on the current and especially on the DC bus voltage. Several additional parameters are available so the user can optimize the drive to his requirements.

Scaling Factor Pre-Magnetizing

With **P-0-0532, Premagnetization factor** you can set the active magnetization current.

The following applies:

Effective magnetization current = magnetization voltage •
scaling factor pre-magnetizing

Fig. 7-19: Calculation of the Effective Magnetization Current

If the pre-magnetizing scaling 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 4kHz switching frequency, when the full magnetization current is flowing. For main spindle applications, it has proven successful to reduce the pre-magnetizing scaling factor to 50%. Through this procedure, the motor stays cooler and is not as noisy, while peak power is maintained. The extended start control 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.

With a 50% pre-magnetizing factor the qualitative connection between the pre-magnetizing scaling factor (pmf) and drive behavior is displayed in the following graphic:

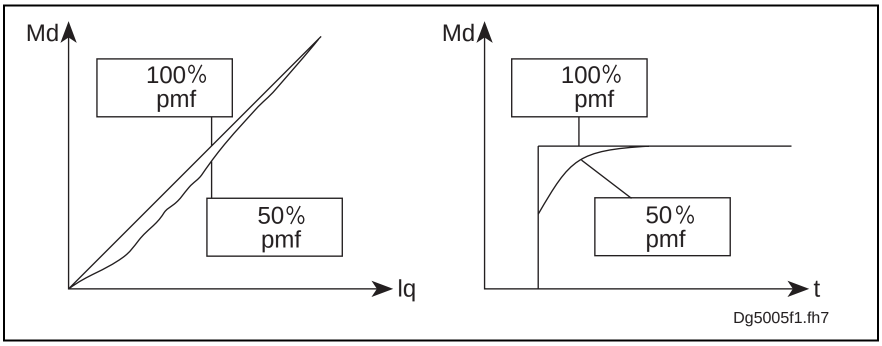

Fig. 7-20: Connection of pre-magnetizing scaling factor and drive behavior

The torque buildup is delayed by about 200ms during pre-magnetizing because the air gap range can only increase slowly in relation to the rotor time constant.

By reducing the pre-magnetizing scaling factor, you can achieve a 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 pre-magnetizing scaling factor was decreased. Warning: Torque constant, continual torque and peak torque are reduced!

Example: The synchronous operation should be improved in a servo drive. The pre-magnetizing scaling 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 base speed increases to 2.5 times the rated base speed.

7.4 Synchronous Motors

With this drive firmware it is possible to run INDRAMAT housing motors

- MHD
- MKD and MKE motors

plus rotary and linear synchronous kit motors MBS and LSF. 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 feedback parameters
- synchronous motor-specific parameters and
- default control parameters

Automatic detection and parameterization of INDRAMAT housing motors (MHD and MKD motors)

are stored. These motors are recognized by the firmware and the correct setting for them is automatic. The compensation between the physical rotor position and the position supplied by the feedback is set at the factory in these motors. The offset results are stored in parameter **P-7-0508, Commutation offset** in the motor feedback memory (synchronous motor parameter). INDRAMAT housing motors are configured ready for operation at the factory meaning that they can be run without having to make any motor settings.

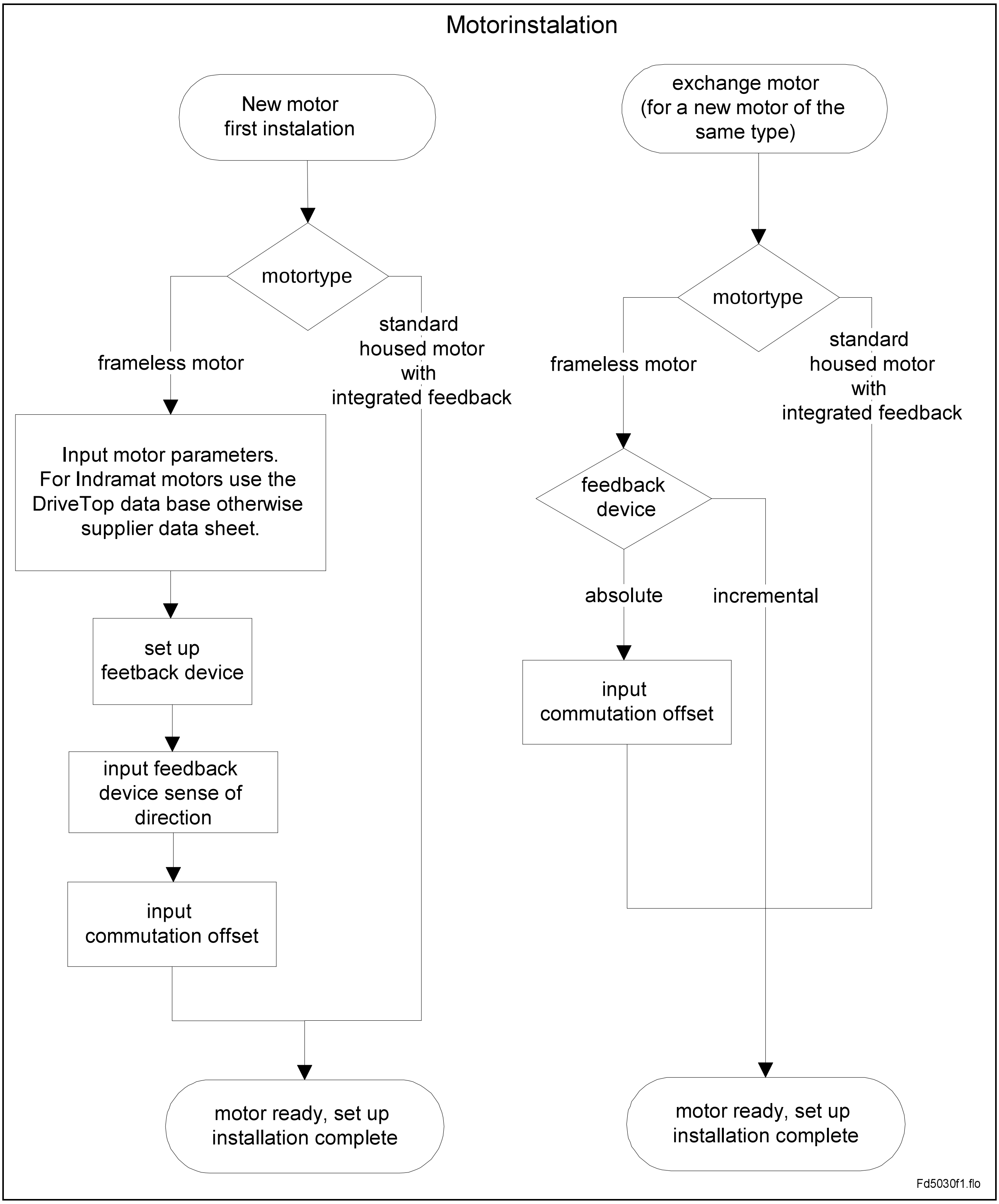

Fig. 7-21: Overview of starting up the motor

Starting up Synchronous Kit Motors

Synchronous kit motors necessitate the additional setting of the following prior to start up:

- motor parameters must be input
- the motor encoder programmed (see section: "Motor Encoder").
- the rotational motion of the motor encoder must be set (see section: "Command Polarities and Actual Value Polarities")
- Commutation offsets.must be determined.

The motor parameters can be input via the motor data bank 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.

(See Determining commutation offset).

Determining commutation offset

A condition for a constant torque through the complete motor rotation of a synchronous machine is the permanent offset setting between stator current vector and the rotor flow vector. If the angle between these two vectors $\gamma = 90°$, then the machine generates maximum torque. The synchronous machine is operated in this state.

To set the stator current vector see the information about absolute rotor positions. The difference between the motor position encoder (rotor raw position) and that of 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 start up the difference is made between absolute and incremental measuring systems used as motor encoder.

Motor with absolute measuring system:

The motor has a motor encoder which makes the absolute rotor position known.

In this case it is necessary

- with the initial start up of the axis
- or after the measuring system has been replaced

to determine the commutation offset <u>one time</u>.

WARNING

Fault in motor control and moving parts

⇒ Commutation offset must be determined every time the mechanical reference between motor feedback and motor has changed. This is the case, for example, when the encoder or the motor have been exchanged.

Motor with incremental measuring system:

The motor is equipped with an incremental measuring system.

Rotor position is unknown every time the control voltage is switched on. Commutation offset must be determined with every transition into operating mode (e.g., after control voltage is switched on).

Setting the motor encoder: This is automatic when the drive enable is applied.

With the help of **P-0-0074, Feedback 1 type** the measuring system type is parameterized. The following illustrates whether it is an absolute or incremental system.

Value of P-0-0074, Feedback 1 type	Absolute rotor information
1	Yes
2	No
3	No
5	No
8	Yes
9	No
10	Yes
11	Yes

Fig. 7-22: Absolute rotor information as dependent on encoder type

How to determine the commutation setting: There are three different ways to determine the commutation offset outlined in the firmware. The following illustrates the relationship between the motor encoder used and the procedure used.

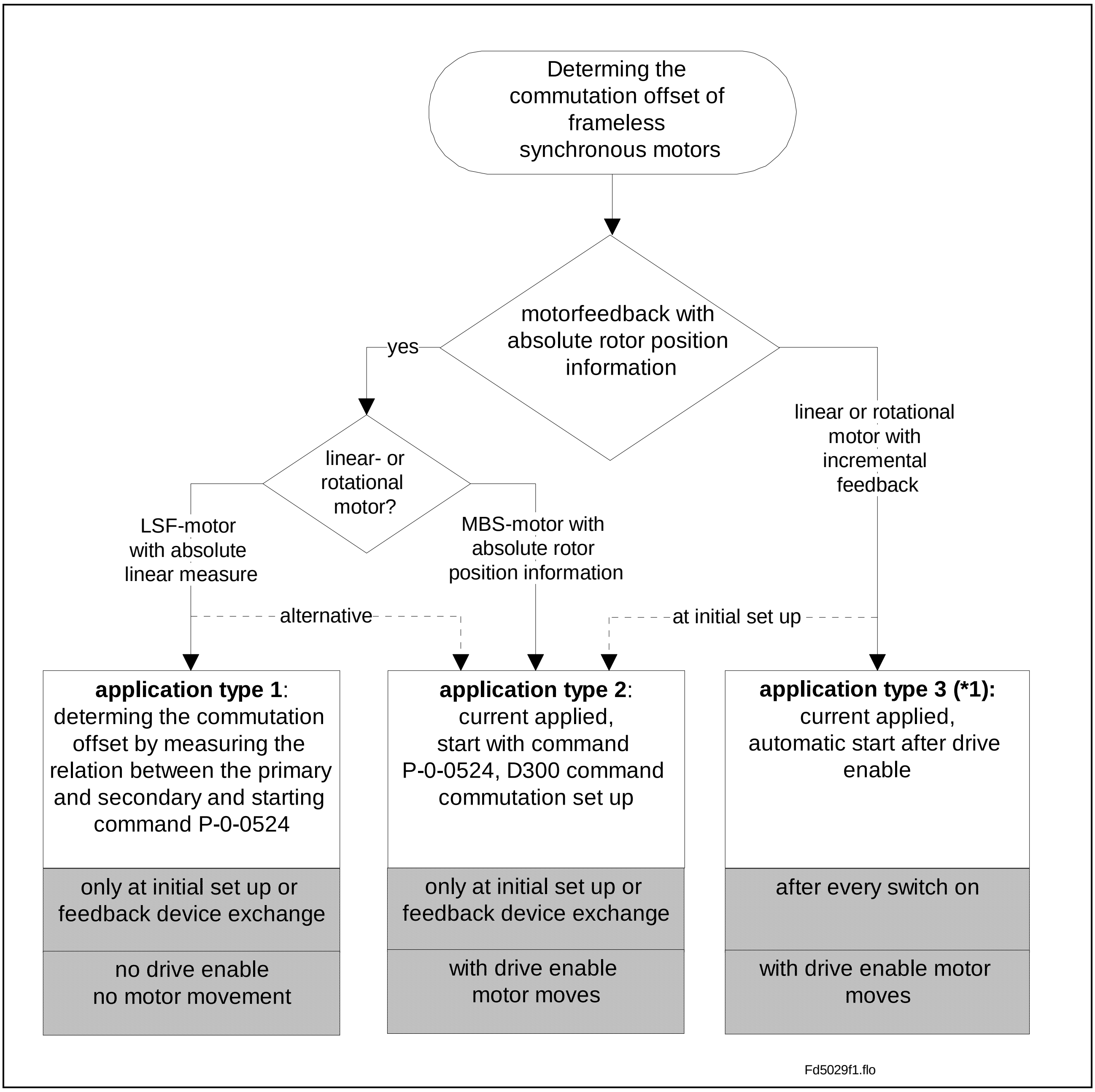

Fig. 7-23: Determining commutation offset in synchronous motors

(*1)

DANGER

Application no. 3 (synchronous motors with incremental encoder) **may not** be used in conjunction with the following applications:

-vertical axis without weight compensation ("Hanging axes")

-or a jammed or blocked axis.

⇒ **This application may only be used after the drive developer has been consulted and given permission!**

Pre-requisites: To successfully conduct this procedure, the following conditions must first be met:

- The rotational direction of the encoder must be set first:
  - for rotary motors:
    If the motor moves clockwise (looking onto motor drive shaft), then the value in parameter **S-0-0051, Position feedback 1 value** must be increasing.
  - for linear motors:
    If the primary part is moving to the direction of the front where the power cable of the motor branches off (see Fig. 7-25: Overview determining commutation offset with an LSF) then 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 motional 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 section: "Command Polarities and Actual Value Polarities" or "Motor Encoder".

The current and velocity control loop parameters must also have default settings or must be parameterized in a sensible way

Application 1: Measuring the reference between primary and secondary parts (linear motors)

Overview: Determining commutation offset in linear synchronous motors (LSF) with absolute encoder systems can be determined by measuring the distance between the front of the primary part and the set screw of the motor secondary.

Note: Commutation offset is determined without axis motions.

Parameters involved:

- **P-0-0508, Commutation offset**
- **P-0-0523, Commutation, probe value**
- **P-0-0524, D300 Commutation adjustment command**

Additional pre-requisites: To successfully execute a command, the following additional conditions must be satisfied:

- The power cables of the motor must be correctly attached (correct rotation of the three phases).
- The drive must be in state **A013 Ready for power on**.
- A suitable primary part constant Kmx value must have been determined.

Sequence: Once the listed conditions have been met, then the value for parameter **P-0-0523, Commutation, probe value** is entered using the following formula:

$$P-0-0523 = d - K_{mx}$$

P-0-0523: Value determined for parameter P-0-0523
d: Measured value of distance between front of primary part and the secondary set screw
Kmx: Primary constant value

Fig. 7-24: Determining the value or commutation offset setting with linear servo motor (LSF).

Note: The distance is measured from the end which the motor power cable is not attached.

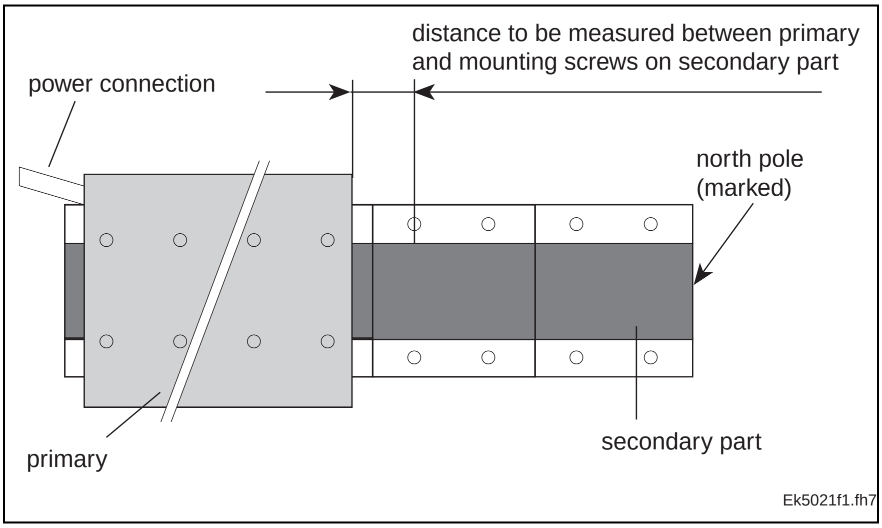

Fig. 7-25: Overview determining commutation offset with an LSF

After the value has been entered, it is necessary to start command **P-0-0524, D300 Commutation adjustment command**. The commutation offset is computed at this time.

Note: If the drive is in control at the time the command is started (i.e., drive enable is set and drive is in torque control mode), then the commutation offset is determined with current flow procedure (Application 2). (See "Alternative" in Fig.: Determining commutation offset in synchronous motors).

The command must be reset to 0 at completion.

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 3)" must be taken into account.

Used: This procedure is used in the following situations:

- The commutation procedure must be completed only once, at first start up or when the encoder is exchanged on rotary synchronous motors with motor encoders containing absolute rotor position information.
- With linear motors with absolute encoder systems at initial start up as alternative to Application 1.
- With linear or rotary synchronous motors with incremental encoders this procedure should be used at initial start up of 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 if synchronous motors with incremental encoders are used. Application 3 is used to do this. As start values for the third procedure, the parameter values determined at the initial start up for **P-0-0560 and P-0-0562** are used.

Parameters involved:

- **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**

The following encoder types are available as motor encoders with absolute rotor position information:

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 *)

Fig. 7-26: Possible motor encoders for synchronous kit motors

Also see parameter description: **P-0-0074, Feedback 1 type**

Note: *) 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 module the value of parameter **P-0-0508, Commutation offset** has to be re-entered or the parameter from the old module must be saved and loaded into new module.

More pre-requisites: To execute this 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 shut off internally. To start the drive again, though, the control must complete the command and set the drive enable again.

The precise sequence is identical to the description in: "Application 3: Current flow procedure, Automatic Sequence after applying drive enable".

Application 3: Current flow procedure, Automatic Sequence after applying drive enable

DANGER

The machine can be damaged if the procedure is performed incorrectly used

⇒ Take the restrictions listed in section: ""Current flow procedure restrictions (Application 2 and 3)" into account.

Use with: This procedure is automatically conducted in linear and rotary synchronous motors with incremental encoders systems whenever the unit is started up.

Parameters involved:

- **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 commutation determined 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 operation mode Diagnosis "AF" is displayed. The drive simultaneously signals in parameter **S-0-0135, Drive status word** status "In operation under torque".

Note:	Maximum motion equals	
	Linear motor:	+/- 1 pole width
	Rotary motor:	+/- 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 changed 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 considerable (up to two minutes).

Initial start up

This is why an initial start up is recommended. The values described above for **P-0-0560, Commutation adjustment current** and **P-0-0562, Commutation adjustment periodic time** are determined and stored in the parameter module. These are then available as start values for setting the commutation offset which is started after transition into operating mode. This means that the drive saves the time needed to determine the best parameter for the commutation setting.

Conducting the initial start up:

1. Switch drive into operating mode and power on.
2. Execute command **P-0-0524, D300 Commutation adjustment command**.

   The drive runs the commutation setting. At the end, the determined values are stored in the parameter memory in parameters **P-0-0560, Commutation adjustment current** and **P-0-0562, Commutation adjustment periodic time**. They can be used as start values for commutation settings in the future.

Current flow procedure restrictions (Application 2 and 3)

Restrictions when using holding brakes or clamps

For the 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 opened 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 stops

Note the following with axes with dead stops:

DANGER

The machine can be damaged if the procedure is performed incorrectly.

⇒ 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 so that each drive can run the arrangement.

If commutation is not yet known (after going from parameter mode into operating mode) then only one drive can generate the drive enable. The second or other axes must be torque free.

If the commutation setting of the first drive is over then it has to go torque free before the second drive of the axis (with commutation setting still applicable) sets the drive enable.

Diagnoses

In conjunction with the commutation setting, the following diagnoses 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 has not been determined because:

- encoder rotational direction was wrong
- axis mechanically blocked
- brake closed
- 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 error is generated.

- **D312 Motion range exceeded during commutation**

Or

- **F812 Motion range exceeded during commutation**

The axis has moved more than one pole width or 360° / number of pole pairs because:

- Parameter for commutation setting is too big
- mechanical motion generated from outside
- velocity controller incorrectly parameterized

Fieldweakening range for synchronous motors

The working range of synchronous motors is limited in conventional mode on converters by the converter voltage. The motor reaches maximum speed once its no-load voltage has reached the converter voltage.

With a fieldweakening range for synchronous motors it has become possible to operate motors outside of this limitation.

If fieldweakening is to be used with synchronous motors then the following parameters must be set motor-specifically as stated in the 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 fieldweakening range.

The fieldweakening function 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 mounted via a potential-free contact built into the drive controller . It 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 motor types MHD and MKD is not a working brake. It wears down after about 20,000 motor revolutions if the brake is closed.

Pertinent Parameters

To set the motor holding brake, use 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-0-0541, B200 Brake check command**
- **P-0-0542, B100 Command Release motor holding brake**

The parameters for the motor holding brake are automatically set in motors with motor feedback data memory

Parameters **P-0-0525** and **P-0-0526** are automatically set in 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 or the motor brake. Parameter **P-0-0126** must be parametrized to meet 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

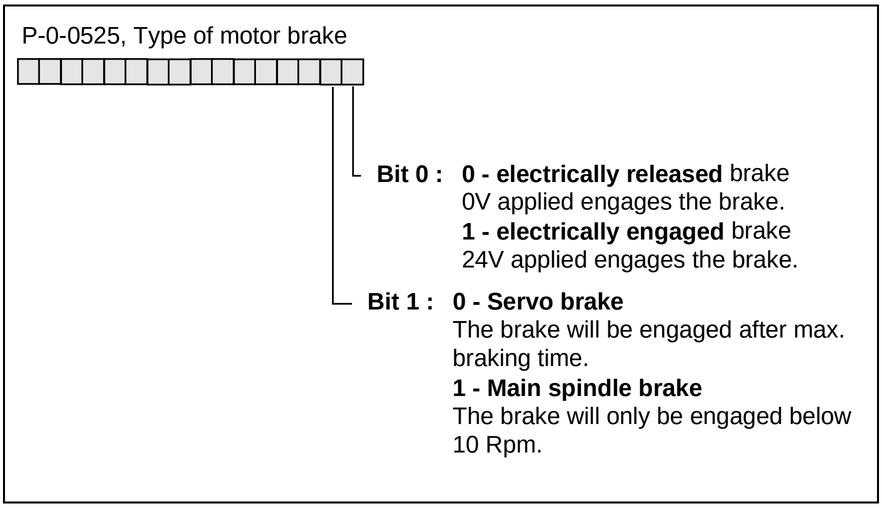

Fig. 7-27: Setting the motor brake type

The behavior with a spindle brake

P-0-0525, Type of motor brake

bit 1 = 1

The motor holding brake is always activated if the actual speed of the motor drops to less than 10 rpm or 10mm/min (linear motor).

The P-0-0126, Maximum braking time is not important

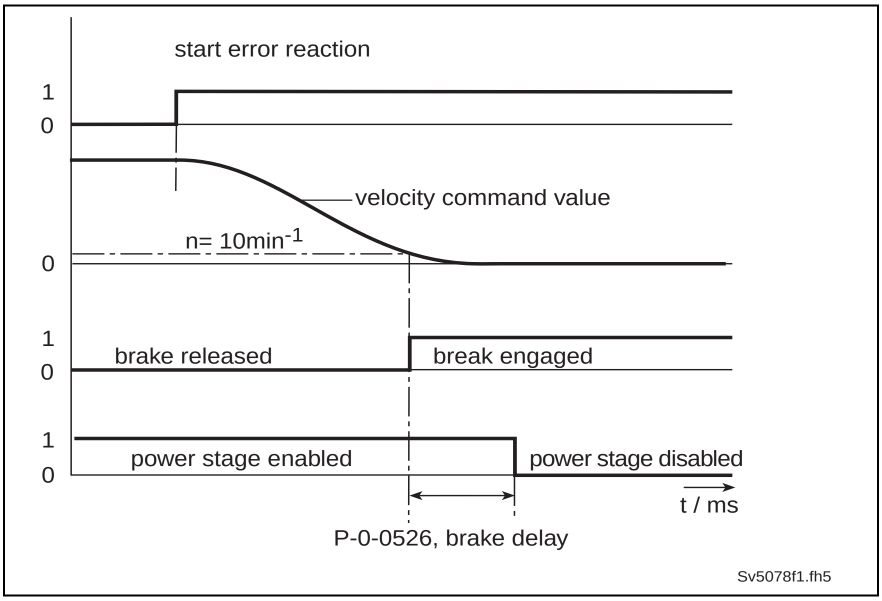

Fig. 7-28: Chronological diagram with command value to zero and P-0-0525, Holding brake type, **Bit 1 = 1** (Spindle brake)

Behavior with servo brake

P-0-0525, Type of motor brake

bit 1 = 0

braking time < P-0-0126

The brake is activated:

- as soon as the velocity of 10 rpm is exceeded during an error reaction or
- no later than upon completion of the maximum decel time.

Correct braking time

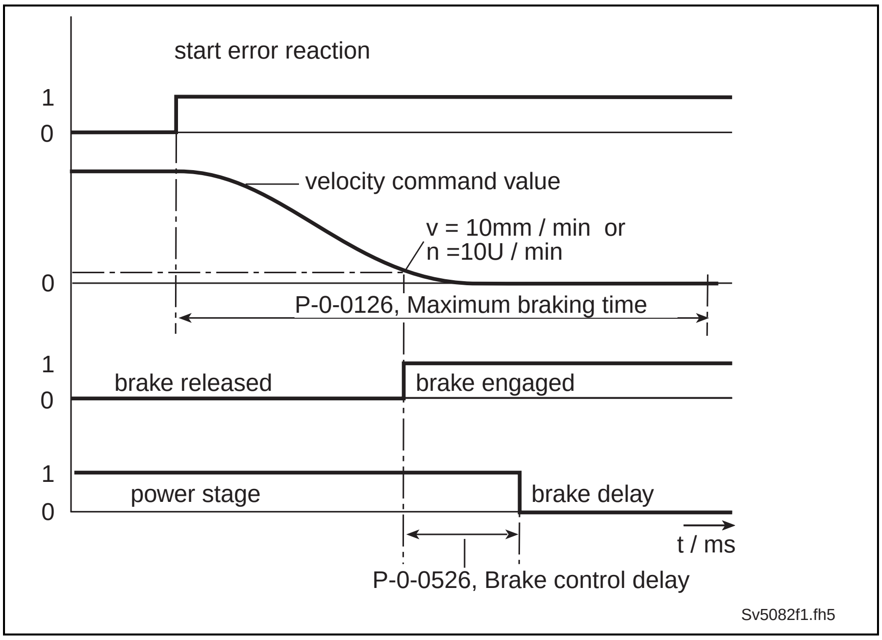

Fig. 7-29: Chronological diagram with command value to zero and P-0-0525, Holding brake type, Bit 1 = 0 (Servo brake) and actual braking time < P-0-0126

Behavior with servo brake
P-0-0525, Type of motor brake
bit 1 = 0
braking time > P-0-0126

Incorrect braking time

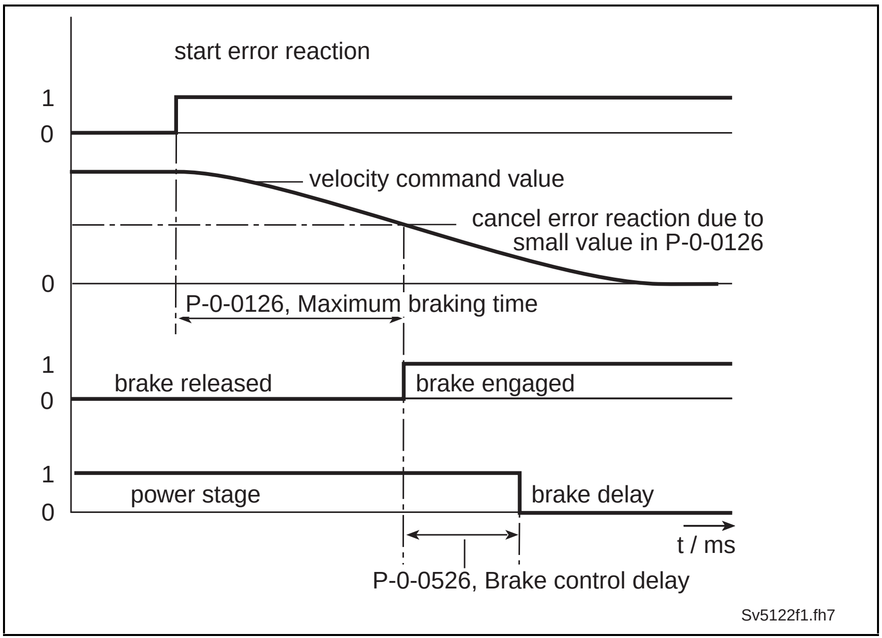

Fig. 7-30: Chronological diagram with command value to zero and P-0-0525, Holding brake type, Bit 1 = 0 (Servo brake) and actual braking time > P-0-0126

Setting the Motor Brake Integral Action Time

In **P-0-0526, Brake control delay** it is necessary to set the time that the motor brake control needs to actually apply the brake.

Note: A standard value for the direct connection of holding brakes of Rexroth Indramat motors equals 150msec.

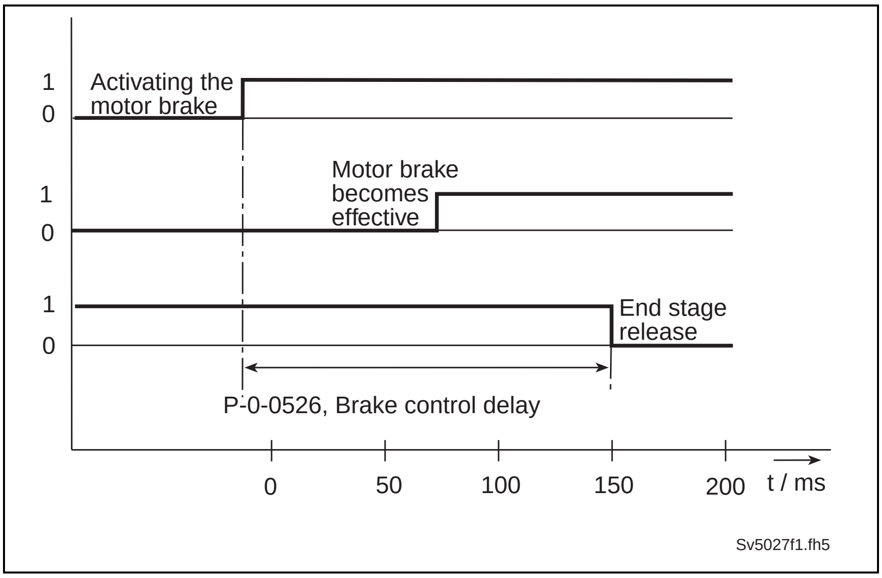

Fig. 7-31: Setting motor brake integral action time

Setting Maximum Decel Time

Parameter **P-0-0126, Maximum braking time** supports decel time monitoring and activation of the motor holding brake if the theoretical decel time is exceeded due to an error.

The motor holding brake is activated if the time since the start of the error reaction exceeds the time set in **P-0-0126, Maximum braking time**.

Note: The value in P-0-0126, Maximum braking time must be set so that the drive can come to a standstill with the greatest possible moment of inertia and force from maximum speed.

ATTENTION

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 UPM. This will damage the brake if permitted to continue over extended periods of time!

Command Release motor holding brake

The open holding brake command as specified in **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 opened upon activation of the command.

Upon completion of the command, the brake is again applied. Given an active command to switch drive enable on and off, then the brake is again closed.

ATTENTION

Releasing the holding brake on a vertical axis may lead to unwanted motion.

Monitoring the Motor Holding Brake

The holding brake monitor can be executed each time the drive enable is switched off or on or by executing command "Brake monitor". An automatic check necessitates that bit 10 is set in motor function parameter (**P-0-0538, Motor function parameter 1**).

Automatic Checks

Applying drive enable

When applying the drive enable, the opening of the brake is checked. This means that the drive is run at maximum decel nominal torque.

If it is possible to move the motor with this torque, then the brake is in order.

If the motor cannot be moved, then the brake is closed. Error "**F269 Error when releasing 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 no movement is possible, then the brake is in order.

If the motor moves during the check, then warning "**E269 Brake torque too low**" is generated.

The warning remains pending until the monitor recognizes one of the brakes as alright.

Command brake monitor

With the activation of the 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 closed.

Error "**F269 Error with motor brake release**" is generated.

If movement is possible, then the nominal brake torque is generated by the motor with closed brake.

If the motor does not move, then the brake is functional. 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

A monitoring of the holding brake generates axis movements.

Connecting the Motor Holding Brake

See relevant Project Planning Manual for details.

8 Operating Modes

8.1 Setting the Operating Mode Parameters

Depending on the type of command communication used different numbers of operating modes are available.

Command communications parallel interface

If the drive is controlled via parallel command communication, then **two** different modes can be used, namely:

- Primary Mode of Operation and
- Secondary Operating Mode 1.

The main operating mode is defined in parameter **S-0-0032, Primary mode of operation**.

Auxiliary operating mode 1 is permanently set to jog. The drive switches from main to auxiliary modes if input "jog positive" or "jog negative" is actuated.

Command communication analog interface

If analog command communication is used, then the drive can only be operated in the main operating mode.

Command communication via SERCOS

If a command communication via SERCOS is used, then using the following four parameters:

- **S-0-0032, Primary Mode of Operation**
- **S-0-0033, Secondary Operating Mode 1**
- **S-0-0034, Secondary Operating Mode 2**
- **S-0-0035, Secondary Operating Mode 3**

four different operating modes can be simultaneously pre-selected.

The above parameters are listed in an overview and specify the input value for each parameter.

8.2 Determining/detecting the active mode

Depending on the type of command communication parameter **S-0-0134, Master control word** has various definitions.

Command communication analog interface or parallel interface

If an analog or parallel command communication are used, then bits 8 and 9 in the master control word display which mode is active.

Command communication via SERCOS

If command communication via SERCOS is used then bits 8 and 9 in the master control word are used to determine which of the four pre-selected modes is actually working.

Bit 8 and 9 in the master control word	Active 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

Fig. 8-1: Determining/detecting the active mode in the master control word

Note: If 0 is entered in one of the operating mode parameters and that operating mode is activated, then the error **F207 Switching to uninitialized operation mode** will be generated.

8.3 Operating Mode: Torque Control

In the operating mode **torque control** the drive is given a torque command value. The diagnostic message reads **A100 Drive in TORQUE control** when this operating mode is active.

The command value is set in parameter **S-0-0080, Torque/Force command**.

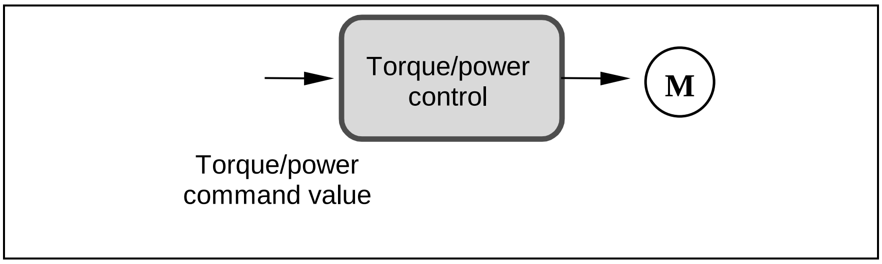

Fig. 8-2: Block diagram of torque control

Pertinent Parameters

- **S-0-0080, Torque/Force command**
- **P-0-4046, Active peak current**
- **P-0-0176, Torque/Force command smoothing time constant**

Torque Control

The command value in **S-0-0080, Torque/Force command** is limited with the effective peak current **P-0-4046, Active peak current**. This current is based on the current and torque limits.

(See section: "Current limits" and "Torque control").

The limited torque command value is filtered through a 1st order filter. The time constant of the filter is set in parameter **P-0-0176, Torque/Force command smoothing time constant**.

After limiting and filtering, the effective torque-generating command value is generated. It is the command value for the effective current control.

Using „Analog output of predefined signals“ the effective command current can be output as an analog value.

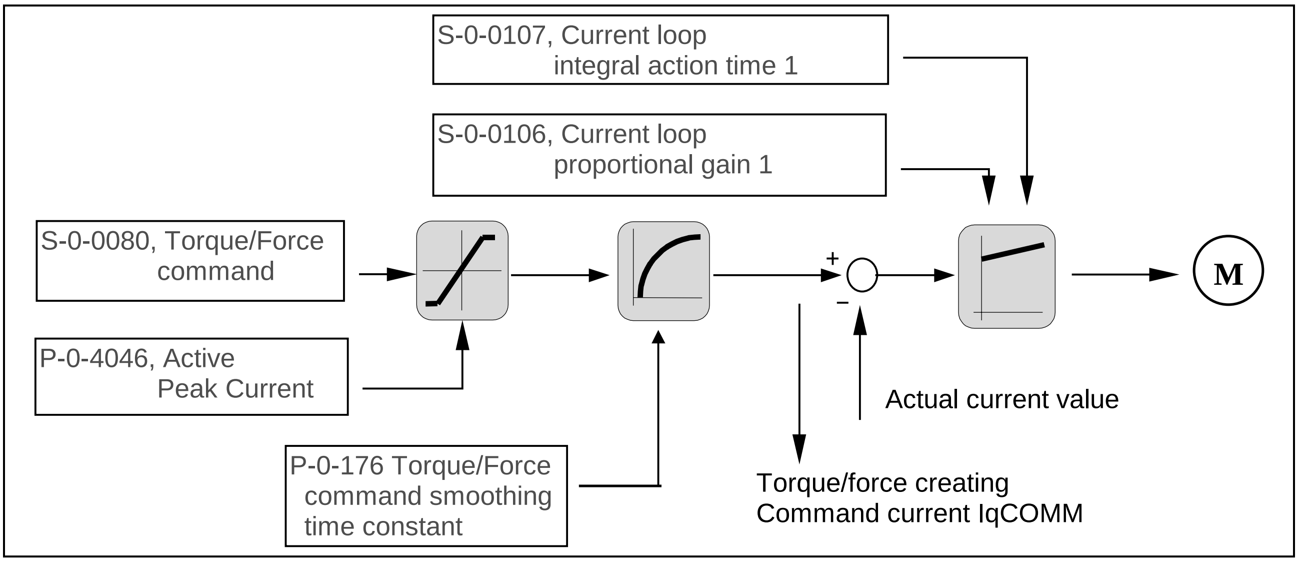

Fig. 8-3: Torque control

Diagnostic Messages

Operating mode-specific monitors are

- Monitoring actual velocity for a 1.125 fold value of parameter **S-0-0091, Bipolar velocity limit value**.

(See section: "Limiting to Bipolar Velocity Limit Value").

If this value is exceeded, then error **F879 Velocity limit S-0-0091 exceeded** is generated.

Torque Control with Analog Command Communications

To activate the operating mode in conjunction with analog command communications, note the following procedure:

- Select the mode with **S-0-0032, Primary mode of operation**
- Parametrize the analog channel **P-0-0213, Analog input 1, assignment to** parameter **S-0-0080, Torque command**
- Define the resolution with the help of **P-0-0214, Analog input 1, scaling per 10V full scale**.
- If necessary, set offset compensation via **P-0-0217, Analog input 1, offset**.

8.4 Operating Mode: Velocity Control

A velocity value is commanded to 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 values are specified in the parameters **S-0-0036, Velocity command value** and **S-0-0037, Additive velocity command value**.

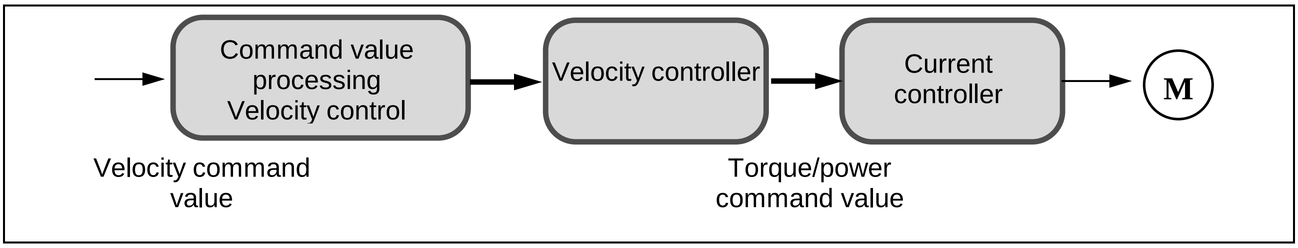

Fig. 8-4: Velocity control block diagram

Pertinent Parameters

- **S-0-0037, Additive velocity command value**
- **S-0-0036, Velocity command value**
- **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-0-1222, Velocity command filter**

Command value processing 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 accel 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 accel limited in terms of value **P-0-1203, Ramp 2 pitch**. The limit velocity command is jerk limited by means of a filter of the 1st order (**P-0-1222, Velocity command filter)**.

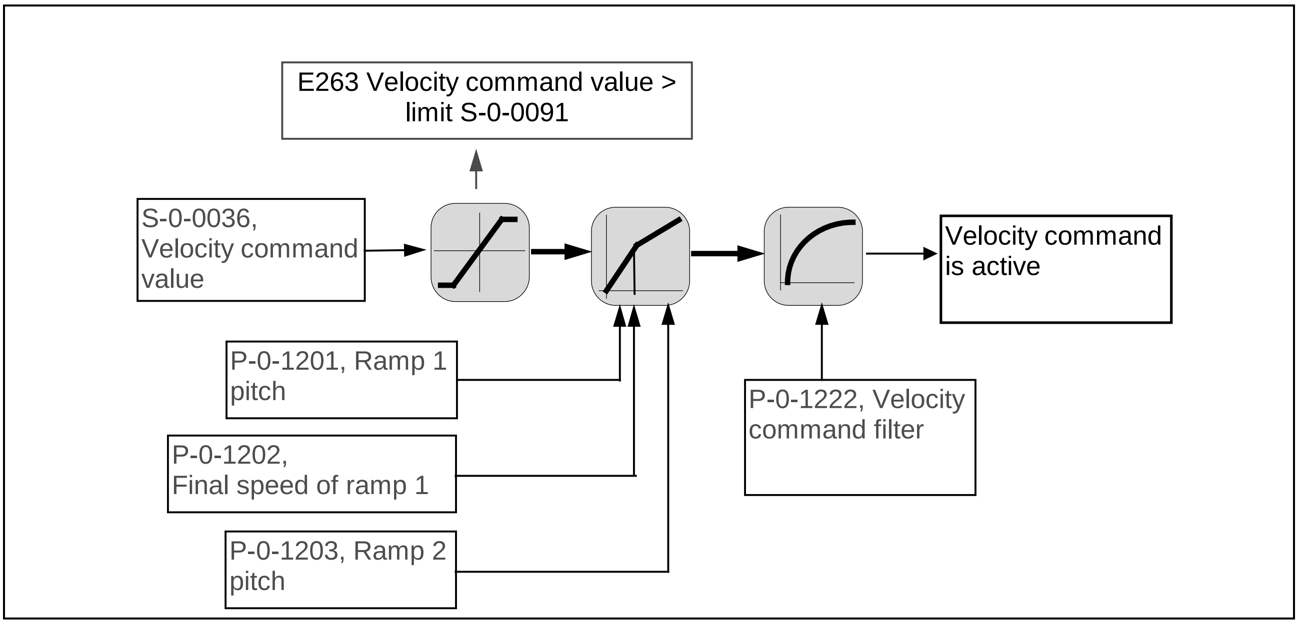

Fig. 8-5: Command value processing: Velocity Controller

See also chapter: "Velocity Controller"

See also chapter: "Current Controller".

Velocity Controller

The effective velocity command value is added with **S-0-0037, Additive velocity command value**.

Further it is limited to **S-0-0091, Bipolar velocity limit value**.

(See also chapter: "Limiting to Bipolar Velocity Limit Value")

If the resulting command value is at the limit, the warning **E259 Command velocity limit active** is displayed.

The velocity control difference is produced by including the feedback velocity in the control loop. The unfiltered feedback velocities of the motor and, if available, the external encoder can be combined into an effective actual velocity value. (See also chapter: "Setting the Velocity Mix Factor".)

Via **P-0-0004, Velocity loop smoothing time constant** you can limit the band of the control difference for the velocity controller.

This variable is then relayed to the current and torque limits.

(See also chapter: "Current Limit" and "Torque Limit".)

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 parametrized.

(See also "Setting the Velocity Controller".)

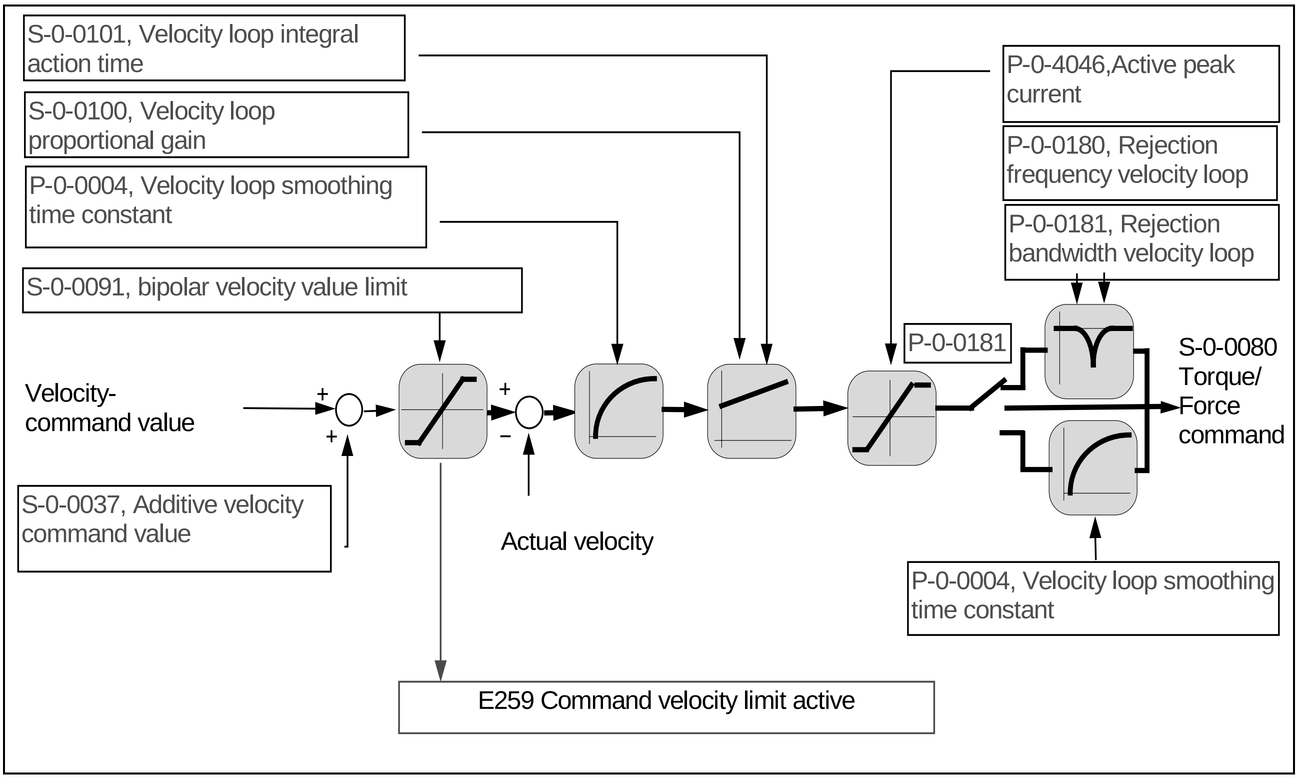

Fig. 8-6: Velocity Controller

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".)

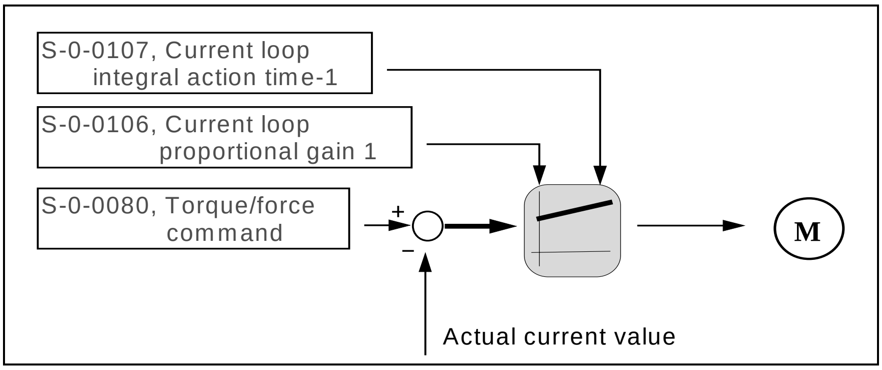

Fig. 8-7: Current Controller

Diagnostic Messages

Operating mode specific monitors 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**. The warning **E263 Velocity command value > limit S-0-0091** is generated.

Velocity Control with Analog Command Communications

To activate the operating mode in conjunction with analog command communications, note the following procedure:

- Select the mode with **S-0-0032, Primary mode of operation**
- Parametrize the analog channel **P-0-0213, Analog input 1, assignment to** parameter **S-0-0036, Velocity command value**
- Define the resolution with the help of **P-0-0214, Analog input 1, scaling per 10V full scale**.
- If necessary, set offset compensation via **P-0-0217, Analog input 1, offset**.

8.5 Operating Mode: Position Control

A position value is commanded to the drive every NC-cycle time in the **Position Control** operating mode. The timebase is defined here in **S-0-0001, NC Cycle time (TNcyc)**. When this mode is activated, the diagnostic message is one of the following:

- **A102 Position Control Encoder 1**
- **A103 Position Control Encoder 2**
- **A104 Position Control Encoder 1 Lagless Positioning**
- **A105 Position Control/ Encoder 2 / Lagless Positioning**

The command value is specified in the parameter **S-0-0047, Position Command Value** .

Monitors specific to this operating mode are:

- Monitoring the command velocity versus the value of the parameter **S-0-0091, Bipolar velocity limit value**.

If this value is exceeded, the error **F237 Excessive position command difference** is generated.

The command value specified in **S-0-0047, Position Command Value** is interpolated within the NC cycle time and is then given to the position controller.

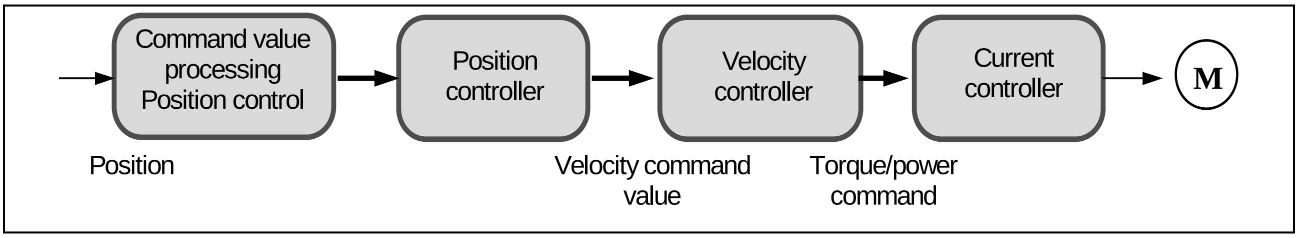

Fig. 8-8: Position control block diagram

Command value processing: Position Control

A command velocity is formed from two successive position command values. The **S-0-0001, NC Cycle Time (TNcyc)** acts as the time base.

The instructions for calculating the command velocity are as follows:

$$Vcommand = \frac{Position\ command\ value(k) - Position\ command\ value(k-1)}{S-0-0001}$$

Vcommand: Command velocity

Fig. 8-9: Calculating the command velocity

This velocity is monitored to see if it exceeds **S-0-0091, Bipolar Velocity Limit Value** (see also Position Command Value Monitoring). If **S-0-0091** is exceeded, the error **F237 Excessive position command difference** is generated.

The commanded position profile can be filtered with the parameter **P-0-0099, Position command smoothing time constant**.

The position loop is closed every 1000usec. The position command value is also fine interpolated within the NC cycle time.

There is either a linear or 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 precontrol.

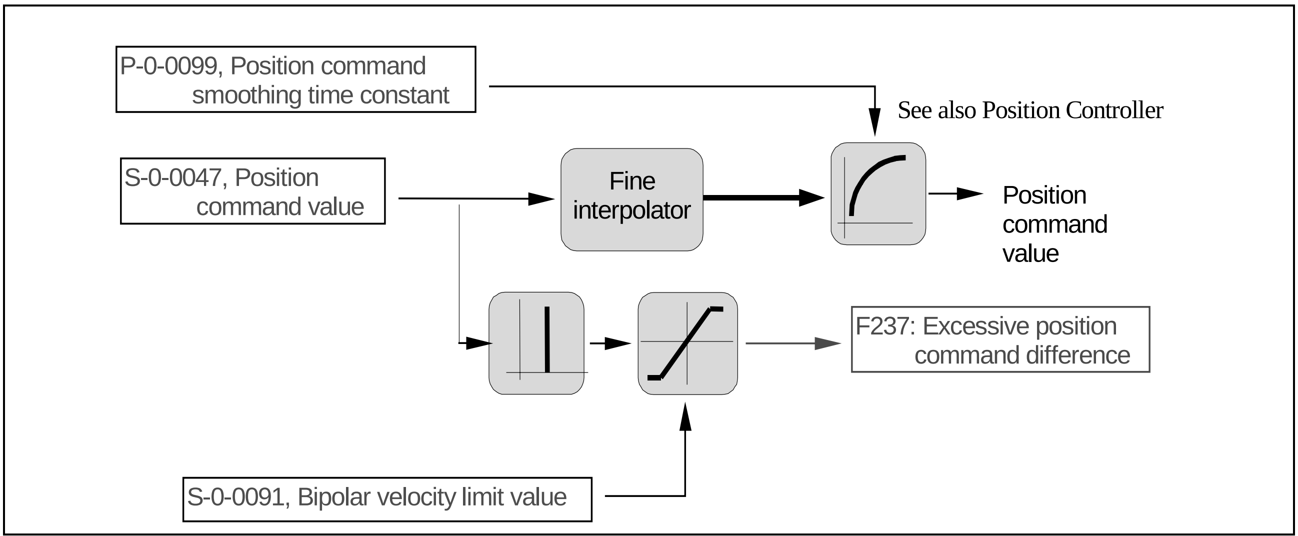

Fig. 8-10: : Command value processing: position control

See also "Current Controller"

See also "Velocity Controller"

See also "Position Controller"

Position Controller

The position controller error is computed from the effective position command value from the generator function of the active operating mode and the position feedback value (encoder 1 or encoder 2) used for the controller.

This is given to the position controller, whose control loop gain is set with **S-0-0104, Position Loop Kv-Factor**.

Bit 3 in the operating mode parameters (S-0-0032..35) indicates if positioning should be subject to the following errors.

Definition of bit 3 of operating mode parameters (S-0-0032 to S-0-0035)

Bit 3=1	lagless	(with velocity precontrol)
Bit 3=0	with lag	(without velocity precontrol)

With lagless position control, an acceleration feed forward component can be included with parameter **S-0-0348, Acceleration Feedforward prop. Gain**.

(See also: "Setting the Acceleration Feed Forward".)

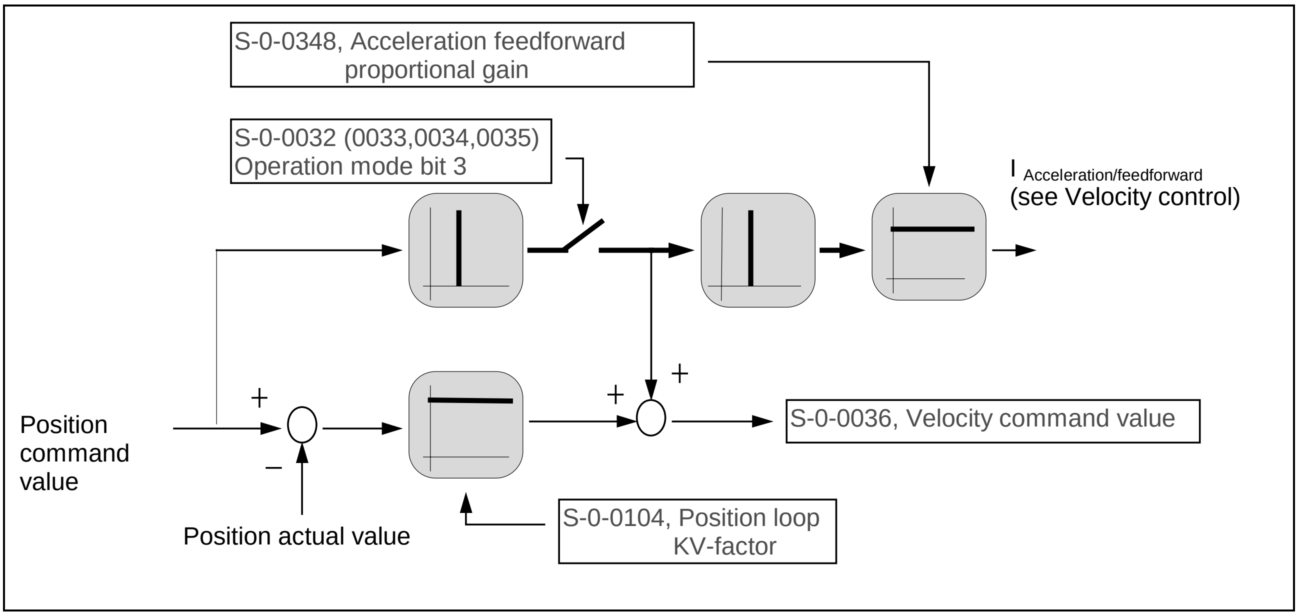

Fig. 8-11: Position controller

See also "Current Controller"

See also "Velocity Controller"

Position Command Value Monitoring

If the drive is operated in the position control mode with cyclical position commands, new position 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 checked for validity.

Reasons monitoring is activated:

- Erroneous control system command values
- Command value transmission error

If the **Position Control** operating mode is active, the velocity produced by the difference in successive 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 of the 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.

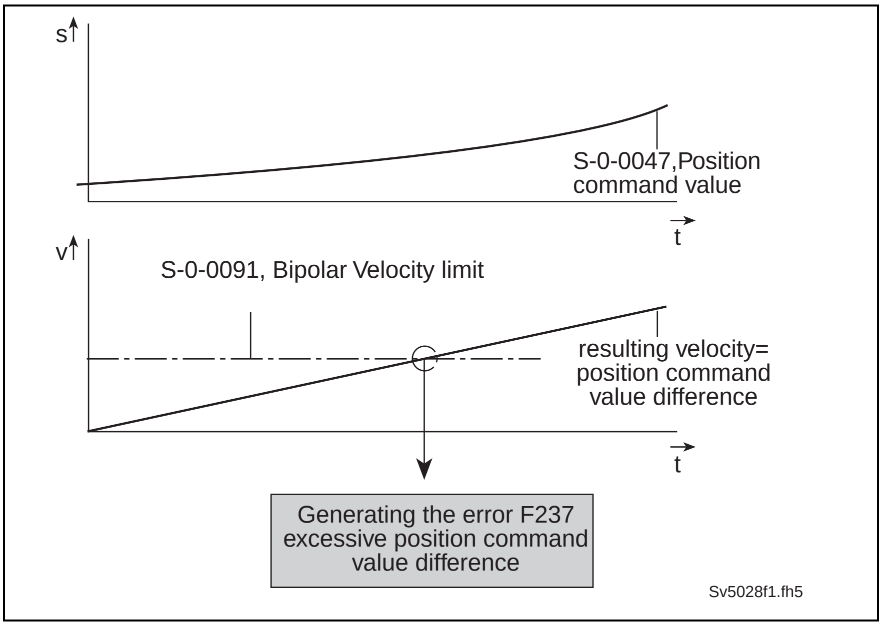

Fig. 8-12: Monitoring the position command value differences and generating the error **F237 Excessive position command difference**

Setting Position Command Value Monitoring

The position command value monitor works with the parameter **S-0-0091, Bipolar Velocity Limit Value**. It should be set to approximately 5 to 10% above the planned maximum velocity of the motor.

8.6 Operating Mode: Drive Internal Interpolation

The drive is given a target position in **Drive Internal Interpolation** mode. When it is activated, the diagnostic message is one of the following:

- **A106 Drive Controlled (Internal) Interpolation / Encoder 1**
- **A107 Drive Controlled Interpolation / Encoder 2**
- **A108 Drive Controlled Interpolation / Encoder 1 / Lagless**
- **A109 Drive Controlled Interpolation / Encoder 2 / Lagless**

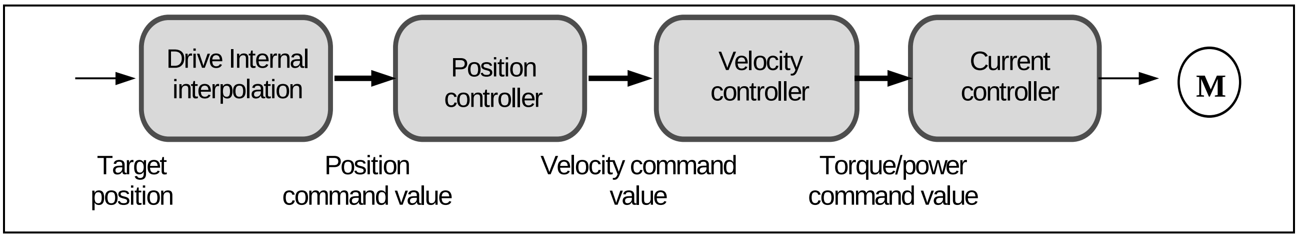

Fig. 8-13: Drive-internal interpolation diagram

Functional Principle Drive Internal Interpolation

The target value is entered in the parameter **S-0-0258, Target Position** . The drive generates the position command profile necessary to move to the target position using the following parameters as limits:

- **S-0-0259, Positioning velocity**
- **S-0-0260, Positioning acceleration**
- **S-0-0193, Positioning jerk**
- **S-0-0108, Feedrate override**

Note: If operating mode "Drive-internal interpolation" is activated, then set in parameter **S-0-0393, Command value mode** whether the drive remains in the actual position or immediately positions to the value in parameter **S-0-0258, Target position**.

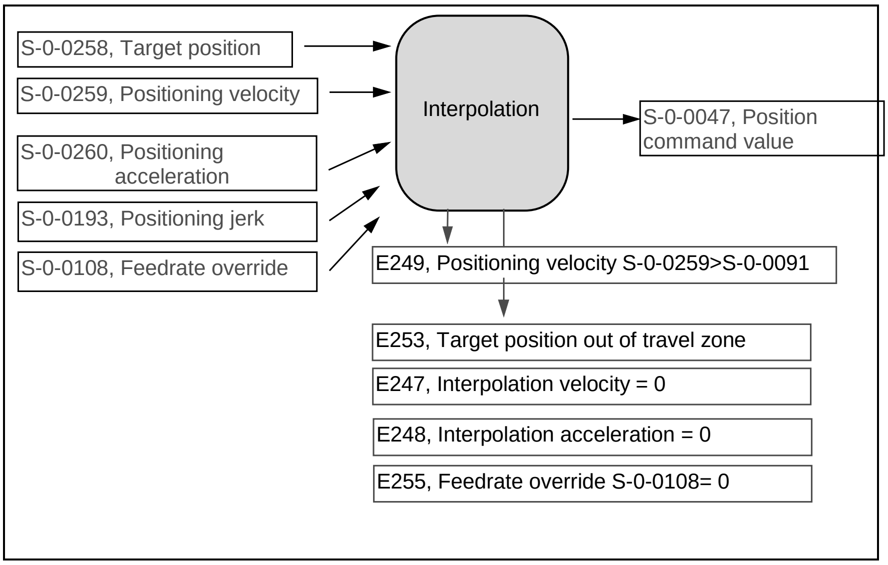

Fig. 8-14: Generator function drive internal interpolation

See also "Position Controller"

See also "Velocity Controller"

See also "Current Controller"

Monitoring in mode: "Drive-internal interpolation"

The following checks are executed:

- If axis 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 axis limit values (S-0-0049 and S-0-0050).
  If these are exceeded, the warning **E253 Target position out of travel zone** is generated.

  The prescribed target position will not be accepted.
- If the prescribed 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.
- If the positioning velocity specified in **S-0-0259, Positioning velocity** equals 0, then warning **E247 Interpolation velocity = 0** is generated.
- If the factor affecting positioning velocity as set in **S-0-0108, Feedrate override** equals 0, then warning **E255 Feedrate-override S-0-0108 = 0** is generated.
- If the positioning acceleration specified in **S-0-0260, Positioning acceleration** equals 0, then warning **E248 Interpolation acceleration = 0** is generated.

Status messages during operating mode "Drive-internal interpolation"

In parameters S-0-0013, class 3 diagnostics and S-0-0182, manufacturers class 3 diagnostics there are the following status messages for this mode:

- **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**
- **IZP**, bit 6 of **S-0-0182, Manufacturer Class 3 Diagnostics**

Also see parameter description: "Status class bits"

The following profile explains how the status messages work:

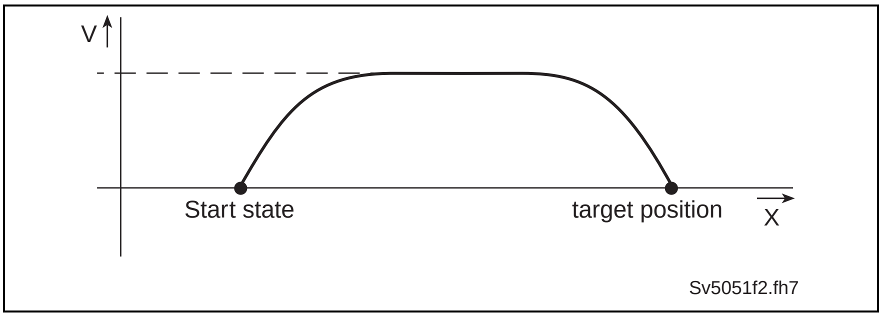

Fig. 8-15: Profile to explain how the interpolation status messages work

In this example, the drive is at the start position, when the new target position is given.

The following time diagram result:

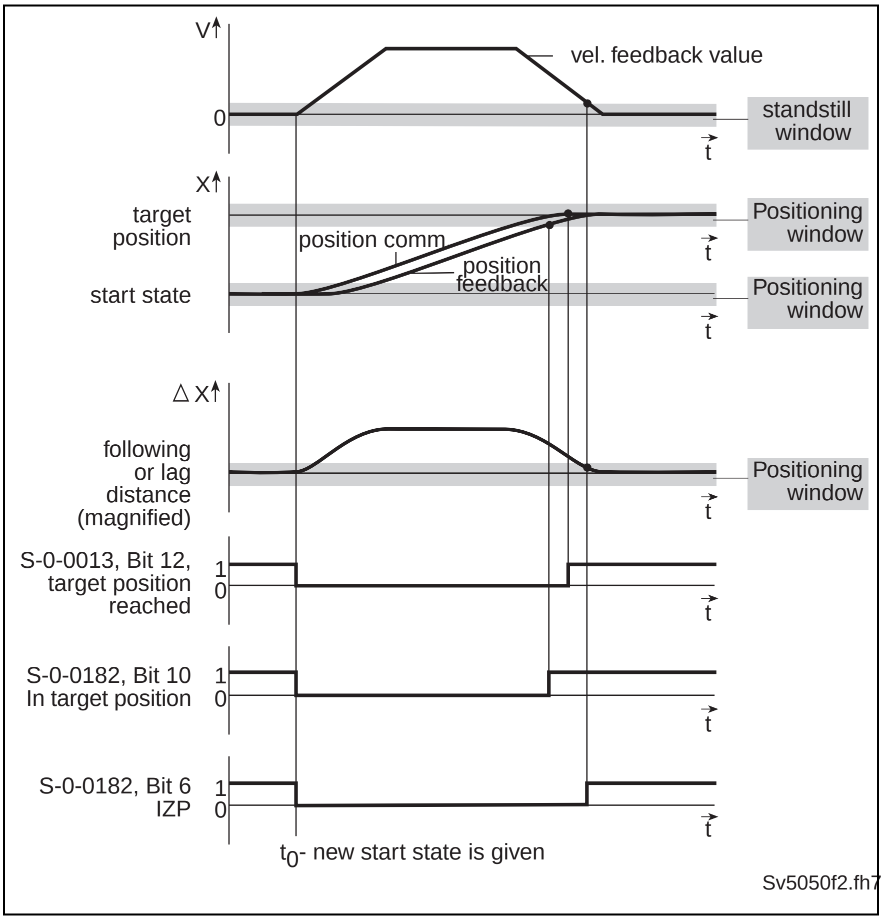

Fig. 8-16: Generating the status bit of the operating modes with drive-internal interpolation

8.7 Mode: Relative drive-internal interpolation

In operating mode **Relative drive-internal interpolation** the drive is given a path in parameter **S-0-0282, Travel distance.** If bit 0 of the acceptance parameter **S-0-0346, Setup flag for relative command values** toggels (change), then it is added to the target position in **S-0-0258, Target position**. The drive generates the needed position command value profile to bring itself to the target position. It hereby maintains the velocity, accel and jerk limit values.

In units equipped with parallel interface or parallel inputs the positioning block transfer input effects parameter **S-0-0346, Setup flag for relative command values.**

A positive edge at positioning block transfer input toggles parameter S-0-0346.

Pertinent Parameters

- **S-0-0258, Target position**
- **S-0-0282, Travel distance**
- **S-0-0259, Positioning Velocity**
- **S-0-0260, Positioning Acceleration**
- **S-0-0193, Positioning Jerk**
- **S-0-0346, Setup flag for relative command values**
- **S-0-0393, Command value mode**
- **S-0-0108, Feedrate override**

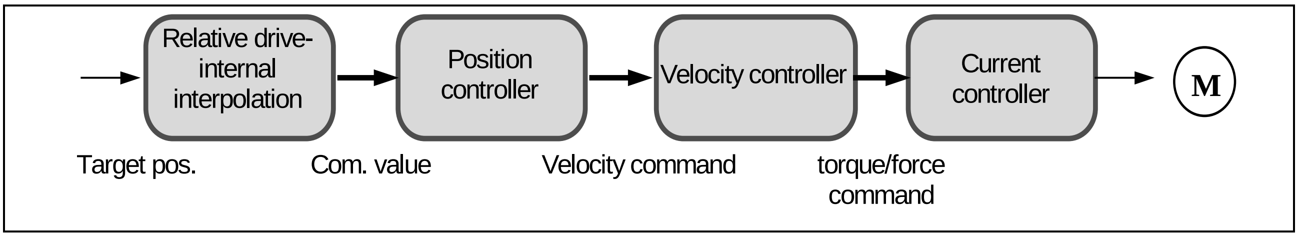

Fig. 8-17: Block diagram of relative drive-internal interpolation

Function principle: Relative drive-internal interpolation

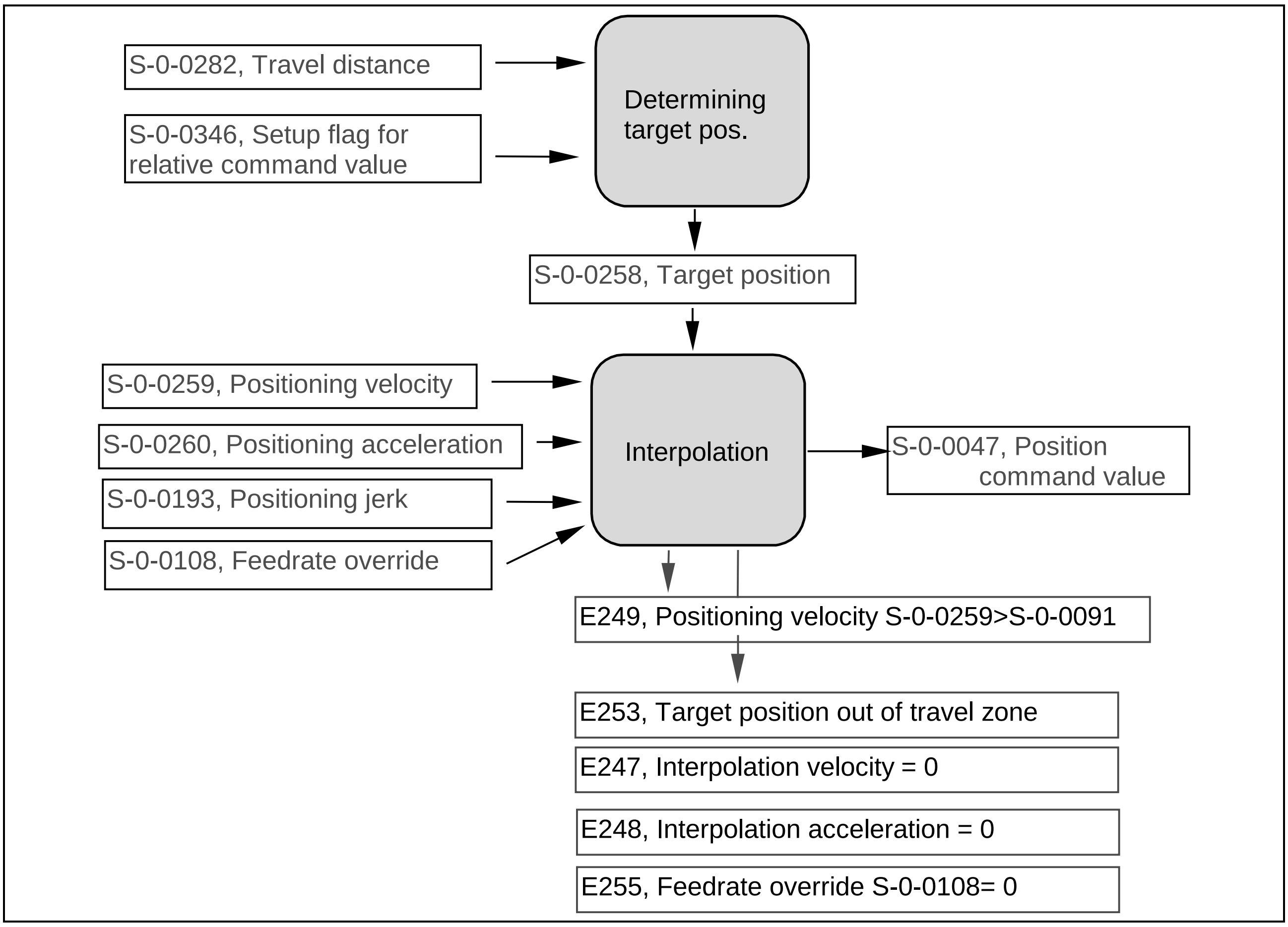

Fig. 8-18: Generator function relative drive-internal interpolation

See also chapter: "Position Controller"

See also chapter: "Velocity Controller"

See also chapter: "Current Controller"

After the operating mode is activated, the drive first positions to that position specified in parameter **S-0-0258, Target position**.

The parameter is stored when the control voltage is switched off so that if an absolute measuring system is used, the target position is still retained. The reference dimension is not lost.

If there is no absolute measuring system then the actual position value is preset in parameter **S-0-0258, Target position**.

Upon activating the operating mode, depend on **S-0-0393, Command value mode,** the traversing path relates to the actual position or the value in parameter **S-0-0258, Target position**.

Diagnostic Messages

The diagnoses read as follows upon activation of an operating mode:

- **A146 Relative drive controlled interpolation, encoder 1**
- **A147 Relative drive controlled interpolation, encoder 2**
- **A148 Relative drive contr. interpolation, enc. 1, lagless**
- **A149 Relative drive contr. interpolation, enc. 2, lagless**

Given an activated operating mode, the following checks are conducted:

- **E253 Target position out of travel range**
  If position limit value monitor is active (bit 4 of **S-0-0055, Position Polarity Parameter** is set) and the measuring system used for the mode is in reference (**S-0-0403, Position feedback value status** = 1), then the sum of **S-0-0282, Travel distance** and **S-0-0258, Target Position** is monitored to ensure that it maintains the position limit value. Otherwise, the sum of the overtravelling of the drive-internally depicted numeric range (visible in the minimum and maximum input values of the travel distance parameter) is monitored. In either case, if the allowable range is exceeded, the warning **E253 Target position out of travel zone** is generated. The set travel path is not accepted if the acceptance toggles.
- **E249 Positioning velocity S-0-0259 > S-0-0091**
  If the positioning velocity set in **S-0-0259, Positioning velocity** exceeds maximum allowable velocity set in **S-0-0091, Bipolar Velocity Limit Value** then the warning **E249 Positioning velocity S-0-0259 > S-0-0091** is generated. The set travel path is not accepted if the acceptance toggels.
- **E247 Interpolation velocity = 0**
  If the positioning velocity set in **S-0-0259, Positioning velocity** equals 0, then warning **E247 Interpolation velocity = 0** is generated.
- **E255 Feedrate-override S-0-0108 = 0**
  If the factor affecting the positioning velocity in **S-0-0108, Feedrate override** equals 0, then warning **E255 Feedrate-override S-0-0108 = 0** is generated.
- **E248 Interpolation acceleration = 0**
  If the positioning acceleration set in **S-0-0260, Positioning acceleration** equals 0, then the warning **E248 Interpolation acceleration = 0** is generated.

Status messages during operating mode "Relative drive-internal interpolation"

see chapter: "Status messages during operating mode Drive-internal interpolation"

8.8 Positioning Block Mode

Positioning blocks that have been pre-programmed can be run with this mode. The drive runs position control to a target position, while maintaining speed, acceleration and jerk limits as defined for each block.

The positioning blocks are actuated by the block selection.

Digital inputs can be used to select the blocks in units with positioning interface (DKC01.3).

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.

- 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, however, can vary.

Note: Following block mode is possible with absolute and relative positioning blocks. The distance remaining is stored. The final block of a chain is not defined as a following block. This identifies the end of the 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 acknowledge**
- **P-0-4052, Positioning block, last accepted**
- **P-0-4057, Positioning block, input linked blocks**
- **P-0-4060, Process block control word**
- **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 **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.**

and fixes how the target position is to be processed (**absolute**, **relative**).

Note: Each parameter has 64 elements, whereby the elements of the same number write this number into the travel profile of the positioning block.

Positioning block control word

With parameter **P-0-4060, Process block control word** the positioning speed can be limited to the value set in parameter **S-0-0259, Positioning Velocity**. Otherwise, the speed set in **P-0-4007, Process block velocity** is used.

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 main mode. 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 parameter **S-0-0346**, **Set-up flag for relative command values**

Note: As long as the parameter is not toggled, the drive will remain on the actual position or brought to a position controlled standstill.

Block selection

In positioning block mode, a positioning block is selected

- by writing into **P-0-4026, Process block selection**
- or via the parallel inputs with parallel interface in the DKC.

Positioning block mode with parallel interface

With parallel interface, the DKC has special hardware available and acknowledgement of positioning blocks and the status messages is available.

With a parallel interface, ten freely configurable digital inputs and ten freely-configurable digital outputs are available. By configuring parameters **S-0-0145, Signal control word** and **S-0-0144, Signal status word** the positioning interface is determined.

The signal control word and status word must be configured with a hardware allocation to connector X20 (parallel interface).

Configuration signal control word:

- Bits 0-5 of positioning block select (P-0-4026 Bit 0-5)
- Bit 6 S-0-0346 bit 0
- Bit 7 command drive-guided referencing (S-0-0148)
- Bit 8 and 9 jogging input (P-0-4056 bit 0 and 1)

Configuration signal status word:

- Bit 0-5 positioning block, acknowledge (P-0-4051 Bit 0-5) = PosQ0–Q5
- Bit 6 S-0-0182 Bit 12 = End position reached
- Bit 7 S-0-0182 Bit 1 = Standstill
- Bit 8 S-0-0403 Bit 0 = in reference
- Bit 9 P-0-0135 Bit 0 = position switching point

Note: With "Load default parameters" the signal control word is preset as described above.

See also the project planning manual: "Inputs and outputs for positioning block mode".

Note: To monitor the block selection lines with parallel control, the acknowledgement **P-0-4051, Process block acknowledge** must be evaluated.

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 memory**
- **Infinite travel in positive / negative direction**
- **Following block processing**

Absolute Positioning

Prerequisite: Parameter **P-0-4019, Process block mode** = 1

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 referenced.
- The travel range can be limited with position limit value. Absolute positioning blocks are only executed if the target position lies within the allowable travel range.

Example Absolute positioning with target position = 700

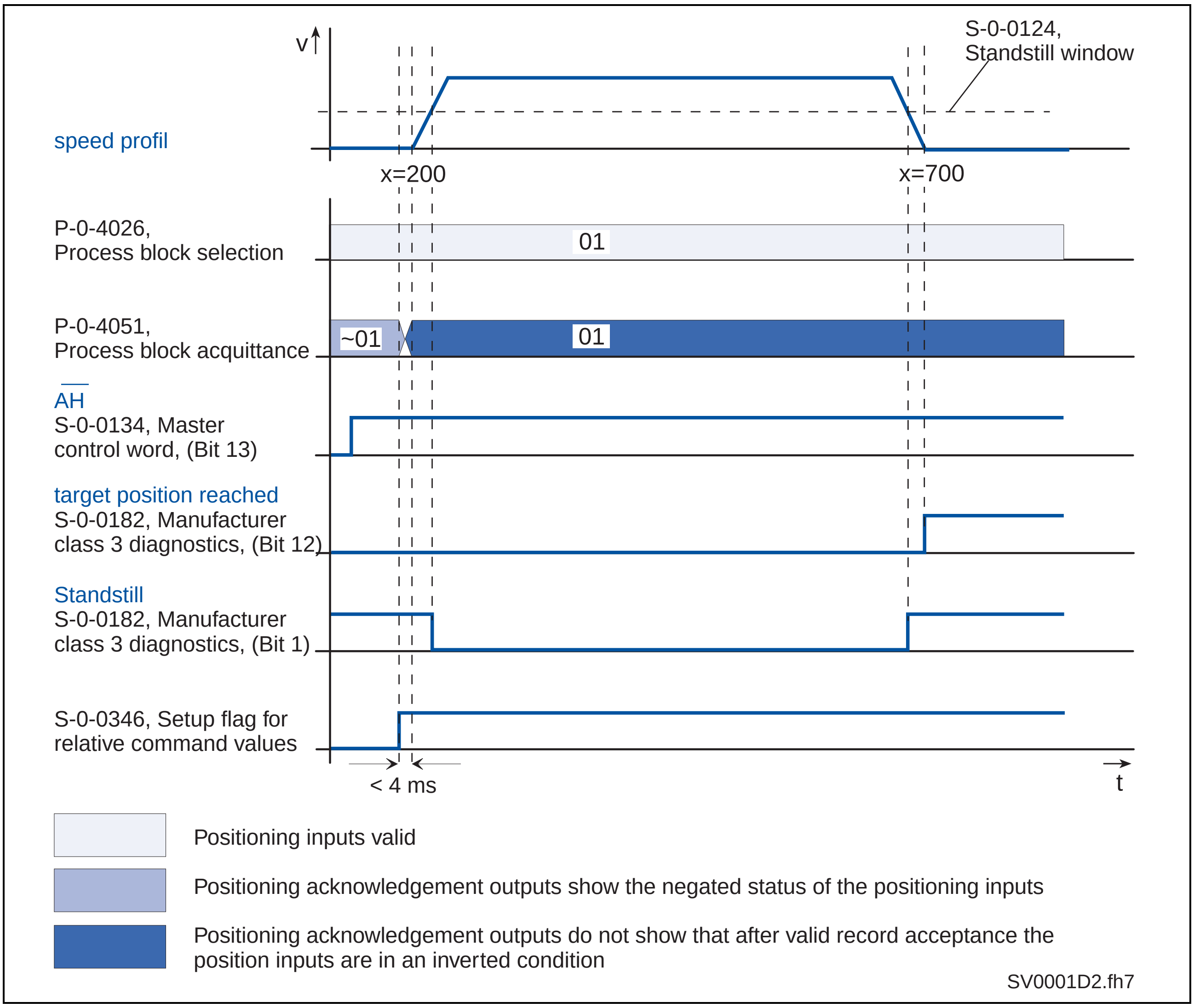

Fig. 8-19: Absolute positioning block

Relative positioning

Prerequisite Parameter **P-0-4019, Process block mode** = 2

Relative positioning blocks are executed if the drive has not been referenced.

Reference position In relative positioning blocks without residual path storage, the target position in the positioning blocks are 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).

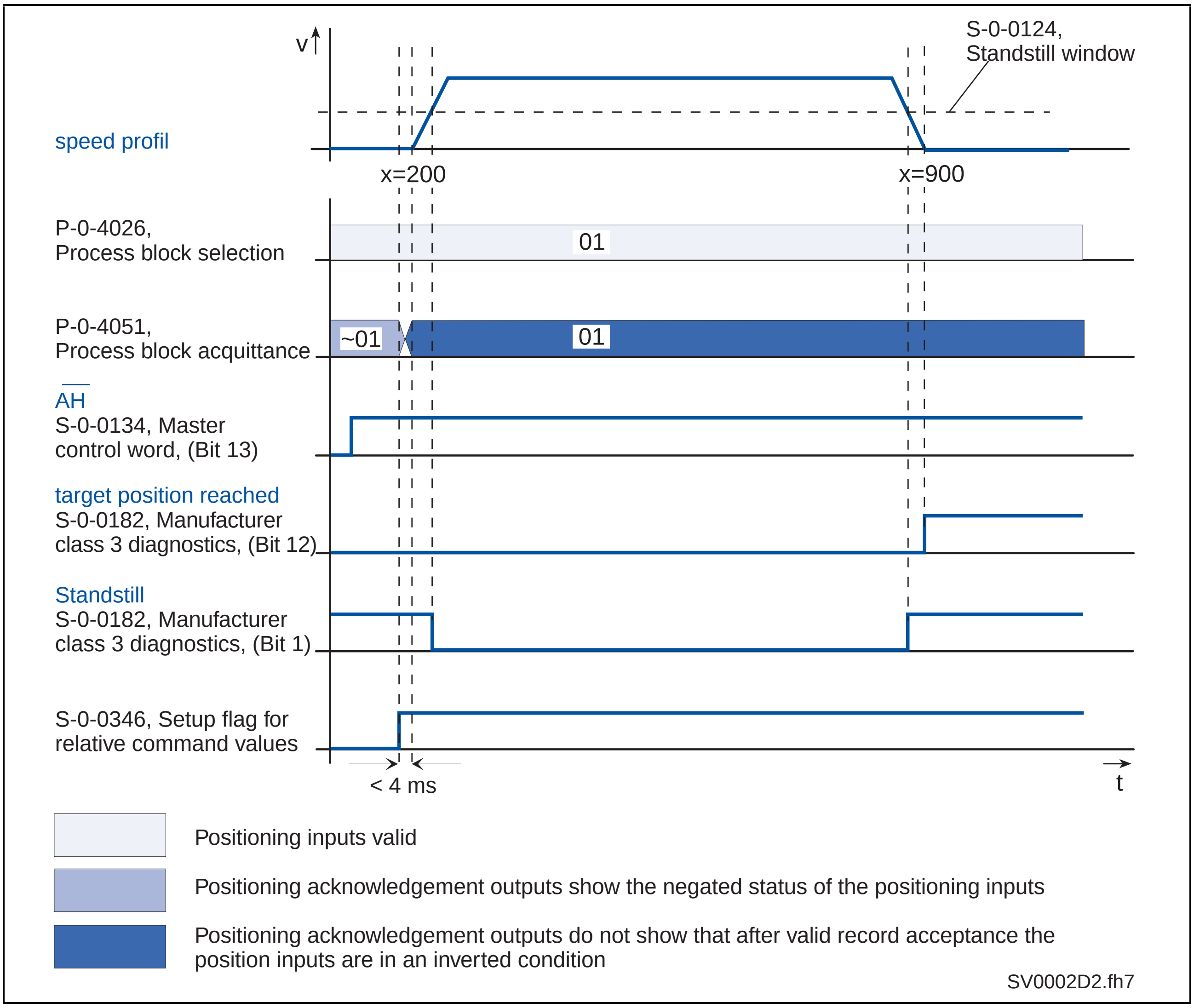

Fig. 8-20: Relative positioning block without residual path storage

Example Relative positioning without residual path storage with target position = 700 (current position = 200). Terminate and start a relative positioning block without residual path storage again.

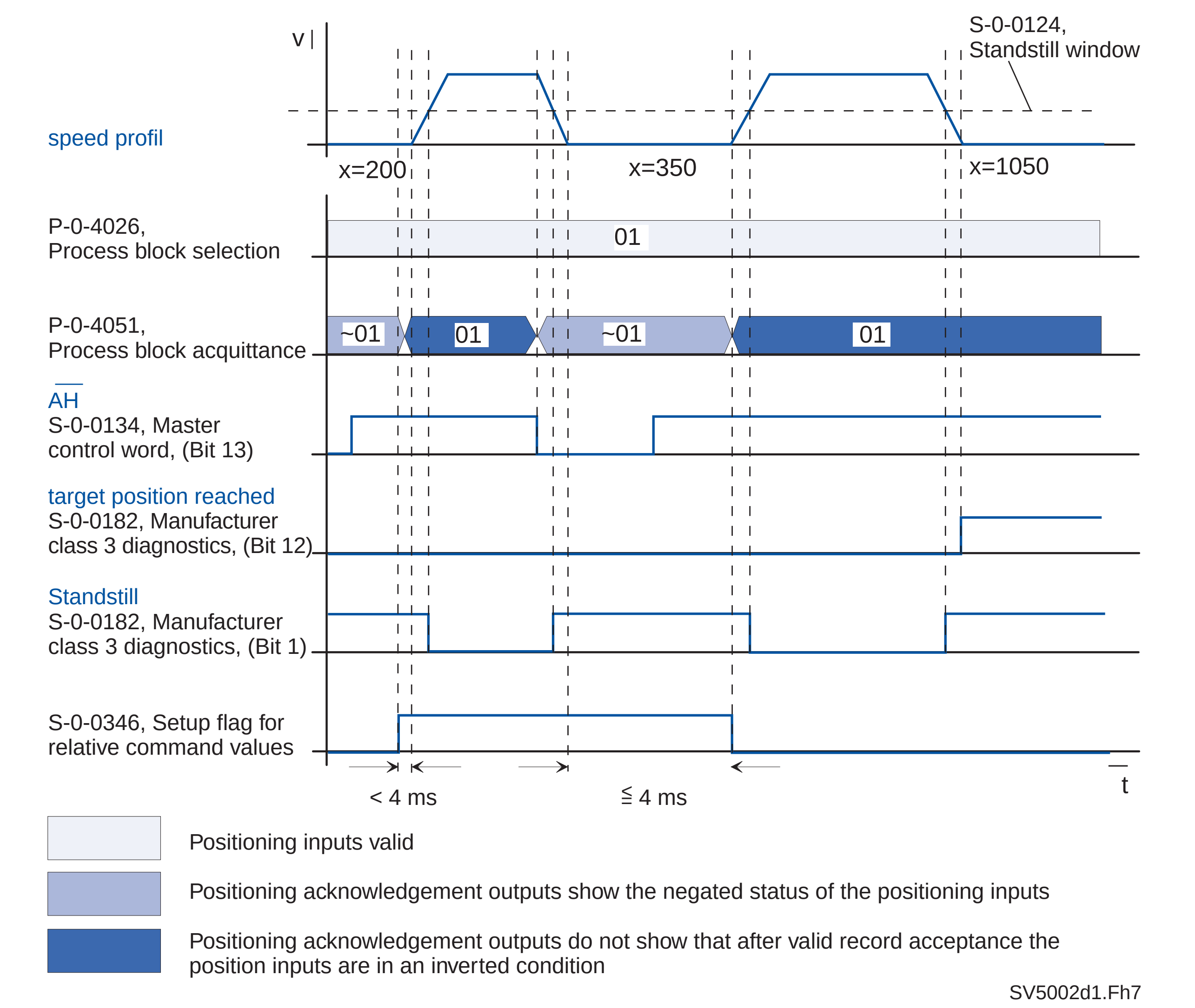

Fig. 8-21: Terminating a relative positioning block without residual path storage

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 is not referenced.

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 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 remainder of the path is discarded. If this is a new block, a relative positioning block with residual path memory, 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).

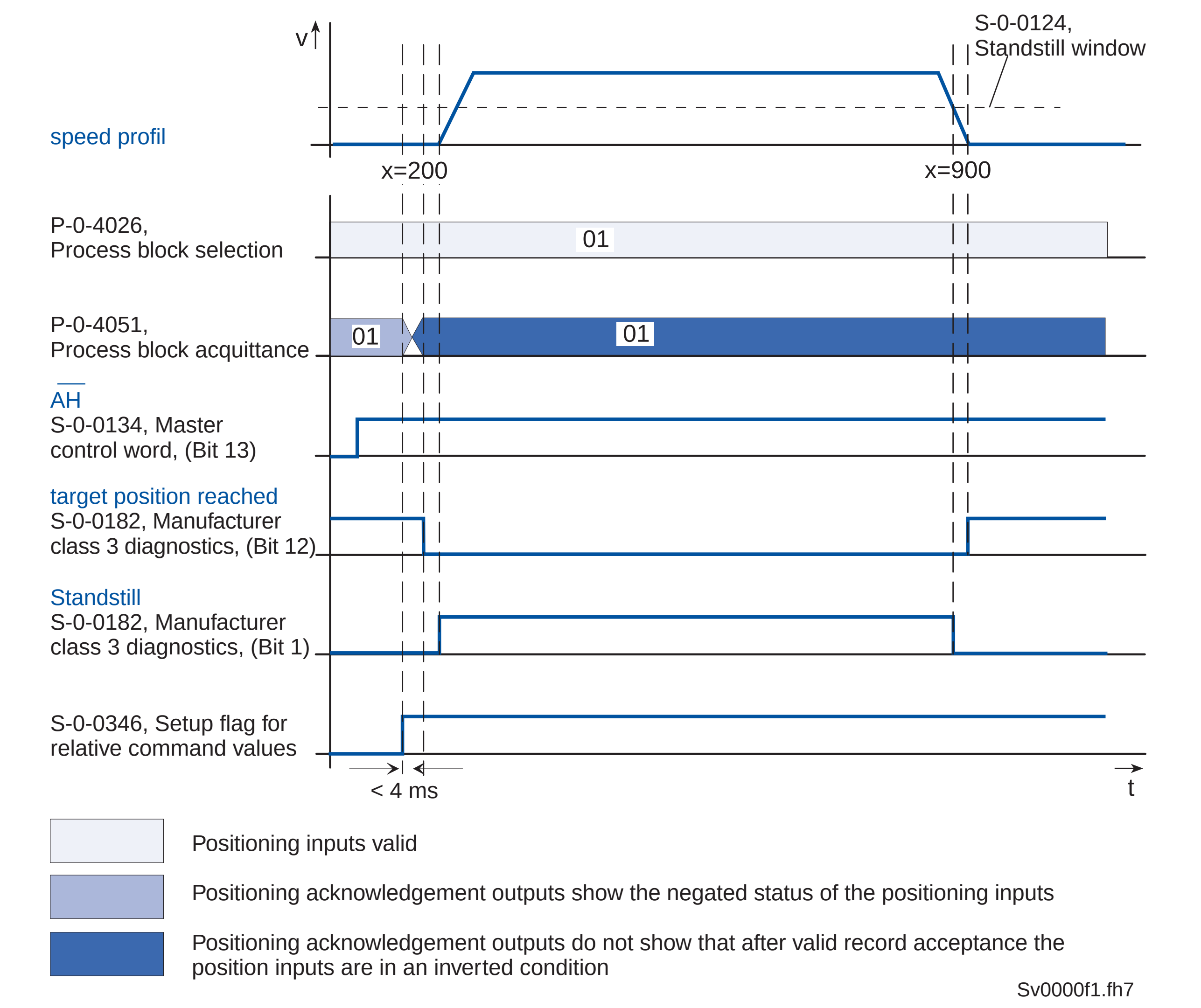

Fig. 8-22: Relative positioning block with residual path storage

Relative positioning block with residual path storage after activating drive enable

Reference position The **last "End position reached" message** is used as reference position.

Note: The chain reference dimension is guaranteed.

Example An interrupted relative positioning block with residual path storage after active drive enable with target position = 600.

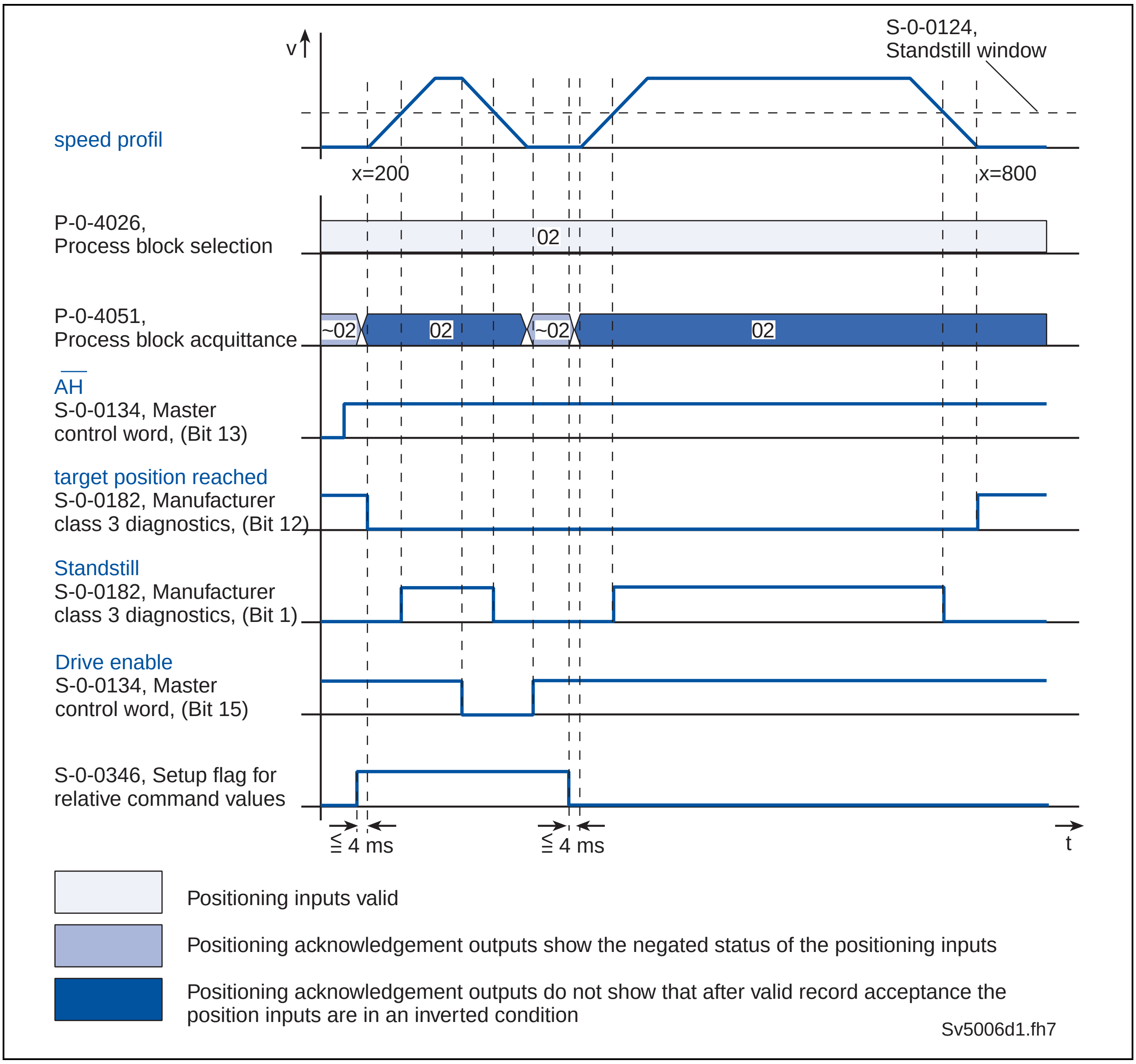

Fig. 8-23: Relative positioning block with residual path storage after activating the drive enable

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 **last "End position reached" message** is used as reference position.

Behavior The stretch 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 **last "End position reached" message** is used as reference position.

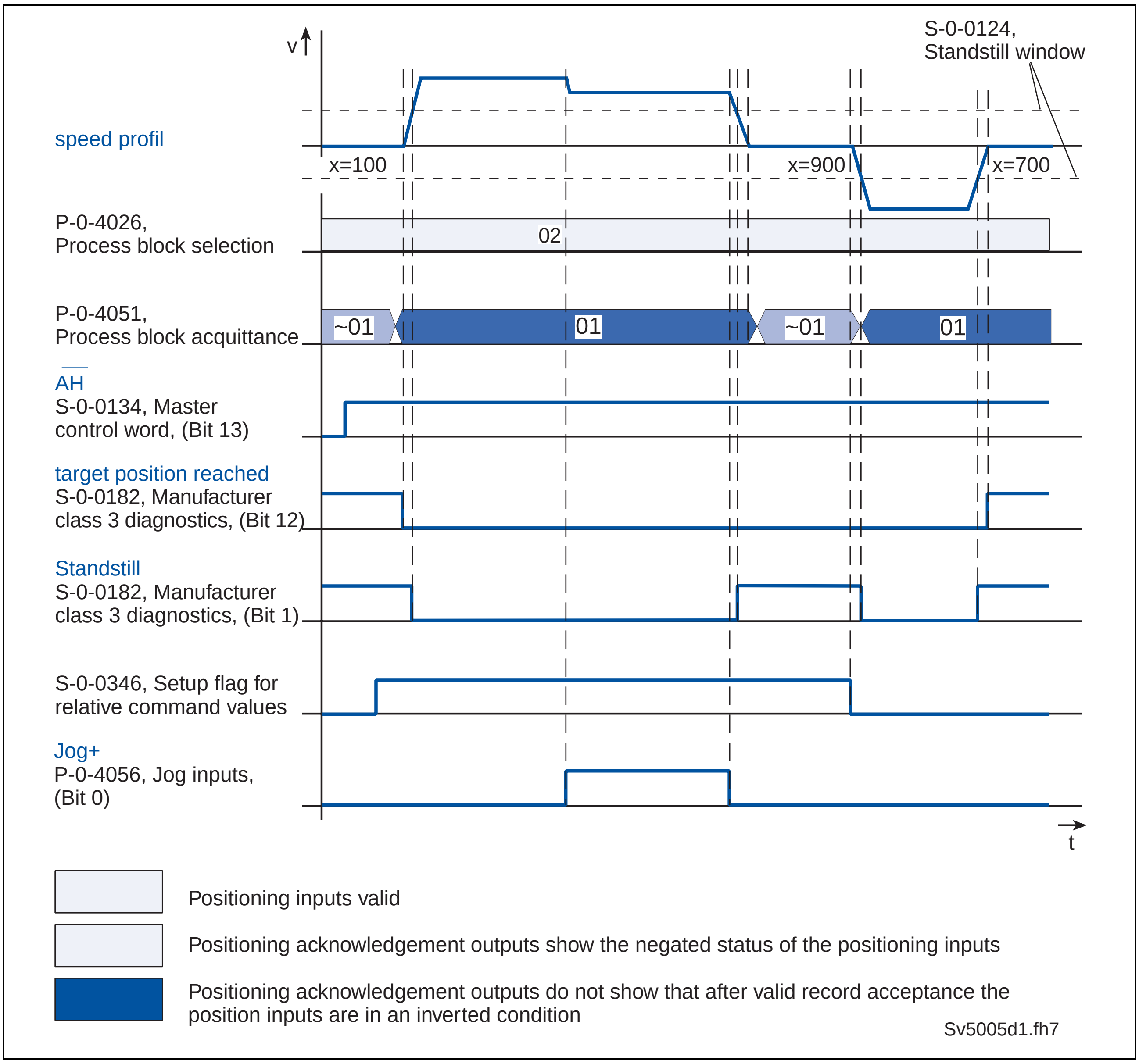

Fig. 8-24: Relative positioning block with residual path storage after jogging

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 travelled after the interrupted relative positioning block with residual path storage is activated.

Behavior

If a **single turn encoder** is used, then the remaining path is discarded and added to the actual position.

Reference position

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 speed, 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 the position limit value or the travel range limit switch is reached.

The set target position is not used in this positioning mode.

Parameter **P-0-4019, Process block mode** =

- 4h travel in positive direction
- 8 h travel in negative direction

See also section: "Operating Mode: Jogging"

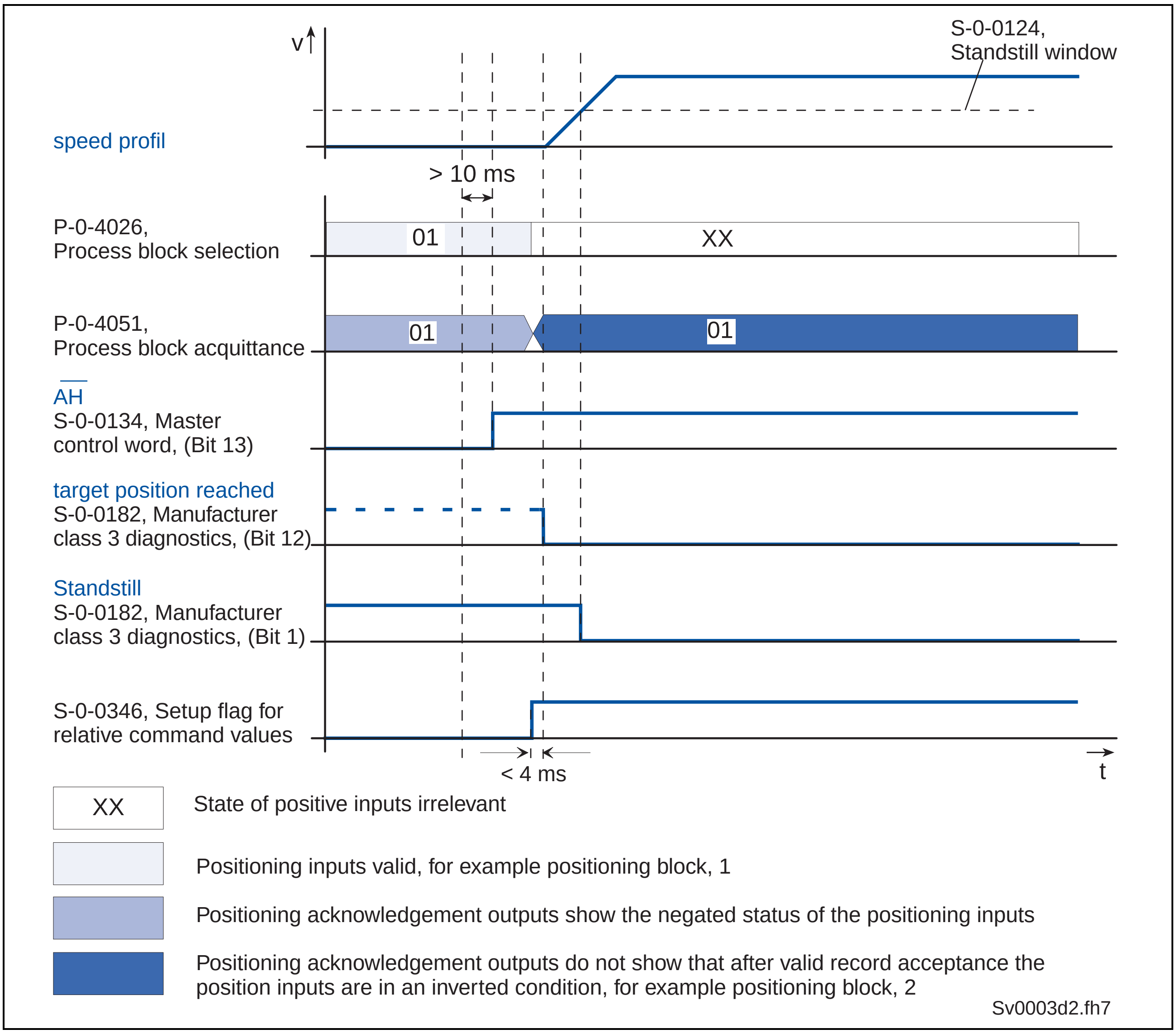

Fig. 8-25: Example: Infinite travel in positive / negative direction

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 continue in following block mode

There are **two possibilities** for continuing block mode. These are also broken down into:

1) Position-dependent continue block mode

With position-dependent continue block mode, 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 at old positioning speed (Mode 1)

P-0-4019, Process block mode = 11h: absolute block with following block

P-0-4019, Process block mode = 12h: relative block with following block

P-0-4019, Process block mode = 14h: infinite block in positive direction with following block

P-0-4019, Process block mode = 18h : infinite block in negative direction with following block

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.

Definition

With relative and absolute blocks with sequential processing, 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 positive or negative. As soon as the **target position is exceeded**, the drive switches to **next positioning block n+1**. (**"n"** represents the block currently in process).

Note: If the target position is not in travel direction, then it will never be reached. The drive does not switch to the next positioning block.

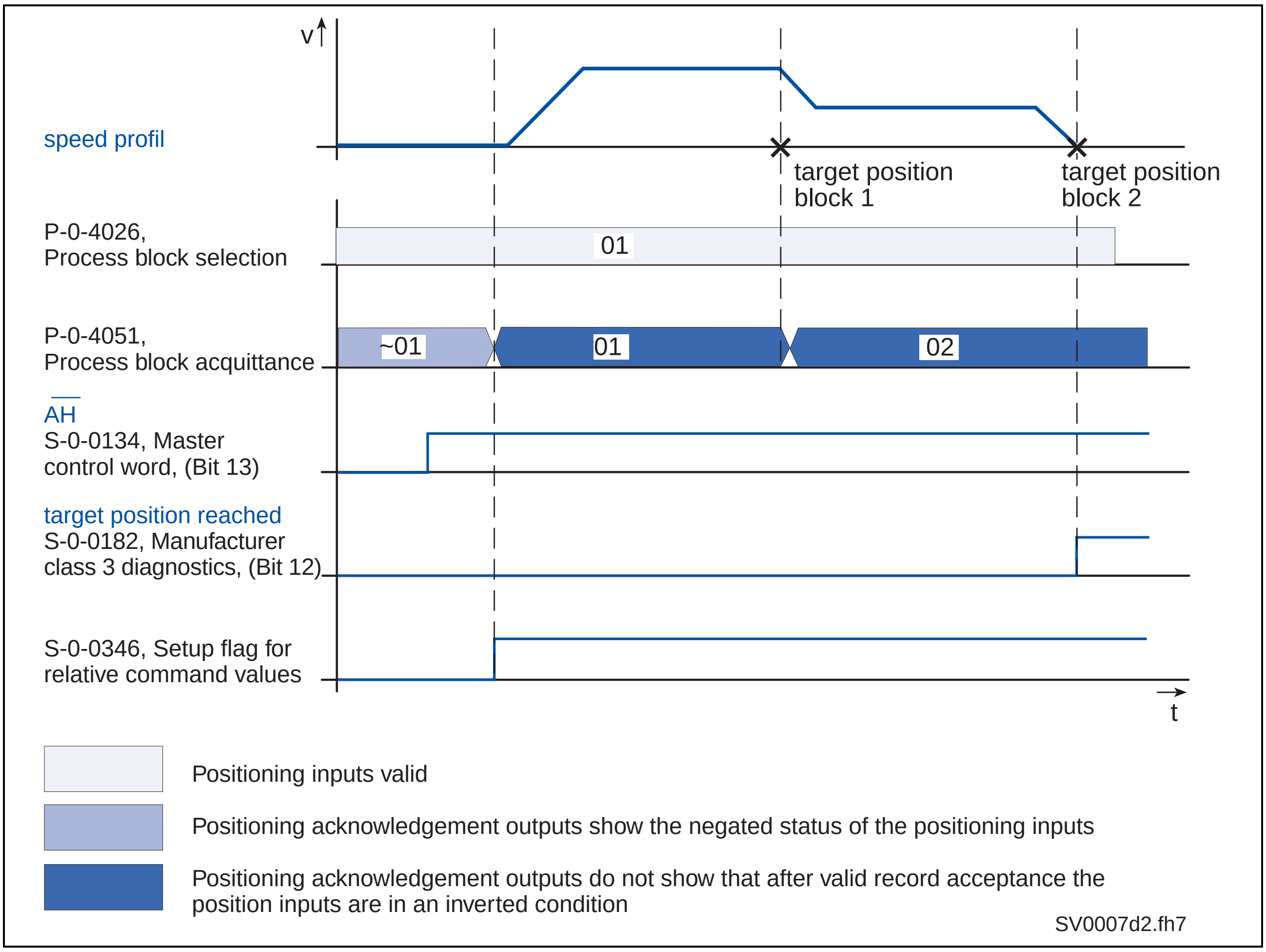

Fig. 8-26: Example: Position-dependent block commutation (mode 1)

b) Block transition with new positioning speed (Mode 2)

P-0-4019, Process block mode =21h: absolute block with following block

P-0-4019, Process block mode =22h: relative block with following block

P-0-4019, Process block mode =24h: infinite block in positive direction with following block

P-0-4019, Process block mode =28h: infinite block in negative direction with following block

In following block mode 2, position-dependent block commutation means that the target position of the start block is run through at the positioning speed of the following block.

Definition

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 $\mathbf{X_n}$, there is acceleration $\mathbf{a_n}$ to the **next** positioning speed $\mathbf{v_{n+1}}$ so that the speed $\mathbf{v_{n+1}}$ can be achieved prior to target position $\mathbf{X_n}$.

The switch to the next positioning block does not occur here either until the next target position is overrun.

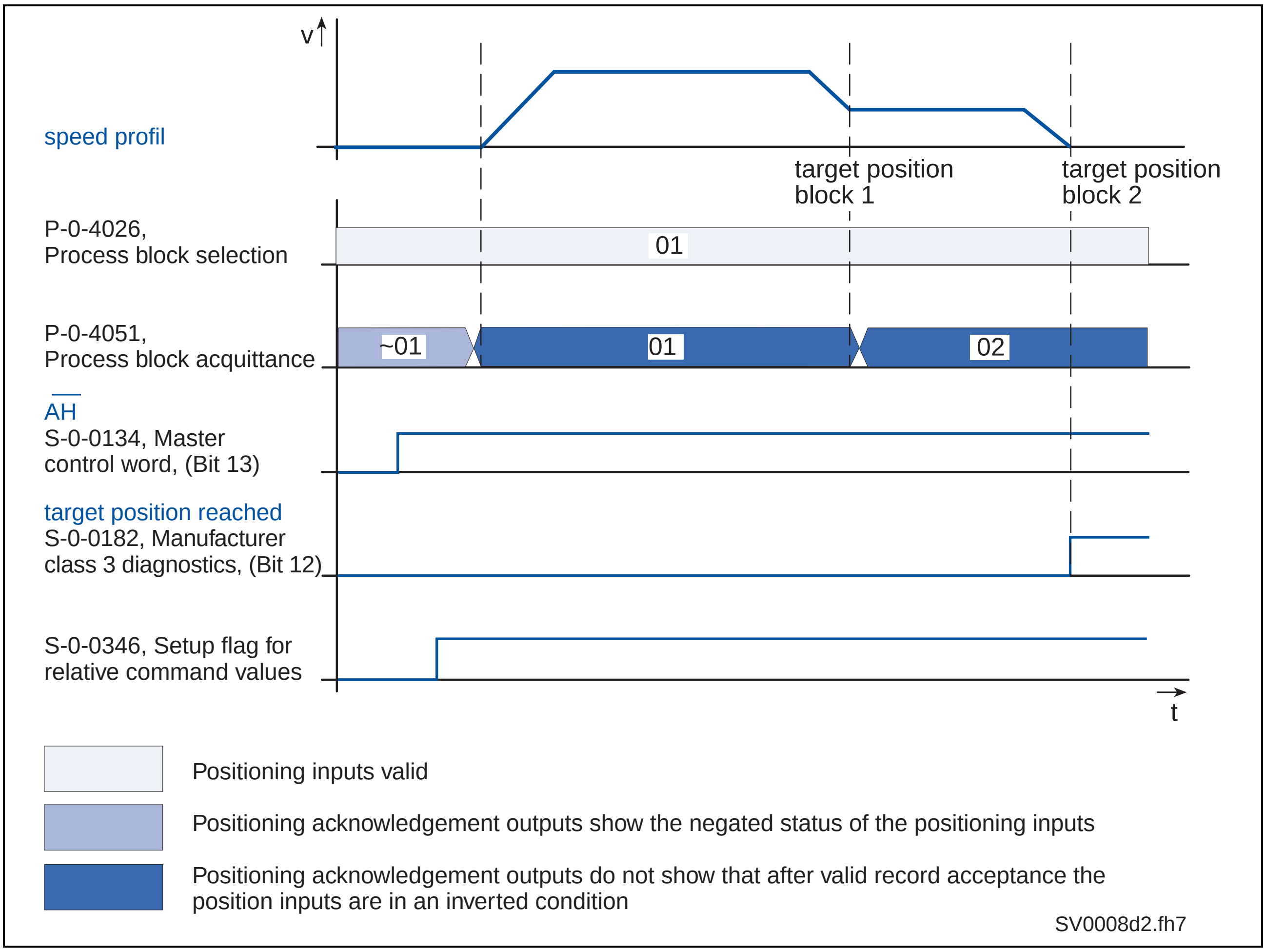

Fig. 8-27: Example: Position-dependent block commutation (Mode2)

c) Block transition with intermediate halt

P-0-4019, Process block mode =41h : absolute block with following block

P-0-4019, Process block mode =42h : relative block with following block

With block commutation with intermediate stop, 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.

Definition

As the drive approaches the target position, the drive is decelerated to speed 0 at the target position and then accelerated to the new positioning speed.

Note: Commutation 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.

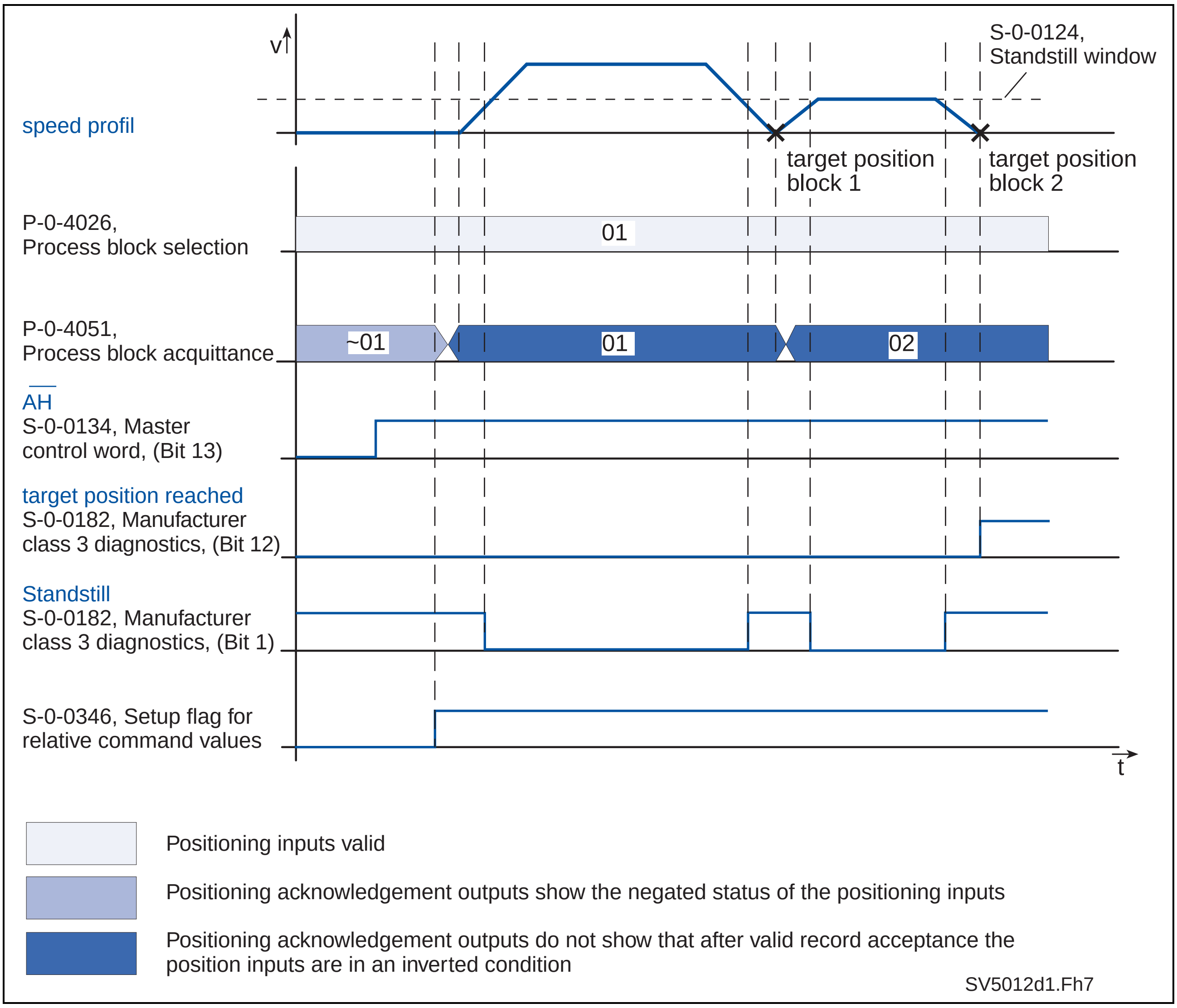

Fig. 8-28: Example: Following block commutation with target position with intermediate halt

Note: This mode should be used if there is a change in direction with two sequential following blocks within one following block change. Otherwise, the position at which the direction is to be changed will be overrun.

2) Switching signal dependent block commutation

P-0-4019, Process block mode = 81h: absolute block with following block

P-0-4019, Process block mode = 82h: relative block with following block

P-0-4019, Process block mode = 84h: infinite block in positive direction with following block

P-0-4019, Process block mode = 88h infinite block in negative direction with following block

Block commutation 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 commutation makes a transition to a following block possible based on an external switching signal. As signal input the two following block 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->1**. If the target position is not reached then the new positioning block is switched into while travelling.

The drive switches to the **penultimate travel block** n+2 as soon as the input for the **following block cam 2** goes from **0->1**. If a following block cam is actuated during this run, then the drive switches to the positioning block after the next.

Reference position

A following relative positioning block references that 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 speed at the time of overrun.

Allocation table for cams

Cam 2	Can 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

Fig. 8-29: Drive reaction with different switching signal sequences

X = Don’t Care

n = positioning block selected via parallel inputs or parameter **P-0-4026, Process block selection**.

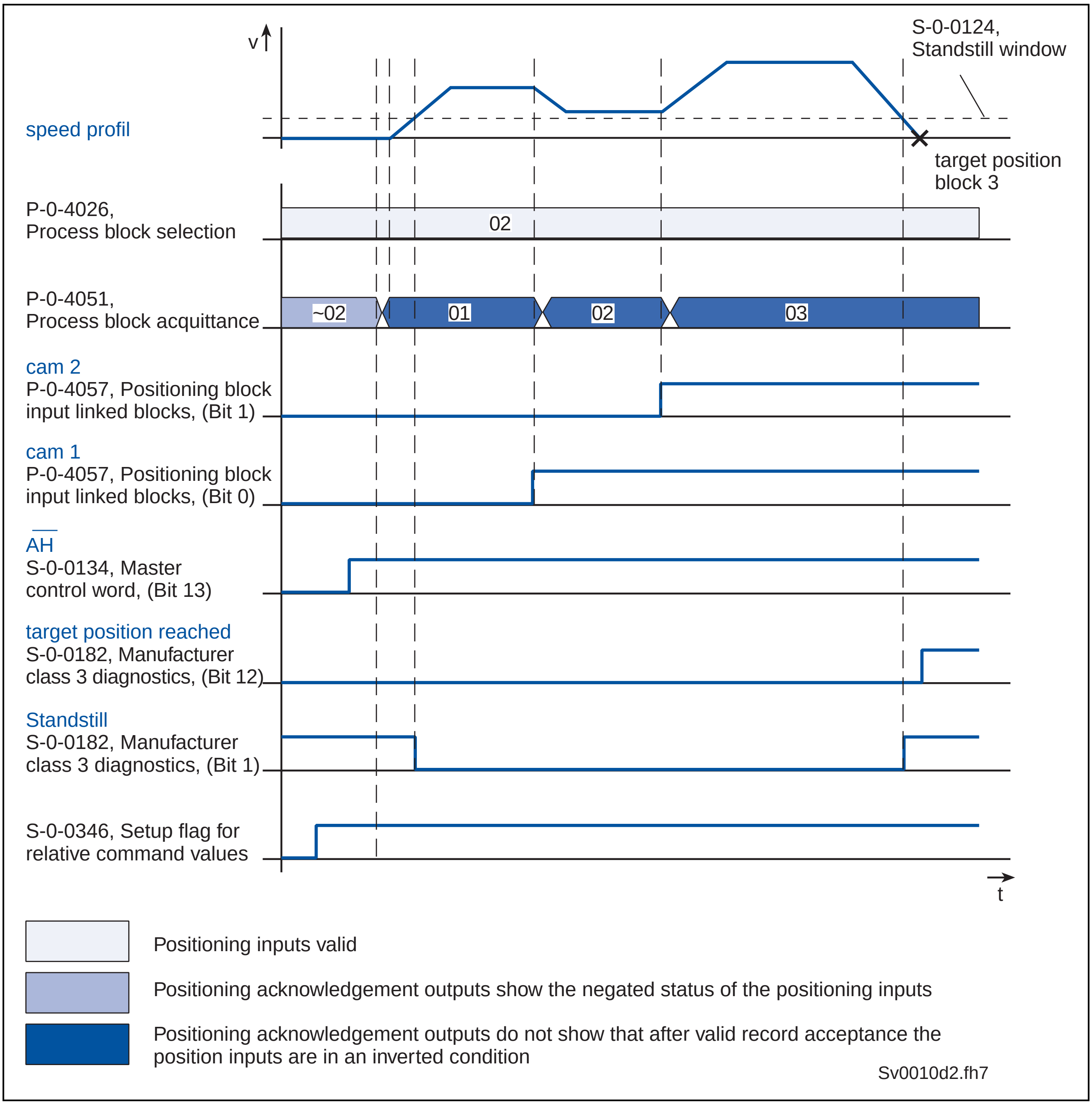

Fig. 8-30: Example: switching signal dependent block commutation

No switching signal for block commutation

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 commutation 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.

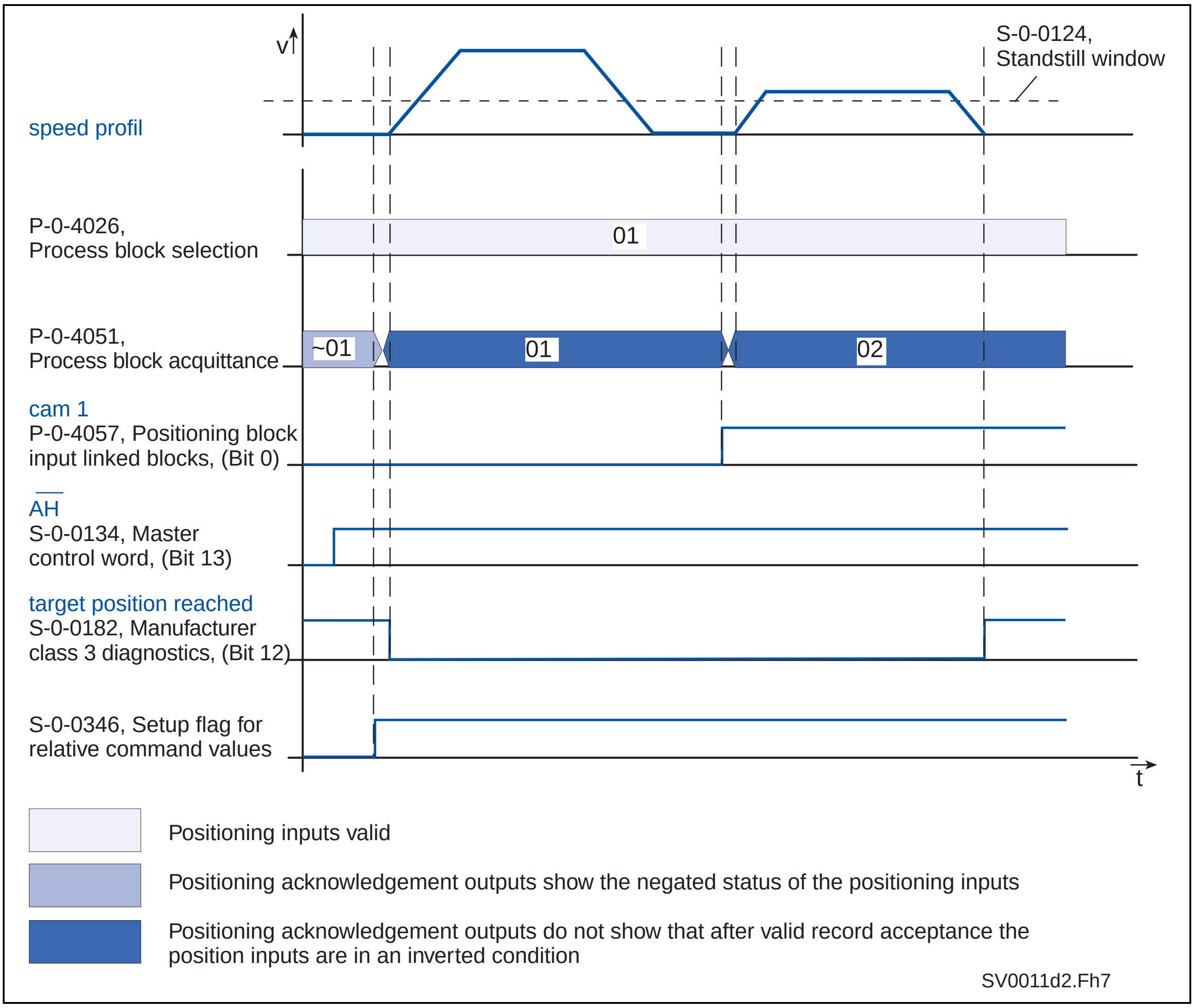

Fig. 8-31: Example: Switching-signal dependent block expansion (behavior with no switching signal)

Note: All four commutation conditions 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 commutation conditions occurring during a break 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
- or a removal of the drive start signal.

Depending on the block type of the following block sequence that was interrupted and the events causing this interruption, the following block chain is processed differently after a restart.

Note: In following block mode relative positioning blocks <u>without</u> residual path storage are not allowed as otherwise the chain dimension reference will be lost.

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Interrupting a following block chain by selecting the same block number

Given an interruption (e.g., with drive halt), a restart will end the following block chain.

Reference position

The reference position is the original start position of the block chain.

The chain is retained as only absolute and relative positioning blocks with residual path storage are used in following block mode!

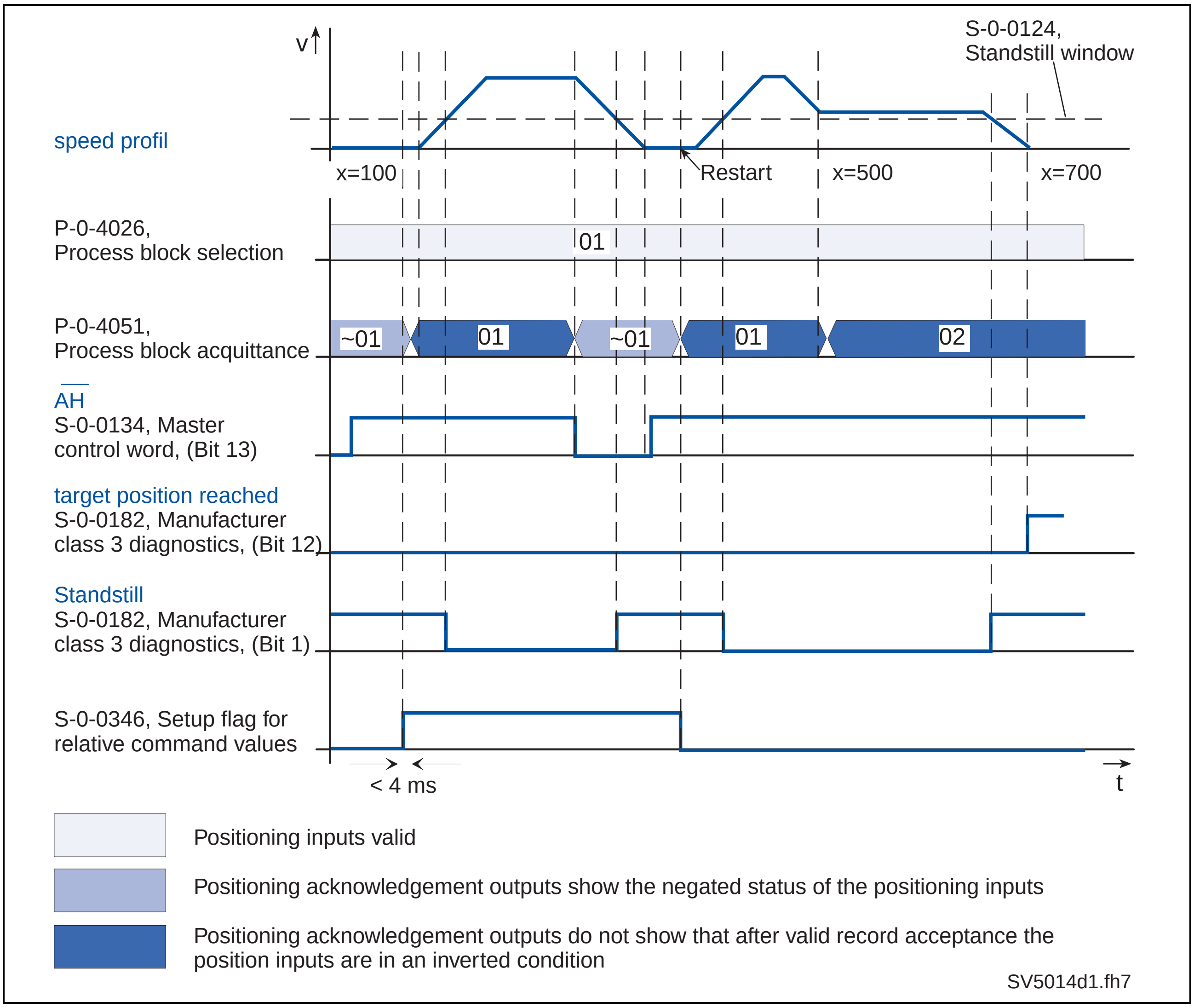


Fig. 8-32: Example: Following block interrupt with same block selected

Changing into jog mode

Note: Given a change into a different mode with an interrupt, the previously interrupt chain is completed upon restart unless a new block is selected. Given a following block with commutation 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 commutation conditions due to switching signals is always detected.

Terminating 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

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 absolute dimension is always guaranteed.

.. when selecting a new block number

If a new block number is selected with an interruption, then the interrupted following block **is not completed** if **S-0-0346 Set-up flag for relative command values,** is toggled. Instead, the current block is executed.

.. with selecting the same block number

If the same block number is selected with an interruption, then the interrupted following block **is completed** if **S-0-0346, Set-up flag for relative command values** is toggled.

Parametrization notes for positioning blocks

Taking drive limits into account

When parametrizing following blocks, the maximum values of the drive must be taken into account.

These are:

- maximum accel capability
- maximum speed (mains voltage dependent)

If blocks are parametrized that demand values greater than the maximum value 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 accel and jerk

General information

Accel 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 accel value**

$$acceleration > \frac{\text{speed difference}^2}{2t\arg et position difference} = \frac{\left(v_{n+1} - v_n\right)^2}{2 \cdot \left(X_{n+1} - X_n\right)}$$

X_{n+1} = targetposition of the block n + 1

v_n = block speed n

v_{n+1} = blockspeed n + 1

Fig. 8-33: Minimum accel value with following block mode (translatory)

Note: The above relationship applies to a very large jerk, i.e., a jerk filter that has been switched off (= 0). If such a filter is used, then the computed values are doubled. The stretch to be run with a block and its speed are generally fixed in percents. If the minimum accel value computed already causes the maximum value of the previous section to be exceeded, then a lower positioning speed must be selected.

- **Minimum jerk value**

If accel values are parametrized too small, then this could mean that the parametrized speed 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 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

Following block n-1 with mode 1 following by following block n with intermediate halt, because a **change in direction** occurs when changing from block n to block n+1.

This means there is a sign change for the speed for target position n. If the accel parametrized in block n is too small to decel within the path difference = X_n-X_{n-1} from speed v_{n-1} to value 0, then the parametrized target position X_n will be overrun.

This can cause software or hardware limit switches to trigger.

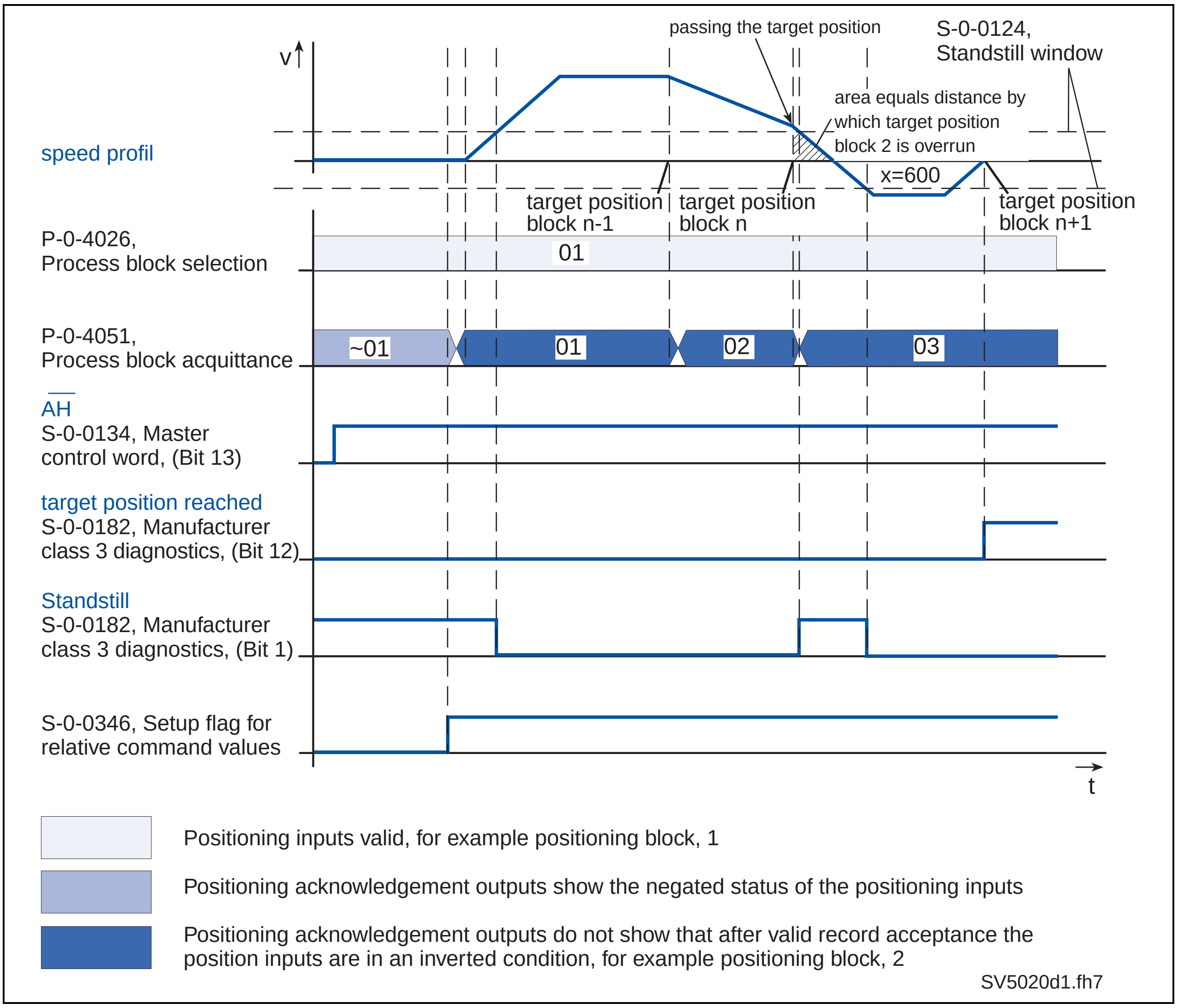


Fig. 8-34: Parametrizing a following block with directional change

Note: In this case it is necessary to take the rule of thumb into account for minimum acceleration to avoid overshooting of position!

Acknowledge positioning block selected

Acknowledging 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, Setup flag for relative command values**) is generated. As of the first start signal and if operating is problem-free, the block number of the positioning block that has started, is generated. 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 remains standing.

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 acknowledge**.

Acknowledge with auxiliary modes, error reaction or command settings

Acknowledgement is not effected, i.e., parameter **P-0-4051, Process block acknowledge** retains its value.

Acknowledge with drive enable removed

After removing the drive enable the **last accepted positioning block** is output. If the drive is at the target position of the last positioning block, then the message "**end position reached**" is additionally generated.

The example below shows the same absolute positioning block being started once more time.

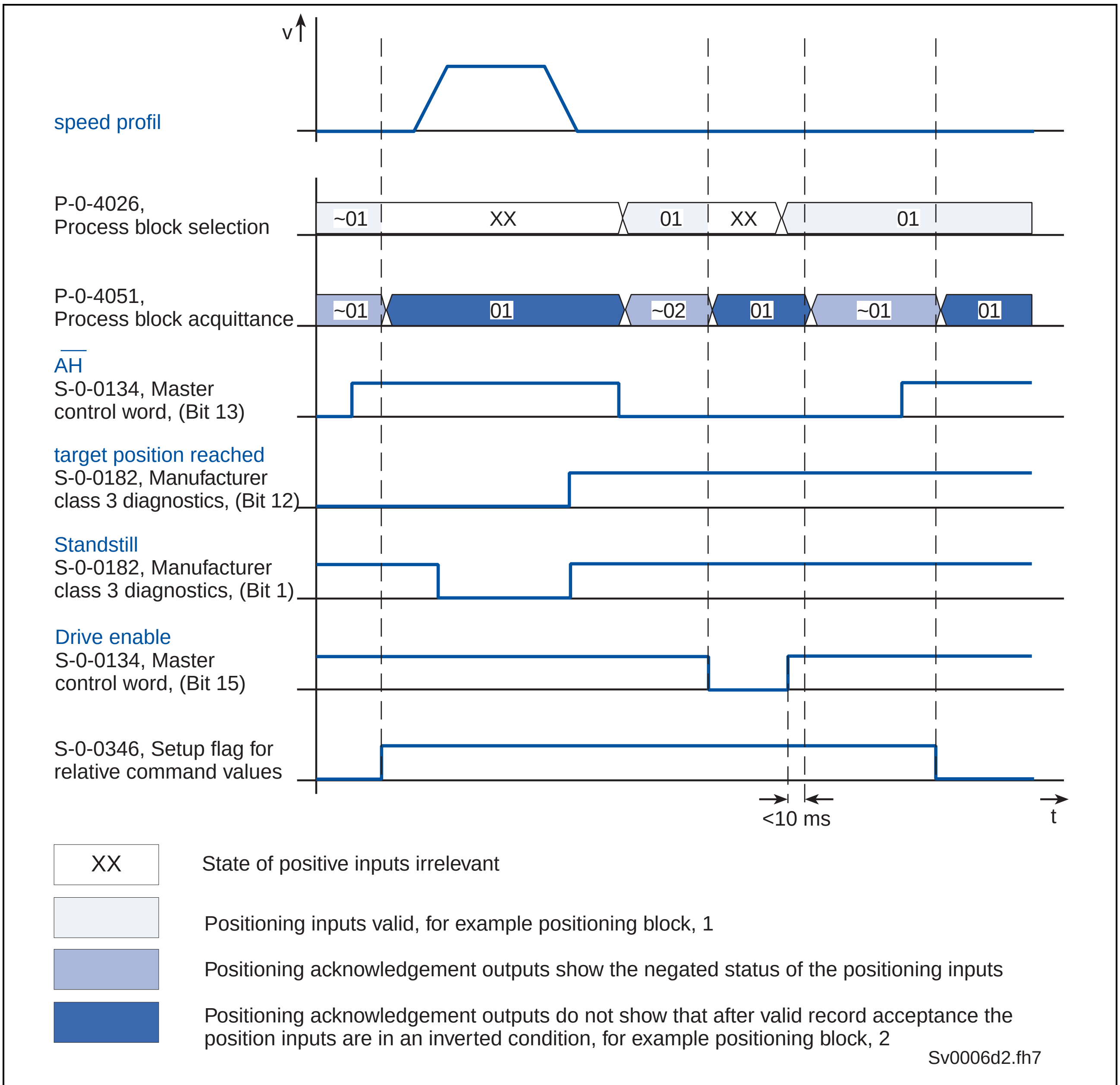


Fig. 8-35: Acknowledging and signalling "End position reached" after drive enable removed

Acknowledge with control voltage interrupt

If the control voltage is switched off, then the last positioning block secured is stored in parameter **P-0-4052, Positioning block, last accepted.** This means that after powering up the last 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 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 is approached or referenced.

Note: The "End position reached" message is only retained if the axis is not moving during the interruption. If the axis is moved into the positioning window during the interruption, then the IN-POS message will also be generated. After activating the drive enable, positioning block acknowledge changes to as described in "Acknowledge with drive enable removed".

Status Messages in "Positioning Block Mode"

In addition to the messages listed in section: "Status messages during drive-internal interpolation", the following status messages are also generated in positioning block mode:

- **End position reached**, Bit 12 of **S-0-0182, Manufacturer status class 3** is 1, it applies if:
  message "**In-target position**" (S-0-0182, Bit10) is active and no slave block has been selected.

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**

Hardware Connections

See project planning manual

8.9 Operating Mode: Stepper Motor Operations

In "Stepper motor mode" the drive behaves like a conventional stepper motor drive. This means that conventional stepper motor controls can be used to control the drive.

The operating mode is only available in conjunction with the parallel interface. This is why it is only used with DKC01.3 units.

Note: Due to the digital limitation of a stepper motor drive, the use of the controller in precision applications is not recommended. Rexroth Indramat offers exceptionally well-suited drive systems with SERCOS interface for applications such as these.

It is only available in the main operating mode (**S-0-0032, Primary mode of operation**).

The drive is in this mode in position control. The position command values are set by the relevant stepper motor signals. The read-in steps are added up and smoothed with a PT1 filter and then specified to the position controller.

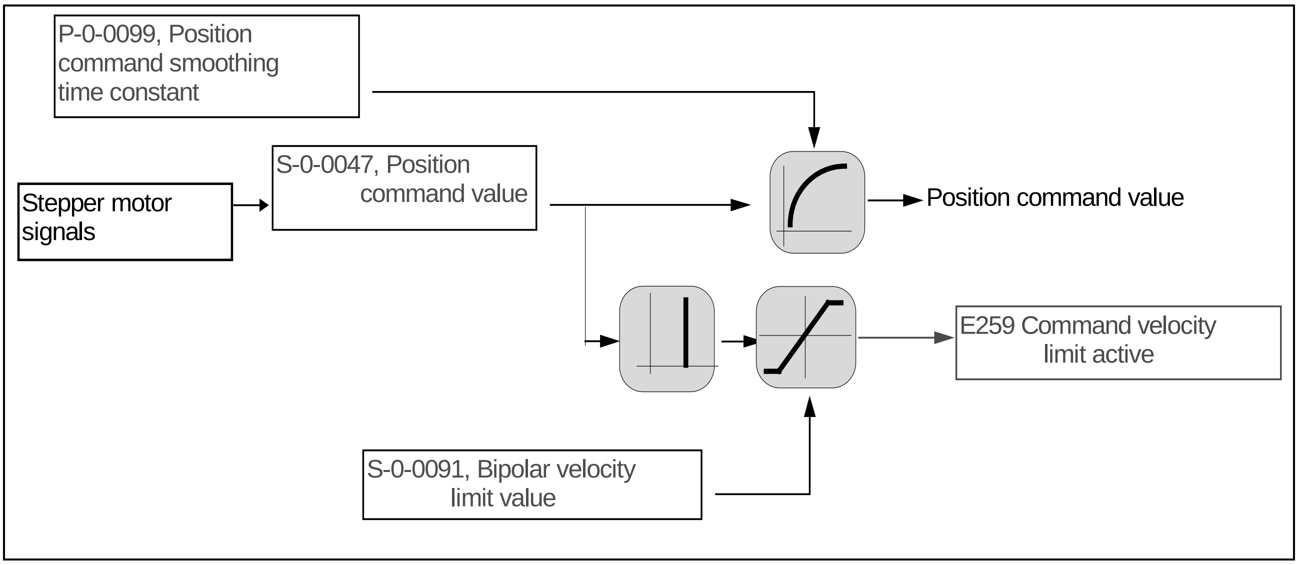


Fig. 8-36: Processing stepper motor signals

The operating mode always relate to the actual position values of encoder 1.

Pertinent Parameters

- **P-0-4033, Stepper motor resolution**
- **P-0-4034, Stepper motor interface mode**
- **P-0-0099, Position command smoothing time constant**

Stepper motor signal processing

In "Stepper motor mode" the drive converts externally fed pulses into defined position changes. Using parameter **P-0-4034, Stepper motor interface mode various** it is possible to select various modes:

- quadrature signals
- forwards/backwards signals
- one step and one direction signal

The pulses pending processing are applied at the relevant inputs of the parallel interface.

The number of steps per motor revolution can be set in parameter **P-0-4033, Stepper motor resolution**. The steps are set in increments of mm in linear motors.

Note: The drive only processes the fed in pulses if both drive enable and AH/start signal are applied and no drive error is pending. In other words, fed in pulses are lost if the drive is without drive enable or in "drive halt". The processed pulses are given to the position controller without filtering.

Interface Mode

The stepper motor signals must meet the demands illustrated in the figure below.

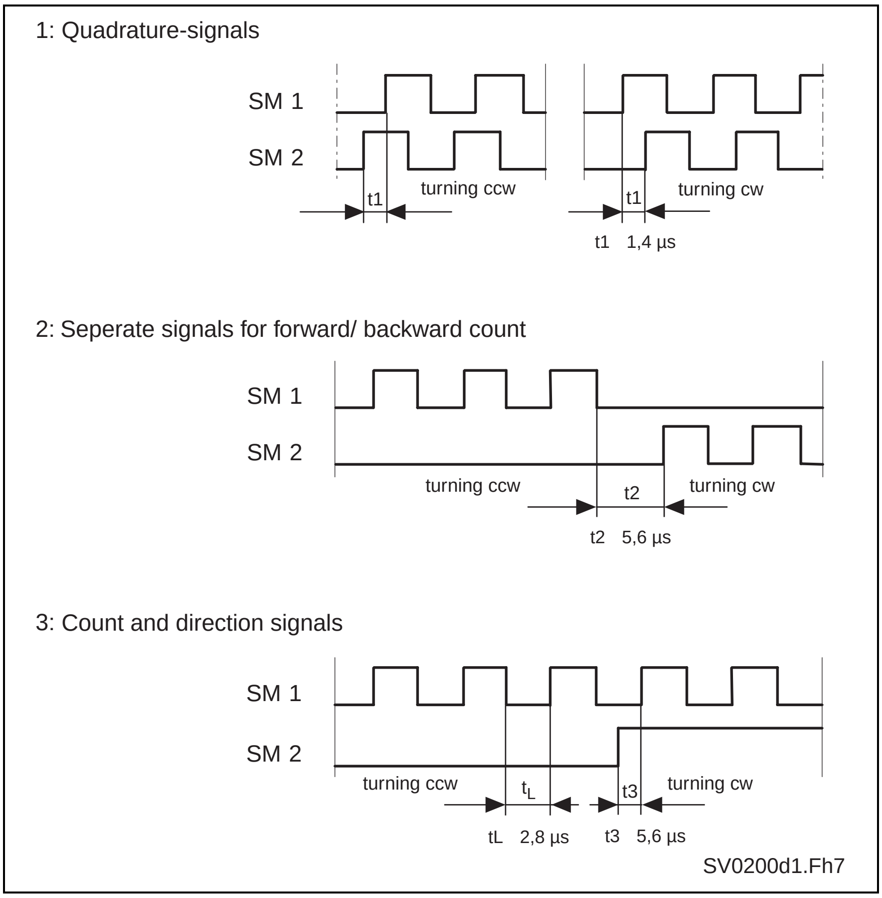


Fig. 8-37: Stepper motor interface

Diagnostic Messages

With the step motor mode it makes sense to put the message**"In-Position"** (**S-0-0013, Class 3 diagnostics, Bit 6:** lag error < positioning window) on the signal status word and thus on the Digital Outputs"

Also see section: "Configurable Signal Status Word".

Connecting the Parallel Interface

The allocation of the parallel interface connections is described in detail in the Project Planning Manuals.

See Project Planning Manual; Control inputs for Stepper Motor Operations.

8.10 Operating Mode: Jogging

Operating mode is used to run an axis in "Manual mode", i.e., without the use of the control program.

In units with positioning interface or step-motor interface, it is possible to mount circuits at the jogging inputs which can be moved to use the axes.

Pertinent Parameters

- **P-0-4030, Jog velocity**
- **P-0-4056, Jog inputs**
- **S-0-0260, Positioning Acceleration**
- **S-0-0193, Positioning Jerk**

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**

How it works

Activating the operating mode ogging:

In units with SERCOS interface jogging can be parametrized as any operating mode. In units with parallel interface these can only be parametrized as the 1st auxiliary mode. If the jog inputs are connected to switches in the case of parallel interface, then the drive automatically goes into the 1st auxiliary mode once these inputs are actuated. The state of the inputs is reflected in parameter **P-0-4056, jogging inputs**.

Also see section: "Command Communication Using Parallel Interface".

Functional Sequence of operating mode jogging

Upon activation of the mode, the drive runs position controlled while maintaining the:

- speed limit value (**P-0-4030, Jog velocity**),
- acceleration limit value (**S-0-0260, Positioning Acceleration**)
- jerk limit value (**S-0-0193, Positioning Jerk**).

The Jogging direction is fixed in parameter **P-0-4056, Jog inputs**.

Jog inputs	Drive	Display
00b	stand still	AF
01b	moving forward	JF
10b	moving backward	Jb
11b	stand still	AF

Fig. 8-38: Relationship of jog input to 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 speed.

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 and
- after jogging in the opposite direction.

Hardware Requirements for operating mode jogging

In units with positioning interface (e.g., DKC01.3) parameter **P-0-4056, Jog inputs** is write accessed directly by the hardware inputs jog+ (jog inputs =1) and jog- (jog inputs =2).

9 Basic Drive Functions

9.1 Physical Values Display Format

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 "Parameter") is necessary for interpreting the operating data of a parameter. The value of the operating data is produced from these data.

The following illustration shows this with an example.

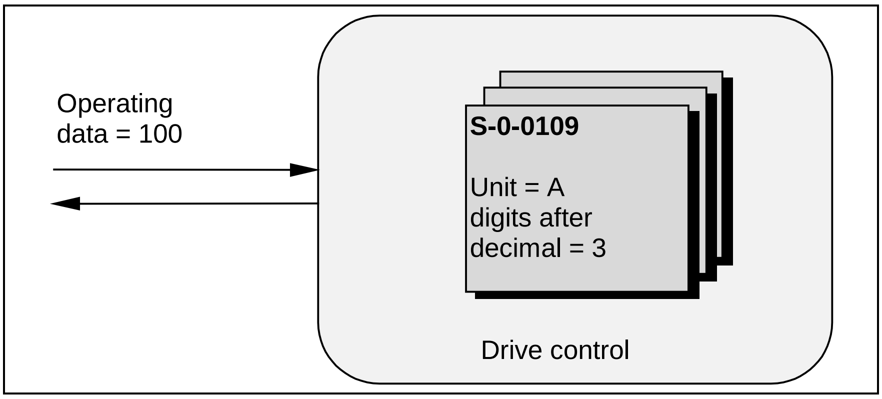


Fig. 9-1: Example for interpreting operating data in the drive

The combination of unit and number of decimal places is expressed with the term scaling.

The operating data of the parameter S-0-0109 is given the value 100 in the picture shown above. When combined, the unit A (ampere) that belongs to this parameter and the number of decimal places produce the physical value **0.100 A**.

Each parameter can therefore be called up with a unit and the number of decimal places. The combination of these two criteria is united under the term **scaling**. When interpreting operating data, these must always be included in the analysis. Units and number of decimal places are listed along with all other parameter attributes in the Parameter Description.

Adjustable Scaling for Position, Velocity, and Acceleration Data

The value of position, velocity, and acceleration data can be set by adjustable scaling.

The parameter scaling for

- position,
- velocity 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 control drive, or, 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 described with linear units, for example, and rotary movements can be described 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 a linear scale. Rotary motors use either a rotary or linear scale if their rotary movement is converted into a 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 parameter and the scaling exponent parameter are not entered. The preferred scaling adjusts itself to the selection of linear or rotary scaling.

The following preferred scalings are 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.

With rotary load reference, the scaled data from the motor format is converted to the transmission output format with the transmission ratio **S-0-0122, Output revolutions of load gear** / **S-0-0121, Input revolutions of load gear**.

load reference

With linear load reference, the scaled data from the motor format is converted to feed constant format with the transmission 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**.

The parameter is defined as follows:

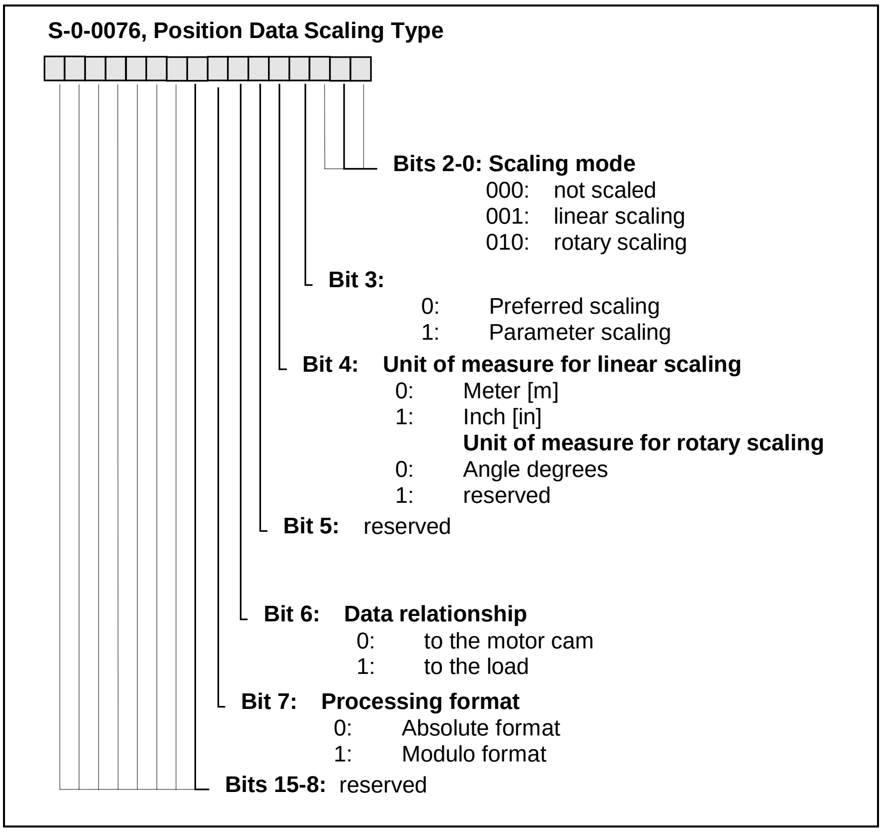


Fig. 9-3: S-0-0076, Position Data Scaling Type

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**.

The parameter is defined as follows:

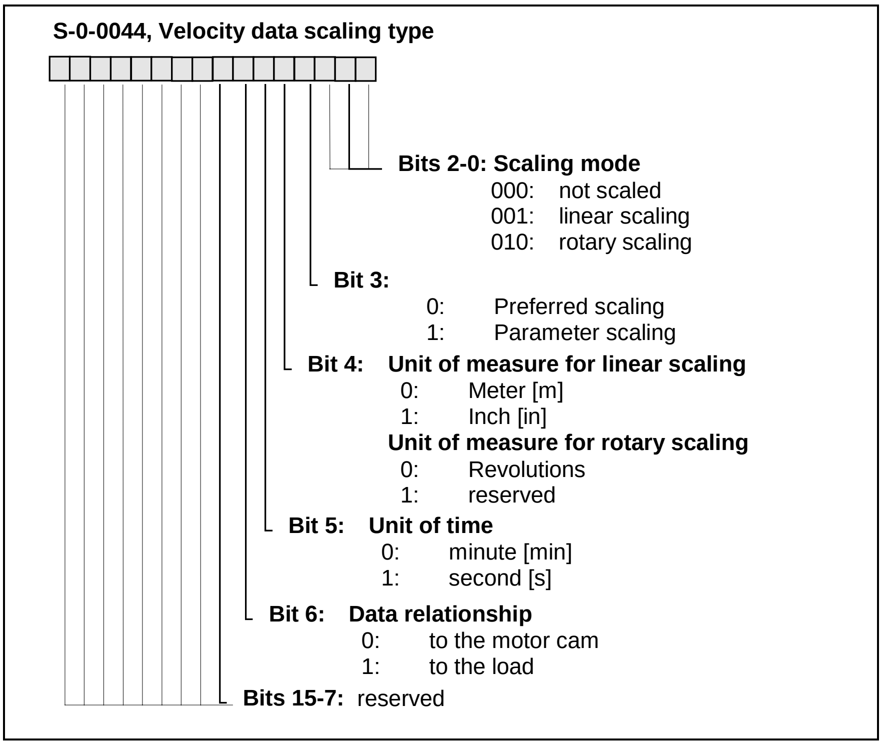


Fig. 9-4: S-0-0044, Velocity data scaling type

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**. The parameter is defined as follows:

- **S-0-0160, Acceleration data scaling type**

Bits 2-0: Scaling mode
000: percentual scaling
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: radians [rad]
1: reserved

Bit 5: Unit of time
0: second [s]
1: reserved

Bit 6: Data relationship
0: to the motor shaft
1: to the load

Bits 15-7: reserved

Fig. 9-5: S-0-0160, Acceleration data scaling type

The actual scaling type is set in bit 0..2.

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 Polarities and Actual Value Polarities

The drive-internal polarities of position, velocity, torque/force and actual value are fixed. The following applies:

Motor type:	Drive internal positive direction definition:
Rotary motors	Clockwise rotation facing the motor shaft
Linear motors	Move in the direction of the connection of the power cable on the primary component

Fig. 9-6: Drive internal positive direction definition

The positive direction is specified by the manufacturer for MHD-, MKD and MKE motors. Asynchronous motors, linear synchronous motors and MBS motors should be set in this direction during installation. (see "Other Motor Encoder Characteristics"). The command polarity and actual value polarity of the drive is thereby fixed.

If the motor definition of the positive direction 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 and actual value polarities.

Note: If the polarity needs to be changed, all 3 parameters should always be inverted at the same time, so that the polarities of the position, velocity and torque have the same sign.

The following illustration shows the operating characteristics of the polarity parameters.

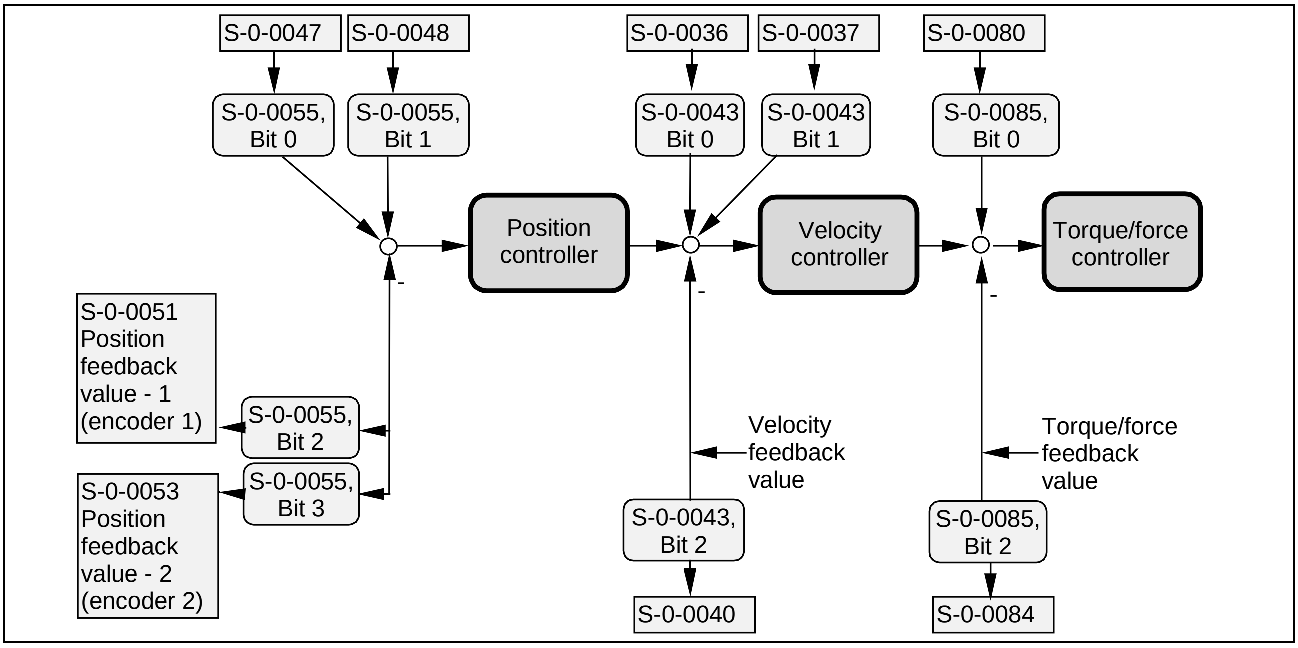


Fig. 9-7: Polarity parameter operating characteristics

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 parameter are also inverted. This protects against the danger of adding positive feedback into the control loop (command and feedback values with opposing polarities) due to incorrectly set command and feedback value polarities.

Mechanical Transmission Elements

Mechanical transmission elements are gearboxes and feed mechanisms between the motor shaft and the load. Entering this data is necessary for the load to convert the position, velocity, and acceleration physical values, if these are scaled for the load.

(See also "Adjustable Scaling for Position, Velocity, and Acceleration Data".)

To see if this parameter has been entered correctly, move the shaft and compare the path followed with the position feedback value and the path actually taken.

Transmission Ratio

The transmission 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 transmission input and transmission output is parameterized here.

Example:

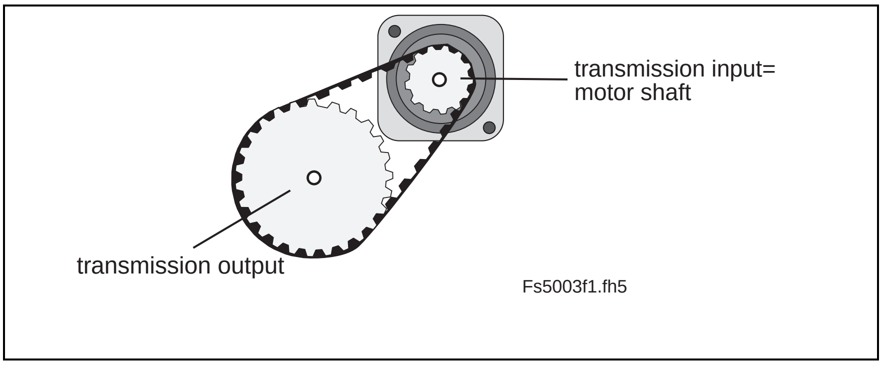


Fig. 9-8: Transmission ratio parameterization

In the illustration above, 4 transmission input revolutions (= motor revolutions) were equivalent to 2 transmission output revolutions. The proper parameterization for this would be :

S-0-0121, Input revolutions of load gear = 4

S-0-0122, Output revolutions of load gear = 2

Feed Constant

The feed constant defines how far the load moves linearly per transmission output revolution. It is specified in the parameter **S-0-0123, Feed constant**.

The value programmed here is used along with the transmission ratio for converting the position, velocity, and acceleration data from motor reference to load reference.

Example:

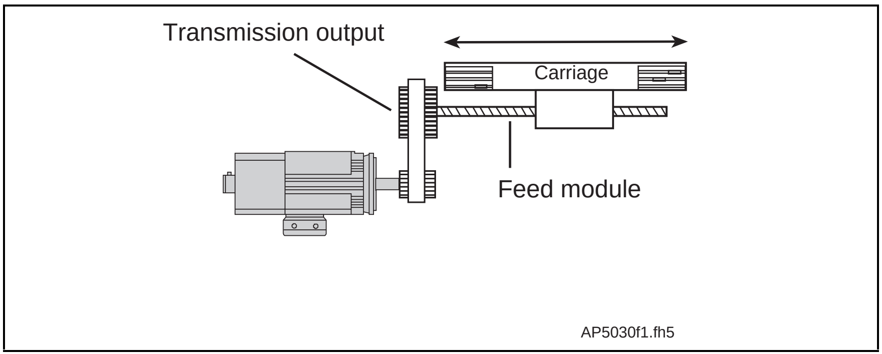


Fig. 9-9: Feed constant parameterization

Example:

In the illustration above, the feed module would cover 10 mm per transmission output revolution. The proper parameterization for this would be:

S-0-0123, Feed Constant = 10 mm/Rev

Modulo Feature

When the modulo function is activated, all position data are displayed in the range 0... (modulo value). Thus it is possible to implement an axis which can move infinitely in one direction. There is no overrunning of the position data.

The modulo value is set with the parameter **S-0-0103, Modulo Value**.

The modulo function is activated by the parameter **S-0-0076, Position Data Scaling Type**.

(See also "Display Format of Position Data".)

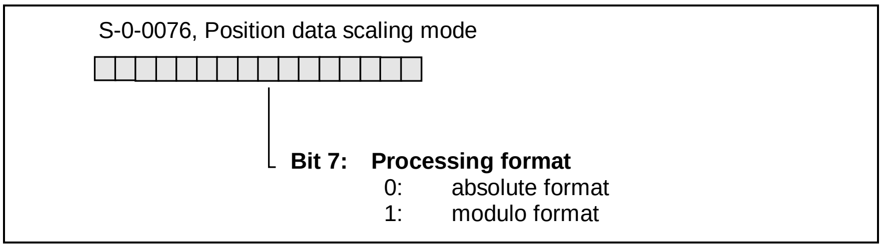


Fig. 9-10: Setting absolute format - modulo format

Note: Modulo processing of position data is only allowed with rotary motor types. This is checked in **S-0-0128, C200 Communication phase 4 transition check** and generates the command error **C213 Position Data Scaling Error** if necessary.

The following illustration shows the difference in displaying the position data in absolute format and modulo format:

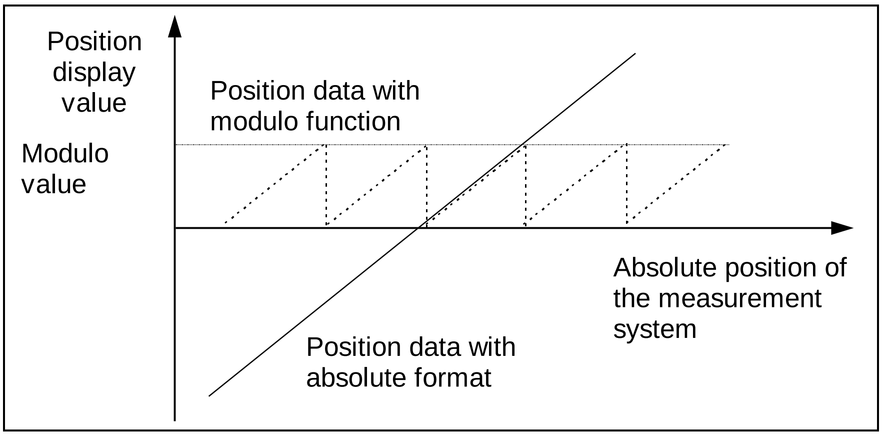


Fig. 9-11: Display value of positions in absolute format and modulo format

Modulo Processing-Limiting Conditions

If modulo processing of position data is selected, in connection with

- 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 limiting conditions are as follows:

- 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 without angle synchronization is used as the operating mode, 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, in addition to this, an external measurement system is used, the additional requirements are:

- If rotary position scaling with motor reference and no angle synchronization operating mode is used, 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.
- If rotary position scaling with motor reference and angle synchronization operating mode is used, the product of **S-0-0237, Slave drive 1 revs.**, **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** when the modulo function has been activated is dependent on the selected mode.

The following possibilities exist:

- Shortest Path
- Positive Direction
- Negative Direction

Parameter **S-0-0393, Command value mode** is used to set the mode. This parameter is effective only if 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 of 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 of 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 of the modulo value.

9.2 Setting the Measurement System

The drive controller is equipped with two permanently installed encoder interfaces, i.e., 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 1Vss
- incremental encoder with square-wave signals (TTL)
- measuring system with EnDat interface
- gearwheel encoder with 1Vss signals

Both encoder interfaces can be used to connect either a motor or an optional encoder.

At which interface the motor encoder should be connected and what type it 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 1Vss signals	2	9
Resolver without feedback data storage	1	10
Resolver without feedback data storage + incremental encoder with sine signals	1 + 2	11
Hall encoder + square wave encoder	1 + 2	12
ECI encoder	1	13
Hall encoder plus sinus encoder	1 + 2	14

Fig. 9-12: Measuring systems > connections

The table illustrates that some combinations are not possible as each encoder interface is only physically present once.

To display the actual position value 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 measurement 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 measurement system. If a second measurement system is attached directly to the load, than this direct measurement system (see "Optional encoder"). Hereafter, are shown typical applications of indirect distance measuring.

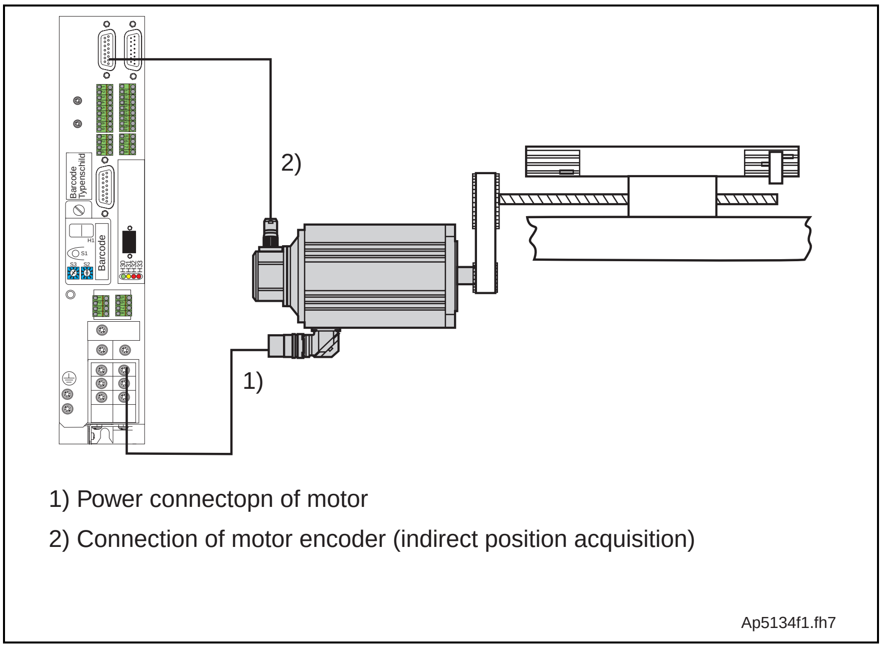
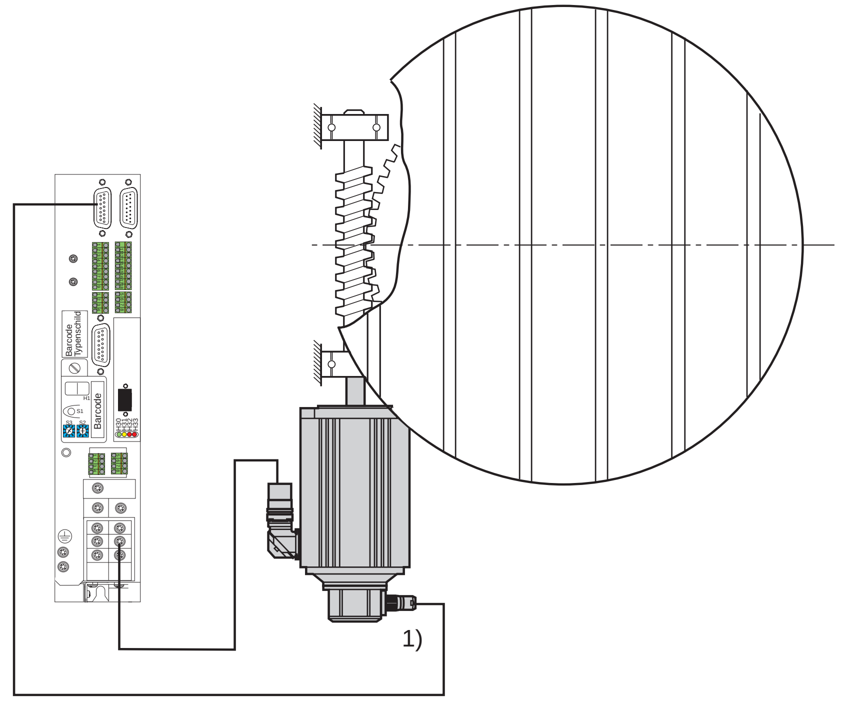


Fig. 9-13: Application: Motor encoder with linear servo axis



1) Indirect position acquisition with internal encoder

Ap5135f1.fh7

Fig. 9-14: Application: Motor encoder with rotary servo axis

The following parameters

- **P-0-0074, Feedback type 1**
- **S-0-0116, Feedback 1 Resolution**
- **S-0-0277, Position feedback 1 type**

are used to parameterize the motor feedback. These specify the interface number to which the measurement system is connected, the motor feedback resolution, as well as the direction of movement, etc. The parameter **S-0-0051, Position feedback 1 value** displays the position of the motor feedback.

The absolute measurement relative to the machine zero point is set with

- **S-0-0148, C600 Drive controlled homing procedure command**

or, for absolute encoders,

- **P-0-0012, C300 Command 'Set absolute Measurement'**

Note: For Rexroth Indramat MHD, MKD and MKE motors (with housings) all motor specific data is set-up automatically; no further user intervention is required for the installation of these motors.

Determining the Feedback Interface of the Motor Feedback

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 measurement systems and modules 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 (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 1Vss 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
ECI encoder	1	13	yes	yes
Hall encoder plus sinus 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 loadside 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 graduation scale of the motor feedback. If using a measurement system with intrinsic feedback data storage, the resolution will be taken from this and does not need to be entered.

Measurement systems with feedback storage:

- DSF, HSF
- Resolver
- EnDat

Depending on whether a rotary or linear motor is used, the units and the number of decimal places are changed via **S-0-0116, Feedback 1 Resolution**.

(see also chapter: Linear-Rotational)

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:

S-0-0277, Position feedback 1 type

Bit 0 : Encoder type
0: rotary
1: linear

Bit 1 :Distance-coded reference marker
0: no distance-coded reference marker
1: distance-coded reference marker

Bit 3 :Rotational direction
0: non-inverted
1: inverted

Bit 6 :Absolute evaluation possible
0: Absolute evaluation not possible
1: Absolute evaluation possible

Bit 7 :Absolute evaluation activated
0: Absolute evaluation activated (only if bit 6 = 1)
1: Absolute evaluation deactivated

Fig. 9-16: Parameter S-0-0277

Note: The bits in the position encoder type parameter are partially set or deleted by the drive itself.

There are following criterias:

- 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.

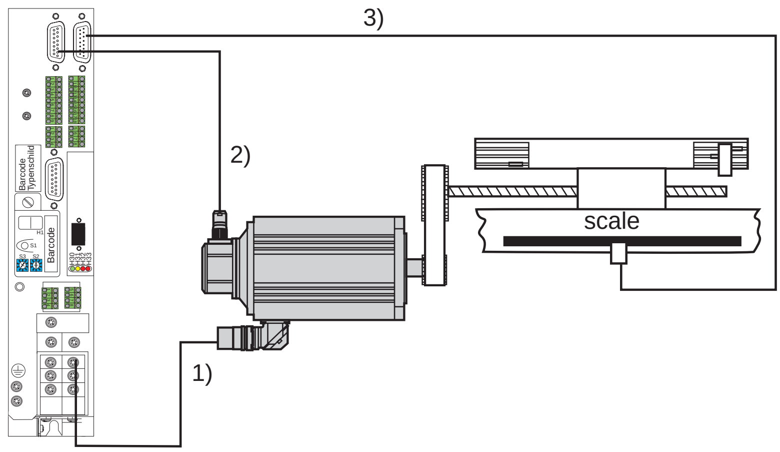
(See also chapter: "Supplementary Settings for Absolute Measuring Systems".)

Optional encoder

A control with a direct measuring system facilitates higher positioning accuracy and thus higher contour precision of the machined workpieces in terms. With setting the operation mode, you can determine that the position control in the drive is done with the position feedback of the optional encoder. Additionally, the velocity control can be completely or partially done with the velocity feedback signal of an optional measurement system.

(See also sections: "Operating Modes" and "Setting the Velocity Mix Factor".)

Typical application examples are shown in the following two pictures:



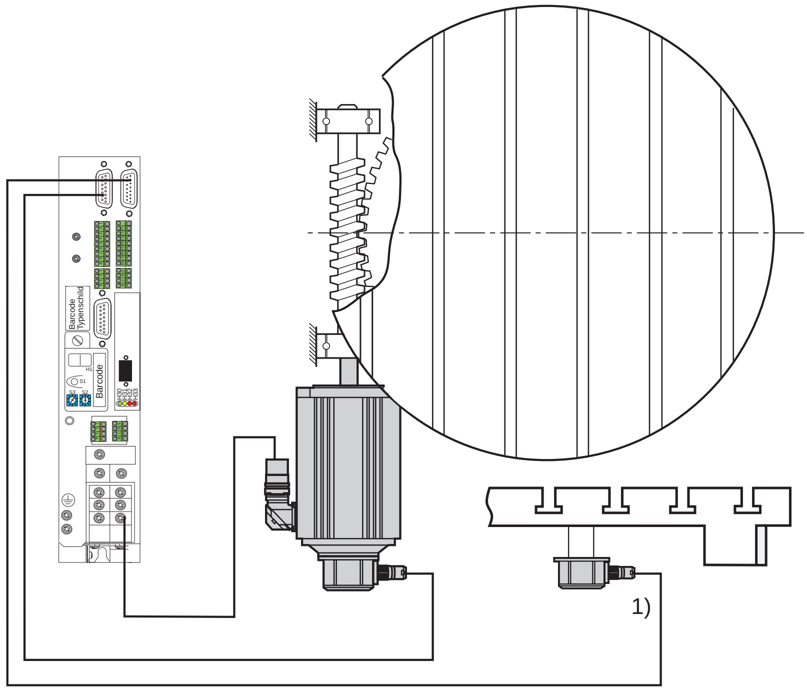
1) Power connectopn of motor

2) Connection of motor encoder

3) Connection of optional encoder (direct positon acquisition)

Ap5133f1.fh7

Fig. 9-17: Application: Optional encoder by linear servo axis



1) Direct position acquisition with external encoder

Ap5136 f1.fh7

Fig. 9-18: Application: Optional encoder by rotary servo axis

The optional encoder is parameterized with the

- **P-0-0075, Feedback type 2**
- **S-0-0117, Feedback 2 Resolution**
- **S-0-0115, Position feedback 2 type**
- **P-0-0185, Function of encoder 2**

parameters. These specify:

- the feedback 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.

Set the reference measure to the machine zero point as follows:

- **S-0-0148, C600 Drive controlled homing procedure command**

or, for absolute encoders,

- **P-0-0012, C300 Command ’Set absolute measurement’**

The optional encoder can be used for different purposes.

The evaluation mode for the optional encoder is set in parameter **P-0-0185, Function of encoder 2**.

Value in P-0-0185, Function of encoder 2	Meaning
0	Optional encoder 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 this, error F246 Max signal frequency for encoder 2 exceeded is generated and the position status (S-0-0403) cleared.
2	Optional encoder as only load-side control encoder (only with rotary asynchronous motors). In this case, there is no other motor encoder (P-0-0074 = "0”). Parameter P-0-0121, Velocity mix factor Feedback 1 & 2 must be set to 100%.
4	Optional encoder as spindle encoder. Handled like “optional encoder as additional load-side control encoder for position and/or velocity control loops". Upon exceeding signal frequency, no error is generated but rather only the position status cleared.

Fig. 9-19: Function of the optional encoder

Determining the Encoder Interface of the Optional Encoder

Determining the encoder interface of the optional encoder uses parameter **P-0-0075, Feedback type 2**. The number of the encoder type must be entered there. 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 1V signals	2	2
Incremental encoder with square wave signals from Heidenhain	2	5
encoder with EnDat interface	2	8
gearwheel encoder with 1Vss signals	2	9

Fig. 9-20: Encoder interface of the optional encoder

If "0" is entered in **P-0-0075, Feedback type 2** 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**.

This parameter indicates the number of lines of the optional encoder. If using a measurement system with intrinsic feedback data storage, the resolution will be taken from this and does not need to be entered.

Measurement systems with feedback storage are available if

- **DSF, HSF**
- **Encoder with EnDat-Interface**

is used as the optional encoder interface.

Depending on whether a rotary or linear measurement system was parameterized in bit 0 of **S-0-0115, Position feedback 2 type**, the unit and number of digits after the decimal is switched by **S-0-0117, Feedback 2 Resolution**.

Rotary: Cycles/Rev.

Linear: 0.00001 mm

Actual Feedback Value Monitoring

In applications where an optional measurement system is used, the position feedback monitor can offer an additional margin of safety.

The actual position 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 error:

- Slip in the drive mechanical system
- Measurement system errors (as far as this is not recognized by the other measurement 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 value of the encoder 1 with the 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 value 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.

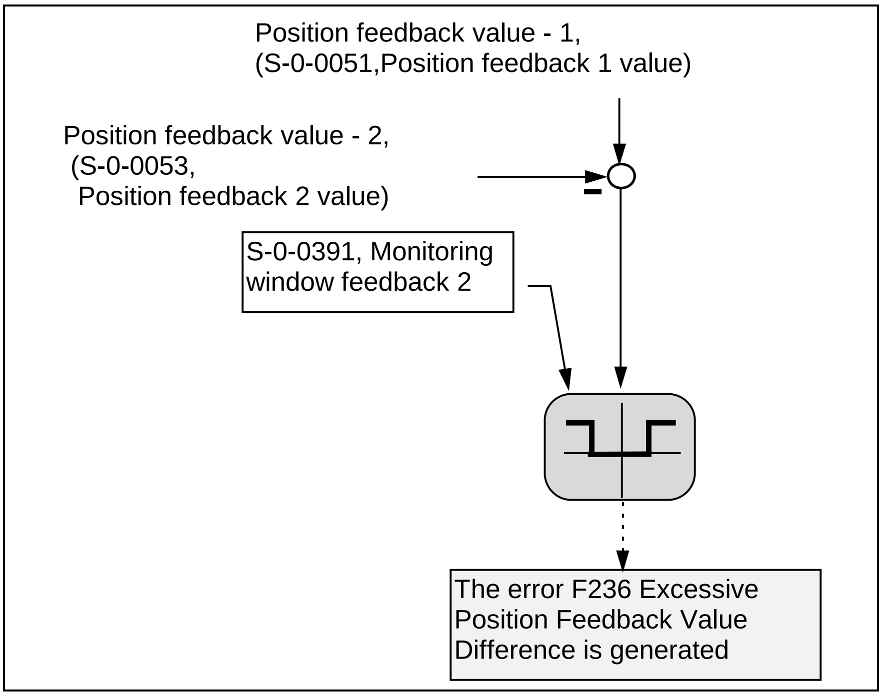


Fig. 9-21: Position feedback value monitoring schematic

Setting the Position Feedback Monitoring Window

The requirements for setting the position feedback value monitor are:

- All drive regulator loops must be set correctly.
- The axis mechanical system must be in its final form.
- 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. While doing this, set the planned acceleration and velocity data of the axis.
- Enter progressively smaller values in the parameter **S-0-0391, Monitoring window feedback 2** until the drive gives 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, 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 statical 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 measurement 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**.

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:

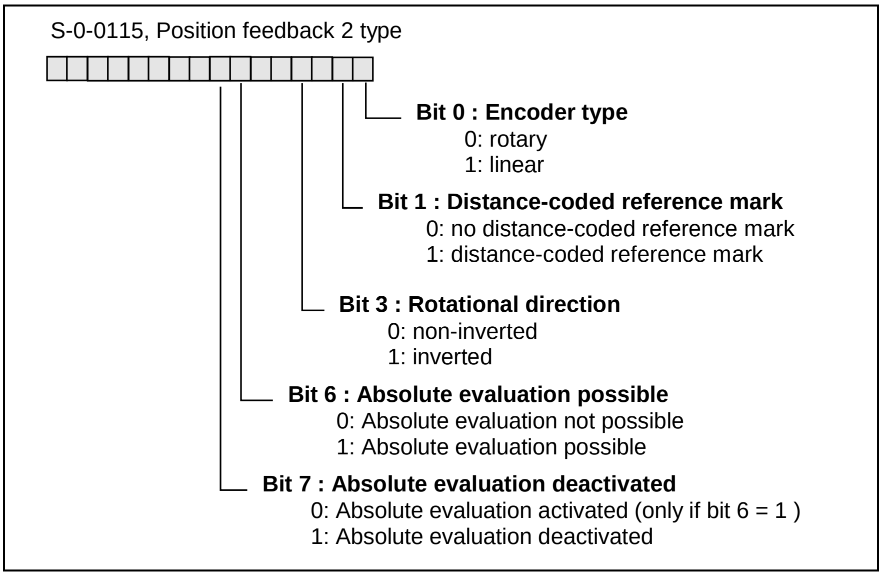


Fig. 9-22: Parameter S-0-0115

Note: The bits in the position encoder type parameter are partly set or cleared by the drive itself, depending on the following criteria:

- 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".)

Actual Feedback Values of Non-Absolute Measurement Systems After Initialization

If there is no absolute measuring system then the initialization value can be changed via parameter **P-0-0019, Position start value**.

It hereby applies:

If the parameter is write accessed in either phase 2 or 3 then this value is assumed as the initialization value:

P-0-0019 written:	Position feedback value 1	Position feedback value 2
no	init. motor encoder value	init. motor encoder value
yes	position start value	position start value

Fig. 9-23: Non-absolute measurement system position feedback values after initialization

Warning

No valid position feedback values exist before the measurement system is initialized.
Initialization is performed during the transition check for communication phase 4.

Some measurement systems have limitations concerning the maximum velocity during their initialization.

Measurement 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.

The display format defines the unit, i.e., the value with which the position data are exchanged between drive and control/surface. When a position data parameter is read, it is sent in the display format to the control. The display format is set with parameter **S-0-0076, Position Data Scaling Type**, **S-0-0077, Linear Position Data Scaling Factor**, **S-0-0078, Linear Position Data Scaling Exponent** and **S-0-0079, Rotational position resolution**. The control generally sets the format.

(See also "Physical Values Display Format"“.)

The drive-internal position resolution depends on the travel range to be described

The drive-internal format determines the value, the position command and feedback value editing as well as how the position control loop in the drive is performed. The drive uses the value of parameter **S-0-0278, Maximum travel range** to calculate the drive-internal format.

Functional principle of the drive-internal position data formats

Position data processing in the drive has a constant data width from which the resolution of the position data to cover the travel range of the axis depends.

Note: The longer the distance to be represented, the smaller the drive-internal position resolution.

These parameter values are used to compute the **drive-internal resolution**:

- **S-0-0116, Feedback 1 Resolution** and
- **S-0-0256, Multiplication 1**.

The parameters for the encoder resolution are listed in the data sheets of the measuring system or they are automatically read out of the feedback memory if such a measuring system is present. The number of lines per encoder revolution or the grid constant of a linear scale (distance per division period) is set there. The parameter values for the multiplication are calculated by the drive during command **S-0-0128, C200 Communication phase 4 transition check**. They describe the resolution per division period (dp).

It thus applies for the drive-internal resolution:

for rotary motors:

$$resolution = multiplication * encoder\,resolution$$

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/Incr]

Fig. 9-25: Drive-internal resolution of rotary motors

and for linear motors:

$$resolution = \frac{multiplication}{encoder\,resolution}$$

Resolution:	drive-internal resolution of positon data [Incr/mm]
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/motor 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 (How to compute the drive-internal resolution if an optional encoder is used, is described in greater detail below).

Note: The value for the multiplication is limited to 4 .. 4194304 for technical reasons.

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 start-up

This parameter must be set at the time when an axis is commissioned 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 mounted, for **S-0-0257, Multiplication 2** as well. These parameters thus help to display the resolution.

Multiplication is only reduced if the travel range can no longer be described

The maximum possible resolution of the position feedback value of a position encoder for technical reasons equals 32768 increments per division period of the measuring system. This maximum resolution is only reduced if the travel range is set so large that it can no longer be described with the maximum resolution.

To compute the **multiplication**, the following calculations are conducted in the command **S-0-0128, C200 Communication phase 4 transition check**:

for rotary measuring systems:

$$\text{multiplication} = \frac{2^{31}}{\text{travel range} \times \text{encoder resolution}}$$

travel range:	travel range shown 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, a multiplication of 2^31 / (2048 • 512) = 2048.
2. MHD motor with S-0-0116 = 512, maximum travel range 20 motor revolutions, therefore, a multiplication of 2^31 / (20 • 512) = 209715. The highest possible value equals 32768, thus a multiplication = 32768.

for <u>linear</u> scales:

$$\text{multiplication} = \frac{2^{31} \times \text{encoder resolution}}{\text{travel range}}$$

travel range:	travel range shown 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 in linear scales

Example:

1.) Linear scale with 0.02mm grid division, maximum travel range 5m, therefore a multiplication of $2^{31} \times 0.02 / 5000 = 8589$ ($\rightarrow$ 8192).

This results in a resolution of 0.02mm / 8192 = 0.002441 µm.

Note: When computing multiplication always use the next lower binary value of the precise results.

Drive internal representation of position data when an optional encoder is present

If an optional encoder is mounted, the multiplication of the motor encoder is guided by the optional encoder

If there is an optional measuring system, then the multiplication of this encoder is computed as per the above formula in terms of the travel range set. The multiplication of the motor encoder is calculated so that it also covers this travel range. This means that values exceeding 32768 for the multiplication of the motor encoder can be generated depending on the mechanical transformation elements!

Example: MKD motor with rotary optional encoder

motor encoder resolution	= 4
optional encoder resolution	= 1000
travel range	= 50 revolutions
gear ratio	= 1:1

1. Calculating the multiplication of the optional encoder:

2^31 / (1000 • 50) = 42949, technical maximum 32768, thus S-0-0257 = 32768.

This results in a resolution of 0.00001098 Degrees.

2. 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 0.0002146 Degrees.

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 transmission ratio	= 3:1

1. Calculating the multiplication of the optional encoder :

2^31 • 0.02mm / 5000mm = 8589

Technically reasonable is a maximum of 8192, therefore

S-0-0257 = 8192. This gives a resolution of 0.00244 µm.

2. Calculation of the Multiplication of the motor encoder:

5m of travel range give 500 gear output revolutions and therefore 1500 gear input revolutions (motor revolutions).

2^31 / (256 • 1500) = 5592, the nearest smaller binary value = 4096, therefore S-0-0256 = 4096. This results in a resolution of 0.000343 Degrees referred to the motor shaft.

Processing format of the drive-internal position command interpolator

In the drive-internal position command interpolator, the position command profile for the drive-controlled travel commands such as drive halt, drive-controlled homing, operating mode drive-internal interpolation and so on are generated. The format of the drive-internal position data affect the maximum acceleration limit which can be pre-defined for the interpolator.

The limits are not valid for cyclic command values, e.g. in operation mode Position control.

The following relationships apply:

for rotary motors:

$$\text{amax} = \frac{51.471.854.040}{\text{encoder resolution} \times \text{multiplication}} \left[\frac{\text{rad}}{\text{s}^2}\right]$$

amax: maximum acceleration of position command of the interpolator
encoder resolution: value in S-0-0116
multiplication: value in S-0-0256

Fig. 9-29: Maximum acceleration of the position command interpolator as dependent on the drive-internal position data format

for linear motors:

$$\text{amax} = \frac{8.192.000.000 \times \text{encoder resolution}}{\text{multiplication}} \left[\frac{\text{mm}}{\text{s}^2}\right]$$

amax: maximum acceleration of position command of the 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 interpolator as dependent on the drive-internal position data format

Example:

MHD motor with S-0-0116 = 512, multiplication = 32768, equalling a maximum acceleration of the position command interpolation 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 motor encoder or optional encoder and the range which they can absolutely evaluate. The relevant encoder interface is also listed.

Measuring system	Absolute encoder range	Interface (input no.):	as motor encoder:	as optional encoder:
Single/Multiturn-DSF/HSF	1rev./4096rev.	Standard(1)	yes	yes
Single/Multiturn resolver	1TP./65535TP.	Standard(1)	yes	no
Linear scale made by Heidenhain with EnDat interface	depends on encoder lengths	Optional(8)	yes	yes
Single/Multiturn rotary encoder made by Heidenhain with EnDat interface	1rev./4096rev.	Optional(8)	yes	yes

Fig. 9-31: Absolute measuring systems and their interfaces

Absolute encoder range and absolute encoder evaluation

Motor and/or optional encoders can be used as absolute encoders

Measuring systems that supply absolute position information within one or several revolutions (single or multiturn encoder) or a within a specific traversing 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 Absolute encoder range 1** or **S-0-0379 Absolute encoder range 2** the drive displays those absolute encoder ranges which can be evaluated.

Absolute measuring systems do not have to be homed after initialization of the drive firmware. The actual position value lies within the absolute encoder range, machine zero related, after initialization. It is only necessary to conduct a single set-up procedure (setting absolute dimension).

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, Absolute encoder 1, range / S-0-0379, Absolute encoder 2, range)** of the relevant encoder.
- the set position scaling (position data represented absolute or in modulo formats) in **S-0-0076, Position data scaling type**

- the travel range set in **S-0-0278, Maximum travel range** or
- the modulo value set in parameter **S-0-0103, Modulo value.**

Note the following relationships:

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

Fig. 9-32: Absolute encoder evaluation as depends 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 results are 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. The measuring system is then treated as if it were a non-absolute encoder.

The position encoder type parameter is structured as follows:

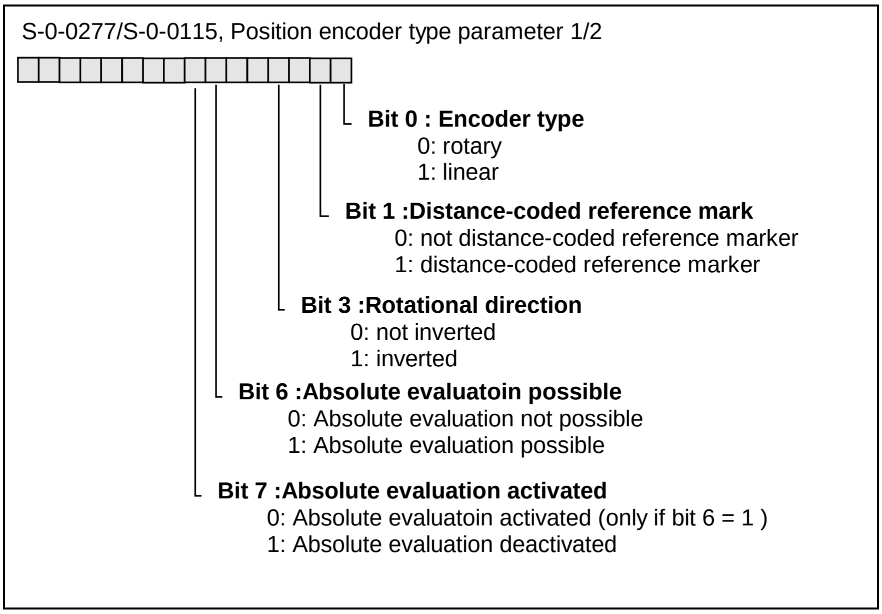


Fig. 9-33: Structure of the position encoder type parameter

Pre-requisites for correctly generating absolute position information:

The correct generation of the machine zero-point related feedback position value is only possible if the relevant conditions have not changed. The conditions for the correct conversion of the measurement system related position information into the machine zero point related actual position value are made up of:

Monitoring absolute encoder evaluation conditions

- 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 in parameters **S-0-0256, Multiplication 1** or **S-0-0257, Multiplication 2** calculated using **S-0-0278, Maximum travel range** .
- the value stored in the parameters **S-0-0177, Absolute distance 1** or **S-7-0177, Absolute distance 1.**

If one of these four conditions changes, then the position status of the relevant measuring system is cleared (**S-0-0403, Position feedback value status** = "0“) and the error **F276 Absolute encoder out of allowed window** is generated.

Absolute Encoder Monitoring

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 in command **S-0-0128, C200 Communication phase 4 transition check** the actual position value is generated and monitored. The monitoring 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 actual position of the axis is loaded into resident memory. When switching the axis back on, the difference of the stored position and the newly initialized position of the measuring system is calculated. If this difference is greater than the parametrized position window in parameter **P-0-0097, Absolute encoder monitoring window**, the error message **F276 Absolute encoder out of allowed window** is given.

The absolute encoder monitor is appropriate for the following applications:

- The motor is equipped with a holding brake.
- The drive mechanical 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 allowable motion of the axis when shutdown. Assuming that the axis has a brake or is self-locking, you can enter 0.1 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 axis that can or must be moved manually 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 0 to **P-0-0097, Absolute encoder monitoring window**.

Modulo Evaluation of Absolute Measuring Systems

If measuring systems are evaluated absolutely and modulo evaluation of the position data is activated, then the following restrictions apply:

The distance which can be traversed when all is shutdown must be smaller than one-half maximum travel range set in parameter **S-0-0278, Maximum travel range.**

Actual position values of absolute measuring systems after initialization

The condition of the position feedback values of the motor feedback and, if available, of the optional feedback 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 feedback as the motor or optional feedback.
- The reference of the relevant absolute encoder.

Motor feedback:	**Optional feedback:**	**S-0-0147 Bit 3:**	**S-0-0051, Position feedback value 1:**	**S-0-0053, Position feedback value 2:**	**S-0-0403, Pos. status:**
absolute	not absolute	0	absolute value of motor feedback	absolute value of motor feedback	1
absolute	not absolute	1	absolute value of motor feedback	absolute value of motor feedback	0
not absolute	absolute	0	absolute value of optional feedback	absolute value of optional feedback	0
not absolute	absolute	1	absolute value of optional feedback	absolute value of optional feedback	1
absolute	absolute	arbitrary	absolute value of motor feedback	absolute value of optional feedback	1

Fig. 9-34: Position feedback values of absolute measurement systems after initialization

Note: When changing polarity, scaling, gearbox and so on it is possible to lose the absolute reference (see also **S-0-0403, Status Actual position values**).

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 set by the user for another purpose.

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**

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 and torque to a fixed maximum value.

The maximum possible currents for the machine are fixed by the peak current of the machine 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. (Motor current limitation).

Thermal current limit of the controller

To protect the controller from overheating, the current is dynamically reduced to **P-0-4045, Active permanent current**. (Thermal current limit of the controller).

Note: At high speeds, the maximum possible motor current is also reduced by the pullout 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.

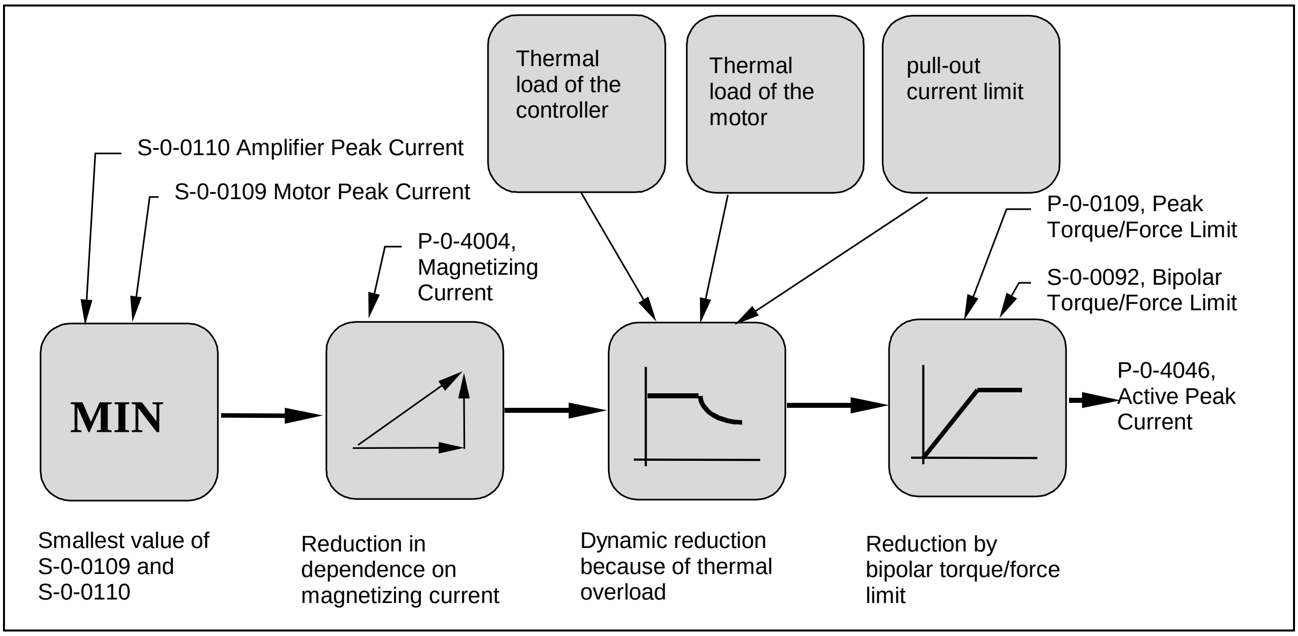


Fig. 9-35: Value displayed in P-0-4046, actual peak current

P-0-4045, Active permanent current

That 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 machine type and
- the switching frequency of the output stage.

This **unit-specific** value is additionally reduced by the magnetization current as parameter **P-0-4045, Active permanent current** only displayed 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 under the continuous current of the controller.

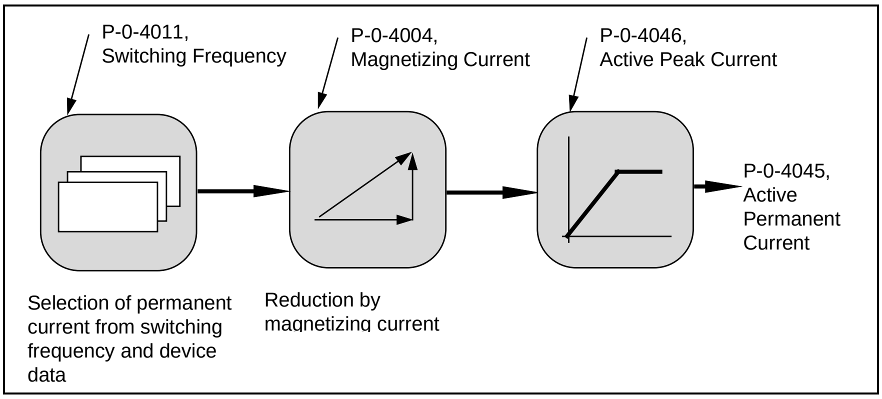


Fig. 9-36: Parameter value of the effective continuous current

Thermal current limit of the controller

It is the task of the thermal current limit of the controller to **protect the unit 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 by exceeds the effective continuous current.

Should the current being supplied once again drop to under the effective continuous current, then the load of the unit sinks and the maximum possible current increases.

To monitor the thermal controller load, two warnings are issued:

- **E257 Continuous current limit active** is issued when the load reaches 100%.
- **E261 Continuous current limit pre-warning** is issued 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 parametrize a value of **80%** for this purpose. This value should not be exceeded when operating the drive under normal conditions.

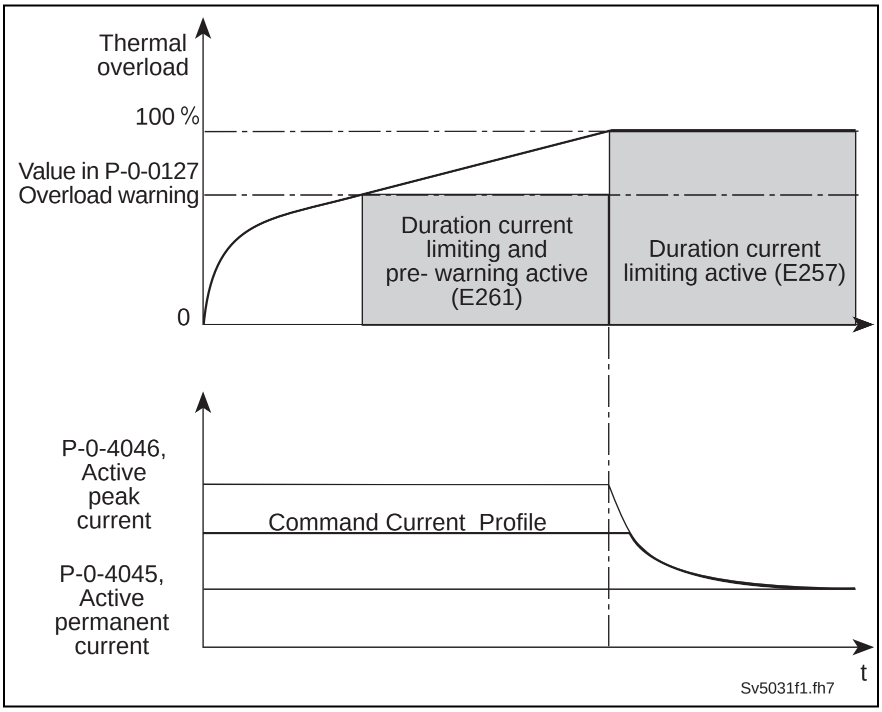


Fig. 9-37: Monitoring the thermal load and continuous current limit

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 machining process, 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 demonstrate 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 **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 pre-setting **P-0-0141, Thermal drive load** to 80%, the processing cycle is set to this load.

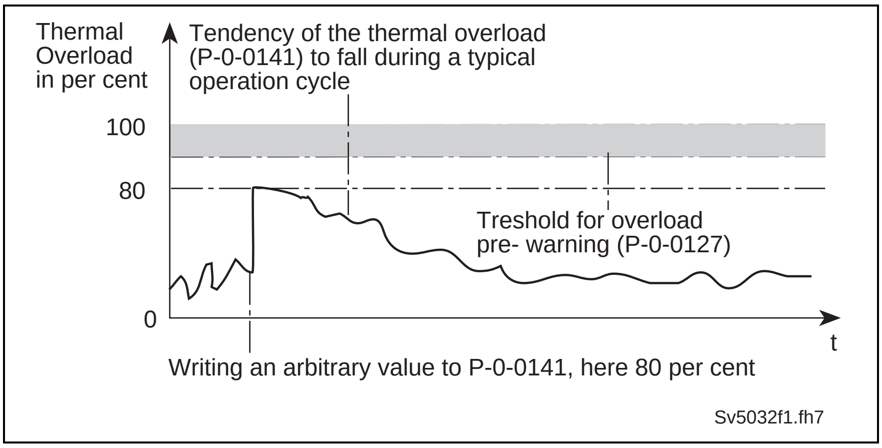


Fig. 9-38: Checking the thermal load

Motor current limit

The motor may be loaded for a maximum of 400 msec 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.

Pull-out current limit

For physical reasons it is necessary to limit the maximum actual current of the motor to a specific speed. The pull-out current limit is used for this purpose. This limit is limited 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 section: "Asynchronous Motors".)

Torque Limit

Parameters

- **S-0-0092, Bipolar torque/force limit value**
- **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 mode	**Parameter value** **P-0-0640Cooling type**	**Factor**
uncooled	0	100 %
cooled	1	150 %
water cooled	2	190 %

Fig. 9-39: Factor cooling type

Variable torque limit

Parameter **S-0-0092, Bipolar torque/force limit value** is used to specify variable limits of the maximum drive torque to values smaller than the maximum possible one. This makes sense, for example, given a successive and quick approaches to an end limit.

Peak torque limit

Due to the maximum allowable current of any motor/controller combination, there is a specific peak torque which is desirable with many applications for acceleration processes. There are, however, cases where the maximum peak torques must be limited to lower values for application reasons. Parameter **P-0-0109, Torque/force peak limit** can be used to limit the maximum peak torque of a drive for an application. This parameter ensures that the allowable maximum peak torque for an application then not exceeded even if **S-0-0092, Bipolar torque/force limit value** is set to a high value.

The following illustrates the interplay of current limit and torque limit for determining the maximum output current.

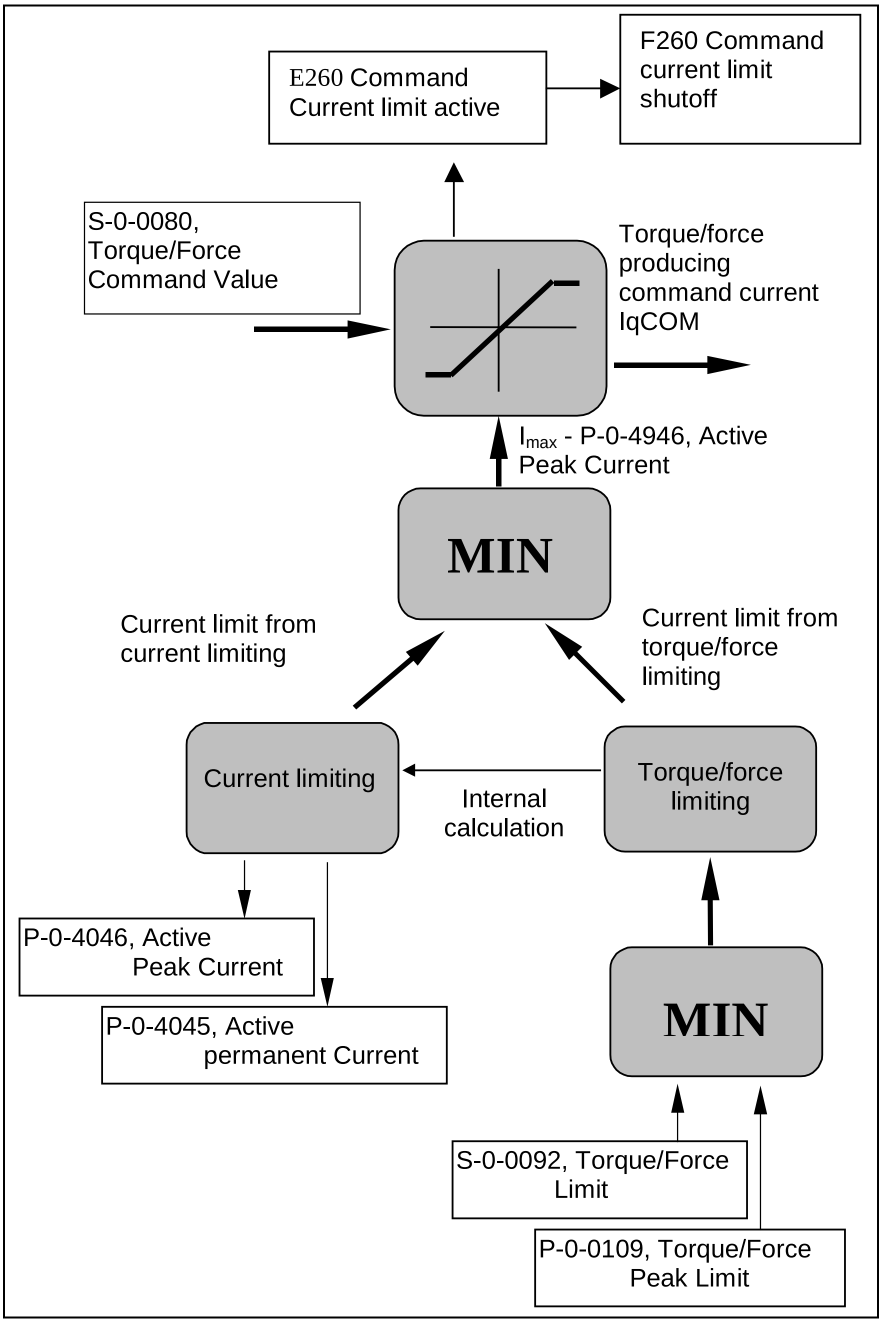


Fig. 9-40: Current limitation and torque/force limitation

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 limitation is active, then the drive generates warning **E260 Command Current limit active**. If the drive remains here for more than 5s, then it shuts itself down 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 shuts the function off.) With main spindle axes, the drives are generally accelerated to the current limit which is the reason why this function does not make sense.

Accel dependent current command value limitation

The function of accel dependent torque limitation is switched on with bit 12 of parameter **P-0-0538, Motor function parameter 1**.

The required accel torque is computed based on load moment of inertia, torque constant and specified command value accel. 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 appropriate to the machine.

Generating the accel command value with position-controlled drives:

$$a_{soll} = dv_{soll}/dt = d^2x_{soll}/dt^2$$

x_{soll}: Command position at position controller
v_{soll}: Command velocity on speed controller
a_{soll}: Command accel

Fig. 9-41: Accel command values with position-controlled drives

Generaing the accel command value with speed-controlled drives:

$$a_{soll} = dv_{soll}/dt$$

Fig. 9-42: Accel command value with speed-controlled drives

Required torque equals:

$$M_B = a_{soll} * J_{ges} = a_{soll} *(J_{Mot} + J_{Last})$$

J_{Mot}: Motor moment of inertia
J_{Last}: Load inertia

Fig. 9-43: Required torque

Required torque-generating motor current:

$$i_B = (a_{soll} * J_{ges})/Km$$

Km: Torque constant of motor
i_B: Accel current

Fig. 9-44: Motor current

The allowed maximum current thus equals

$$I_{max} = S\text{-}0\text{-}0092 * I_{DauerMotor}/100\% + |\, I_B \,|$$

$I_{DauerMotor}$: S-0-0111, Motor current at standstill

Fig. 9-45: Maximum current

or if the value is smaller than:

$$I_{max} = P\text{-}0\text{-}0109 * I_{DauerMotor}/100\%$$

Fig. 9-46: 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 control 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: Error reactions leading to velocity to zero (**P-0-0119, Best possible deceleration** =0) and fatal warnings, mean that the torque is limited to the value set in **P-0-0109, Torque/force peak limit**.

Limiting Velocity

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 allowable 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 storage of MHD-, MKD and MKE motors and does not need to be entered, but with other types of motors this value must be taken from the motor parameter specifications.

Limiting to Maximum Motor Velocity

The maximum motor velocity defines the maximum velocity of the drive. It becomes active and 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 defines the maximum velocity of the drive for the user. It becomes active as

- the monitor of the encoder 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 difference in the **position control** operating mode

  (see also "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 at 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

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 following measures:

- Software limits in the control (only active with axis in reference)
- Position limits in the drive (only active with axis in reference)
- Limit switches in the drive
- Safety limit switches (in the emergency/safety chain)

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

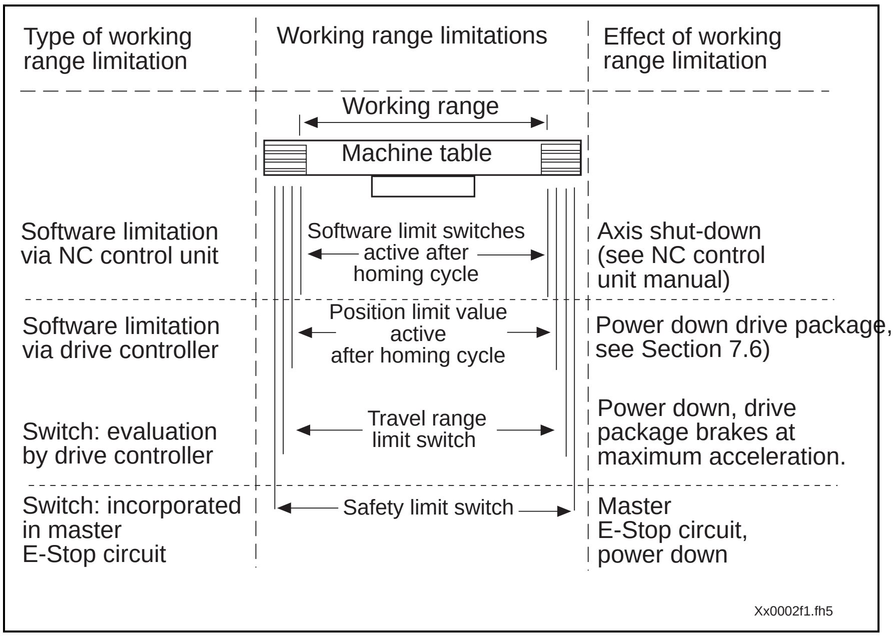


Fig. 9-47: Effect and ways of limiting the working range

There are two methods in the drive itself.

These are the monitors for

- Travel zone limit switches and
- Position Limit Values for the axis

The travel range is exceeded when either a travel zone limit switch is activated or one of the two axis limit values is exceeded by the homed position feedback value that is, the value referring to the machine zero point.

The drive's response to exceeding the travel range is selectable. The following possibilities exist:

- An error with a "Set Velocity Command Value to Zero" reaction and automatic drive enable shutoff
- A warning with a "Set Velocity Command Value to Zero" reaction and automatic reset when the error conditions are gone.

This is set in bit 2 of **P-0-0090, Travel limit parameter**:

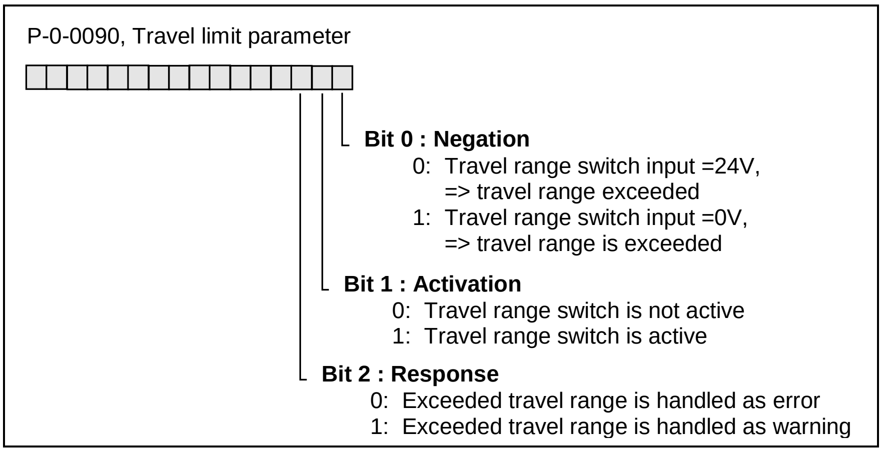


Fig. 9-48: Setting the drive reaction to exceeding the travel range (bit 2)

Note: Decelerating the axis with the use of a velocity command value ramp is not possible! Braking always occurs at maximum allowable torque

(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 of the velocity command value being set 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-installation

- Clear the error with the command **S-0-0099, C500 Reset class 1 diagnostic** or press the S1 button.
- Reactivate the drive with the 0-1 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 limits are still exceeded, only command values that go back into the allowable 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 created by the given position command values

Fig. 9-49: Monitoring the command values in error conditions

If command values are given that would lead out of the allowable 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 as a warning is handled with setting the velocity command value to zero.

The drive does not turn 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 limits are still exceeded, only command values that go back into the allowable range will be accepted. Monitoring the command values is dependent on the active operating mode. (See previous chapter.)

Travel Zone Limit Switch Monitoring

The state of the travel range limit switch is illustrated in parameter **P-0-0222, Status Inputs travel range limits**. Bit 0, in this case, is the positive end switch, bit 1 the negative one.

The monitor for exceeding the travel zone limit switch is only activated if

- the monitor is switched on in bit 1 of **P-0-0090, Travel limit parameter**

Exceeding the travel zone limit switch is recognized when these are activated. The diagnostic message depends on the type of reaction:

How handled:	SS display:	Diagnostic message:
As an error	F643	**F643 Positive travel limit switch detected**
	F644	**F644 Negative travel limit switch detected**
As a warning	E843	**E843 Positive limit switch activated**
	E844	**E844 Negative limit switch activated**

Fig. 9-50: Diagnostic message when travel zone limit switch is exceeded

Travel Zone Limit Switches - Activation and Polarity

The travel zone limit switches are activated with the parameter **P-0-0090, Travel limit parameter**. Additionally, the inputs can be inverted in this parameter (0V on E2/3 -> Travel range exceeded).

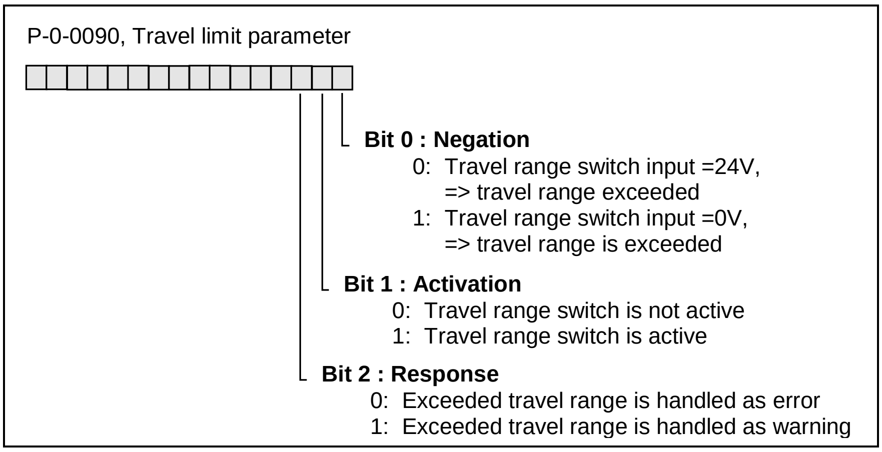


Fig. 9-51: Activating and negating the limit switches (bit 0 or 1)

Axis Limit Values

The monitor for exceeding the axis limit parameters:

- **S-0-0049, Positive position limit value**
- **S-0-0050, Negative position limit value**

is executed only if

- the encoder system of the active operating mode has been homed, i.e. the position encoder values are in relation to the machine's zero point. The **S-0-0403, Position feedback value status** is therefore 1

and

- the monitor for the axis limit values in **S-0-0055, Position polarities**, bit 4 was activated.

It is recognized that the axis limit values have been exceeded if the position feedback value of the active operating mode exceeds the travel range set by the axis limit values.

Bit 3 of the parameter **S-0-0147, Homing parameter** determines whether the position feedback value of the encoder 1 or of encoder 2 is monitored. If drive-internal interpolation is used as the active operating mode, the drive checks to see if the target position is outside of the axis 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 for the case that the axis limit values have been exceeded depends on the type of reaction:

How handled:	SS display:	Diagnostic message:
As an error	F629	**F629 Positive travel limit exceeded**
	F630	**F630 Negative travel limit exceeded**
As a warning	E829	**E829 Positive position limit exceeded**
	E830	**E830 Negative position limit exceeded**

Fig. 9-52: Diagnostic message when axis limits have been exceeded

Axis Limit Values - Activation

The axis limit value monitor is activated in bit 4 of **S-0-0055, Position polarities**.

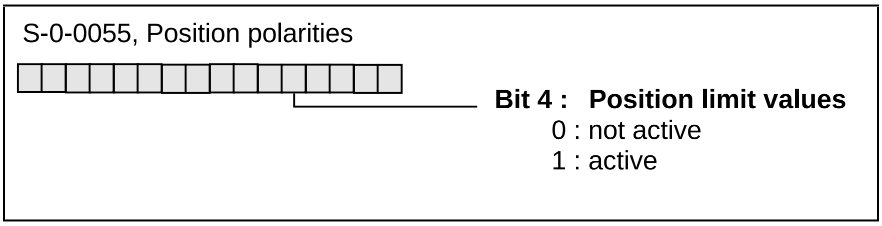


Fig. 9-53: Activating the axis limits

Travel Zone Limit Switches - Connection

see project planning

9.5 Drive Error Reaction

The error response depends on the current error class.

If an error is recognized in the drive controller, a preset error response occurs.

This drive error response 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 defines the behaviour in the event of a fault.

There are 4 error classes, which have different priorities.

(see also "Error Classes")

Error Class	Diagnostic Messages	Drive Response
Fatal	F8xx	The error response parameter settings in **P-0-0117, NC reaction on error** and **P-0-0119, Best possible deceleration** will be ignored, since a driver response 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 response corresponds to the settings P-0-0117 = 0 (no NC Reaction) P-0-0119 = 0 (Velocity Command Value Reset). This setting provides the fastest stop of the axis if the drive range is exceeded.
Interface	F4xx	A response from the control is impossible, since the communication to the control became inoperative. The drive proceeds instantly with **P-0-0119, Best possible Deceleration**.
Non-fatal	F2xx F3xx	The drive conducts the decel procedure set in **P-0-0117, NC reaction on error** and **P-0-0119, Best possible deceleration.** If NC reaction is set as an error response, 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 a controlled standstill. The drive then conducts the response set in P-0-0119.

Fig. 9-54: Error Response of the Drive

Best Possible Deceleration

The drive reaction **P-0-0119, Best possible deceleration** is conducted automatically with

- interface errors F4xx
- non-fatal errors F2xx

At the end of each error response, 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:	Response
0	Velocity Command Value Reset
1	Torque Disable
2	Velocity command value to zero with command ramp and filter
3	Return motion

Fig. 9-55: Setting options for Best possible Deceleration

The drive response, which is defined as "Best possible Deceleration," controls the response of the drive if

- the drive enable signal changes from 1 to 0 (disable the drive enable)
- the operating mode is switched to parameter mode while the drive is enabled. (Reset of the communication phase)

Velocity Command Value Reset

Best possible deceleration P-0-0119 = 0

Given an error, the drive will stop with command value = 0. The drive stops with its maximum permissible torque.

(See also section: "Current Limit").

Failure reaction sequence with spindle brake present

The procedure for the motor brake activation (if mounted) and the power stage disable with velocity command value deceleration to zero (with spindle brake) are displayed below.

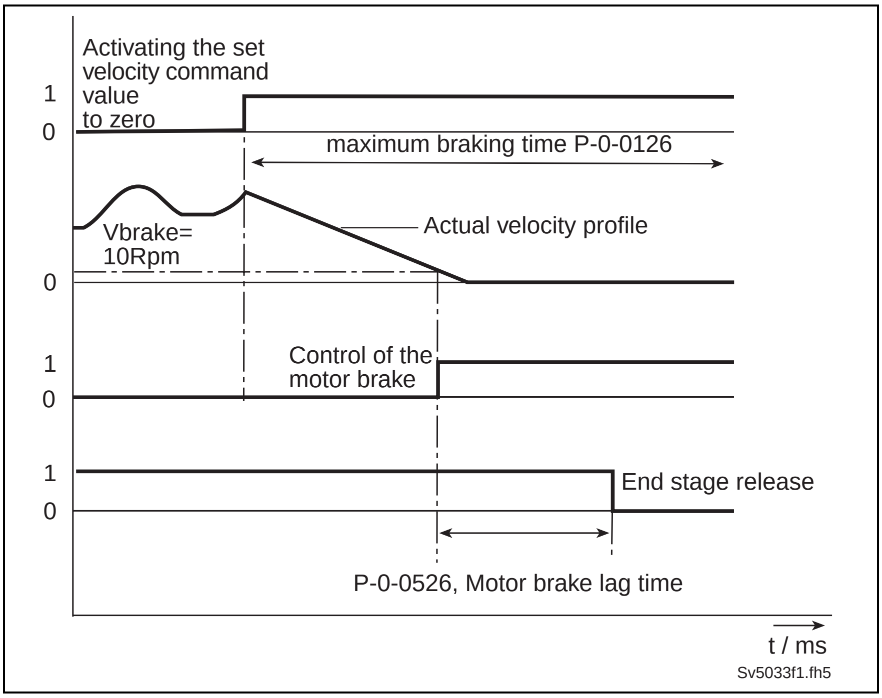


Fig. 9-56: Time sequence of the velocity command value reset

Note: Activation of the motor holding brake depends on **P-0-0525,** bit 1.
See section: "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

Best possible standstill P-0-0119 = 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 particularly with spindles.

Note:	It is not sensible to set the best possible standstill to torque disable when using a motor holding brake at the same time. In this case, when performing the best possible standstill, the drive does not brake actively, but only with the holding brake. After 20000 turns, the brake is at the end of its life.

Note:	The error reaction "**Torque disable**" is absolutely necessary with **fatal errors (F8xx)** because braking with a defective end stage or feedback is no longer possible!

DANGER

Drive continues to move unbraked with 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 section: "Motor holding brake“.

The temporal behavior of the brake in conjunction with an error reaction depends on the brake.

Torque disable with brake type: Spindle brake

The motor holding brake is not activated until the motor speed drops **below 10min^{-1}.**

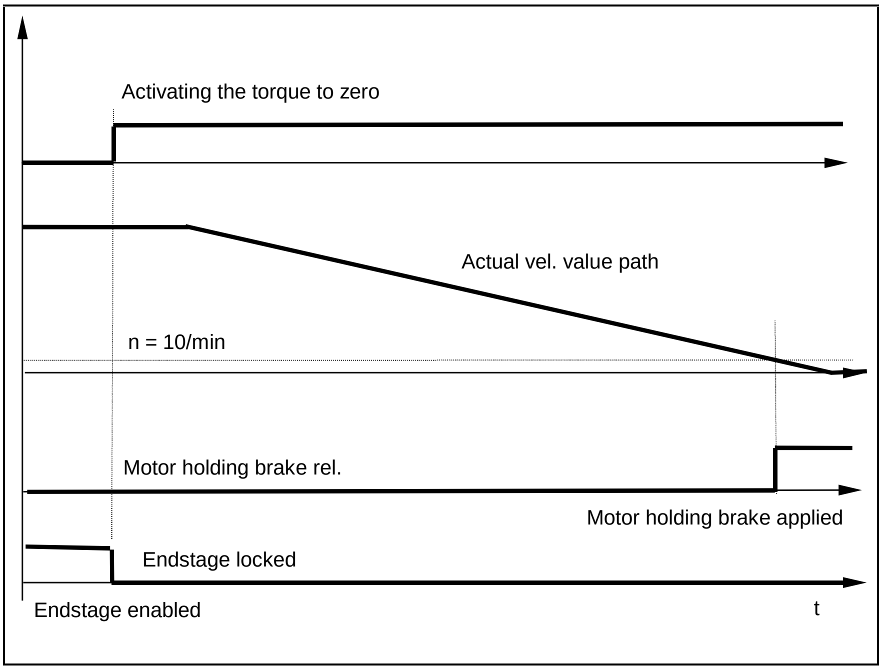


Fig. 9-57: Time diagram with torque to zero and **P-0-0525, Type of motor brake, Bit 1 = 1**

Torque disable with brake type: Servo brake

The motor holding brake is immediately activated!

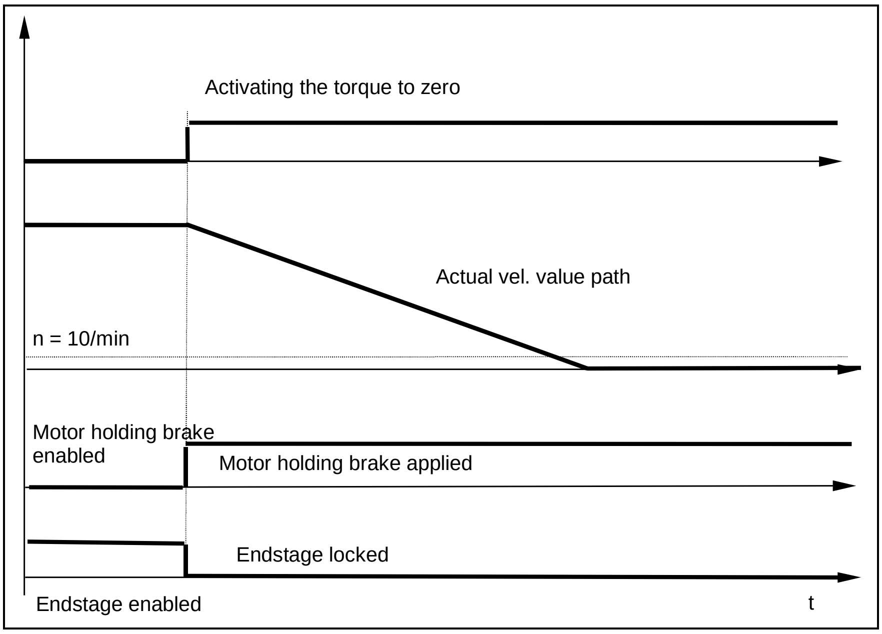


Fig. 9-58: Time diagram with torque to zero and **P-0-0525, Type of motor brake, Bit 1 = 0**

See also chapter: "Motor Holding Brake".

Velocity command value to zero with filter and ramp

Best possible standstill P-0-0119 = 2

In the event of an error the drive is brought to a standstill with velocity control 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-0-1222, Velocity command filter**

These parameters work as described in section: "Operating Mode: Velocity Control".

Note: Activation of the motor holding brake depends on **P-0-0525**, bit 1

See section: "Motor Holding Brake“

Return motion

Best possible Deceleration P-0-0119 =3

If a 3 has been set for "Best possible Deceleration" as a return motion, then the drive generates a position command profile to complete the desired travel distance in the case of an error. In other words, in the case of an error a relative process (travel) block is activated.

Note: If **P-0-0096** is positive, then in reference to the machine coordinate system the drive moves in the positive direction.

This travel block is defined by the parameters

- **P-0-0096, Distance to move in error situation**
- **S-0-0091, Bipolar velocity limit value**
- **S-0-0138, Acceleration bipolar**
- **S-0-0349, Jerk limit bipolar**

Once the drive has covered the distance, i.e., has reached the desired target position, then the motor holding brake is activated (if mounted) and the drive is switched torque free at the end of the motor brake delay time. The distance to move is considered as completed, i.e., the motor holding brake is activated, if

- target position = active position command value, i.e., bit 12 in **S-0-0013, class 3 diagnostics** = 1 and
- V_{actual} = 0, i.e., bit 1 in **S-0-0013, class 3 diagnostics** = 1 (feedback velocity smaller than **S-0-0124, Standstill window**).

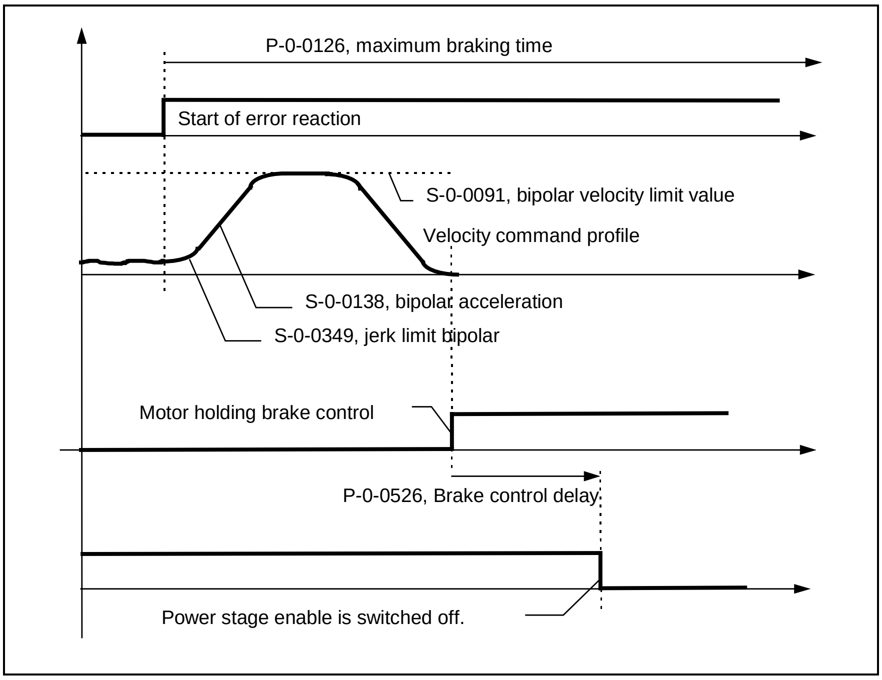


Fig. 9-59: Time sequence of the error reaction "return motion“

Error reaction "Return motion" with position limit values activated

If the drive-internal position limit values (**S-0-0049, positive position limit value and S-0-0050, negative position limit value**) have been activated, in other words,

- in **S-0-0055, position polarity parameter** bit 4 for "activating the position limit value" has been set to 1 and
- the encoder set in **S-0-0147, homing parameter, bit 3** is in reference (**S-0-0403, position status** = 1),

then the drive will not leave the travel range set when executing the error reaction "return motion".

Note: If the drive is in a position that would take it outside of the position limit values when executing a return motion, then the drive will, in this case, move to a position just in front of the relevant position limit value (precisely by **S-0-0057, Positioning window** in front of the position limit value

Power off on error

BB contact

Project planning 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, powering up requires the BB contact to open.

The signalling 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 signal **BBdrive** (X11/5 and X11/14).

The 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 therfore no power off on error (exception bleeder overload always switches power off)
1: package reaction and power off on error

Condition power on
0: power on possible with no error and operating mode (comm.phase 4)
1: power on possible if no error ("passive axis“)

Bit 2 : Instant of power off on error (only if bit 0 =1)
0: message generated immediately when error occurs (package reaction of all controllers on same power supply module (preferred setting)
1: message not generated until error reaction completed This means that power will not be shut off until the end of the error reaction

Bit 3 : Reaction to DC bus undervoltage
0: undervoltage is treated as if it were an error of non-fatal warning
1: undervoltage treated as if it were a fatal warning and prevents operation of motor

Bit 4 : Automatic clearing of the undervoltage error
0 : undervoltage error is stored
1 : undervoltage error deleted by drive upon removal of drive enable

Bit 5 : Undervoltage as non-fatal warning
0 : undervoltage as error or fatal warning
1 : undervoltage error treated as if it were a 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 (this is defined as a collection of multiple drives that have a power supply common to all and which can execute errors commonly), it is possible to inform 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. This communication utilizes **signal line "BBdrive" (x11/5 and X11/14).**

If the controllers without error detect the error state on the signal line BB drive, then they will, in turn, also conduct the error reaction and shut power off.

The point in time at which the drive package is signalled (at start or end of the error reaction) is set in bit 2.

Condition for Power On

Using bit 1 of **P-0-0118, Power off on error** it is possible to set that point in 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 initialization of the drive, in other words, in communication phase 0 ("passive axis").

If **bit1 = 0**, then the drive must be in communications phase 4 and without error before the power can be switched on for the first time.

In units that cannot release energy generated during brake (by means of bleeders or a mains-regenerated power supply) bit 2 should be set to 1 to prevent the drive coasting.

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 handle 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 mean value of a periodic quantity).

Undervoltage as fatal warning

Using **Bit3 = 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 parametrized in **P-0-0119, Best possible deceleration** is also not conducted.

Switching the motor 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 drive. Braking then takes place in generator mode.

Automatic deleting of the undervoltage

If undervoltage is treated as an error **(bit 3, 5 = 0),** then bit 4 can be used to set an automatic delete 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 **Bit5 = 1** it is possible to switch off every response to undervoltage in the DC bus, mains errors or mains section errors. 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 is initiated by the mains section for the power supply (mains coupled via the bleeder resistor). If the control does not response by bringing the machine to a standstill, then in response to this warning, error **F220 Shutdown due to bleeder overload** could be generated.

NC Response in Error Situation

NC response during an error situation is only possible during non-fatal errors. Otherwise the drive reacts immediately with an error response.

If the drive control device recognizes an error, it sends a message to the control (CNC) . The control can then decelerate the servo axis of the machine, thus preventing damage.

If this is desired, you have to delay the drive error reaction to allow the axis to continue movement to the values set by the control. This is achieved by setting the time delay between the recognition of the error and the drive's error reaction. This can be set in parameter **P-0-0117, NC Reaction on Error**.

The following applies:

Value of P-0-0117	Function
0	Drive proceeds the error reaction immediately after recognition of an error.
1	Drive continues for 30 sec in the selected operating mode, then follows the "best possible deceleration".

Fig. 9-61: NC Reaction on Error

Note: Activating the "NC Reaction on Error" is only recommended for controls that have a corresponding error reaction procedure.

Emergency stop feature

The E-Stop function supports the braking of the drive via a hardware input on the drive controller. It thus represents the option of shutting down the drive parallel to command communication, in an emergency.

Activation and how to set the deceleration is parametrizable.

The following parameters are used:

- **P-0-0008, Activation E-Stop function**
- **P-0-0223, Status Input 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.

Interpretation as warning E834 Emergency-Stop active

If the interpretation "fatal warning" has been parametrized there (bit 2 = 1), then the drive responds by switching off the external drive enable with the reaction parametrized 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 by reading **S-0-0012, Class 2 diagnostics.**

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 switched off. To re-activate the drive, the E-Stop input must become inactive, and another 0-1 edge must be applied to the external drive enable.

Interpretation as error with adjustable reaction

If bit 2 has been set to treat it as an error, then the reaction selected in bit 1 is performed. The error diagnosis **F434 Emergency-Stop** (or **F634 Emergency-Stop**), E-stop activated appears, and bit 15 is set in parameter **S-0-0011, Class 1 diagnostics** . Bit 13 is set in the drive status word of the drive telegram, i.e., drive interlock, error with class 1 diagnostics is set. 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 parameter P-0-0117, NC reaction on error.

F434 Emergency-Stop active

If bit 1 = 0, the drive shuts down according to **P-0-0119, Best possible deceleration**. The diagnosis upon activating the E-stop input then reads **F434 Emergency-Stop.**

Status of the Emergency-Stop Input

Interpretation as error with reaction as "Velocity command value to zero"

If bit 1 is set to 1 , then the drive is braked at maximum torque, if an E-Stop of the drive is triggered, until the speed = 0, regardless of the error reaction set in parameter P-0-0119. This corresponds to the best possible standstill "Velocity command value to zero". The diagnosis with the activation of the E-Stop input then reads **F434 Emergency-Stop.**

The state of the E-Stop input can be controlled via parameter **P-0-0223, Status Input E-Stop function**. The state of the E-stop input is stored there in bit 0.

Activation and Polarity of the E-Stop Input

For the activation of the E-Stop input and the selection of a response for shutdown of the drive, use parameter **P-0-0008, Activation E-Stop function**.

The following applies:

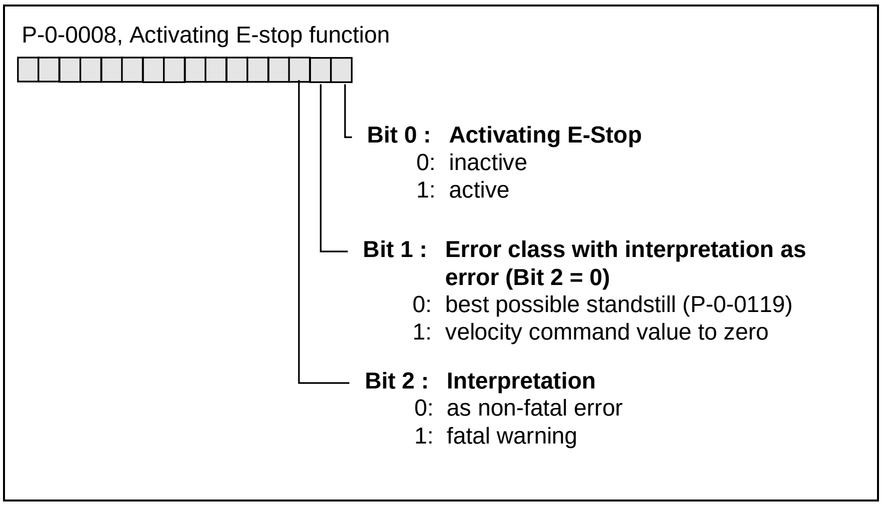


Fig. 9-62: P-0-0008, Activation of E-Stop-Function

Connection of the Emergency-Stop Input

see project planning manual.

9.6 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.

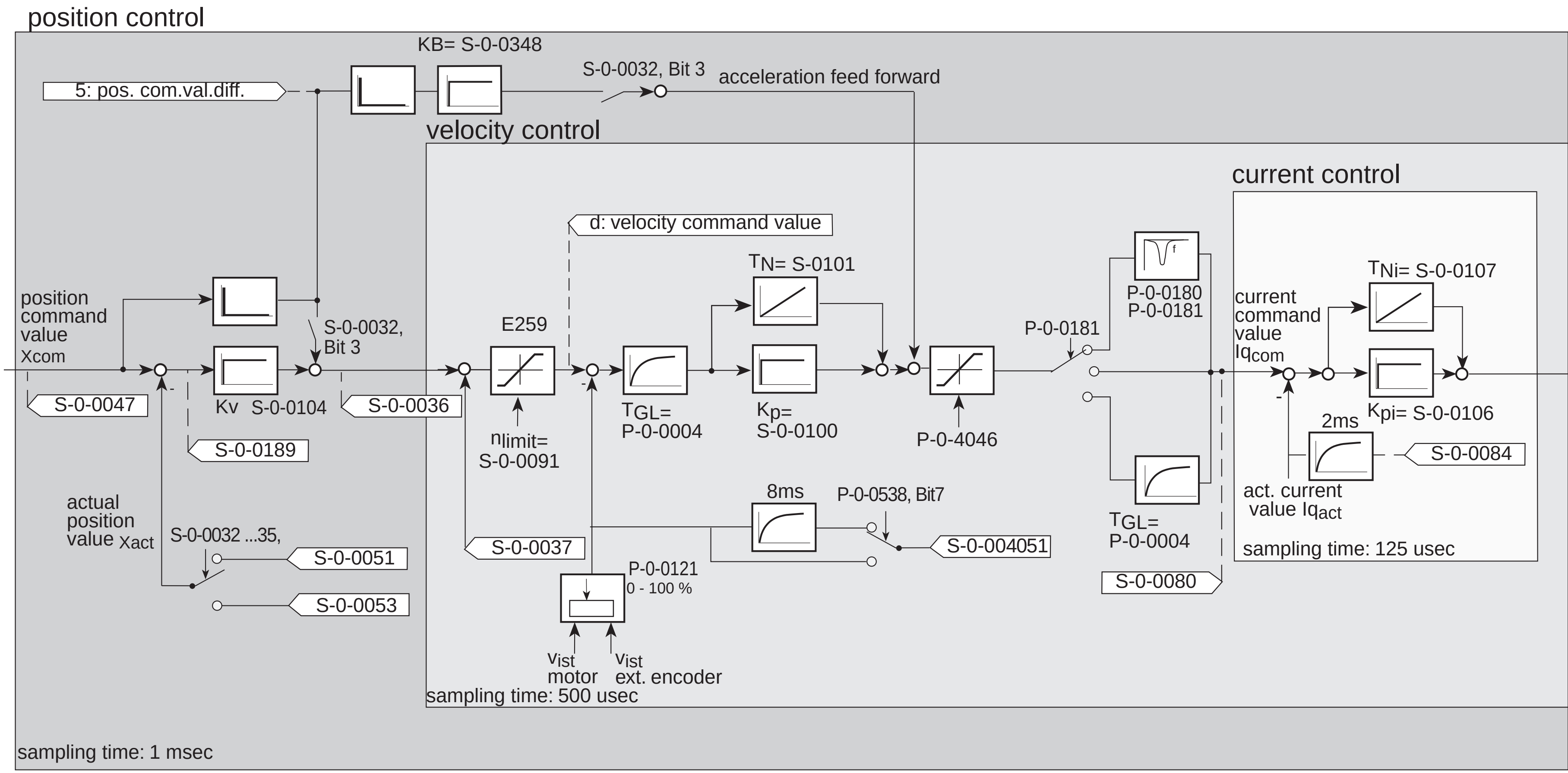
"Optimizing" the regulator settings is generally not necessary!

Determining the control loop settings requires expert knowledge. For this reason, application-specific control parameters are available for all digital Rexroth Indramat drives. These parameters are either contained in the 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 setup/service program. (See also "Load Default Feature")

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 setting. Specific aspects of some applications may require settings that deviate from these guidelines.

The control loop structure is made up of a cascaded (nested) **position, velocity and torque/force loop**. Depending on the operating mode, sometimes only the torque control loop or the torque and velocity control loops become operative. The control is structured as depicted below:



S-0-0032 Primary mode of operation
S-0-0036 Velocity command value
S-0-0037 Additive velocity command value
S-0-0040 Velocity feedback value
S-0-0047 Position command value
S-0-0051 Position feedback 1 value
S-0-0053 Position feedback 2 value

S-0-0080 Torque/force command
S-0-0084 Torque/force feedback value
S-0-0091 Bipolar velocity limit value
S-0-0100 Velocity loop proportional gain
S-0-0101 Velocity loop integral action time
S-0-0106 Current loop proportional gain 1
S-0-0107 Current loop integral action time 1

S-0-0189 Following error
S-0-0348 Acceleration feedforward prop. gain
P-0-0004 Velocity loop smoothing time constant
P-0-0121 Velocity mixfactor feedback 1 & 2
P-0-0180 Rejection frequency velocity loop
P-0-0181 Rejection bandwith velocity loop
P-0-0538 Motor function parameter
P-0-4046 Active permanent current

P-0-0421/424 d: velocity command value
P-0-0420/423 S-0-0036
ID no. and disignation of signal for analog output

Fp5057fq.fh7

Fig. 9-63: Control structure

Load Default

With the command **Basic Load**, you can activate the default control parameters for motor types with **motor feedback data memory** such as

- MHD
- MKD
- MKE

With these parameters, the relevant control 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.

Default values can be set for the following parameters:

- **S-0-0106, Current loop proportional gain 1**
- **S-0-0107, Current loop integral action time 1**
- **S-0-0100, Velocity loop proportional gain**
- **S-0-0101, Velocity loop integral action time**
- **P-0-0004, Smoothing Time Constant**
- **S-0-0104, Position loop Kv-factor**
- **P-0-0181, Rejection bandwidth velocity loop**

The feature **Load Default Settings** can be activated in two different ways:

- Automatic activation during the command procedure **S-0-0128, C200 Communication phase 4 transition check** for the first operation of this motor type with this drive.
- With the command procedure **S-0-0262, C700 Basic Load**

Automatic Execution of the Load Default Feature

If a controller has been operated with a specific type of motor, then the controller will detect this from that point forward. 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 data memory, with the value for 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 the user can reset the error and thus start the base load function, the option of saving a specific set of controller parameters is available.

Error **F208 UL The motor type has changed** can be reset in three different ways:

1.) executing the command
S-0-0099, C500 Reset class 1 diagnostic

2.) Actuating key S1

3.) Applying 24 V at error reset input

In all three cases, the load base values function is activated.

If the execution of load base values is not possible, then the relevant command error of command **S-0-0262, C700 Command basic load** will appear**.**

(Also see section: "Error Conditions of the Load Default Settings Procedure").

Run the Load Default Settings feature as a command

With parameter **S-0-0262, C700 Basic load**, the feature can be run as a command. This might be useful if manually changed control parameters are to be set back to the default values.

Error Conditions of the Load Default Settings Procedure

If the function started by running the command **S-0-0262, C700 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**.

The following could cause an error during basic load:

SS Display	**Diagnostic Message:**	**Cause:**
C702	Default parameters not available	Basic load (or load defaults) is impossible for the motor type selected, load defaults is only possible for MHD-, MKD and MKE
C703	Default parameters invalid	Connection of drive to motor encoder data memory is interrupted or feedback is defective
C704	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	A customer password has been set which locks out changes to 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 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 MKD/MHD motors or must be retrieved from the motor data sheet.

The parameters for the current controller are set via the parameters

- **S-0-0106, Current loop proportional gain**
- **S-0-0107, Current Loop Integral Action Time**

Warning

Changing the values defined by Rexroth Indramat can result in damages to the motor and the drive controller.

⇒ Changes to the current controller parameters are not permitted.

Setting the Velocity Controller

Pre-requisites: The current control must be 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**

as well as the parameters

- **P-0-0180, Rejection frequency velocity loop**
- **P-0-0181, Rejection bandwidth velocity loop**

The setting can be made by:

- conducting the load base values function once
- in accordance with the procedure described below
- by starting the command "automatic control loop settings"

Preparations for Setting the Velocity Controller

A number of preparations must be made in order to be able to set the velocity loop (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 as described in the user manual.
- The safety limit switches must be checked for correct operation (if available)
- 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 = 6500 ms (no integral gain)

P-0-0004, Smoothing Time Constant = Minimum value (= 500µs)

P-0-0181, Rejection bandwidth velocity loop = 0 Hz (deactivated)

Note: When determining the velocity control parameters, the functions for Torque and Backlash compensation should not be active.

Definition of the Critical Proportional Gain and Smoothing Time Constant

- After turning on the controller enable, let the drive move at a low velocity. Rotational motors: 10...20RPM, linear-Motors: 1...2 m/min)
- **Raise the S-0-0100, Velocity loop-proportional gain** until unstable behavior (continuous oscillation) begins.
- Determined the frequency of the oscillation by oscilloscoping the actual velocity (see also "Analog Output"). If the frequency of the oscillation is much higher than 500Hz, raise the **P-0-0004, Smoothing Time Constant** until the oscillation ends. After this, increase the **S-0-0100, Velocity Control Proportional Gain** until it becomes unstable again.
- **Reduce the S-0-0100, Velocity loop proportional gain** until the oscillation ends by itself.

The value found using this process is called the "**critical velocity loop proportional gain".**

Determining the Critical Integral Action Time

- **Set S-0-0100, Velocity loop proportional gain** = 0.5 x critical proportional gain
- **Lower S-0-0101, Velocity loop integral action time** until unstable behavior results.
- **Raise S-0-0101, Velocity loop integral action time** until continuous oscillation vanishes.

The value found using this process is called the "**Critical Integral Action Time."**

Determining the Velocity Controller Setting

The critical values determined before 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 many 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	Kp = 0.5 • Kpcrit	Tn = 2 • Tncrit	Good stiffness and good command response
Feed axis on perforating press or chip-cutter machines	Kp = 0.8 • Kpcrit	Tn = 0	High proportional gain; no I-part, to achieve shorter transient periods.
Feed drive for flying cutting devices	Kp = 0.5 • Kpcrit	Tn = 0	Relatively undynamic control setting without I-part, to avoid structural tension between the part to cut off and the machine.

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 (gear) between the motor and the axis or by the spindle mechanics even in a narrow band. Thus, an increased drive dynamics with good stability can be achieved.

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 to 800 Hz range, depending on the rigidity (or elasticity) and spatial volume of the mechanical system.

This "two mass oscillation" usually has a clear resonance frequency which can be specifically suppressed by a notch filter (band suppressor) provided in the drive.

By 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 band suppression filter.

This results in greater contour accuracy and smaller cycle times for positioning processes, leaving sufficient stability margin.

The rejection frequency and bandwidth can be set. The rejection frequency is the one with highest attenuation, the bandwidth determines the frequency range, at whose borders the attenuation is 3dB less. Greater bandwidth leads to smaller band attenuation of the center frequency!

The following parameters can be used to set both:

- **P-0-0180, Rejection frequency velocity loop**
- **P-0-0181, Rejection bandwidth velocity loop**

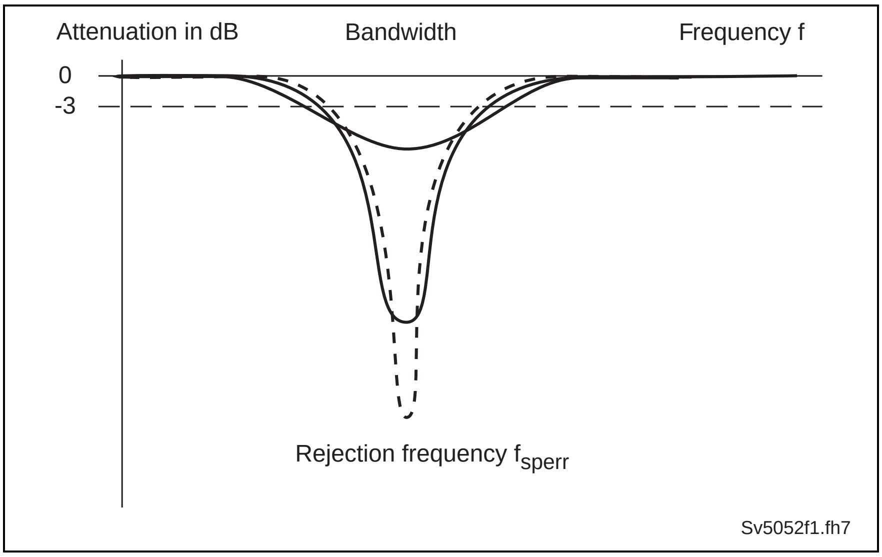


Fig. 9.66: Amplitude response of the rejection filter in terms of bandwidth - qualitative

To set the band filter, we recommend the procedure described as follows:

Pre-settings

⇒ Set rejection filter inactive. Set 0 in parameter **P-0-0181 Rejection bandwidth velocity loop.**

Determing resonance frequency

⇒ Connect oscilloscope to analog output channels. Assign velocity feedback value to analog output 1 (in **P-0-0420, Analog output 1, signal selection** "S-0-0040" and in **P-0-0422, Analog output 1 scaling** enter the scaling, e.g., 100 Rpm / 10 Volts.

- 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 with a rubber hammer.

⇒ Record the time of the velocity oscillations with an oscilloscope or oscilloscope function and analyze the 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 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** means 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 responses 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 (see above).

Filtering with double smoothing filter

⇒ Optimization of the control loop with a notch filter (band suppression) 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 low pass response) 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 notch filter as well as the assigned parameter **P-0-0180, Rejection frequency velocity loop** are deactivated. Instead of the notch filter, a smoothing filter is activated in the control loop. This uses the same smoothing time constant T_{gl} as the smoothing filter with **P-0-0004 Velocity loop smoothing time constant**. Together with the smoothing filter at the input of the velocity controller, you obtain a low pass filter of 2nd order (2 poles). Frequencies greater than the cutoff 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**.

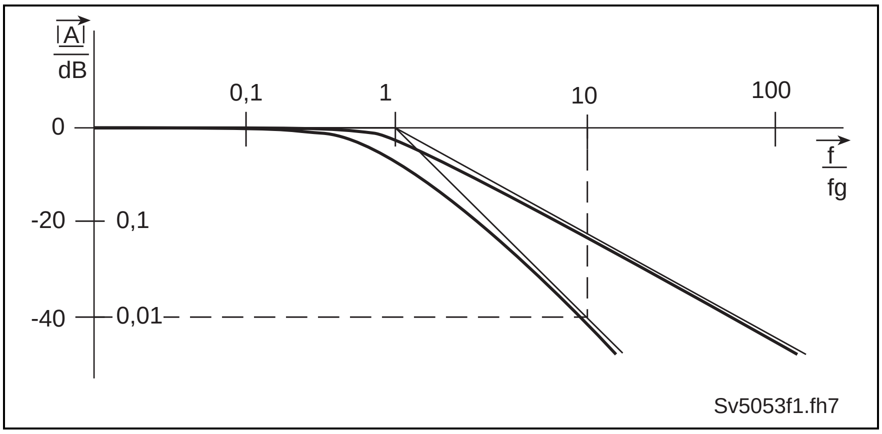


Fig. 9-67: Frequency response of low pass filters with 1 pole and with 2 poles

Note: The adjustment 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 if an operating mode is active with which the velocity control loop in the drive is closed and monitoring activated (always except with torque control)

Activating the monitor

The monitor is activated with parameter **P-0-0538, Motor function parameter 1**.

The structure of the parameter:

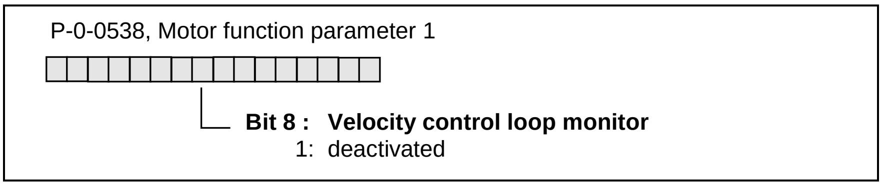


Fig. 9-68: P-0-0538, Motor function parameter 1

See also the parameter description: **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!

The causes of a monitor trigger

The velocity control loop monitor is designed to monitor for those faults that could lead the motor torque in the wrong direction.

The following options are basically possible:

- incorrect poles 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

The following criteria must be met for the velocity control loop monitor to be triggered :

- Current command value limited by **P-0-4046, Active peak current**
- motor accelerating in the wrong direction
- and actual velocity control value is > $0.0125 * n_{Max}$

Setting the position controller

Pre-requisite: Current and speed control must be correctly set.

The position controller can be set with the parameter

- **S-0-0104, Position Controller Kv Factor**

This can be set by either executing the load default settings procedure 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 must be completely assembled and ready for operation.
- The drive controller must be properly connected as described in the user manual.
- The safety limit switches must be checked for correct operation (if available)
- Operate the drive in a mode that closes the position loop in the drive (Operating Mode: Position Control).
- The 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, i.e., with a jog function at a connected NC Control (Rotating Motors: 10...20 Rpm, linear-Motors: 1...2m/min).
- Raise the K_v-factor until instability appears.
- Reduce the K_v-factor until the continuous oscillation ends by itself.

The Kv factor determined through this process is the "**Critical position control loop gain".**

Determining the Position Controller Setting

In most applications, an appropriate position controller setting will lie between 50% and 80% of the critical position controller loop gain.

This means:

S-0-0104, Position Loop KV-Factor = 0.5..0.8 • K_{vcrit}

Position Control Loop Monitoring

The position control loop monitor helps to diagnose errors in the position control loop.

Reasons for errors in the position control loop can be:

- Exceeding the torque or acceleration capability of the drive.
- Blocking of the axis’ mechanical system
- Disruptions in the position encoder

The monitoring of the position circuit is only active when an operation mode with closed position loop is active in the drive.

To set and check the monitoring function, two parameters are used:

- **S-0-0159, Monitoring Window**
- **P-0-0098, Max. Model Deviation**

If the drive detects an error in the position control loop, the error message

- **F228 Excessive deviation**

is issued.

General Operating Characteristics of Position Control Loop Monitoring

To monitor the position control loop, a model actual position value is computed, which depends only on the commanded position profile and the set position loop parameters. This model position is compared continuously to the actual position. If the deviation exceeds **S-0-0159, Monitoring Window** for more than **8msec**, an error **F228 Excessive deviation** will be generated.

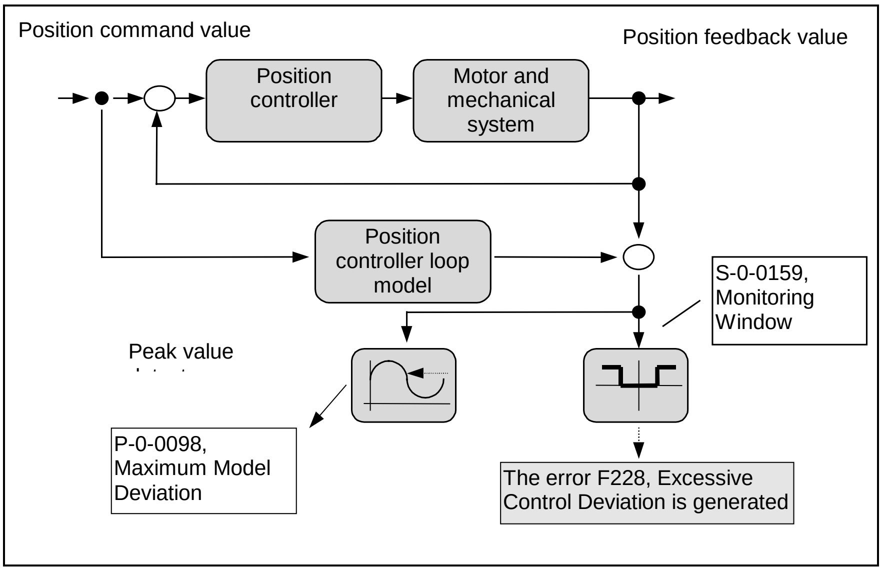


Fig. 9-69: Schematic of Position Control Loop Monitoring

Note: For accurate monitoring, the actual feedback value from the 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.
- The axis in question should be checked mechanically and should be in its final state.

settings

The position control loop monitor settings are performed:

- Through the connected control, you should proceed in a typical operation cycle. In this mode, move at the maximum projected velocity.
- In parameter **P-0-0098, Max. Model Deviation**, the maximum deviation between the actual feedback value and the expected feedback value is always displayed. (Note: The contents of this parameter are not saved. After enabling the drive, this parameter equals zero.)
- This value can be used to help set the monitoring window. Parameter **S-0-0159, Monitoring Window** should 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:

Content of P-0-0098, Maximum Model Deviation:

0.1 mm

⇒ Determination for the parameter S-0-159, Monitoring Window:

0.2 mm (= 2 x 0.1 mm)

Deactivation of the Position Control Loop Monitoring

It is strongly recommended to activate the position loop monitoring. However, there are exceptions for which the position loop monitoring must be deactivated. You can do that with the parameter **S-0-0159, Monitoring Window**, if it is set to very high values.

Note: By default, the Position Control Loop Monitoring 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 brake phases through activation of the acceleration feed forward.

Typical applications for the use of the acceleration feed forward:

- Free form surface milling
- Grinding

To set the acceleration feed forward, use the parameter

- **S-0-0348, Proportional Gain Acceleration Feed Forward**

This value can be determined as follows.

Requirements for a Correct Setting of the Acceleration Feed Forward

- Velocity and position loop have to be set appropriately.
- For the Position Controller, a **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 the 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 the preset value for the acceleration feedforward. For this purpose, you need the size of the complete inertia momentum translated to the motor shaft ($J_{Motor}+J_{Load}$) of the axis. This value is known approximately from the size and set-up of the load. 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** Kt. The preset value is calculated as:

$$Acceleration\ Feedforward = \frac{J_{Motor} + J_{Load}}{Kt} \times 1000$$

Acceleration Feedforward [mA/(rad\s²)]
J_{Motor}: Inertia momentum of the motor [kg m²]
J_{Load}: Inertia momentum of the load [kg m²]
Kt: Torque constant of the motor [Nm/A]

Fig.9-70: Value for the Acceleration Feedforward

The determined value is entered in parameter **S-0-0348, Acceleration Feedforward prop. Gain**.

Checking the effect of the acceleration feedforward and, if necessary, **fine tuning** of the parameter **S-0-0348, Acceleration Feedforward prop. Gain**:

The deviation of the actual feedback value to the position command can be displayed through the analog diagnostic output of the drive controller or the oscilloscope function. To check the effect of the acceleration feed forward, you must oscilloscope the signal during movement of the axis along the desired operation cycle. In acceleration and brake phases, the feedforward must reduce the control deviation drastically.

Setting the Velocity Mix Factor

With the help of the velocity mix factor, you can combine the velocity feedback value, used for velocity control, from the motor and the external measurement system. 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 Mixfactor Feedback1 & 2**

Precondition: The function is only applicable when there is an external measurement system. If this is not 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% actual value of the external encoder (P-0-0121 = 0)
  and
- 0% Velocity feedback value of the motor encoder
  /
  100% actual value of the external encoder (P-0-0121 = 100 %)

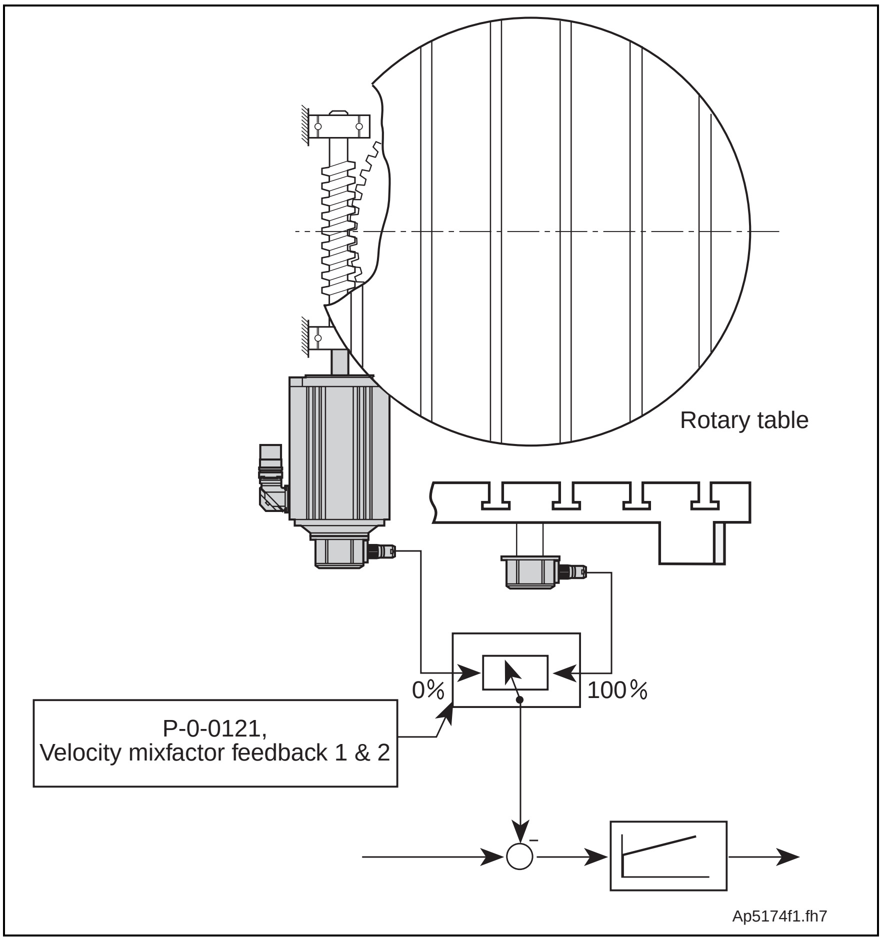


Fig. 9-71: Velocity Mixture Diagram

Setting the Frictional Torque Compensation

The drive-internal frictional torque compensation allows for direction-dependent switching of the torque command value (**S-0-0155, Friction Compensation**). The reason for this is to equalize the frictional torques of the connected mechanical system so that the deviations can be reduced during a directional reverse and so that the exactness of an axis can be increased.

Frictional torque compensation is used in precision tool machines.

Meaningful Use of Frictional Torque Compensation

- The frictional torque of the axis must be a relevant size. If the frictional torque portion is less than 10% of the rated torque of the active drive, then the frictional torque compensation has negligible results.
- The frictional torque to be compensated must remain basically constant independent from the current processing.

Preparation for Setting the Frictional Torque Compensation

- Velocity and position loops must be set according to specification.
- The NC control system must be connected and must allow for the jog feature.
- Travel range limits of the axis must be set and activated.
- If the axis has a temperature-dependent friction characteristic, then the axis must be brought to operating temperature before determining the compensation value.

Determining the Compensation Torque

1. Move the axis in jog mode at the maximum projected operating velocity. During this process, the torque command should be recorded (read) in the phases of constant velocity.
2. Do this procedure in both movement directions of the axis.
3. The value to be set for the frictional torque compensation should be taken from the values determined above. The following applies:

$$\text{frict. torque compens.} = (|\text{frict. value pos.}| + |\text{frict. value neg.}|) \times 0.5$$

Fig.9-72: Frictional Torque Compensation

9.8 Automatic Control Loop Settings

General Comments

To expedite drive parametrization, the firmware offers an automatic control loop setting. Using parameters **P-0-0163**, **Damping factor for autom. control loop adjust** and **P-0-0164**, **Application for autom. control loop adjust**, it is possible to control (control loop dynamics) the results.

Note: It is necessary **to move the drive** in order to conduct the automatic control loop settings.

Prerequisites for starting the automatic control loop settings

WARNING

⇒ Check and make sure that the emergency stop travel range limit switch is working.

See section: "Safety Instructions for Electric Servo Drives and Controls".

⇒ During the command **D900 Command automatic loop tuning,** the drive conducts its own external command value programmed motions.

Definition of travel range for control loop settings

Since the axis must be moved in order to identify and set the control loop, it is necessary to define a travel range. There are two options:

- Define a travel range by inputting the limits, **P-0-0166, Lower position limit for autom. control loop adjust** and **P-0-0167, Upper position limit for autom. control loop adjust** (a downwardly-compatible function).
- Input **P-0-0169**, **Travel distance for autom. control loop adjust** (needed with modulo axes!)

Note: The mode is selected with the use of parameter **P-0-0165, Selection for autom. control loop adjust**.

Inputting the limits P-0-0166, P-0-0167

If bit15 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

- an upper limit position **P-0-0166**
- and a lower limit position **P-0-0167**

This results in the value of **P-0-0169, Travel distance for autom. control loop adjust.**

Inputting P-0-0169, Travel range for automatic controller settings

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 autom. control loop adjust** and
- **Start position** (actual position) **at the start of a command**

This results in the value of **P-0-0166,** lower limit for automatic CL (start position - travel range) and of **P-0-0167**, upper limit for automatic CL (start position + travel range) in which the axis may move to execute the command.

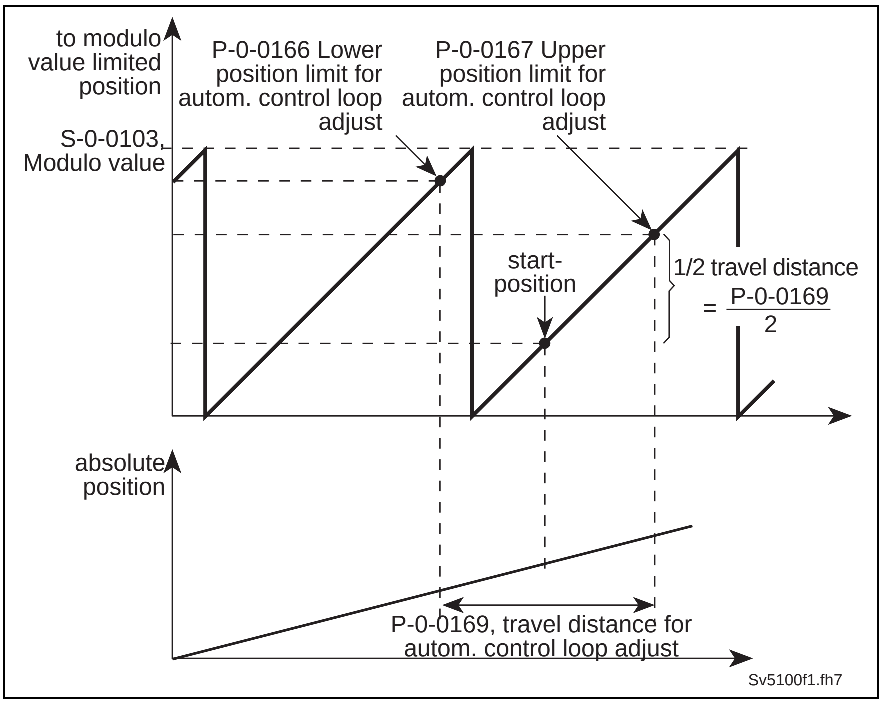


Fig. 9-73: Verfahrbereich bei autom. Regelkreiseinstellung bei Modulowichtung

Note: The travel range defined here is only monitored during the time that the command is being executed.

Possible errors:

D905 Position range invalid, P-0-0166 & P-0-0167

If the defined travel path equals less than six motor revolutions, then command error **D905 Position range invalid, P-0-0166 & P-0-0167** will be generated.

D906 Travel range exceeded

If the axis is not within the above defined range at the start of the command, then command error **"D906 Position range exceeded"** is generated.

Control loop settings

Before executing the command, set the default control parameters stored in the motor feedback. The setting of the axis must be stable so that the command can be executed without any faults.

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 issued.

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 setting.

- **P-0-0163, Damping factor for autom. control loop adjust** Use this parameter to select the desire control loop dynamics.
- **P-0-0164, Application for autom. control loop adjust** helps taking the mechanical conditions with controller optimization into account.
- **P-0-0165, Selection for autom. control loop adjust** Used to select functinalities (modes) of the automatic control loop settings.

Possible causes for command errors: "D903 Inertia detection failed"

- **S-0-0092, Bipolar torque/force limit value**
  The maximum torque for the automatic control loop settings can be programmed with parameter **S-0-0092, Bipolar torque/force limit value**. This can help limit the torque to prevent mechanical wear and tear.
- **S-0-0108, Feedrate override**
  The velocity of the automatic control loop settings can be programmed via the analog channel (Poti) with this parameter.
- **S-0-0259, Positioning Velocity**
  This sets the speed for the control loop settings. If the value is not high enough, the command error D903 is generated.
- **S-0-0260, Positioning Acceleration**
  The maximum positioning speed is set here. If the value is not high enough, then command error D903 is generated.

Note: The reasons that command error **D903 Inertia detection failed** is generated can either be an excessive inertia, a too slow speed, acceleration or torque.

Conducting Automatic Control Loop Settings

Note: **1)** The execution of the settings is connected with a drive motion. This means that 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 conduct the command must be generated prior to command start.

Start command

Initiated by writing into parameter **P-0-0162, D900 Command Automatic control loop adjust** with binary numeric value 3 (11b) (=command start).

Tripping a motion

An axis motion and thus the execution of a setting is only possible if the signal **Drive halt** has not been set.

Otherwise, **D900 Command automatic loop tuning** at the appears in the display start of the command and the axis does not move.

Triggering a motion by starting command D900

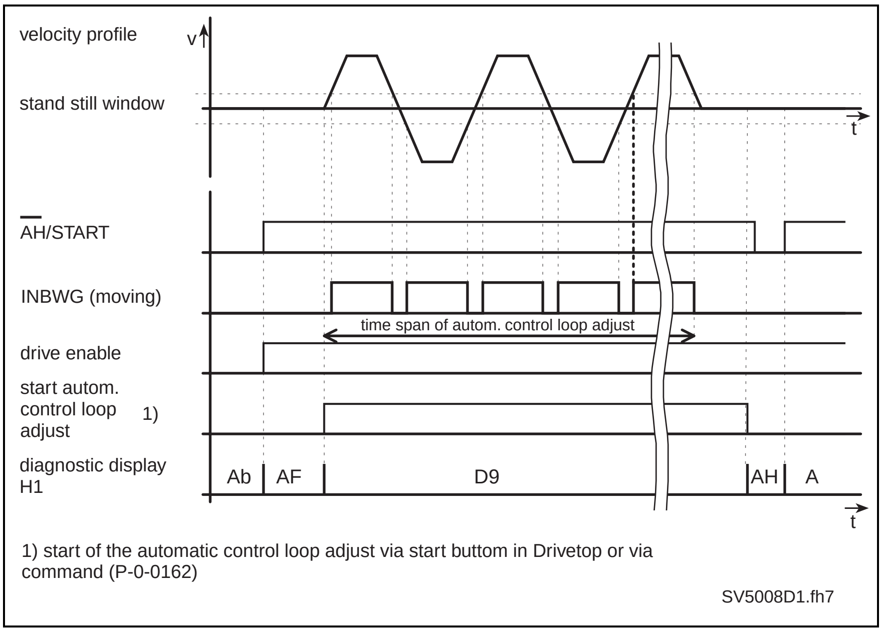


Fig. 9-74: Signal flow chart

Triggering motion with drive start

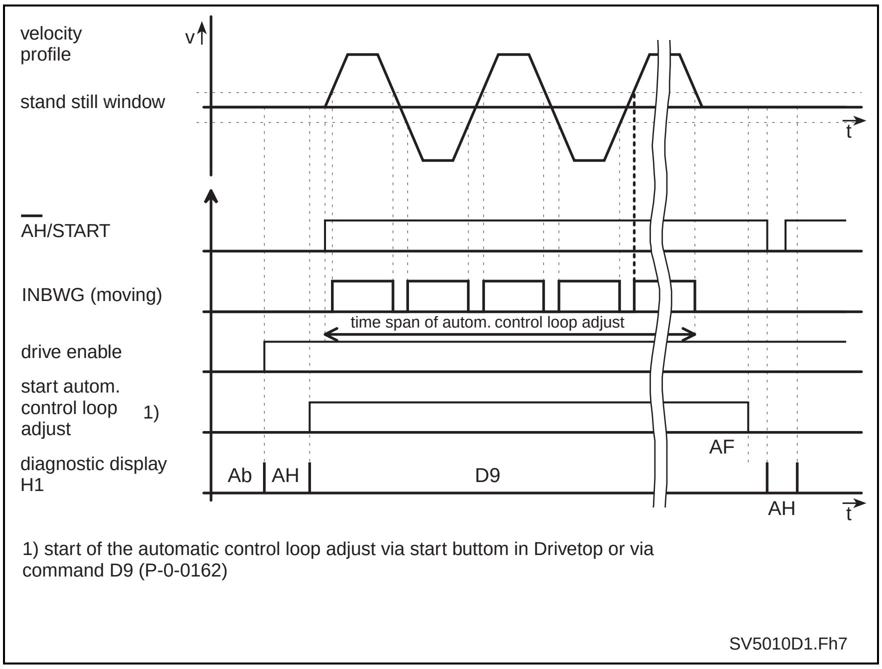


Fig. 9-75: Signal flow chart

Terminating command with drive halt

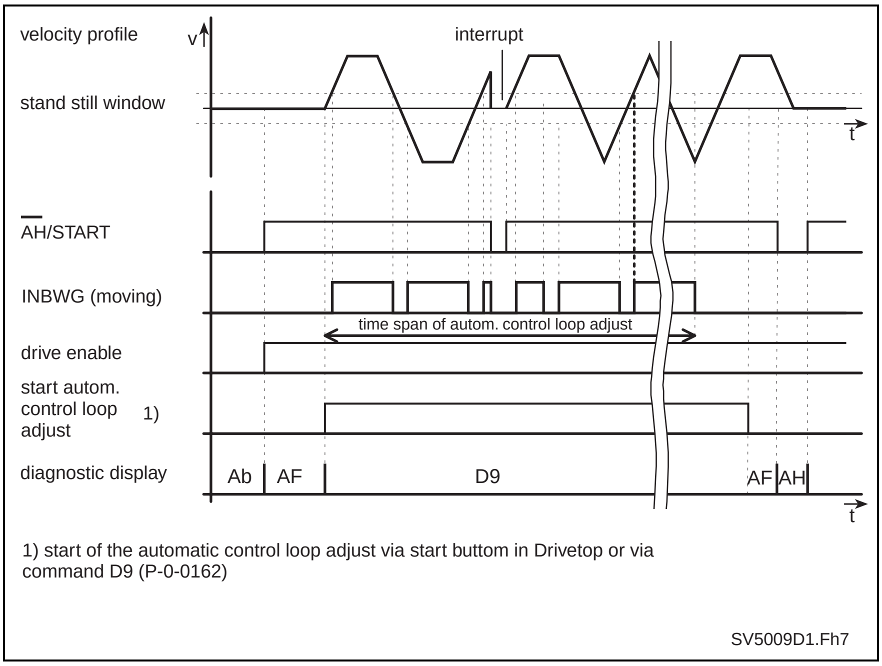


Fig. 9-76: Signal flow chart

Note: A further run with change 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

Note: A further run with change 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

Sequence:

1st step: Check for command errors at command start.

2nd step: **Determine total and extrinsic inertia** by evaluating accel and decel 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 speed control loop** and correct controller parameter, if need be, until correct 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 **new start** or **end of command**.

This drive here is idle (velocity = 0) and the display reads D9.

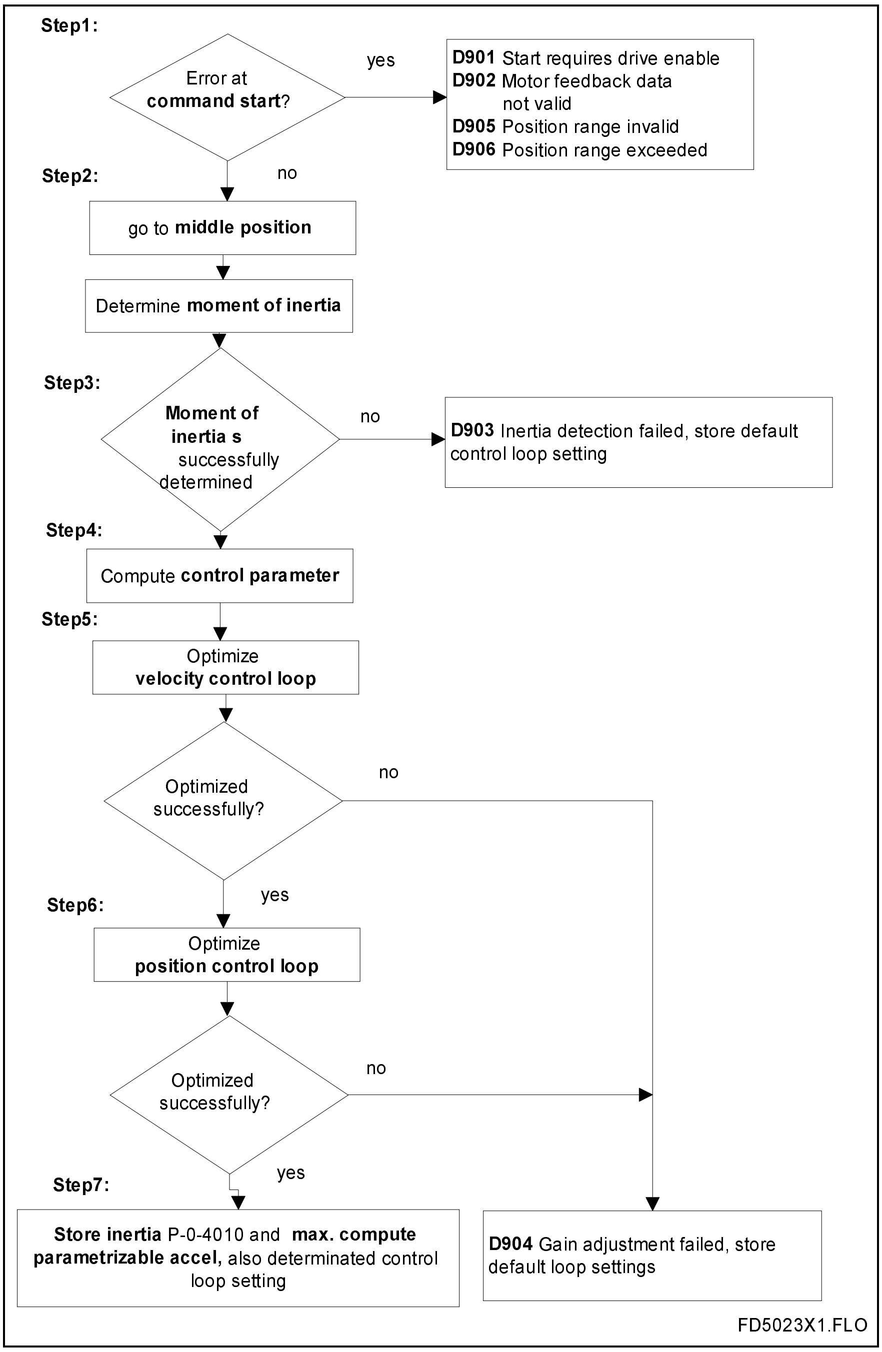


Fig. 9-77: Automatic control loop setting sequence

Results of Automatic Control Loop Settings

Note: The current control loop is not effected hereby as its setting is load-dependent and set to optimum current control parameters at the factory.

The results of automatic control loop settings depends on the selection in **P-0-0165**.

Parameter structure:

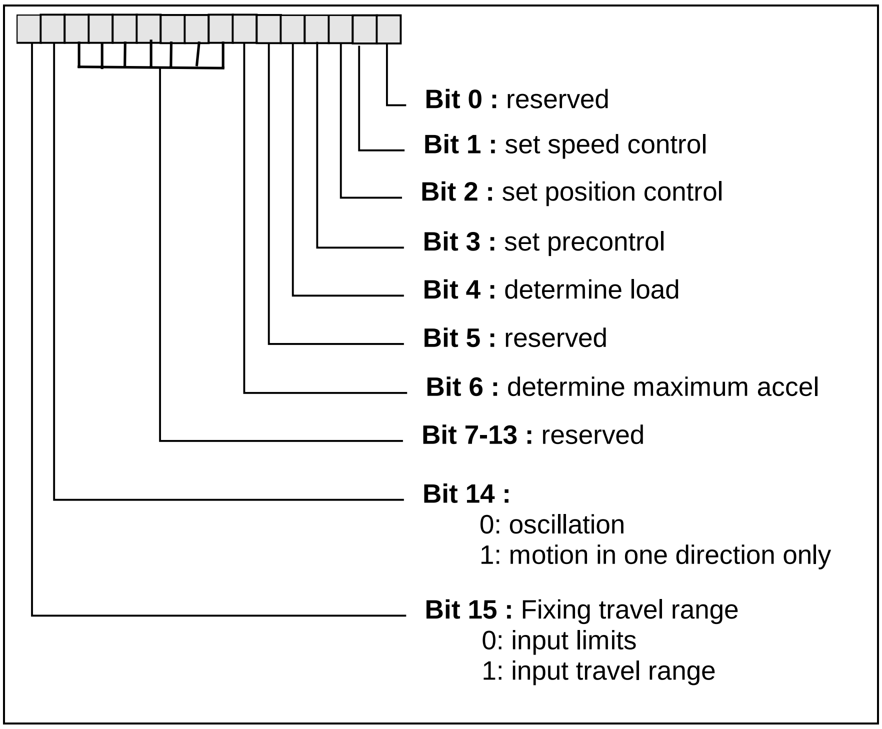


Fig. 9-78: Select parameter for automatic control loop settings

Possible results are:

- Set velocity control loop
- Set **position control loop**
- **P-0-4010, Load inertia** (reduced to motor shaft)
  The load determined for automatic control loop settings is stored here.
- **P-0-0168, Maximum acceleration**
  Maximum drive acceleration for loop settings is stored here.
- **S-0-0348, Acceleration feedforward gain**
  As the results of the automatic settings, the value for accel precontrol is calculated in accordance with the formula:
  S-0-0348 = (P-0-4010 + P-0-0510) / S-0-0051.

9.9 Drive Halt

The drive halt function is used to bring an axis to a standstill with a defined accel and defined jerk.

The function is activated:

- by clearing the drive halt bit (bit 13 in the master control word of command communication SERCOS).
- by setting drive halt input with parallel or analog interface to zero
- or by interrupting a drive control command (e.g., drive-guided referencing).

Pertinent Parameters

- **S-0-0138, Bipolar acceleration limit value**
- **S-0-0349, Jerk limit bipolar**
- **P-0-1201, Ramp 1 pitch**
- **P-0-1202, Final speed of ramp 1**
- **P-0-1203, Ramp 2 pitch**

The following parameters are used for diagnostic purposes:

- **S-0-0124, Standstill window**
- **S-0-0182, Manufacturer's status class 3**

The Functional Principle of Drive Halt

If the drive halt function is activated, then the drive does not follow the command values of the active mode but rather brings the drive to a halt while maintaining the parameterized accel.

The manner in which the standstill takes place depends on the previously activated operating mode.

Bringing to standstill in position control with the previously active limit accel and jerk

If a mode with drive-internal position command generation was active, then the standstill is in position control with the use of the previously active limit accel and limit jerk.

Operating modes with drive-internal position command generation are:

- drive-internal interpolation
- relative drive-internal interpolation
- positioning block mode
- jog mode.

Bringing to standstill in position control with S-0-0138 and S-0-0349

If previously a position-control mode without drive-internal position command generation was active, then the standstill takes place in position control with the use of accel in **S-0-0138, Bipolar acceleration limit value** an the jerk in **S-0-0349, Jerk limit bipolar**.

Operating modes without drive-internal position command generation are:

- position control
- angle synchronization
- step motor mode and so on.

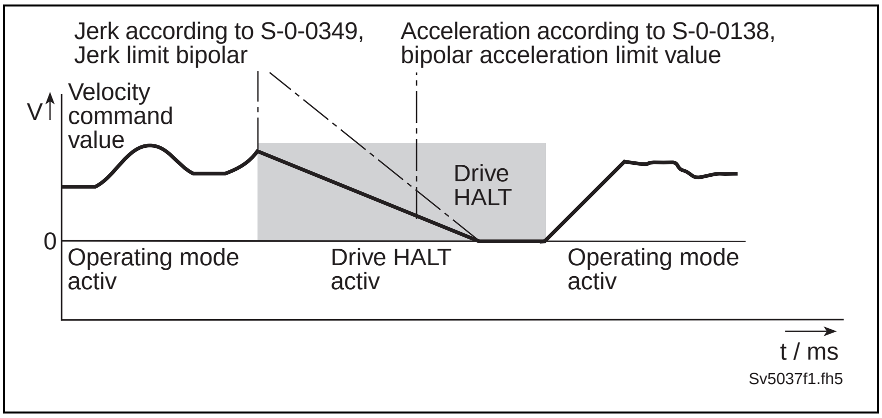


Fig. 9-79: Principle of drive halt with previously active position control without drive-internal position command value generation

Note: If an operating mode with position control with lag error was also previously activated, then the position controlled standstill is conducted with position control with lag error. Otherwise, the function is conducted without lag error.

Standstill in velocity control

If either the **velocity control or torque control modes** were previously active, then deceleration in velocity control uses parameters

- **P-0-1201, Ramp 1 pitch**
- **P-0-1202, Final speed of ramp 1**
- **P-0-1203, Ramp 2 pitch**

Note: In all cases, the SS display reads **AH** and the diagnosis in S-0-0095 reads A010 Drive HALT.

Drive halt acknowledgement

If the actual velocity falls below the value of the parameter **S-0-0124, Standstill window**, the bit 11 "Drive Halt Confirmation" will be set in **S-0-0182, Manufacturer class 3 diagnostics**.

Activating the operating mode

The selected mode becomes active once again if:

- bit 13 in the master control word is set back to "1".
- the drive halt input is set again (with parallel or analog interface)

Connecting the drive halt input

If command communication does not use a fieldbus, e.g., SERCOS interface or Profibus, then the hardware controls the drive halt function.

For more information on this see the Project Planning Manual, sec.: Drive halt and drive enable.

9.10 Drive-Controlled Homing

The position feedback value of the measuring system to be referenced forms a coordinate system referencing 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.

S-0-0148, C600 Drive controlled homing procedure command thus supports

- the establishing agreement between drive (measuring system) and the machine coordinate system in non-absolute measuring systems,
- and a drive-controlled running to the reference point in absolute measuring systems.

Drive-controlled homing means that the drive independently generates the necessary motion which corresponds to the homing velocity settings and homing acceleration settings.

Note: It is possible to perform this for either the motor encoder or the optional encoder.

Pertinent Parameter

To run this feature, use the following parameters:

- **S-0-0148, C600 Drive controlled homing procedure command**
- **S-0-0147, Homing parameter**
- **S-0-0298, Reference cam shift**
- **S-0-0299, Home switch offset**
- **S-0-0052, Reference distance 1**
- **S-0-0054, Reference distance 2**
- **S-0-0150, Reference offset 1**
- **S-0-0151, Reference offset 2**
- **S-0-0041, Homing velocity**
- **S-0-0042, Homing acceleration**
- **P-0-0153, Optimal distance home switch - reference mark**
- **S-0-0177, Absolute distance 1**
- **S-0-0178, Absolute distance 2**
- **S-0-0165, Distance coded reference offset 1**
- **S-0-0166, Distance coded reference offset 2**

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**

also can be used.

Setting the referencing parameters

The basic sequence is dependent on how parameter **S-0-0147, Homing parameter** has been parametrized.

The following settings are performed:

- referencing direction positive/negative
- referencing with motor or optional encoder
- evaluation of the home switch yes/no
- evaluation of the marker 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
Homing
0: with motor feedback (feedback 1)
1: with external feedback (feedback 2)

Bit 5: Home switch evaluation
The home switch is
0: detected.
1: not detected.

Bit 6: Reference mark evaluation
The Reference mark is
0: detected.
1: not detected.

Bit 8,7: Stop/positioning/run path
0 0: once the reference switch or reference marker have been overtravelled the drive stops and switches into the coordinate system
0 1: after the reference swtich of marker have been overtravelled, the drive positions at the reference point and switches into the coordinate system
1 0: drive always run path that is needed to overrun two sequential reference markers and then switches into coordinate system **(only with distance-coded reference marks !)**
1 1: <u>Not allowed!</u>

Fig. 9-80: Structure of parameter S-0-0147, Homing parameter

Note: The sequence also depends on the type and arrangement of the reference markers in terms of the referenced encoder. (see next section).

Overview of the Type and Allocation of Reference Marks of Non-Absolute Measuring Systems

For better a understanding, you can divide the measurement systems into 4 groups according to the type and configuration of their reference marks.

- **Type 1**: Measurement systems with absolute singleturn range, such as the Singleturn DSF or Resolver. These measurement systems have an absolute range of one encoder revolution or fractions of it (resolver). Typical systems are
  - the encoders for the MHD, MKD and MKE motors
  - the GDS measurement system.
  - Singleturn encoder with ENDAT-Interface from Heidenhain
- **Type 2**: Incremental rotational measurement systems with a reference mark for each encoder rotation, such as the ROD or RON types from the Heidenhain Company.
- **Type 3**: Incremental translation measurement systems with one or several reference marks, such as the LS linear scaling of the Heidenhain Company.

- **Type 4**: Incremental measurement systems with distance coded reference marks, such as the LSxxxC linear scaling of the Heidenhain Company.

The drive-internal detection for the configuration 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's a rotary or a linear measurement system, and bit 1 decides whether the measurement system has distance-coded reference markers.

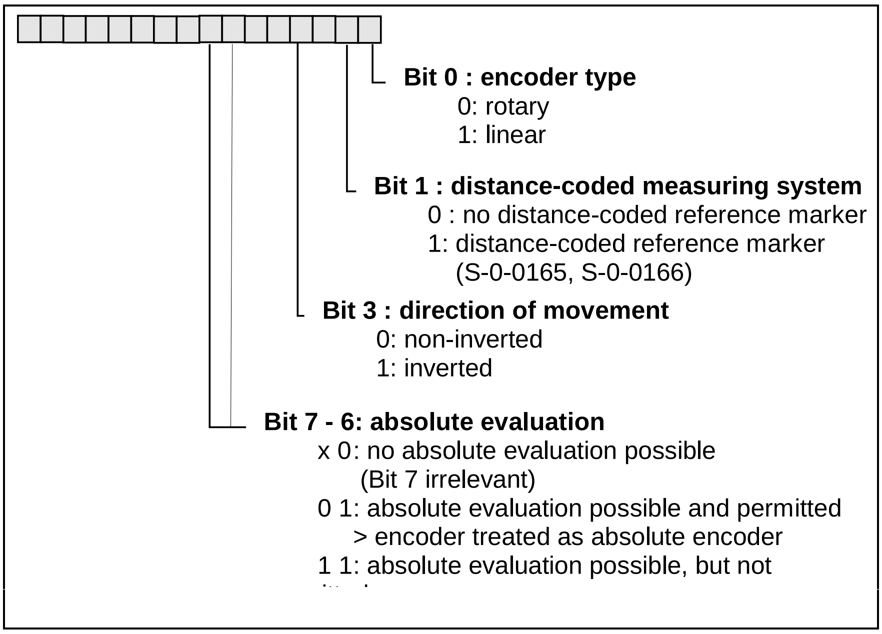


Fig. 9-81: Structure of the position feedback type parameters S-0-0115 / S-0-0277

Note: For measurement 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 position of the home switch edge has a lesser precision 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 in this case is made between "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 marker plus the value in **S-0-0150, Reference offset 1** or **S-0-0151, Reference offset 2**. Once the reference marker is detected, the drive knows the position of this marker 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.**
- 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 marker 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 reference 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 the functional description: "Commissioning with Evaluation of reference marker/home switch edge"

See also the functional description: "Commissioning with Evaluation of distance-coded reference marker"

Functional Principle of Drive-Guided Referencing with Absolute Measuring Systems

If the referenced measuring systems (per bit 3 of S-0-0147) is to be evaluated as an absolute measuring system, i.e., in the relevant encoder type parameter (S-0-0277/S-0-0115) bit 6 is at "1" and bit 7 on "0", then command **S-0-0148, C600 Drive controlled homing procedure command** supports two different purposes**:**

- drive-guided traveling to the reference point
- triggering the switch of the position feedback value if absolute measurement is conducted with drive enable applied.

Drive-guided traveling to reference point

If the absolute encoder is referenced, 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** 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-guided referencing". 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 absolute dimension set

If command **P-0-0012, C300 Command 'Set absolute measurement'** is conducted with drive enable applied, then the switching by the drive of the actual position 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 section: "Setting the Absolute Dimension"")

Sequence control "Drive-Controlled Homing"

The command 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:

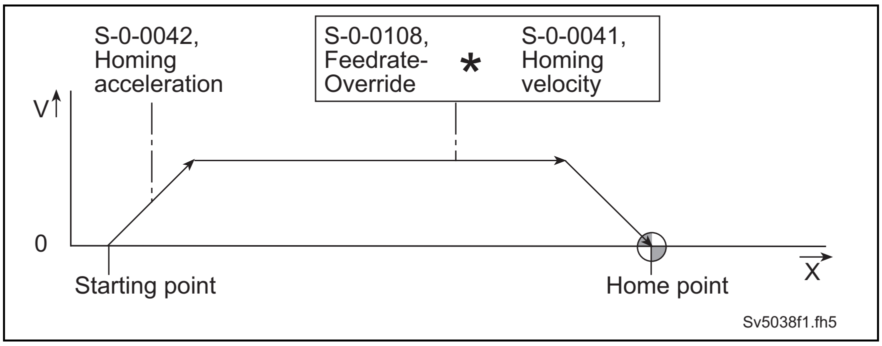


Fig. 9-82: Position command profile with homing velocity and homing acceleration

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** is set with zero, the warning Warnung **E255 Feedrate-Override S-0-0108 = 0** will be output.

motional process

The motional process during drive-controlled homing of non-absolute encoders can be made up of up to three processes:

- If the home switch evaluation process has been activated and there are no distance-coded reference markers, then the drive accelerates to the homing 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 referencing (**S-0-0400, Home switch** = 1), the drive at first accelerates in the opposite direction until the negative home switch edge is detected, and then reverses the direction.

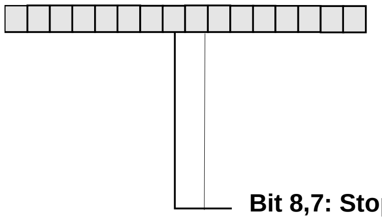
WARNING

⇒ Make sure that the home switch trigger edge lies within the reachable travel range.

- If reference markers are available (type 2 to 4, see above), and if the reference marker evaluation is activated, then the drive runs in homing direction until it detects a reference marker. In distance-coded measuring systems (type 4), two sequential reference markers must be passed. The reference markers are always evaluated there (independent of bit 6 in S-0-0147).

S-0-0147, Bit 7 = 0

- The further action depends on how bit 7 has been set in **S-0-0147, Homing parameter**. If bit 7 = 0 is programmed ("any position after homing"), then the drive brakes with the programmed homing acceleration up to standstill. If the value of the velocity feedback is less than the value set in **S-0-0124, Standstill window**, then the coordinate system of the referenced encoder is set, and the command is signalled as completed.



Bit 8,7: Stop/positioning/run path

0 0: once the reference switch or reference marker have been overtravelled the drive stops and switches into the coordinate system

0 1: after the reference swtich of marker have been overtravelled, the drive positions at the reference point and switches into the coordinate system

1 0: drive always run path that is needed to overrun two sequential reference markers and then switches into coordinate system **(only with distance-coded reference marks !)**

1 1: Not allowed!

Fig. 9-83: Bit 7 and 8 of **S-0-0147, Homing parameter**

Motion profile prior to coordinate system switching

The further course depends on what was set in bits 7 and 8 **S-0-0147, Homing Parameter**. There are three options.

- Stopping: After the necessary motions to detect the reference switch or marker have been executed, the drive stops with the programmed homing acceleration. Once a speed is reached that is less than the value set in **S-0-0124, Standstill window,** then the switch to the coordinate system (position feedback value switching) is performed and the successful completion of the command is signalled.
- Positioning: After the necessary movements to detect the reference swtich or marker have been completed, the drive positions at the reference point. This point for non-distance-coded measuring systems is the sum of the position of the relevant reference mark/switch trigger edge plus the reference dimension offset. The reference point for distance-coded encoders is the position of the 2nd overtravelled reference marker.
- Running paths: During the homing procedure, the drive runs a specific path. This mode is only possible with distance-coded measuring systems. The path is fixed by what has been set in parameter **S-0-0165, distance-coded reference 1**. By following off the path that has been programmed here, it is assured that the drive will always overrun two sequential markers. 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-guided reference** 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 referencing procedure. The mechanically coupled axes only run a relative path. Their shared position reference does not change. (In contrast to the "Positioning" mode that is only possible with non-distance-coded encoders, where the axes are automatically run in parallel by the driveside referencing procedure itself.)

Actual Feedback Values After the "Drive-Controlled Homing" Command

The position feedback values from the motor and optional encoders, after the "**drive-controlled homing"** command is processed, depend on bit 3 in **S-0-0147, Homing parameter** and on the availability of an absolute encoder as a motor or optional encoder.

Motor encoder:	Ext. encoder:	S-0-0147 Bit 3:	Actual feedback value 1:	Actual feedback value 2:
absolute	Not absolute	1	unchanged	reference distance 2
not absolute	absolute	0	reference distance 1	unchanged
not absolute	not absolute	0	reference distance 1	reference distance 1
not absolute	not absolute	1	reference distance 2	reference distance 2

Fig. 9-84: Position feedback values after the drive-controlled homing command

Commissioning with "Evaluation of reference marker/home switch edge"

If the encoder does not have distance-coded reference marks (type 1 to 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 **"Drive-controlled homing"** 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 "Evaluation of the Home Switch"). All additional steps can then be conducted as follows:

⇒ Check the relevant position encoder type parameter (S-0-0277 / S-0-0115) to make sure it has been correctly set.

⇒ Parametrize the following parameter 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.**

⇒ 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).

⇒ Conduct the drive-controlled homing command.

Note:	If the command is cleared, then the original operating mode becomes active. If drive-internal interpolation is set, then the drive immediately runs to the value set in S-0-0258, Target position. This value relates to the new (machine zero point) 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 referencing point as the reference distances (S-0-0052/54) have been parametrized 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 feedback position 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, 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 drive-controlled reference 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 the homing parameter, then the reference point is always set on the position of the selected reference mark. If a measurement system of type 1..3 is present (not distance-coded), you can shift the position of the reference point relatively to the reference marker. Doing so, you can select any position after homing.

The offset is set with the parameters

- **Reference Offset 1** (for motor encoder)
- **Reference Offset 2** (for optional encoder)

positiv 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 moved 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 marker.

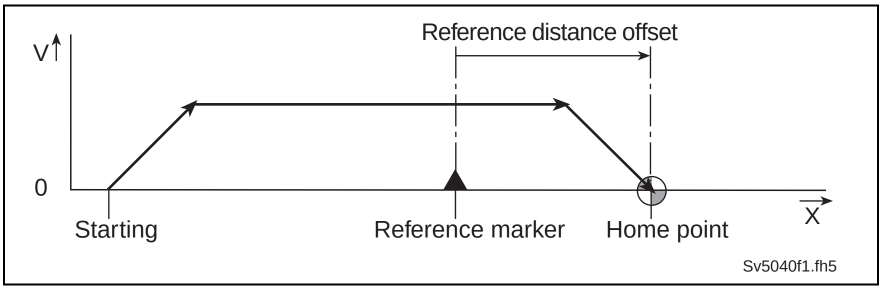


Fig. 9-85: Command value profile for positive reference offset and positive homing direction

If the **reference direction is negative**, then the drive must reverse the direction (with types 2 and 3) after passing the reference marker.

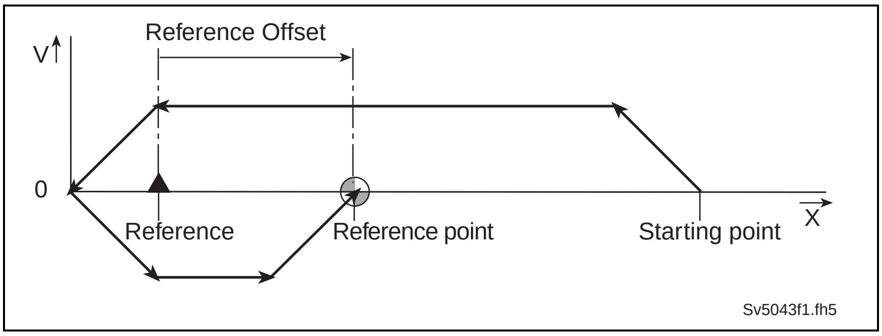


Fig. 9-86: Command profile for positive reference offset and negative homing direction

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 counterclockwise looking towards the motor shaft. If the reference direction is negative, then the drive does not reverse the travel direction once it has passed the reference marker.

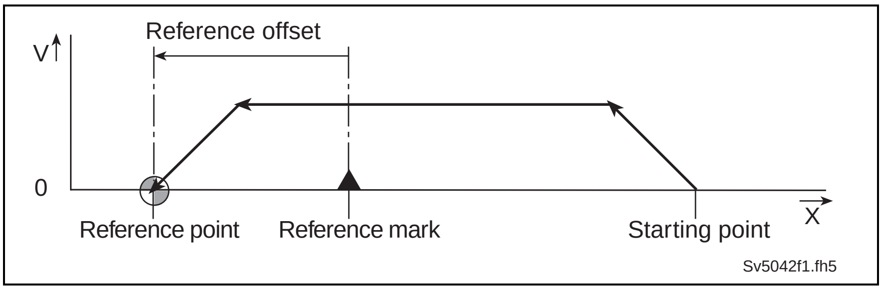


Fig. 9-87: Command profile with negative reference offset and negative homing direction

If the referencing direction is positive, then the drive must reverse the travel direction (with types 2 and 3) after passing the reference marker.

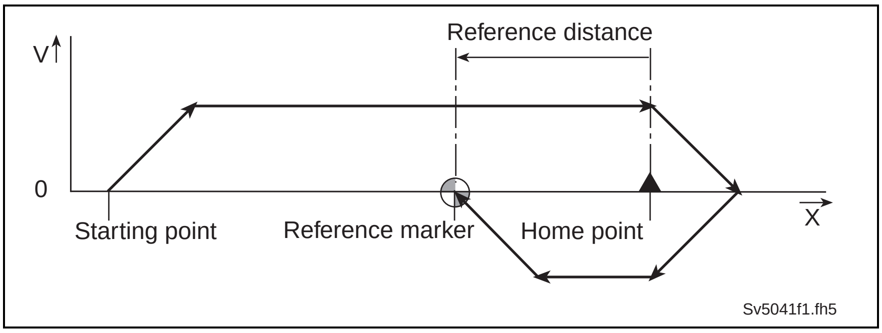


Fig. 9-88: Command profile with negative reference offset and positive homing direction

Evaluation of the Home Switch

Home switch evaluation

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 are used. If bit 5 in S-0-0147 = 0, then the reference mark, that follows the positive edge of the home switch will be evaluated (if the drive is moving towards the homing point).

Note: The home switch input is pictured in parameter **S-0-0400, Home switch**

Example:

Homing of a motor encoder with 1 reference mark per revolution

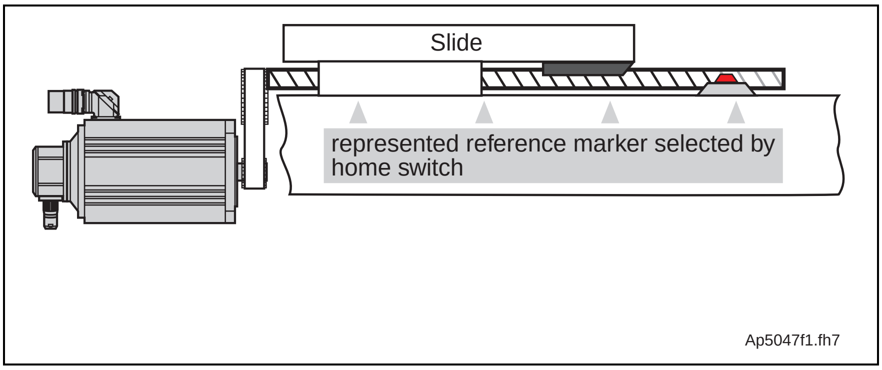


Fig. 9-89: Selection of a reference mark depending on the homing direction

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.

Note: The homing direction must be set so that the positive edge can be found.

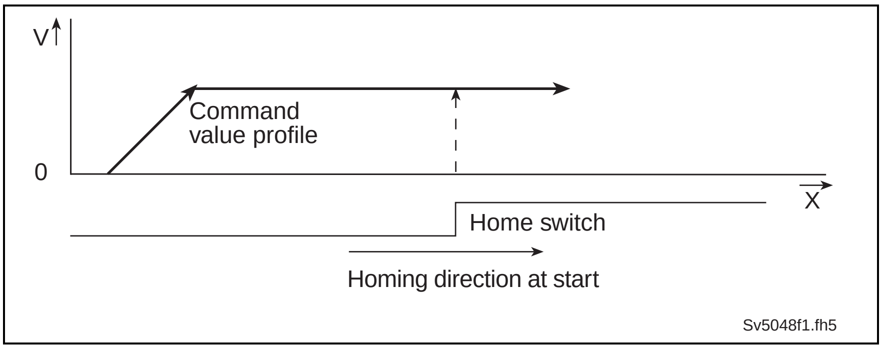


Fig. 9-90: Correct setting of homing direction

WARNING

If the homing direction setting is incorrect, the drive command value moves away from the positive home switch edge. In this case the danger exists that the drive reaches the travel range limits. This may result in damage to the system!

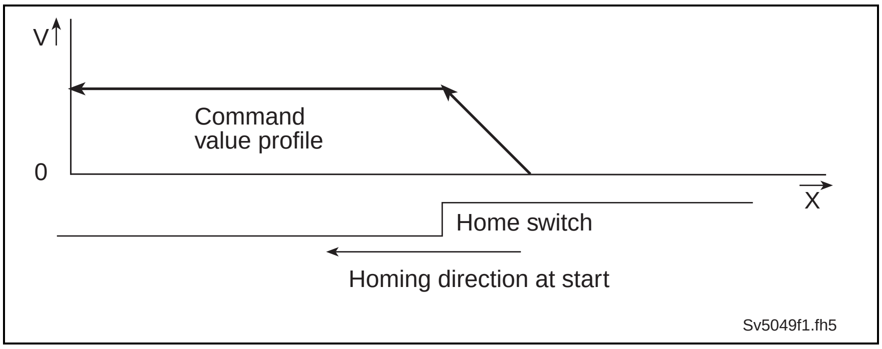


Fig. 9-91: Incorrectly set homing direction

Command value profile with actuated home switch at the start of the command

If the home switch is actuated already 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 from the home switch is detected, the drive reverses its direction and continues as if started outside the home switch range.

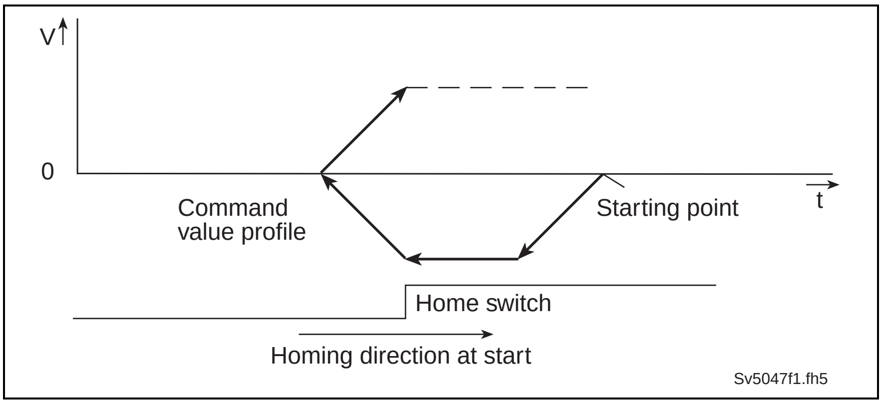


Fig. 9-92: Command profile with start position on the home switch

Monitoring the Distance Between Home switch and Homing Mark

If the distance becomes too small between the home switch edge and the reference mark, then it is possible that the home switch edge will only be detected after the reference mark has already passed. This leads to the detection of the following reference mark, and the reference mark detection becomes ambiguous.

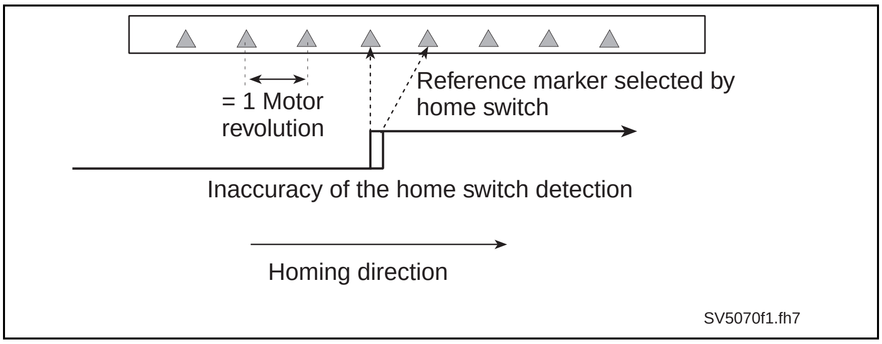


Fig. 9-93: Ambiguous detection of reference markers at small distances between home switch edge and reference mark

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 is:

0.25 • Distance between reference markers

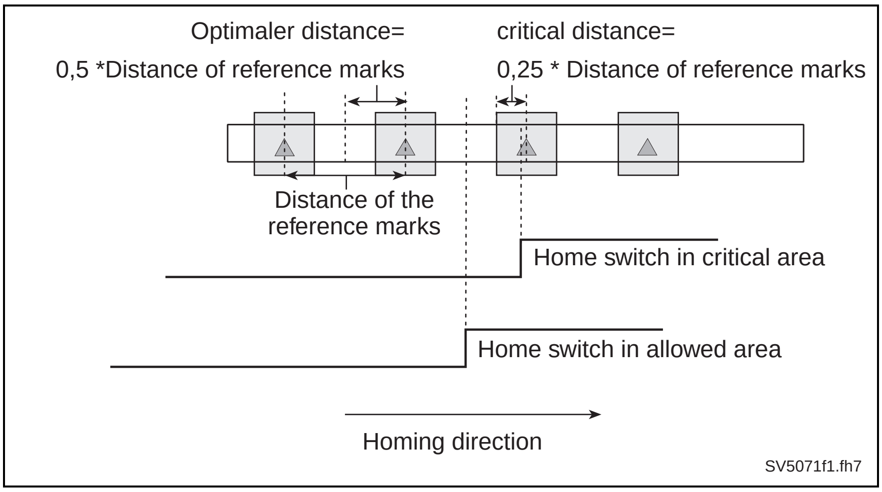


Fig. 9-94: Critical and optimal distance between home switch and reference mark

The optimal distance between the home switch edge and the reference marker is:

0.5 • Distance between reference markers

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 spacing will be calculated internally and amounts to a 1/2 encoder rotation for DSF or incrementally rotational 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 spacing 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 scale does not affect reference marks with consistent intervals. The real distance between the home switch and the reference mark must be big enough to achieve a sure recognition 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 spacing must be entered in **P-0-0153, Optimal distance home switch - reference mark**.

Fig. 9-95: 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 be shifted mechanically for this value.

To avoid a mechanical shifting of the home switch edge, you can set this procedure in the software with the parameter **S-0-0299, Home switch offset**. The value in parameter **S-0-0298, Reference cam shift** is transferred to parameter **S-0-0299, Home switch offset**.

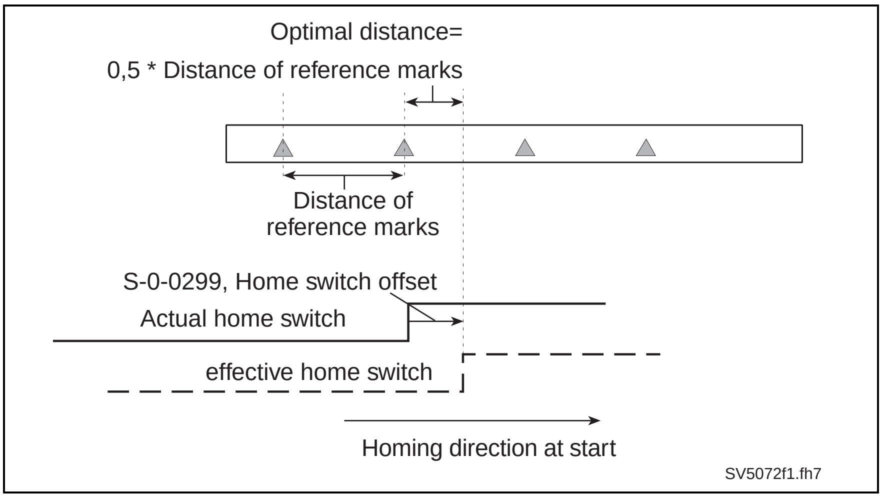


Fig. 9-96: Operation of parameter S-0-0299, Home Switch Offset

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 **S-0-0298, Reference cam shift** into **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 marker"

If the encoder has distance-coded reference markers (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 referencing"), then the drive always runs a path defined by parameter **S-0-0165, Distance coded reference offset 1**.

homing of a translatory motor encoder (encoder 1)

For the homing of a translatory motor encoder (encoder 1) it applies:

$$S_{Refen} = S\text{-}0\text{-}0165 \bullet S\text{-}0\text{-}0116$$

S-0-0165: Value in Parameter S-0-0165, Distance coded reference offset 1
S-0-0116: Feedback 1 Resolution
S_{Refen}: Travel path

Fig. 9-97: Travel path when referencing with distance-coded reference marks and in "Run path" mode for translatory measuring systems (linear scales)

homing of a translatory optional encoder (encoder 2)

For the homing of a translatory optional encoder (encoder 2) it applies:

$$S_{Refen} = S\text{-}0\text{-}0165 \bullet S\text{-}0\text{-}0117$$

S-0-0165: Value in Parameter S-0-0165, Distance coded reference offset 1
S-0-0117: Feedback 2 Resolution
S_{Refen}: Travel path

Fig. 9-98: Travel path when referencing with distance-coded reference marks and in "Run path" mode for translatory measuring systems (linear scales)

homing of a rotary motor encoder (encoder 1)

For the homing of a rotary motor encoder (encoder 1) it applies:

$$S_{Refen} = \frac{360Deg \bullet S-0-0165}{S-0-0116}$$

S-0-0165: Value in parameter S-0-0165, Distance coded reference offset 1
S-0-0116: Feedback 1 Resolution
S_{Refen} Travel path

Fig. 9-99: Travel path when referencing with distance-coded reference marks and in "Run path" mode for rotary measuring systems

homing of a rotary optional encoder (encoder 2)

For the homing of a rotary optional encoder (encoder 2) it applies:

$$S_{Refen} = \frac{360Deg \bullet S-0-0165}{S-0-0117}$$

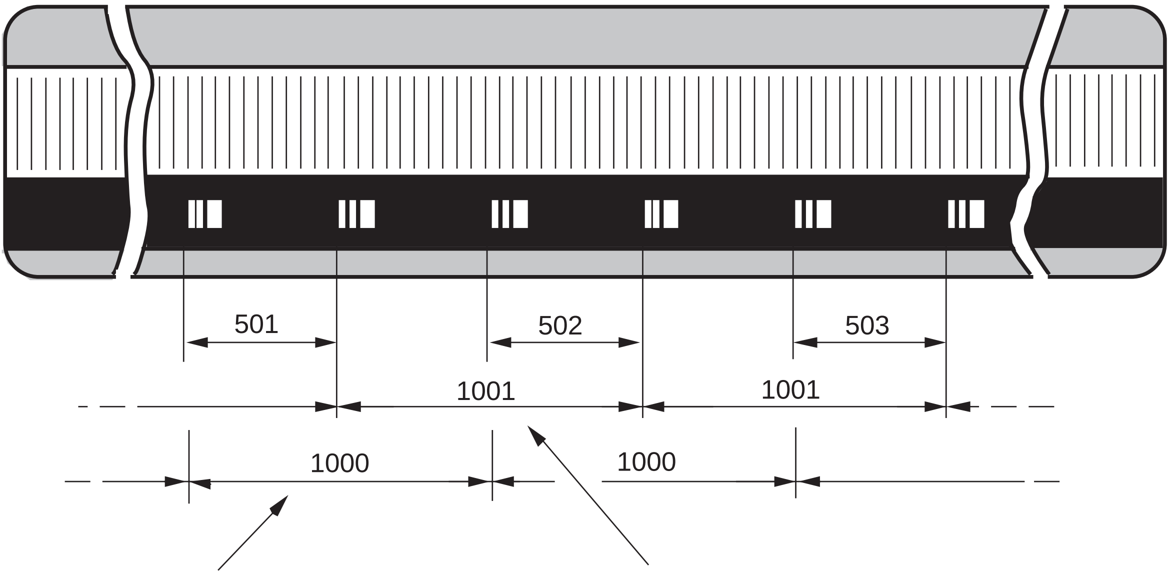
S-0-0165: Value in parameter S-0-0165, Distance coded reference offset 1
S-0-0117: Feedback 2 Resolution
S_{Refen} Travel path

Abb. 9-100: Travel path when referencing 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“ (larger value) SERCOS ID No. S-0-0165. Input unit: pitch unit

For Heidenhein length measuring system the larger 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.fh5

Fig. 9-101: Distance-coded measuring system 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 distances with a resolution of 0.02mm. In parameter S-0-0165/166 enter the value 1001 or 1000.

The further steps are outlined below.

⇒Check the relevant position encoder type parameter (S-0-0277/S-0-0115) to the correct setting.

⇒The parameters **S-0-0177, Absolute distance 1** or **S-0-0178, Absolute distance 2** must be parametrized with 0.

⇒The parameters **S-0-0041, Homing velocity** and **S-0-0042, Homing acceleration** must be set to smaller values (e.g., S-0-0041 = 10 rpm, S-0-0042 = 10 rad/s²).

⇒Execute command drive-controlled reference

WARNING

⇒ Þ 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 relates to the new (machine zero point related) coordinate system!

Result of the Drive-Controlled-Home 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 parametrized 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:

⇒ Move 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 drive-controlled reference command is again completed, 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 Markers

To evaluate a home switch together with homing of a distance coded measuring system serves only one purpose: 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 marker positions. This distance is

$$s_{\mathrm{Re}\,f\,\max} = (\text{S-0-0165} * \text{ Feedback Resolution}) + \frac{v^2}{2 \times a}$$

S-0-0165: Distance coded reference offset 1 S-0-0165, Distance coded reference offset 1
v : value in S-0-0041, Homing velocity
a : value in S-0-0042, Homing acceleration
$s_{\mathrm{Re}\,f\,\max}$: maximum travel distance for homing with distance coded reference markers
S-0-0116: Feedback 1 Resolution
S-0-0117: Feedback 2 Resolution

Fig. 9-102: Travel distance for homing with distance coded reference markers

If the drive is closer to the travel limit in homing direction than the necessary travel distance S_{Refmax}, it can leave the allowed travel range and do mechanical damage to the machine. To avoid this,

- make sure that the distance of the axis to the travel 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

If the home switch is evaluated, and if at the command start the home switch is already activated (**S-0-0400, Home switch** = 1), the drive automatically starts in the opposite homing direction.

Therefore, the home switch must be mounted in such a way that it covers at least the max. necessary travel distance S_{Refmax} until reaching the travel range limit in the homing direction.

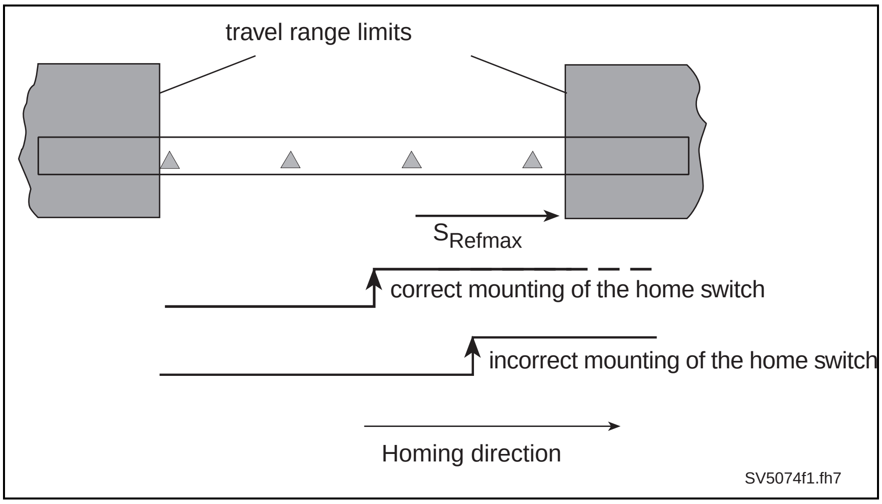


Fig. 9-103: Mounting the home switch with distance coded reference markers

Functions of the Control During "Drive-Controlled Homing"

The control's interpolator must be set to the position command value read from the drive.

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 corresponding to the machine zero point will be made available in parameter **S-0-0047, Position command value**. This value must be read through the service channel by the control before ending the command, and the control interpolator must be set to this value. If this command is completed by the control and if the command values of the control for the drive become active again, 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 execute the command by writing to the parameter **S-0-0148, C600 Drive controlled homing procedure command** (Input = 3 = 11bin). The drive confirmation has to be received from the data status out of the same parameter. The command is finished when the command-change bit in the drive status word is set and the confirmation changes from *in process* (7) to *command executed* (3) or to *command error* (0xF).

If the command is interrupted (Input = 1) during processing (when confirmation = 7), the drive responds by activating the drive halt feature. The program continues if the interruption is cancelled.

(See also chapter: "Drive Stop".)

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**
  While starting 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 Monitoring the Distance Between Home switch and Homing Mark on page 9-99
- **C604 Homing of absolute encoder not possible**
  The homing encoder is an absolute encoder. The command "Drive-Controlled Homing" was started without first starting the command

  "Setting the Absolute Dimension".

- **C606 Reference mark not detected**
  For incremental encoders, the recognition of the reference mark captures the actual position. While searching the reference mark during homing, the performed distance is monitored. If the performed distance is greater than the calculated max. distance necessary to detect a reference mark, the error message C606 Reference not detected is generated. The monitoring is done with the following encoder types:
  - Rotary incremental encoders, the max. distance is 1 revolution of the encoder.
  - Distance coded measuring systems, the max. distance is defined by S-0-0165, Distance-coded reference offset 1.

    The cause for this error message can be:
  - No recognition of the reference marks possible (because of wire break, defective encoder, etc.)
  - S-0-0165, Distance-coded reference offset has a wrong value.

Configuration of the Home switch

Note: The home switch should be set up, so that the activation range remains within the travel range of the axis. Otherwise, the travel range may be overrun at command start if the start position is in an unfavourable position. Damage to the system is possible !

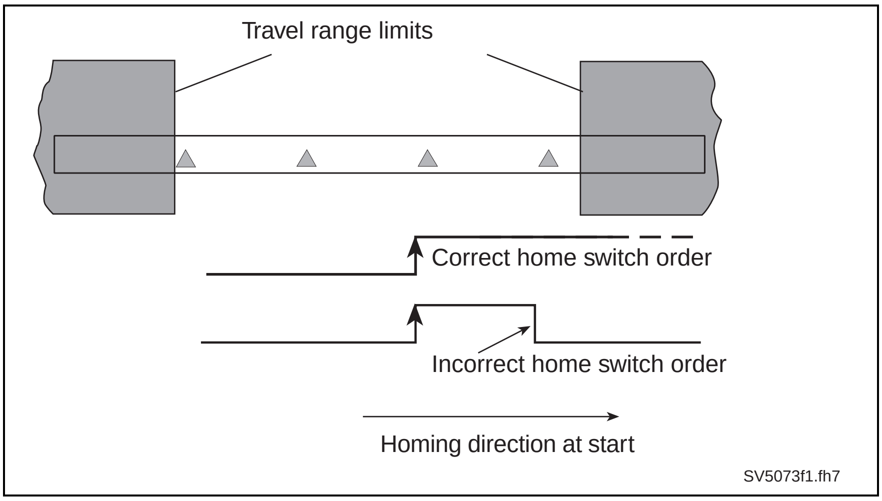


Fig. 9-104: Configuration of the home switch in reference to the travel range

Connection of the Home switch

see project planning manual.

Homing of Gantry axis

Gantries are used to process workpieces with large surfaces. The digital AC servo drive with SERCOS interface is equipped with a "Gantry Axis" function allowing gantries to be traversed without the danger of skewing.

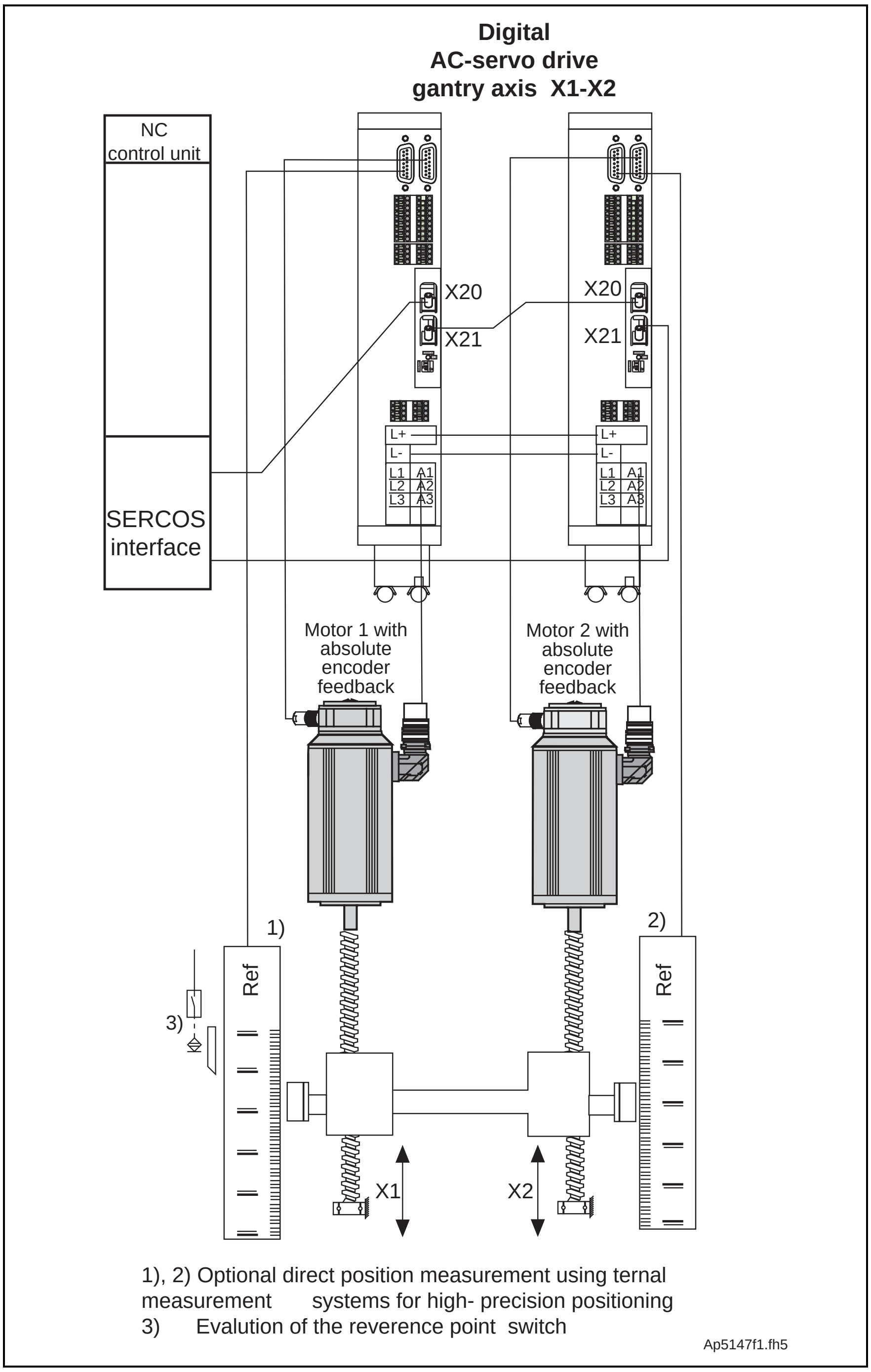


Fig. 9-105:Schematics of a "Gantry" axis with digital intelligent INDRAMAT AC servo drives

"Gantry" axes have an inherent "skewing" problem. This skewing must always be tolerated by the mechanical structure of the machine in such a way that the machine will never under any circumstances be damaged.

Pre-requisites for operating "Gantry" axes

- Both "Gantry" axes are registered as a single axis in the NC control.
- The axis are identically parametrized.
- The "Gantry" drives are equipped with absolute encoders.
- The guide rails of the gantries (X1; X2) must be parallel.

Setting up "Gantry" axes

Procedure:

I. Align the gantry axis at right angles to the traversing direction. This can be done manually or by jogging the axis.

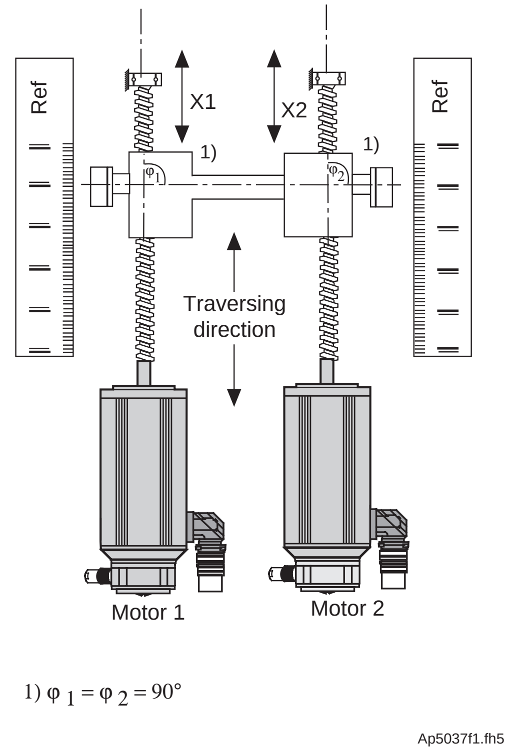


Fig. 9-106: Rectangular aligning of "Gantry" axis

II. Set absolute reference dimension

1. Record the distance from the gantry axis to the machine zero point.
2. Enter distance A to machine zero point in parameter **S-0-0052 Reference distance 1.**
3. Trigger command **P-0-0012 Set absolute Measurement.**
4. Cancel the drive enable signal.
   The value entered in parameter **"Reference distance 1"** is transferred to **S-0-0051 feedback value 1.**
5. Reset the command.

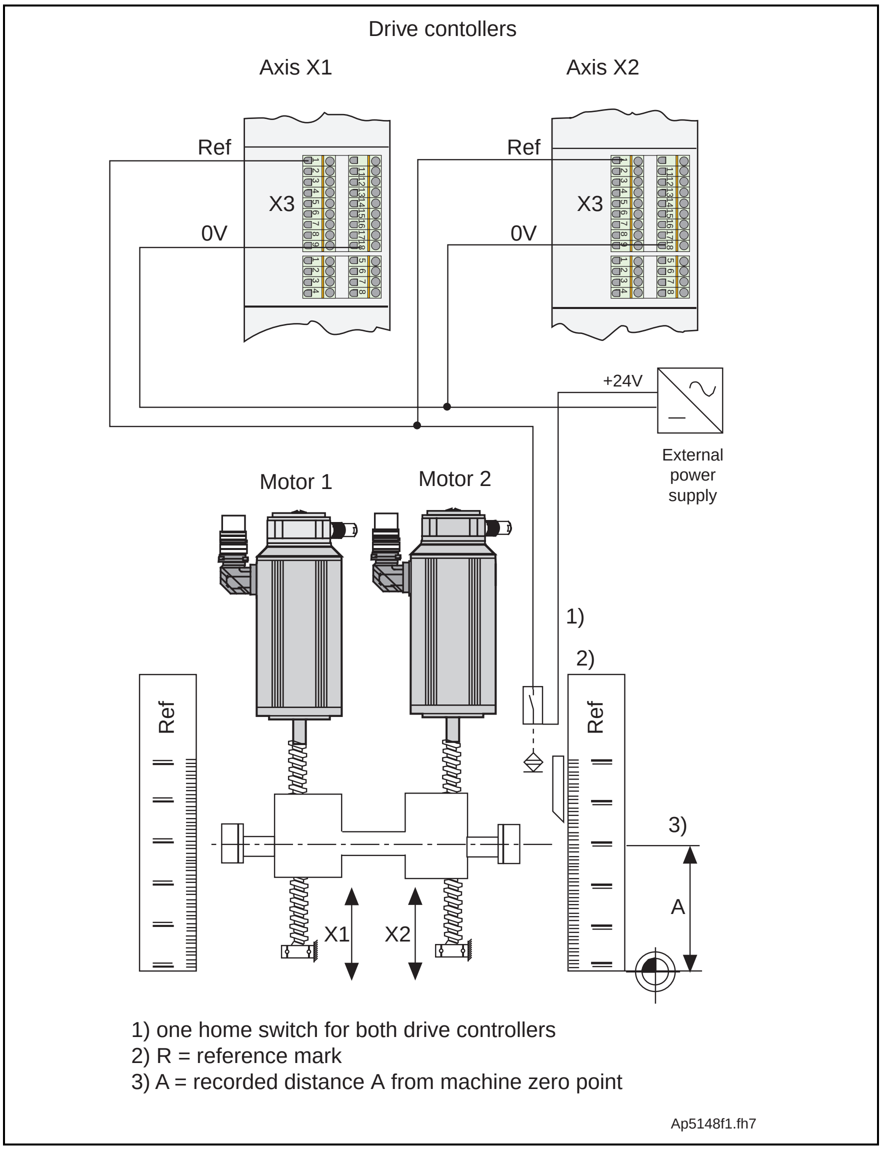


Fig. 9-107:Connecting the home switch to the drive controllers of gantry axis X1/X2

III. Setting the reference distance of the direct position measuring system (if installed).

Procedure:

- Set the homing procedure parameters
  S-0-0041 homing velocity
  S-0-0042 homing acceleration
  S-0-0147 homing parameter
  S-0-0108 feedrate override

  in both axis to the same values. Check the connection of the home switch as illustrated below.
- Check that the home switch works correctly.

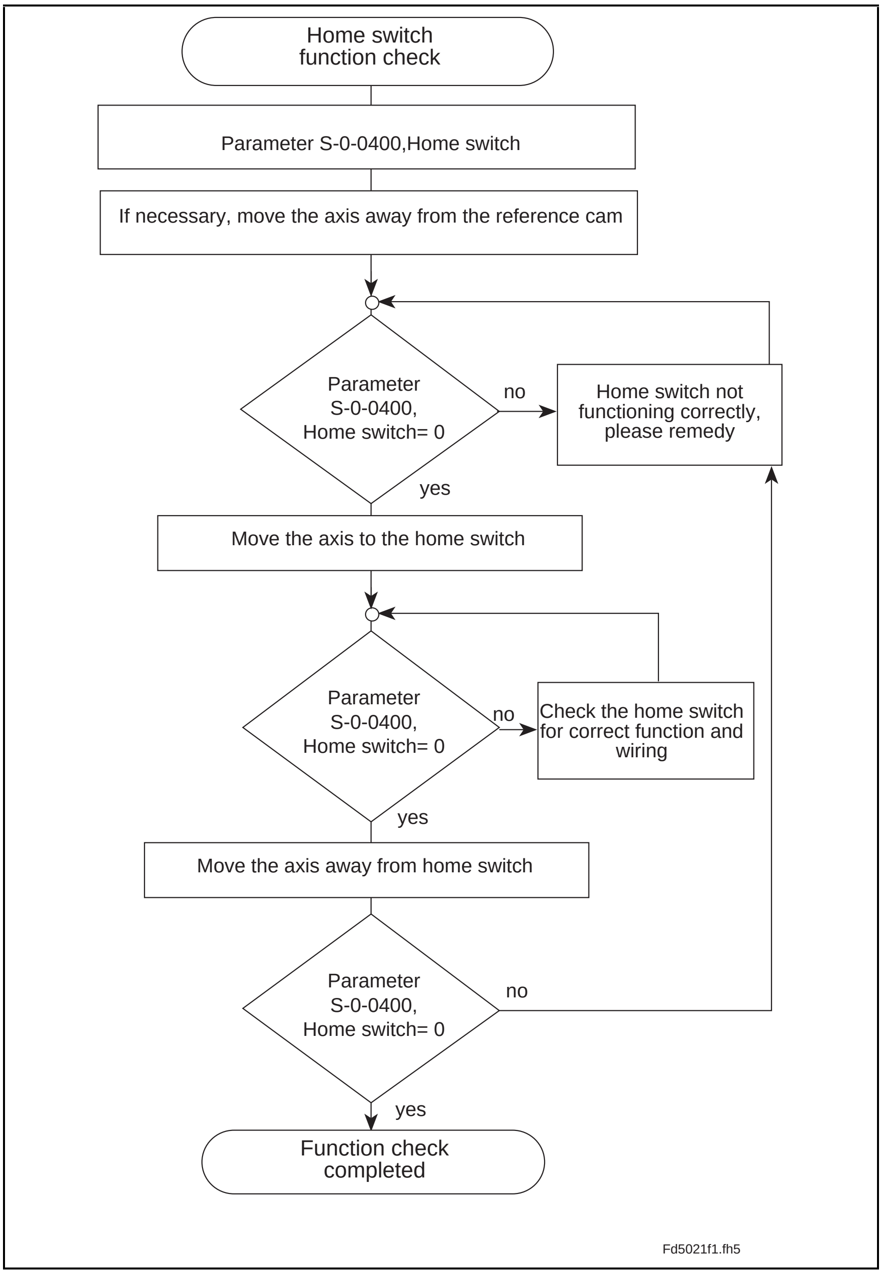


Fig. 9-108:Checking the function of the home switch

- Detecting the reference mark positions of external feedback systems

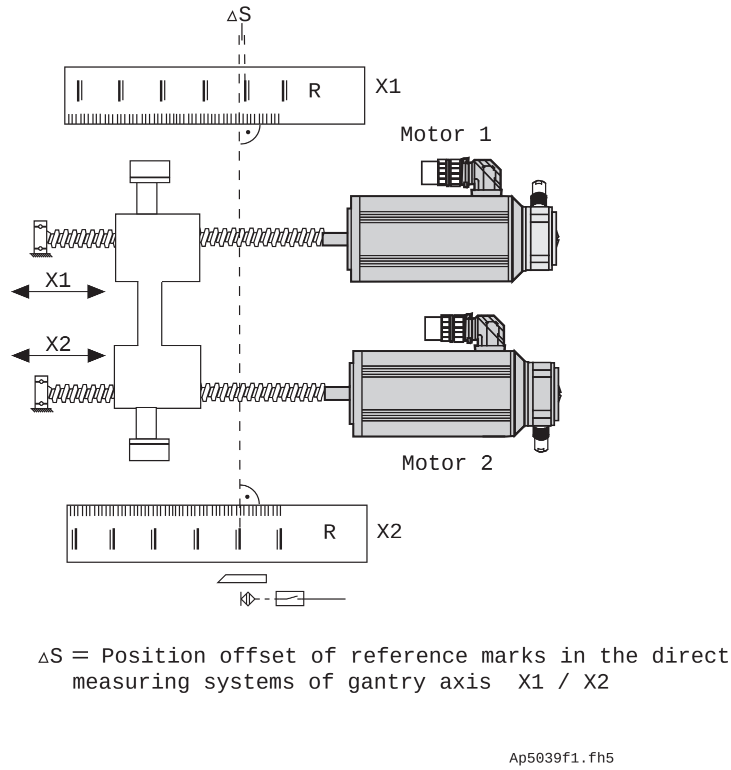


Fig. 9-109: Position offset of reference marks in the direct measuring system of gantry axes X1/X2

Procedure:

1. Trigger command **P-0-0014 Determine marker position** in both axis (see control manual).
2. Move both axis towards the reference marks by forwarding the same position command values through the NC control.

Note: The direction of travel must be the same as that of the subsequent homing cycle.
(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 relevant corresponding marker position (**S-0-0173 Marker position A**). Once the reference marks have been acquired, the drive acknowledges the command "Determine marker position". When both gantry axes have acknowledged the command, the NC control must brake the drives to a standstill.

3. Determining the reference mark offset (ΔS):

ΔS = Markerposition axis X1	-	Marker position axis X2
(S-0-0173, Marker position A)		**(S-0-0173 Marker position A)**

- Compute and enter reference offset 2 of each axis.

For the axis whose reference mark occurs first, it applies:

$$\text{S-0-0151, Reference offset 2} \geq \frac{Vref^2}{2 \times a_{ref}} + \Delta S$$

ΔS reference mark spacing
V_{ref} S-0-0041, Homing velocity
a_{ref} S-0-0042, Homing acceleration

Fig. 9-110: Computing S-0-0151, reference offset 2 for the axis whose reference mark occurs first

For the axis whose reference mark occurs last, it applies:

$$\text{S-0-0151, Reference offset 2} \geq \frac{Vref^2}{2 \times a_{ref}}$$

V_{ref} S-0-0041, reference travel velocity
a_{ref} S-0-0042, reference travel acceleration

Fig. 9-111:Computing S-0-0151, reference offset 2 for the axis whose reference marks occurs last

Danger:
A reversal of direction of travel of one of the two drives may lead to accidents. This will happen when the values entered in Reference Offset 2 are 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 direction of the reference travel. That means, with negative homing direction in one or both axis, also the reference offset must be input with neg. sign. This avoids a direction reversal after passing the reference mark

(See "Consideration of the Reference Offset".)

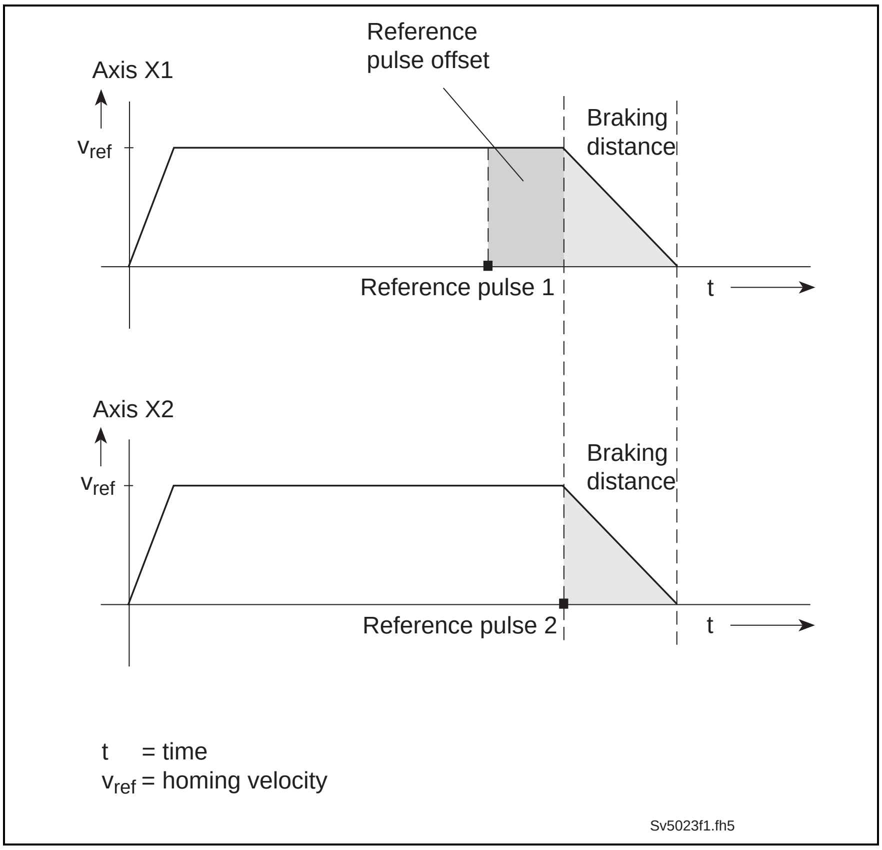


Fig. 9-112: Velocity paths of gantry axis during homing

9.11 Setting the Absolute Dimension

When commissioning an absolute measuring system, the initial actual position value represents just any point on the machine and not 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, finding the absolute dimension of an absolute measuring system is something that only has to be done once, namely at the time that the axis is commissioned.

With the use of command "**C300 Set absolute measuring**" the actual position value of this measuring system can be set to the desired value. After "Setting the absolute dimension" procedure has been completed, then the actual position value of the relevant encoder has a defined reference point for its machine zero point.

Activating the function

The command can be triggered by:

- writing into parameter **P-0-0012, C300 Command 'Set absolute measurement'**
- or with a zero switch input flank.

Command reference point

If there is only one absolute measuring system, then the command automatically references this one system. Given two absolute systems, however, then the selection must be set in **Bit 3** of **S-0-0147, Homing parameter**.

Saving the data

All information is retained by buffering all the data of the system in a feedback memory or a parameter memory. The actual position value retains its reference to the machine zero point each and every time the machine is switched on after being switched off.

Pertinent Parameters

The following parameters are relevant to the execution of commands:

- **P-0-0012, C300 Command ’Set absolute measurement’**
- **P-0-0612, Control word for setting absolute measurement**
- **S-0-0147, Homing parameter**
- **S-0-0052, Reference distance 1**
- **S-0-0054, Reference distance 2**
- **S-0-0403, Position feedback value status**
- **P-7-0514, Absolute encoder offset**

Functional Principle

The motor is brought to a precise position. The value of the actual position 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 any other encoders).

Upon successful completion of command **P-0-0012, C300 Command ’Set absolute measurement’,** the actual position value is set to that value entered in the relevant **Reference dimension** and after **S-0-0403**, **Position feedback value status** has been set to **"1"**.

Control word setting the absolute dimension

The execution of the command depends on **P-0-0612, Control word for setting absolute measurement** the absolute dimension. Bit 0 fixes whether the current coordinate system is retained even after the control voltage is switched on and off, i.e., whether the current **P-7-0514, Absolute encoder offset** is stored in the feedback data memory and is resistant to change.

Note: Given frequence “Setting of absolute dimension" bit 0 = 1 should be set as 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:

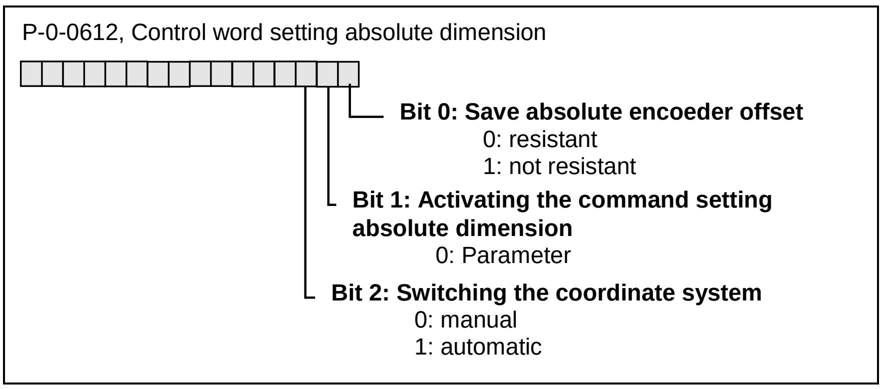


Fig. 9-113: P-0-0612, Control word setting the absolute dimension

"Setting the absolute dimension" without drive enable

The command

Bit1 of **P-0-0612** is used to select whether the command is started

- by writing into parameter **P-0-0012** with "11b" (if bit1 ="0") or
- a 0->1 flank at the zero switch input (if bit1 ="1").

Switching the co-ordinate system

Note: **If the drive enable is not applied and command** "Setting the absolute dimension" is started, then drive-internally the co-ordinate system is always automatically and immediately switched (bit 2 is not relevant in this case!).

Case	P-0-0612	Behavior when executing the command
A1	Bit1 = 0 Bit2 = x	Setting the absolute dimension by conducting **P-0-0012, C300 Command 'Set absolute measurement** • by writing "11b" into **P-0-0012,** then, in addition to command start "Setting the absolute dimension", the co-ordinate system is also automatically switched.
B1	Bit1 = 1 Bit2 = x	**Setting the absolute dimension with a 0-1 flank at the reference switch input** • a 0->1 flank at zero switch input stores the actual position • and the co-ordinate system is also immediately switched

Fig. 9-114: Overview: setting the absolute dimension without drive enable

Case A1:

When activating the command by writing into the parameter, proceed as follows:

- The axis must be brought into the precisely measured position.
- The actual position value of the position wanted must be entered.
- The command can be started by writing "11b" into **P-0-0012, C300 Command 'Set absolute measurement"**.
- The command immediately sets the actual position value of the measuring system to the reference dimension and the position status becomes "1". The drive completes 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 the flank at the zero switch input.

Note: Bit1 of **P-0-0612** and the command itself are deleted automatically and drive-internally upon completion of "Setting the absolute dimension"!

"Setting the absolute dimension" 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.

The command

With bit1 of **P-0-0612** it is set whether the command is started by

- writing "11b" into **P-0-0012** (bit 1 ="0") or
- a 0->1 flank at the zero switch input (bit 1 ="1").

Note: For safety reasons, flank evaluation is automatically deactivated after "Setting the absolute dimensions" has been completed. This means that applications in systems with slip must cyclically use bit 1 in **P-0-0612**.

Switching the co-ordinate system

Use bit2 of **P-0-0612** to select whether, when executing command **P-0-0012, C300 Command Setting the absolute dimension,**

- there is also an immediate drive-internal switch of the co-ordinate system (bit 2 ="1") or
- the start of **S-0-0148, C600 Drive controlled homing procedure command** is delayed until the drive enable is removed by the control before the co-ordinate system is switched (bit 2 ="0").

Case	P-0-0612	Behavior when executing the command
C1	Bit1 = 0 Bit2 = 0	• By writing "11b" into **P-0-0012, C300 Command 'Set absolute measurement'**" the command is started but the co-ordinate system not switched. • By starting the command **S-0-0148** or removing RF, the co-ordinate system is switched
C2	Bit1 = 0 Bit2 = 1	• By writing "11b" into **P-0-0012, C300 Command 'Set absolute measurement'"** the command is immediately started and the co-ordinate system switched
D1	Bit1 = 1 Bit2 = 0	• a 0->1 flank at the zero switch input stores the actual position • and starts command **S-0-0148** but the control waits to switch the co-ordinate system!
D2	Bit1 = 1 Bit2 = 1	• a 0->1 at the zero switch input stores the actual position • and immediately switches the co-ordinate system

Fig. 9-115: Overview: setting the absolute dimension with drive enable

Note: Make sure that an encoder has been programmed in bit 3 of **S-0-0147, Homing parameter**.

Case C1: In the event that the co-ordinate system switch does not automatically take place drive-internally, (**P-0-0612,** bit 2 ="0"), then proceed as follows:

- take the axis to the measured position
- enter the actual position value wanted into the relevant reference dimension actual position value parameter
- Start command **P-0-0012, C300 Command 'Set absolute measurement'** (write "11b" into 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 function recognizes that it is dealing with an absolute measuring system and conducts "Setting the absolute dimension". In other words, the actual position value is set to the reference dimension. The position command value is simultaneously set to the same value (**S-0-0047, Position command 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 referencing command is cleared.
- Clearing command "**C300 Set absolute measuring** the absolute **dimension"**

Case C2: In the event that the co-ordinate system is to be automatically and drive-internally switched at the start of command "Setting the absolute dimension" **(P-0-0612**, Bit 2 ="1**")** then proceed as follows:

- Bring the axis to the measured position.
- Enter the desired actual position value in the relevant reference dimension actual position value parameter.
- Start command **C300 Set absolute measuring** the absolute dimension (write "11b" into 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 "Setting the absolute dimension". In other words, the actual position value is set to the reference dimension. The position command value is simultaneously set to the same value (**S-0-0047, Position command value**). In position control mode this automatically leads to the automatic switch of the co-ordinate system, but as the control cannot bring its command value immediately up to the new actual value, there is an abrupt transition.
- Clear command **P-0-0012, C300 Command 'Set absolute measurement'.**

Case D1: In the event that the co-ordinate system switch is not automatic and drive-internal (**P-0-0621**, Bit 2 ="0"), then basically the same procedure as with case C1 should be followed, but the command is here activated by a flank 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).
- and so on ...

Note: Both bit1 of **P-0-0612** and the command itself are automatically, drive-internally deleted after "Setting the Absolute Dimension"!

Case D2: If the co-ordinate system is to be switched drive-internally and automatically at the start of command "Setting the absolute dimension" **(P-0-0621,** Bit 2 ="1"), then basically proceed as with case C2 but here the command is activated by a flank at the zero switch input.

- Activate the zero switch input with **P-0-0612,** Bit1="1"
- Run the axis to the measured position (e.g., jog it there).
- and so on ....

Note: Both bit1 of **P-0-0612** and the command itself are automatically, drive-internally deleted after "Setting the absolute dimension"!

Actual Position Value after Setting the absolute dimension

The state of the actual position value of the motor encoder, and any other encoders that might be mounted, after the execution of the setting the absolute dimension command depends on bit 3 in **S-0-0147, Homing parameter** and whether the absolute encoder is a motor or an optional encoder.

Motor encoder	Optional encoder	S-0-0147 Bit 3:	Actual position value 1	Actual position value 2
absolute	not absolute or not there	any	Reference dimension 1	Reference dimension 1
not absolute	absolute	any	Reference dimension 2	Reference dimension 2
absolute	absolute	0	Reference dimension 1	unchanged
absolute	absolute	1	unchanged	Reference dimension 2

Fig. 9-116: Actual position value after setting the absolute dimension

Actual position value of absolute encoders after power on

(See section: "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 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 zero switch input (terminal X3 pin1).

Notes

10 Optional Drive Functions

10.1 Configurable Signal Status Word

The configurable signal status word supports the acceptance of a maximum of 16 copies of bits from other drive parameters. This makes it possible for a user to put a bit list together which contains drive status information that is important to the control.

Note: The bits in the signal status are put together in every command communication cycle at **S-0-0007, Feedback acquisition starting time (T4)**.

Pertinent Parameters

These parameters are used with this function:

- **S-0-0144, Signal status word**,
  The desired bits are applied there.
- **S-0-0026, Configuration list signal status word,**
  ID number list with variable length to configure the bit strip.
- **S-0-0328, Assign list signal status word**
- Bit number list with variable length to configure the bit strip.

Configuration of the Signal Status Word

Configuration of the ID number

The ID numbers of the parameters which contain the original bits (sources) are specified in parameter **S-0-0026, Configuration list signal status word.** The position of an ID number in the list determines the bit in the signal status word to which the ID number applies. So the first list element informs as to what parameter bit 0 of the signal status word comes from.

Configuring the bit numbers

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 parameter is automatically copied. Otherwise, the bit taken out of the source parameter is specified here.

Bit number 0 (LSB) to 31 (MSB) can be specified. For each bit number of this list there must be an ID number in the same list position in list S-0-0026. Otherwise, the drive, when writing the bit number list, will issue the error message "ID number not available". This is why list **S-0-0026, Configuration list signal status word** must be written into before **S-0-0328, Assign list signal status word**.

Example: A signal status word with the following configuration must be put together:

Bit no. in S-0-0144,Signal status word	ID number of original parameter	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. Transmission is from bit 4.

Fig. 10-1: Example of a configurable signal status word

Signal status word output

Bit 0 – 9 of parameter **S-0-0144, Signal status word** are copied in the DKC01.3 to the digital outputs (X15.14-24).

Note: A maximum of 16 bits can be configured. Configuration is performed from the least-significant to 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.

Note: The setting of the signal status word corresponds to the assignment of the digital outputs in a basic unit with parallel interface.

Diagnostic / 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 **S-0-0026, Configuration list signal status word** then error message "*0x1001, ID number not available*" is generated.
- If an ID number 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 variable data length (list parameters) specified in **S-0-0026, Configuration list signal status word** exists 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 the inputs up until the faulty element is 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.

Application

This mechanism can be used, for example, for

- positioning block mode via parallel interface
- main spindle mode via parallel interface
-

Accessing signal control word

Depending on the **command communications** parameter **S-0-0145, Signal control word** is accessed in various ways:

- With parallel interface (DKC01.3) the 10 digital inputs (X15.1-10) on the lowest ten bits are copied into the signal control word!
- With SERCOS and fieldbus interface, **S-0-0145, Signal control word** must be relevantly configured in cyclical data so that the mechanism can be used.

Note: The bits in the signal control word are effective in each interface cycle at **S-0-0008, Command valid time (T3).**

Involved Parameters

The following parameters are used for the functions

- **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 lists

Only those parameters 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 ID numbers

The ID numbers of the parameters which are to be configured with the help of the signal control word (=target) are specified in parameter **S-0-0027, Configuration list signal control word.**

The position of an ID number in the list determines which bit in the signal control word is allocated to which ID number (target). For example, the first list element fixes which parameter bit 0 of the signal control word is allocated to.

Configuration of the bit numbers

Which bit of the selected parameters (=target in **S-0-0027, Configuration list signal control word)** is set by the signal control word (or reset) is set 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 parameters is specified here.

Bit numbers from **0 (LSB) to 31 (MSB)** are entered here.

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, Setup flag for relative command values**, then a positive edge in the relevant bit of the control word effects a toggling of the parameter **S-0-0346, Setup flag for relative command values**.

ID number not available

For every bit number in list **S-0-0329, Assign list signal control word** there must be an ID number at the same list position in the list in **S-0-0027, Configuration list signal control word**. Otherwise, when writing the bit number list from the drive, error message "ID number not available" will be generated.

Note: This is why list S-0-0027 must be written prior to list S-0-0329.

When the firmware is delivered (basic parameter block) the following values are defined for the parameters that are relevant to the configurable signal control word.

Example:

Bit no. In S-0-0145	ID number of the target parameter	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 referencing 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)

Parameters **S-0-0027, Configuration list signal control word** and **S-0-0329, Assign list signal control word** must be configured as follows to obtain the wanted assignment of the control word.

Note: Up to **16 Bits** can be configured. Configuration takes place from the lowest to the highest value bit. In other words, The position of the bit copy in the signal control word is derived from the continuous configuration in S-0-0027.

Note: The illustrated assignment of the control word is the same as the assignment of the parameter interface in DKC01.3 Also see Project Planning Manual:
Section: Terminal diagram of parallel interface

Diagnostic / 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** then in **S-0-0027, Configuration list signal control word**, then error message "*0x1001, ID number not available*" is generated.
- If an ID number 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 ID number specified in **S-0-0027, Configuration list signal control word** is not on the list of the configured data S-0-0399 then error message "*0x7008, Data not correct"* is generated.

Note: In each of these cases, only that input prior to the faulty element will be 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-to-analog converters. The maximum output voltage equals +/- 10 volts. There is an output every 500 usec.

Possible output functions

1. Direct writing into the analog outputs
2. Assigning ID numbers to analog outputs
3. Output of pre-set signals
4. Byte output of RAM memory cell
5. Bit output of RAM memory cells

To parametrize 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**
- **P-0-0423, Analog output 2, signal selection**
- **P-0-0424, Analog output 2, expanded signal selection**
- **P-0-0425, Analog output 2, scaling**
- **P-0-0426 Analog outputs, IDN list of assignable parameters**

Direct analog outputs

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 into these parameters, ranging between -10.000 volts and +10.000 volts, are output by the drive to the analog outputs. The quantization equals 78 mV.

A precondition for the 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 by inputting 0 for the used channel.

Analog output of existing parameters

selection list All parameters in the list **P-0-0426 Analog output, IDN list of assignable parameters** can be output as analog value.

configuration This first requires that their ID number 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 mode, then the settings there apply to the scaling as well.

scaling With **P-0-0422 Analog output 1, scaling** or **P-0-0425, Analog output 2, scaling** is it then fixed at what value 10 volts are output.

For example, for rotary preferred position scaling and signal selection position command (S-0-0047), the unit of the scaling factor is set to degrees, and the number of decimal places is set to four. Inputting 90.0000 degrees in the evaluation factor means that 10 volts per 90 degrees at the load will be output .

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 fractional part. 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 -10 volts are output and for logical 1 + 10 volts (bit output).

Outputting pre-set signals

To be able to show 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 these via the expanded analog output.

The parameters

- **P-0-0421, Analog output 1, expanded signal selection** and
- **P-0-0424, Analog output 2, expanded signal selection**

do the selection.

Activation of the expanded 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.

The following list shows which signal is output with which signal number.

Signal number P-0-0421/424	Output signal	Reference unit: Evaluation factor 1.0000
0x00000001	motor encoder sine signal	0.5V/10V
0x00000002	motor encoder cosine signal	0.5V/10V
0x00000003	Opt. enc. sine signal	0.5V/10V
0x00000004	Opt. enc. sine cosine	0.5V/10V
0x00000005	Position command difference on the pos. controler	rot. ⇒ 1000rpm/10V lin. ⇒ 100m/min/10V
0x00000006	DC bus power	1kW/10V
0x00000007	absolute DC bus power amount	1kW/10V
0x00000008	effective current	S-0-0110/10V
0x00000009	relative current	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

Fig. 10-3: Signal selection list with pre-defined signal selection

See also Control loop structure in chapter "General Information for Control Loop Settings"

This information is scaling independent and always relates to the motor shaft. The scaling of the signals is possible via the parameters **P-0-0422 Analog output 1, scaling** and **P-0-0425 Analog output 2, scaling.** These have been set as factors with 4 decimal places in the expanded signal selection. If the evaluation factors are 1.0000, then the standards specified in the table apply.

Example: Output of the position command difference with a value 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 = 0.1500

Bit and byte outputs of the data memory

Note:	Use of this feature is meaningful only with information about the structure of the internal data memory; therefore, this feature can be used effectively only by Rexroth Indramat employs.

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.

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 (half byte with bits 28..31), byte output is activated with a 1 and bit output with a 2. The least significant 24 bits of the parameter inputs the storage address.

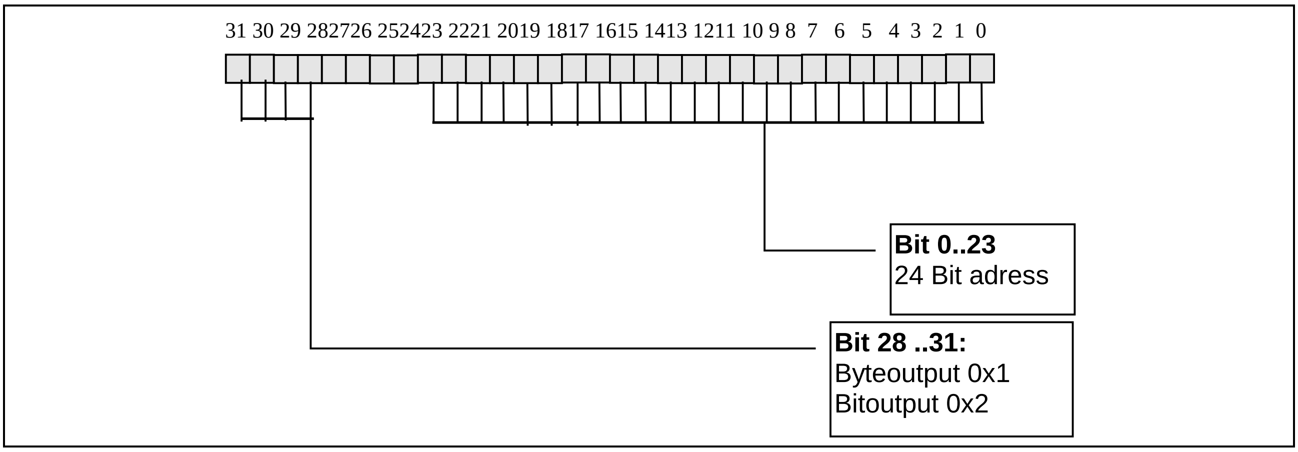


Fig. 10-4: Parametrizing bit or byte output

scaling

The parameters

P-0-0422 Analog output 1, scaling and

P-0-0425 Analog output 2, scaling

either select the bit to be output or determine which (least signifiant) bit to begin with on the byte to be generated will start. 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 volt (bit = 0) or +10 volt (bit = 1) is output.

Byte output

With byte outputs, the MSB of the byte to be output is interpreted as sign bit. Voltages ranging from -10 to +10 volts are output.

Terminal assignment - analog output

see project planning manual.

10.4 Analog Inputs

Using the function "Analog inputs", two analog inputs can be used via analog/digital converters in one parameter each. The analog voltages, in the form of both of these parameters, can then either be

- transmitted to the control and supports the control as an analog input function or
- it can be 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 specific 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**
- **P-0-0215, Analog input 2, Assignment**
- **P-0-0216, Analog input 2, Scaling per 10V**
- **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 over two **differential inputs** E1+ / E1- and E2+ / E2- .

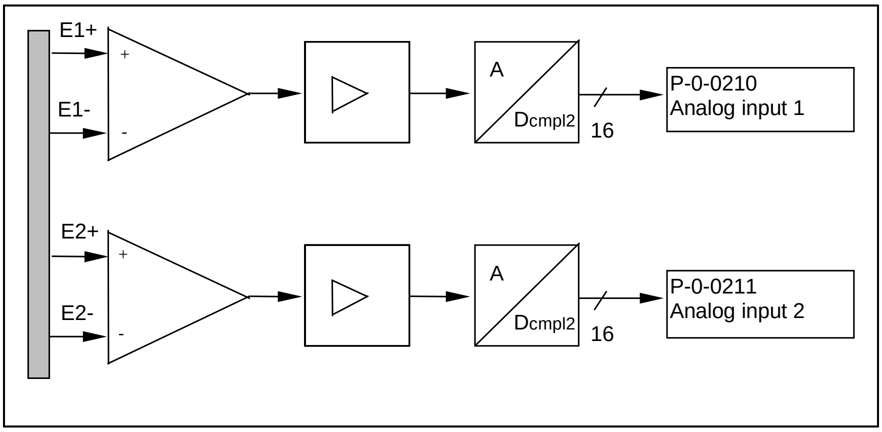


Fig. 10-5: Functinal principle of the analog inputs

The digitalized 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 **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 500 µs**
- Analog channel 2 **is processed every 8 ms**

Exception: In modes "velocity control" or "torque control", the command values are read every **500 µs**.

The assignment applies the following principle:

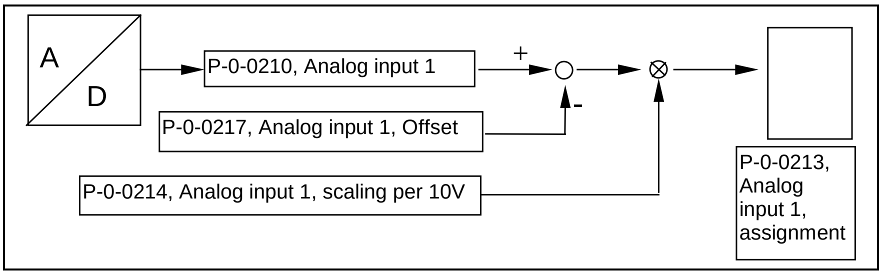


Fig. 10-6: Functional principle of assigning analog input 1 to a parameter

Displaying analog value 1

The converted voltage signals of both differential inputs are stored in parameter **P-0-0210, Analog input 1** respectively.

Configuring the 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 not equal to S-0-0000 has been parametrized. 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** and then copied into the parameter with the ID number set for the assignment 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** 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 allocation of analog input 2 can be conducted accordingly.

Example:

Assignment of analog input 1 to **S-0-0036, velocity command value** with 10 V equal to 1000 rpm

Parameter setting:

- **P-0-0213, analog input 1** = S-0-0036
- **P-0-0214, analog input 1, evaluation per 10V** = 1000.0000 rpm

Analog Inputs - Connection

See also project planning manual.

10.5 Digital Output

The drive controller has two digital outputs available to it with the basic unit independent of command communications.

Pertinent Parameters

- **P-0-0124, Assignment IDN -> Digital output**
- **S-0-0097, Mask class 2 diagnostic**

Functional Principle

With parameter **P-0-0124, Assignment IDN -> Digital output** it is possible to assign any parameter to these outputs.

Parameter structure P-0-0124: This parameter is a 4 byte parameter. The lowword contains the ID number of the assigned parameter, the highword the number of digital interfaces.

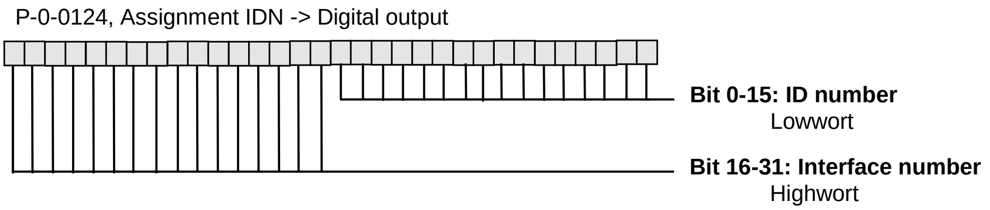


Fig. 10-7: P-0-0124, Assignment IDN -> Digital output

Example:

Parameter S-0-0144 is to be brought to the digital outputs of the drive controller.

1. interface number = 1 -> highword =1
2. ID number = S-0-0144 –> lowword = 0x90

The value 0x10090 must therefore be written into P-0-0124.

Note: With a DKCx.3 the number of digital interfaces is always 1.

If ID number = 0 in P-0-0124 is entered, then the drive automatically puts the READY signal (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.

Hardware Requirements

DKC.3** The following applies with a DKC**.3:

P-0-0124, Assignment IDN -> Digital output

Bit 0 => Ausgang X3/8

Bit 1 => Ausgang X3/10

DKC01.3

Note: The freely configurable signal status word are assigned to digital outputs X15/14 to X15/23 in a DKC01.3.

10.6 Oscilloscope Feature

The oscilloscope feature is used to diagram internal and external signals and output variables. Its function is comparable to a 2-channel oscilloscope. The following parameters are available to set the oscilloscope feature:

- **P-0-0021, List of Scope Data 1** (always 4-byte data)
- **P-0-0022, List of Scope Data 2** (always 4-byte data)
- **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** (cannot be written)
- **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**

Main Functions of 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 was 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.

The triggering is activated by setting the bit 1 in the "Trigger Control Word" parameter. 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 - P-0-0029 Trigger Level**.

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 function will end. Parameters **P-0-0031 Timebase** and **P-0-0032 Size of Memory** can define the recording duration and the time intervals for the measurement samples.

The sampled values are stored in **P-0-0021 and P-0-0022 List of scope data** 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 the **P-0-0023 and P-0-0024 Signal Selection** parameters. 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 probe value list:
0x00	Channel not activated	--
0x01	Actual 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

Fig. 10-8: 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 is constructed in terms of a list parameter and transmits the ID numbers of the possible signals.

Expanded Oscilloscope Recording Function

In addition to the oscilloscope feature with preset signals, the drive also allows for recording of any desired internal signals. Use of this feature is meaningful only with information about the structure of the internal data memory; therefore, this feature can be used effectively only by the corresponding developer. The feature can be activated with the **Signal Selection P-0-0023 & P-0-0024** parameters by setting bit 12 = "1". The format for the data to be saved can be defined with bit 13.

P-0-0023 & P-0-0024, Oscilloscope Function Signal Selection

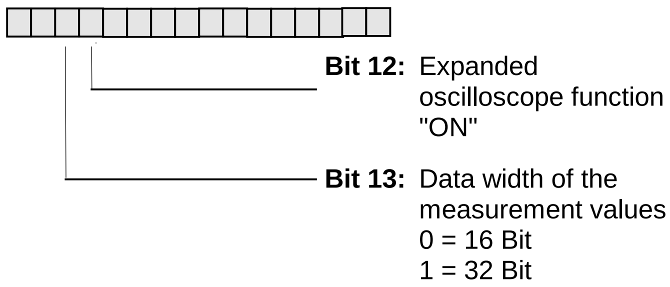


Fig. 10-9: Structure of Parameters P-0-0023 and P-0-0024

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 for the user to choose between two trigger types.

External trigger (P-0-0025 = 0x01)

The trigger is activated by the control through bit 0 in the **Trigger Control Word**. This makes it possible to transmit a trigger event to several drives. This parameterization supports parameter P-0-0035, 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. The "Delay from Trigger to Start" parameter 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. 10-10: 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 edge:
0x00	no trigger signal	not defined
0x01	Actual **position** feedback 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)

Fig. 10-11: 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 desired internal signal. Use of this feature is meaningful only with information about the structure of the internal data memory; therefore, this feature can be used effectively only by the corresponding developer. This feature can be activated with the parameter **P-0-0026 Trigger Signal Selection** by setting bit 12 to 1.

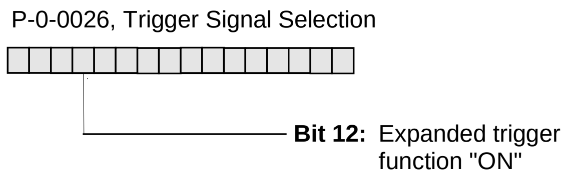


Fig. 10-12: Structure of parameter P-0-0026

If the expanded trigger feature is activated, then the trigger signal address must be defined via the parameter **P-0-00146 Expanded Trigger Address**. The associated trigger level is entered in the parameter **P-0-0145 Expanded Trigger Level**. This parameter is defined as follows:

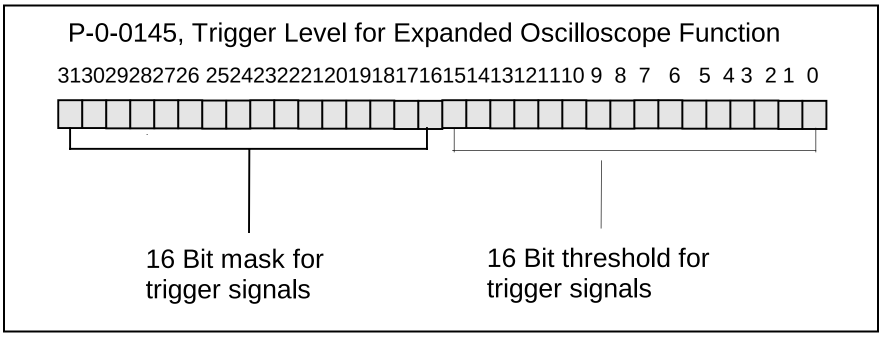


Fig. 10-13: Structure of parameter P-0-0145

The 16-bit value of the trigger edge is monitored and the trigger signal will be ANDed with the trigger signal screen mask.

Setting the Time Resolution and the Memory Depth

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 memory depth is 512 samples. If you need fewer samples, 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 samples are recorded. The minimum recording duration is 256 ms; the maximum recording duration is 51.2 s.

In general:

$$\text{Recording duration} = \text{Time resolution} \times \text{Size of Memory} \left[\mu s\right]$$

Fig. 10-14: Determining of the recording duration

Setting the Trigger Delays

By setting the parameter **P-0-0033 Number of Samples after Trigger**, it is possible to record probe values before the trigger event occurs (trigger delay function of an oscilloscope). The setting occurs 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 the P-0-0032 Size of Memory parameter is entered, then only the probe values occurring after the trigger event will be recorded.

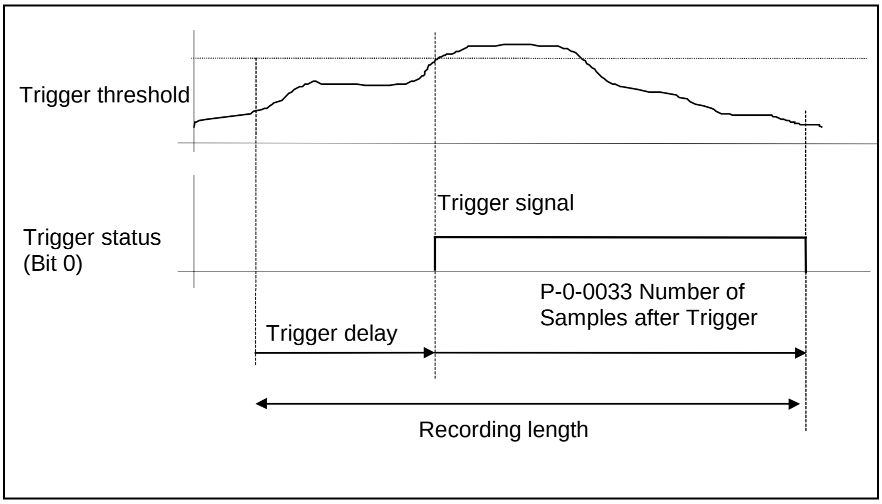


Fig. 10-15: Trigger delay - Number of samples after trigger

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:

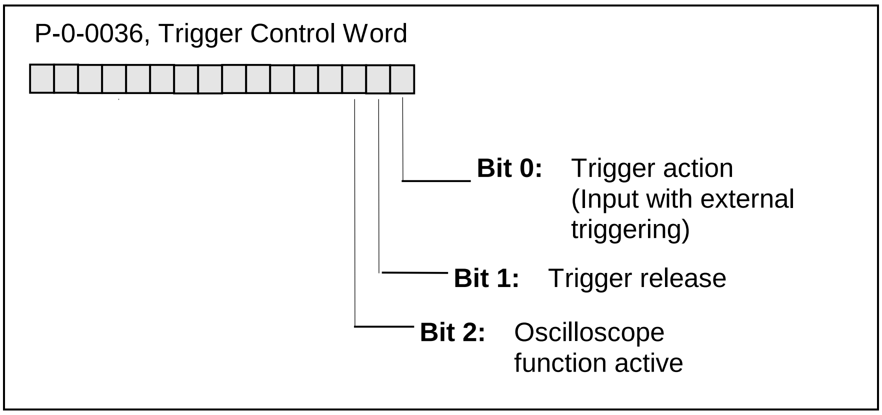


Fig. 10-16: Structure of Parameter P-0-0036

The oscilloscope feature is activated by writing "1" into bit 2; i.e., the internal probe value memory is continually written with the selected measurement signals. 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 & 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 be initiated 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 it will not trigger. 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 enabling of this trigger, the delay is measured by the drive controller and stored in the parameter **P-0-0035, Delay from Trigger to Start**. A time-correct display of the signal can be guaranteed by using this parameter for the visualization of the probe values.

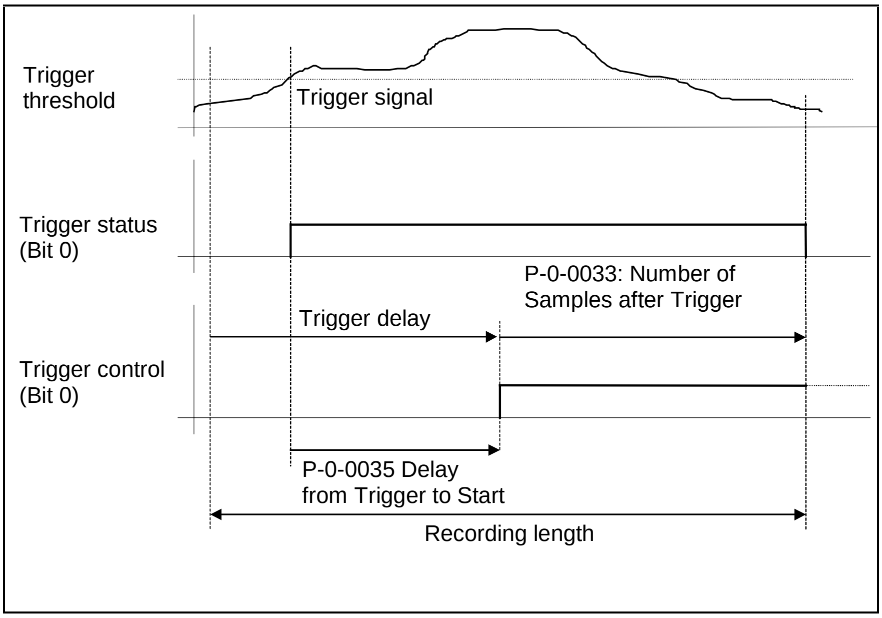


Fig. 10-17: Delay from trigger to start

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**.

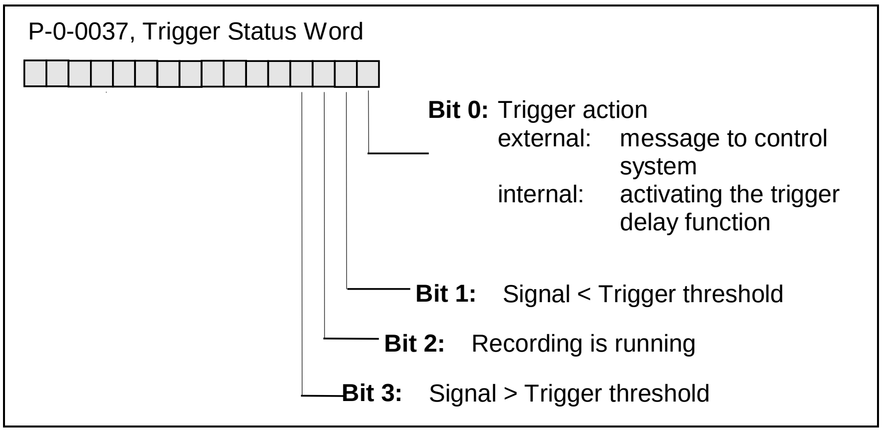


Fig. 10-18: Structure of Parameter P-0-0037

Number of Valid Probe Values

As soon as bit 2 is set by the **P-0-0036, Trigger Control Word**, the drive starts to record probe values.

If the trigger event is recognized after the bit is set, the oscilloscope feature records the number of samples 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 samples after trigger and the time when the trigger event occurs.

This means that the memory can contain samples which are not valid for the measurement.

The parameter **P-0-0150, Number of valid Samples** indicates the number of valid samples for the current recording.

10.7 Probe Input Feature

Two digital inputs are available for measuring positions and times. The measured values are determined with the positive and negative edges.

The following measured values can be determined:

- Position feedback value 1
- position feedback value 2
- relative internal time in [usec]

Note: The probe inputs are read every 1 msec. The measured signals are generated every 500 usec. Linear interpolation taking place between these two steps with an accuracy of 1 usec.

Measuring the absolute signals and the difference between measured values for positive and negative flanks

Through the parameters you can read the absolute values of these signals at the time of a positive or negative edge as well as the difference in their parameters.

Automatic rapid halt with positive edge from probe 1

There is also the option upon detection of a positive flank of probe 1 to execute an automatic quick halt of the drive.

Pertinent Parameters for the Probe Analysis

- **S-0-0170, Probing cycle procedure command**
- **S-0-0401, Probe 1**
- **S-0-0402, Probe 2**
- **S-0-0169, Probe control parameter**
- **P-0-0200, Signal select probe 1**
- **P-0-0201, Signal select probe 2**
- **S-0-0405, Probe 1 enable**
- **S-0-0406, Probe 2 enable**

- **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**
- **P-0-0202, Difference Probe Values 1**
- **P-0-0203, Difference Probe Values 2**
- **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**

Main Function of the Probe Analysis

S-0-0170, Probing cycle procedure command activates the feature. The feature is activated as a command, but does not send a command acknowledgement. The Command Change bit is not used.

To activate the feature, S-0-0170 must be written with 3 (decimal) = 11 binary.

From this point on, the status of the probe signals will be displayed in the parameters **S-0-401, Probe 1** and **S-0-402, Probe 2**.

A probe input is enabled with parameter **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.

It must be set in parameter **S-0-0169, Probe control parameter** which probe inputs are to be evaluated and whether the positive or negative flanks.

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. 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 following status messages will be set to 1: **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**.

When the probe enable is cancelled, the following status messages will be erased: **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**.

Note: Only the first positive and the first negative signal edge of the input will be evaluated after the 0→1 (rising) 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 cancelled, the corresponding probe-value latched parameters are also cancelled.

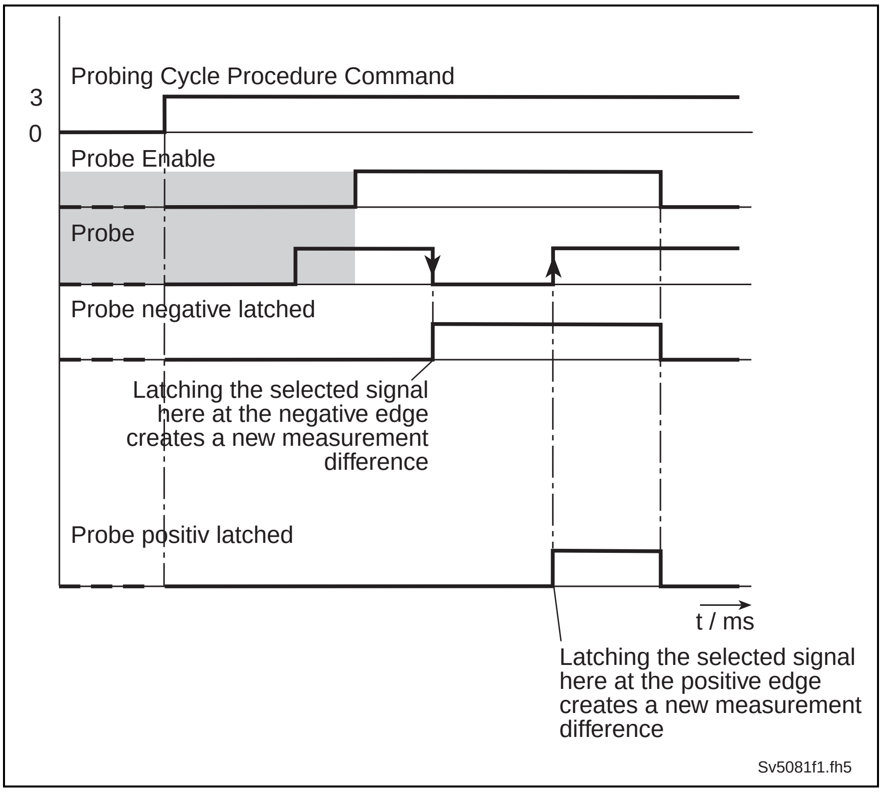


Fig. 10-19: Evaluation of probe signal edges, when positive and negative signal edge evaluation are set in the probe control parameter

Results of Writing "3" to the S-0-0170, Probing Cycle Procedure Command

The probe feature begins when 3 (decimal) = 11 binary is written into the parameter **S-0-0170, Probing cycle procedure command**. The following will happen:

- The **data status** will be set to **7** by **S-0-0170, Probing cycle procedure command**.
- All probe values and probe value differences will be set to 0.
- All "probe ... latched" parameters will be cancelled.
- The external voltage monitor will be activated (if it has not yet been activated).
-

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 the 0→1 (rising) edge of the probe signal, and the negative probe value is assigned the 1→0 (falling) edge. The **S-0-0169, Probe control parameter** determines whether both occurring edges will be evaluated and will lead to the positive/negative probe values being saved.

The parameter should be set before activating this feature.

parameter structure:

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 4: Position Feedback Value Selection
0: S-0-0053 is always used as the measurement, if an optional feedback is connected and position feedback values are chosen in the signal selection.
1: S-0-0051 is always used as the measurement, if position feedback values are chosen in the signal selection.

Bit 5 : Enable Mode Probe 1
0 : **Single measurement**, after each measuring, another measuring must be released with a 0-1 edge of the enable.
1 :**Continuous measurement**, the measuring is done as long as the enable stays 1.

Bit 5 : Enable Mode Probe 2
0 : **Single measurement**, after each measuring, another measuring must be released with a 0-1 edge of the enable.
1 :**Continuous measurement**, the measuring is done as long as the enable stays 1.

Bit 7 : Quick Stop, when Probe 1 is latched positive
0 : Recognition of probe 1 does not lead to a quick stop of the drive.
1 : Quick stop, when the positive edge of probe 1 is latched.

Fig. 10-20: S-0-0169, Probe control parameter

Signal Selection for the Probe Inputs

Values to be measured are:

- actual position value 1 (motor encoder)
- actual position value 2 (optional encoder, if mounted)
- internal time

The choice is made via parameters

- **P-0-0200, Signal select probe 1**
- **P-0-0201, Signal select probe 2** as well as in bit 4 of
- **S-0-0169, Probe control parameter.**

Using P-0-0200 or P-0-0201 it is possible to determine for both probe inputs whether an actual position value or an internal time is to be measured.

Value of P-0-0200/201:	Signal:
0	position feedback value 1/2
1	time

Fig. 10-21: Probe function determining signals

Depending on this choice, the units and the decimal places of parameters for the measured values corresponding to the positive and the negative edges as well as the difference in these measured values of the relevant probe are switched.

If the position feedback value is selected in the signal select parameters, then bit 4 in **S-0-0169, Probe control parameter** decides whether **S-0-0051, Position feedback 1 value** or **S-0-0053, Position feedback 2 value** will be used as signal.

Quick Stop with Probe Detection

If **S-0-0169, Probe control parameter**, bit 7 is set to "1" for quick stop with a positive edge of probe 1, then the drive, upon detection of a positive edge, automatically goes to "Velocity command value to zero". The drive decels at maximum possible torque. The drive stays in this state until the probe enable for probe 1 is cleared by the control in parameter **S-0-0405, Probe 1 enable.** The drive thereafter complies with the command value of the control.

Note: The use of quick stop upon detection of probe 1 cannot be simultaneously set with continuous measuring of probe 1. In other words, bits 7 and 5 of S-0-0169 cannot be simultaneously set to "1".

Note: If the drive is operated in "Position control", then prior to clearing Probe 1 enable, the drive-internal interpolation must be set to the position feedback value.

Mode "Continuous Measure"

Principle:

Enable mode is activated with bits 5 and 6 in **S-0-0169, Probe control parameter**

If a probe edge is detected, then bit 0 is latched into the relevant "Probe latched" parameter

- **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 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 probe 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 has not been cleared

- **S-0-0405, Probe 1 enable or**
- **S-0-0406, Probe 2 enable**

If there were no probes latched in the previous cycle, then bit 0 of the relevant "probe latched" parameter is cleared.

Note: The use of quick stop upon detection of probe 1 cannot be simultaneously set with continuous measuring of probe 1. In other words, bits 7 and 5 of S-0-0169 cannot be simultaneously set to "1".

Introducting a measurand counter in "Measurand latched" parameter

To detect any overruns during the continuous measuring, a probe counter is inserted in bits 8 through 15 of the relevant "probe latched" parameter. This is then incremented once a probe input is detected. If the maximum value of 2^8-1 (255) is reached, then the counter starts at 0 again!

With the help of this parameter it is ensured that

- measured values are not lost (e.g., AT failure),
- with an excessive measuring rate (more than one measuring cycle per SERCOS cycle) the available measurements can still be allocated within a given framework and
- overflow detection can be executed for an excessive measuring rate.

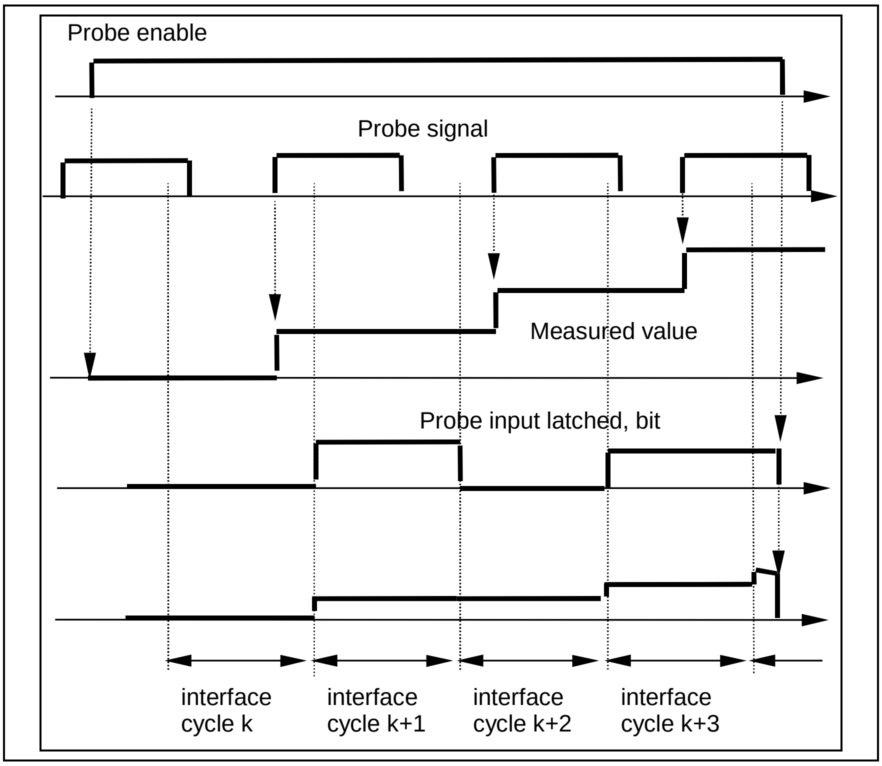


Fig. 10-22: Probe enable, probe signal, probe latched and measurand without overrun, for example a "positive probe flank"

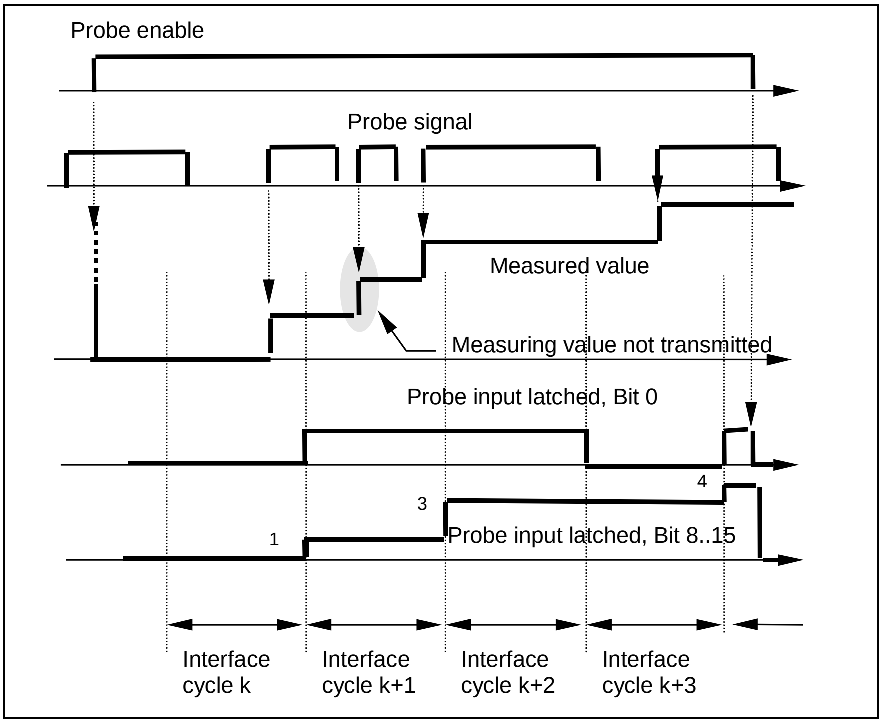


Fig. 10-23: Probe enable, probe signal, probe latched and measurand with overrun, for example a "positive probe flank"

Note: If the measuring rate exceeds the value of one measuring value per interface cycle then even the overrun counter cannot count every missing value!

"Probe latched"-Parameter, Bit 8..15 (probe counter)	"Probe latched"-Parameter, Bit 0 (probe status)	Definition
not incremented	0	no new probe input and no overrun
incremented by "1"	1	new probe input and no overrun
incremented	0	drive telegram failure in previous transmission cycle and new probe input, no new measured value in current interface cycle
incremented by more than "1"	1	New probe input and overrun (more than one edge per interface cycle)

Fig. 10-24: Relationship between measurand status and overrun counter

Connecting the Probe Inputs

see project planning manual

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.

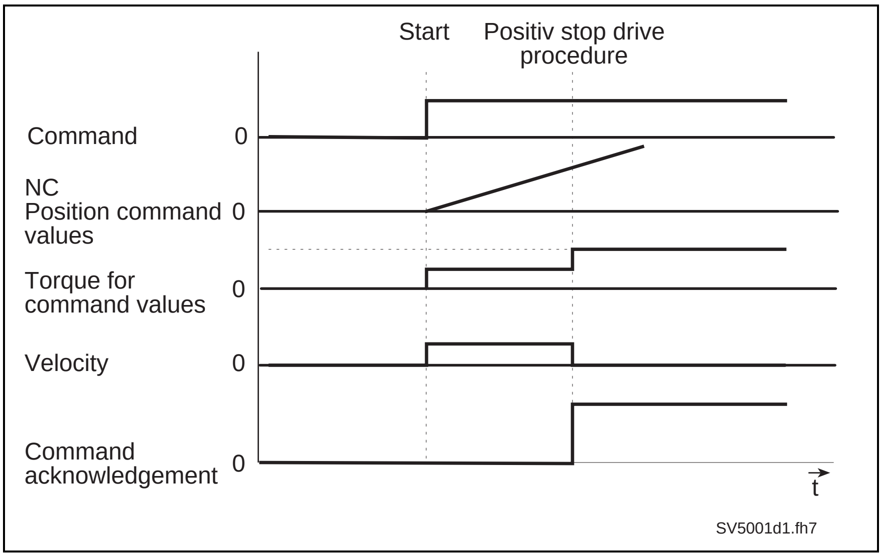


Fig. 10-25: Time sequence when activating the command: Positive stop drive procedure

10.9 Reversal backlash compensation

With the help of backlash compensation it is easy to correct backlash in the axis mechanics.

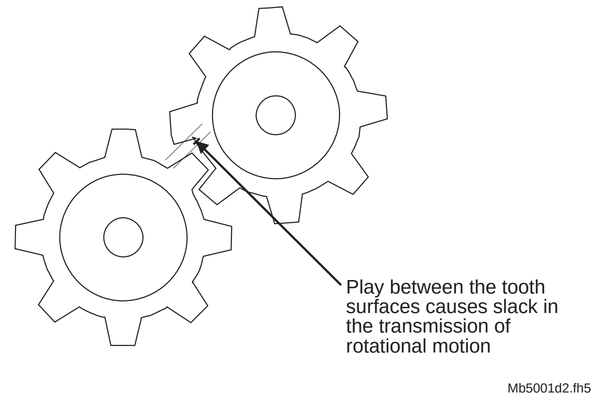


Fig. 10-26: Backlash with toothed wheels – an illustration

Pertinent Parameters

- **S-0-0051, Position feedback 1 value**
- **S-0-0053, Position feedback 2 value**
- **S-0-0058, Reversal clearance Reversal clearance**
- **S-0-0124, Standstill window**
- **S-0-0147, Homing parameter**
- **P-0-0401, Pos. corr., active correction value**
-

Functional Principle

How backlash compensation works

The function is activated by entering the backlash into parameter **S-0-0058, Reversal clearance.** With this value, the actual position value selected via **S-0-0147, Homing parameter** is corrected while allowing for the motional direction.

Note: Backlash compensation becomes effective if the encoder has its reference dimension. Backlash compensation is only active when reference encoder has been referenced. This can be done with the help of drive-internal referencing procedures.

It applies:

For v(soll) > S-0-0124, standstill window:
then x(ist) = x(ist)
For v(soll) < **-** S-0-0124, standstill window:
then x(ist) = x(ist) + corrected value

x(ist): actual position value 1 or 2

Fig. 10-27: The affect of backlash compensation on the actual position value

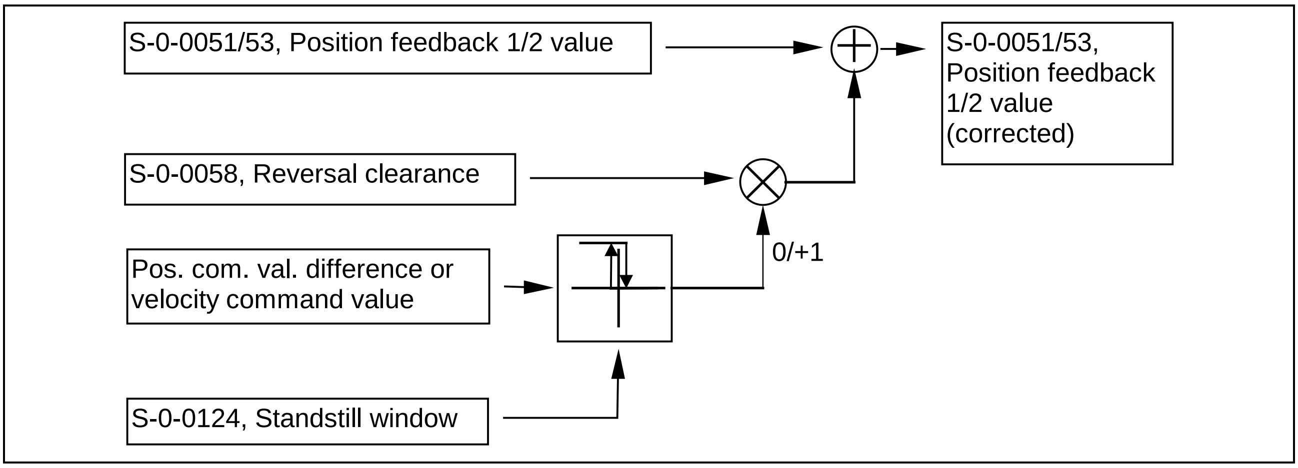


Fig. 10-28: Reversal backlash compensation

Displaying the active correction value

Parameter **P-0-0401, Pos. corr., active correction value** displays the value with which the actual position value has been corrected. In other words, the parametrized value of **S-0-0058, Reversal clearance** or 0 is displayed.

The displayed correction value relates to the encoder selected in **S-0-0147, Homing parameter** (Bit 3).

Determining the backlash

The following procedure will determine the correct value for the parameter **S-0-0058, Reversal clearance**:

1. Move axis in a positive direction in jog mode
2. Put the micrometer to an appropriate point on the mechanical system of the axis and set it to zero.
3. Jog the axis in a negative direction until the micrometer registers a change in position.

Then, the following calculation determines the reversal clearance:

$$\text{Reversal backlash} = \Delta\text{Xcontrol} - \Delta\text{Xmeas}$$

ΔXcontrol: Path travelled according to control display
ΔXmeas: Path travelled according to measurement

Fig. 10-29: Calculating the reversal play

10.10 Command - detect marker position

The command "Detect marker position" supports

- the control of a error free detection of the reference marker in an incremental measuring system or
- determining the position of the reference marker if the referencing procedure is conducted by the control. In this case, this information is used to switch the coordinate system in the control.
- A reference switching 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 activated, the following is done:
- The diagnosis **D500 detect marker position command** 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 runover, then its position feedback value is stored in parameter **S-0-0173, Marker position A.** This command is now signalled as completed.

Note: The drive generates no command values. The mode active at command start remains unchanged. To override the reference marker, the control must generate command values (e.g., by jogging), that cause a motion in the direction in which the reference markers are 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**. This relates, however, to the "old" coordinate system (before the coordinate system was switched while performing a homing function).

10.11 Command Parking Axis

The command "Parking Axis" supports the operational decoupling of 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.

The following parameter is available for this function:

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** it follows:

- that 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 display reads "**PA**".

This drive no longer accepts the drive enable.

10.12 Programmable Limit Switch

The "Programmable Limit Switch" feature allows for 8 PLS points. An individual on- and off-switch position and a delay time are available for each PLS point.

The reference signal for the PLS can be selected

The reference signal can be either

S-0-0051, Position feedback 1 value or

S-0-0053, Position feedback 2 value.

The cycle time for evaluation is 2msec.

The corresponding PLS bit can be inverted depending on how the on- and off-switch level is set.

The following parameters are available for this feature:

- **P-0-0131, Signal Select Position Switch**
- **P-0-0132, Switch-On Treshold Position Switch**
- **P-0-0133, Switch Off-Treshold Position Switch**
- **P-0-0134, Position Switch Lead Time**
- **P-0-0135, Status Position Switch**

Function diagram for the Programmable Limit Switch

This feature shows whether the selected reference signal lies within the range between the on- and off-switch position.

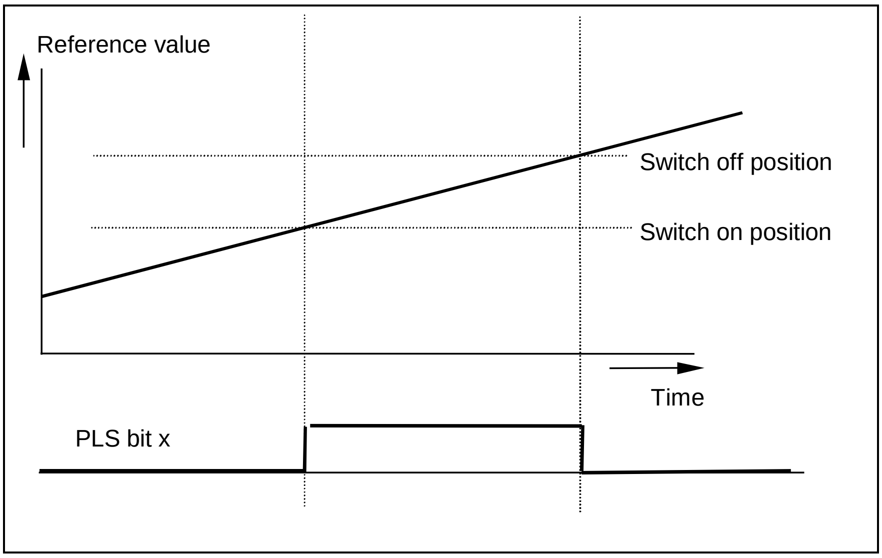


Fig. 10-30: General Function Diagram for the Programmable Limit Switch

Inverting occurs by exchanging the on- and off-switch level

The corresponding bit in the status position switch can be inverted by setting the on- and off-switch level.

There are two different situations that apply.

Switch-on position smaller than the switch-off position

If the switch-on position is programmed smaller than the switch-off position, then the following applies:

The position switch is "1" if:

- Reference signal > Xon

  AND

- Reference signal < Xoff

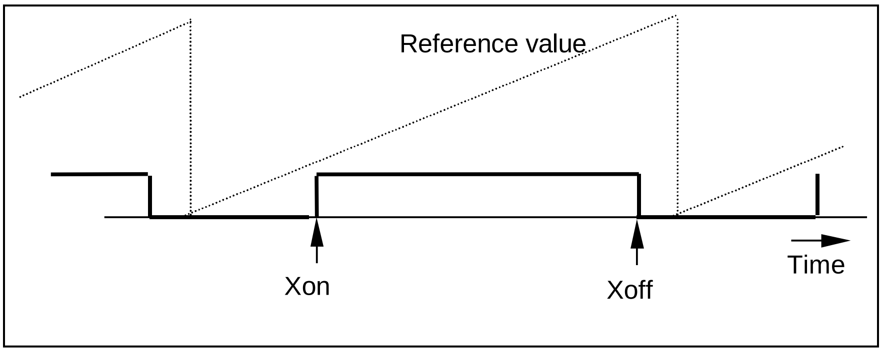


Fig. 10-31: Programmable Limit Switch With Xon < Xoff

Switch-on Position larger than the switch-off Position

The programmable limit switch is "1" if the following applies:

- Reference signal > Xon

  OR

- Reference signal < Xoff

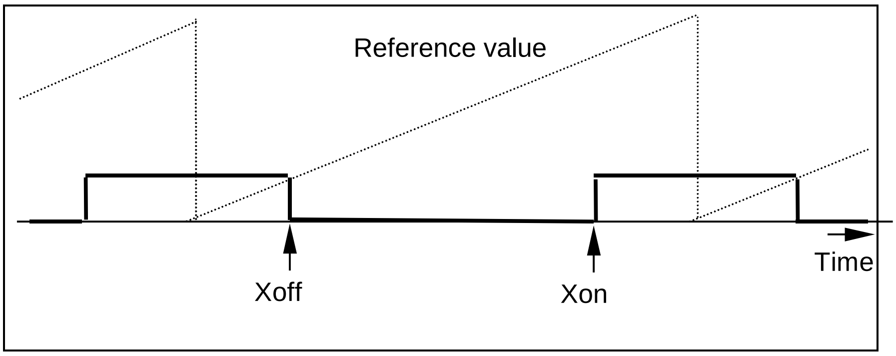


Fig. 10-32: Programmable Limit Switch With Xon > Xoff

A switch hysteresis is available to avoid position-switch flickering when the on- or off-switch level is reached.

Programmable Limit Switch Lead Time

The velocity of the drive should remain constant while using the lead time.

By setting a lead time, compensation can be made for the delay of an external switch element that is controlled by a PLS bit. In that way, a theoretical adjustment value can be calculated from the lead time and the current drive velocity for the on- and off-switch positions. The PLs bit switches by the lead time before reaching the corresponding position.

The assumption is that the velocity is constant in the range between the theoretical and real on- or off-switch position.

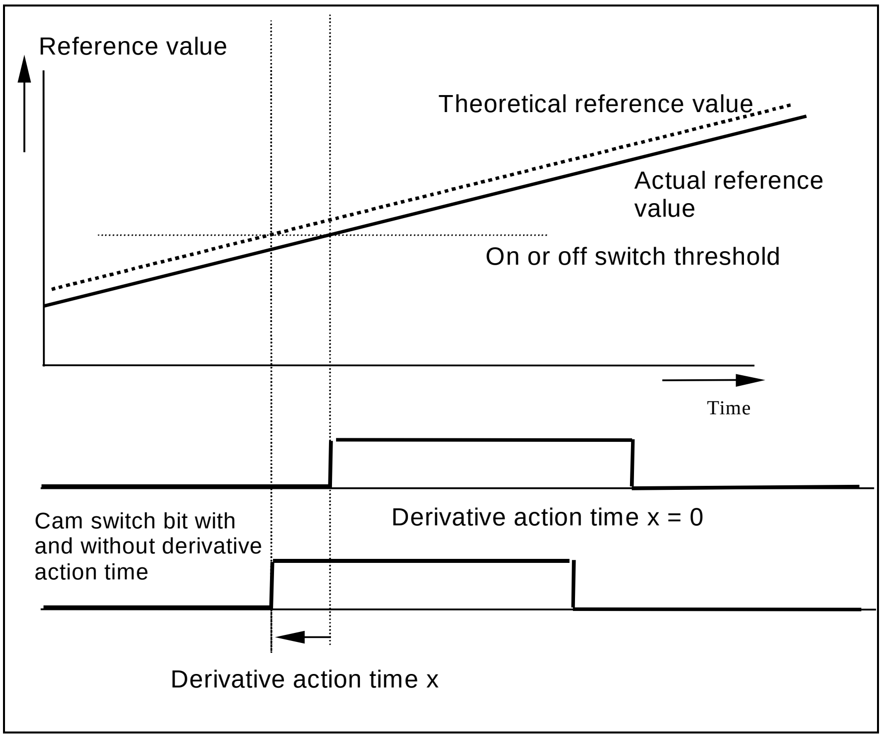


Fig. 10-33: Diagram for the Programmable Limit Switch Lead Time

Parameterizing the Programmable Limit Switch

The **P-0-0131, Signal Selection for Programmable Limit Switch** parameter is used to activate the programmable limit switch and to select a signal. The following values can be entered:

P-0-0131:	Feature:
0	The programmable limitswitch is not activated.
1	The programmable limit switch is activated; the reference signal is S-0-0051, Position feedback 1 value.
2	The programmable limit switch is activated; the reference signal is S-0-0053, Position feedback 2 value.

Fig. 10-34: Programmable Limit Switch: Activation and Setting the ReferenceSignal

The P-0-0134Programmable Limit Switch Lead Time parameter always should be parameterized completely (i.e., with all 8 elements), even if not using the delay..

The programmable limit switch parameters P-0-0132, Switch-On position, P-0-0133, Switch-Off position and P-0-0134, Lead Time can be used to set the on- and off-switch thresholds as well as the lead time.

Each of these parameters contains 8 elements. Element 1 is assigned for position switch bit 1, element 2 for bit 2, and so forth.

If one or more switch bits are not given a delay, then "0" should be set for these elements in **P-0-0134, Programmable Limit Switch Lead Time**.

The status of the position switch bits are shown in parameter P-0-0135, Status Position Switch. The following diagram shows the structure of this parameter.

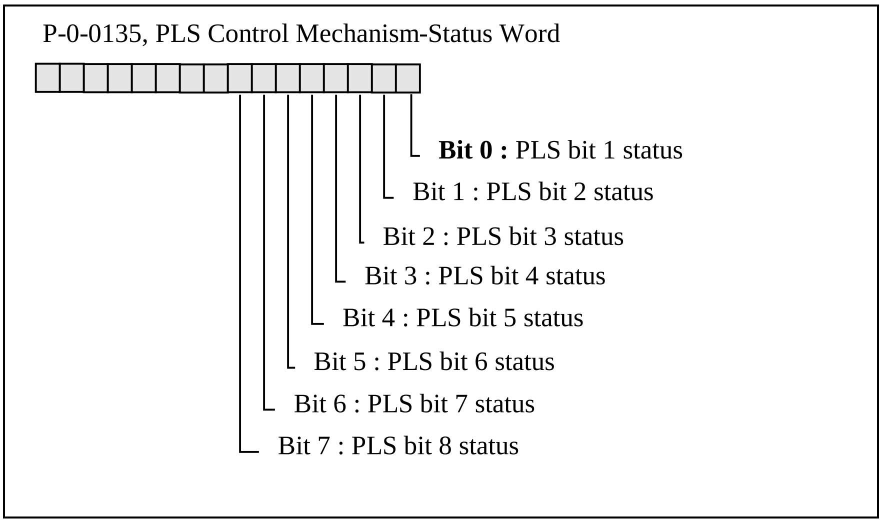


Fig. 10-35: Position Switch Status

10.13 Encoder Emulation

It is possible, with the help of encoder emulation to generate positions in the following standard formats

- **TTL format** with incremental encoder emulation
- **SSI format** with absolute encoder emulation.

This makes it possible to close the position control loop with an external control.

Incremental encoder emulation

Incremental encoder emulation is the reproduction of a real incremental encoder by a driver controller.

From the emulated incremental encoder signal, signals are relayed via a higher-ranking numeric control (NC) with information about the velocity of the motor mounted to the controller. By integrating this signal, the control generates information for itself about position. It is thus able to close a higher-ranking position control loop.

Absolute encoder emulation

"Absolute encoder emulation" means that the drive controller has the option of emulating 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'**

Parameter

- **P-0-0503, Marker pulse offset**

is used for **incremental encoder emulation.**

Parameter

- **S-0-0052, Reference distance 1**

is used for **absolute encoder emulation.**

Activating Encoder Emulation

It is possible to control the behavior of the function with the help of parameter **P-0-4020, Encoder emulation type.**

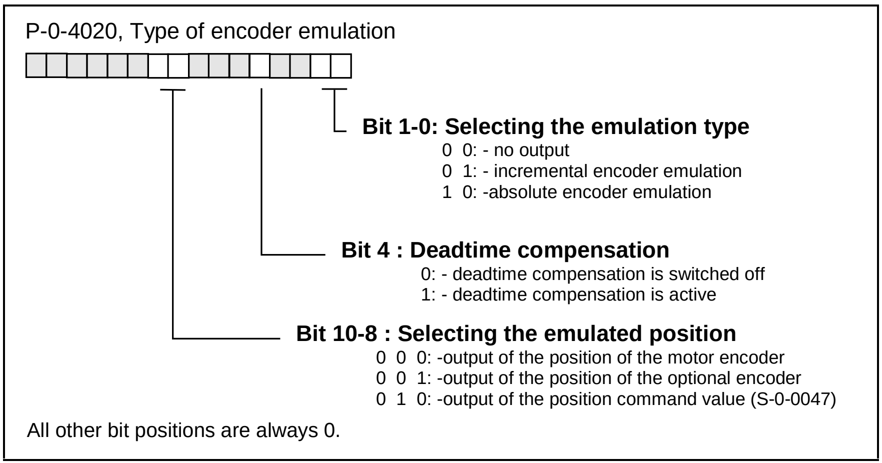


Fig. 10-36: Parameter encoder emulation type P-0-4020

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 generates as many zero pulses per 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, i.e.,

- 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 position within one motor revolution after initialization, or within one electrical revolution with resolvers, the zero pulse is always generated at the same motor position each time the unit is switched on.

Non-absolut encoder

Non-absolut encoders do not have an automatic method of determining position after powering up. This is why it is necessary to home. Homing uses the incremental encoder emulator zero pulse.

With non-absolut encoders, e.g., sine, gearwheel encoders, the following occurs automatically with each progression of phases 2 to 4 (in other words after each powering up of 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 can now be run via the position control loop by the control (homing, going to zero or referencing).

Drive-guided referencing

The drive can also conduct drive-guided referencing 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 referencing is successfully completed. It is output at the same position, however, (reference marker).

Zero pulse offset

With **rotary motors** it is possible to offset the zero pulse using **P-0-0503**, **Marker pulse offset** within a (electrical or mechanical) rotation in a clockwise direction.

The **unit** of P-0-0503 is **degrees.** The input range for motor encoders that are absolute after their initialization with unequivoal positions within a **motor revolution** of **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.

Limiting Incremental Encoder Emulation

In contrast to the conventional incremental encoder with which the pulse output frequency is practically infinitely seperated into very fine increments (i.e., the pulses are allocated to a fixed position), 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 for devices is 1024 kHz. If this frequency is exceeded, then pulses could be lost. The non-fatal 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.

$$l_{max} = \frac{f_{max} * 60}{n_{max}}$$

l_{max}: maximum line number
n_{max}: allowable maximum speed in 1/min

Fig. 10-37: Computing the maximum number of lines

Compensation of delay (deadtime) between real and emulated positions

Between position measurement and pulse output, there is a dead time (delay) of about 1ms in devices. 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 level** for a specific period can **remain constant**. The output frequency may not be changed during the time interval of T_A. This is especially true of high frequencies, i.e., with a large number 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.

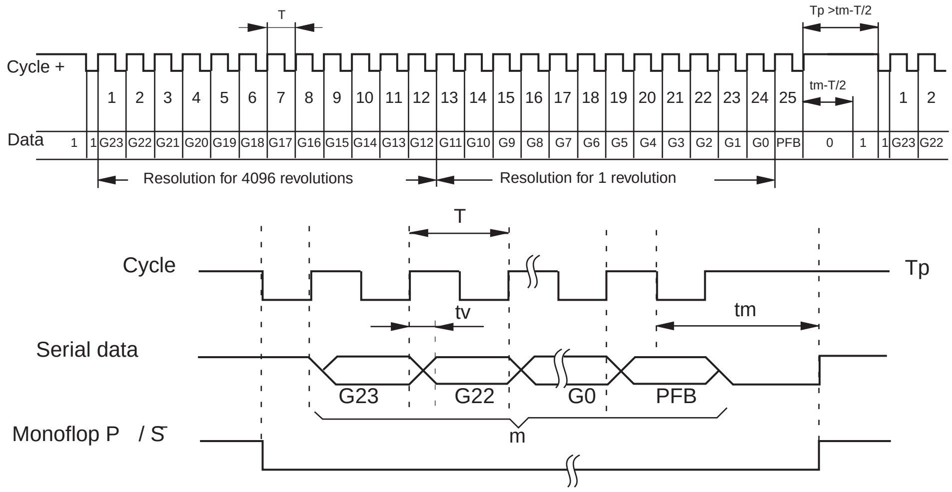
Remedy:

- Decrease input for **P-0-0502, Encoder emulation, resolution**
- Drop travel speed

Functional Principle: Absolute Encoder Emulation

SSI Format

The following illustrates the format of SSI data transmission.



G0 = lowest value bit in the Gray-Code
G23 = highest value bit in the Gray-Code
m = saved parallel information
T = cycle signal period duration
tm = monoflop time 15µs to 25µs
Tp = cycle rest
tv = delay time for the first cycle max. 540ns, for all others max. 360ns
PFB = Power Failure Bit (is not used and is logically always... "0")

ap5002d1.fh7

Fig. 10-38: SSI format as pulse diagram

Note: The **Power Failure Bit** is not evaluated in the drive!

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 depends on **S-0-0076, Position data scaling type.** The following combinations are possible:

- 12 .. 24 bit / revolution
- 4 .. 24 bit / mm
- 8 .. 24 bit / inch.

The output direction is set in parameter **S-0-0055, Position polarities**.

Note: The **unit** of the parameter is **switched** when selecting SSI emulation via parameter **P-0-4020, Encoder emulation type**.

Referencing with Absolute Encoder Emulation

Using parameter **P-0-0012, C300 Command 'Set absolute measurement'** it is posible to reference the absolute position output by the absolute encoder emulator .

With set absolute dimension, the value of parameter S-0-0052 Reference distance 1 is set.

Position jumps at the Display Limits of Absolute Encoder Emulation

Using SSI emulation, it is possible to illustrate 4096 revolutions absolutely. If when using SSI emulation the limit has been reached, then small position fluctuations lead to large **jumps in the emulated SSI position**.

This is the case with position 0 and 4096 revolutions.

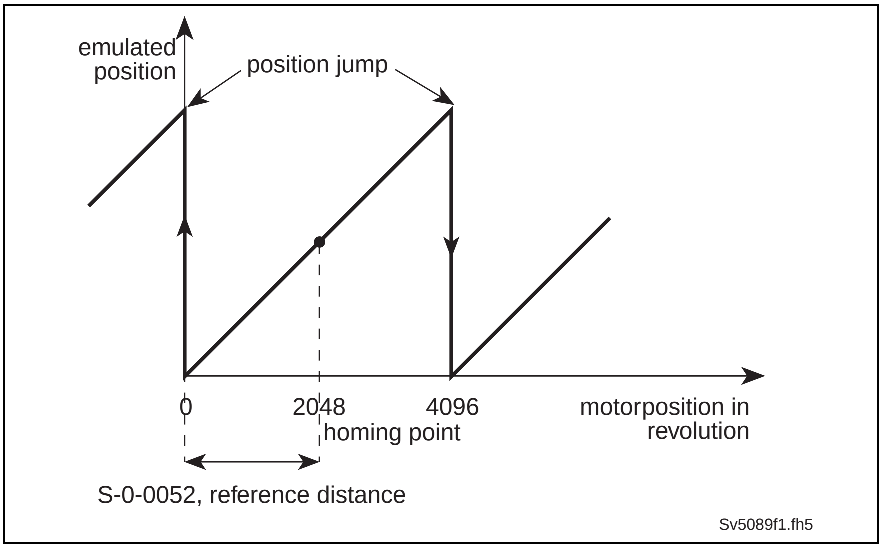


Fig. 10-39: SSI display limits

To avoid this, then use commando **P-0-0012, C300 Command 'Set absolute measurement'** to shift the SSI position value.

It is recommended to move the position into the center of the SSI display range by means of the **S-0-0052, Reference distance 1**. This offers the option of running 2048 revolutions to the left and to the right.

10.14 Spindle Positioning

Spindle positioning in milling and drilling spindles were used

- to prepare the change of the workpiece while the spindle remained a defined position.

Spindle positioning in lathe main spindles support the orientation of the spindle

- when changing the workpiece, if necessary,
- the putting into place of balancing drill holes in workpieces that are to be balanced,
- to index the workpiece for further machining.

In rotary tables, spindle positioning

- the relaying of the rotary table to bring the workpieces in the machining stations into a defined machining position.

A command from the control makes the drive move the spindle in terms of the zero position of the spindle. The command position can be set by means of parameters. It can be set as either an absolute or a relative position.

The spindle positioning command can, for example, position the spindle in velocity control mode in a position-controlled manner without having to switch from velocity to position control mode. The velocity command set by the control is ignored for the duration of the command.

Pertinent parameters

The following parameters are needed for setting up spindle positioning and to execute the command:

- **S-0-0013, Class 3 diagnostics, Bit 6**
- **S-0-0041, Homing velocity**
- **S-0-0042, Homing acceleration**
- **S-0-0057, Position window**
- **S-0-0103, Modulo value**
- **S-0-0124, Standstill window**
- **S-0-0138, Bipolar acceleration limit value**
- **S-0-0147, Homing parameter**
- **S-0-0152, C900 Position spindle command**
- **S-0-0153, Spindle angle position**
- **S-0-0154, Spindle position parameter**
- **S-0-0180, Spindle relative offset**
- **S-0-0222, Spindle positioning speed**
- **S-0-0294, Divider for modulo value**
- **S-0-0349, Jerk limit bipolar**
- **S-0-0403, Position feedback value status**
- **P-0-1201, Ramp 1 pitch**
- **P-0-1202, Final speed of ramp 1**
- **P-0-1203, Ramp 2 pitch**
- **P-0-1222, Velocity command filter**

Functional Principle

The command spindle positioning entails two different cases:

Spindle positioning with non-referenced drive

If the drive is not in reference (**S-0-0403, Position feedback value status** bit 0 = 0) then referencing is automatically started prior to positioning.

The drive first brakes to referencing speed. At this speed, it searches for the reference pulse. As soon as it is located, the actual position values are displayed in terms of the reference pulse (also see the section: Drive-Controlled Referencing) and positioned to spindle angle position.

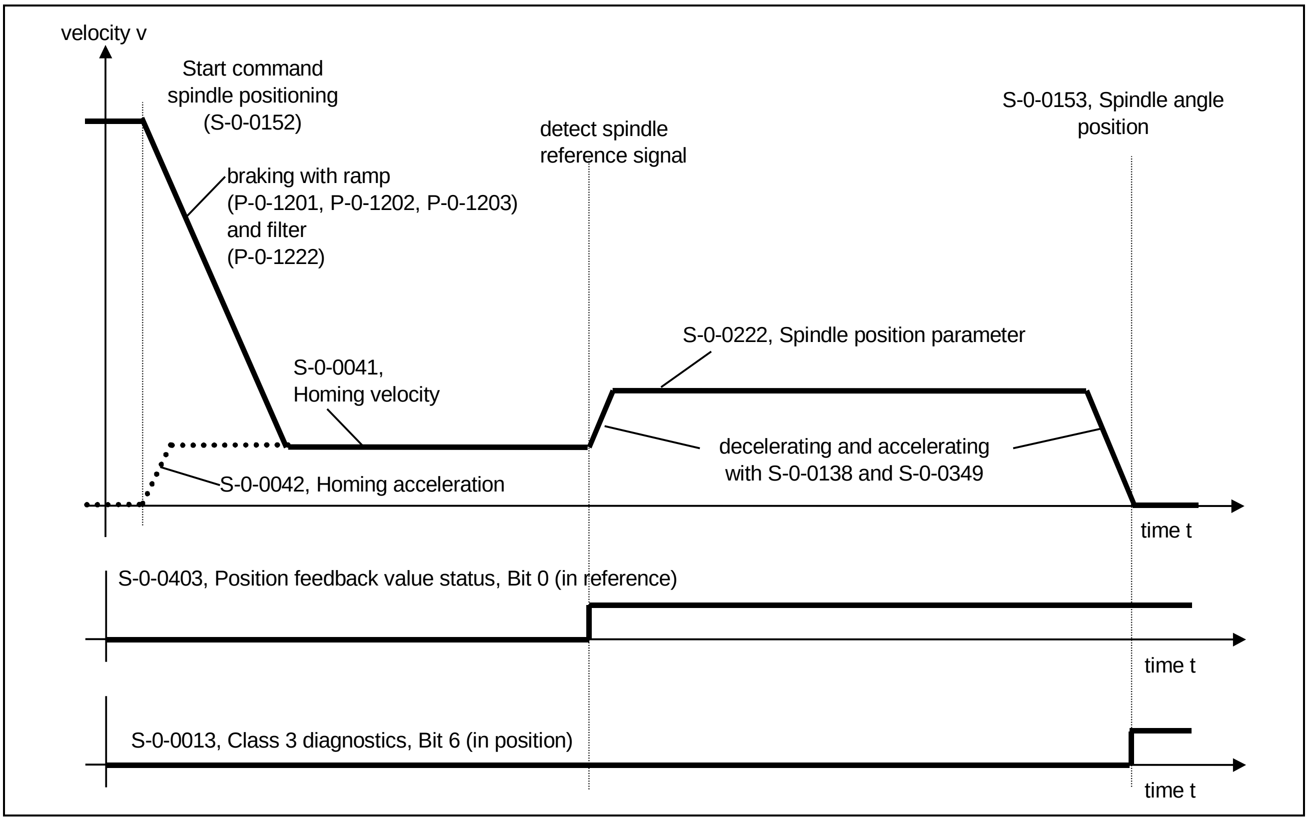


Fig. 10.40: Velocity/time diagram of spindle positioning with referencing

Spindle positioning with drive already referenced

The turning spindle brakes at the velocity command value ramp set (or with active command value smoothing) to the spindle positioning velocity and runs to the specified command position with that absolute positioning which has been set.

The drive holds the position in a position controlled manner until the command is completed or a new command position is set.

Once the command is completed, the drive runs with the current velocity or torque command value.

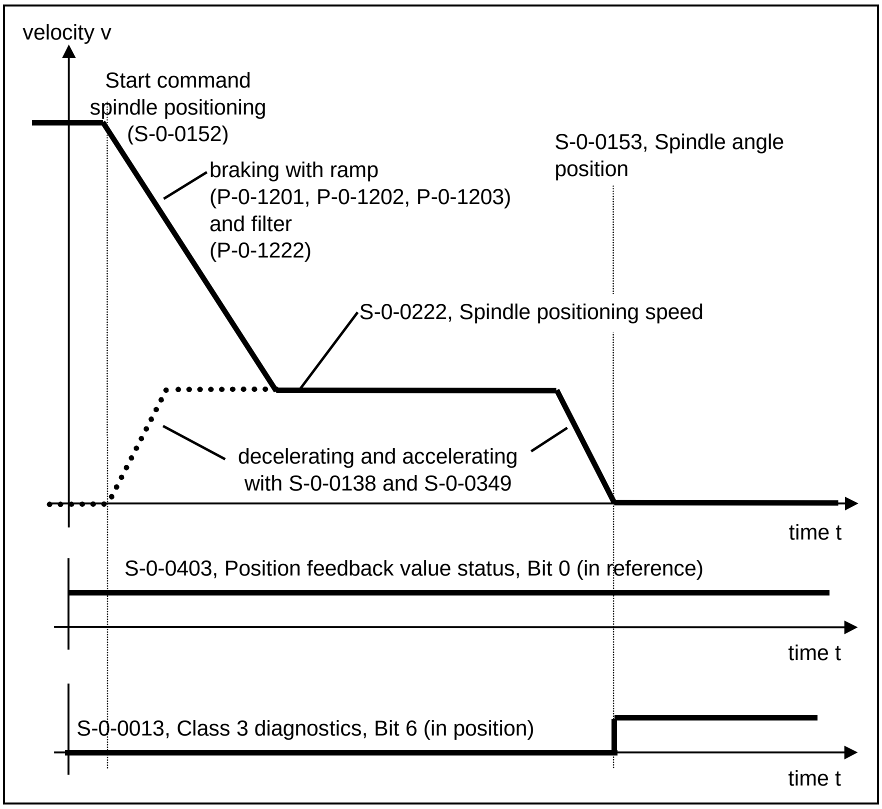


Fig. 10.41: Velocity/time diagram of spindle positioning

Note: Once the command is completed, the drive returns with the currently pending speed or toque command values.

Positioning

With the command spindle positioning, it is possible to position the spindle via an encoder or a spindle reference switch.

Which positioning procedure is actually used depends on the way the motor is mechanically coupled to the spindle.

Using parameter **S-0-0147, Homing parameter** it is possible to choose between:

- positioning to the motor encoder
- Positioning to spindle encoder
- positioning to spindle reference switch.

Spindle motor coupling	Positioning procedure: Spindle positioning via...	Setting in S-0-0147
rigid coupling, i = 1	motor feedback	xxxx xxxx x01x 0xxx
gearbox and indexing mechanical, non-slip, i≠1	spindle reference switch	xxxx xxxx x10x 0xxx
gearbox and indexing mechanical, non-slip, i≠1	spindle feedback	xxxx xxxx x01x 1xxx
belt coupling, slip	spindle feedback	xxxx xxxx x01x 1xxx

Abb. 10-42: Positioning procedure depends on spindle/motor coupling

Note: Spindle reference switch equals reference point switch spindle feedback equals an optional encoder

Positioning Accuracy

Positioning accuracy with motor encoder

If the spindle positioning command is conducted only over the motor feedback, then the following factors are decisive for the accuracy of positioning:

- the absolute accuracy of the measuring system used as motor encoder
- the accuracy of the mechanical transmission elements (gearbox, etc.)

Positioning accuracy with spindle encoder

If the command spindle positioning is conducted via a spindle encoder, then inaccuracies of the mechanical transmission elements can be eliminated to a considerable degree.

The achievable positioning accuracy of the spindle then depends on:

- the absolute precision of the measuring system used as spindle encoder

Positioning accuracy with spindle reference switch

The accuracy of this type of positioning is less than with positioning with a spindle encoder. The following factors play a roll:

- direct dependent on reference velocity (see below)
- the switching hysteresis of the spindle reference switch
- the precision of the mechanical transmission elements (gearbox, etc.)

Mechanical arrangement of the spindle reference switch

If the spindle is coupled to the motor via a slip free gearbox then positioning to an operating cam mounted to the spindle is possible.

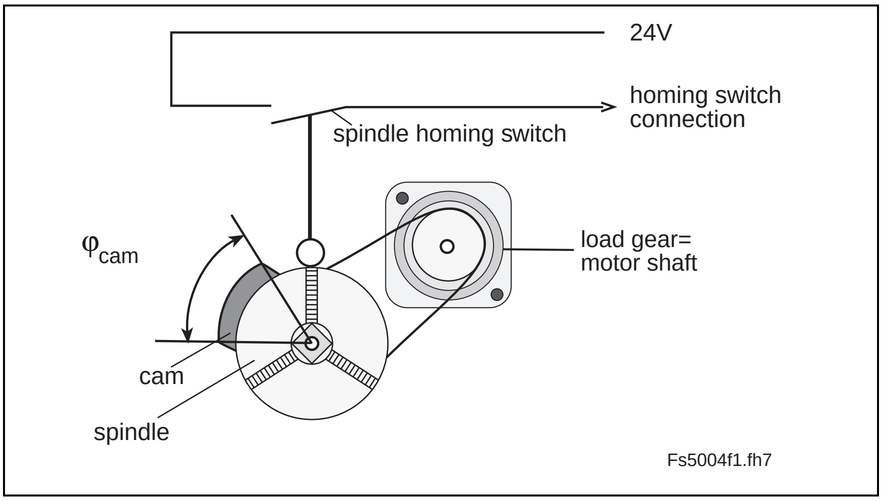


Fig. 10-43: Cam angle of the spindle reference switch

Accuracy of Spindle Reference Switch Detection

Positioning accuracy depends directly on the referencing velocity:

$$\Delta\varphi_{\max} = n_{ref} * 250\mu s * \frac{360° * \min}{60s}$$

$\Delta\varphi_{max}$: greatest inaccuracy with the detection of the spindle reference signal

n_{ref}: referencing velocity in min^{-1}

Fig 10-44: Computing the systematic inaccuracy of spindle reference signals detection

minimum effective switching cam angle

To make sure that the spindle reference signal is correctly read in, the operating cam must cover a minimum angle:

$$\varphi_{Nocken} > n_{ref} * 250\mu s * \frac{360° * \min}{60s}$$

φ_{Nocken}: angle of the operating cam

n_{ref}: referencing velocity in min^{-1}

Fig 10-45: Computing the cam angle

The minimum angle of the operating cam computed as above simultaneously represents the systematic inaccuracy of spindle reference switch detection.

Detecting the Spindle Reference Switch Signal

The spindle reference switch signal is always detected at the same cam edge independent of the rotational direction of the spindle.

The cam edge is set with the reference direction in parameter **S-0-0147, Homing parameter**

- **Referencing direction positive**

A clockwise rotation of the spindle means the right cam edge is detected as rising edge and set as reference position.

A counterclockwise rotation means the right cam edge is seen as a falling edge and is set as reference position.

- **Reference direction negative**

With counterclockwise rotating of the spindle, the left cam edge is seen as a rising edge and set as reference position.

With clockwise the left cam edge is seen as a falling edge and set as reference position.

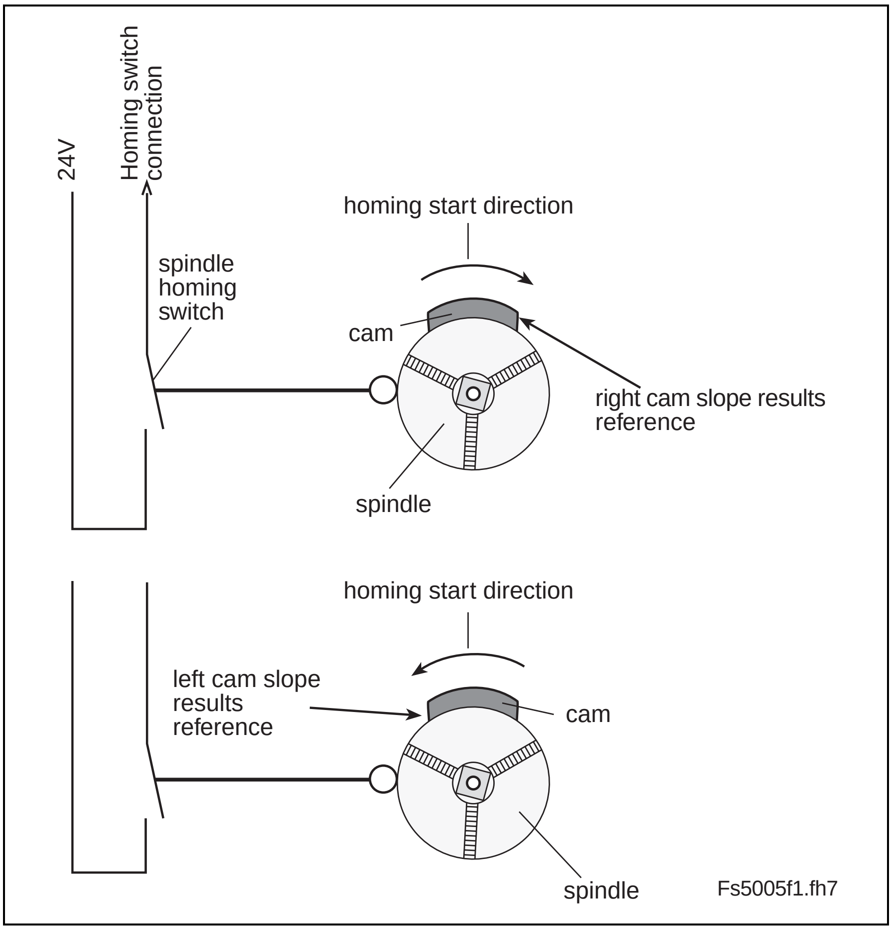


Fig. 10-46: Reference position with spindle positioning

Einfluß der Schalterhysterese des Spindelreferenzschalter

Because the different rotation directions of the spindle see the selected flank of the spindle reference switch as either rising or falling, the accuracy of positioning increases by the switching hysteresis of the spindle reference switch.

Positioning type

The type of spindle positioning can be set in Parameter **S-0-0154, Spindle position parameter**. It is possible to individually set:

- Positioning direction clockwise
- Positioning direction counterclockwise
- Positioning direction shortest path
- absolute positioning
- relative positioning

Spindle turning clockwise or counterclockwise / shortest path

The rotational direction of the drive is set in **Bits 0 and 1**.

Note: The positioning direction "clockwise" or "counterclockwise" is only noted if the spindle is standing still prior to start of the command or moving at a speed smaller than set in **S-0-0124, Standstill window**. If the spindle is already turning, then positioning takes place out of the current rotational direction.

Absolute/relative positioning

Bit 2 sets whether a spindle angle position is to be approached (absolute positioning) or whether the spindle path is to be run (relative positioning).

Note: It makes sense to have the spindle standing still before switching from absolute to relative positioning to start the traversing angle with a defined start position. The switch from absolute to relative positioning and vice versa is immediate even if the spindle positioning command is running.

Selecting Modulo Range

S-0-0103, Modulo value is generally set to one spindle revolution = 360° (=physical modulo value). By setting as a modulo axis, maximum velocity in cyclic position control is limited to

V_{max} = (S-0-0103 modulo value / 2) / NC cycle time

If the velocity is too low, then the modulo value must be increased to a multiple integer of a spindle revolution.

To get short positioning durations, the spindle angle position always reference the physical modulo value.

The ratio between **S-0-0103, Modulo value** and the physical modulo value can be illustrated in parameter **S-0-0294, Divider for modulo value.**

Example: Spindle axis,

physical modulo value = 1 revolution = 360°

NC cycle time = 4ms

S-0-0103, Modulo value = 360°

S-0-0294, Divider for modulo value = 1

Vmax = (360° / 2) / 0.004 sec = 45000°/sec = 7500 U/min

If maximum value is to equal 20,000 rpm, then the following values result:

Modulo value > 20000 U/min * 360° / 60 * 0.004sec * 2 = 960°

S-0-0103, Modulo value = 3 * 360° = 1080°

S-0-0294, Divider for modulo value = 3

Executing spindle positioning

The command is started with parameter **S-0-0152, C900 Position spindle command**.

Once it is completed, the spindle is held in position control at the command position (**S-0-0153, Spindle angle position**) or it has turned by the relative position (**S-0-0180, Spindle relative offset**).

Upon completion of command, the drive sets **Bit 6** in parameter **S-0-0013, Class 3 diagnostics**

Conditions for S-0-0013, Class 3 diagnostics, Bit 6 (spindle in position)

1. Value of actual velocity smaller than standstill window |S-0-0040| <= S-0-0124.
2. Value of spindle angle position minus spindle position is smaller than positioning window.
   | S-0-0153 - S-0-0051| < S-0-0057 with motor encoder or
   | S-0-0153 - S-0-0053| < S-0-0057 spindle encoder.

Note that the state of this signal cannot be made current any sooner than 10 ms after the start of spindle positioning or the change of spindle position.

Spindle in Position

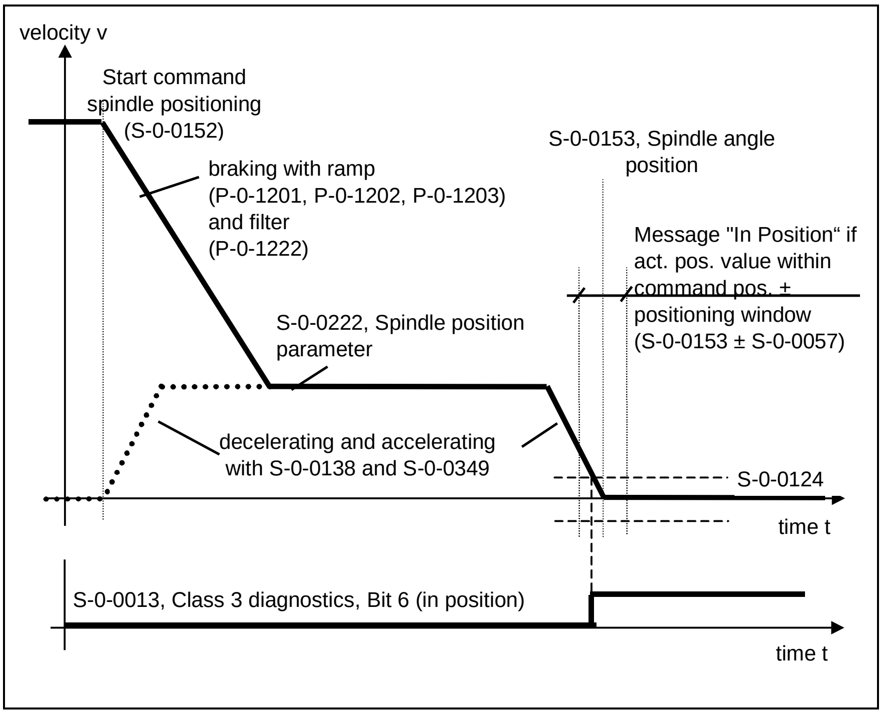


Fig. 10.47: Velocity/time diagram with in position message when spindle positioning

Diagnostic messages

While executing command spindle positioning, the following diagnostic messages can occur.

Messages with error-free execution

While the command is being executed the H1 display of the controllers reads "C9“.

Messages with faults

C902 Spindle positioning requires drive enable:

Drive enable not set at the start of the command.

⇒ Set drive enable prior to command start!

C904 Encoder 2 not present:

The direct measuring system needed as per the homing parameter (spindle feedback or encoder 2) is either missing or not connected.

⇒ Check spindle feedback connection.

C905 Positioning with non-init. absolute encoder impossible:

Motor or spindle feedback is an absolute encoder. The spindle, however, cannot position as command "Set absolute dimension" has not yet been executed.

⇒ Command **P-0-0012, C300 Command ’Set absolute measurement’** must be executed (see section: "Setting the Absolute Dimension").

Other fault causes

If the spindle turns after command start without positioning:

- The spindle reference switch is not recognized.

⇒ Check spindle reference switch and wiring functions!

If the spindle runs to the wrong target position:

- The value in parameter **S-0-0103, Modulo value** is not equal to 360.
- Gear ratio not correct (with positioning via motor feedback with spindle reference switch).

⇒ Enter correct gear ratio in parameter **S-0-0121** and **S-0-0122**, **Output revolutions of load gear** and **-Input revolutions of load gear**.

- or -

- Motor or spindle feedback faulty or not synchronous

⇒ Motor or spindle feedback and its synchronization must be checked in the relevant parameters.

- or -

- Parameter **S-0-0076, Position data scaling type** for position data is incorrectly set.

If the drive shuts down with error message "F228 Excessive deviation":

The spindle cannot follow the internally set position command values.

⇒ Check whether the spindle is mechanically blocked.

⇒ Check whether the parameter value in **S-0-0159, Monitoring window**, is sufficiently high and increase, if necessary!

⇒ Reduce value in parameter **S-0-0138, Bipolar acceleration limit value**.

If the spindle is in the desired position, but "S-0-0336, Message In position" is not signalled:

The spindle position cannot be held by position control in the positioning window around the position command value

⇒ Check whether **S-0-0057, Position window** on 0, if yes, change

⇒ Check whether **S-0-0124, Standstill window** correctly parametrized

⇒ Stabilize an erratic actual position value by changing position and speed control parameters!

⇒ If actual position value cannot be stabilized, increase the value in parameter **S-0-0057, Position window**

⇒ Check configuration of **S-0-0144, Signal status word** and **S-0-0013, Class 3 diagnostics**

Connecting the reference switch

See the Project Planning Manual.

11 Glossar

Data status

Every parameter has at its disposal a data status. It can be read by the control via the required data channel. The information on the validity of the parameter or the command acknowledgment of the command are contained therein.

Error reaction or response

If an error is detected in the drive, then the drive reacts independently by executing an error reaction. At the end of each error reaction there is a deactivation of the drive. The error reaction type is dependent on the error class of the error that occurred as well as the setting in parameters P-0-0117..119.

E-Stop

E-Stop (Emergency Stop) is the determination for a hardware input at the drive controller. It is used to trigger the emergency stop function in the drive.

External encoder

An external measuring system is optional. It is generally mounted directly to the load. The position feedback value of the encoder can be seen in S-0-0053, Position feedback 2 value. By activating the position control operating mode with encoder 2, the position control loop is closed with the help of the position feedback value of the external encoder.

Ident Number

Every parameter is designated unambiguously by its ident number (IDN). It consists of these 3 components: S-Sercos/P-Product specific, parameter set (0..7) and a number (1..4096).

Load default or basic load

The control parameters are stored in the motor feedback data memory in both MDD and MKD motors. This makes it possible for the drive controller to work trouble-free with this motor. The control parameters have not been optimized for the application.

Modulo format

Both position feedback and command values can be processed in modulo or absolute format. If modulo processing has been set, then the position data move within the range of 0..S-0-0103, modulo value. With this function, it is possible to realize an endlessly turning axis.

Motor encoder

The motor encoder is the measuring system that is used during commutation. A measuring system is absolutely necessary. The position feedback value of the encoder can be seen in S-0-0051, position feedback value 1. By activating the position control operating mode with encoder 1, the position control loop is closed with the help of the position feedback of the motor encoder.

Operating data

The operating data is data block element 7 of a parameter. The value of the parameter is stored there.

Operating mode

Operating mode is set in parameters S-0-0032..35. It determines in what way a command value is processed in the drive and eventually initiates an axis movement. The operating mode does not define how the command value reaches the drive.

Parameterization mode

The drive is in parameterization mode if communication phases 1..3 have been set. The drive cannot be activated (drive enable signal applied). Operating mode must first be switched into. Some parameters can only be written into during parameterization mode.

Programming module

The programming module contains the software and parameter memory. It is mounted in slot U5. When exchanging the controller, a simple insertion of the programming module out of the old into the new unit means that the features of the replaced unit have been transferred to the new one.

Home Switch

If during the command **S-0-0148, C600 Drive controlled homing** several reference marks can be reached within the travel range, it’s the home switch which must specify one singular mark. The home switch is connected to the respective input at the drive and activated by bit 5 in S-0-0147, Homing Parameter. This input is mirrored in the parameter **S-0-0400, Home switch**.

Scaling

The combination of unit and number of decimal places of a parameter are defined as scaling. It can be set for position, velocity and acceleration data.

SERCOS interface

Digital interface for communication between control and drives in numerically controlled machines. One or multiple ring structures are implemented. The physical connection of the participants generally implements a fiber optic cable.

Service Channel

The non-cyclic reading and writing of parameters via the SERCOS-Interface is done in the service channel

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ECODRIVE03
Drive for Machine Tool Applications
With SERCOS-, Analog- and Parallelinterface

Supplement A
Serial Communication
SMT 02VRS

DOK-ECODR3-SMT-02VRS**-FK01-EN-P

Contents

Notes

1 Serial Communikations

1.1 An Overview

The drive controller is equipped with a serial interface. It supports the parametrization of the drive. Using this interface, it is possible to alter:

- **Parameters**
- **Commands and**
- **Diagnoses**

Interface mode

The interface can be operated in either

- **RS232 mode** or
- **RS485 mode**

Interface protocol

Two different protocols are supported:

- the Indramat **SIS protocol**
  The usable data are transmitted in INTEL format.
- **and an** ASCII protocol

Its precise structure is outlined in the following section.

Note:	If an ASCII protocol is used, then the number of bytes differs from the data length in the parameter description (internal number format).

1.2 Pertinent Parameters

The data exchange which implements 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**

1.3 Function Principle

Basic State once the Control Voltage is Switched On

After the control voltage is switched on, serial communications in the drive is in "**Passive mode**“. Communications is not possible in passive mode.

Selecting a Protocol

To be able to take up serial communications with the drive it is necessary to set the communications mode (protocol)

- with a "**Change Drive“ command** (with **ASCII protocol**)
- or a valid **Start telegram** (with **SIS protocol**).

Note:	Internally, the first detected protocol that is valid (SIS or ASCII) is switched into. If a different protocol is to be used at some later point in time, then this is only possible by switching the 24 volt power supply off.

Note: The two listed options for establishing a connection, are extensively described in the section on Communications procedures**.**

Setting the Drive Address

The drive address is set via the serial interface by write accessing communications parameter **P-0-4022, Drive address.** DriveTop or a PLC can be used for this purpose.

Exception:

If value "**256**“ is entered into communication parameter **P-0-4022,** then the unit address set via the address switch will be used for serial communications and not the value used in **P-0-4022.**

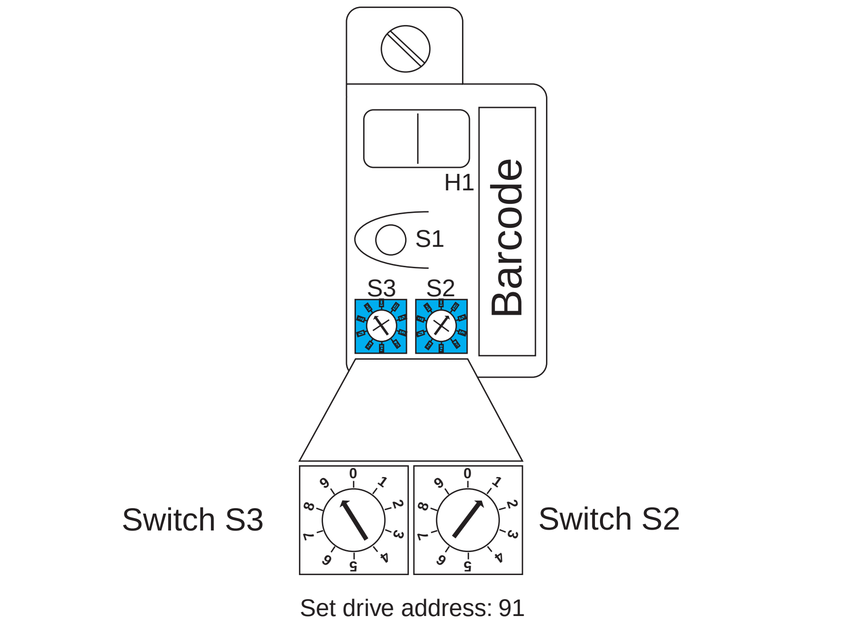

Fig. 1-1: Setting the address via the address switch on the programming module

RS485 mode

It is only absolutely necessary to set the drive address if communications uses the RS485 bus because each bus participant 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 participant is connected (peer-to-peer connection).

Communications via RS232 Interface

Features:

The RS232 interface is intended for use when connecting a PC with the **DriveTop** startup program.

- Transmission rate: 9600 and 19200 baud
- Maximum transmission path: 15m
- 8-bit **ASCII** protocol or 8-bit **SIS** protocol
- no parity bit
- a stop bit

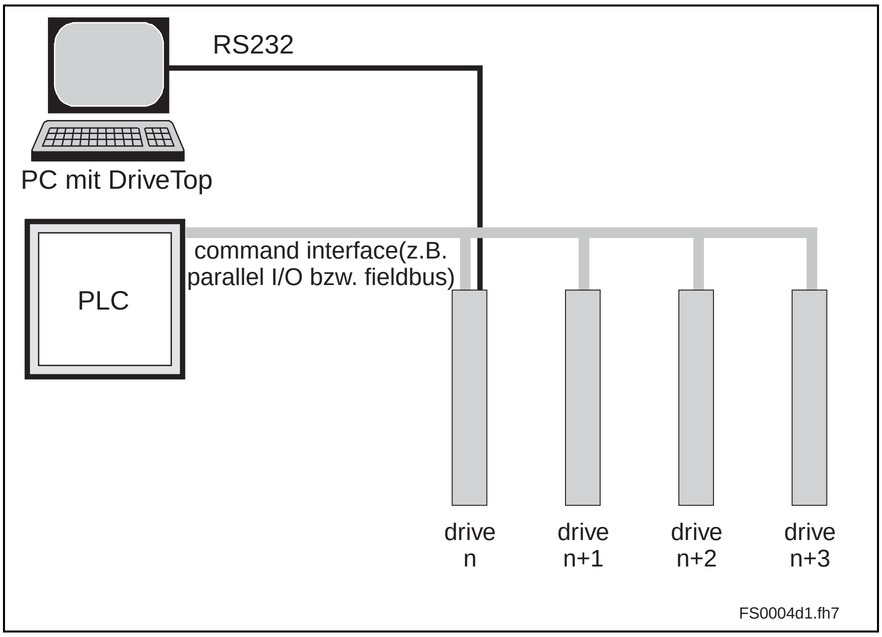

Fig. 1-2: Communications via RS 232 interface

Communications via RS485 Interface

Features

Communications via RS485 interface helps implement 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: **500m**
- **Half duplex** mode over a **2-wire** line
- 8-bit **ASCII** protocol or 8-bit **SIS** protocol
- no **parity bit**
- a stop bit

Operting Several Drives with DriveTop

Application advantages:

- Starting up several drives without replugging an interface cable (central parametrization and diagnostics connection).
- Implementing a central PC-supported visualization unit.

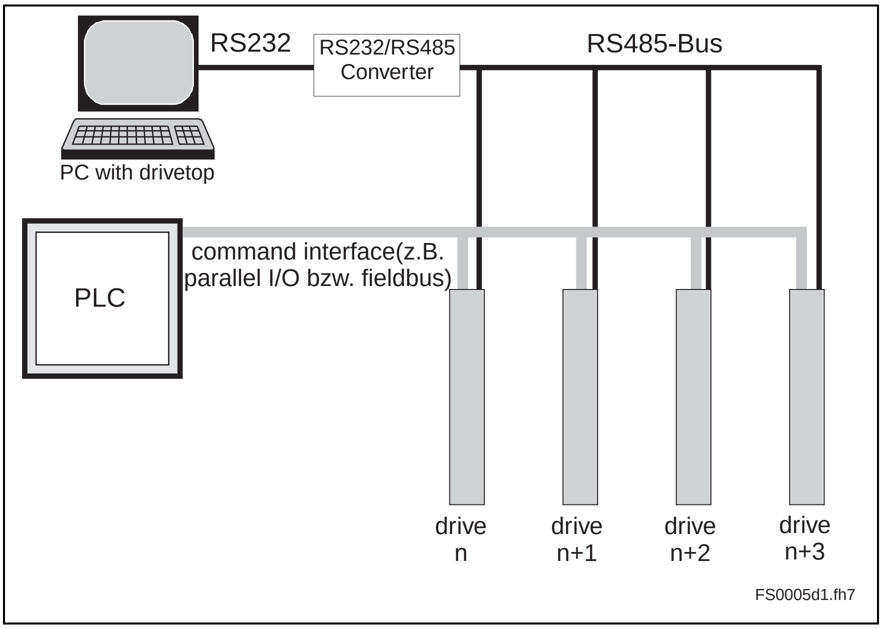

Fig. 1-3: Operating several drives with DriveTop

Parametrization and Diagnosing with a PLC

Application advantages:

- Parameters can be changed with a PLC (e.g., adjuting positioning blocks).
- Expanded diagnostics options for the PLC by reading in error codes.

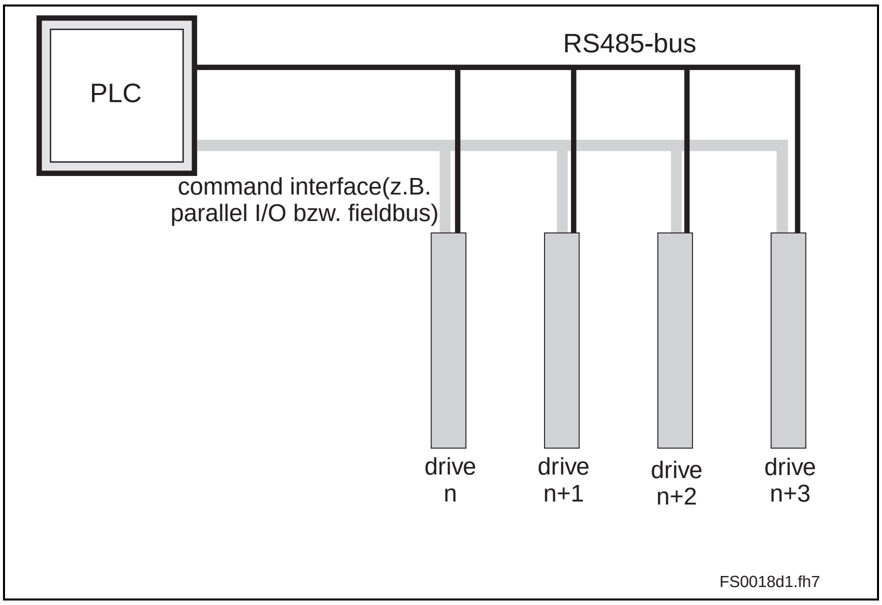

Fig. 1-4: Parametrizing and diagnosing with a PLC

Parametrization and Diagnosing Drive Groups Using a Control Unit

Application advantages:

- Using a central visualization unit.

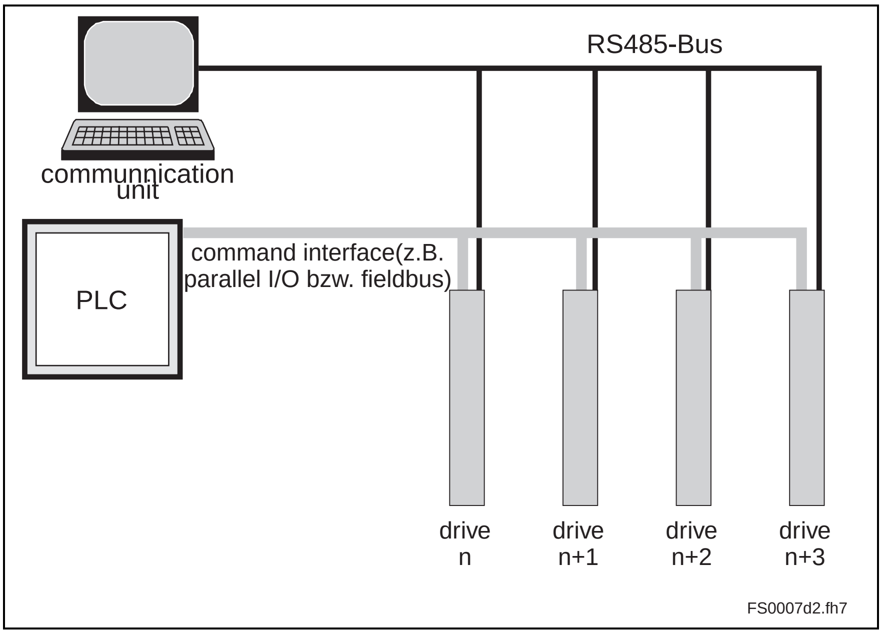

Fig. 1-5: Parametrization and diagnoses of drive groups using a control unit

1.4 Transmission Protocols

When switching on the 24V power 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 and baud rate.

The drive supports two different protocols:

- ASCII protocol
- SIS protocol

These are explained below in greater detail.

ASCII Protocol

Features:

- Transmission rates of: **9600** and **19200** baud
- Maximum transmission path: 1**5m**
- 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 AS-CII symbol is converted and interpreted. It is only necessary to maintain a specified order.

SIS protocol

Features:

- This is a **binary protocol.**
- A checksum test is conducted (higher Hamming distance D).
- All telegrams are identified by an unequivocal start symbol.
- There is a defined telegram frame structure.
- It is possible to trigger movements via an SIS telegram (e.g., jogging).

Structure, Telegram frame:

An SIS telegram is basically broken down into three blocks:

- Telegram head
- user data head
- user data head

Telegram head	User data head	User data

Fig. 1-6: 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 telgram 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 {running 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: 'running 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	Adress 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	running telegram number (package number), **if bit 3 in byte cntrl has been set**

Fig. 1-7: SIS-Telgram 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 telegram** (Master --> Slave):

This is the telegram that the master sends to the slave (drive) !

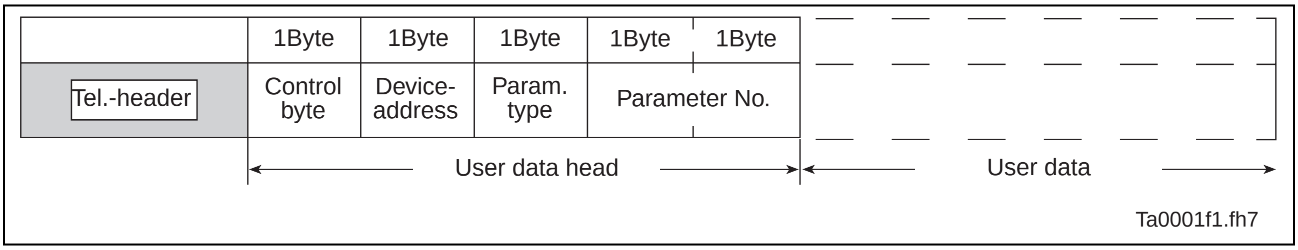

Fig. 1-8: User data head structure in the command telegram

- **Reaction telegram** (Slave--> Master):

This is the telegram that the slave sends to the master (Drive)!

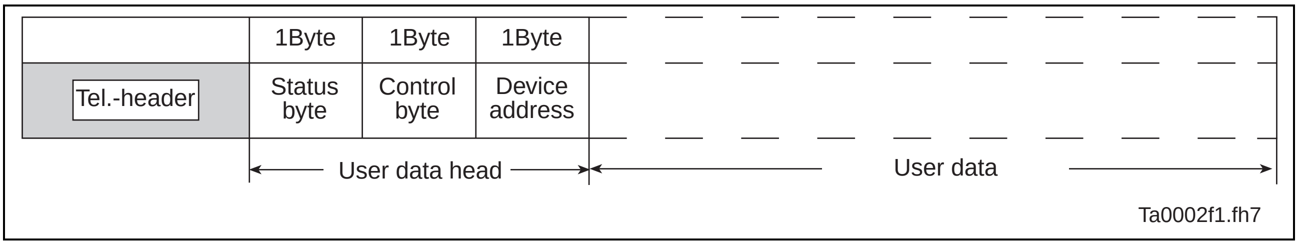

Fig. 1-9: User data head structure in reaction telegram

The definition of the user data head

The user data head describes the mode of transmission in the command telegram.

Control byte

The data block element of a parameter which is being accessed is described 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.

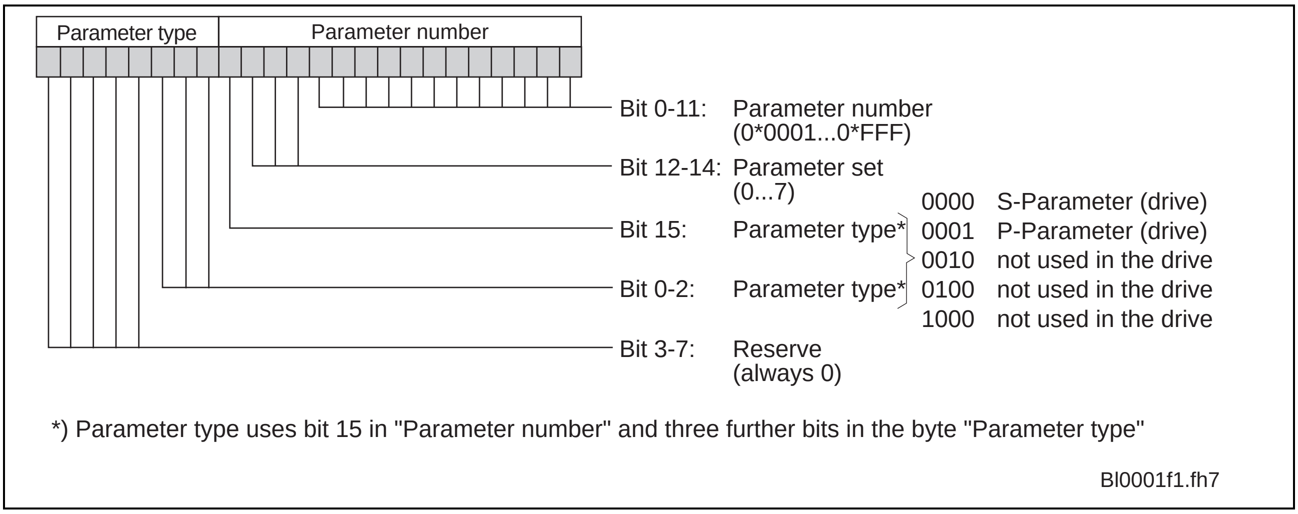

Fig. 1-10: Parameter number and type in user data head

Structure of the User Data Field

Values of any kind can be entered in the user data byte. These cans 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 length of the user data field is set with both the DatL and DatLW bytes in the telegram head.

1.5 Communications procedures

General Information on the Parameter Structure

All parameters of the drive controller are stored in a uniform parameter structure. Each parameter is made up of 7 elements. The table below describes the individual elements and access possibilities. The parameter structures illustrated here will be referenced in the following sections.

Element no.	Data block element	Access posibilities
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. 1-11: Parameter structure

Note: Attached is a parameter description with detailed data of the features of all available parameters.

Communicating with an ASCII Protocol

Actuating a Specific Bus User

To communicate with a bus user then it must be directly addressed with a CHANGE DRIVE command, specifying the drive address. With each CD command, the drive specified by the address is activ. All other ddrives 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.

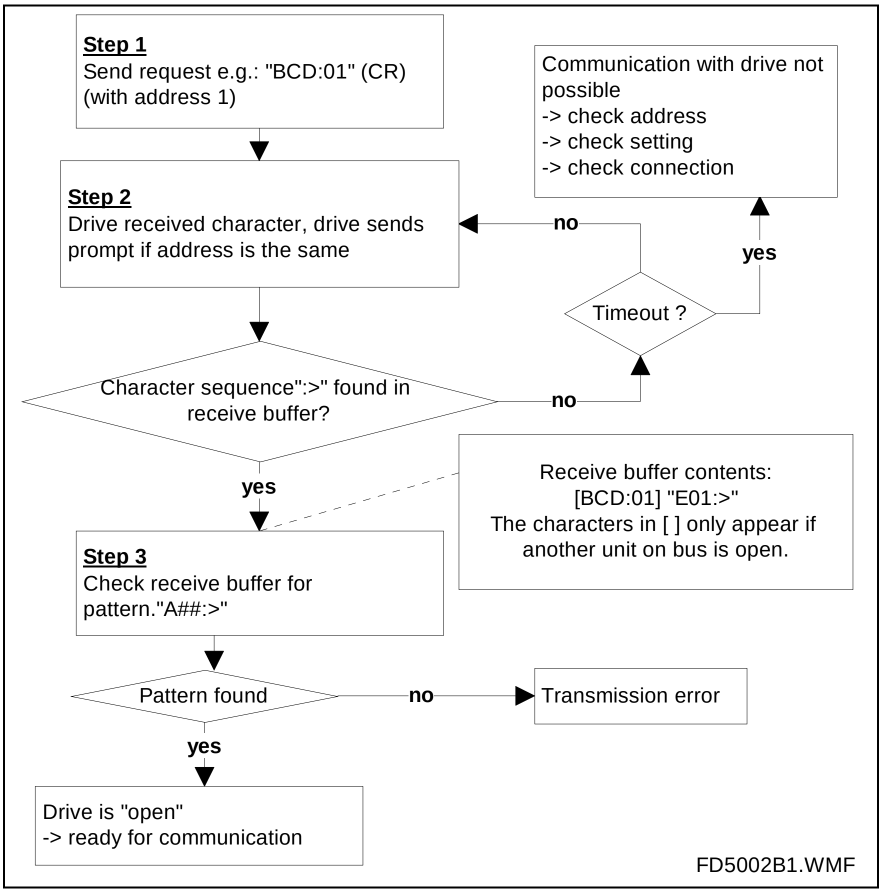

Fig. 1-12: Actuating a bus user

Write Accessing a Parameter

The write accessing of a parameter generally takes place as follows:

ID number of parameter, data block element number, with 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).

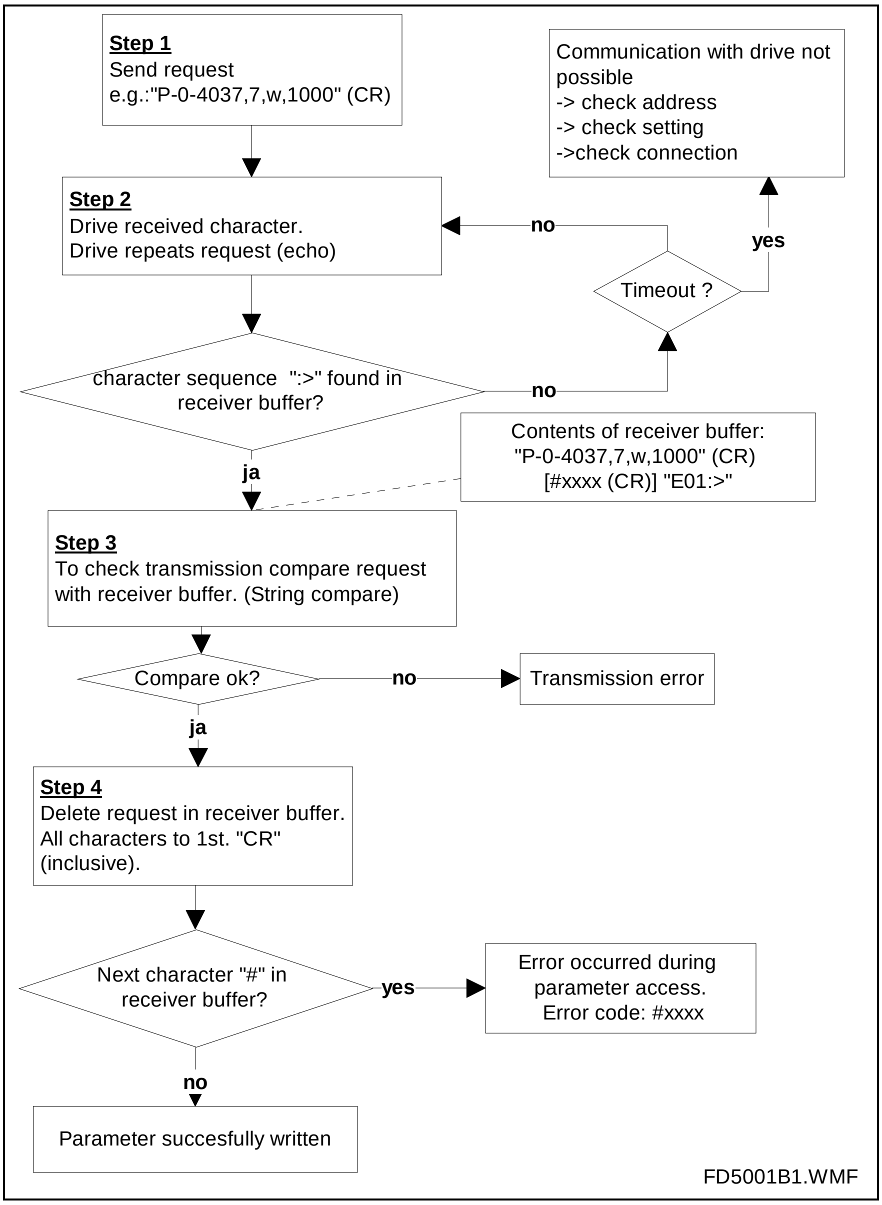

Fig. 1-13: Write accessing a parameter

Also see "Error Messages

Read Accessing a Parameter

Read accessing a parameter looks like this :

ID number of parameter, data block element number (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:

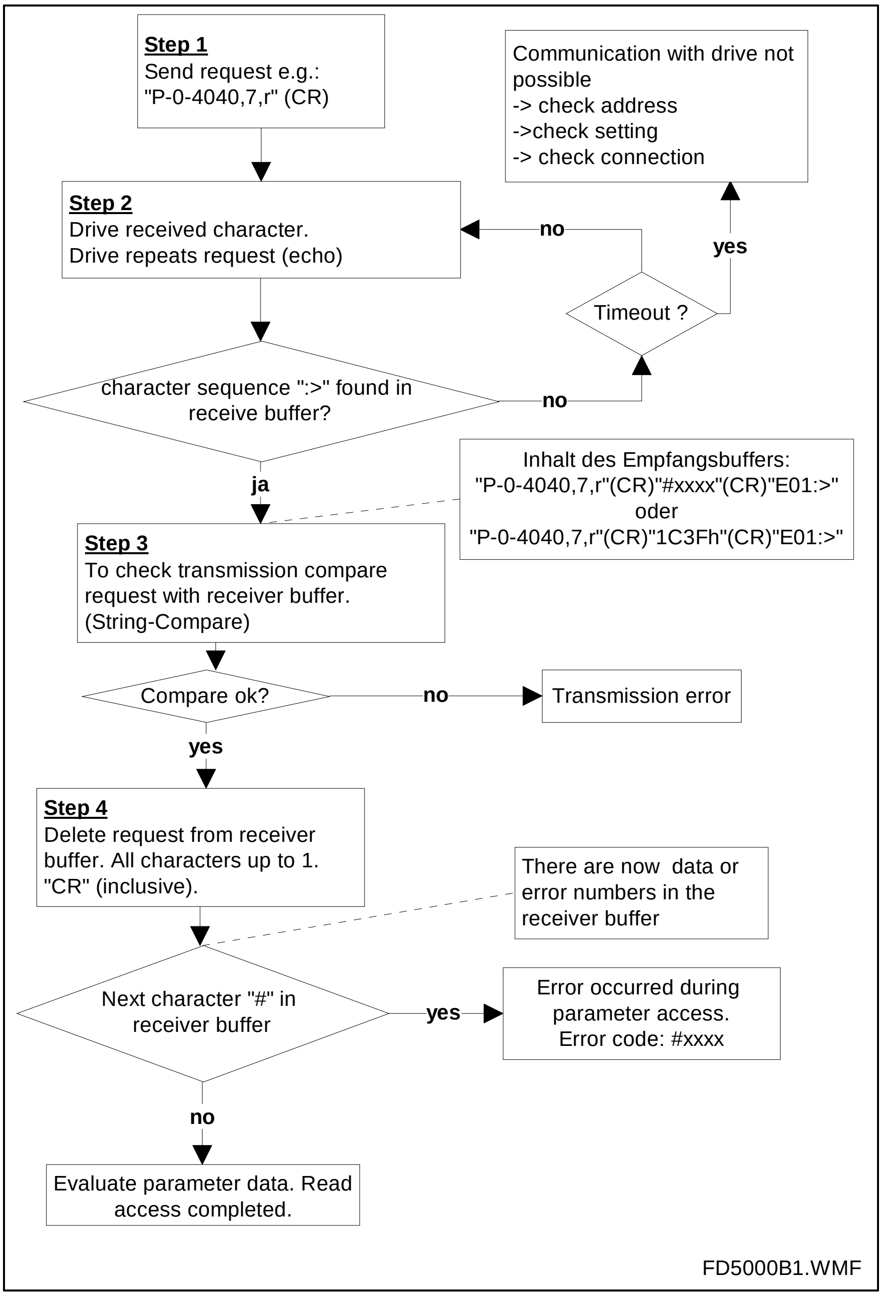

Fig. 1-14: Read accessing a parameter

Write Accessing List Parameters

There are a number of lists in the drive. These can be addressed when writing in a modified way.

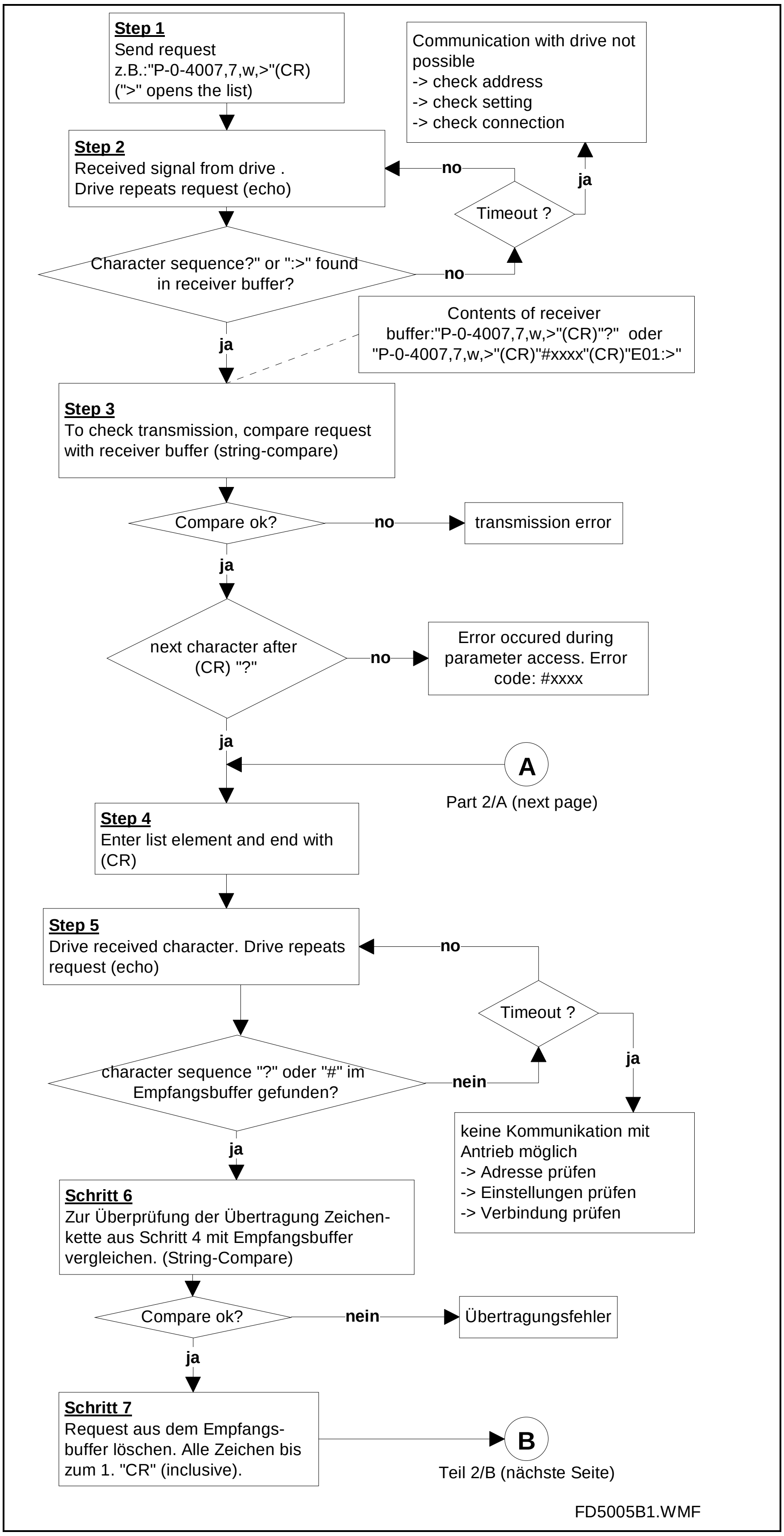

Fig. 1-15: Write accessing list parameters (part 1)

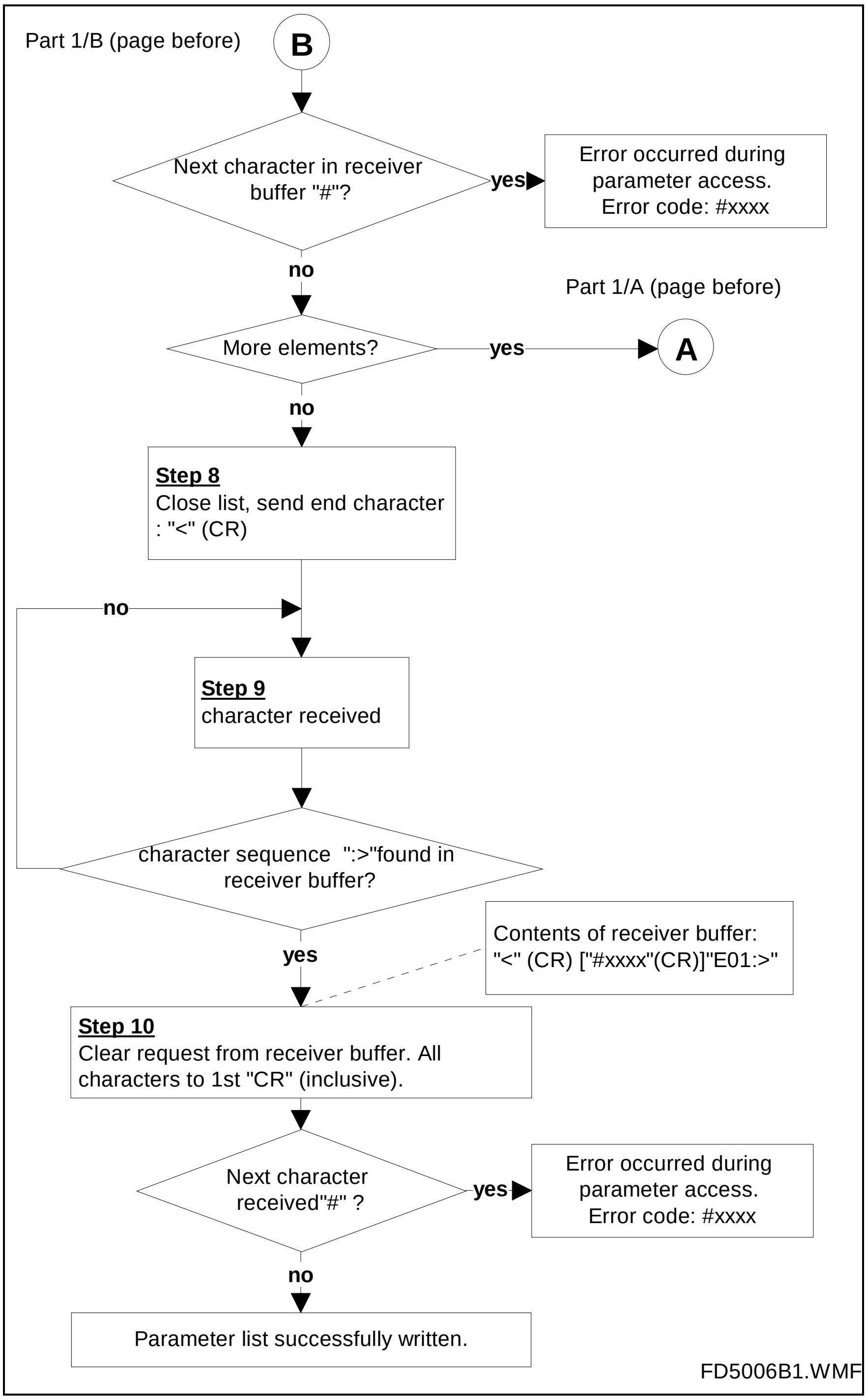

Fig. 1-16: Write accessing list parameters (part 2)

It is important to conclude the input with a "<" symbol as only then will be the data be assumed in the drive.

Reading Accessing List Parameters

List parameters are read accessed in the same way as normal parameters. The drive supplies a list element as response, however.

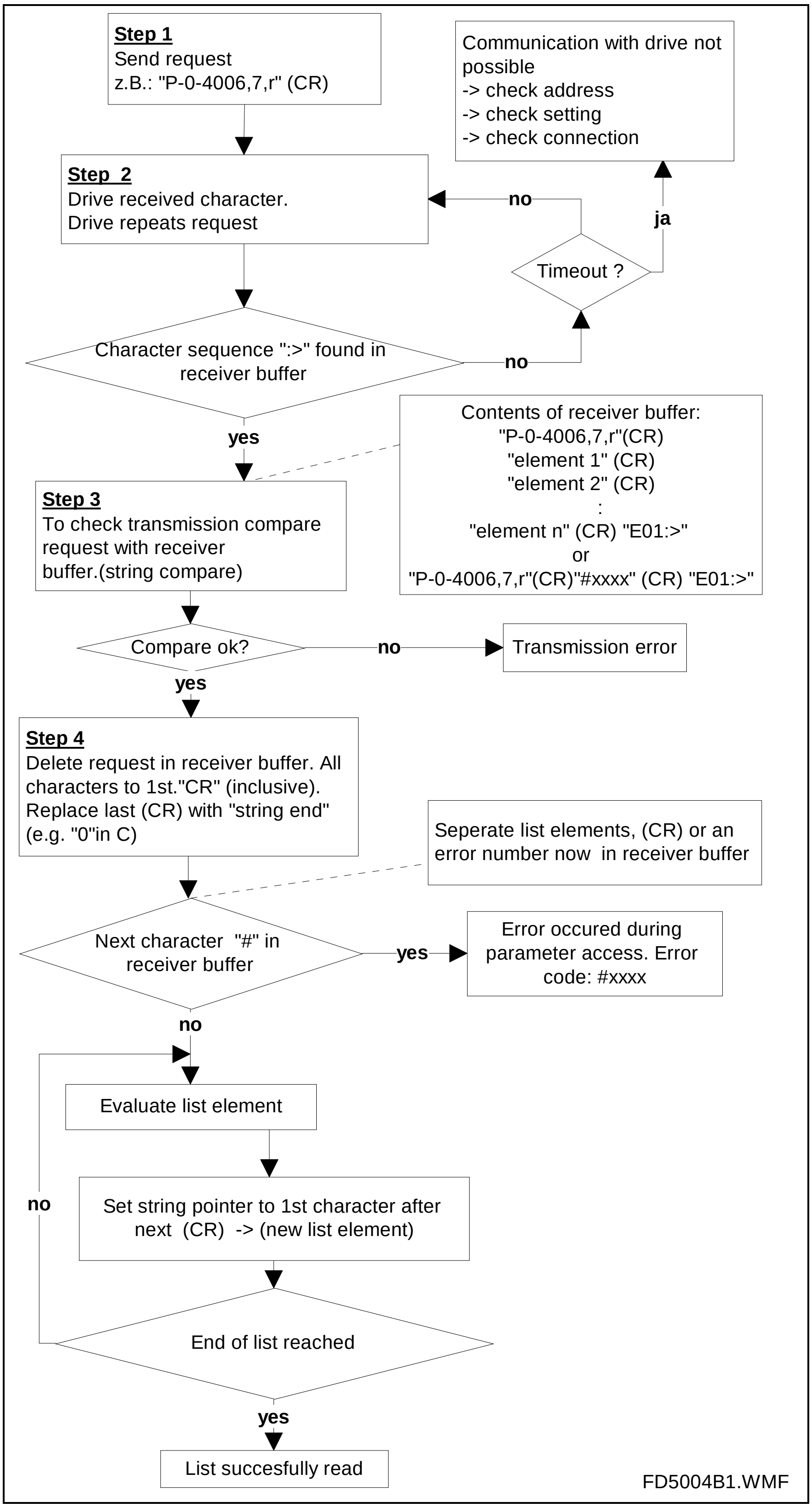

Fig. 1-17: Read accessing list parameters

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 parametrization 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:

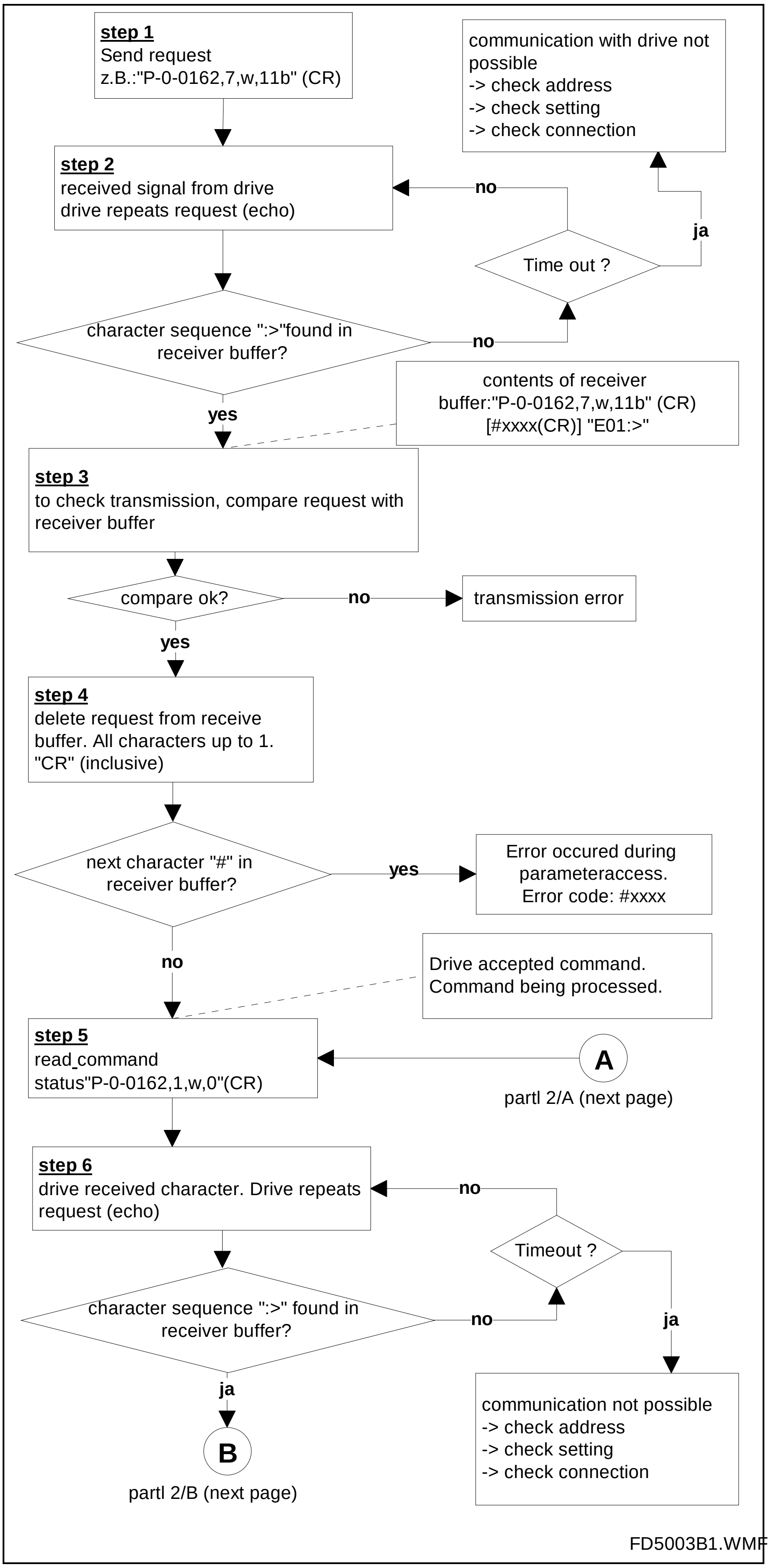

Fig. 1-18: Starting a command, part 1

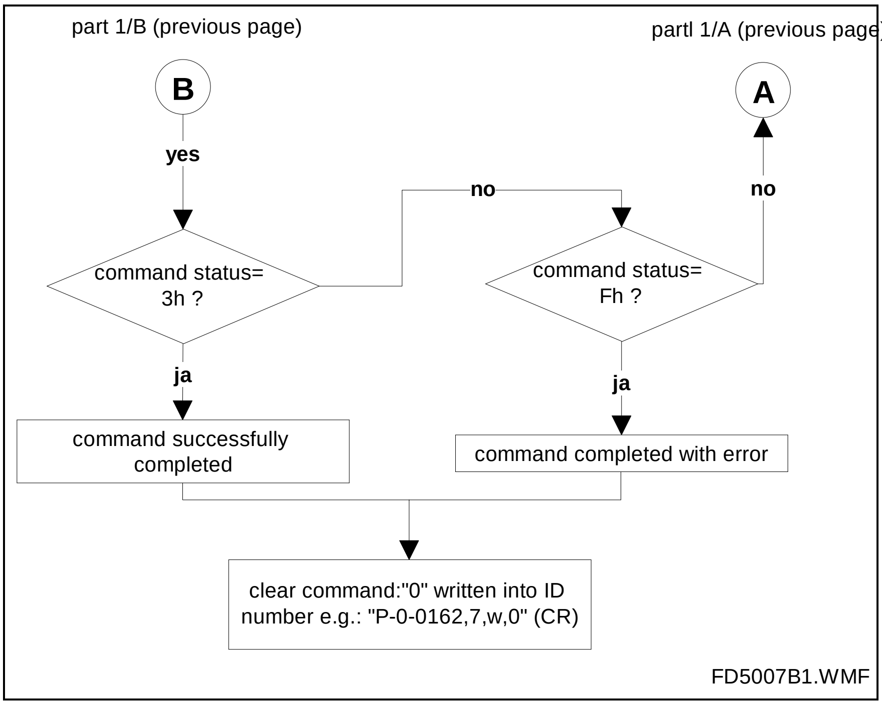

Fig. 1-19: Starting a command, part 2

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. 1-20: Status messages

The command status is transmitted in bit list form. The definition of the individual bits is illustrated below.

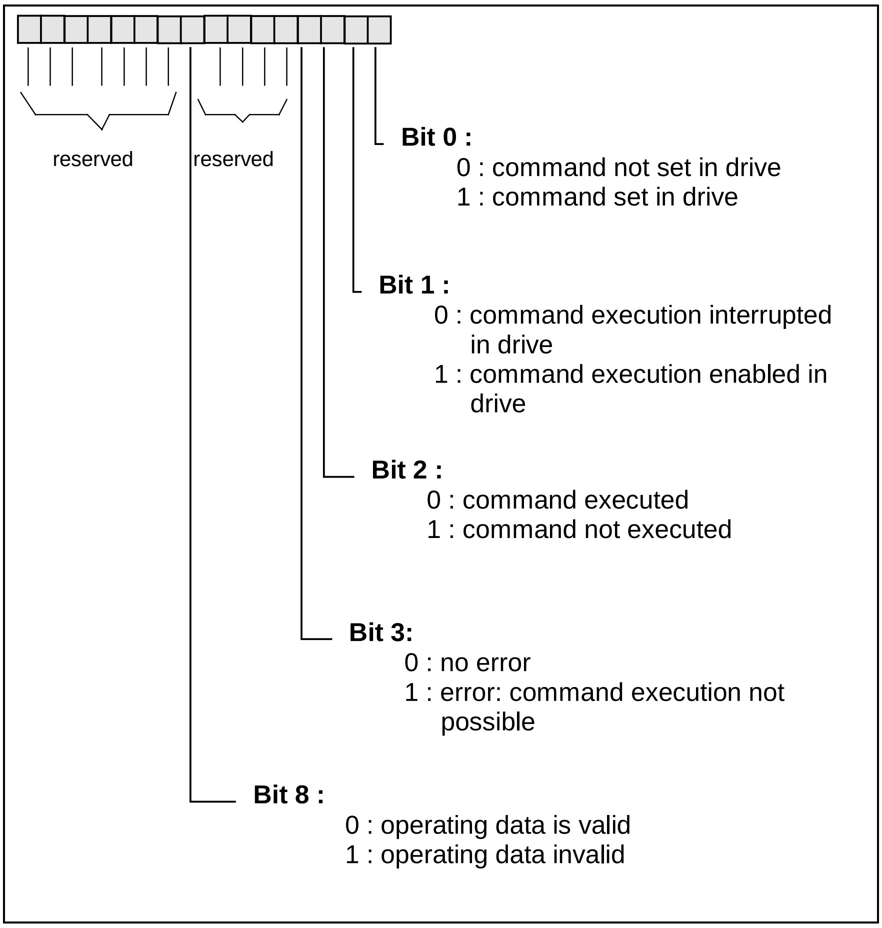

Fig. 1-21: Command acknowledgement (data status)

Ending a command

A command is ended as follows:

ID number of command,7,w,0 (Carriage Return)

Communicating with the SIS protocol

Actuating a Drive via an SIS protocol

When communicating with SISprotocols, a difference is made between **comand telegram** and **reaction telegramm** depending on transmission direction. A user 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 a valid SIS telegram is the SIS channel free for further communications.

The individual **access modes** are described briefly below before the individual **services** are explained.

General information about read accessing

If a command telegram is used to start a read of a parameter, then the drive checks whether a **following telegram is needed.** In this case, the reaction telegram in the control byte is retained in

Bit 2 (running / final transmission) at "**0“** until the final reaction telegram is sent. Bit 2 is set to 1 herein.

The transmission of a following reaction telegram is triggered by the renewed transmission of an unchanged command telegram.

General information for following telegram accessing

If write or read of a parameter is started in the drive with a following telegram, then this must be concluded of terminated 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 telegrams can then be processed as usual in the next command telegram, or terminated.

A difference is made between

- **general** and
- **special services**.

Service 0x01 Terminating a Data Transmission

Command telegram

- Enter 0x01 in the service of the telegram head.
- Enter the terminated service in the user head.

Reaction telegram

If there is **no error,** then the reaction telegram has the following structure:

Telegram head	Status byte

Fig. 1-22: 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 specificaiton.

Telegram head	User data head	User data

Fig. 1-23: 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 0x0F Token Passing

Note: This service is not suppported in ECODRIVE!

Reaction telegram

Error code 0x0F "**Invalid service**“ is sent in the status byte of the des **user data**.

Telegram head	User data head

Fig. 1-24: Structure des Reaction telegrams

Service 0x80 read a parameter

Command telegram

- Enter **0x80** in the service of the telegram head.
- Enter the parameter to be read in bytes **Parameter type** and **Parameter no**. of the user data head.
- Do not enter **user data bytes**.

Reaction telegram

- Using bit 2 the running / final transmission is designated in the control byte of the 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 of the **offset** within the list as word =16 Bit
- in user data bytes 2 and 3 the **number** of the **words** to be read

Reaction telegram

- Bit 2 identifies the running / 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 of the **offset** within the list as word =16 Bit
- in user data bytes 2 and 3 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 change must be specified. It is not possible to operate in following telegram mode.

Service 0x8F write a parameter

Command telegram

- Enter 0x8F in the service of the telegram head.
- Enter the parameter to be written into into in parameter type and number bytes of the user data head.
- Enter the value to be written into the user data head.

Reaction telegram

Note: This service can be used to start all commands in the drive.

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	1 byte user data

Fig. 1-25: Structure of the command telegram

- Enter 0x8F in the service of the telegram head.
- Enter the actuating command in parameter type and number bytes of the user data head.
- Enter the default of the command in the user data head.

Possible commands in the drive

Command	Drive parameter	Parameter no. in telegram
Drive-guided referencing	S-0-0148	0x0094
Reset C1D	S-0-0099	0x0063
Communications phase 3 transition check	S-0-0127	0x007F
Communications phase 4 transition check	S-0-0128	0x0080
Base load	S-0-0262	0x0106
Set absolute measure-ment	P-0-0012	0x800C
Load base parameters	P-0-4094	0x8FFE
Communications phase 2 transition check	P-0-4023	0x8FB7
Set absolute dimension emulator	P-0-4032	0x8FC0
Automatic control loop settings	P-0-0162	0x80A2

Fig. 1-26: Commands in drive

Always set parameter type to 0x00. Thus only S and P parameters are possible.

Default in user data byte	Effects
0	clears command
3	starts command

Fig. 1-27: Command default

Note: Command status can be read by writing "0" into the first element of the command parameter.

1.6 Error Messages

The error codes defined in the SERCOS interface specification are used. (See **SERCOS Interface specification, sec. 4.3.2.3 "Error messages in service channel**"). These codes are also used with faulty accessing of control and system parameters.

Error code	Explanation
0x1001	IDN not available
0x1009	element 1 incorrectly accessed
0x2001	name not available
0x2002	name transmission too short
0x2003	name transmission too long
0x2004	name cannot be changed
0x2005	name presently write protected
0x3002	attribute transmission too short
0x3003	attribute transmission too long
0x3004	attribute cannot be changed
0x3005	attribute presently write protected
0x4001	unit not available
0x4002	unit transmission too short
0x4003	unit transmission too long
0x4004	unit cannot be changed
0x4005	unit presently write protected
0x5001	minimum input value not available
0x5002	minimum input value transmission too short
0x5003	minimum input value transmission too long
0x5004	minimum input value cannot be changed
0x5005	minimum input value presently write protected
0x6001	maximum input value not available
0x6002	maximum input value transmission too short
0x6003	maximum input value transmission too long
0x6004	maximum input value cannot be changed
0x6005	maximum input value presently write protected
0x7002	data transmission too short
0x7003	data transmission too long
0x7004	data cannot be changed
0x7005	data presently write protected
0x7006	data smaller than minimum input value
0x7007	data greater than maximum input value
0x7008	data not correct
0x7009	data password protected

Fig. 1-28: Error specification per SERCOS

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. 1-29: Error messages during ASCII communications

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 not active)" A new request is started before the last one is completed.

Fig. 1-30: 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.

It generally applies:

Status byte results	Code number
transmission no error	0x00
protocol error	0xF0 ... 0xFF
execution error	0x01 ... 0xEF

Fig. 1-31: Definition of status bytes

Protocol error	Code Number	Error description
"Invalid service“	0xF0	The requested service is not specified or is not supported by the addressed user.
"General protocol violation“	0xF1	The command telegram cannot be evaluated. (**Example**: wrong telegram length)

Fig. 1-32: Definition of protocol error

Execution error	Code Number	Error description
"Error during parameter transmission“	0x01	An error occurred during read/write of a parmeter
"Error during phase transition“	0x02	The specified target phase was not reached

Fig. 1-33: Definition of execution errors

Example:

Write accessing a write-protected parameter **S-0-0106, Current loop proportional gain 1**:

The master is trying to write 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. 1-34: Write 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. 1-35: Read S-0-0106 (Reaction telegram)

1.7 Application Examples (Changing Position Block Data)

ASCII Protocol

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 communications with the relevant drive

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)*			
A01:>				

SIS Protocol

Parameter read access (Service 0x80)

A single read is concluded with 1 transmission step. The master enters the following information into the command telegram:

- The desired element is selected in the **control byte** in bits 3-5 "Element". Bit 2 is set to ’1’ (last transmission).
- The unit **address** is entered.
- **Parameter type and number** are entered.
- No user data are transmitted.

The answer to a read access is put together as follows:

- The acknowledgement to a request is written in to the **status byte**.
- The **control byte** is read out of the command telegram and copied into the reaction telegram.
- The unit **address** is read out of the command telegram and copied into the reaction telegram.
- The requested data is written into the **user data**.

Example:

Read parameter S-0-0044 (Velocity data scaling type) out of drive with address ‘3’. The value of the parameter is 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. 1-36: Read 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. 1-37: Read S-0-0044 (Reaction telegram)

access

Read access with following telegrams (Service 0x01)

Parameters or elements with a length exceeding maximum data field length of 245 bytes are read in several steps. Bit 2 in the control byte (Reaction telegram) designates the current transmission step as either **running** or **last** 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				

Ta0007f1.fh7

Fig. 1-38: Following command telegram 1

	..	38	..	.. ..
Tel. header	Status byte	Control byte	Device address	245 Data bytes
	User data head			User data

Ta0008f1.fh7

Fig. 1-39: Following command telegram 1

2nd step:

	3C	..	..	..	..
Tel. header	Control byte	Device address	Param. type	Parameter No. (LSB)	(MSB)
	User data head				

Ta0007f1.fh7

Fig. 1-40: Following command telegram 2

	..	38	..	.. ..
Tel. header	Status byte	Control byte	Device address	245 Data bytes
	User data head			User data

Ta0008f1.fh7

Fig. 1-41: Following command telegram 2

Last step

	3C	..	..	..	..
Tel. header	Control byte	Device address	Param. type	Parameter No. (LSB)	(MSB)
	User data head				

Ta0007f1.fh7

Fig. 1-42: Following command telegram 3

	..	3C	..	.. ..
Tel. header	Status byte	Control byte	Device address	1...245 Data bytes
	User data head			User header

Ta0015f1.fh7

Fig. 1-43: Following command telegram 3

Parameter Write (Service 0x8F)

A single write-access is concluded with one transmission step.

The master enters the following information into the command telegram:

- The unit address is entered.
- In the **control byte** in bits 3-5 "Element" the operating data is selected. Bit 2 is set to ’1’ (last transmission).
- The ID number of the parameter to be written into the **parameter number.**
- The value of the operating data is entered in the **user data**.

The response to a write accessing is put together as follows:

- The acknowledgement of a request is written into the **status byte**.
- The **control byte** is read out of the command telegram and copied into the reaction telegram.
- The unit address is rad out of the command telegram and copied into the reaction telegram.
- No **user data** are transmitted.

Example:

Transmit parameter S-0-0044 (Velocity data scaling type) to drive with address ‘3’. The value 0x0042 is written into 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. 1-44: Write parameter S-0-0044 (Command telegram)

Reaction telegram:

	00	3C	03
Tel. header	Status byte	Control byte	Device address
	User data head		

Ta0010f1.fh7

Fig. 1-45: Write parameter S-0-0044 (Reaction telegram)

Write accessing with following telegrams (Service 0x8F)

Parameters or elements with a length exceeding **243 bytes** are read in **several steps**. A transmission of lists of this kind are performed in several steps. Bit 2 in the control byte identifies the current transmission steps as either **running of final** transmission.

The **control word for a transmission in several steps** is described below.

1st step:

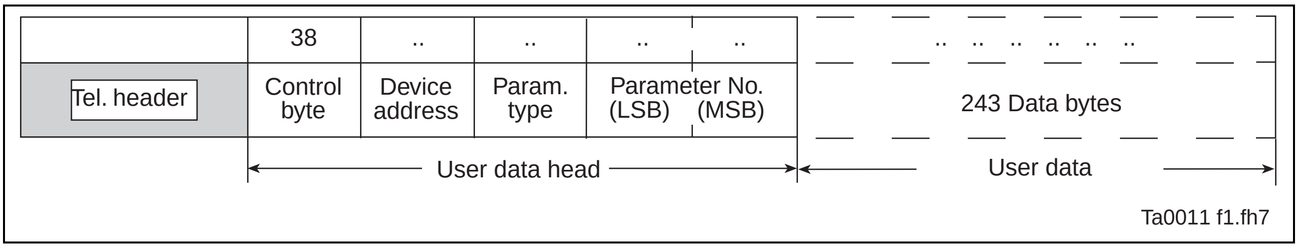

Fig. 1-46: Write following command telegram (step 1)

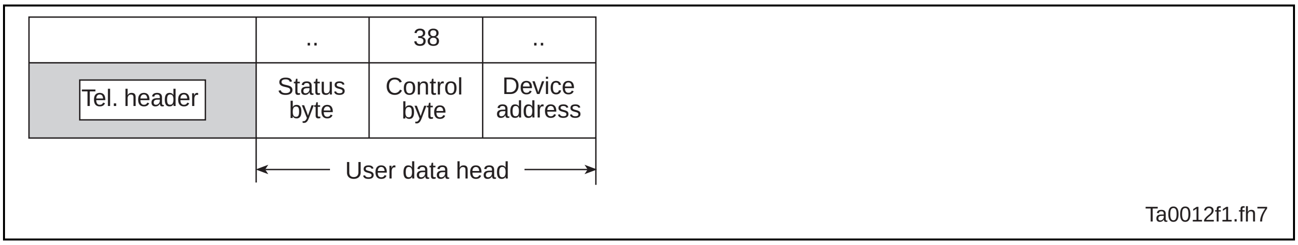

Fig. 1-47: Write following reaction telegram (step 1)

2nd step:

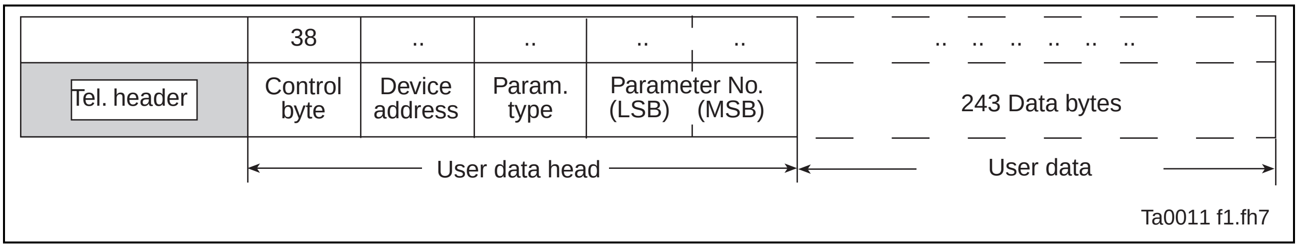

Fig. 1-48: Write following command telegram (step 2)

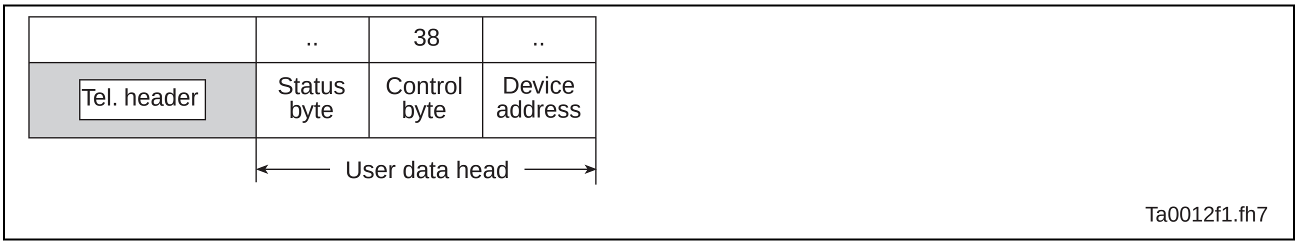

Fig. 1-49: Write following reaction telegram (step 2)

Final step:

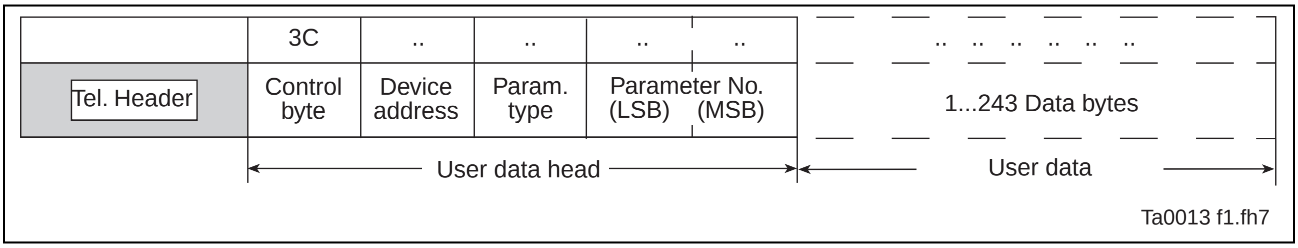

Fig. 1-50: Write with following reaction telegram (step 3)

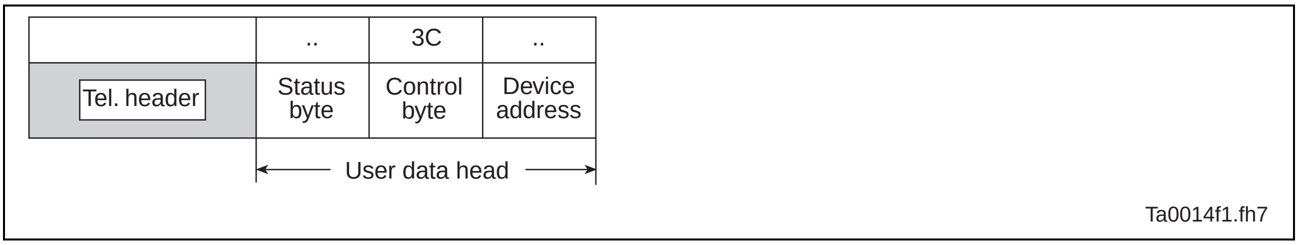

Fig. 1-51: Write with following reaction telegram (step 3)

1.8 Connection Techniques

See Project Planning Manual.

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S

W

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