Rexroth

DIAX04
Drive With Electric Gear Function

Functional Description: ELS 06VRS

SYSTEM200

Rexroth Indramat

DOK-DIAX04-ELS-06VRS**-FK01-EN-P

Title DIAX04 Drive With Electric Gear Function

Type of Documentation Functional Description: ELS 06VRS

Document Typecode DOK-DIAX04-ELS-06VRS**-FK01-EN-P

Internal File Reference

- Box 60-06V-EN
- Based on ELS 06VRS
- 120-0800-B339-01/EN

Purpose of Documentation

This following documentation describes the functions of the firmware FWA-DIAX04-ELS-06VRS.

This documentation serves:

- for description of all functional features
- for parameterization of the drive controller
- for data security of the drive parameter
- for error diagnosis and error removal

Record of Revisions

Description	Release Date	Notes
DOK-DIAX04-ELS-06VRS**-FK01-EN-P	06.02	First edition

Published by

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

Telephone +49 (0)93 52/40-0 • Tx 68 94 21 • Fax +49 (0)93 52/40-48 85

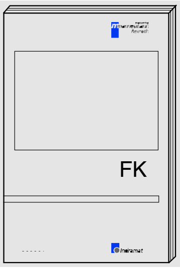
http://www.boschrexroth.de/

Dept. EDF2/EDY1 (KT/US)

Note

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

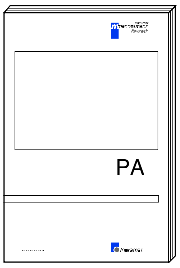
Summary of Documentation - Box



Functional Description:

Description of all implemented Function based on SERCOS-Parameters

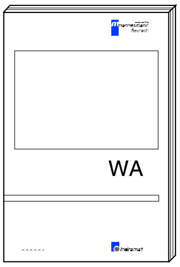
Order designation:
DOK-DIAX04-ELS-06VRS**-FK01-EN-P



Parameter Description:

A description of all parameters used in the firmware

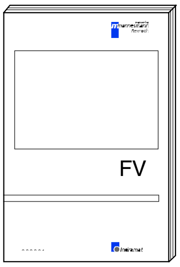
Order designation:
DOK-DIAX04-ELS-06VRS**-PA01-EN-P



Troubleshooting Guide:

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

Order designation:
DOK-DIAX04-ELS-06VRS**-WA01-EN-P

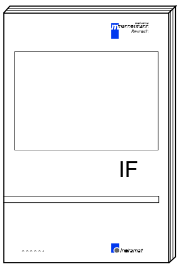


Firmware Version Notes:

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

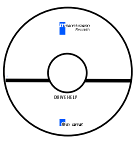
-FWA-DIAX04-ELS-06VRS-MS

Order designation:
DOK-DIAX04-ELS-06VRS**-FV01-EN-P



Drive Configuration:
-Determining the motor type
-Choosing the motor – motor feedback combination
-Choosing the desired function of the drive control device

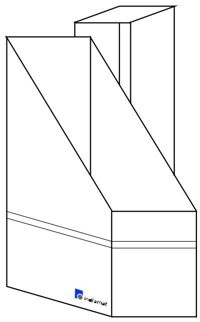
Order designation:
DOK-DIAX04-ELS-06VRS**-IF01-EN-P



CD: DRIVEHELP

Collection of Windows help systems which contain documents on firmware derivatives

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



Order designation
DOK-DIAX04-ELS-06VRS**-6001-EN-P

Notes

Contents

1 System Overview

1.1 Range of Uses

DIAX04 is a range of digital, intelligent drives. DIAX04 offers solutions for applications in the following markets:

- Converting
- Printing
- Packaging
- General Industrial Automation

DIAX04 consists of:

- A standardized digital drive SERCOS interface
- Operation with the complete line of Rexroth Indramat motors
- Complete power range from 1kW to 100kW
- User-friendly software features
- Adaptability to various applications by configuring the drive with optional plug-in cards

1.2 DIAX04- a Drive Range

There are five application-related firmware types available for the **DIAX04 range**:

FWA-DIAX04-ELS-0xVRS-MS
- DIAX04 Drive With Electric Gear Function, SERCOS interface

FWA-DIAX04-SSE-0xVRS-MS
- DIAX04 Drive With Servo Function, SERCOS interface

FWA-DIAX04-ASE-0xVRS-MS
- DIAX04 Drive With Servo Function, Analog And Parallelinterface

FWA-DIAX04-SHS-0xVRS-MS
- DIAX04 Main Spindle Drives

FWA-DIAX04-AHS-0xVRS-MS
- DIAX04 Drive With Main Spindle Function, Analog And Parallelinterface

The following function description relates to the firmware type:

FWA-DIAX04-ELS-06VRS-MS
- DIAX04 Drive With Electric Gear Function (SERCOS interface)

For each listed type, there is individual documentation.

1.3 Drive Controllers

The DIAX04 range consists of five drive controllers:

Modular Digital Servo Drives (Drive Controllers)

- HDD 02.*
- HDS 02.*
- HDS 03.*
- HDS 04.*
- HDS 05.*

The type of digital drive used is stored in parameter **S-0-0140, Controller type**.

1.4 Function Overview: FWA-DIAX04-ELS-06VRS-MS

Command Communications Interface

- SERCOS interface

Possible Operating Modes

- torque/force control
- velocity control
- position control with cyclic position command values
- drive-internal interpolation
- relative drive-internal interpolation

Supported Types of Motors

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

The motor type used is stored in parameter **S-0-0141, Motor type**.

Supported Measuring Systems

- digital servo feedback
- resolver
- incremental encoder with sine signals
- incremental encoder with square-wave signals
- Rexroth Indramat gearwheel encoders
- measuring systems with SSI interface
- measuring systems with EnDat interface
- gearwheel encoders with 1Vpp signals
- resolver without feedback memory
- 1 pole pair resolver without feedback memory + incremental encoder with sine signals

Which combination is possible, is outlined in section: “Setting the Measurement System”.

General Functions

- Diagnostic possibilities
- Parameterizable torque/force limit
- Current limit
- Velocity limit
- Travel range limitations
- Drive-side error reactions:
  - best possible deceleration "velocity command to zero"
  - best possible deceleration "torque free"
  - best possible deceleration "velocity command to zero with ramp and filter”
  - NC reaction on error
  - E-Stop function
- Control loop settings
  - base load function
  - acceleration precontrol
  - velocity mix factor
  - velocity precontrol
- Language selection
- Starting lockout
- Drive halt
- Drive-controlled homing procedure
- Evaluates absolute measuring system with setting of absolute dimension
- Analog outputs
- Oscilloscope function
- Probe function with:
  - measuring signal actual position value 1/2
  - measuring signal time
- Modulo function
- Error memory and hours-run meter
- Configurable signal status word
- Customer password
- Command "Park axes"
- Command “Detect marker position"
- Programmable, drive-internal position resolution

Additional Firmware Features: Drive With Electric Gear Function

Operating modes

- Velocity synchronization
- Phase synchronization
- Electronic cam shaft

Functions

- Probe function
- Programmable limit switch
- Measuring wheel mode command
- Incremental encoder emulation for master axis and actual position value

Notes

2 Important directions for use

2.1 Appropriate use

Introduction

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

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

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

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

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

Areas of use and application

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

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

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

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

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

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

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

Typical applications of drive controllers are:

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

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

2.2 Inappropriate use

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

Drive controllers may not be used if

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

3 Safety Instructions for Electric Drives and Controls

3.1 Introduction

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

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

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

WARNING

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

3.2 Explanations

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

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

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

3.3 Hazards by Improper Use

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

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

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

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

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

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

CAUTION	**Risk of injury due to incorrect handling of batteries!**

3.4 General Information

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

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

3.5 Protection Against Contact with Electrical Parts

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

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

DANGER

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

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

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

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

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

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

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

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

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

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

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

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

To be observed with electrical drive and filter components:

DANGER

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

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

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

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

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

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

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

WARNING

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

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

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

3.7 Protection Against Dangerous Movements

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

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

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

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

DANGER

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

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

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

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

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

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

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

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

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

⇒ Secure vertical axes against falling or dropping after switching off the motor power by, for example:

- mechanically securing the vertical axes
- adding an external braking/ arrester/ clamping mechanism
- ensuring sufficient equilibration of the vertical axes

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

⇒ Disconnect electrical power to the equipment using a master switch and secure the switch against reconnection for:
  - maintenance and repair work
  - cleaning of equipment
  - long periods of discontinued equipment use

⇒ Prevent the operation of high-frequency, remote control and radio equipment near electronics circuits and supply leads. If the use of such equipment cannot be avoided, verify the system and the installation for possible malfunctions in all possible positions of normal use before initial startup. If necessary, perform a special electromagnetic compatibility (EMC) test on the installation.

3.8 Protection Against Magnetic and Electromagnetic Fields During Operation and Mounting

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

WARNING

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

⇒ Persons with heart pacemakers, hearing aids and metal implants are not permitted to enter the following areas:
  - Areas in which electrical equipment and parts are mounted, being operated or started up.
  - Areas in which parts of motors with permanent magnets are being stored, operated, repaired or mounted.

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

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

3.9 Protection Against Contact with Hot Parts

CAUTION

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

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

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

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

3.10 Protection During Handling and Mounting

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

CAUTION

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

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

⇒ Use appropriate mounting and transport equipment.

⇒ Take precautions to avoid pinching and crushing.

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

⇒ Use lifting devices and tools correctly and safely.

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

⇒ Never stand under suspended loads.

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

3.11 Battery Safety

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

CAUTION

Risk of injury by incorrect handling!

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

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

⇒ Never throw batteries into a fire.

⇒ Do not dismantle batteries.

⇒ Do not damage electrical components installed in the equipment.

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

3.12 Protection Against Pressurized Systems

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

CAUTION

Danger of injury by incorrect handling of pressurized systems !

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

⇒ Observe the operation instructions of the respective manufacturer.

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

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

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

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

Notes

4 General instructions for commissioning

4.1 Definition of terms, introduction

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

Parameters

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

They can be used for

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

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

The data status

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

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

(see also chapter: "Commands")

Parameter structure

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

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

Fig. 4-1: Data block or parameter structure

Write accessibility

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

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

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

Possible error messages when reading and writing operating data

see chapter "Error messages"

Data storage

Non-volatile parameter storage registers

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

The operating data apply to:

- setting the configuration and
- parameterizing the controller settings

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

The following modules contain non-volatile memories:

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

Parameters stored in the drive controller

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

This applies to the following parameters:

- **S-0-0110, Amplifier peak current**
- **S-0-0112, Amplifier nominal 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-0-0518, Amplifier nominal current 2**
- **P-0-0519, Amplifier peak current 2**
- **P-0-4002, Current-amplify-trim phase U**
- **P-0-4003, Current-amplify-trim phase V**
- **P-0-4015, Intermediate DC bus voltage**
- **P-0-4035, Trim-current**

Parameter storage in motor feedback

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

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

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

Parameters stored in programming module

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

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

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

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

Data backup

Backup & restore

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

Parameter buffer mode

The drive controller is capable of storing data, that are transmitted via the user data channel (e.g. service channel in the case of SERCOS), either temporarily (in volatile form) or permanently (in non-volatile form).

The parameter **S-0-0269, Parameter buffer mode** determines what will be done with the parameters.

Basic parameter block

The drive parameters are set to default values 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 default parameter set is constructed so that

- all important monitoring functions are activated
- 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

The set mode is velocity control.

Note: The default parameter set does not guarantee a matching of the drive to the machine. 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

Drive firmware is stored 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 function default parameter set 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 parmeters must be stored prior to an exchange and must be reloaded after exchange and load default parameter set.

Password

All important axis-specific parameters are stored in the programming module. If a controller is replaced, for example, because of a defect then the features of the axis can be transferred from the old controller to the new one by simply using the old programming module. The respective parameters are listed in **S-0-0192, IDN-list of backup operation data**. To secure these parameters against unwanted or non-authorized changes, they can be write-protected by activating a customer password.

The password function can be accessed by means of parameter **S-0-0267, Password**.

Length of password

min. 3 characters, max. 10 characters

Allowed characters for password

characters: a - z, A - Z; numbers: 0 - 9

3 different password states are possible

The password function can have 3 different states. Depending on the string that is entered for S-0-0267, the current password status can be changed.

The following figure illustrates the possible password states and the strings to be entered for parameter S-0-0267.

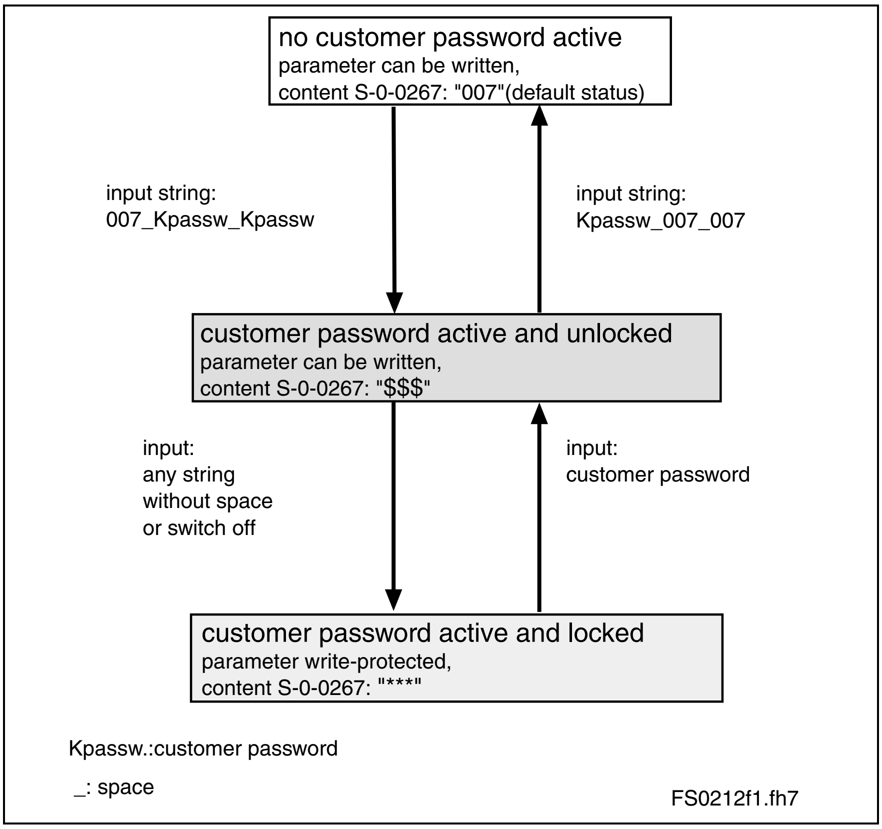


Abb. 4-2: Possible password states

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

Master password

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

Commands

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

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

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

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

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

List of all procedure commands

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

Command types

There are 3 command types.

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

Command input and acknowledgement

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

The command input value can be:

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

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

See also chapter: "Parameters"

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

Data status

The condition can be:

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

Command change bit

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

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

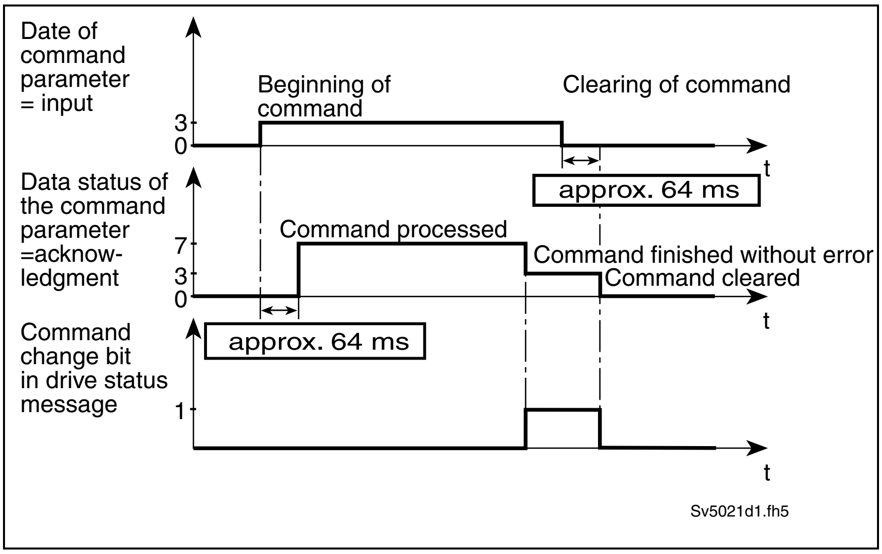


Fig. 4-3: Input, acknowledgement and command change bit during proper execution

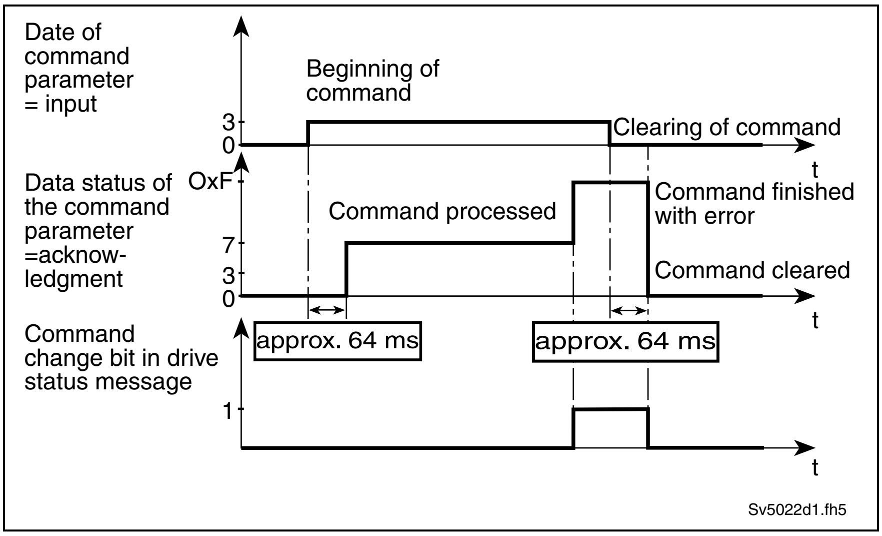


Fig. 4-4: Input, acknowledgement and command change bit during erroneous execution

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

Operating modes

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

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

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

The drive displays "AF".

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

See also chapter: "Operating modes"

Warnings

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

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

Warning classes

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

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

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

Fig. 4-5: Breakdown of the warning classes

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

Errors

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

Error classes

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

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

Fig. 4-6: Error class divisions

Drive error reaction

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

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

Clearing errors

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

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

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

Clearing errors when controller enable is set

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

To reactivate the drive:

- clear the error

  AND
- again input a positive edge for controller enable

Error memory and operating hours counter

Error memory

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

Operating hours counter

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

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

IDN 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.

4.2 Parameter Mode - Operation Mode

After the drive is turned on, it does not automatically switch to the operating mode. The drive is put through a series of checks before the SERCOS control can switch the drive into operation mode.

Switching the drive to the operating mode is dependent on making the SERCOS interface system ready to operate.

This must occur in steps and is controlled by the master control by entering the communication phase 0 through 4 and starting/ending the commands:

- **S-0-0127, C100 Communication phase 3 transition check**
- **S-0-0128, C200 Communication phase 4 transition check.**

If the drive reaches phase 4 without errors, "**bb**" will appear on the H1 display. The diagnostic message is: **A013 Ready for power on**

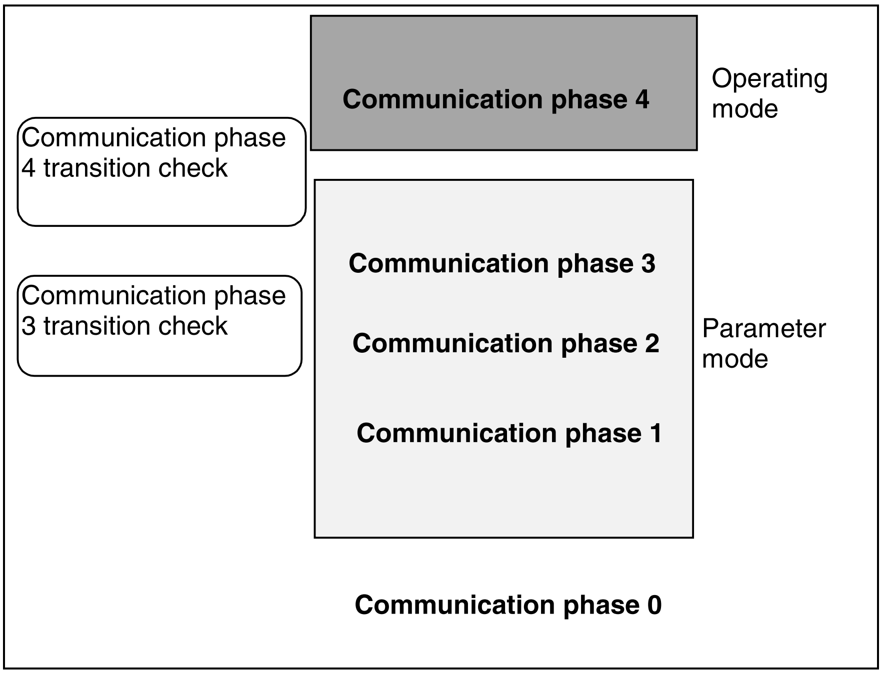


Fig. 4-7: Communication Phases

Communication between the SERCOS control and the drive is not possible during phase 0. Parameterization mode is given during communication phases 1...3.

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.

Monitoring in the Transition Check Command

Transition check commands must be activated in the drive in order to switch from communication phase 2 to 3 and from 3 to 4. This commences a series of checks and parameter calculations.

S-0-0127, C100 Communication Phase 3 Transition Check

The following checks are run when this command is activated.

- The telegram configuration is checked. The SERCOS cyclic telegram is checked for valid parameters configured in the MDT or AT data blocks and to ensure that the maximum length is not exceeded.

The following command errors may occur:

- **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**

Parameters are checked for proper values before the drive can switch into phase 3. If a parameter has an improper value, the following command error will occur:
C101 Invalid communication parameter (S-0-0021) The SERCOS ID numbers of invalid parameters are listed in **S-0-0021, IDN List of Invalid Op. Data for Comm. Ph.2** and must be corrected before allowing a transition to phase 3.

The timing parameter for SERCOS communication in phase 3 and 4 are checked for proper values.

The following command errors may occur:

- **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**
- **C118 Order of MDT configuration wrong**

S-0-0128, C200 Communication Phase 4 Transition Check

The following checks are run when this command is activated.

- Parameter **P-0-4014, Motor Type** is checked for a proper value. The command error **C204 Motor type P-0-4014 incorrect** occurs if 1 (MDD) or 5 (MKD/MKE) is entered in this parameter but the corresponding motor type is not found in the motor feedback data memory.
- The parameters are checked for proper values required for switching in phase 4. The command error **C201 Invalid parameter(s) (->S-0-0022)** occurs if one or more of the required parameters are invalid. The SERCOS ID numbers of the invalid parameters are listed in **S-0-0022, IDN List of Invalid Op. Data for Comm. Ph.3** and must be corrected.
- The drive-controller reads the operating data out of the EEPROM of the drive controller. If an error occurs during this process, then the command error **C212 Invalid amplifier data (->S-0-0022)** appears. The ID numbers of the faulty parameters are listed in **S-0-0022, IDN List of Invalid Op. Data for Comm. Ph.3**.
- A check is done to see if an external encoder is needed according to the operating mode parameters *S-0-0032..35* or homing parameter *S-0-0147*, but is not available because a 0 is entered in the parameter **P-0-0075, Interface Feedback 2, external**. The invalid parameters are listed in **S-0-0022, IDN List of Invalid Op. Data for Comm. Ph.3**. The command error **C210 External feedback required (->S-0-0022)** is issued.
- Check whether no motor encoder is available (**P-0-0074, Interface Feedback 1** = 0) and in function parameters **P-0-0185, Function of ext. Encoder** a value of 2 has not been entered for the loadside motor encoder. If this is the case, then command error **C236 Motor feedback required (P-0-0074)** is generated**.**
- Checking motor encoder settings: If the encoder interface parametrized in **P-0-0074, Interface Feedback 1** is not available, then error message **C232 Motor encoder interface not present** is generated. If a motor encoder with feedback memory is used, but its data cannot be read, then error message **C217 Motor feedback data reading error** is generated.
- Checking the settings for the external encoder. If the encoder interface parametrized in **P-0-0075, Interface Feedback 2, external** is not available, then error message **C233 External encoder interface not present** is generated. If the encoder interface set in **P-0-0075, Interface Feedback 2, external** is already occupied by the motor encoder, then error message **C234 Encoder combination not possible** is generated. If an external encoder with feedback memory is used, but its data cannot be read, then error message **C218 External feedback data reading error** is generated. If in parameter **P-0-0185, Function of ext. Encoder** "loadside motor encoder" is selected, but no rotary asynchronous motor is available, then error message **C235 Load-side motor encoder with inductance motor only** is generated.
- The parameters stored in memory are read from motors with feedback data storage. If an error is found, the command error **C211 Invalid feedback data (->S-0-0022)** appears.
- Check whether an internal position resolution has been set via **S-0-0278, Maximum travel range,** which guarantees a correct commutation of the motor. If not, then command error **C223 Input value for max. range too high** is generated.

- The scaling format is checked for position, acceleration, velocity and torque for proper configuration. If an error is found, one of the following errors
  C213 Position data scaling error
  C214 Velocity data scaling error
  C215 Acceleration data scaling error
  C216 Torque/force data scaling error
  is issued.
- Values are checked for each parameter. The minimum and maximum values of each of the parameters are checked, and parameters with bit format are checked for proper configuration. If an error is found, the command error **C202 Parameter limit error (->S-0-0022)** is issued. The SERCOS ID numbers of the invalid parameters are listed in **S-0-0022, IDN List of Invalid Op. Data for Comm. Ph.3** and should be corrected.
- The parameter **S-0-0103, Modulo Value** is checked for its ability to be processed when modulo scaling is activated. If the parameter cannot be processed, the command error **C227 Modulo range error** is generated.
- Determines if the coprocessor is ready for initialization. If it is not, the error message **C225 Coprocessor not ready for initialization** will appear.
- Special checks executed for specific parameters. For example, the encoder interface parameters P-0-0074/75 are checked to see if the selected encoder interface is actually available. If discrepancies are found, the command error **C203 Parameter calculation error (->S-0-0022)** is issued. The ID numbers of the invalid parameters are listed in **S-0-0022, IDN List of Invalid Op. Data for Comm. Ph.3** and should be corrected.
- Encoder initializations are executed. Depending on the type of encoder, specific errors may occur during initialization (for example, invalid position with DSF feedback). One of the following command errors
  C220 Motor feedback initializing error
  C221 Ext. feedback initializing error
  will be issued.
- Query whether coprocessor has processed initialization value and accepted it. If not, then command error **C226 Coprocessor acknowledge failed** is generated.
- 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 current actual position prior to the last shutdown, +/- **P-0-0097, Absolute encoder monitoring window,** then error **F276 Absolute encoder out of allowed window** will be generated. The transition command will not be acknowledged as an error, but the error may be cleared by executing the command **S-0-0099, C500 Reset class 1 diagnostic, error reset**.

  (See also "Clearing error".)

4.3 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.

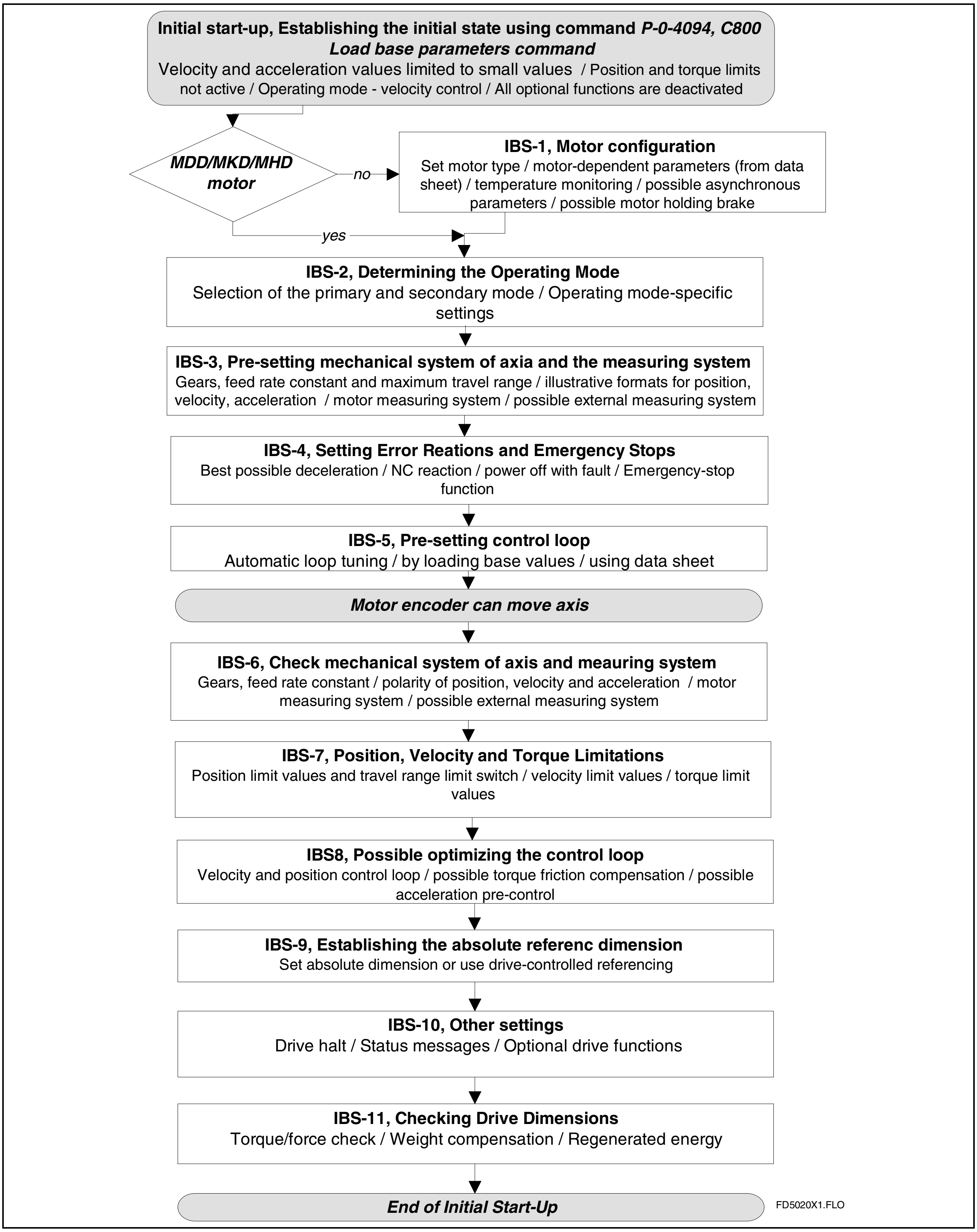


Fig. 4-8:Commissioning guidelines

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 resolution of the motor encoder, and where available, optional encoders.

(See also chapter : -"Physical Values Display Format"mat"
-"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 **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.

4.4 Diagnostic Configurations

Overview of Diagnostic Configurations

The diagnostics are configured into 2 groups:

- Current operating status and diagnostics
- Class diagnostics

Parameters exist for all important operating data.

Drive-Internal Diagnostics

The current operating condition of the drive is evident by which errors, warnings, commands, drive stop signals and drive interlock 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 current diagnostic message with the highest priority is always shown in the H1 display, in the diagnostic parameter **S-0-0095, Diagnostic Message** and in the parameter **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. An overview of all diagnostic messages can be found in the diagnostic description.

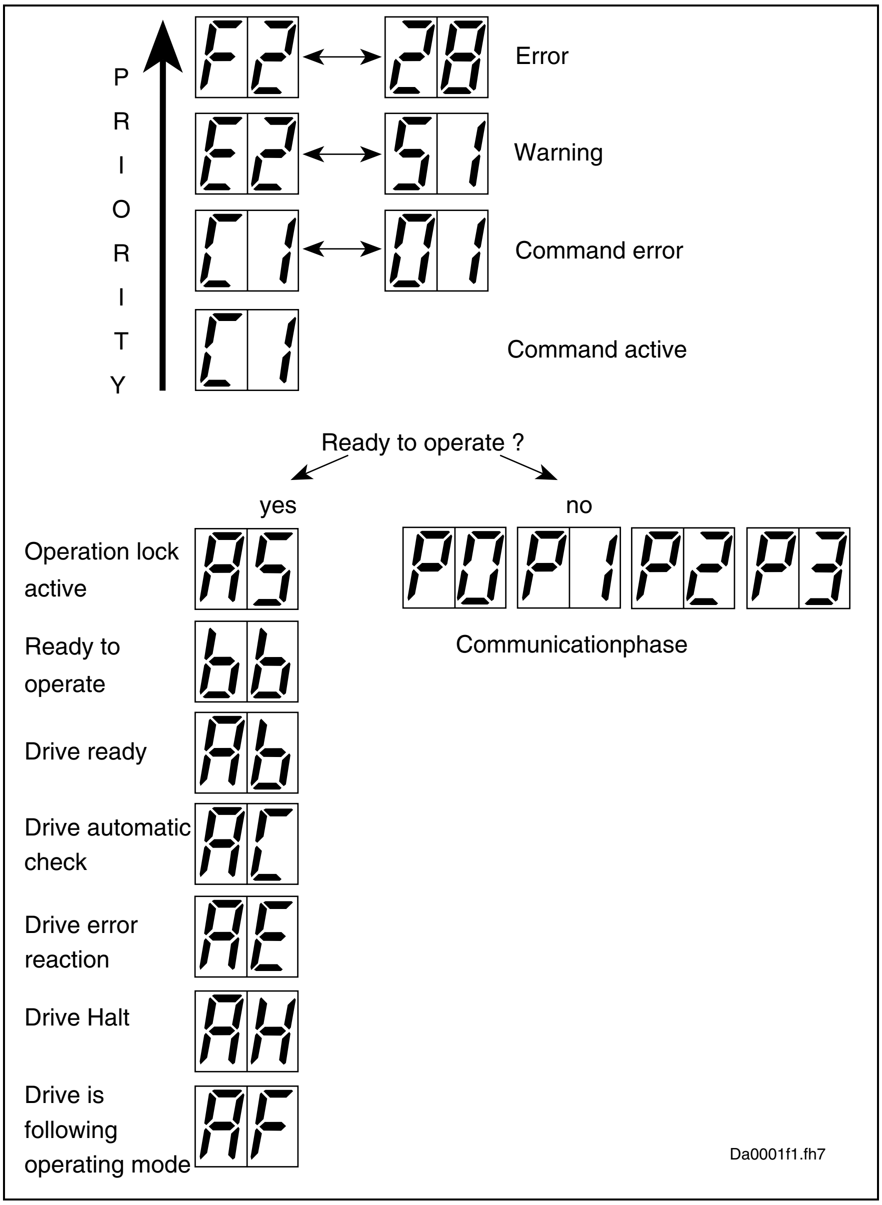


Fig. 4-9: Priority-dependent diagnostic formation in the H1 display

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.

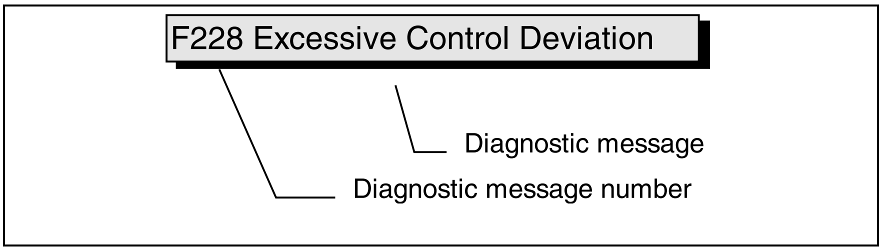


Fig. 4-10: Diagnostic message composition with a diagnostic message number and text

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**.

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."

Collection of Status

The class diagnostics parameters provide a collection of status and diagnostic information for displaying operating conditions. These parameters are:

- **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

Bits for the various errors are contained in parameter **S-0-0011, Class 1 Diagnostics**. A bit is set in this parameter in the case of a drive error. The bit Drive Interlock, Error in Class 1 Diagnostics is set simultaneously in the **drive status word**.

All bits in Class 1 Diagnostics can be cleared by executing the command **S-0-0099, C500 Reset class 1 diagnostic**.

(see Clearing Errors)

The following bits are supported in Class 1 Diagnostics.

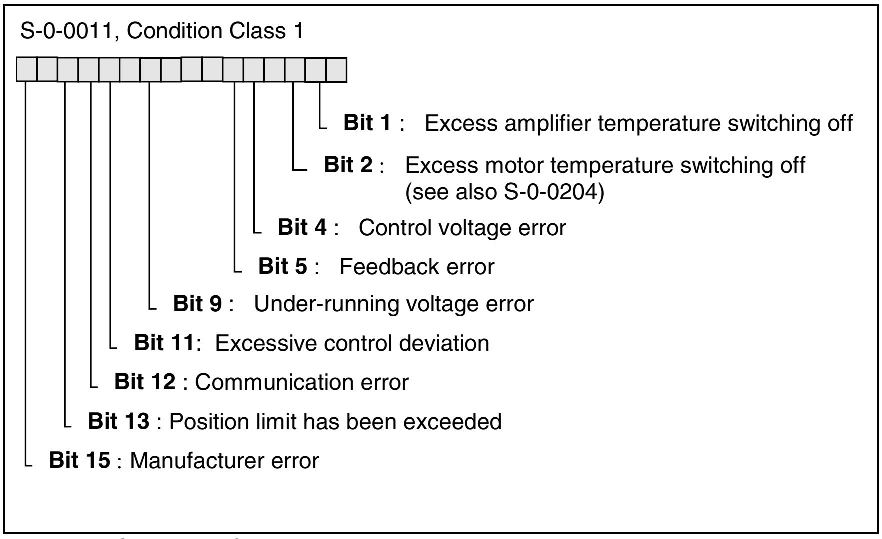


Fig. 4-11: S-0-0011, Class 1 Diagnostics

S-0-0012, Class 2 Diagnostics

Toggling a bit is signalled by a change bit in the drive status word.

Bits for various warnings are contained in this parameter. A bit is set in this parameter when a warning occurs. The bit Change Bit Class 2 Diagnostics is set simultaneously in the **drive status word**. This change bit is cleared by reading **S-0-0012, Class 2 Diagnostics** . Warnings may be masked in regards to their effect on the change bit with the parameter **S-0-0097, Mask class 2 diagnostic** .

The following bits are supported in class 2 diagnostics.

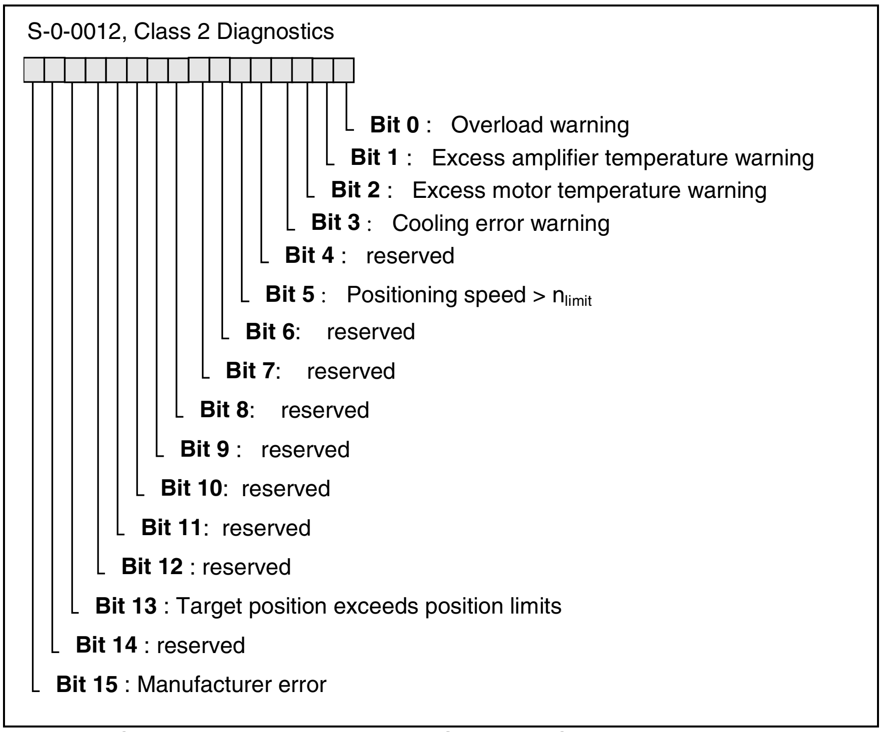


Fig. 4-12: Composition of the parameter S-0-0012, Class 2 Diagnostics

S-0-0013, Class 3 Diagnostics

Various operating status messages are stored here. If the status of a message changes, a bit will also be set here in the **Drive Status Word** (Change Bit Class 3 Diagnostics). This change bit is cleared by reading **S-0-0013, Class 3 Diagnostics**. Warnings may be masked in regards to their effect on the change bit with the parameter **S-0-0098, Mask class 3 diagnostic**.

The following bits are supported in Class 3 Diagnostics.

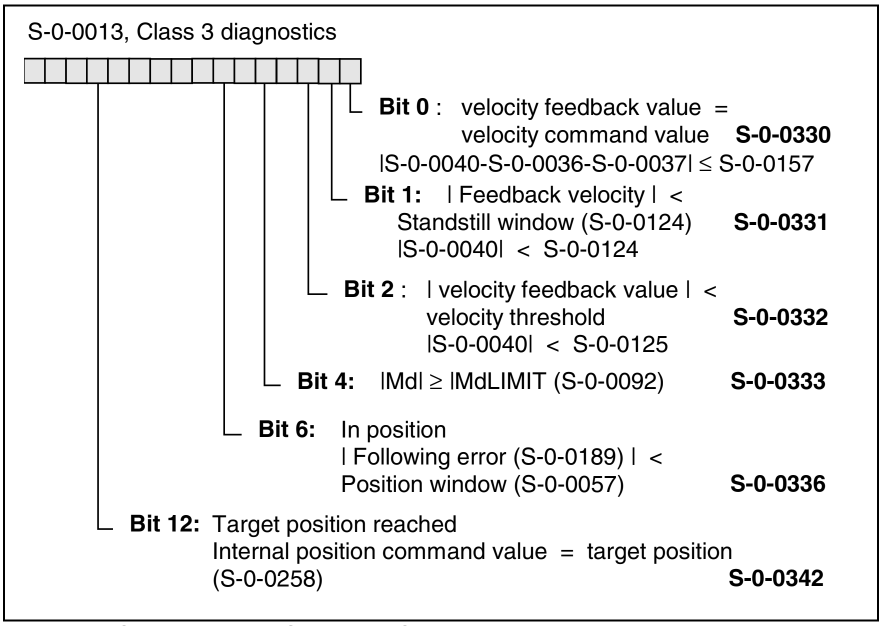


Fig. 4-13: Composition of S-0-0013, Class 3 Diagnostics

Class 2 and 3 Diagnostic Change Bits in the Drive Status Word

If the condition of a bit in **S-0-0012, Class 2 Diagnostics** or **S-0-0013, Class 3 Diagnostics** changes, the change bit class 2 or 3 diagnostics is set in the drive status word. This change bit is cleared by reading both parameters. Setting the change bit with bit-toggling in S-0-0012 or

S-0-0013 can be masked with the help of the parameter **S-0-0097, Mask class 2 diagnostic** or **S-0-0098, Mask class 3 diagnostic** .

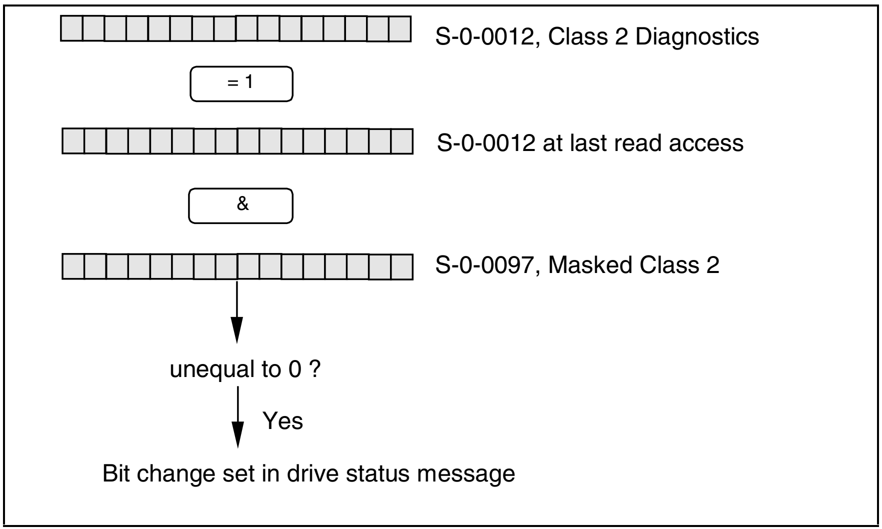


Fig. 4-14: Composition of the class 2 diagnostics change bit

S-0-0182, Manufacturer Class 3 Diagnostics

The parameter **S-0-0182, Manufacturer Class 3 Diagnostics** contains the current operating status. If the status changes, this is not signalled with a change bit.

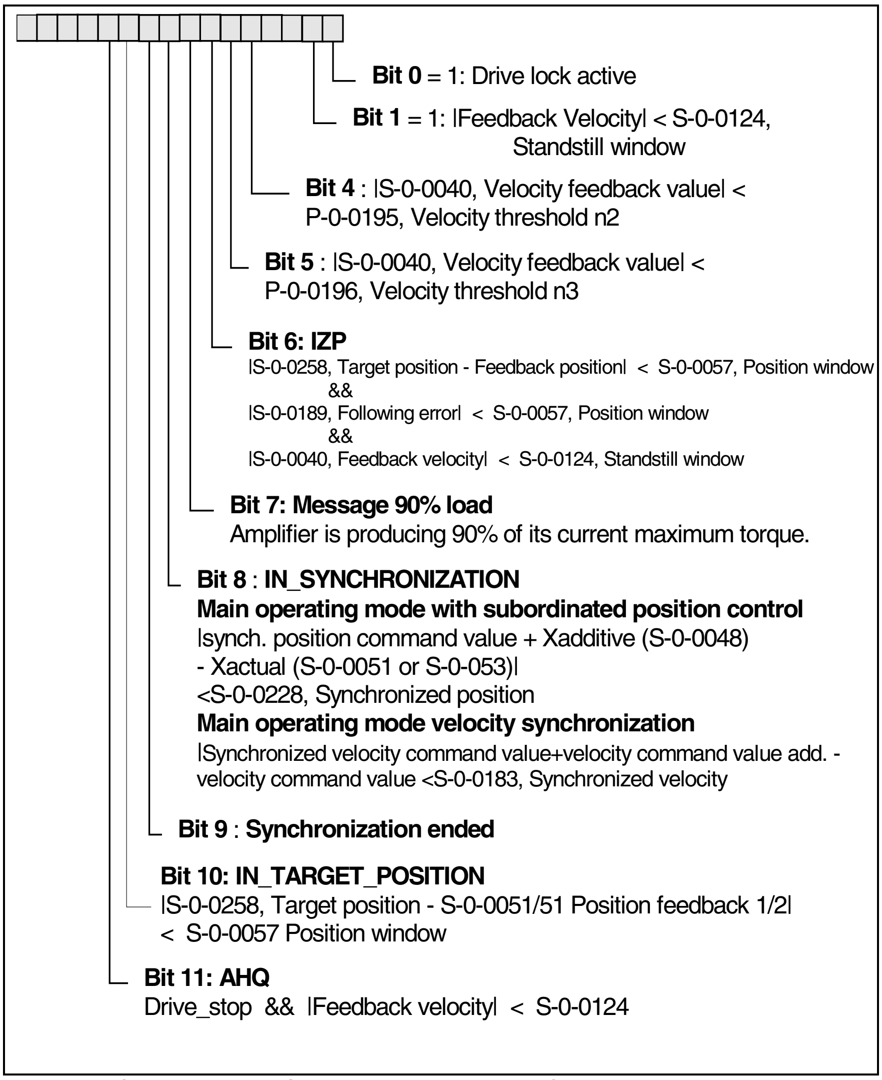


Fig. 4-15: Composition of S-0-0182, Manufacturer Class 3 Diagnostics

Refer to the Phase Synchronization Chapter for more information about bit 8, IN_SYNCHRONIZATION and bit 9, Synchronization Completed.

4.5 Language selection

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

- parameter names and units
- diagnostic texts

The following languages are implemented:

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

Fig. 4-16: Language selection

5 Communication Through the SERCOS-interface

5.1 Overview of SERCOS Communication

Communication of devices with DIAX software can be done only through the SERCOS interface at this time. The basic features of this interface are:

- Cyclical data exchange of 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 B, granularity 2, i.e., a multiple of 500 µs as cycle time can be set.

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

5.2 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:

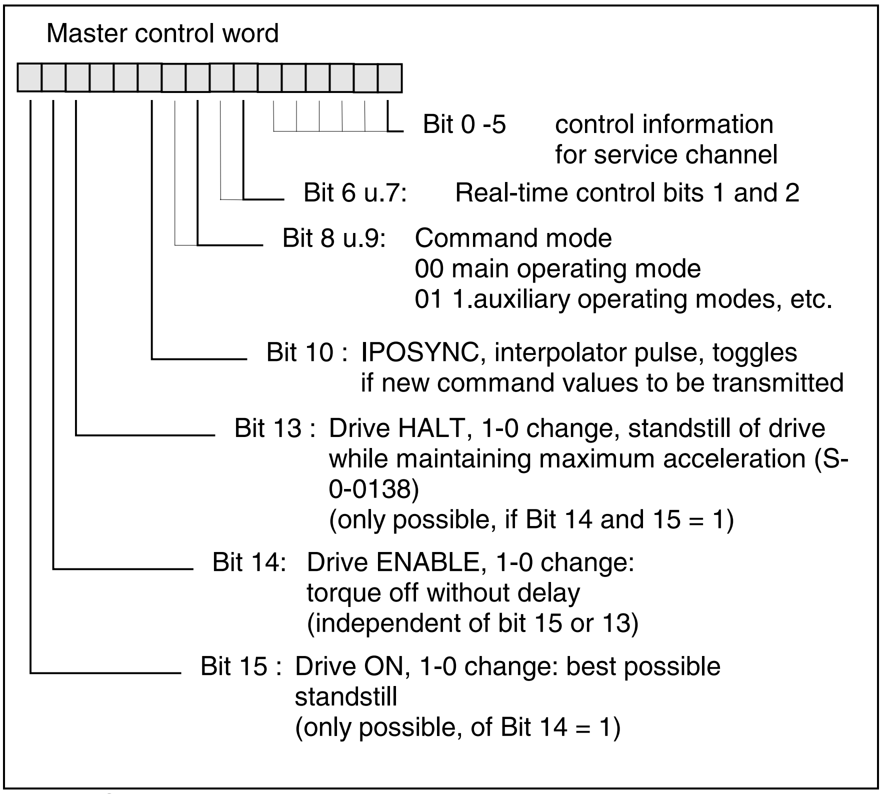


Fig. 5-1: Structure of the master control word

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:

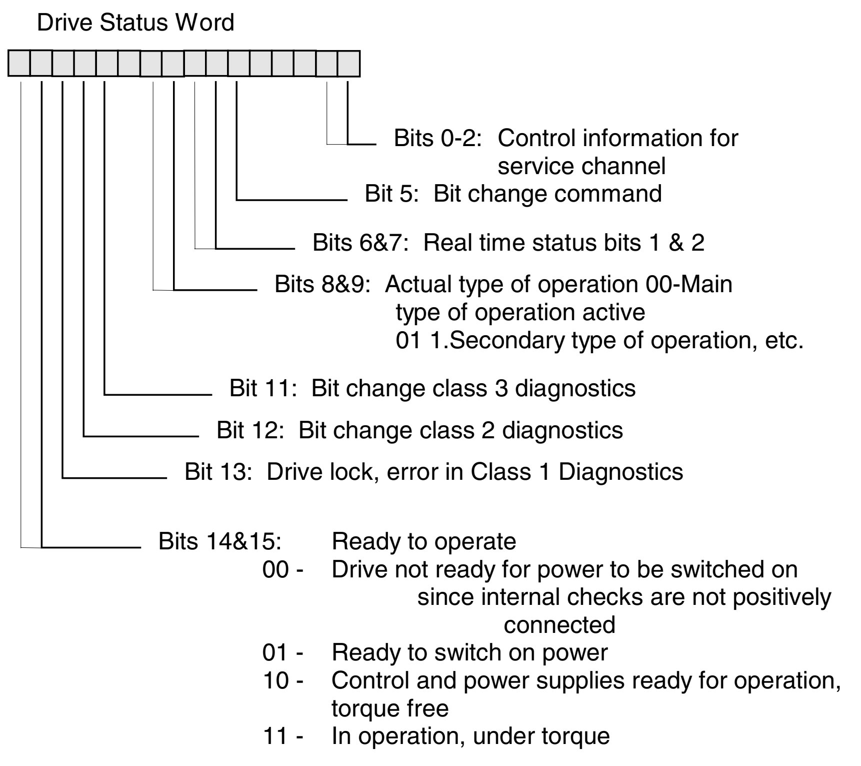


Fig. 5-2: Structure of the drive status word

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

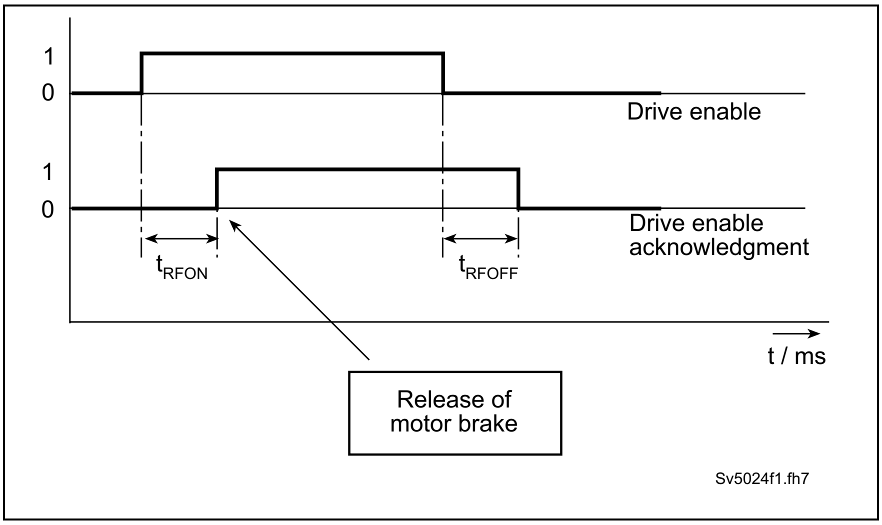


Fig. 5-3: Confirmation of the drive enable

Typical values for the time t_{RFON} are e.g.:

- abt. 10 ms for synchronous motors with housing (MHD, MKD, ...)and synchronous motors with absolute position information within one pole pair.
- abt. 300 ms for asynchronous motors.
- abt. 1 s to 5 s for synchronous motors with incremental measuring system on the motor.
- The time t_{RFOFF} is determined by the stopping function.

See also: "Drive side Error Reaction".

5.3 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.

5.4 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

5.5 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 or directly on the plug-in card of the interface module DSS 2.1.

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

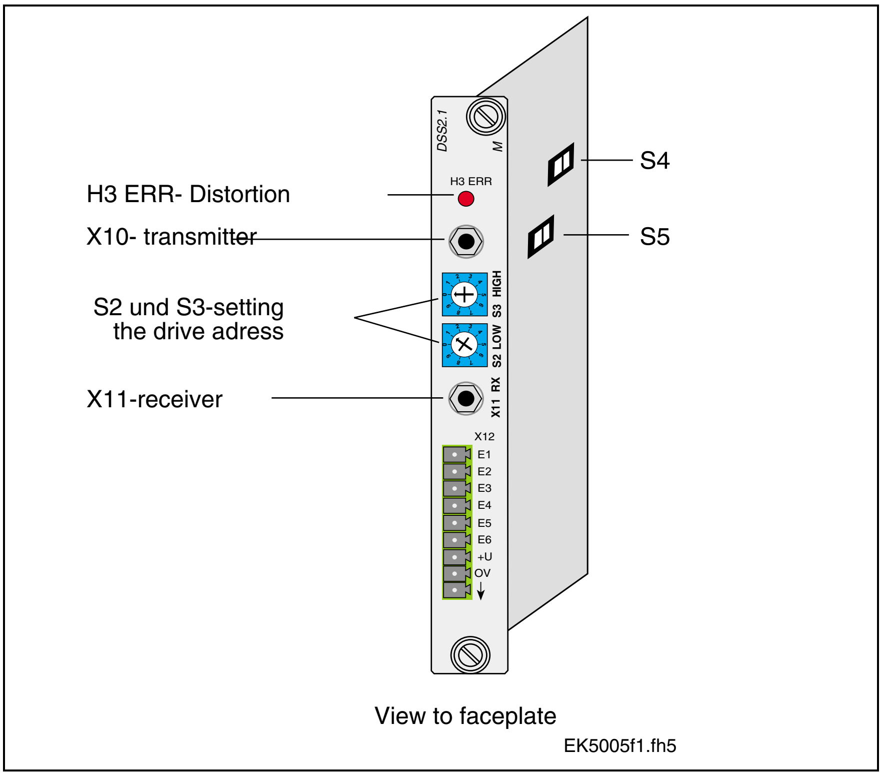


Fig. 5-4: Control communication module DSS2

See also Supplement **"E410 Slave not scanned or address 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).

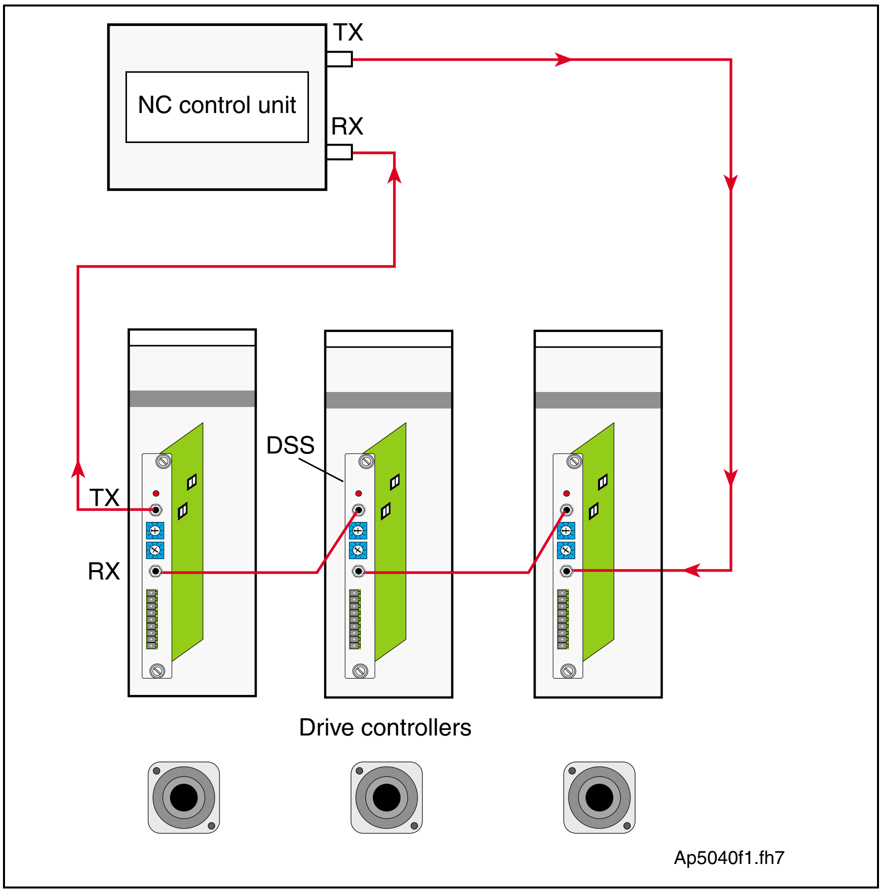


Fig. 5-5: Ring topology

The ring starts and ends at the control.

The optical output of the control is connected with the optical input of the first drive (X11). The output of the latter (X10) 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 on the front plate of the DSS 2.1 through switches S2 and S3. You can set addresses in the range of 0 to 99.

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 (see also Fig. 5-4: Control communication module DSS2, LED H3 ERR) stays dark.

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

To do this, check the distortion indicators, starting from the transmitter output of the master (control) in the direction of the signal flow.

The distortion indicator at the drives is the LED "H3 ERR“.

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 (see also Fig. 5-4: Control communication module DSS2, LED H3 ERR) 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 transmission rate is set by the manufacturer to 2 MBaud. The rate can be set with switch S4 on the interface module DSS 2.1. To do this, you have to remove the card from the slot.

(see also Fig. 5-4: Control communication module DSS2)

Baud Rate:	Switch S4:	Remarks:
2 Mbaud	OFF	Shipping condition
4 Mbaud	ON	

Fig. 5-6: Setting the transmission rate

Setting the optical Transmission Power

DIAX (DSS 2.1)

The transmission power is adjusted with the switches S5A and S5B on the DSS 2.1 card. (see also Fig. 5-4: Control communication module DSS2).

Cable length	0 .. 15 m	15 m .. 30 m	30 m .. 50 m
	S5A = OFF S5B = OFF	S5A = ON S5B = OFF	S5A = ON S5B = ON

Fig. 5-7: Setting the transmission power for plastic fiber cables

Cable length	0 .. 500 m
	S5A = ON / S5B = ON

Fig. 5-8: Setting the transmission power for Glass fiber 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.

5.6 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 config. data record in the AT**
- **S-0-0186, Length of the config. 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**
- **C118 Order of MDT configuration wrong**

5.7 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 error shutdown**
- **F402 Double MDT error 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).

Notes

6 Motor configuration

6.1 Characteristics of the different motor types

You can use the following motor types.

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

The individual motor types can differ in the following points:

- Availability of data memory in the motor feedback for all motor-specific parameters
- Linear motor – rotary motor
- Synchronous motor - asynchronous motor
- Temperature monitoring function can be parameterized or not
- Motor encoder interface can be parameterized or has a fixed setting
- Type of temperature sensor
- Basic load (load default) is possible when a feedback data memory is available
- Start of commutation offset setting command possible or not

The individual motor types have the following characteristics

Motor type	Motor feedback data memory	sync./async.	Temp. mon. function	Motor-encoder interface	Load default	Temp. sensor
MHD/MKD/MKE	yes	synchronous	fixed	fixed	possible	PTC
2AD/ADF	no	asynchronous	param.	param.	no	NTC
1MB	no	asynchronous	param.	param.	no	NTC
LAF/LAR	no	asynchronous	param.	param.	no	PTC
LSF	no	synchronous	param.	param.	no	PTC
2AD with PTC	no	asynchronous	param.	param.	no	PTC
MBS	no	synchronous	param.	param.	no	PTC

Fig. 6-1: Characteristics of the motor types

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

Motor feedback data memory

For MHD, MKD and MKE motors, a motor feedback-data memory is provided, in which all motor-dependent parameters are stored. The drive controller recognizes this automatically and reads those parameters after turning on the device from the data memory during the command **S-0-0128, C200 Communication phase 4 transition check**.

The data memory contains values for the following parameters:

- **S-0-0109, Motor peak current**
- **S-0-0111, Motor current at standstill**
- **S-0-0113, Maximum motor speed (nmax)**
- **S-0-0141, Motor type**
- **P-0-0018, Number of Pole Pairs/Pole Pair**
- **P-0-0051, Torque/Force constant**
- **P-0-0510, Moment of inertia of the rotor**
- **P-0-0511, Brake current**

Note: For motor types without motor feedback memory it is necessary to input these parameters at the initial commissioning using the data sheet.

Linear motor – rotary motor

Depending on whether a linear or rotary motor is being used, changes in the units and the number of decimal places of the parameters will be made. The following table displays the differences in scaling of these parameters:

ID number	rotary motor	linear motor
S-0-0100	0.1 As/rad	0.1As/m
S-0-0113	0.0001 RPM	0.0001 mm/min
S-0-0116	Cycles/Rev.	0.00001 mm
P-0-0018	Pole pairs	0,1mm
P-0-0051	Nm/A	N/A
S-0-0348	mAs²/rad	mAs²/mm

Fig. 6-2: Scaling in linear and rotary motors

The selected motor type also affects the scaling of the position data.

For example, it is impossible to set rotary motor settings for linear motors and linear motor settings for rotary motors. This would generate the command error **C213 Position data scaling error** during a phase progression.

Synchronous motor – asynchronous motor

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

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

Synchronous

- **P-0-4004, Magnetizing current** is set to 0 if need be
- **P-0-0508, Commutation offset** is checked for validity
- **P-0-4047, Motor inductance** is initialized

Asynchronous

- **P-0-4004, Magnetizing current** is initialized
- **P-0-0508, Commutation offset** is not checked

Temperature monitoring

The following parameters are used to monitor the motor temperature:

S-0-0201, Motor warning temperature

S-0-0204, Motor shutdown temperature

For MHD, MKD and MKE motors, the parameters have been set to the following values and cannot be changed:

S-0-0201, Motor warning temperature = 145.0 °C

S-0-0204, Motor shutdown temperature = 155.0 °C

For all other motor types the parameters can be parameterized. However, you must ensure that the switch-off limit is not set higher than the maximum permissible temperature of the motor.

The maximum input value for **S-0-0201, Motor warning temperature** is **S-0-0204, Motor shutdown temperature**.

If the temperature of the motor exceeds the value in **S-0-0201, Motor warning temperature**, the warning **E251 Motor overtemp. prewarning** is generated.

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

The minimum input value for **S-0-0204, Motor shutdown temperature** is **S-0-0201, Motor warning temperature**.

Note: To display the motor temperature, the parameter **S-0-0383, Motor Temperature** is used.

The drive controller checks for proper functioning of the motor temperature monitoring system. If discrepancies occur (temperature drops below –10 °C), the warning **E221 Warning Motor temp. surveillance defective** will be displayed for 30 seconds. After that, the error message **F221 Error Motor temp. surveillance defective** is generated.

Load default feature

MHD, MKD and MKE motors have a data memory in their feedbacks. In addition to all motor-dependent parameters, the data memory contains a set of default control parameters.

These parameters are activated with the load default feature.

(See also chapter: "Load default")

6.2 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"

6.3 Asynchronous Motors

With DIAX-Firmware, you can use asynchronous motors in the entire velocity 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.**
- **P-0-0537, S1-Kink-Speed**

The user has two additional parameters to adjust the drive to his requirements:

- **P-0-0532, Premagnetization factor**
- **P-0-0538, Motor Function Parameter 1**

Basics for the Asynchronous Motor

Asynchronous motors are divided in three working ranges.

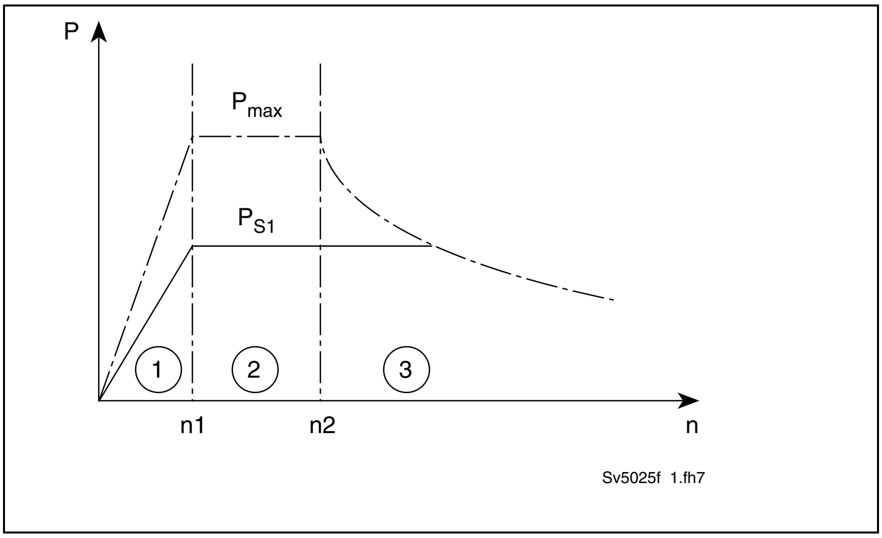


Fig. 6-3: Subsections of Work Ranges

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 sweep stability; through the vector control, the current is maintained at an efficient level. According to the parameter "stability current 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:

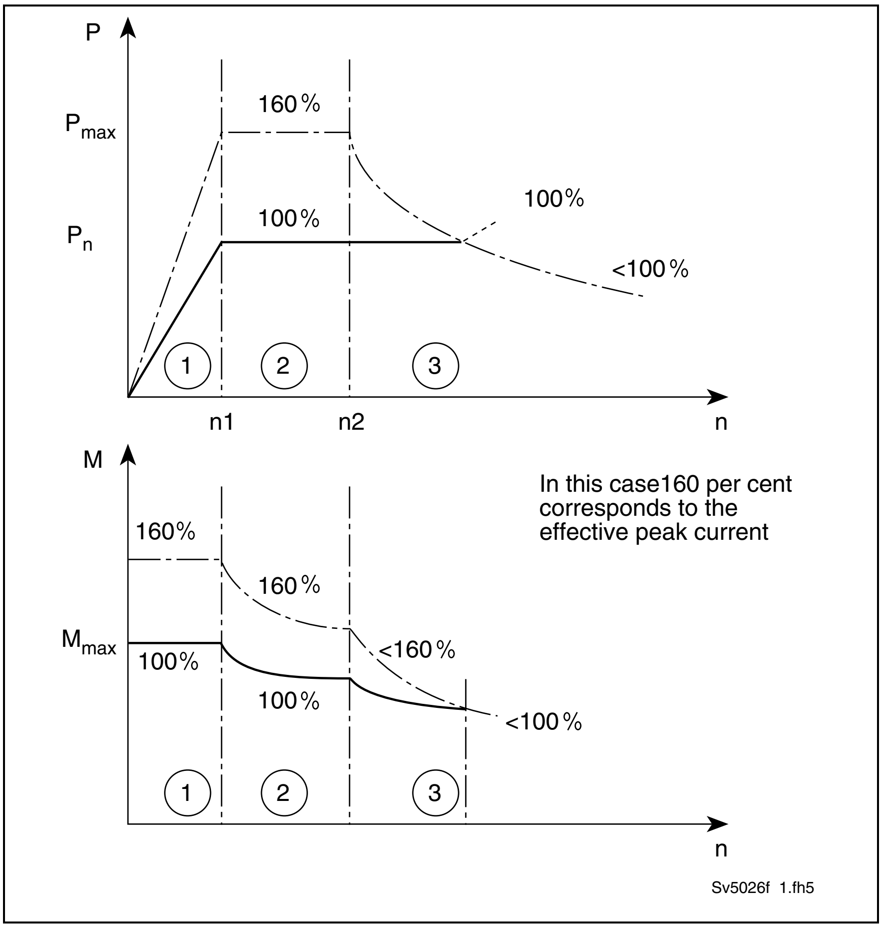


Fig. 6-4: Torque assignment

In range 1, the torque value is the actual torque. 100% = rated torque.

In range 2, the torque value corresponds to the power.
100% = rated power according to selection list. (The rated power of the motor 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 DIAX motor parameters in the controller. The parameters are stored on the programming module and are therefore transferable to another controller.

Note: Motor-specific parameters are used by all DIAX 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 the pre-magnetizing scaling factor (P-0-0532), you can set the active magnetization current.

The following applies:

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

Fig. 6-5: 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 level 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.

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

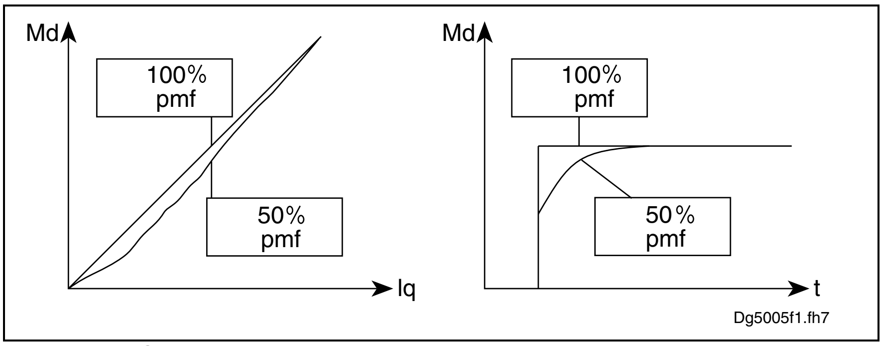


Fig. 6-6: Connection of pre-magnetizing scaling factor and drive behavior

With a 50% pre-magnetizing factor 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.

"S1-Operation" Function

By setting Bit 0 in the parameter "Motor function parameter," the function "S1-Operation" is activated.

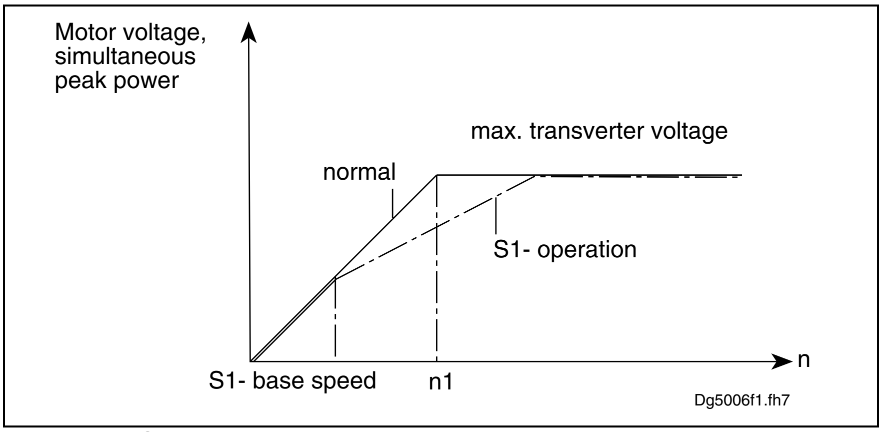


Fig. 6-7: Operating characteristics of the reference speed

Starting from the S1 base speed (P-0-0537), a controlled field weakening prevents a continued increase in iron losses. If the motor-typical S1 base speed drops drastically below the motor type and DC bus dependent corner base speed n1, then the iron loss in the range S1 base speed is kept constant until the rared voltage is reached. The peak torque does decrease, but the motor losses are lower for loads ≤ set rated loads. So activation of "S1-Operation" is advantageous for drives that are used with constant velocity in the medium RPM range, as would be the case for printing machines.

The S1 base speed can be drastically below the rated base speed n1 especially with non-ventilated motors.

The S1 operation also can be used in connection with the reduced pre-magnetizing scaling factor.

Motor Function Parameter 1

Bit No.	Meaning
#0	= 0: no magnetizing current drop = 1: S1-magnetizing current drop active since the S1 kink speed

Fig. 6-8: Definition of P-0-0538, motor function parameter

6.4 Synchronous Motors

With this drive firmware it is possible to operate not only Indramat motors with housing such as

- MHD and
- MKD and MKE motors

but also rotary and linear synchronous kit motors such as MSB and LSF. INDRAMAT motors with housing have a stator, rotor, bearings and feedback already built in. They have motor feedback memory in which

- motor parameters
- motor feedback parameters
- synchronous motor-specific parameters and
- default control parameters

are stored. This motors are recognized by the firmware and all settings automatically instituted. With these motors the alignment between the physical rotor positon and the position as supplied by the feedback has been performed at the factory prior to delivery. The resulting offset is stored in parameter **P-0-0508, Commutation offset** in the motor feedback memory (synchronous motor specific parameters).

INDRAMAT motors with housing configured at the factory

This motors can, therefore, immediately be operated without the need for motor-specific settings.

In the case of synchronous kit motors, additional settings must be made at the time of commissioning.

These are:

- motor parameters must be input and
- commutation offset must be determined.

To input the motor parameters, a data sheet from the motor manufacturer can be used. The commutation offset, on the other hand, is determined with the help of command **P-0-0524, Commutation Command.**

WARNING

Error in the control of motor and moving elements.
Determining the commutation offset must be conducted each time after there has been a change in the mechanical relationship between motor feedback and motor. This is the case, for example, when the encoder or motor are replaced.

Determining the commutation offset

A condition for a temporally constant torque of the synchronous motor is the synchronism between the stator current vector and the vector of the rotor flux. If the angle between these two vectors, hereinafter termed γ equals 90°, then the motor will generate its maximum torque. A synchronous motor is operated in this state.

In order to set the stator current vector correctly, the data on γ is needed. This generally necessitates a measuring system which can supply absolute information about this angle. Once the measuring system is mounted to the motor, only the absolute raw position is at first available. The difference between raw positon and absolute angle of rotor and stator field is designated the commutation offset. This is generally stored in the feedback memory in the form of parameter **P-0-0508, Commutation offset.**

If this parameter is to be determined, then the commutation setting function must be activated. The following two parameters are intended for this purpose:

- **P-0-0523, Commutation, Probe value**
- **P-0-0524, Commutation Command**

Two different processed have been implement. These are:

- mechanical reference between rotor and stator is entered in P-0-0523 and then commutation offset is computed while command P-0-0524 is executed.
- Automatic determination of the commutation offset by switching defined stator current vector on with accompanying automatic measurement.

Which process is used at the state of the **P-0-0524, Commutation Command** depends on the type of motor which has been mounted. It thus applies:

LSF (synchronous linear)	reference between rotor and stator is measured (see item 1)
MSB (synchronous rotary)	automatic determination (see item 2)

Fig. 6-9: Setting the commutation offset

Note: To successfully conduct the command, the motor measuring system must be completely operable. The rotational direction of the measuring system must also be set! (See "Motor encoder“)

Determining the commutation offset in rotary synchronous motors (MSB)

In rotary synchronous motors, the commutation offset is determined by switching to a defined stator current vector. The rotor goes into a torque-free position. If the raw position of this torque-free position is measured, then it can be used to determine the commutation offset. This procedure is repeated ten (10) times, whereby the points of measurement are distributed over the entire mechanical rotation of the rotor. The mean value of these ten measurements equals the commutation offset.

Amount and angle of the stator current are illustrated below.

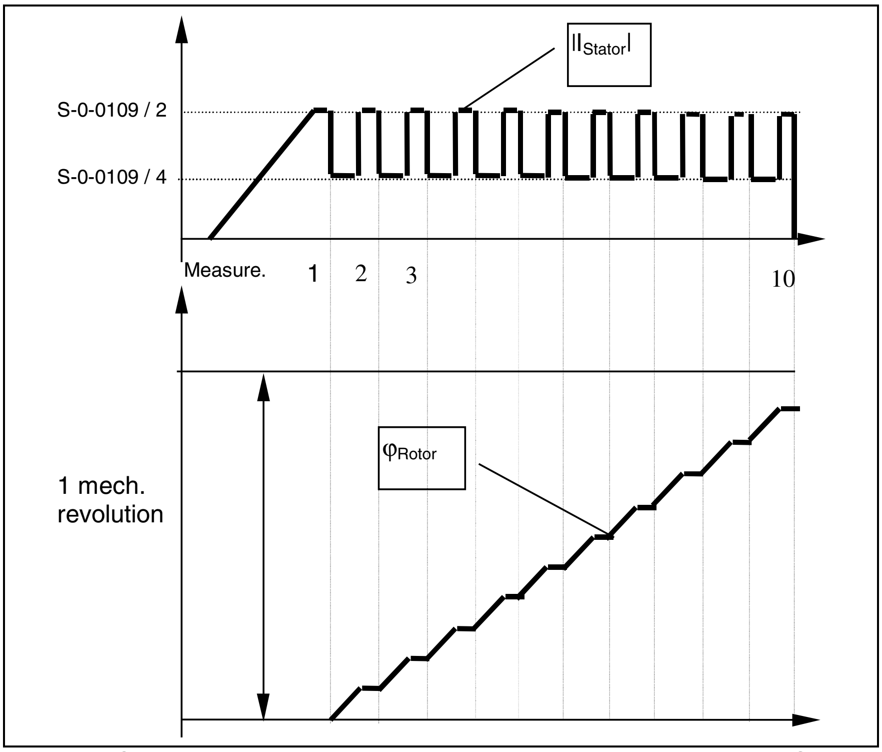


Fig. 6-10: Current and position when determining commutation offset in MSB motors

At the start of the command, the drive must be in **torque mode.** If not, then the command error

D301 Drive not ready for commutation command

is generated. The value of **P-0-0508, Commutation offset** is stored in the motor feedback memory, if one is available. Allowable motor encoders for rotary synchronous motors must supply an absolute position of at least one pole pair after powering up. For this reason, the following values for **P-0-0074, Interface Feedback 1** are permitted:

Possible values for P-0-0074, Interface Feedback 1 with motor type MSB (rotary synchronous kit motor)	Motor encoder interface
1	DSF or resolver with feedback data storage
8	Heidenhain encoder with Endat Interface
10	Resolver without feedback data storage *)
11	Resolver + incremental encoder with sine signals without feedback data memory *)

Fig. 6-11: Possible motor encoders with motor types "rotary synchronous kit“

Note: *) With this type of motor encoder, there is no feedback memory. The parameter **P-0-0508, Commutation offset** is stored in the programming module. When exchanging the programming module, the value of parameter **P-0-0508, Commutation offset** must be re-entered or assumed by storing the parameter and loading from the previous module.

Determining the commutation offset in linear synchronous motors (LSF)

The commutation offset in linear synchronous motors (LSF) is fixed by measuring the distance between front end of primary part and setting device of the secondary part. This value plus the motor type dependent primary nominal value is entered in parameter **P-0-0523, Commutation, Probe value.** Then the command **P-0-0524, Commutation Command** is started. The drive computes the commutation offset from the measured value. To successfully conduct the command, the following conditions must be met:

- The direction of movement of the measuring system must be set so that if the primary part is moving towards the front end at which the power cable of the motor branches off (front end 1, see picture 2), then **S-0-0051, Position Feedback Value 1 (Motor Feedback)** is moving in a positive direction. (With inverted position polarity!) If this is not the case, then the direction of movement of the motor encoder must be inverted. Do this in bit 3 of **S-0-0277, Position feedback 1 type parameter.**
- The power cables of the motor must be correctly connection (three phases must be assigned).
- The drive must be in **A013 Ready for power on.**
- A characteristic value, K_{entire}, for the primary part of the motor must be determined.

If these conditions have been met, then the distance between front end 2 of the primary part of the setting device (d) can be measured and this value plus the primary part characteristic value K_{entire} can be entered in P-0-0523. Front end 2 means the front end opposite the end where the power cables of the motor emerge.

$$P\text{-}0\text{-}0523 = d + K_{entire}$$

P-0-0523: value determined for parameter P-0-0523
d: measured distance between front end of primary part and setting device
K_{entire}: primary part characteristic value

Fig. 6-12: Determining the measured value of the commutation offset setting in LSF motors

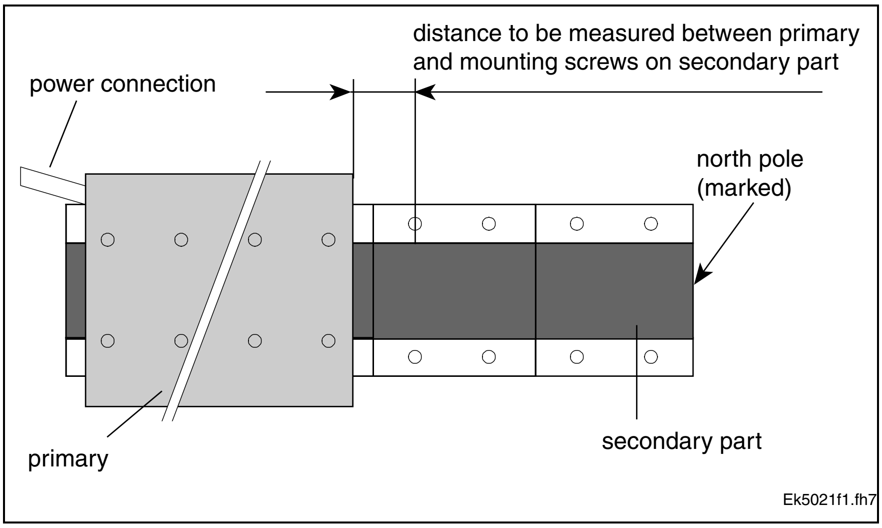


Fig. 6-13: Overview of determining the commutation offset in LSF

Finally, the command **P-0-0524, Commutation Command** is started. The commutation offset is computed during this process.

At command start, the drive must be **A013 Ready for power on.** If not, then command error

D301 Drive not ready for commutation command

is generated. The command must be cleared when all is completed!

6.5 Motor Holding Brake

The drive controllers of the DIAX series allow for control of a motor holding brake. This is used to prevent undesired axis movements when the controller enable is turned off.

Note: The holding brake is not designed for regular operation. The brake will be worn out after 20.000 - 30000 rotations in engaged state.

To set the motor holding brake, use the parameters

- **P-0-0525, Type of motor brake**
- **P-0-0526, Brake control delay**
- **P-0-0511, Brake current**

The parameters will be set automatically for motors with motor feedback data memory. For all other motor types, you have to retrieve the values from the data sheet for the motor or the motor brake.

DANGER

Dangerous movements! Danger to personnel from falling or dropping axes!

⇒ The standard equipment motor brake or an external brake controlled directly by the servo drive are not sufficient to guarantee the safety of personnel!

⇒ Personnel safety must be acquired with higher-ranking procedures:

Dangerous areas should be blocked off with fences or grids.

Secure vertical axes against falling or slipping after switching off the motor power by, for example:

- Mechanically securing the vertical axes
- Adding an external brake / clamping mechanism
- Balancing and thus compensating for the vertical axes mass and the gravitational force

Connection of the Motor Holding Brake

You connect the motor brake through connector X6 on the drive controller.

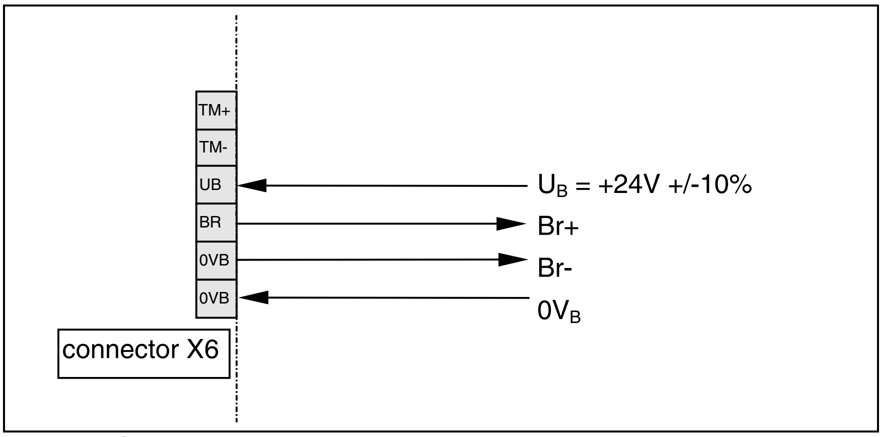


Fig. 6-14: Connection of the motor brake

To provide the required brake control voltage, you have to connect +24 V external voltage. The brake is controlled with the contacts Br+ and Br-.

Note: To ensure error-free monitoring, a connection between the 0V of the brake supply and the 0V of the drive controller is recommended.

Setting the Motor Brake Type

In **P-0-0525, Type of motor brake** , you set either a self-locking (MHD, MKD or MKE motors) or a self-releasing brake.

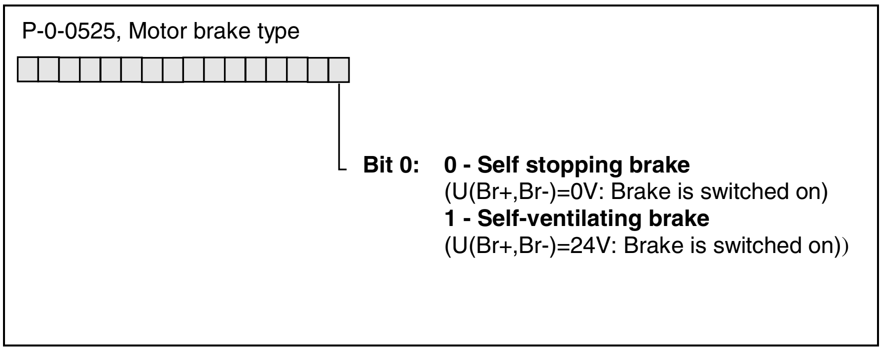


Fig. 6-15: Setting the motor brake type

Setting the Brake Control Delay

In **P-0-0526, Brake control delay**, you set the time it can take for the brake to become effective.

The standard value for the direct connection of holding brakes for Rexroth Indramat motors should be set at 100 ms.

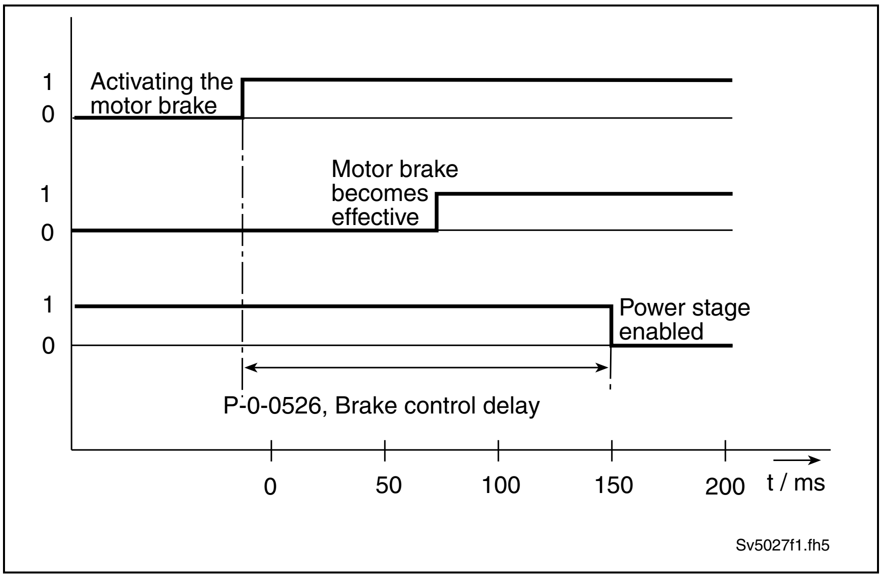


Fig. 6-16: Setting the brake control delay

Setting the Motor Brake Current

The motor holding brake is controlled by the drive controller with connector X6. The supply voltage of +24 V for the brake control has to be fed externally. If the brake is actuated (electrically released or electrically engaged), the current flowing through the connection contacts of the brake will be monitored.

Note: The maximum output voltage for the control of the motor brake is 2,0 A.

In **P-0-0511, Brake current**, the rating of the brake current is defined. If the actual brake current after actuation is outside (0,4..1,6) • P-0-0511, then the error message **F268 Brake fault** will be generated.

The monitoring of the brake current is deactivated when a **P-0-0511, Brake current** equal to 0 is entered.

7 Operating Modes

7.1 Setting the Operating Mode Parameters

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 operating mode.

7.2 Determining the Active Operating Mode

Command communication via SERCOS

If command communication via SERCOS is used then bits 8 and 9 in the **S-0-0134, Master control word** are used to determine which of the four pre-selected modes is active.

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. 7-1: Determining 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.

7.3 Operating Mode: Torque/Force Control

A torque/force value is commanded to the drive in the **Torque/Force Control** operating mode. When the operating mode is activated, the diagnostic message reads **A100 Drive in Torque Mode**.

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

Monitors specific to this operating mode are:

- Monitoring of the actual speed at 1.125 times the value of the parameter **S-0-0091, Bipolar Velocity Limit Value**. (See also "Limiting to Bipolar Velocity Limit Value ")

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

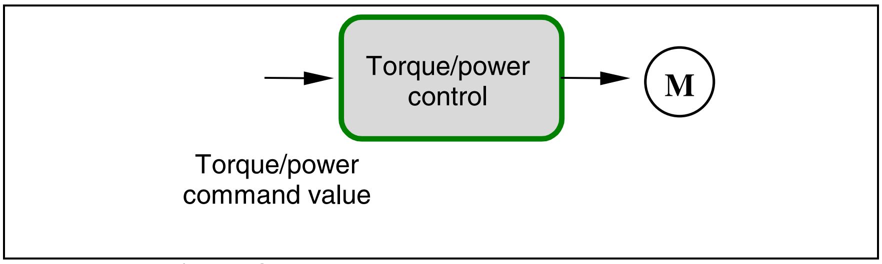


Fig. 7-2: Torque/Force Control Block Diagram

Torque/Force Controller

The command value in **S-0-0080, Torque/Force Command** is limited with the effective peak current **P-0-4046, Active peak current**. The effective peak current is derived from the current and torque/force limit.

(See also "Current Limit and "Torque/Force Limiting")

The torque/force generating command current "Iqcom" is derived according to these limits. This is the command value for the (effective) current regulator.

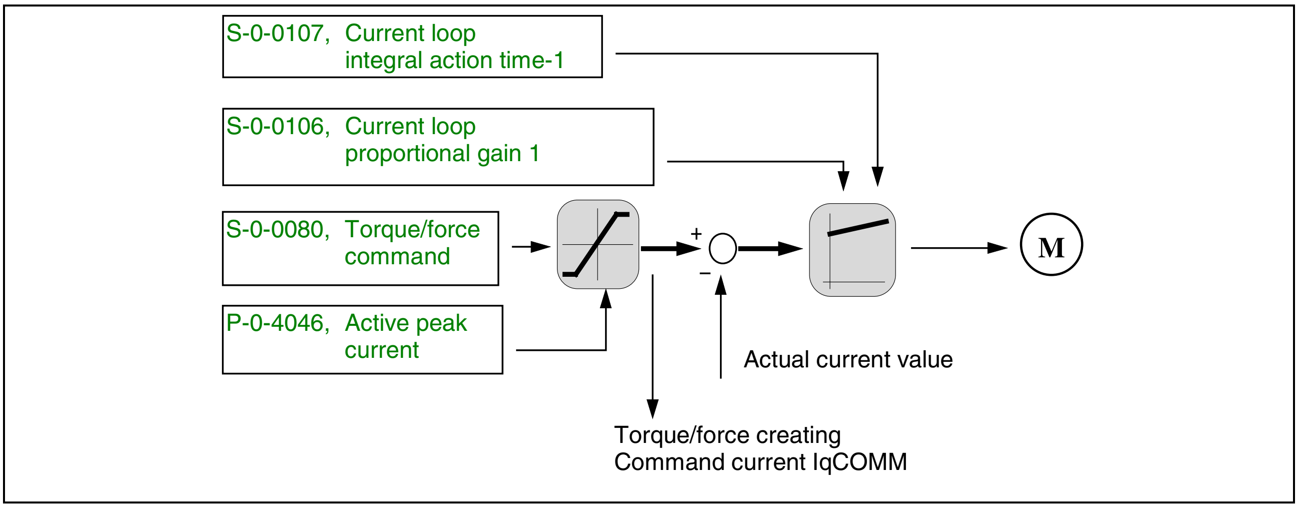


Fig. 7-3: Torque/Force Controller

7.4 Operating Mode: Velocity Control

A velocity value is commanded to the drive in the **Velocity Control** operating mode. 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**.

Monitors specific to this operating mode are:

- The parameter **S-0-0036, Velocity Command Value** is limited to the value of the parameter **S-0-0091, Bipolar Velocity Limit Value**. This generates the warning **E263 Velocity command value > limit S-0-0091** .

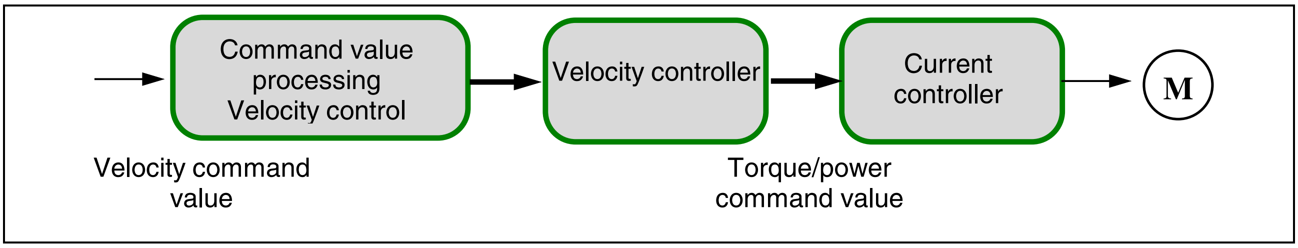


Fig. 7-4: Velocity control block diagram

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 **E 263, Velocity Command Value > Limit S-0-0091** is shown. After that the acceleration is limited with **P-0-1201, Ramp 1 pitch** and the jerk is limited with **P-0-1222, Velocity command filter**.

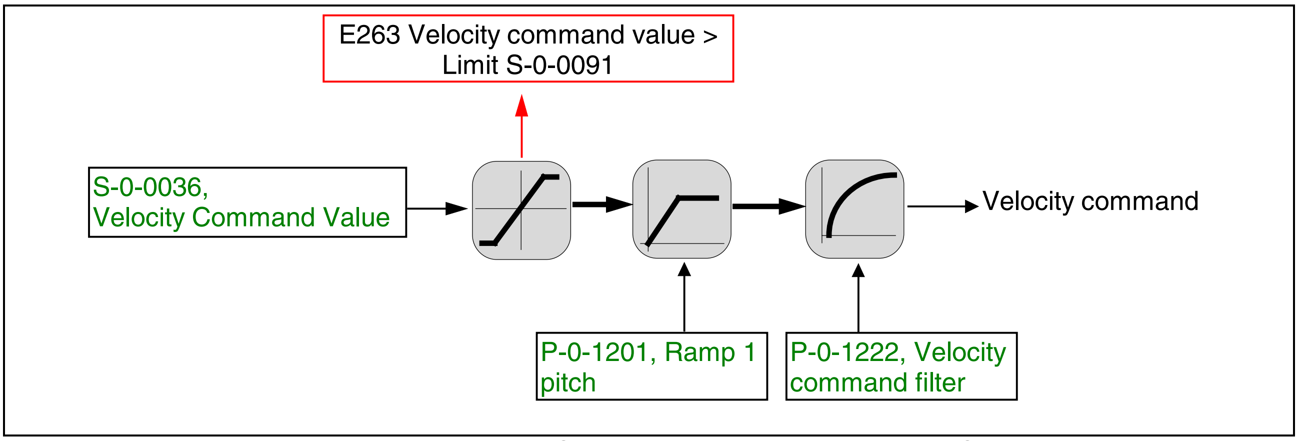


Fig. 7-5: Command value processing: Velocity Controller

See also "Velocity Controller"

See also "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 "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" Setting the Velocity Mix Factor".)

Via **P-0-0004, Smoothing Time Constant** you can limit the band of the control difference for the velocity controller.

The output from the velocity controller is added with a feed forward component when a lagless position control mode is activated and **S-0-0348, Acceleration Feedforward prop. Gain** is set to a non-zero value.

This value is commanded according to the current and torque/force limit.

(See also" Current Limit" and "Torque/Force Limitation".)

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".)

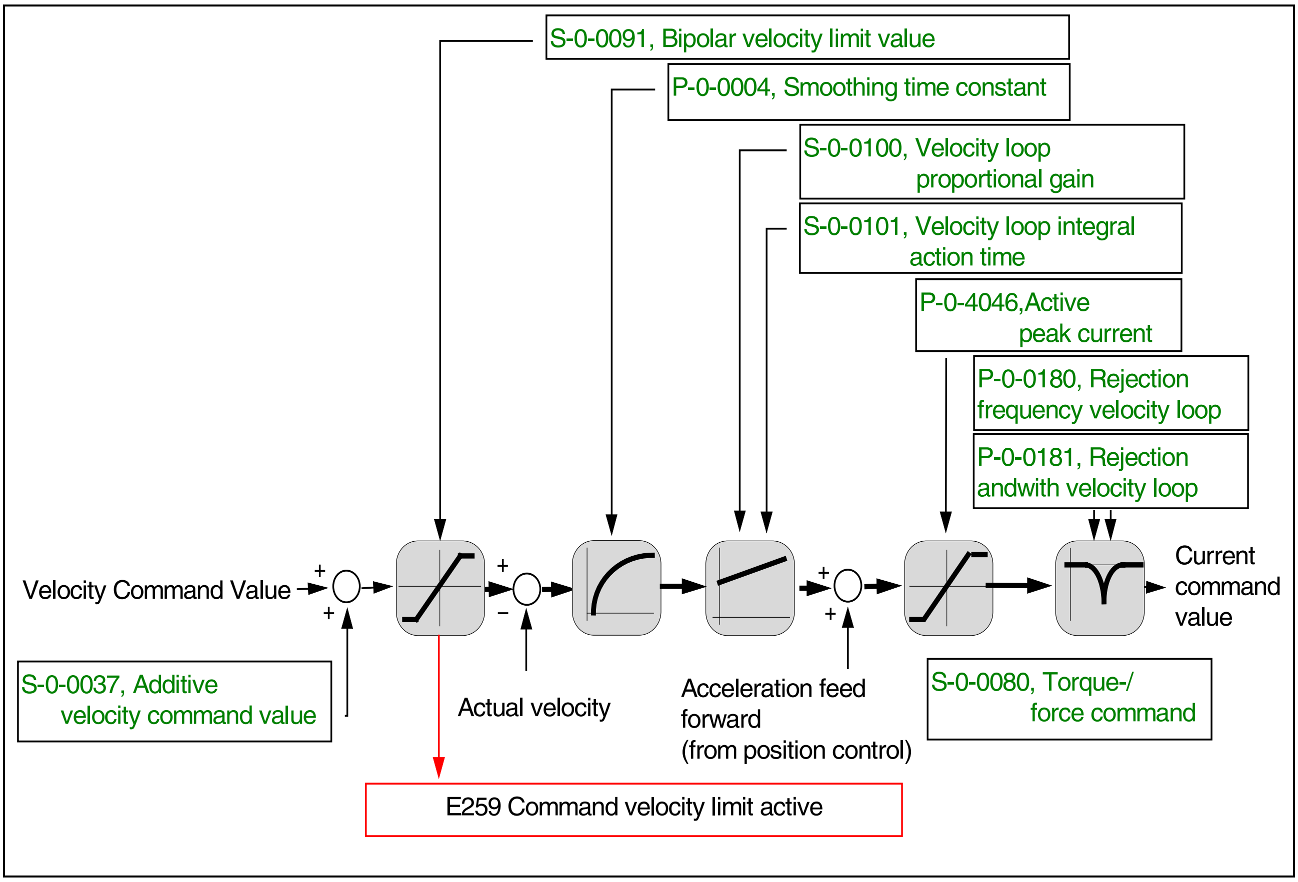


Fig. 7-6: Velocity Controller

See also "Command value processing Velocity control"

See also "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 "Setting the Current Controller".)

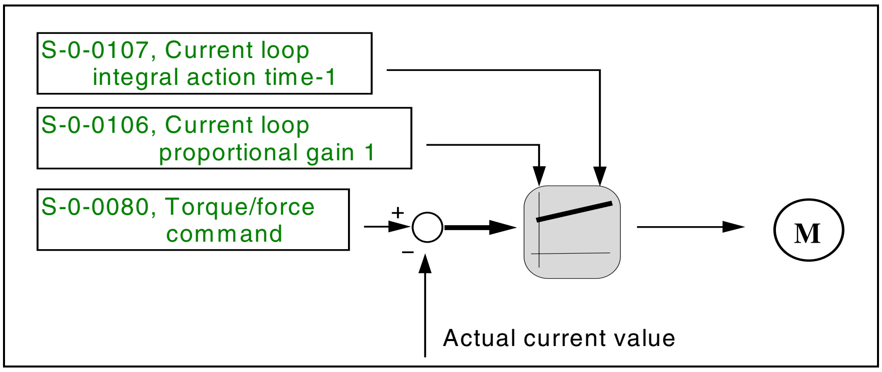


Fig. 7-7: Current Controller

Velocity Control with Analog Command Communication

To activate the mode together with an analog command communications, the following procedure must be complied with:

- Select the mode with **S-0-0032, Primary mode**
- Parameterize the analog channel **P-0-0213, Analog input 1, Allocate** on parameter **S-0-0036, Velocity command value**
- Define the desired resolution with the help of **P-0-0214, Analog-input 1, evaluation per 10V**.
- If necessary, execute offset compensation via **P-0-0217, Analog input 1, offset**.

7.5 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 at 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.

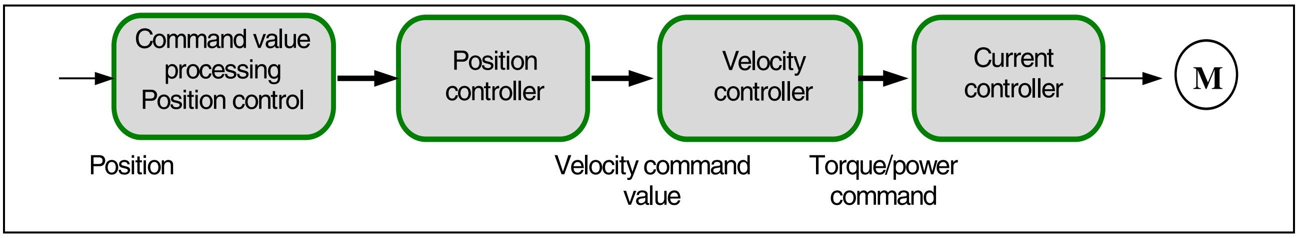


Fig. 7-8: Position control block diagram

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. 7-9: 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 250usec. The position command value is also fine interpolated within the NC cycle time.

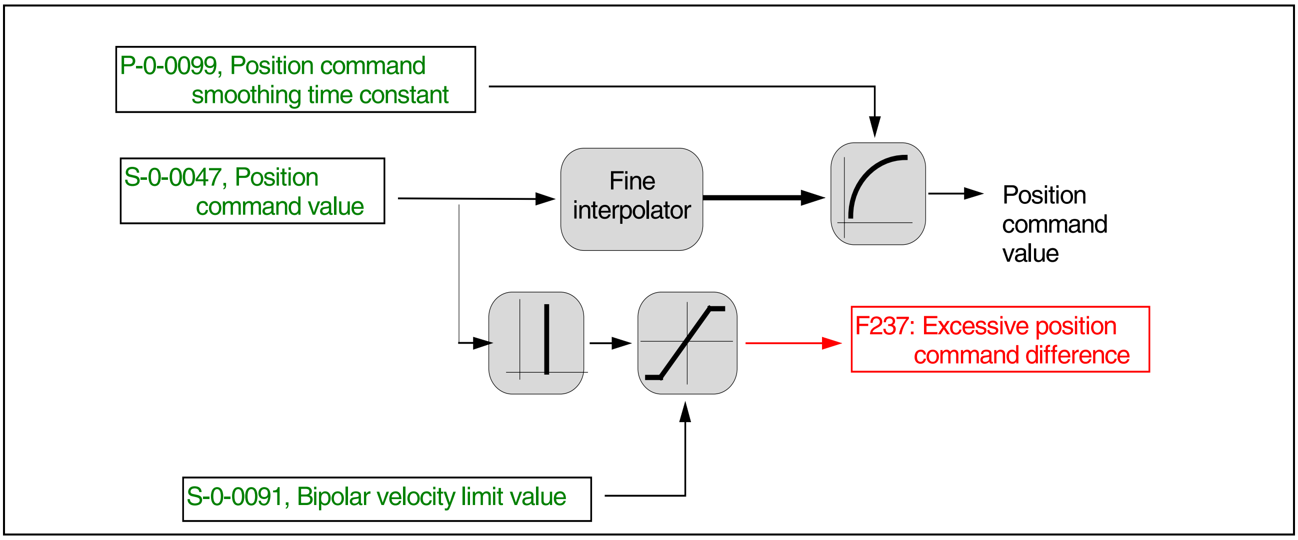


Fig. 7-10: : Command value processing: position control

See also Current Controller

See also Velocity Controller

See also Position 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.

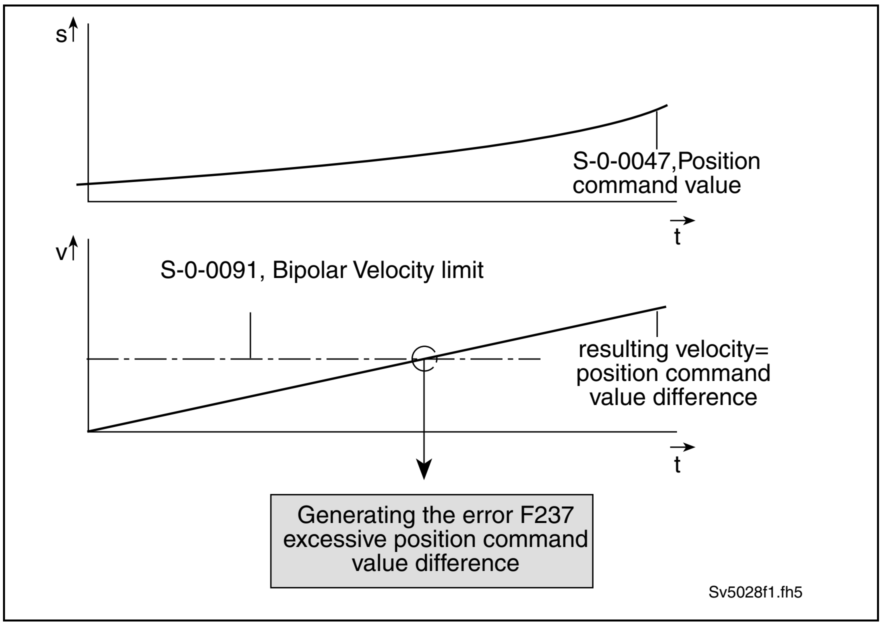


Fig. 7-11: Monitoring the position command value differences and generating the error **F237 Excessive position command difference**

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 with approximately 5 to 10% above the planned maximum velocity of the shaft.

7.6 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**

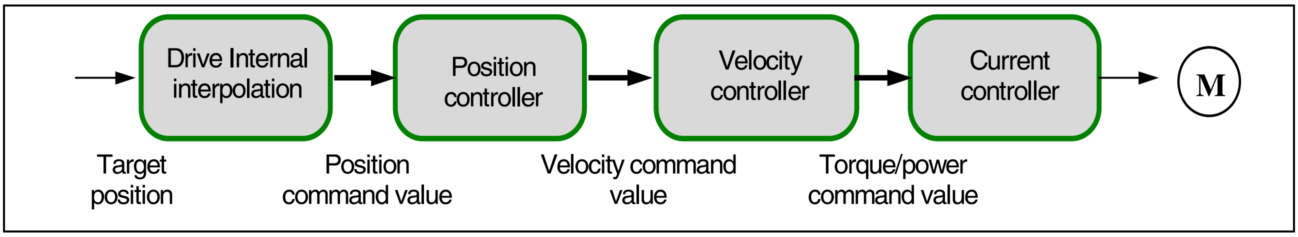


Fig. 7-12: Drive-internal interpolation diagram

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**

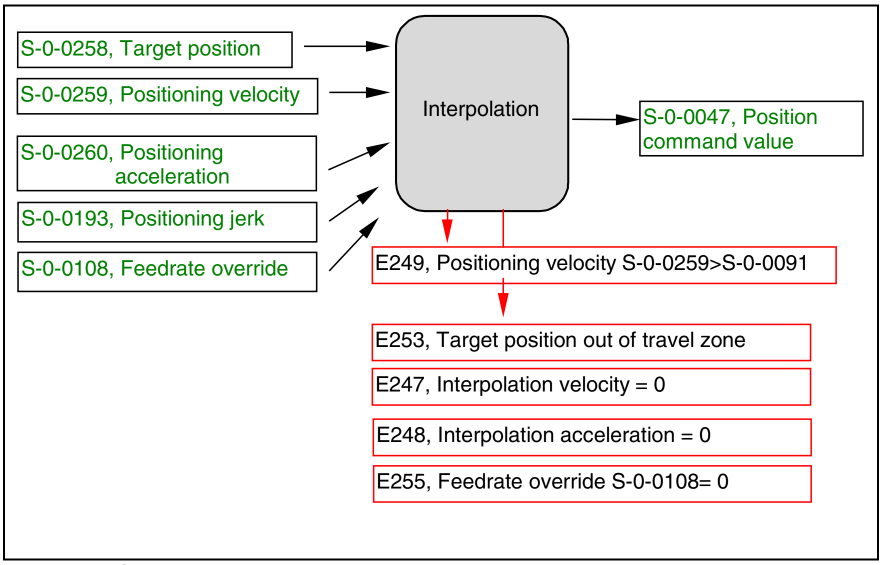


Fig. 7-13: Generator function drive internal interpolation

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:

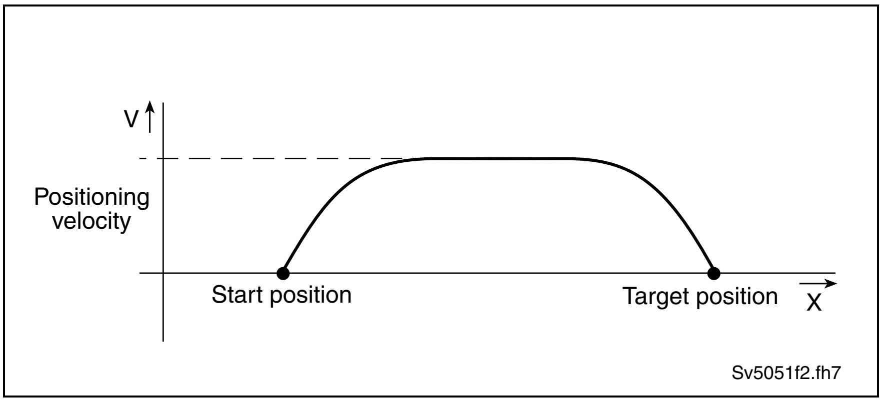


Fig. 7-14: Profile to explain how the interpolation status messages work

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

The following time diagram result:

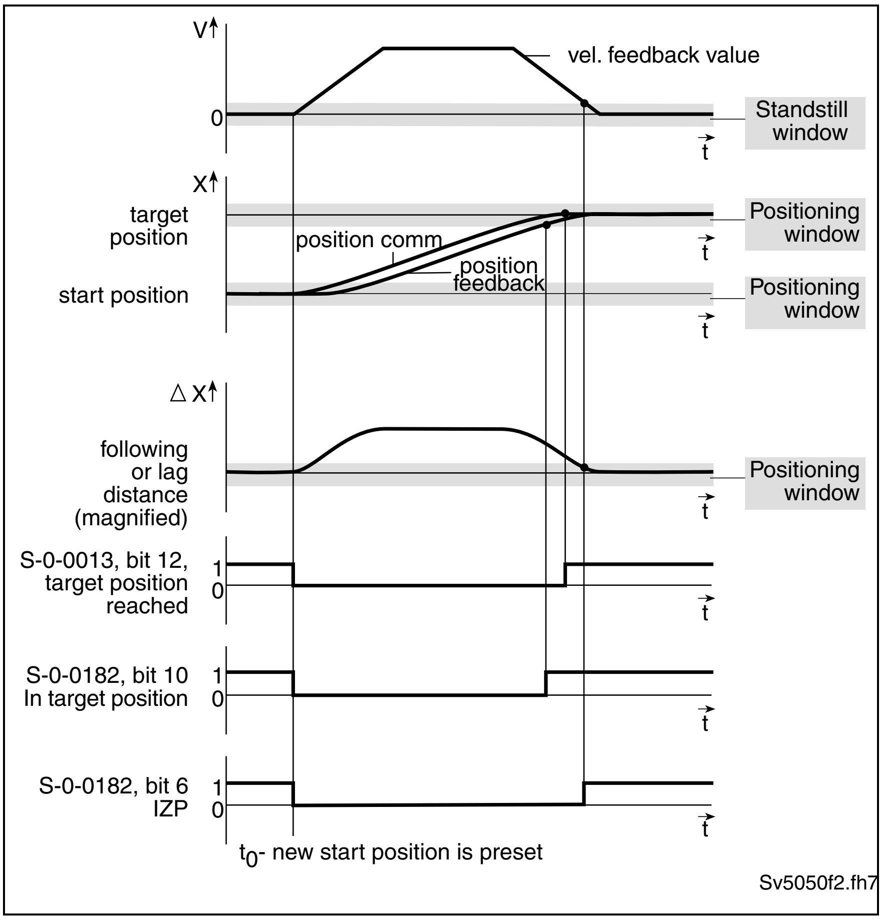


Fig. 7-15: Generating the status bit of the operating modes with drive-internal interpolation

7.7 Operating 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** toggles, then it is added to the target position in **S-0-0258, Target Position**. The drive generates the position command profile it needs to run to the target position while maintaining all marginal conditions in:

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

The diagnosis with activated operating mode is one of the following:

- **A146 Relative drive-internal interpolation, encoder1**
- **A147 Relative drive-internal interpolation, encoder2**
- **A148 Relative drive contr. interpolation, Enc. 1, lagless**
- **A149 Relative drive contr. interpolation, Enc. 2, lagless**

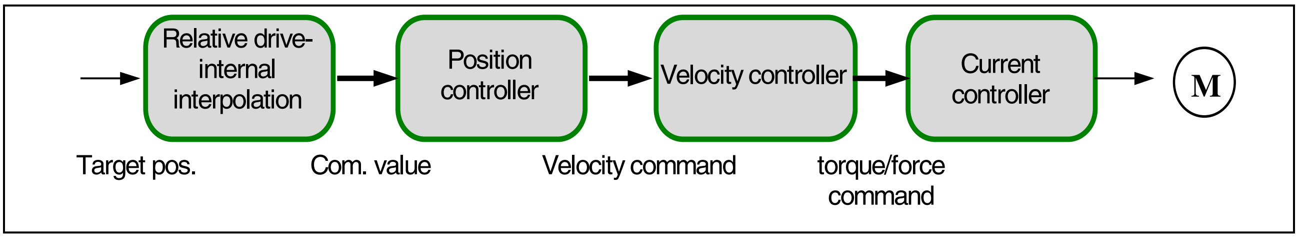


Fig. 7-16: Block diagram of relative drive-internal interpolation

Generator function: Relative drive-internal interpolation

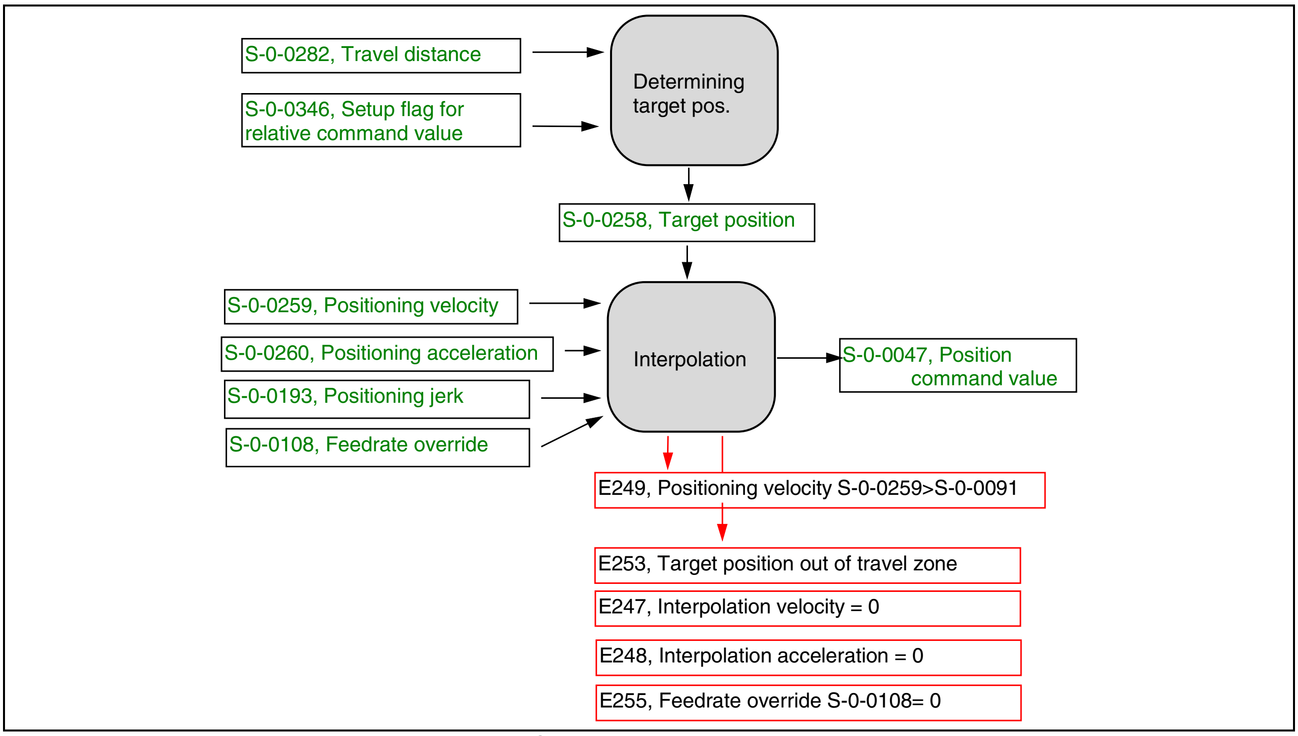


Fig. 7-17: Generator function relative drive-internal interpolation

See also position controller

See also velocity controller

See also current controller

Monitoring during mode "Relative drive-internal interpolation"

With activated mode, the following monitoring functions are performed:

- 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.

- 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 toggles.
- If the positioning velocity set in **S-0-0259, Positioning velocity** equals 0, then warning **E247 Interpolation velocity = 0** is generated.
- 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.
- 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 functional description:

Status messages during operating mode Drive-internal interpolation

7.8 Operating mode: velocity synchronization with virtual master axis

Velocity synchronization is used in printing machines in such cases as simple transport rolls. The drive runs with a velocity synchronous to the master axis. The track speed at the circumference of the transport roll or the winder is preset by the electrical gear. A defined tension can be set with the fine offset of the gear.

The master axis position in this mode is set by the control.

The structure of the mode is illustrated below:

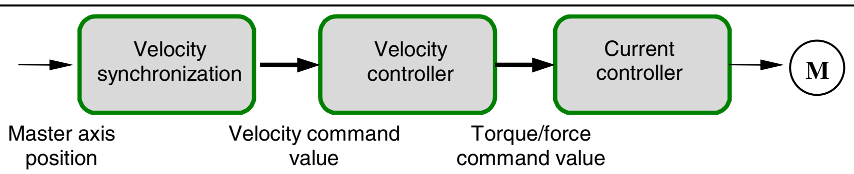


Fig. 7-18: Velocity synchronization with virtual master axis block diagram

Pertinent parameters

- **P-0-0053, Master drive position**
- **P-0-0083, Gear ratio fine adjust**
- **P-0-0108, Master drive polarity**
- **P-0-0142, Synchronization acceleration**
- **P-0-0155, Synchronization mode**
- **P-0-0156, Master drive gear input revolutions**
- **P-0-0157, Master drive gear output revolutions**

Command value preparation for velocity synchronization with virtual master axis

After the slave drive has been synchronized to the master axis position, the drive generates the "synchronous velocity command value" (this is a component of the velocity command value which is transmitted to the velocity controller).

The synchronous velocity command value (dX_{synch}) is calculated in terms of the polarity selected for the master drive (**P-0-0108, Master drive polarity**) and the set scaling type (**S-0-0076, Position data scaling type**) in accordance with the following equation:

$$dX_{Synch} = \pm[(P\text{-}0\text{-}0053_{(n)}) - (P\text{-}0\text{-}0053_{(n-1)}) * \frac{P\text{-}0\text{-}0157}{P\text{-}0\text{-}0156} * (1 + P\text{-}0\text{-}0083)]$$

d_{XSynch}: synchronous velocity command value
n: probe cycle

Fig. 7-19: Generating the synchronous velocity value for rotary scaling

The fine adjustment of the gear ratio that can be configured as cyclical data permits velocity changes at the slave axis at a constant master axis speed. Velocity can also be changed by changing the master axis gear parameters. These can also be cyclically changed.

The following illustrates how the velocity command value is generated in accordance with the above equation:

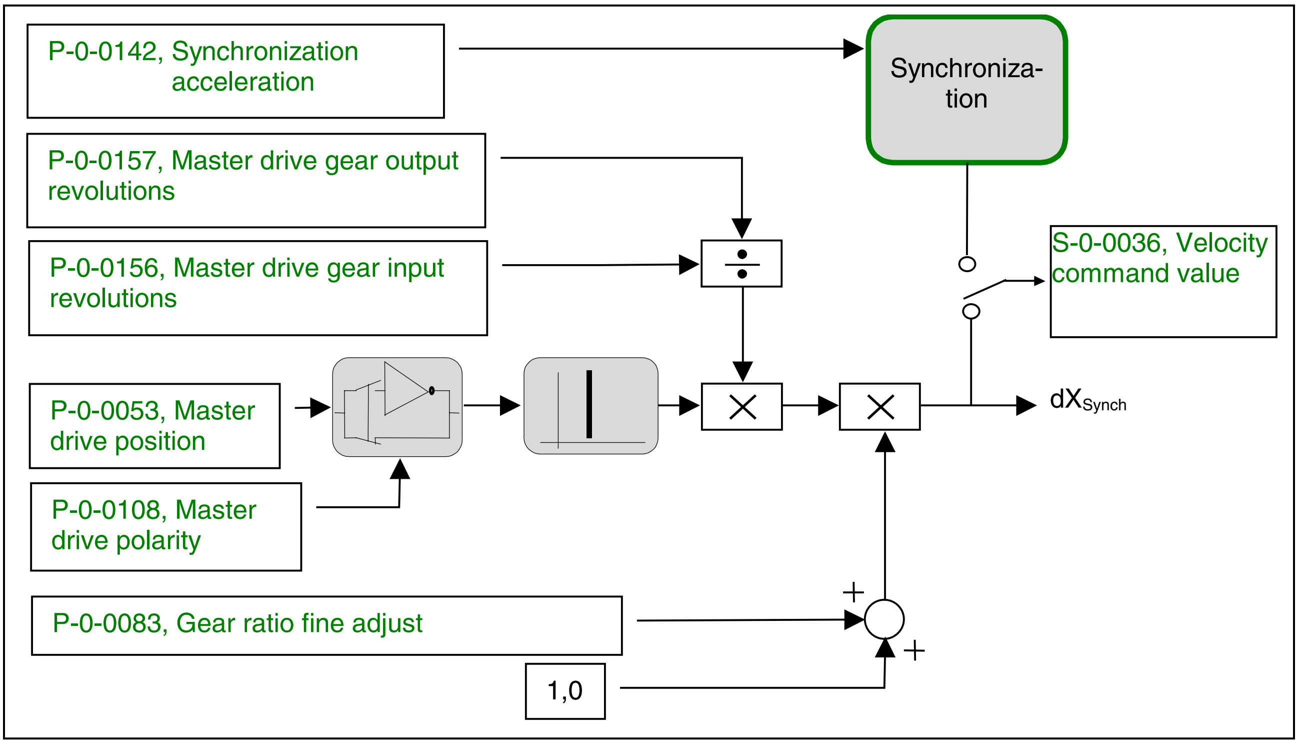


Fig. 7-20: Command value preparation for velocity synchronization

see also "Velocity controller"
see also "Current controller"

Dynamic synchronization in the velocity synchronization operating mode

Pertinent parameters:

- **P-0-0142, Synchronization acceleration**
- **P-0-0155, Synchronization mode**

Dynamic synchronization is included in the "velocity synchronization" operating mode.

By generating velocity command values, the drive accelerates or decelerates during synchronization until the synchronous velocity has been reached. The velocity command values are generated in consideration of the synchronization acceleration.

The settings in parameter **P-0-0155, Synchronization mode** are decisive for synchronization.

Synchronization status message during the velocity synchronization operating mode

Pertinent parameters:

- **S-0-0037, Additive velocity command value**
- **S-0-0040, Velocity feedback value**
- **S-0-0182, Manufacturer class 3 diagnostics**
- **S-0-0183, Velocity synchronization window**

The drive sets bit 8 ("In_Synchronization") in **S-0-0182, Manufacturer class 3 diagnostics** if:

$$\left| dX_{Synch} + S-0-0037 \quad - \quad S-0-0040 \right| < S-0-0183$$

7.9 Operating mode: phase synchronization with virtual master axis

In machining processes that require absolute phase synchronization, e.g. printing, punching or perforating in printing machines, the position reference to the master axis is established in operating mode "phase synchronization".

In this operating mode, the drive synchronizes to the (virtual) master axis position (P-0-0053) preset by the control.

The structure of the operating mode "phase synchronization with virtual master axis" is illustrated below:

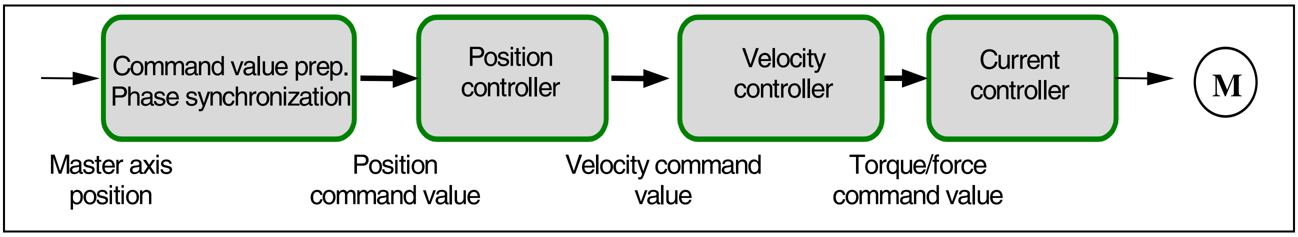


Fig 7-21: Phase synchronization block diagram

Pertinent Parameters

- **S-0-0048, Position command value additional**

S-0-0048 is used to establish a position offset between master axis and slave axis.

- **P-0-0053, Master drive position**

The master axis position is preset cyclically and in equidistant intervals by the control (virtual master axis). Format: 2^{20} increments/master axis revolution.

- **P-0-0083, Gear ratio fine adjust**

The gear ratio of the master drive gear is modified by the percentage parameterized in P-0-0083. For a master drive gear free of drift the value must equal zero.

- **P-0-0108, Master drive polarity**

P-0-0108 is used to invert the master drive gear.

- **P-0-0155, Synchronization mode**
- **P-0-0156, Master drive gear input revolutions**
- **P-0-0157, Master drive gear output revolutions**

Parameters P-0-0156 and P-0-0157 define the master drive gear.

- **P-0-0159, Slave drive feed travel**

With translatory scaling, the slave axis moves by the feed travel, per output revolution of the master drive gear, parameterized in P-0-0159.

- **P-0-0750, Master axis revolutions per master axis cycle**

Parameter P-0-0750 contains the number of master axis revolutions required in order to bring all drives, that are to follow the master axis, back to a defined position with respect to each other.

- **P-0-0752, Load revolutions per actual value cycle slave axis**

Parameter P-0-0752 defines the range in which the actual position value is displayed in absolute form. With modulo scaling, the actual position value is within a range of 360° * number of load revolutions per actual value cycle. The current actual position value within this range can be read from parameter **P-0-0753, Position actual value in actual value cycle**.

Diagnostic parameters

- **P-0-0034, Position command additional actual value**

P-0-0034 indicates the difference between actual position value and synchronous position command value.

- **P-0-0753, Position actual value in actual value cycle**
- **P-0-0754, Command value cycle**

The result of the multiplication of "master drive gear" and number of "master axis revolutions per master axis cycle" defines the command value cycle of the slave axis. This is the range for the calculated synchronous position command values. This calculation is done by the drive.

Command value preparation with phase synchronization with virtual master axis

In the operating mode "phase synchronization with virtual master axis" the position command value is generated by adding the synchronous position command value (X_{Synch}) and **S-0-0048, Position command value additional**.

$$S\text{-}0\text{-}0047 = X_{Synch} + S\text{-}0\text{-}0048$$

S-0-0047, Position command value
X_{Synch}: synchronous position command value
S-0-0048, Position command value additional

Fig. 7-22: Generating the position command value

The synchronous position command value (X_{synch}) is calculated in terms of the selected polarity for the master axis (**P-0-0108, Master drive polarity**) and the scaling type (**S-0-0076, Position data scaling type**) using the following formula:

$$X_{Synch} = \pm P\text{-}0\text{-}0053 * \frac{P\text{-}0\text{-}0157}{P\text{-}0\text{-}0156} * (1 + P - 0 - 0083) * 360°$$

X_{Synch}: synchronous position command value

Fig. 7-23: Generating the synchronous position command value with rotary scaling

$$X_{Synch} = \pm P\text{-}0\text{-}0053 * \frac{P\text{-}0\text{-}0157}{P\text{-}0\text{-}0156} * (1 + P\text{-}0\text{-}0083) * P\text{-}0\text{-}00159$$

X_{Synch}: synchronous position command value

Fig. 7-24: Generating the synchronous position command value with translatory scaling

Note: As a standard, the master axis position is fixed at 2^{20} increments/master axis revolution.

The following figure illustrates how the synchronous position command value is generated using the formulas above.

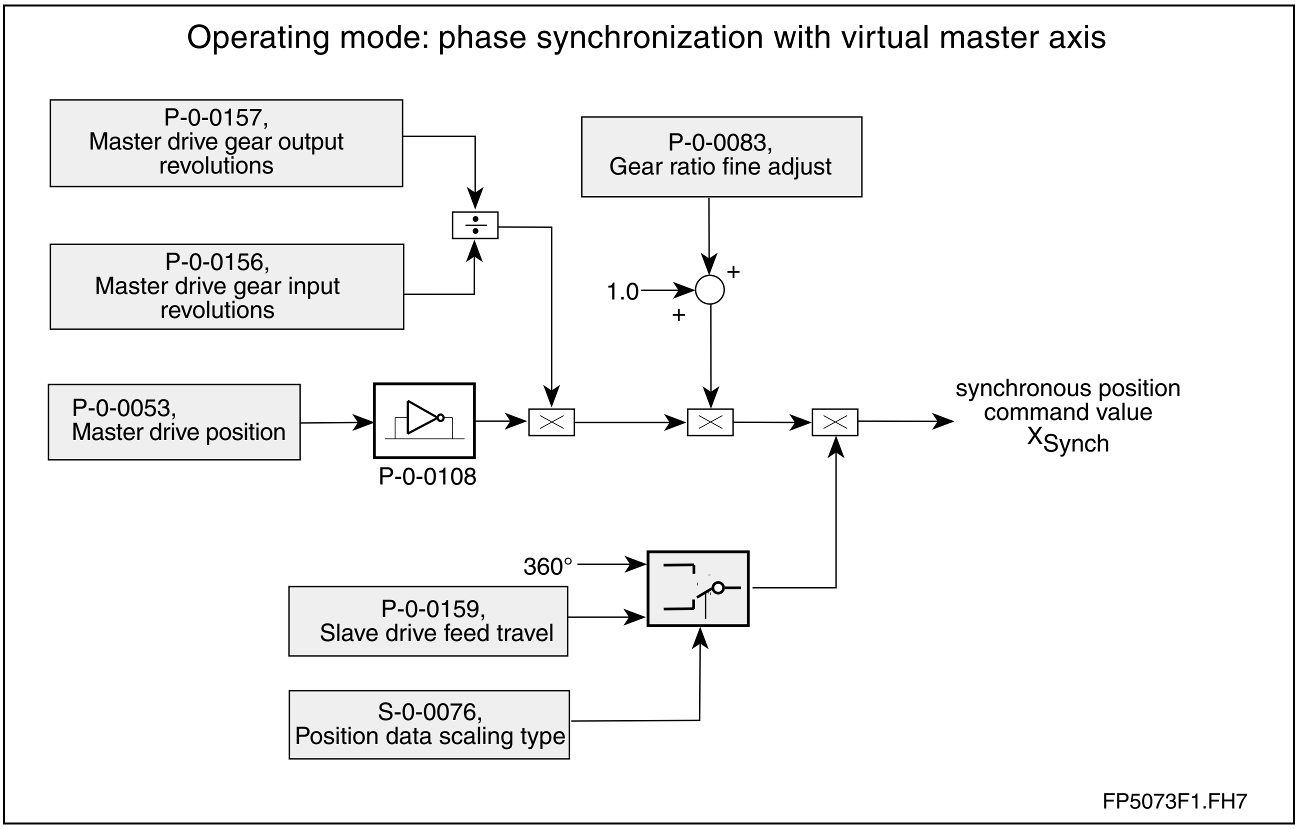


Fig. 7-25: Generation of synchronous position command value

see also "Position controller"

see also "Velocity controller"

see also "Current controller"

Dynamic synchronization in the phase synchronization operating mode

Associated parameters:

- **S-0-0048, Position command value additional**
- **P-0-0060, Filter time constant additional pos. command**
- **P-0-0142, Synchronization acceleration**
- **P-0-0143, Synchronization velocity**
- **P-0-0151, Synchronization init window for modulo format**
- **P-0-0154, Synchronization direction**
- **P-0-0155, Synchronization mode**
- **P-0-0751, Synchronization divisions per command cycle slave axis**

Dynamic synchronization is included in the "phase synchronization" operating mode. It consists of drive-controlled movement which aims at absolute synchronization.

For synchronization operating modes with outer position control loop, synchronization is carried out in two steps:

Step 1 of synchronization

Upon activating the operating mode, a velocity adjustment is first executed.

This means that the drive either accelerates or decelerates from the current feedback velocity at the time of activation to the synchronous velocity.

The drive generates the synchronous velocity by differentiating the synchronous position command values. These synchronous position command values X_{Synch} are generated in terms of the operating mode from **P-0-0053, Master drive position**.

Velocity adjustment already takes place in position control. When accelerating or braking, the drive takes **P-0-0142, Synchronization acceleration** into account.

After velocity adjustment is complete, there is a difference between the active position command value and the sum of the synchronous position command value X_{Synch} and **S-0-0048, Position command value additional**.

Step 2 of synchronization

In the second step of dynamic synchronization the drive moves a distance equal to this difference, taking **P-0-0142, Synchronization acceleration** and **P-0-0143, Synchronization velocity** into consideration. This position adjustment is added to the synchronous movement.

The difference is calculated according to the following equation:

$$\text{Path} = X_{Synch} + \text{S-0-0048} - \text{S-0-0047}$$

X_{synch}: synchronous position command value

Fig. 7-26: Travel path for absolute synchronization

In **P-0-0155, Synchronization mode** synchronization to a position in the modulo range, in the command value cycle or in the division of the command value cycle can be set. The path to be traveled is then limited to this range.

Synchronization in the command value cycle

The range for the command value cycle of the slave axis is defined by the master axis cycle and the master drive gear:

$$\text{Command value cycle} = \text{P}-0-0750 * \frac{\text{P}-0-0157}{\text{P}-0-0156} * 360°$$

Fig. 7-27: Command value cycle

The active value is displayed in parameter **P-0-0754, Command value cycle**.

The path traveled during synchronization is the result of the difference between synchronous position command value (+ **S-0-0048, Position command value additional**) and the actual position value. The synchronous position command value is calculated from the master axis position and the master drive gear. The actual position value in the command value cycle range is derived from the actual position value in the actual value cycle. Prerequisite for this is that the command value cycle is an integral multiple of the actual value cycle. For modulo division the number of command value cycles per actual value cycle is used. The number is calculated with the following formula:

$$\text{Number of command value cycles} = \frac{\text{P}-0-0752}{\text{P}-0-0750} * \frac{\text{P}-0-0156}{\text{P}-0-0157}$$

Fig. 7-28: Number of command value cycles per actual values cycle

Synchronization in a division of the command value cycle

The path traveled during synchronization is the result of the difference between synchronous position command value (+ **S-0-0048, Position command value additional**) in the **division** of the command value cycle and the actual position value in the **division** of the command value cycle. The synchronous position command value in the command value cycle is calculated from the master axis position and the master drive gear. By means of parameter **P-0-0751, Synchronization divisions per command cycle slave axis** a command value in the division is determined by modulo division. The actual position value in the division of the command value cycle is derived from **P-0-0753, Position actual value in actual value cycle**. For modulo division the number of divisions per actual value cycle is used. The number is calculated with the following formula:

$$\text{Number of divisions} = P-0-0751 * \frac{P-0-0752}{P-0-0750} * \frac{P-0-0156}{P-0-0157}$$

Fig. 7-29: Number of synchronization divisions per actual value cycle

Synchronization in the modulo range

The path traveled during synchronization is the result of the difference between synchronous position command value (+ **S-0-0048, Position command value additional**) in the **modulo range** and the actual position value in the **modulo range**. The synchronous position command value in the command value cycle is calculated from the master axis position and the master drive gear. By means of the product of the number of master axis revolutions per master axis cycle and the master drive gear a command value in the modulo range is determined by modulo division. The actual position value in the modulo range is derived from the actual position value in the actual value cycle. For this modulo division the number of load revolutions per actual value cycle is used.

Relative synchronization

Absolute synchronization can be switched off. Relative synchronization is carried out instead during which only the adjustment to the synchronous velocity is realized. The bit assignment of parameter P-0-0155 is as follows:

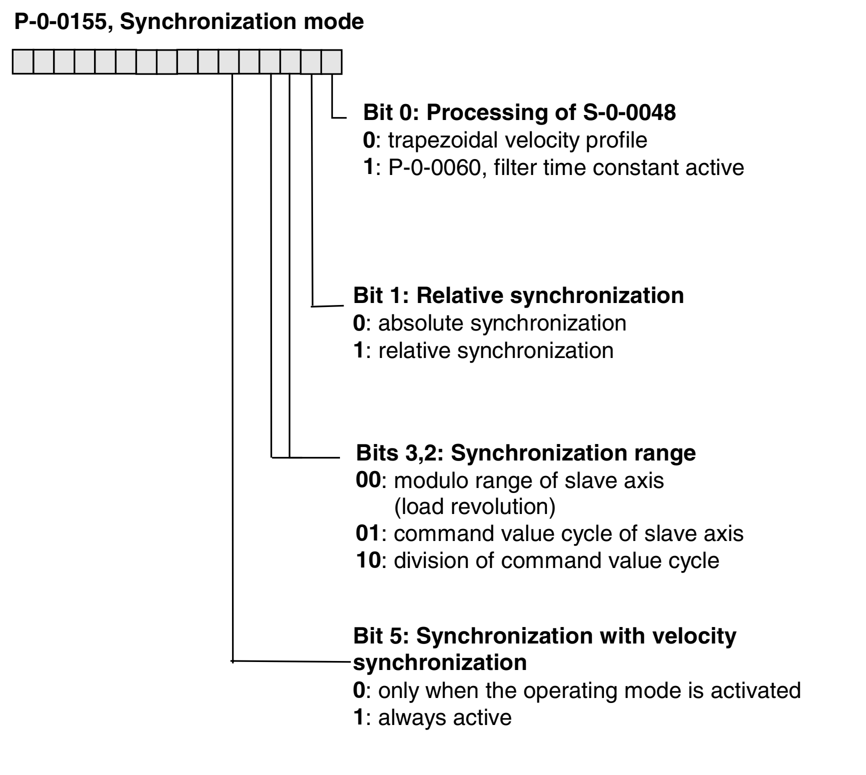


Fig. 7-30: P-0-0155, Synchronization mode

With modulo axes, the path first is limited to +/- **S-0-0103, Modulo value**. Then, parameters **P-0-0154, Synchronization direction** and **P-0-0151, Synchronization init window for modulo format** are taken into consideration.

Note: The synchronization direction parameter will only work, if the shortest path (value ≤ 0.5 * modulo value) is larger than the synchronization window. Then, the synchronization direction will be set with the parameter (positive or negative or shortest path). If the shortest path is smaller than the synchronization window, then the shortest path will always be traveled.

The drive will be in absolute synchronization after the conclusion of the second synchronization phase. The drive sets bit 9 in parameter **S-0-0182, Manufacturer class 3 diagnostics** ("Synchronization concluded").

The following applies:

$$S\text{-}0\text{-}0047 = X_{Synch} + S\text{-}0\text{-}0048$$

S-0-0047, Position command value
X_{Synch}: Synchronous position command value
S-0-0048, Position command value additional

Fig. 7-31: Generation of the position command value

Every time the additive position command value (S-0-0048) is changed, a new path will be determined and traveled according to the above equation.

The following figure shows the components of **S-0-0047, Position command value**.

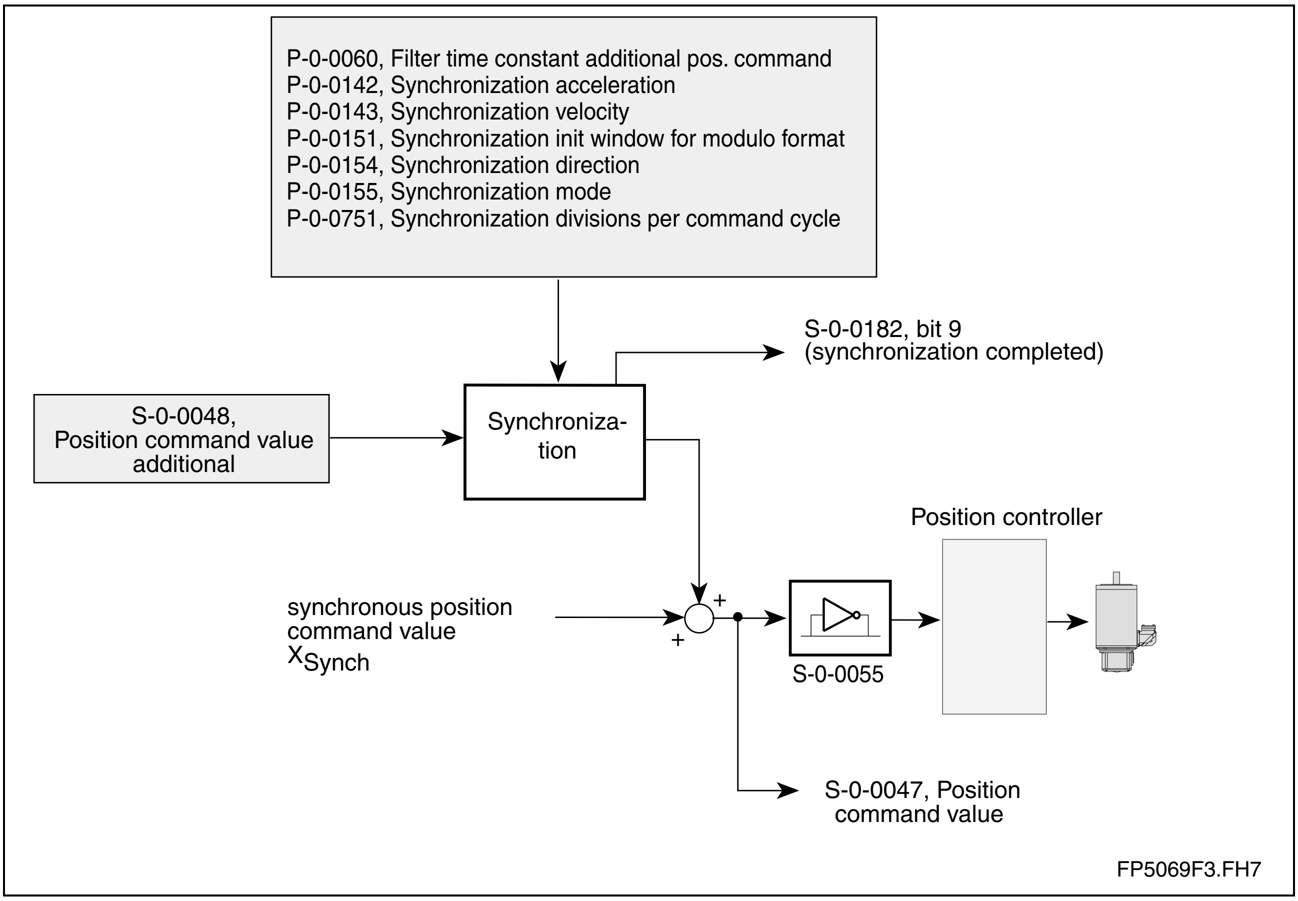


Fig. 7-32: Generation of the position command value

P-0-0155, Synchronization mode

The **P-0-0155, Synchronization mode** parameter can be used to switch off the dynamic synchronization after first reaching absolute synchronization.

To do this, bit is set to 1. In this synchronization mode the following parameters will be inoperative after absolute synchronization is reached:

P-0-0142, Synchronization acceleration

P-0-0143, Synchronization velocity

P-0-0151, Synchronization init window for modulo format

P-0-0154, Synchronization direction

The following changes to the additional position command value will be smoothed with a filter of the first order. The time constant for the filter will be set with the parameter **P-0-0060, Filter time constant additional pos. command**. The status bit "Synchronization completed" is set when reaching absolute synchronization and won't be cleared even with further changes in **S-0-0048, Position command value additional**.

If the dynamic synchronization remains active (**P-0-0155, Synchronization mode** bit 0 = 0), then the bit will be set only if the above equation is satisfied.

The following figures show the time flow of the velocity for the standard and register controller synchronization modes.

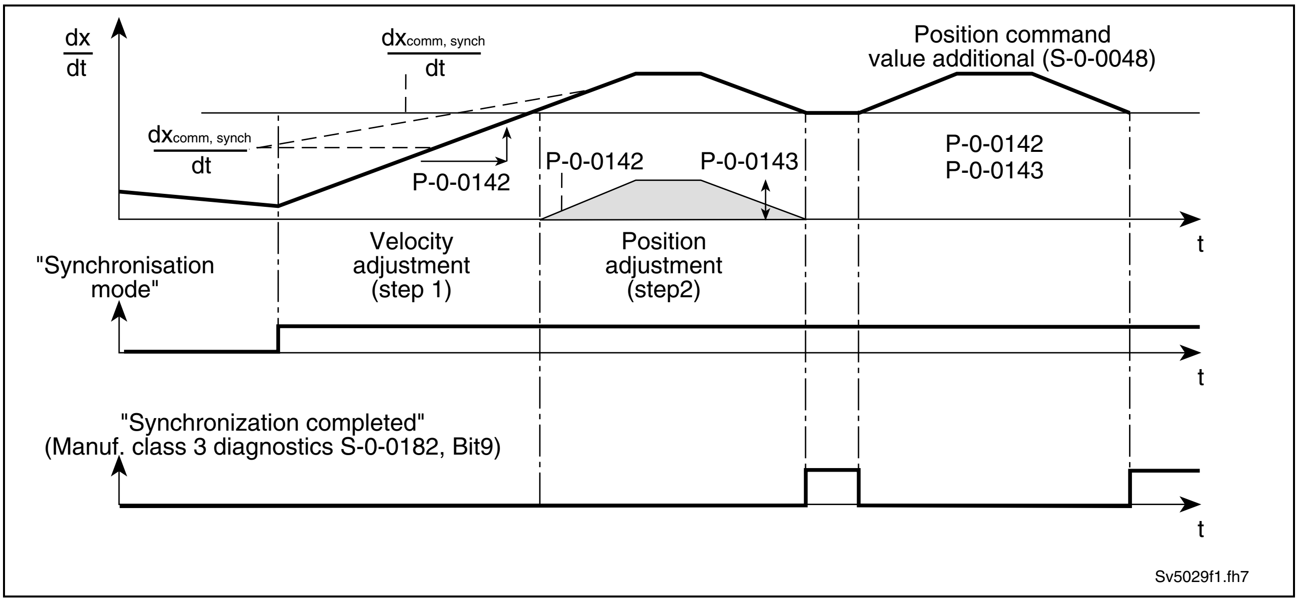


Fig. 7-33: Standard synchronization mode (P-0-0155, bit 0 = 0)

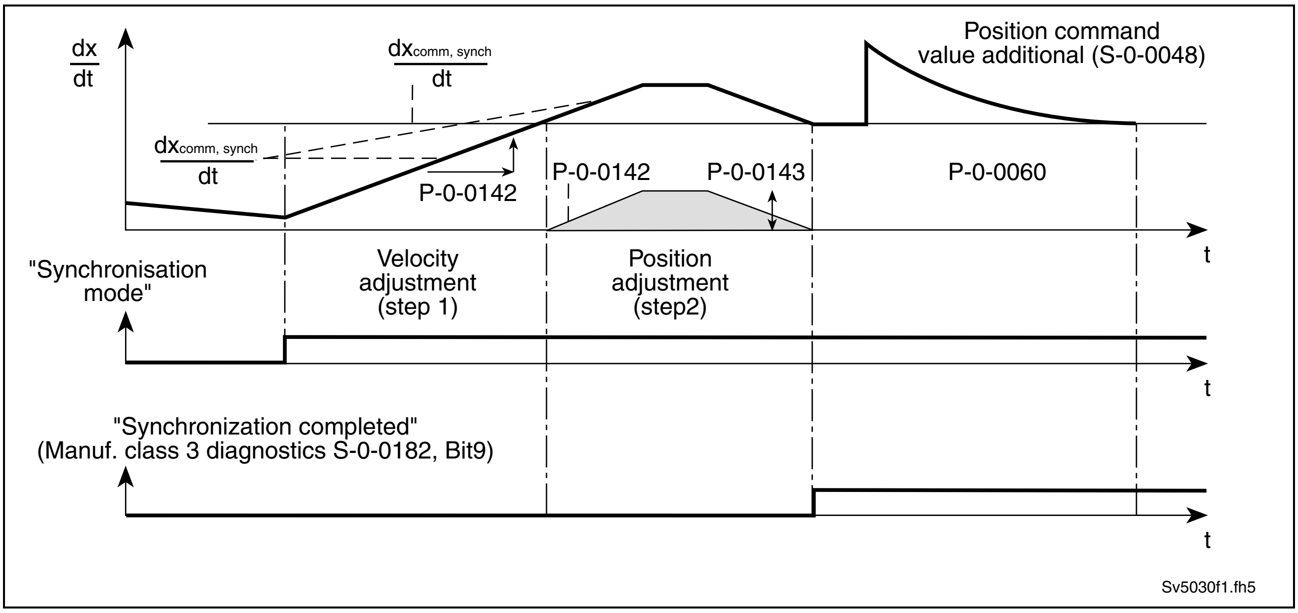


Fig. 7-34: Register controller synchronization mode (P-0-0155, bit 0 = 1)

Relative synchronization (P-0-0155, Synchronization mode, bit 1=1):

After the operating mode is activated, only step 1 of the synchronization procedure is conducted. This realizes a relative position-synchronous slave axis. To do this, parameter **S-0-0048, Position command value additional** is initialized by the drive in such a way that there is no second step to the synchronization process. A phase offset is nonetheless possible by changing parameter **S-0-0048, Position command value additional**. The change is processed in differential form.

Synchronization status message for the phase synchronization operating mode

Associated parameters:

- **S-0-0048, Position command value additional**
- **S-0-0051, Position feedback 1 value**
- **S-0-0053, Position feedback 2 value**

- **S-0-0182, Manufacturer class 3 diagnostics**
- **S-0-0228, Position synchronization window**

The drive sets bit 8 in the Manufacturer Class 3 diagnostics if:

$$\left| X_{Synch} + S-0-0048 \quad - \quad (S-0-0051 \text{ or } S-0-0053) \right| < S-0-0228$$

The bit will be generated only if a synchronization operating mode has been parameterized in the **S-0-0032, Primary mode of operation**.

During the first phase of dynamic synchronization (velocity adjustment), the bit will be set to 0 to avoid being set too early for modulo axes.

7.10 Operating mode: electronic cam shaft with virtual master axis

In the operating mode "Electronic cam shaft with virtual master axis" there is a fixed relationship between the master axis position and the slave axis. The (virtual) master axis position is set by the control.

The structure of the operating mode "Electronic cam shaft with virtual master axis" is illustrated below:

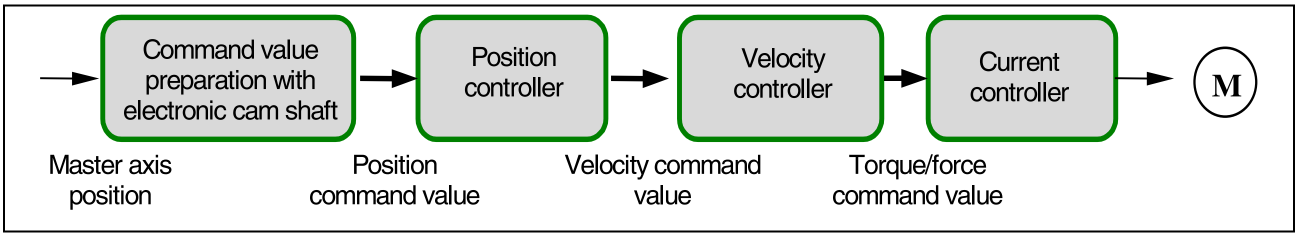


Fig 7-35: Electronic cam shaft block diagram

see also "Position controller"

see also "Velocity controller"

see also "Current controller"

Pertinent parameters

- **S-0-0048, Position command value additional**

S-0-0048 is used to establish a position offset between master axis an slave axis.

- **P-0-0053, Master drive position**

The value in P-0-0053 is preset cyclically and in equidistant intervals by the control (virtual master axis). Format: 2^20 increments/master axis revolution.

- **P-0-0061, Angle offset begin of profile**

With the value in P-0-0061 the access angle for the cam shaft profile is offset with regard to the master axis position. 360° correspond to the total length of the cam shaft profile.

- **P-0-0072, Cam shaft profile 1**

Contains a table with 1024 elements with tab(φ) data points for the cam shaft profile. The first element in the table is the data point for φ = 0. The last element of the table is the data point for φ = 2^20.

- **P-0-0083, Gear ratio fine adjust**

The gear ratio of the master drive gear is modified by the percentage parameterized in P-0-0083. For a master drive gear free of drift the value must equal zero.

- **P-0-0085, Dynamic angle offset**

With the value in P-0-0085 the effective master axis position is shifted according to the following equation:

$$\varphi_{\text{master axis, effective}} = \varphi_{\text{master axis}} + \frac{\text{master axis velocity}}{\text{position controller KV}} * \text{dyn. angle offset}$$

Fig. 7-36: Dynamic angle offset

- **P-0-0088, Control word for synchronous operating modes**
- **P-0-0089, Status word for synchronous operating modes**
- **P-0-0092, Cam shaft profile 2**
- **P-0-0093, Cam shaft distance**

This parameter defines the distance with which the profile of the cam shaft is multiplied.

- **P-0-0094, Cam shaft switch angle**

If the effective master axis position exceeds the angle entered in P-0-0094 in positive or negative direction, switchover is carried out to the cam shaft profile that has been selected by bit 0 of parameter **P-0-0088, Control word for synchronous operating modes**.

- **P-0-0108, Master drive polarity**

P-0-0108 is used to invert the master axis position.

- **P-0-0144, Cam shaft distance switch angle**

A new value for **P-0-0093, Cam shaft distance** will only become active, when the current profile access angle passes the switch angle **P-0-0144, Cam shaft distance switch angle**. In the case of immediate distance switching, the parameter is irrelevant.

- **P-0-0155, Synchronization mode**
- **P-0-0156, Master drive gear input revolutions**
- **P-0-0157, Master drive gear output revolutions**

Parameters P-0-0157 and P-0-0157 define the master drive gear.

- **P-0-0158, Angle offset change rate**
- **P-0-0159, Slave drive feed travel**
- **P-0-0750, Master axis revolutions per master axis cycle**

Parameter P-0-0750 contains the number of master axis revolutions required in order to bring all drives, that are to follow the master axis, back to a defined position with respect to each other. This parameter informs the drive of the range in which the master axis position (P-0-0053) is situated.

- **P-0-0752, Load revolutions per actual value cycle slave axis**

For modulo axes, parameter P-0-0752 defines the range in which the actual position value is displayed in absolute form. With modulo scaling, the actual position value is within a range of 360° * number of load revolutions per actual value cycle. The current value can be read from parameter **P-0-0753, Position actual value in actual value cycle**.

- **P-0-0755, Gear reduction**

P-0-0755 is used to parameterize a motion synchronous to the master axis that is superimposed to the motion determined by cam shaft profile and distance. These command values are not active, when the gear reduction is 0.

Diagnostic parameters

- **P-0-0034, Position command additional actual value**

P-0-0034 indicates the difference between position feedback value and synchronous position command value.

- **P-0-0753, Position actual value in actual value cycle**

Command value preparation for electronic cam shaft

Upon activation of the operating mode "Electronic cam shaft with virtual master axis", the position command value of the drive is initialized in terms of the following relation:

$$X_{F(\varphi L)} = h * tab(\pm\varphi_L * \frac{G_a}{G_e} * (1+F) - \varphi_V) + (\varphi_L * \frac{G_a}{G_e} * (1+F) - \varphi_V)/U + X_v$$

X_F : Position command value of slave drive (S-0-0047)
+/- : P-0-0108, Master drive polarity (P-0-0108=1 > -)
φ_L : Master drive position (P-0-0053)
φ_V : Angle offset begin of profile (P-0-0061)
h : Cam shaft distance (P-0-0093)
tab(φ) : Cam shaft profiles (P-0-0072 or P-0-0092)
X_v : Position command value additional (S-0-0048)
G_a : Master drive gear output revolutions (P-0-0157)
G_e : Master drive gear input revolutions (P-0-0156)
F : Fine adjust (P-0-0083)
U : Gear reduction (P-0-0755)

Fig. 7-37: Initializing the position command value

With the operating mode activated, differences, that later on will be added again, are processed in the master drive gear and the cam shaft profiles. Therefore changes in the master drive gear and the cam shaft distance do not cause position command value jumps. Velocity jumps, however, can occur and the absolute position reference, that is established when activating the operating mode, is lost.

In every control cycle, a profile value is taken from the cam shaft profiles, the difference to the last profile value is generated, multiplication with the cam shaft distance is carried out and the result is added to the position command value. If **P-0-0755, Gear reduction** is unequal 0, the master axis position at the output of the master drive gear is additionally divided by the gear reduction, multiplied with the factor $360°/2^{20}$, the product is differentiated and the result is added to the position command value.

If profile limits are exceeded in positive direction, then the profile continues with its first value, the same happens if the limits are exceeded in negative direction.

The position command value generated as per the following relation:

$$X_{F(n)(\varphi L)} = X_{F(n-1)(\varphi L)} + \left(h * \Delta tab\left(\pm\varphi_L * \frac{G_a}{G_e} * (1+F) - \varphi_V + \varphi_d\right) + \left(\Delta\varphi_L * \frac{G_a}{G_e} * (1+F) - \Delta\varphi_V\right)/U + X_v\right)$$

X_F :	Position command value of slave drive (S-0-0047)
+/- :	P-0-0108, Master drive polarity (P-0-0108=1 > -)
φ_L :	Master drive position (P-0-0053)
φ_V :	Angle offset begin of profile (P-0-0061)
φ_d :	Dynamic Angle offset (P-0-0085)
h :	Cam shaft distance (P-0-0093)
tab(φ) :	Cam shaft profiles (P-0-0072 or P-0-0092)
X_v :	Position command value additional (S-0-0048)
G_a :	Master drive gear output revolutions (P-0-0157)
G_e :	Master drive gear input revolutions (P-0-0156)
F :	Fine adjust (P-0-0083)
U :	Gear reduction (P-0-0755)

Fig. 7-38: Generating the position command value for the slave drive

The generation of the synchronous position command value is illustrated in the following figure:

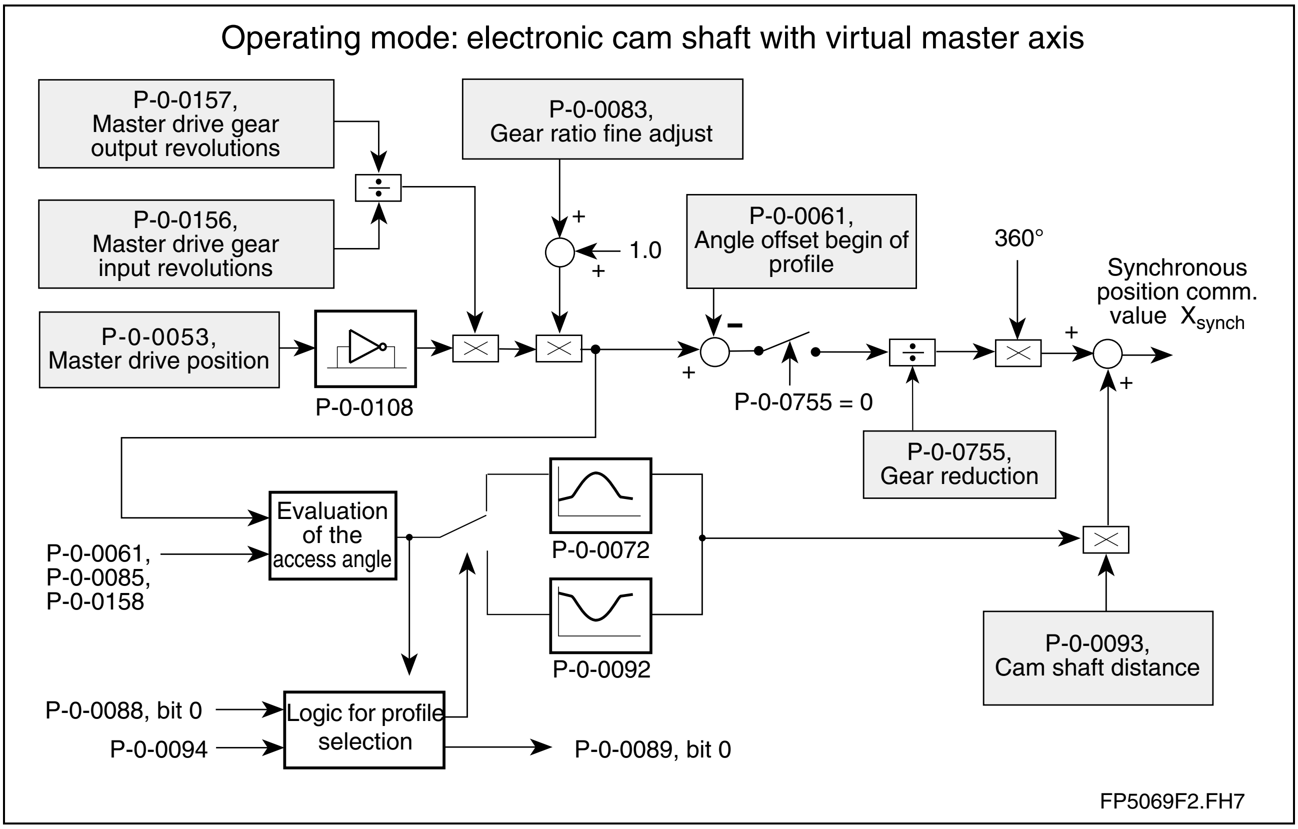


Fig. 7-39: Generating the synchronous position command value

Changes of P-0-0061, Angle offset begin of profile

To avoid jumps of the profile access angle, a new value for parameter **P-0-0061, Angle offset begin of profile** does not immediately become effective. Starting with the current value, a ramp-like approximation of the new value is conducted. The approximation is conducted along the shortest possible path. The gradient of the ramp is set in parameter **P-0-0158, Angle offset change rate**.

P-0-0085, Dynamic angle offset

Parameter **P-0-0085, Dynamic angle offset** is used to compensate a lag error if the position controller has not been set to lagless control. The profile access angle is offset in velocity-dependent form.

$$\varphi d = \frac{P\text{-}0\text{-}0085 * (\varphi L(n) - \varphi L(n-1)) * \frac{Ga}{Ge})}{Kv}$$

φ_L :	Master drive position (P-0-0053)
P-0-0085 :	Dynamic angle offset
G_a :	P-0-0157, Master drive gear output revolutions
G_e :	P-0-0156, Master drive gear input revolutions
K_v :	S-0-0104, Position loop Kv-factor

Fig. 7-40: Generating the dynamic angle offset

Modulo axes

With infinitely turning axes, modulo scaling must be set in **S-0-0076, Position data scaling type**.

Note: For constantly fault-free processing of the position data with infinitely turning axes, the values resulting from gear reduction (P-0-0755≠0) must be considered for forward motion. A finite cam shaft profile can be superimposed. When using an infinite cam shaft profile (difference between first and last profile value > 50%), a small error can occur with each profile sequence. With infinite motion in one direction this error multiplies and an unexpected drift can occur.

Selecting the active cam shaft profile 1

The active cam shaft profile (P-0-0072 or P-0-0092) is selected with parameters **P-0-0088, Control word for synchronous operating modes** and **P-0-0094, Cam shaft switch angle**. The active cam shaft is included in **P-0-0089, Status word for synchronous operating modes**. Switching is started by changing the control word. It is conducted and acknowledged by the drive in the status word, when the profile access angle passes **P-0-0094, Cam shaft switch angle**.

Changing the cam shaft distance

Parameter **P-0-0144, Cam shaft distance switch angle** defines at which profile access angle and thus profile element a change in value becomes effective for the cam shaft distance. If the profile values in the switch range are 0, an absolute position reference is maintained in the case of a change.

Activating the distance

With bit 3 of parameter **P-0-0088, Control word for synchronous operating modes** you can select whether a new value for **P-0-0093, Cam shaft distance** becomes effective immediately or only when the profile access angle passes **P-0-0144, Cam shaft distance switch angle**.

Cross cutter

By means of the command values of **P-0-0755, Gear reduction** a cross cutter axis can be operated. A cross cutter (rotating knife) is required to cut a defined piece (format) off some material that is transported with constant velocity. The format is set by the master drive gear. With a master drive gear 1:1 the format corresponds to the circumference of the cutting cylinder (with a number of knives = 1). Smaller formats are realized by a master drive gear [(output/input)>1]. The slave axis (cutting cylinder) then turns faster than the master axis. In this case, the cutting cylinder, in the cutting range (at 180 degrees of profile access angle), has to be decelerated to the transport velocity of the material. After the cutting range the cylinder is accelerated again. This is achieved by superimposing a more or less sinusoidal cam shaft to the constant velocity of the axis that is caused by the linear proportion. With constant cam shaft profile it is then possible to define, by means of the distance, whether the axis decelerates (distance>0) or accelerates (distance<0) in the cutting range.

The number of knives that are distributed at the circumference of the cutting cylinder is entered in parameter **P-0-0755, Gear reduction**. The cutting cylinder will then turn accordingly slower. Per cam shaft profile sequence, the cutting cylinder will move by the distance of two knives at the circumference.

To change the format "on the fly" it is necessary to simultaneously change master drive gear and distance in the cutting range. This function is switched on by setting bit 4 in **P-0-0088, Control word for synchronous operating modes**. A change in the master drive gear will only become effective, when the distance is changed and the new distance value is accepted when **P-0-0144, Cam shaft distance switch angle** is being passed.

Dynamic synchronization in the cam shaft operating mode

Basically, dynamic synchronization is identical with synchronization in the "phase synchronization" operating mode (see also "Dynamic synchronization in the phase synchronization operating mode"). There are the following differences:

In the "cam shaft" operating mode, the number of selectable synchronization ranges depends on the type of position scaling. Modulo axes can synchronize to a position in the command value cycle of the slave axis, in a division of this command value cycle or in the modulo range. The drive controller determines the command value cycle according to the following formula:

$$\text{Command value cycle} = P-0-0750 * \frac{P-0-0157}{P-0-0156 * P\text{-}0\text{-}0755} * 360°$$

Fig.: 7-41: Command value cycle

The active value is displayed in parameter **P-0-0754, Command value cycle**.

With absolute position scaling, absolute synchronization is carried out. Please observe that for initialization of the synchronous position command value, only the master axis position within one master axis revolution (considering master drive gear and fine adjustment) will be taken into account. The synchronous position command value is obtained by multiplying the profile value of this master axis position with the distance.

8 Basic drive functions

8.1 Physical values display format

The data exchange between the controller and the primary control system or user interface occurs by reading and writing controller parameters. Information about the unit and the number of decimal places (see also chapter "Parameter") is necessary for interpreting the operating data of a parameter. The value of the operating data results from these data. The following illustration shows this with an example.

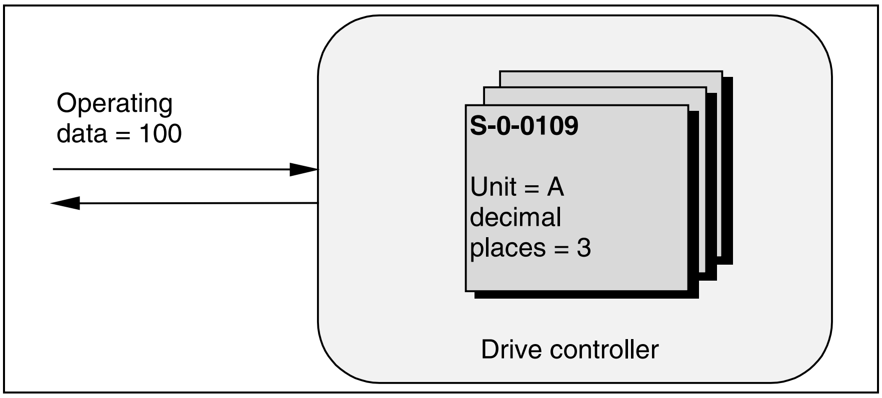


Fig. 8-1: Example for interpreting operating data in the drive

In the above picture, the value 100 is written to the operating data of parameter S-0-0109. When combined, the unit A (Ampere) that belongs to this parameter and the number of decimal places (3) produce the physical value 0.100 A.

Each parameter therefore has a unit and the number of decimal places. The combination of these two criteria is called scaling. When interpreting operating data, these must always be included in the analysis.

Adjustable scaling for position, velocity and acceleration data

The parameter scaling for

- position data,
- velocity data and
- acceleration data

can be adjusted. It can be set by the user with scaling parameters.

It enables

- the value of this data to be made compatible for exchange between control system and drive, in other words, the data can be exchanged in the control system's internal format. The control system will not need to convert this data.
- this data to conform to machine kinematics. Linear movements can be written with linear units, for example, and rotary movements can be written with rotary units.

It is possible to select between linear and rotary scaling, and preferred and parameter scaling, as well as between motor and load reference.

Linear - rotary scaling

Adjustable scaling allows either linear or rotary scaling to be selected. Linear motors normally use linear scaling. Rotary motors use either rotary or linear scaling, if their rotary movement is converted into linear movement (with a ballscrew, for example).

Preferred scaling - parameter scaling

Adjustable scaling allows either preferred scaling or parameter scaling to be selected. If preferred scaling is selected, the appropriate scaling factor parameters and scaling exponent parameters in **S-0-0128, C200 Communication phase 4 transition check** are overwritten with preferred values. This sets a pre-defined scaling. The scaling factor parameters and the scaling exponent parameters are not entered. The preferred scaling depends on whether linear or rotary scaling has been selected.

The following preferred scaling is available:

Physical value	Rotary preferred scaling	Linear preferred scaling (mm)	Linear preferred scaling (Inch)
Position data	0.0001 Degrees	0.0001 mm	0.001 Inches
Velocity data	0.0001 RPM, or 10^-6 Rev/s	10^-6 m/min	10^-5 in/min
Acceleration data	0.001 rad/s²	10^-6 m/s²	--

Fig. 8-2: Preferred scaling

Motor reference - load reference

Either motor reference or load reference can be selected when adjusting the scaling.

Load reference

With rotary load reference, the scaled data are converted from the motor reference format to the gear output format with the gear ratio **S-0-0122, Output revolutions of load gear / S-0-0121, Input revolutions of load gear**.

With linear load reference, the scaled data are converted from the motor reference format to feed format with the gear ratio **S-0-0122, Output revolutions of load gear** / **S-0-0121, Input revolutions of load gear** and the feed constant **S-0-0123, Feed constant**.

The following restrictions apply in relationship to the motor type being used:

- Rotary motor reference cannot be set with linear motors.
- Linear motor reference cannot be set with rotary motors.

Display format of position data

The scaling of drive controller position data is adjustable. This is done with the parameters

- **S-0-0076, Position Data Scaling Type**
- **S-0-0077, Linear Position Data Scaling Factor**
- **S-0-0078, Linear Position Data Scaling Exponent**
- **S-0-0079, Rotational position resolution**

This differentiates between linear and rotary scaling. **S-0-0079, Rotational position resolution** sets the rotary position scaling. **S-0-0077, Linear Position Data Scaling Factor** and **S-0-0078, Linear Position Data Scaling Exponent** set the linear position scaling.

The scaling type is set in **S-0-0076, Position Data Scaling Type**.

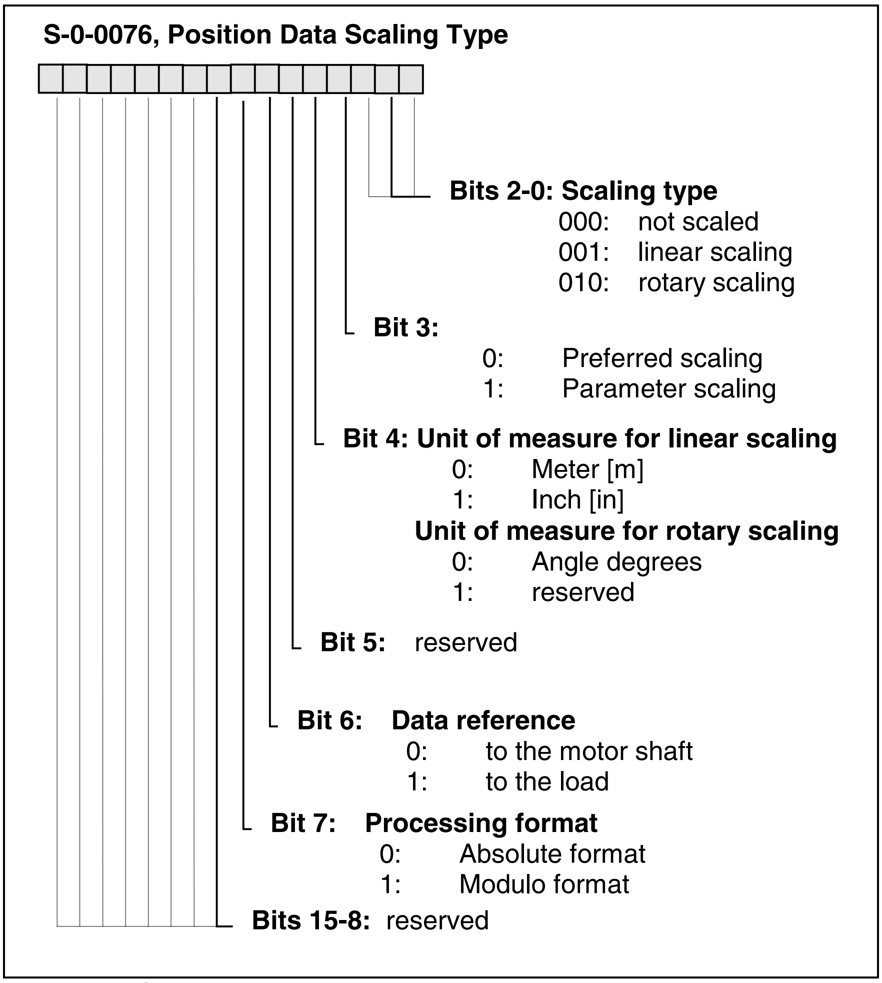


Fig. 8-3: S-0-0076, Position data scaling type

The scaling type setting is checked for plausibility in **S-0-0128, C200 Communication phase 4 transition check**, and the command error message **C213 Position Data Scaling Error** is generated, if necessary.

Velocity data display format

The scaling of the drive controller's velocity data is adjustable.

This is done with the parameters

- **S-0-0044, Velocity data scaling type**
- **S-0-0045, Velocity data scaling factor**
- **S-0-0046, Velocity data scaling exponent**

The scaling type is set in **S-0-0044, Velocity data scaling type**.

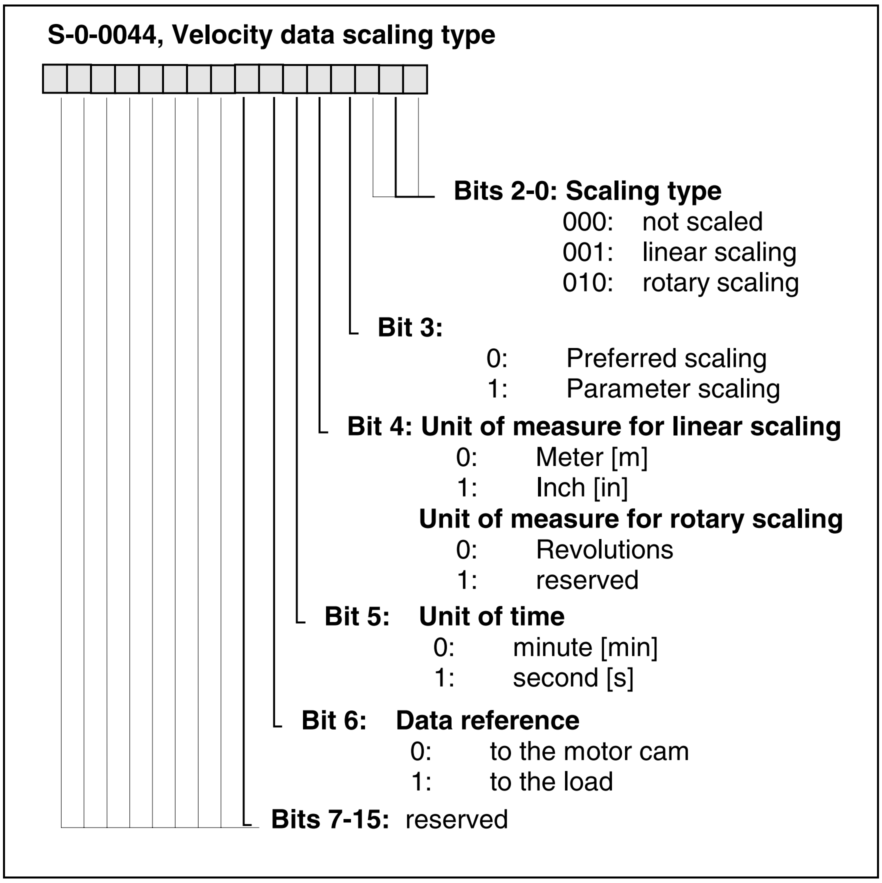


Fig. 8-4: S-0-0044, Velocity data scaling type

The scaling type setting is checked for plausibility in **S-0-0128, C200 Communication phase 4 transition check,** and the command error message **C214 Velocity Data Scaling Error** is generated, if necessary.

Acceleration data display format

The scaling of the drive controller's acceleration data is adjustable.

This is done with the parameters

- **S-0-0160, Acceleration data scaling type**
- **S-0-0161, Acceleration data scaling factor**
- **S-0-0162, Acceleration data scaling exponent**

The scaling type is set in **S-0-0160, Acceleration data scaling type**.

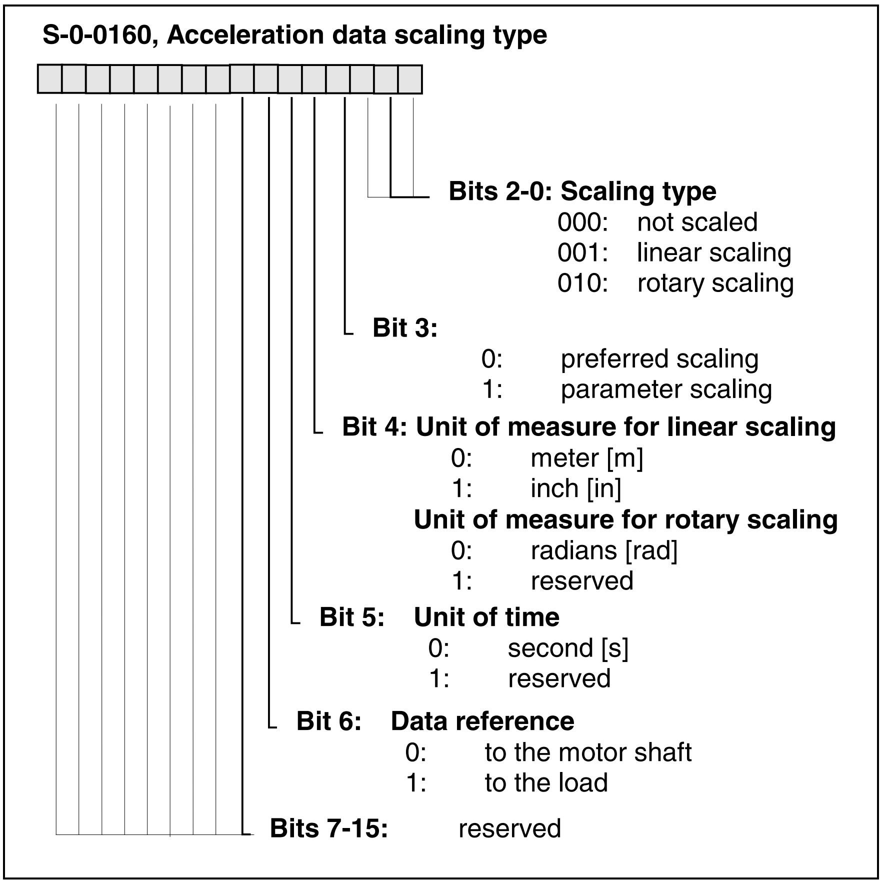


Fig. 8-5: S-0-0160, Acceleration data scaling type

The scaling type setting is checked for plausibility in **S-0-0128, C200 Communication phase 4 transition check,** and the command error message **C215 Acceleration Data Scaling Error** is generated, if necessary.

Command value polarities and actual value polarities

The drive-internal polarities of position, velocity, torque/force and actual values are fixed.

The following applies:

Motor type	Definition of "drive-internal positive direction"
Rotary motors	Clockwise rotation facing the motor shaft
Linear motors	In the direction of the connection of the power cable on the front side of the primary part

Fig. 8-6: Definition of "drive internal positive direction"

The positive direction is specified by the manufacturer for MHD, MKD and MKE motors. For asynchronous motors, linear synchronous motors and MBS motors the positive direction has to be set during commissioning (see chapter: "Other motor encoder characteristics"). The command value polarity and actual value polarity of the drive is thereby fixed.

If the definition of the positive direction of the motor does not conform to the requirements of the machine, the parameters

- **S-0-0055, Position Polarity Parameter**
- **S-0-0043, Velocity polarity parameter**
- **S-0-0085, Torque/Force polarity parameter**

can invert the command value and actual value polarities.

Note: If the polarity needs to be changed, all 3 polarity parameters should always be inverted at the same time, so that the polarities of the position, velocity and torque/force have the same sign.

The following illustration shows the operating characteristics of the polarity parameters.

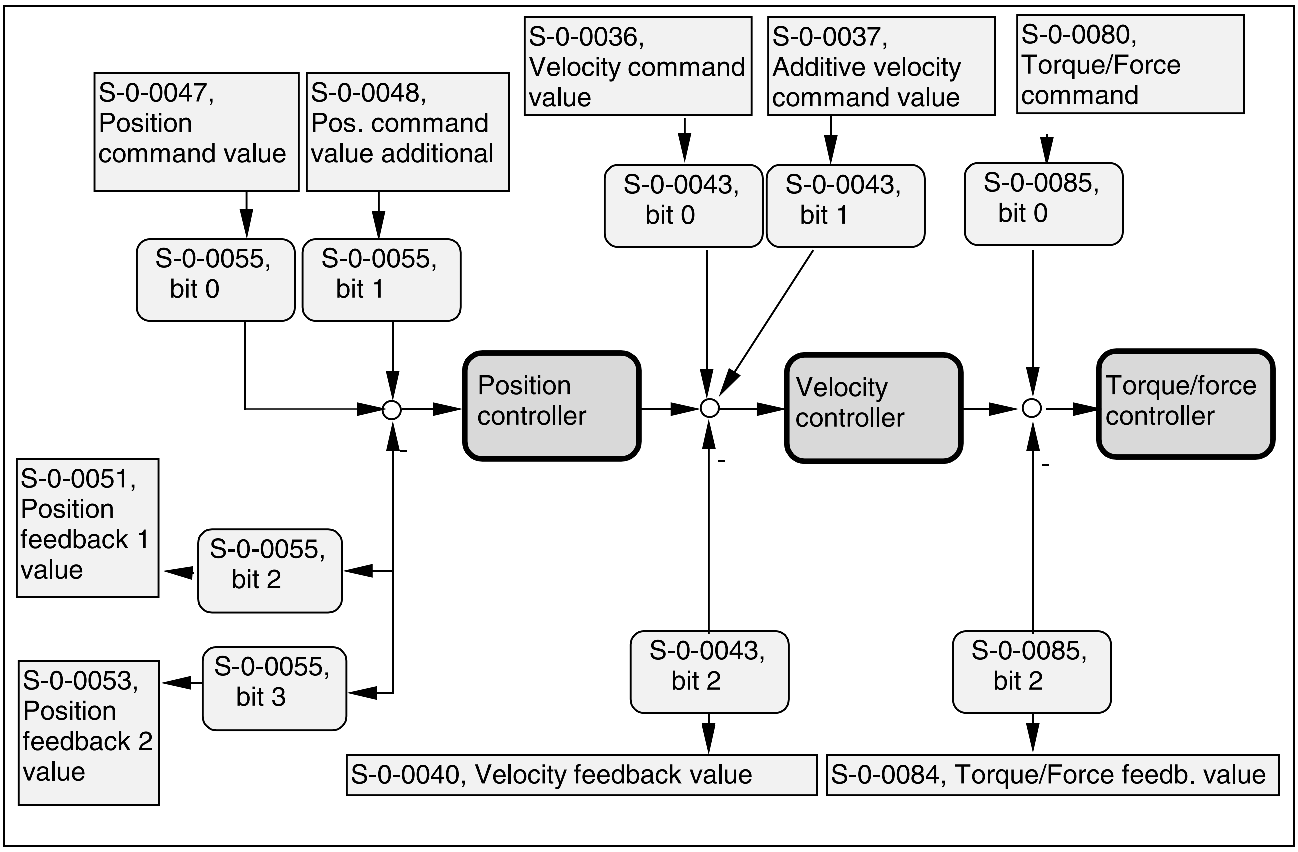


Fig. 8-7: Polarity parameter operating characteristics

The polarity parameters affect only the display values, not the control feedback values.

The drive software only allows all bits within a polarity parameter to be inverted. If bit 0 is inverted, all other bits of the respective parameter are also inverted. This protects against the danger of adding positive feedback into the control loops (command and feedback values with opposing polarities) due to incorrectly set command and feedback value polarities.

Mechanical transmission elements

Mechanical transmission elements are gear and feed mechanisms between the motor shaft and the load. Entering this data is necessary for the load-side conversion of the physical values position, velocity and acceleration, if these are scaled for the load (see also chapter: "Adjustable scaling for position, velocity, and acceleration data"). To see if these parameters have been input correctly, move the shaft and compare the traveled path with the position feedback value and the path actually taken.

Gear ratio

The gear ratio can be set with the parameters

- **S-0-0121, Input revolutions of load gear**
- **S-0-0122, Output revolutions of load gear**

The ratio between gear input and gear output is parameterized in these two parameters.

Example:

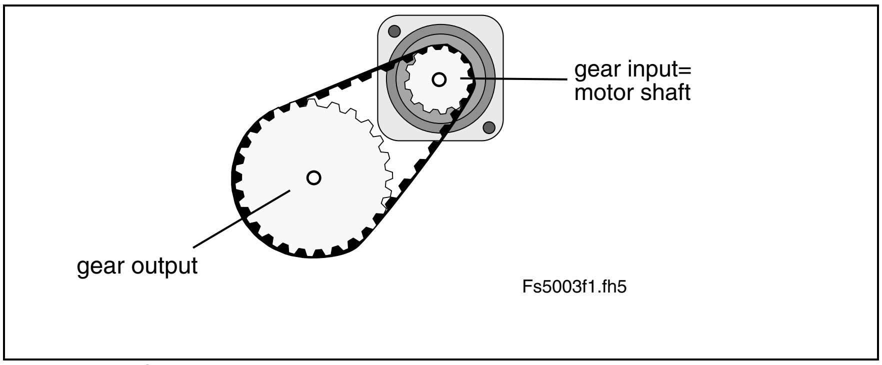


Fig. 8-8: Gear ratio parameterization

Supposing in the illustration above, two gear input revolutions (= motor revolutions) were equivalent to one gear output revolution, the proper parameterization would be:

S-0-0121, Input revolutions of load gear = 2

S-0-0122, Output revolutions of load gear = 1

Feed constant

The feed constant defines how far the load moves linearly per gear output revolution. The feed constant is specified in the parameter **S-0-0123, Feed constant**. The value programmed in this parameter is used along with the gear ratio for converting the position, velocity and acceleration data from motor reference to load reference.

Example:

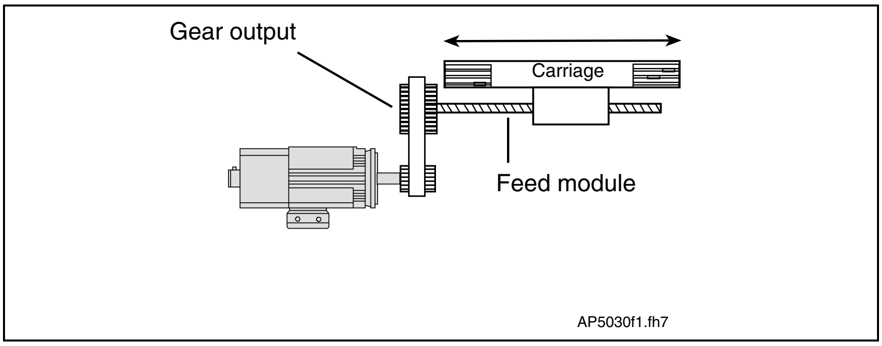


Fig. 8-9: Feed constant parameterization

In the illustration above, the feed module would cover 10 mm per gear output revolution. The proper parameterization for this would be:

S-0-0123, Feed Constant = 10 mm/Rev

Modulo feature

If the modulo feature is activated, all position data in the range of 0 to the modulo value are displayed. It is therefore possible to realize an axis that moves endlessly in one direction. There is no overflow of position data.

The modulo value is set via the parameter **S-0-0103, Modulo Value**.

The modulo feature is activated in the parameter **S-0-0076, Position Data Scaling Type.**

(see also chapter: "Display format of position data")

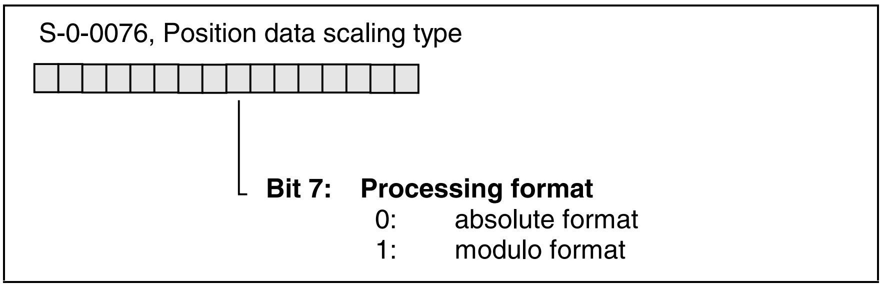


Fig. 8-10: Setting absolute format – modulo format

Note: Processing position data in modulo format is only allowed with rotary motor types. This is checked in **S-0-0128, C200 Communication phase 4 transition check** and acknowledged by command error **C213 Position data scaling error**, if necessary.

The difference, in the display of position data, between absolute format and modulo format is shown in the following figure:

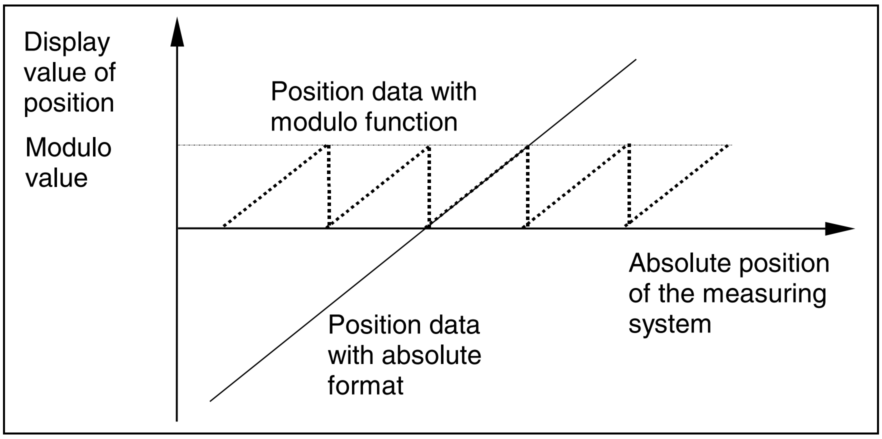


Fig. 8-11: Display value of positions with absolute format and with modulo format

Modulo processing-limiting conditions

If modulo processing of position data is selected, depending on

- the active operating mode and
- the selected position scaling

the following limiting conditions for error-free processing of the position data must be observed:

- The modulo range (**S-0-0103, Modulo Value**) may not be greater than the maximum travel range.
- If rotary or linear position scaling with load reference and no phase synchronization is used as operating mode, then the product of **S-0-0103, Modulo Value**, **S-0-0116, Resolution of motor feedback** and **S-0-0121, Input revolutions of load gear** must be smaller than 2^63.
- If rotary position scaling with load reference is used as operating mode, the modulo value cannot be set. The setting of S-0-0103 is always fixed to one load revolution = 360°. If the operating mode "phase synchronization" is used, linear position scaling mustn't be set.

If, in addition to this, an external measurement system is used, the additional requirements are:

- If rotary position scaling with motor reference and not the operating mode "phase synchronization" is used, then the product of **S-0-0103, Modulo Value**, **S-0-0117**, **Feedback 2 Resolution** and **S-0-0122, Output revolutions of load gear** must be smaller than 2^63.

Compliance with the limiting conditions is checked in **S-0-0128, C200 Communication phase 4 transition check**, and the command is terminated with the error **C227 Modulo Range Error**, if necessary.

Processing command values in modulo format, shortest path - direction selection

The interpretation of position command values, such as **S-0-0047, Position Command Value** and **S-0-0258, Target Position**, with activated modulo feature depends on the mode that has been set.

The following possibilities exist:

- Shortest path
- Positive direction
- Negative direction

The mode is set in parameter **S-0-0393, Command value mode**. This setting is only effective, if the modulo format has been activated in **S-0-0076, Position data scaling type**.

The following settings can be entered:

S-0-0393 = 0 **Modulo mode "Shortest path"**

The next command value is reached with the shortest path. If the difference between two successive command values is greater than half the modulo value, the drive moves toward the command value in the opposite direction.

S-0-0393 = 1 **Modulo mode "Positive direction"**

The command value is always approached in a positive direction, regardless of whether or not the difference between two successive command values is greater than half the modulo value.

S-0-0393 = 2 **Modulo mode "Negative direction"**

The command value is always approached in a negative direction, regardless of whether or not the difference between two successive command values is greater than half the modulo value.

8.2 Setting the Measurement System

The following feedback systems can be evaluated with the DIAX series of controllers:

- Digital servo feedback
- Resolver
- Incremental encoder with sine signals
- Incremental encoder with square-wave signals
- Indramat gearwheel-type encoder
- Measurement system with SSI interface
- Measurement system with EnDat interface
- Gearwheel encoder with 1Vpp signals
- Resolver without feedback memory
- Resolver with one pole pair without feedback data memory plus incremental encoder with sine signals.

The drive is connected to an encoder interface (standard), either a digital servo feedback or a resolver. Additional plug-in cards are available for evaluating different types of encoders. Specifically, the following measurement systems can be implemented with the corresponding module shown below.

Feedback System:	Module:	Value in P-0-0074/75
Digital servo feedback or resolver	Standard	1
Incremental feedback with sine signal from the Heidenhain company, either µA or 1V signals selectable	DLF01.1M	2
Indramat gearwheel encoder	DZF02.1M	3
Digital servo feedback	DFF01.1M	4
Incremental encoder with square-wave signals from the Heidenhain company	DEF01.1M	5
Incremental encoder with square-wave signals from the Heidenhain company	DEF02.1M	6
Encoder with SSI interface (only 4096 incr./rev.)	DAG01.2M	7
Encoder with EnDat interface	DAG01.2M	8
Gearwheel encoder with 1Vpp signals	DZF03.1M	9
Resolver without feedback memory	Standard	10
Resolver without feedback memory plus incremental encoder with sine signals	Standard + DLF01.1M	11

Fig. 8-12: Feedback systems > necessary plug-in modules

Each module is assigned a number that determines the feedback interface. The module number is entered into the following parameters:

- **P-0-0074, Interface Feedback 1**
- **P-0-0075, Interface Feedback 2, external**

(See also Possible error messages when reading and writing the operating data).

This check is also made in the command **S-0-0128, C200 Communication phase 4 transition check**. The command error **C203 Parameter Conversion Error (->S-0-0022)** is generated there.

Displaying the position feedback values of the individual measurement systems is done with the parameters

- **S-0-0051, Position Feedback Value 1 (Motor Feedback)**
- **S-0-0053, Position Feedback Value 2 (Ext. Feedback)**

Setting the absolute relationship of the position feedback values-1/2 to the machine zero point is done with the commands

- **S-0-0148, C600 Drive controlled homing procedure command, or**
- **P-0-0012, C300 Command 'Set absolute Measurement'**

Limiting Conditions for Encoder Evaluation

The following limitations exist:

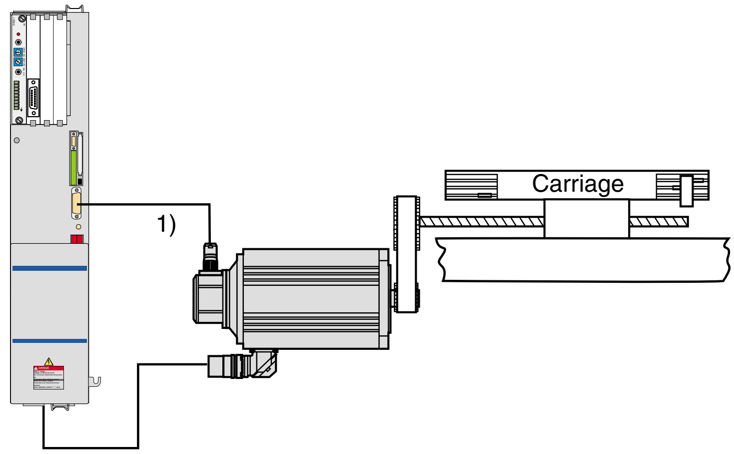
- The DLF, DZF, DEF 1 modules may not be simultaneously operated within a controller.

  ⇒ **Danger of Damage!**

  The combination of DLF and DZF is not possible. The DEF 2 module can be used to operate an incremental feedback with square-wave signals while a DLF or DZF is also being used.
- The DAG 1.2 contains a switch that allows the interface to be changed to an SSI interface (7) or an EnDat interface (8). Make sure that the switch is set correctly.
- If attempting to evaluate an external encoder with an SSI interface, only measurement systems with a resolution of 4096 Incr./Rev. and absolute resolution can be used. If the position loop is closed via this measurement system, only a limited dynamic can be achieved because of the serial transmission from the feedback to the controller.
- Only the standard module, DLF, DZF, or DAG 1.2 can be used to evaluate a motor encoder.
- It is not possible to use a resolver as an external measurement system.

Motor Encoder

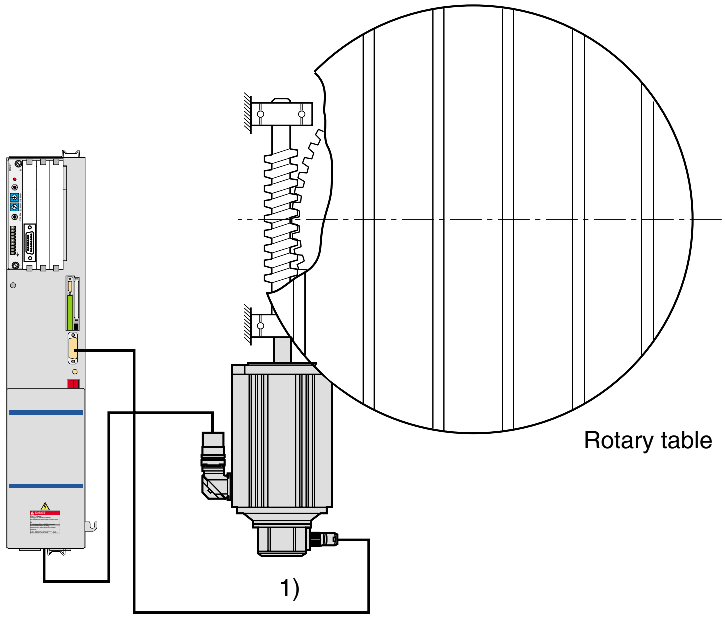
The measurement system which is directly coupled with the motor shaft without a gearbox between is called the motor encoder. As the motor is usually coupled to the load with a mechanical gearbox and probably a feed unit, we call this also an indirect distance measurement. If a further measurement system is attached directly to the load, we call this a direct distance measuring (see "External Encoder"). Hereafter, we show typical applications of indirect distance measurements.



1) Indirect position feedback acquisition via the drive's internal position measuring system

Ap5044f1.fh7

Fig. 8-13: Application: Motor encoder with linear servo axis



1) Indirect position feedback acquisition via the drive's internal position measuring system

Ap5045f1.fh7

Fig. 8-14: Application: Motor encoder with rotary servo axis

The following parameters

- **P-0-0074, Interface Feedback 1**
- **S-0-0116, Resolution of motor feedback**
- **S-0-0277, Position feedback 1 type parameter**

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 Value 1 (Motor Feedback)** 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

Determining the encoder interface of the motor encoder is done with the parameter **P-0-0074, Interface Feedback 1**. Enter the number of the module to which the motor feedback is connected in the parameter. The motor encoder interface in P-0-0074 is automatically set with certain types of motors.

(See also "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.

Feedback System	Module	Number	for Synchronous motors	for Asynchronous motors
None (only with rotary asynchronous motors)	--	0	no	yes
Digital servo feed back or resolver	Standard	1	yes	yes
Incremental encoder with sine signals from the Heidenhain company, with either µA or 1V signals	DLF01.1M	2	no	yes
Indramat gear-type encoder	DZF02.1M	3	no	yes
Incremental encoder with square-wave signals from the Heidenhain company	DEF01.1M	5	no	yes
Encoder with EnDat interface from the Heidenhain company	DAG01.2M	8	yes	yes
Gearwheel with 1Vpp signals	DZF03.1M	9	no	yes

Feedback System	Module	Number	for Synchronous motors	for Asynchronous motors
Resolver without feedback data memory	Standard	10	yes	no
Resolver without feedback data memory plus incremental encoder with sine signals	Standard + DLF01.1M	11	yes	no

Abb. 8-15: Determining the 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 "External Encoder").

Motor Encoder Resolution

The motor encoder resolution is parameterized in the parameter **S-0-0116, Resolution of motor feedback**. 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 are available if

- Standard (1)

or

- DAG 1.2 (8)

is used as the motor encoder interface.

Depending on whether a rotary or linear motor is used, the units and the number of decimal places are changed via **S-0-0116, Resolution of motor feedback**.

(see also Linear-Rotational)

Other Motor Encoder Characteristics

To parameterize the other motor encoder characteristics, such as

- Direction of movement not-inverted/inverted
- Distance-coded reference mark yes/no
- Rotary / linear measurement system
- Absolute evaluation possible
- Absolute evaluation activated

use **S-0-0277, Position feedback 1 type parameter**.

The structure of this parameter is as follows:

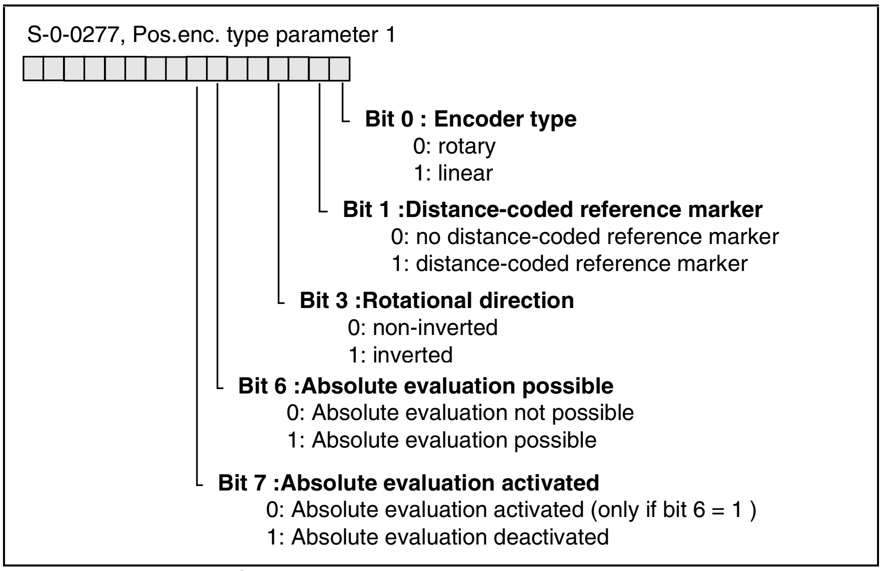


Fig. 8-16: Parameter S-0-0277

The bits in the position encoder type parameter are partially set or deleted by the drive itself.

There are following dependencies:

- 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 "Other Settings for Absolute Measurement Systems".)

Optional encoder

The control with optional encoder facilitates a higher contour precision of the machined workpieces resp. a higher positioning accuracy. 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 this measurement system.

(See also "Operating Modes" and "Setting the Velocity Mix Factor".)

Typical application examples are shown in the following two pictures:

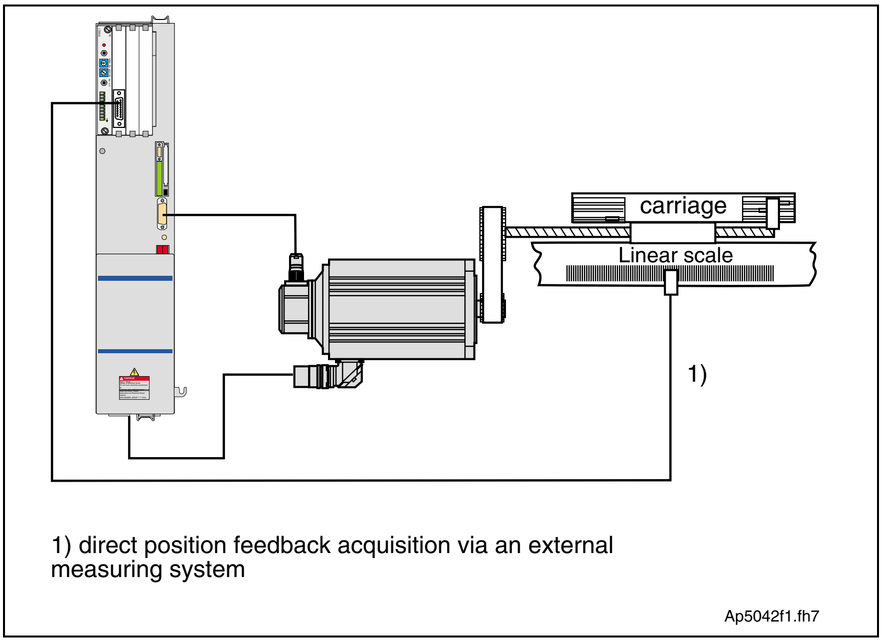


Fig. 8-17: Application: Optional encoder with linear servo axis

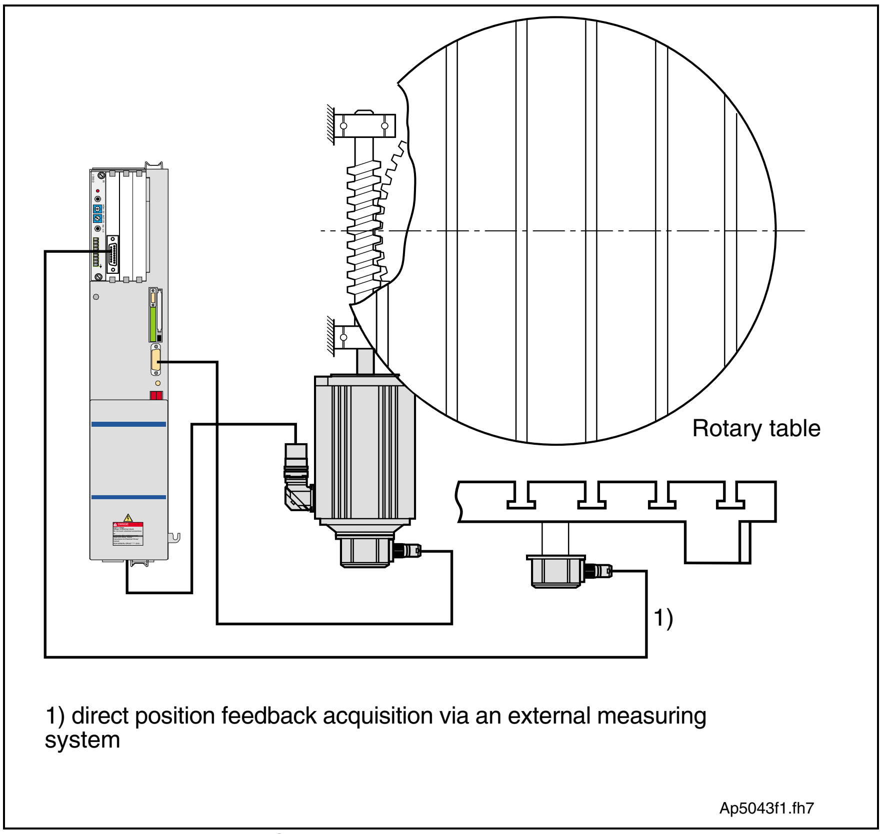


Fig. 8-18: Application: Optional encoder with rotary servo axis

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 interface number to which the measurement system is connected, the resolution of the optional encoder, as well as 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	Definition
0	optional encoder as additional load-side control encoder for position and/or velocity control loops
1	optional encoder as master axis encoder
2	optional encoder as only load-side control encoder (only with rotary asynchronous motors)
3	optional encoder as measuring wheel encoder

Fig. 8-19: Function of the optional encoder

The use of the optional encoder as master axis encoder is described in the section on master axis encoder evaluation.

Determining the Encoder Interface of the Optional Encoder

The encoder interface of the optional encoder is determined with the parameter **P-0-0075, Feedback type 2**. The number of the module to which the optional encoder is connected must be entered in this parameter.

The following measuring systems and modules for the evaluation of an optional encoder are allowed:

Feedback System:	Module:	Number:
None	--	0
Digital servo feedback	Standard	1
Incremental encoder with sine signals from the Heidenhain Company, with either uA or 1V signals	DLF01.1M	2
Indramat gear-type encoder	DZF02.1M	3
Digital servo feedback from the Heidenhain or Stegmann companies	DFF01.1M	4
Incremental encoder with square-wave signals from the Heidenhain company	DEF01.1M	5
Incremental encoder with square-wave signals from the Heidenhain company	DEF02.1M	6
Encoder with SSI interface	DAG01.2M	7
Encoder with EnDat interface	DAG01.2M	8
Gearwheel encoder with 1Vpp signals	DZF03.1M	9

Fig. 8-20: Encoder interface of the optional encoder

If 0 is entered as the module number, the encoder evaluation of the optional encoder is switched off.

Warning

Do not use an encoder with an SSI-interface in the velocity control and position control operating modes.

⇒ Long dead times occur when reading the SSI-interface.

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

- **Standard (1) ,**
- **DFF (4) or**
- **DAG 1.2 (8)**

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 position feedback monitor can diagnose the following errors of the axis:

- 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 motor encoder with the optional encoder. 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 position status' 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.

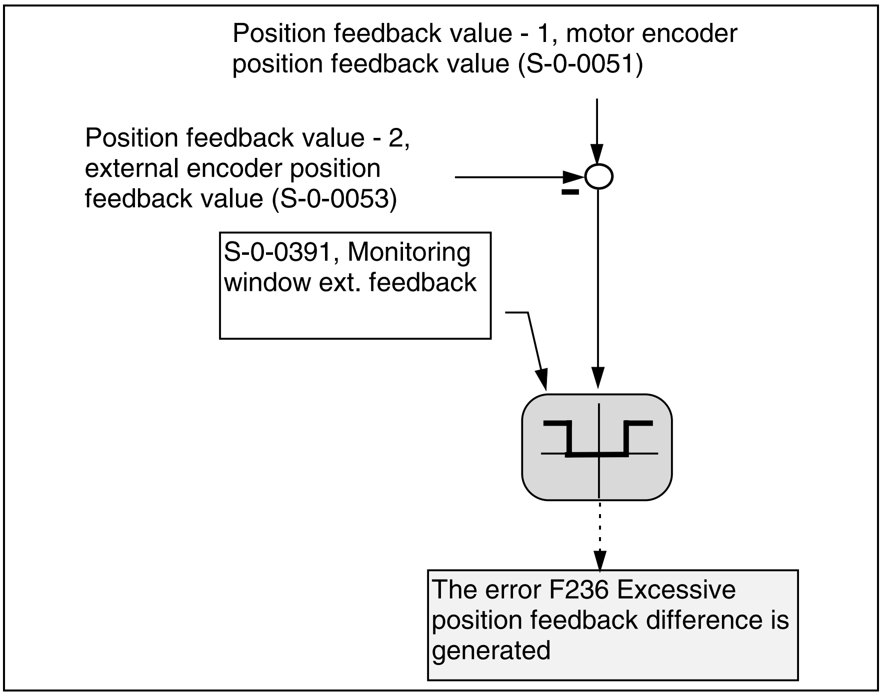


Fig. 8-21: Position feedback value monitoring schematic

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, such as

- Direction of movement not-inverted/inverted
- Distance-coded home mark yes/no
- Rotary / linear measurement system
- Absolute evaluation possible
- Absolute evaluation activated

use **S-0-0115, Position feedback 2 type.**

The structure of this parameter is as follows:

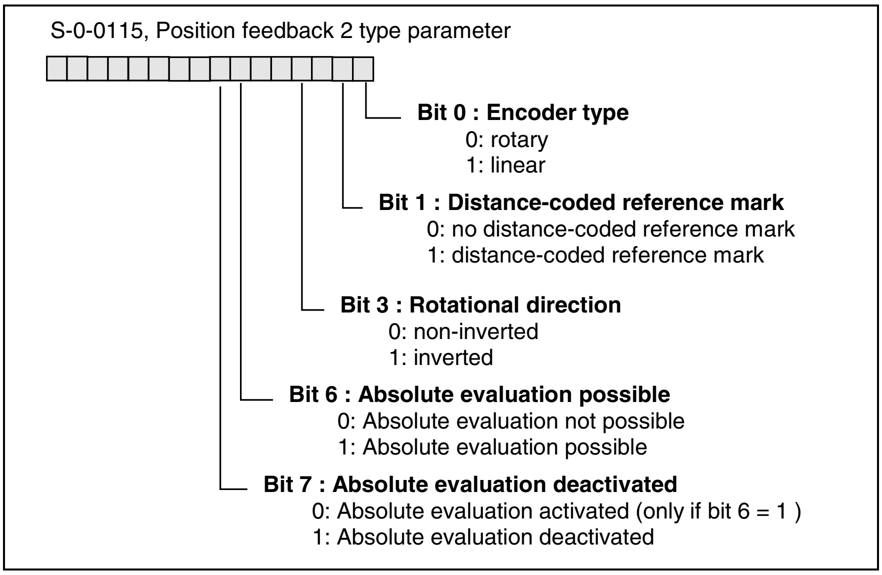


Fig. 8-22: Parameter S-0-0115

The bits in the position encoder type parameter are partly set or cleared by the drive itself. There is following dependency:

- Depending on the absolute encoder range and the maximum travel range or modulo value, bit 6 is either set or cleared.

(See also "Other Settings for Absolute Measurement Systems".)

Position feedback values of non-absolute measuring systems after initialization

If there is no absolute measuring system available, then the initialization value can be changed via parameter **P-0-0019, Position start value**.

The following applies:

If the parameter is write accessed in either phase 2 or 3, then this value is accepted as the initialization value:

P-0-0019 write accessed?	**Position feedback value 1**	**Position feedback value 2**
no	init. original position of motor encoder	init. original position of motor encoder
yes	position start value	position start value

Fig. 8-23: Position feedback values of non-absolute measuring systems after initialization

WARNING

No valid position feedback values exist before the measuring system is initialized.

Initialization is performed during the transition check for communication phase 4.

Some measuring systems have limitations concerning the maximum velocity during their initialization.

Measuring system	Maximum initialization velocity
DSF/HSF	300 rpm
EnDat	Initialization should occur at standstill
Multiturn resolver	300 rpm

Fig. 8-24: Velocity allowed during initialization

Drive-internal format of position data

There are two different formats in the drive used to display position data. We differentiate between

- display format and
- drive-internal format.

Display format

The display format defines the unit, i.e. the valence with which the position data are exchanged between drive and control/user interface. When a position data parameter is read, it is sent in the display format to the control. The display format is set with parameters

- **S-0-0076, Position data scaling type**
- **S-0-0077, Linear position data scaling factor**
- **S-0-0078, Linear position data scaling exponent**
- **S-0-0079, Rotational position resolution**

The control that is used generally presets the display format.

(See also chapter: "Physical values display format")

Drive-internal format

The drive-internal format determines the valence with which the position command and feedback value editing, as well as the closing of the position control loop in the drive are performed. The drive uses the value of parameter **S-0-0278, Maximum travel range** to calculate the drive-internal format, i.e. the drive-internal position resolution depends on the travel range to be displayed.

Functional principle of the drive-internal position data format

Position data processing in the drive is done with a constant data width. From this fact results the dependence of the resolution of the position data on the travel range of the axis to be covered.

Note: The longer the distance to be displayed, the smaller the drive-internal position resolution.

Rexroth Indramat

The values of the following parameters are used to compute the drive-internal resolution:

- **S-0-0116, Feedback 1 Resolution** and
- **S-0-0256, Multiplication 1**.

The parameter for the encoder resolution is to be taken from the data sheet of the measuring system or it is automatically read out of the feedback memory if the respective measuring system is used. The number of division periods per encoder revolution or the grid constant of a linear scale (distance per division period) is to be set in this parameter. The parameter value for the multiplication is calculated by the drive during command **S-0-0128, C200 Communication phase 4 transition check**. It indicates the resolution per division period (dp).

The following applies to the drive-internal resolution of rotary motors:

$$\text{resolution} = \text{multiplication} * \text{encoder resolution}$$

Resolution:	drive-internal resolution of position data [Incr/rev]
multiplication:	value in S-0-0256 or S-0-0257 [Incr/dp]
encoder resolution:	value in S-0-0116 or S-0-0117 [dp/rev]

Fig. 8-25: Drive-internal resolution of rotary motors

The following applies to the drive-internal resolution of linear motors:

$$\text{resolution} = \frac{\text{multiplication}}{\text{encoder resolution}}$$

Resolution:	drive-internal resolution of position data [Incr/rev]
multiplication:	value in S-0-0256 or S-0-0257 [Incr/dp]
encoder resolution:	value in S-0-0116 or S-0-0117 [mm/dp]

Fig. 8-26: Drive-internal resolution of linear motors

Examples

1. MKD motor, S-0-0116 = 4, S-0-0256 = 32768, therefore: drive-internal resolution = 131072 increments/revolution or 0.00275 degrees/increment.
2. Linear scale as optional measuring system, S-0-0117 = 0.02 mm (grid division = 20µm), S-0-0257 = 32768, therefore: drive-internal resolution of approximately 1638400 increments/mm or 0.00061 µm/increment. (How to compute the drive-internal resolution if an optional encoder is used, is described in greater detail below.)

Note: For technical reasons, the value for the multiplication is limited to 4 to 4194304 increments/mm.

Setting the drive-internal position data format

To set the drive-internal resolution, use the parameter **S-0-0278, Maximum travel range**.

Setting the maximum travel range at initial commissioning

At initial commissioning of an axis, this parameter must be set to a value that equals at least the distance that the axis must travel. While executing the command **S-0-0128, C200 Communication phase 4 transition check**, the drive computes the values for **S-0-0256, Multiplication 1** and, if an optional measuring system is available, for **S-0-0257, Multiplication 2**. These parameters thus help to display the resolution.

Note: For technical reasons, the maximum possible resolution of the position feedback value of a position encoder equals 32768 increments per division period of the measuring system. The maximum resolution is reduced, if the travel range is set so large that it can no longer be displayed with the maximum resolution.

To compute the multiplication, one of the following calculations is conducted in the command **S-0-0128, C200 Communication phase 4 transition check**, depending on the measuring system that is used:

For rotary measuring systems:

$$\text{multiplication} = \frac{2^{31}}{\text{travel range} \times \text{encoder resolution}}$$

travel range:	travel range displayed in encoder revolutions
multiplication:	value in S-0-0256 or S-0-0257
encoder resolution:	value in S-0-0116 or S-0-0117

Fig. 8-27: Relationship between maximum travel range and multiplication with rotary measuring systems

Examples

1. MHD motor with S-0-0116 = 512, maximum travel range 2048 motor revolutions, therefore: multiplication of 2^31/(2048*512) = 2048.
2. MHD motor with S-0-0116 = 512, maximum travel range 20 motor revolutions, therefore: multiplication of 2^31/(20*512) = 209715. The highest possible value equals 32768, thus multiplication = 32768.

For linear measuring systems:

$$\text{multiplication} = \frac{2^{31} \times \text{encoder resolution}}{\text{travel range}}$$

travel range:	travel range displayed in mm
multiplication:	value in S-0-0256 or S-0-0257
encoder resolution:	value in S-0-0116 or S-0-0117

Fig. 8-28: Relationship between maximum travel range and multiplication with linear measuring systems

Example

3. Linear scale with 0.02 mm grid division, maximum travel range 5 m, therefore a multiplication of 2^31*0.02/ 5000 = 8589 (→ 8192*).

This results in a resolution of 0.02 mm/8192 = 0.002441 µm.

***Note:** When computing multiplication always use the next lower binary value of the precise result of the calculation.

Drive internal display of position data when an optional encoder is available

Note: If an optional encoder is available (P-0-0185 ≠ "1" or "5"), the multiplication of the motor encoder depends on the one of the optional encoder.

If there is an optional measuring system, then the multiplication of this encoder is computed in terms of the travel range set (see also: "Setting the drive-internal position data format"). The multiplication of the motor encoder is calculated so that it also covers this travel range. This means that values exceeding the greatest reasonable value (32768) for the multiplication of the motor encoder can be generated depending on the mechanical gear elements and encoder resolutions!

Example

MKD motor with rotary optional encoder, motor encoder resolution = 4, optional encoder resolution = 1000, travel range = 50 revolutions, gear ratio = 1:1

Calculating the multiplication of the optional encoder:

2^31/(1000*50) = 42949, technically reasonable is a maximum of 32768, thus S-0-0257 = 32768. This results in a resolution of 0.00001098 degrees.

Calculating the multiplication of the motor encoder:

2^31/(4*50) = 10737418, the next smaller binary value = 8388608, thus S-0-0256 = 8388608. However, the technical maximum resolution is 4194304. Therefore, we set the value in S-0-0256 to 4194304. The resolution is 0.00002146 degrees.

Note: The resolution can never exceed 4194304 * S-0-0116!

Example

MHD motor with linear optional encoder, resolution of the motor encoder = 256, resolution of the optional encoder = 0.02 mm, travel range = 5 m, feed constant = 10 mm, gear ratio = 3:1

Calculating the multiplication of the optional encoder:

2^31*0.02 mm/5000 mm = 8589, technically reasonable is a maximum of 8192, therefore: S-0-0257 = 8192. This results in a resolution of 0.00244 µm.

Calculating the multiplication of the motor encoder:

5 m of travel range result in 500 gear output revolutions and therefore 1500 gear input revolutions (motor revolutions).

2^31/(256*1500) = 5592, the next smaller binary value = 4096, therefore: S-0-0256 = 4096. This results in a resolution of 0.000343 degrees referred to the motor shaft.

Processing formats of the drive-internal position command value interpolator

In the drive-internal position command value interpolator, the position command value profile for the drive-controlled travel commands "such as "Drive halt", "Drive-controlled homing procedure", operating mode "Drive-internal interpolation",...) are generated. The format of the drive-internal position data affect the maximum acceleration limit which can be preset for the interpolator.

Note: The limits are not valid for presetting cyclic command values (e.g. operating mode "Position control").

The following relationships apply to rotary motors:

$$a_{max} = \frac{51.471.854.040}{\text{encoder resolution} \times \text{multiplication}} \left[\frac{\text{rad}}{\text{s}^2}\right]$$

a_{max}:	max. acceleration of position command interpolator
encoder resolution:	value in S-0-0116 in mm
multiplication:	value in S-0-0256

Fig. 8-29: Maximum acceleration of the position command value interpolator as dependent on the drive-internal position data format

The following relationships apply to linear motors:

$$a_{max} = \frac{8.192.000.000 \times encoderresolution}{multiplication} \left[\frac{mm}{s^2}\right]$$

a_{max}: max. acceleration of position command interpolator
encoder resolution: value in S-0-0116 in mm
multiplication: value in S-0-0256

Fig. 8-30: Maximum acceleration of the position command value interpolator as dependent on the drive-internal position data format

Example MHD motor with S-0-0116 = 512, multiplication = 32768, this results in a maximum acceleration of the position command interpolator of 3067 rad/s².

8.3 Supplementary settings for absolute measuring systems

Encoder types and relevant interfaces

The table below shows the absolute measuring systems which can be used as a motor encoder or optional encoder and the range which they can evaluate in absolute form. The relevant encoder interface is also listed.

Measuring system	Absolute encoder range	Module (no.)	as motor encoder?	as optional encoder?
Single-/multi-turn DSF	1rev./4096rev.	Standard(1)	yes	yes
Single-/multi-turn DSF	1rev./4096rev.	DFF01.1U(4)	no	yes
Single-/multi-turn resolver	1dp/65535dp	Standard(1)	yes	yes
SSI encoder with 4096 incr./rev.	4096rev.	DAG01.2U(7)	no	yes
Linear scale from Heidenhain with EnDat interface	encoder length-dependent	DAG01.2U(8)	yes	yes
Single-/multi-turn rotary encoder from Heidenhain with EnDat interface	1rev./4096rev.	DAG01.2U(8)	yes	yes

Fig. 8-31: Modules required for absolute measuring systems

Absolute encoder range and absolute encoder evaluation

Measuring systems that supply absolute position information within one or several encoder revolutions (single- or multi-turn encoders) or over a certain distance (absolute linear scales) can be used as motor and/or optional measuring systems. The range (absolute encoder range) in which a measuring system can supply absolute position information is stored in the data memory of the measuring system or the drive software.

Note: The absolute encoder range which the drive can evaluate can be limited with the use of **S-0-0278, Maximum travel range**. In parameters **S-0-0378, Encoder 1, absolute range** or **S-0-0379, Encoder 2, absolute range** the drive displays those absolute encoder ranges which can be evaluated.

Absolute measuring systems do not have to be homed after every initialization of the drive firmware. After initialization, the actual position value is available within the absolute encoder range, machine zero-point related. It is only necessary to conduct a single setup procedure (setting absolute measurement).

Whether a motor or an optional measuring system are to be evaluated as absolute encoders, depends on the following variables:

- the absolute encoder range (**S-0-0378, Encoder 1, absolute range / S-0-0379, Encoder 2, absolute range**) of the relevant encoder.
- the set position scaling (position data represented in absolute or in modulo format) in **S-0-0076, Position data scaling type**
- the travel range set in **S-0-0278, Maximum travel range**
- the modulo value set in parameter **S-0-0103, Modulo value**
- the actual value cycle of the slave axis (**P-0-0752, Load revolutions per actual value cycle slave axis**) in the case of synchronous operating modes.

Note the following relations:

Position scaling (bit 6 of S-0-0076)	**S-0-0278, Max. travel range**	**S-0-0103, Modulo value**	**Absolute encoder evaluation possible**
Absolute format	< S-0-0378 / S-0-0379	not relevant	yes
	> = S-0-0378 / S-0-0379	not relevant	no
Modulo format	S-0-0103	<= S-0-0378/S-0-0379	yes
	S-0-0103	> S-0-0378/S-0-0379	no
Modulo format in conjunction with synchronous operating mode	>= S-0-0103*P-0-0752	S-0-0103*P-0-0752 <= S-0-0378/S-0-0379	yes
	> S-0-0103*P-0-0752	S-0-0103*P-0-0752 > S-0-0378/S-0-0379	no

Fig. 8-32: Absolute encoder evaluation depending on position format, modulo format and maximum travel range

The check whether a measuring system can be evaluated as an absolute system is conducted during command **S-0-0128, C200 Communication phase 4 transition check**. The result is displayed in bit 6 of the relevant position encoder type parameter (S-0-0277 / S-0-0115).

Activating the absolute encoder evaluation

If the absolute evaluation of a measuring system is possible but not wanted, this can be deselected in bit 7 of the respective position encoder type parameter. The measuring system is then treated as if it were a non-absolute encoder.

The position feedback type parameters are structured as follows:

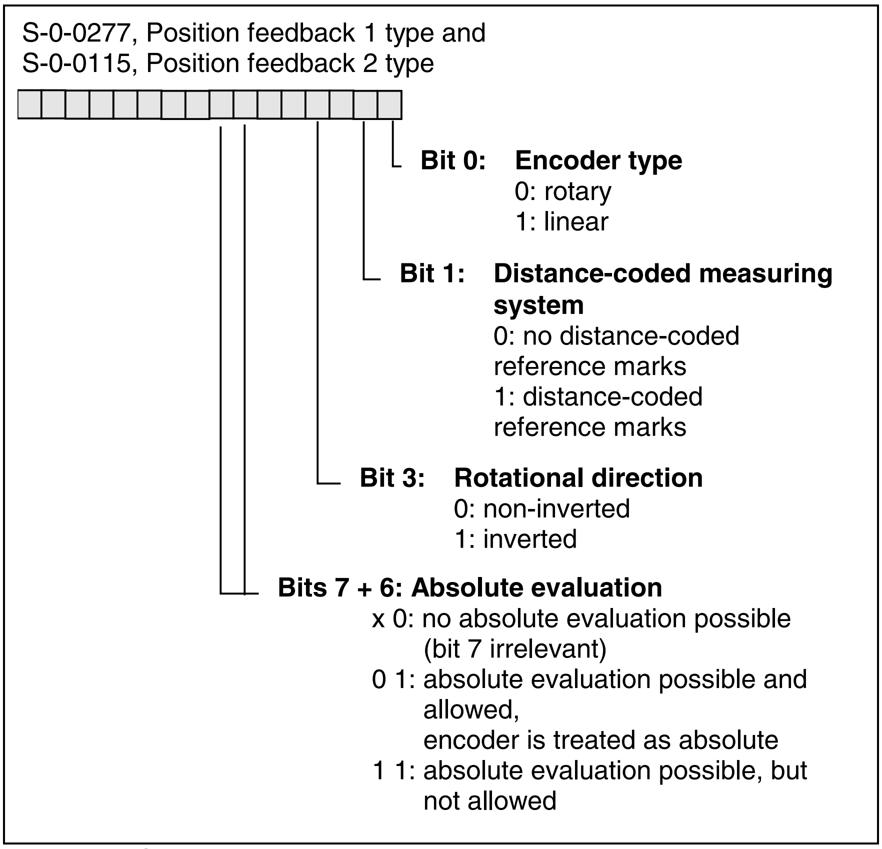


Fig. 8-33: Structure of the position feedback type parameters

How to correctly generate absolute position information

The correct generation of the machine zero-point related feedback position value is only possible if the conditions do not change. The conditions for correct conversion of the measuring system related position information to the machine zero-point related feedback position value change, if one of the following conditions changes:

Monitoring the conditions for absolute encoder evaluation

- the rotational direction of the measuring system set in parameters **S-0-0277, Position feedback 1 type** or **S-0-0115, Position feedback 2 type** in bit 3
- the position polarity set in **S-0-0055, Position polarities**
- the multiplication calculated using **S-0-0278, Maximum travel range** (**S-0-0256, Multiplication 1** or **S-0-0257, Multiplication 2**).
- the value stored in parameters **S-7-0177, Absolute encoder offset 1** or **S-7-0178 Absolute encoder offset 2**

If one of these four conditions changes, then the position status of the respective measuring system is cleared and error **F276 Absolute encoder exceeds monitoring window** is generated.

Absolute encoder monitor

If the absolute evaluation of a measuring system has been activated (position encoder type parameter S-0-0277 or S-0-0115 = 01xx.xxxxb), then the position feedback value generated in command **S-0-0128, C200 Communication phase 4 transition check** can be monitored. The monitor of the actual position value is only active, if the encoder is in reference.

Functional principle of the absolute encoder monitor

When turning off the drive's power supply, the current feedback position of the axis is loaded into a non-volatile memory. When switching the axis back on, the difference between the stored position and the position newly initialized by the measuring system is generated. If this difference is greater than the parameterized position window in parameter **P-0-0097, Absolute encoder monitoring window**, the error message **F276 Absolute encoder out of allowed window** is generated.

The absolute encoder monitor is appropriate for the following applications:

- The motor is equipped with a holding brake.
- The mechanical drive system is self-locking and cannot be moved manually.

Setting the absolute encoder monitor

The absolute encoder monitoring window must be set by the user. Always select a value greater than the maximum allowed motion of the axis when shutdown. Assuming that the axis has a brake or is self-locking, you can enter 1/10 motor revolutions (36° in reference to the motor shaft) as a standard value for the parameter **P-0-0097, Absolute encoder monitoring window**.

Deactivating the absolute encoder monitor

The absolute encoder monitor cannot be effectively used with axes that **can** or **must** be moved manually in a simple way when switched off. The absolute encoder monitor should be turned off in such situations, in order to prevent unnecessary error conditions.

The absolute encoder monitor can be turned off by writing the value "0" to parameter **P-0-0097, Absolute encoder monitoring window**.

Modulo evaluation of absolute measuring systems

If measuring systems are evaluated in absolute form and modulo evaluation of the position data is activated, then the following restriction applies:

The distance which can be traversed when all is shutdown must be smaller than half the maximum travel range set in parameter **S-0-0278, Maximum travel range** and smaller than the absolute range of the encoder (S-0-0378 or S-0-0379).

Position feedback values of absolute measuring systems after initialization

The condition of the position feedback values of the motor encoder and, if available, of the optional encoder after initializing the position feedback values in the command **S-0-0128, C200 Communication phase 4 transition check** depends on:

- bit 3 in **S-0-0147, Homing parameter**
- availability of an absolute encoder as the motor or optional encoder
- the reference of the relevant absolute encoder

Motor encoder	Optional encoder	Bit 3, S-0-0147	S-0-0051, Position feedback value 1	S-0-0053, Position feedback value 2	Bit 0, S-0-0403
absolute	not absolute	0	absolute value of motor encoder	absolute value of motor encoder	1
absolute	not absolute	1	absolute value of motor encoder	absolute value of motor encoder	0
not absolute	absolute	0	absolute value of optional encoder	absolute value of optional encoder	0
not absolute	absolute	1	absolute value of optional encoder	absolute value of optional encoder	1
absolute	absolute	arbitrary	absolute value of motor encoder	absolute value of optional encoder	1

Fig. 8-34: Position feedback values of absolute measuring systems after initialization

Note: Reference distance can get lost with changes in polarity, scaling, gearbox, ... (see also **S-0-0403, Position feedback value status**).

8.4 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 current for the machine is fixed by the peak current of the drive and the peak current of the motor. These values may

Rexroth Indramat

not be exceeded. And, as this is the total flowing currents, the magnetization current is deducted from this value 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 "pull out 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.

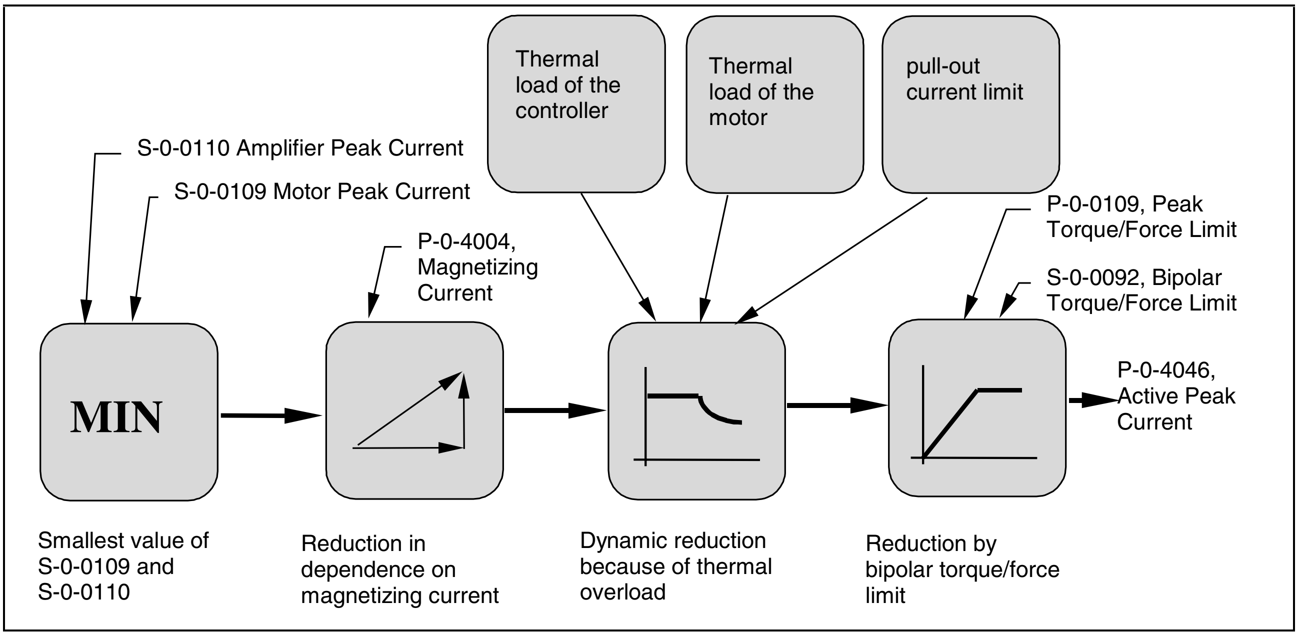


Fig. 8-35: Value displayed in P-0-4046, actual peak current

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.

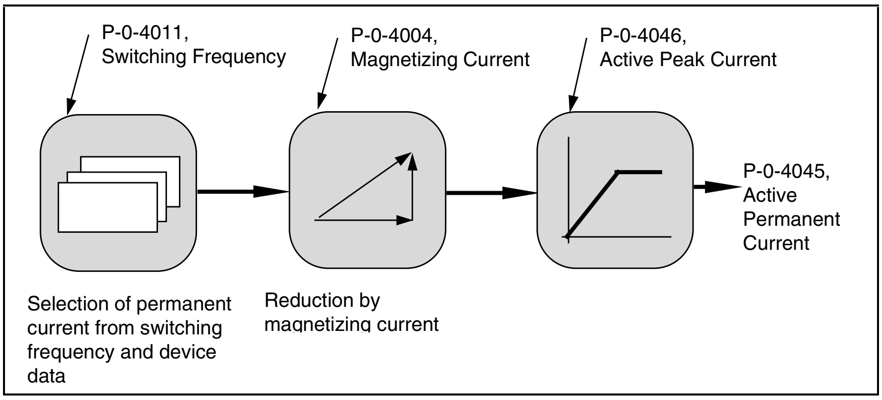


Fig. 8-36: Parameter value of the effective continuous current

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 controller thermal 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 prewarning** 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 parameterize a value of **80%** for this purpose. This value should not be exceeded when operating the drive under normal conditions.

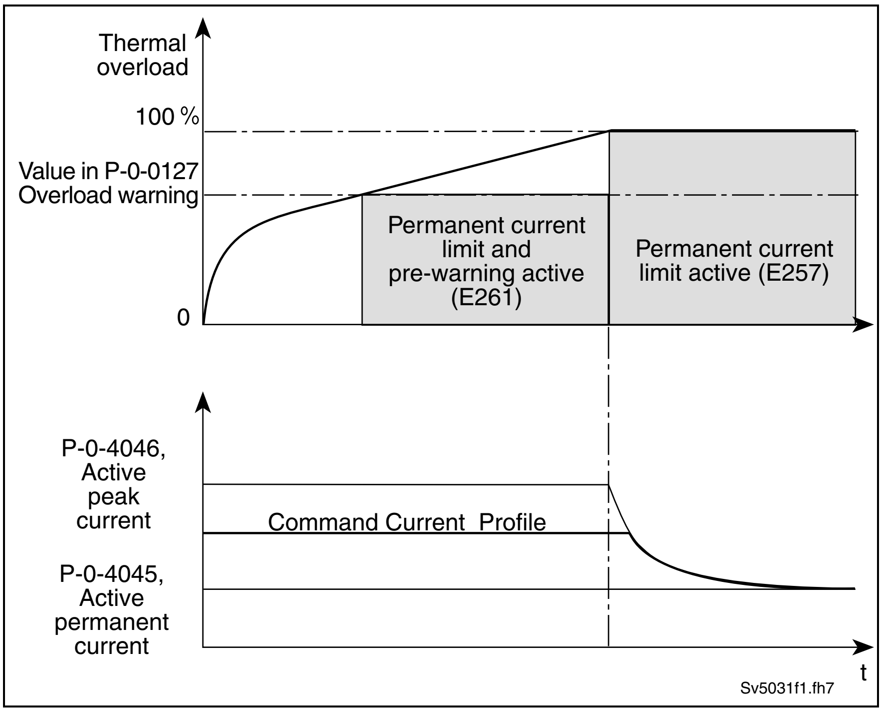


Fig. 8-37: Monitoring the thermal load and continuos current limit

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 sizing 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 startup 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 presetting **P-0-0141, Thermal drive load** to 80%, the processing cycle is set to this load.

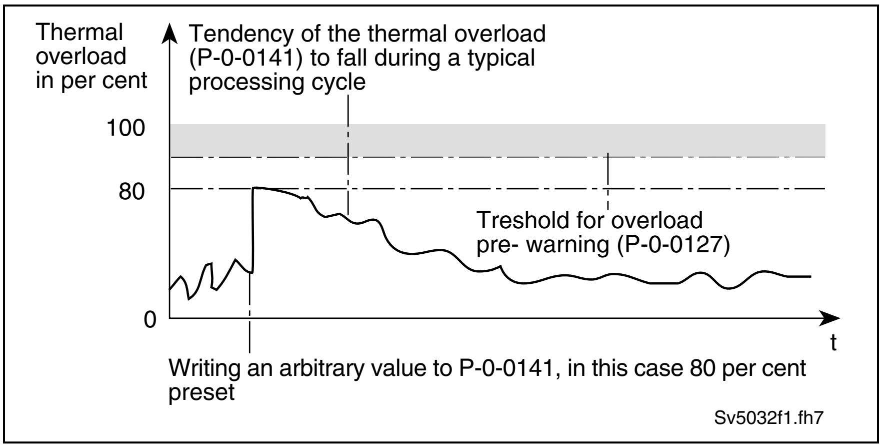


Fig. 8-38: Checking the thermal load

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 starting at 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-0-0531, Stall current 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** that can be maximally made available.

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 temporary 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 is 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.

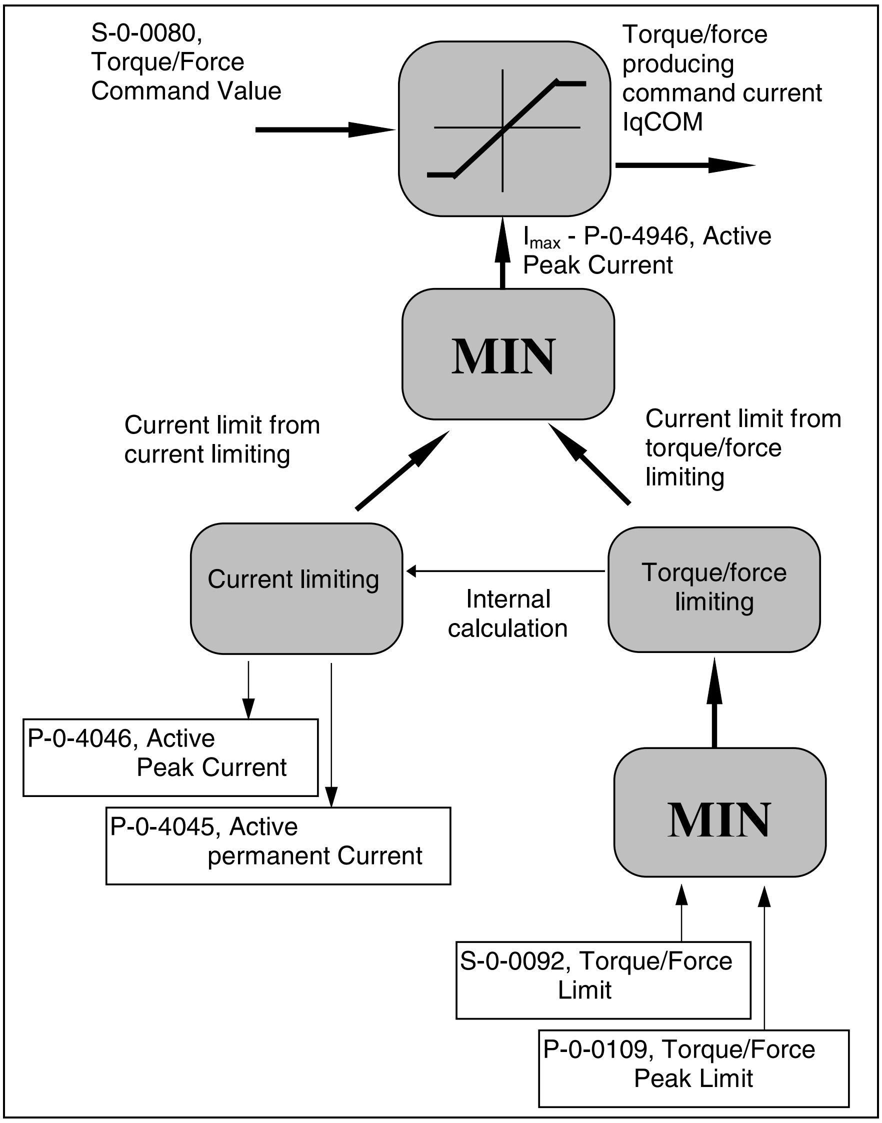


Fig. 8-39: Current limitation and torque/force limitation

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!

Velocity limit

The following parameters limit the velocity of the drive:

- **S-0-0113, Maximum Motor Speed (nmax)**
- **S-0-0091, Bipolar Velocity Limit Value**

The parameter **S-0-0091, Bipolar Velocity Limit Value** is designed to allow variable limits of the maximum velocity to values smaller than the maximum allowed velocity during operation.

The parameter **S-0-0113, Maximum Motor Speed (nmax)** designates the maximum possible motor velocity. It is contained in the motor encoder data memory of MHD, MKD and MKE motors and does not need to be entered. With other types of motors this value must be taken from the motor data sheet.

Limiting to maximum motor velocity

The maximum motor velocity defines the maximum velocity of the drive on the drive-side. It is included in the calculation of the maximum value entered in the parameter **S-0-0091, Bipolar Velocity Limit Value**.

Limiting to bipolar velocity limit value

The bipolar velocity limit value (S-0-0091) defines the maximum velocity of the drive for the user. It becomes active as

- the monitor of the feedback velocity in the "Torque control" operating mode
- the limit for the resulting command value in the velocity controller
- the monitor of the position command value differences in the "Position control" operating mode (see also chapter: "Position command value monitoring")
- the limit of **S-0-0036, Velocity Command Value** in the "Velocity control" operating mode

Monitoring the feedback velocity in the "Torque control" operating mode

Monitoring the feedback velocity in the "Torque control" operating mode occurs with regard to 1.125 times the value of **S-0-0091, Bipolar Velocity Limit Value**. If this value is exceeded, the fatal error **F879 Velocity limit S-0-0091 exceeded** is generated. The drive switches to torque-free operation afterwards.

Limiting the resulting command value in the velocity controller

In all operating modes in which the velocity controller is active (all operating modes except for "Torque control"), the given velocity command value is limited to the value of **S-0-0091, Bipolar Velocity Limit Value**. If this condition is reached, the warning **E259 Command Velocity Limit active** is generated.

Limiting S-0-0036, Velocity Command Value in the Velocity Control Operating Mode

Limiting S-0-0036, Velocity command value in the "Velocity control" operating mode

In the "Velocity control" operating mode, the input of **S-0-0036, Velocity Command Value** is limited to **S-0-0091, Bipolar Velocity Limit Value**. If the value entered in S-0-0036 exceeds this limit, the warning **E263 Velocity command value > limit S-0-0091** is generated.

Travel Range Limits

To avoid accidents and damages to the machine, many safety precautions are provided. A part of these safety measures refers to limiting the allowed working range. These limits can be introduced by 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)

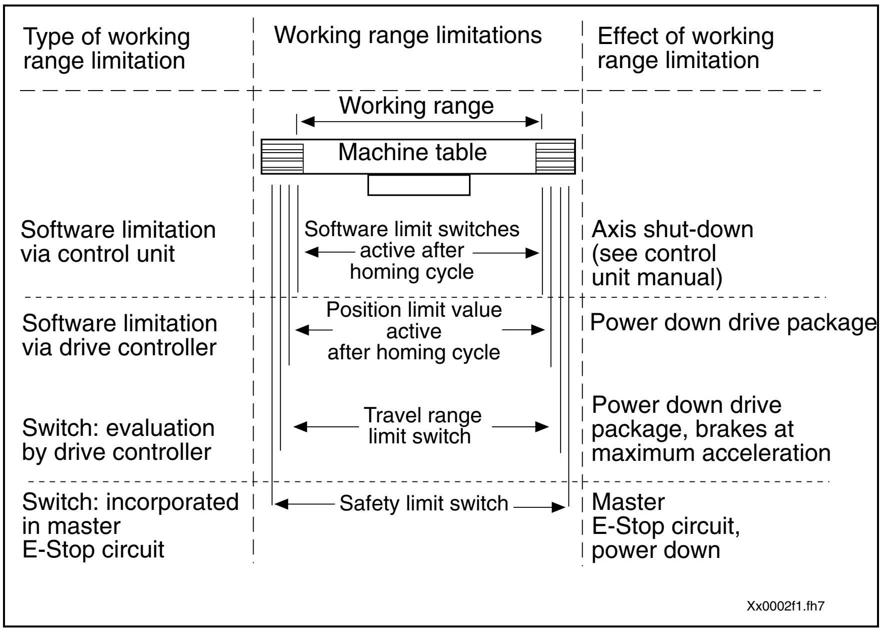


Fig. 8-40: Effect and ways of limiting the working range

In the drive itself, there exist two methods

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**:

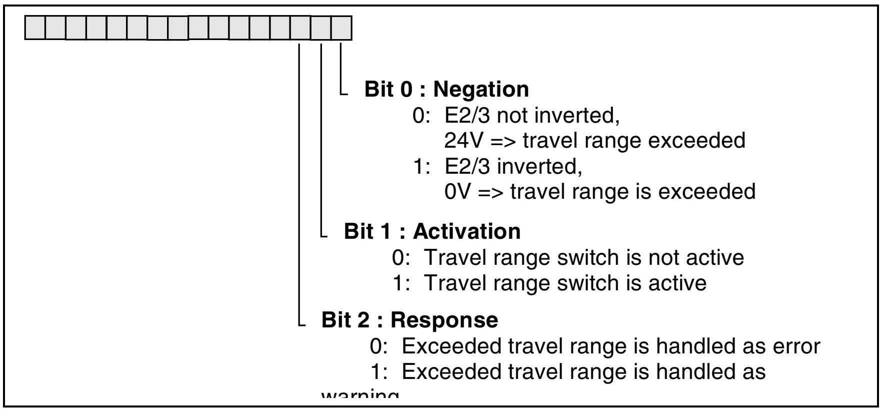


Fig. 8-41: Setting the drive reaction to exceeding the travel range (bit 2)

Note: It is not possible to bring the axis to a standstill with a command ramp (slope) over **P-0-1201, Ramp 1 pitch** (velocity ramp 1) (Best possible standstill = 2)! The braking to standstill always occurs with the maximum allowable torque/force. (See **P-0-4046, Active peak current**.)

Exceeding the Travel Range as an Error

If a 0 is entered in bit 2 of P-0-0090, then exceeding the travel range is handled as an error with the reaction of the velocity command value being set to zero. (See also "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. 8-42: 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 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 range limit switch activated/detected
	F644	F644 Negative travel range limit switch activated/detected
As a warning	E843	E843 Positive travel range limit switch activated/detected
	E844	E844 Negative travel range limit switch activated/detected

Fig. 8-43: 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).

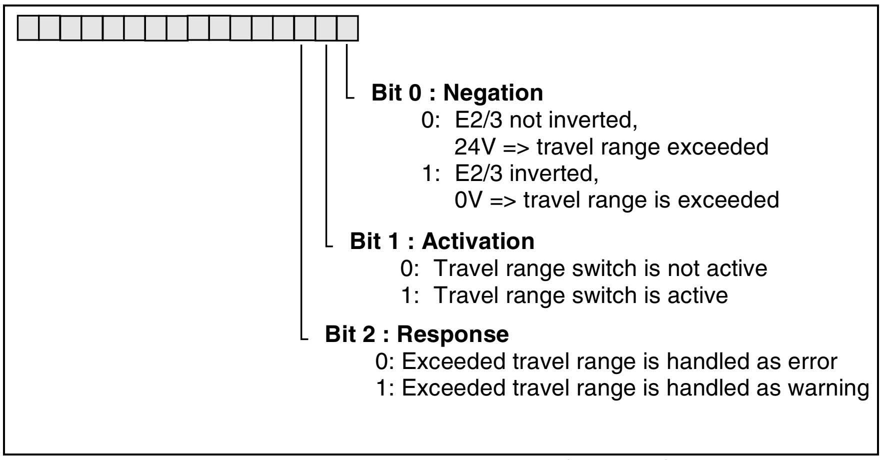


Fig. 8-44: Activating and negating the limit switches (bit 0 or 1)

If the monitor in bit 1 of P-0-0090 is turned on, the +24V DSS 2.1 +UL input monitor is simultaneously activated, if it was not already activated by using other X12 connector ports.

I.e.: if the +UL voltage falls below +18V, the error **F271 Error power supply travel limit switch** is generated.

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 Polarity Parameter**, 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 motor encoder or of the external encoder 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 outside of Travel Zone** is generated, and bit 13 in parameter **S-0-0012, Class 2 Diagnostics** is also set.

How handled:	SS display:	Diagnostic message:
As an error	F629	F629 Positive position limit value exceeded
	F630	F630 Negative position limit value exceeded
As a warning	E829	E829 Positive position limit value exceeded
	E830	E830 Negative position limit value exceeded

Fig. 8-45: 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 Polarity Parameter**.

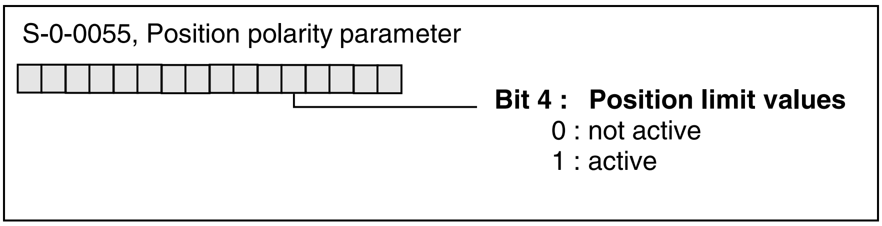


Fig. 8-46: Activating the axis limits

Travel Zone Limit Switch - Connection

The drives in the DIAX family have 2 binary inputs available for connecting travel zone limit switches. These can be found in the DSS 2.1 plug-in module. The inputs are galvanically isolated and must be supplied with +24V by the same connector (X 12).

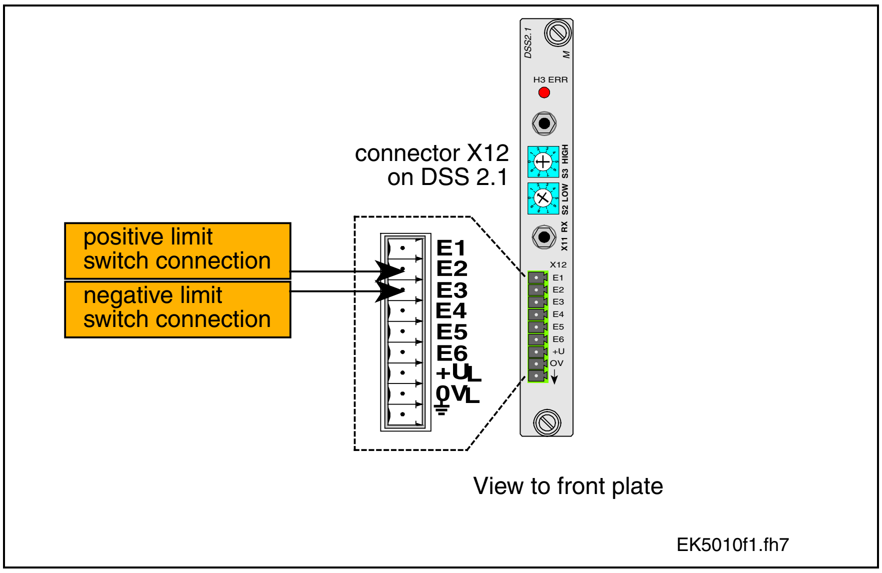


Fig. 8-47: Connecting the limit switches to X12

The travel zone limit switches are connected to the E2 and E3 inputs of the X12 connector.

8.5 Master axis feedback analysis

Functional principle of master axis feedback analysis

The "master axis feedback analysis" feature is used to analyze a master axis encoder in the drive. The master axis encoder can be analyzed as an optional external measuring system instead of the motor encoder. It is used to detect the position of the vertical shaft in the case of only partial electronic coupling of printing groups or cylinders.

The actual position value of the master axis encoder is made available in parameter **P-0-0052, Position feedback value 3**. This parameter normally is configured as a cyclic data in the drive telegram and is therefore made available for the control unit. The control unit transmits the parameter to the drives as **P-0-0053, Master drive position** as a command value for the gear modes.

To use the external encoder as a master axis encoder, a 1 must be set in parameter **P-0-0185, Function of encoder 2**.

All those supported rotary measuring systems are allowed as master axis encoders the resolution of which can be represented by a power of 2 (2^n increments/rev). There is another restriction for encoders with SSI interface (**P-0-0075, Feedback 2 type** = 7): The resolution must be 4096 increments/rev.

Parameterizing the master axis encoder

The following parameters are available to parameterize the master axis encoder:

- **P-0-0075, Feedback 2 type**
- **P-0-0087, Offset position feedback value 3**
- **S-0-0115, Position feedback 2 type**
- **S-0-0117, Feedback 2 Resolution**

- **P-0-0185, Function of encoder 2**
- **P-0-0186, Position feedback value 3, smoothing time**
- **P-0-0765, Range of master encoder**
- **P-0-0766, Master encoder, monitoring window**

To use the optional encoder as a master axis encoder, a 1 must be entered in parameter **P-0-0185, Function of encoder 2**.

The parameter **P-0-0052, Position feedback value -3** displays the position of the master axis encoder.

The position feedback value -3 can be given an offset. Use the parameter **P-0-0087, Offset position feedback value 3** to do this.

The format of the actual position value 3 is 2^{20} increments per revolution, the format cannot be changed.

Determining the encoder interface of the master axis encoder

The **P-0-0075, Feedback 2 type** parameter is used to determine the encoder interface of the master axis encoder. The number of the encoder interface that is used has to be entered in this parameter.

If the number entered is "0" the encoder analysis is disabled.

Resolution of the master axis encoder

The resolution must be entered in parameter **S-0-0117, Feedback 2 Resolution**.

Parameterization of the resolution of the master axis encoder is only needed, if an encoder without encoder data memory is used.

Rotational direction of the master axis encoder

To parameterize the rotational direction of the master axis encoder use bit 3 of **S-0-0115, Position feedback 2 type**.

For inversion the bit has to be set.

Determining the master axis encoder range

Parameter **P-0-0765, Range of master encoder** determines the absolute range of the master axis encoder. The input is a factor of 2^{20}, the following applies: Modulo range of the master axis encoder = master axis range * 2^{20}. **P-0-0052, Position feedback value 3** then is within this range.

If the product of master axis encoder range is * 2^{20} smaller than the absolute range of representation of the master axis encoder (automatically specified by the selected encoder), bit 6 is set in parameter **S-0-0115, Position feedback 2 type** ("absolute encoder evaluation possible").

Setting absolute measuring of the master axis encoder

The setup of an absolute (see above) master axis encoder is realized by the parameters and the command:

P-0-0012, C300 Command Set absolute measuring

S-0-0054, Reference distance 2 (unit/scaling switched depending on P-0-0185)

S-0-0147, Homing parameter bit 3 determines which encoder the "Set absolute measuring" command will affect.

To monitor the absolute encoder function it is possible to parameterize a **P-0-0766, Master encoder, monitoring window**. In this parameter the maximum distance is entered by which the master axis encoder moves after it was switched off. The unit of the input value is increments with: LSB = 2^{-20} revolution. The input 0 switches the monitor off.

(See Functional Description "Set absolute measuring")

Smoothing the actual position value

The original position value can be smoothed using a low-pass filter. The time constant is determined by the **P-0-0186, Actual Position value 3, smoothing time** parameter.

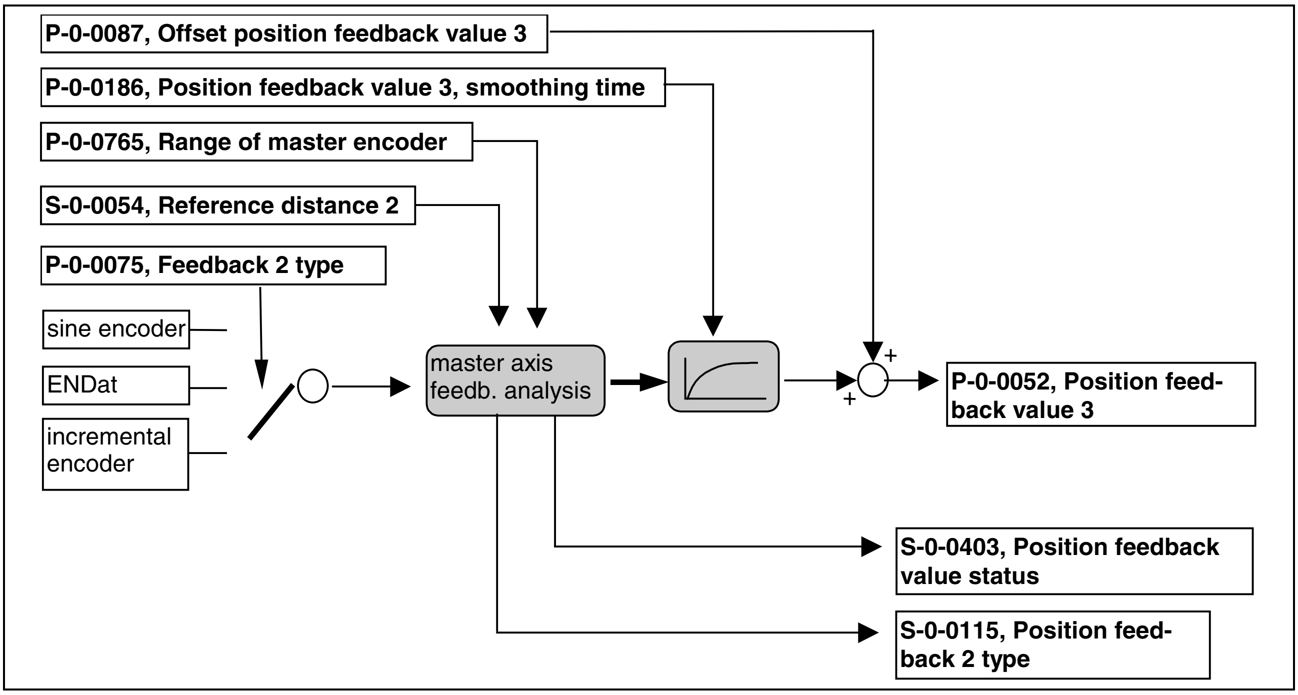


Fig. 8-48: Principle of master axis feedback analysis

Homing the master axis encoder

After being switched on, absolute measuring systems supply an absolute position and therefore do not have to be homed. A one-time setting of absolute measuring can set the desired position. In addition, the actual position can be offset using the parameter **P-0-0087, Offset position feedback value 3**.

Incremental measuring systems cannot be homed. Apart from the position status of the motor encoder (bit 1), the **S-0-0403, Position feedback value status** parameter contains the position status of the optional encoder (bit 2). This means that in bit 2 the position status of the master axis encoder is available. If an incremental measuring system is used as a master axis encoder, then its position status is always "0".

8.6 Drive error reaction

If an error is recognized in the drive controller, the controller reacts with a preset error reaction.

This drive error reaction depends on the error class of the current error and the setting of the parameters

- **P-0-0117, NC Reaction on Error**
- **P-0-0118, Power off on Error**
- **P-0-0119, Best Possible Deceleration**

Note: The error class determines whether the drive reaction parameterized as above can be carried out in the case of error or not.

There are 4 error classes, which have different priorities.

(see also "Error classes")

Error class	Diagnostic message	Drive reaction
Fatal	F8xx	The error reaction parameter settings in **P-0-0117, NC reaction on error** and **P-0-0119, Best Possible Deceleration** will be ignored, since a drive reaction is impossible. Torque/force is instantly cut off.
Travel range	F6xx	Independently of the settings in parameters **P-0-0117, NC reaction on Error** and **P-0-0119, Best possible deceleration**, the velocity command value is immediately set to zero. This reaction corresponds to the setting P-0-0117 bits 0 and 1 = 00 (no NC Reaction) P-0-0119 bits 0 and 1 = 00 (velocity command value reset). This setting provides the fastest possible deceleration of the axis if the travel range is exceeded.
Interface	F4xx	An NC reaction is impossible, since the communication with the NC became inoperative. The drive proceeds instantly with the deceleration procedure parameterized by **P-0-0119, Best possible deceleration** -or- if bit 1 has been set to the value "1" in **P-0-0117, NC reaction on error**, an error reaction is carried out via DISC macro (see also: "DISC – Drive macros").
Non-fatal	F2xx	The drive carries out the deceleration procedure set in **P-0-0117, NC reaction on error** and **P-0-0119, Best possible deceleration**. If NC reaction on error has been activated, then the drive continues to operate for 30 seconds after detecting an error, as if no error had been detected. The NC has this time to bring the axis to an NC-controlled standstill. The drive then carries out the reaction set in P-0-0119.

Fig. 8-49: Error reaction of the drive

Best possible deceleration

The drive reaction **P-0-0119, Best possible deceleration** is carried out automatically with

- interface errors F4xx
- non-fatal errors F2xx

At the end of each error reaction, the drive's torque is cut off.

With

- fatal errors F8xx
- travel range errors F6xx

P-0-0119, Best possible deceleration is ignored.

The following settings are possible:

Value of P-0-0119	Reaction
0	velocity command value reset
1	torque command value reset
2	velocity command value reset with command value ramp and filter

Fig. 8-50: Parameterization options for "Best possible deceleration"

The drive reaction, which is defined by "Best possible deceleration," determines the reaction of the drive if

- the drive enable signal changes from 1 to 0 (disable the drive enable) and
- the operating mode is switched to parameter mode while the drive is enabled (reset of the communication phase)

Velocity command value reset

P-0-0119, Best possible deceleration = 0

Given an error, the drive in velocity control will stop with command value = 0. The drive stops with its maximum permissible torque (see also chapter: "Current limit").

Failure reaction sequence with spindle brake present

The sequence for the motor brake activation (if available) and the power stage release with velocity command value reset (with spindle brake) are displayed below.

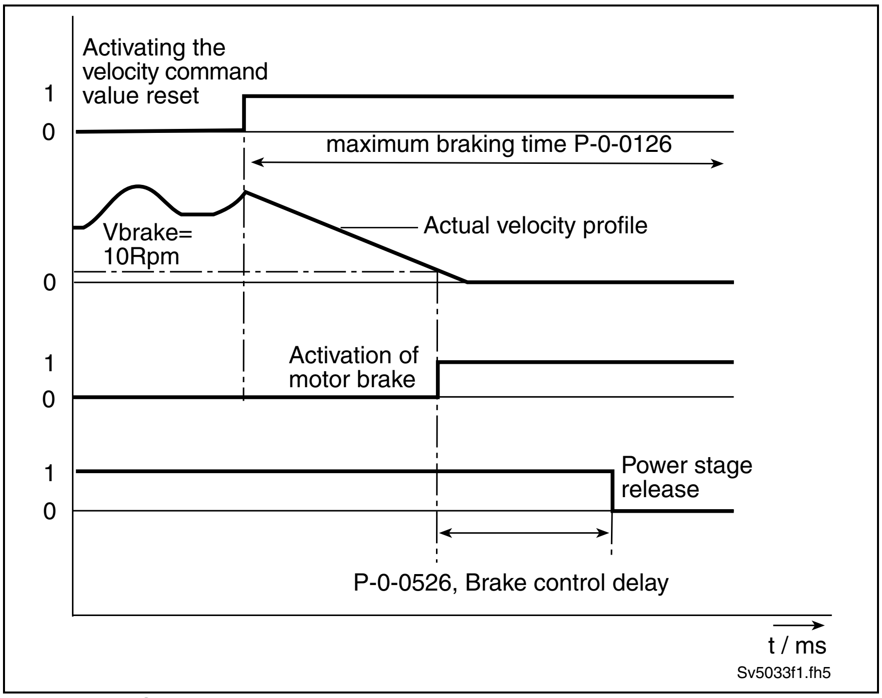


Fig. 8-51: Sequence of the velocity command value reset

Note: Activation of the motor holding brake depends on P-0-0525, bit 1.
see also chapter: "Motor holding brake"

Note: If the value entered in P-0-0126 is too small, then the error reaction could be terminated without axis standstill.

WARNING

Danger of damaging the motor brake if P-0-0126, Maximum braking time is set too low

⇒ The value for **P-0-0126, Maximum braking time** must always be set higher than the time needed to decelerate the axis with the velocity command value reset, taking maximum possible velocity into account.

Disable Torque

If "Best Possible Deceleration" is set to 1, then the drive is set to torque disable in case of an error. The brake will be activated instantly.

WARNING

Disable torque as error response when motor brake is connected

Danger of damaging the motor brake
Avoid setting this error reaction.

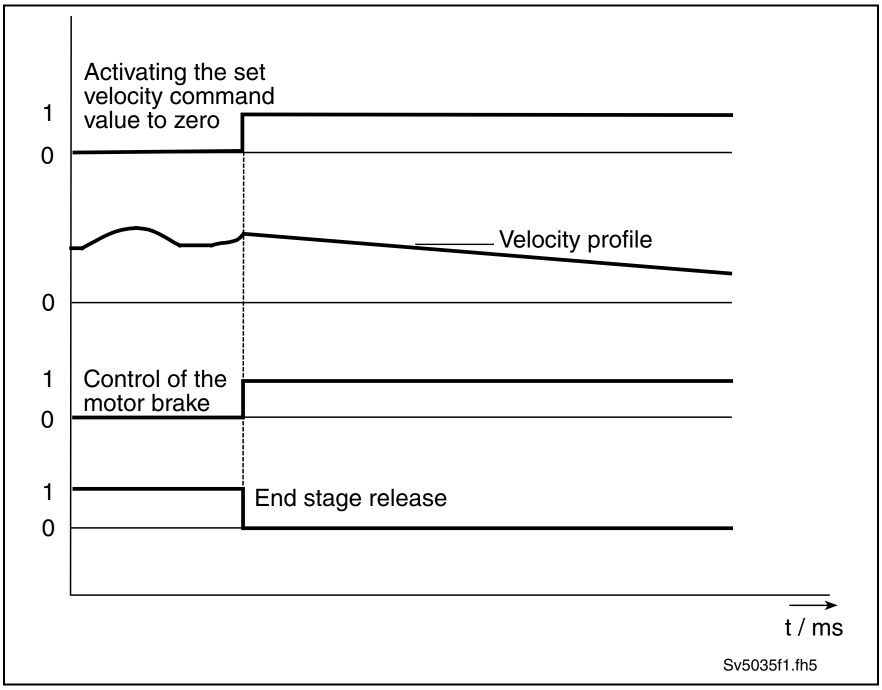


Fig. 8-52: Time sequence of torque disable

Velocity command value reset with filter and slope

If the setting for the "Best possible Deceleration" is 2, the drive will do a deceleration ramp to 0 velocity, if an error occurs. The acceleration or deceleration of the ramp is set with the parameter **P-0-1201, Ramp 1 pitch**. The velocity command passes through a jerk-limiting filter, whose time constant is defined with **P-0-1222, Command Value Smoothing Time Constant**.

The velocity profile is equal to the profile of the velocity control with comparison and filter with a preset value of 0.

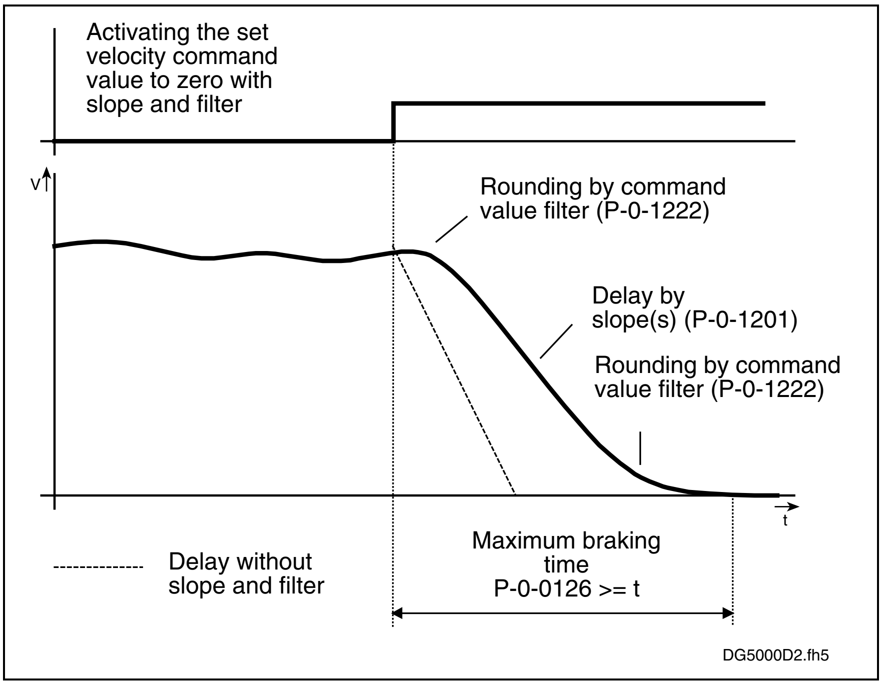


Fig. 8-53: Time sequence of velocity with activated filter

Note: You must ensure that the **P-0-0126, Max. braking time** is greater than the time needed by the drive to decelerate from its max. velocity to v = 0.

Example:

Vmax = 1000 Rev/min

ramp deceleration = 100 rad/s²

Time from 1000 Rpm to 0 Rpm =

$$\frac{\frac{1000}{60}\left[\mathrm{Rev}/\mathrm{s}\right] \times 2 \times \pi\left[\mathrm{rad}/\mathrm{Rev}\right]}{100\left[\mathrm{rad}/\mathrm{s}^2\right]} = 1.05\mathrm{s}$$

For the max. braking time in the previous example, we would propose 1.5s.

The time sequence of the control for the motor brake (if mounted) and the enable for the power stage is the same as for the velocity command reset.

(See also "Velocity Command Value Reset".)

Power off on error

In the case of modular units, via a signal line of the control voltage bus, the power supply unit can be informed as to whether the drive has detected an error that should lead to powering down. If the power supply unit receives such a message, then it shuts the DC bus voltage off. All other drives connected to the same power supply module also conduct the drive reaction as set in **P-0-0119, Best possible standstill**. This signaling of a drive error to the power supply unit can be set in the parameter **P-0-0118, Power off on error**.

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

Bit 1: 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. 8-54: P-0-0118, Power off on error

Units with extrinsic power supplies are signaled through connector X1, pin 2. If power off on error has been set, then bit 2 of compact units should be set to 1. The error message of the drive causes a mains separation meaning that the energy generated during braking cannot be fed back into the mains. Without a braking resistor (bleeder), the drives then coast to a standstill.

Using bit 1 of P-0-0118 it is possible to set when the error message from the drive to the power supply unit can be removed for the first time. If this bit is 1, then immediately after the basic initialization of the drive, the error reaction is removed and powering up thus becomes possible in communications phase 0. If bit 1 = 0, then the drive must be in communications phase 4 and error free before the error message to the power supply unit will be removed for the first time.

Reaction to Undervoltage

Bits 3 , 4 and 5 of parameter P-0-0118 offer the options on how to handle the undervoltage. Undervoltage happens when the drive is enabled (with torque) and signal for the DC bus voltage goes down.

With **bit 3 = 1**, undervoltage can be treated 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 the synchronized deceleration of several drives. The drive, in this case, does not signal a class 1 diagnostics error, and the reaction parametrized in **P-0-0119, best possible standstill** is not executed. Shutting the motor off brings about a slower drop in the DC bus voltage. This means that asynchronous motors can still retain a magnetic field once the control begins to bring the drives to a synchronized standstill. Braking takes place in generator mode.

If the undervoltage is treated as an error (bit 3, 5 = 0), then bit 4 can be used to set whether the error automatically clears itself once the control switches off the drive enable. This makes sense if the error also occurs during the course of a normal shutdown caused by the fact that the control does not clear the enable quickly enough.

With **bit 5 = 1**, you can suppress any reaction to the state of undervoltage. In this case, **only** a **warning** is generated.

NC Response in Error Situation

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**.

Note: NC response during an error situation is only possible during non-fatal errors. Otherwise the drive reacts immediately with an error response.

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. 8-55: 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 emergency stop feature is used to shutdown the drive through a hardware input on the drive controller. Parameter **P-0-0008, Activation E-stop function** is used to set this function**.**

After activation of the E-Stop Input (bit 0 = 1), the drive is prompted to perform the selected procedure to shutdown the drive. This reaction at first depends on bit 2 of P-0-0008.

If the interpretation "fatal warning" has been parametrized there (bit 2 = 1), then the drive responds as with switching off the external drive enable with the reaction parametrized in **P-0-0119, Best possible standstill**. 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.** Using parameter **S-0-0097, Mask class 2 diagnostic,** warnings can be masked in terms of their effects on the change bits. The functional principle at work when actuating the E-Stop input is that of a series connection to an external drive enable. In other words, when activating the E-Stop input, the drive responds as if the external drive enable had been 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**.

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, Reset class 1 diagnostics, or** key S1 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 and without delay, independent of p**arameter** P-0-0117, NC reaction on error.

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.**

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 **F634 Emergency-Stop.**

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 of the E-Stop-Function**.

The following applies:

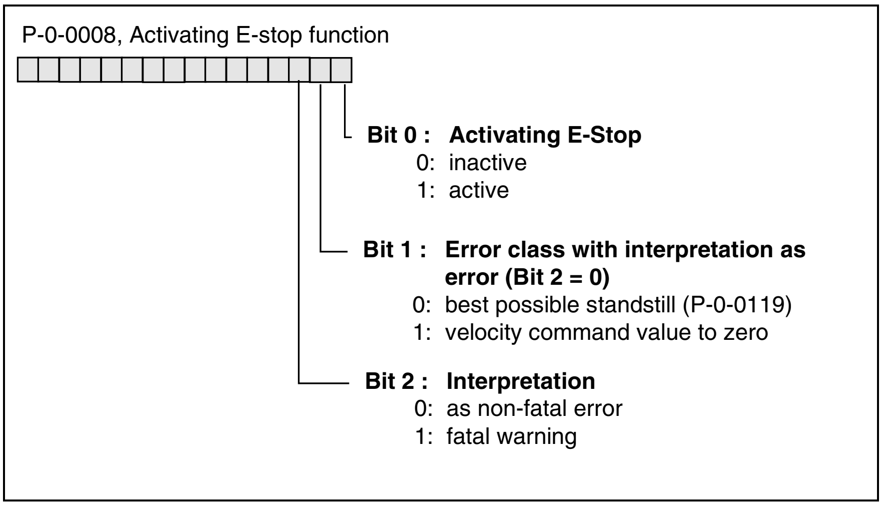


Fig. 8-56: P-0-0008, Activation of E-Stop-Function

The input polarity cannot be selected. It is always 0-active; i.e., 0 V on E6 of the connector means the E-Stop is active.

If the evaluation of the E-Stop signal is activated, the monitoring of +UL (external +24 V) is also activated, if it has not yet been active.

Connection of the Emergency-Stop Input

The drive controllers are provided with a binary input for the emergency-stop signal. You can find it on the plug-in module DSS 2.1. The input is galvanically separated and has to be supplied through the same connector (X 12) with +24 V.

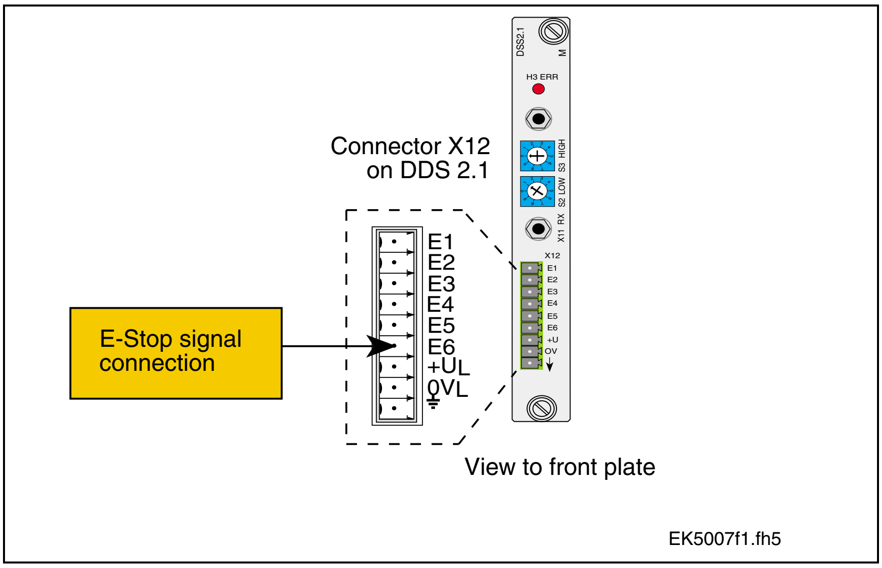


Fig. 8-57: Connection of E-Stop-Signal to X12

If the emergency stop input was activated but the 24 V supply failed, then the error **F273 Error power supply E-Stop** is generated.

8.7 Control Loop Settings

General Information for Control Loop Settings

The control loop settings in a digital drive controller are important for the characteristics of the servo axis.

Determining the control loop settings requires expert knowledge. For this reason, application-specific 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")

Note: "Optimizing" the regulator settings is generally not necessary!

In some exceptions, however, it may be necessary to adjust the control loop settings for a specific application. The following section gives a few simple but important basic rules for setting the control loop parameters in such cases.

In every case, the given methods should only be seen as guidelines that lead to a robust control 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:

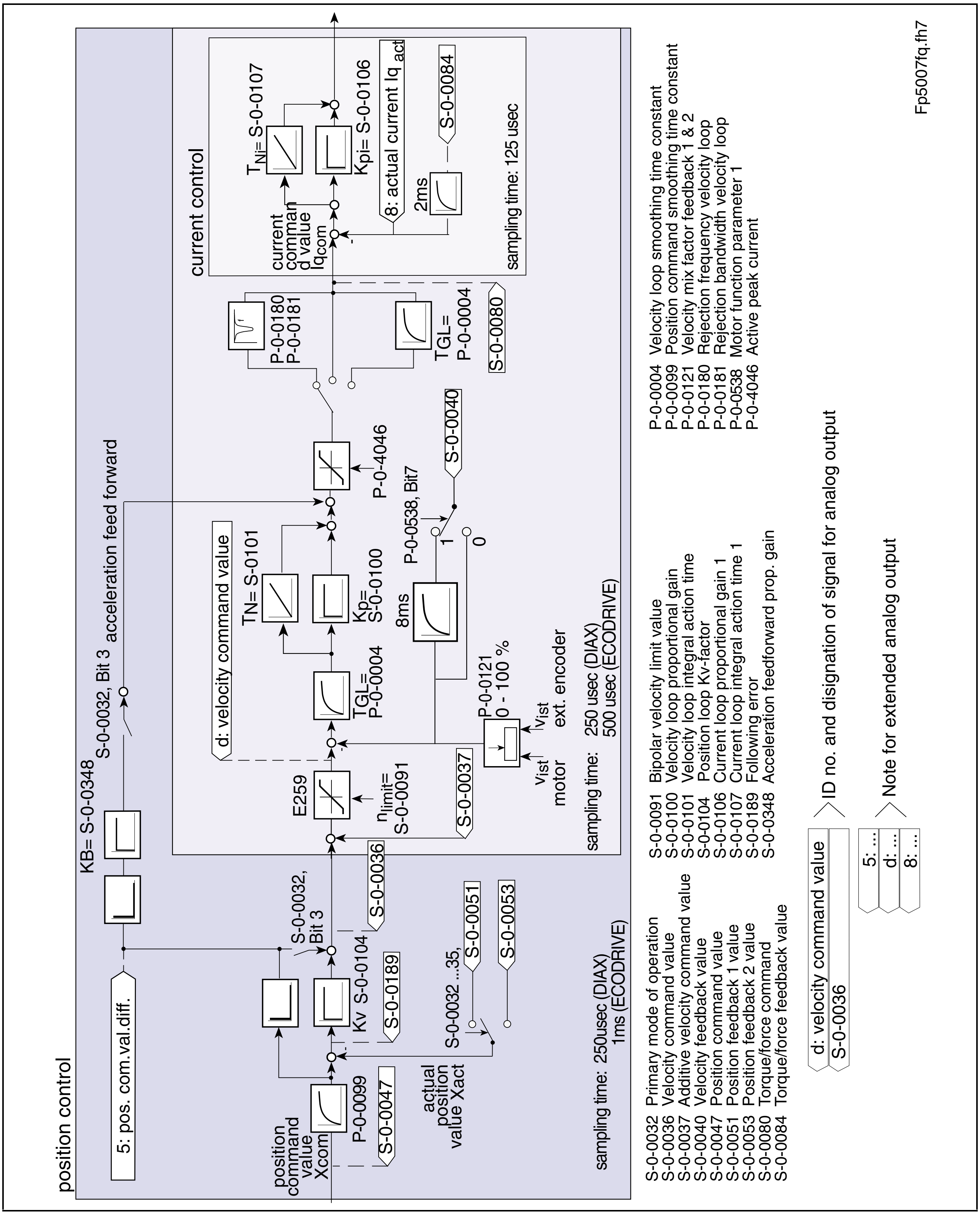


Fig. 8-58: Control structure

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 for the appropriate motor type used can be set.

Note: The parameters are pre-defined by the manufacturer for the moment of inertia relationship of $J_{own} = J_{load}$.

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**
- **P-0-0176, Torque/Force command smoothing time constant**
- **S-0-0104, Position loop Kv-factor**
- **P-0-0180, Rejection frequency velocity loop**
- **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-0-0141, Motor type**, which is read out of the data memory, with the value for parameter **S-7-0141, 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 secure a specific set of controller parameters is available.

Error **F208 UL The motor type has changed** can be reset in two different ways:

1.) executing the command
S-0-0099, C500 Reset class 1 diagnostic

2.) Actuating key S1

In both cases, the load base values function is activated.

If the execution of load base values is not posible, then the relevant command error of command **S-0-0262, C700 Command basic load** will appear**.**

(Also see section: "Error causes when executing load base value function").

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.

Note: This command cannot be run when the control enable signal is applied.

Error Conditions of the Load Default Settings Procedure

If the feature 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:
C701	Basic load (= load defaults) not possible if drive is enabled	At the start of the command, the controller enable is set, which is not allowed
C702	Default parameters not available	Basic load (or load defaults) is impossible for the motor type selected, only 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 not copyable	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. 8-59: Possible errors during Basic Load command

Note: If an error occurs during this procedure, then the default values for the indicated invalid parameters can be set. This serves safety purposes and helps in diagnosing additional errors.

Setting the Current Controller

The parameters for the current loop are set by 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

In order to be able to set the velocity controller, the current controller must have been correctly set.

The velocity controller is set via the parameters

- **S-0-0100, Velocity Loop Proportional Gain**
- **S-0-0101, Velocity Loop Integral Action Time**
- **P-0-0004, Smoothing Time Constant**
- **P-0-0180, Rejection frequency velocity loop**
- **P-0-0181, Rejection bandwidth velocity loop**

The setting can be made by:

- one-time execution of the "Load default" feature
- the procedure described below

Preparations for setting the velocity controller

A number of preparations must be made in order to be able to set the velocity controller:

- The mechanical system must be set up in its final form in order to have actual conditions while setting the parameters.
- The drive controller must be properly connected.
- The safety limit switches (if available) must be checked for correct operation.
- The "Operating mode: velocity control" must be selected in the drive.

Start settings

The controller setting must be selected for the start of parameterization as follows:

- **S-0-0100, Velocity Loop Proportional Gain** = default value of the connected motor.
- **S-0-0101, Velocity Loop Integral Action Time** = 0 ms (no integral gain)
- **P-0-0004, Smoothing Time Constant** = minimum value (= 250 µs) ➔ filter is switched off
- **P-0-0181, Rejection bandwidth velocity loop** = 0 Hz (deactivated)

Note: When determining the velocity controller parameters, the functions for torque and backlash compensation must not be active.

Definition of the critical proportional gain and smoothing time constant

After turning on the controller enable, let the drive move at a low velocity. rotary motors: 10...20 RPM, linear motors: 1...2 m/min)

Increase **S-0-0100, Velocity loop-proportional gain** until unstable behavior (continuous oscillation) begins.

Determine the frequency of the oscillation by oscilloscoping the actual velocity (see also chapter: "Analog output"). If the frequency of the oscillation is much higher than 500 Hz, increase the parameter **P-0-0004, Smoothing Time Constant** until the oscillation stops. After this, increase the **S-0-0100, Velocity Control Proportional Gain** until instability occurs again.

Reduce **S-0-0100, Velocity loop proportional gain** until the oscillation stops by itself.

The value found using this process is called the "critical velocity loop proportional gain".

Note: By inputting **P-0-0181, Rejection bandwidth velocity loop** = -1 a PT_2 filtering function can be activated. (see also block diagram with control loop structure in chapter: "General information for control loop settings").

Determining the critical integral action time

1. Set **S-0-0100, Velocity loop proportional gain** = 0.5 x "critical proportional gain"
2. Reduce **S-0-0101, Velocity loop integral action time** until unstable behavior results.
3. Increase **S-0-0101, Velocity loop integral action time** until continuous oscillation stops.

The value determined through this process is called the "critical integral action time."

Determining the velocity controller setting

The critical values determined before (see "Determining the critical integral action time" and "Definition of the critical proportional gain and smoothing time constant") can be used to derive a control setting with the following features:

- Independent from changes to the axis since there is a large enough safety margin to the stability boundaries.
- Safe reproduction of the characteristics in series production machines.

The following table shows some of the most frequently used application types and the corresponding control loop settings.

Application Type	Velocity controller proportional gain	Velocity loop Integral Action Time	Comments
Feed axis on standard tool machine	$K_p = 0.5 \times K_{pcrit}$	$T_n = 2 \times T_{ncrit}$	Good stiffness and good command response
Feed axis on perforating press or chip-cutter machines	$K_p = 0.8 \times K_{pcrit}$	$T_n = 0$	High proportional gain; no I-part, to achieve shorter transient recovery times.
Feed drive for flying cutting devices	$K_p = 0.5 \times K_{pcrit}$	$T_n = 0$	Relatively non-dynamic control setting without I-part, to avoid structural tension between the part to cut off and the cutting device.

Fig. 8-60: Identification of velocity controller settings

Filtering oscillations from mechanical resonance

The drives are able to suppress oscillations caused by the drive train between the motor and the axis or spindle mechanics over a narrow frequency band. Thus, increased drive dynamics with good stability can be achieved.

With distortion-resistant drive mechanics, the mechanical system of rotor-drive train-load is induced to generate mechanical oscillations as a result of position/velocity feedback in a closed control loop. This behavior identified as a "two mass oscillator" is generally within the 400-800 Hz range, depending on the rigidity and spatial volume of the mechanical system.

This "two mass oscillation" usually has a clear resonance frequency which can be specifically suppressed by a rejection filter installed in the drive.

When suppressing the mechanical resonance frequency, the dynamics of the velocity and position control loops in terms of control can be significantly improved compared to without a rejection filter.

This results in greater contour accuracy and smaller cycle times for positioning processes, leaving sufficient stability margin.

The filter can be set in rejection frequency and bandwidth. The rejection frequency is the one with highest attenuation, the bandwidth determines the frequency range with which the attenuation is less than -3 dB. Greater bandwidth leads to smaller band attenuation of the rejection frequency! The following parameters can be used to set both values:

- **P-0-0180, Rejection frequency velocity loop**
- **P-0-0181, Rejection bandwidth velocity loop**

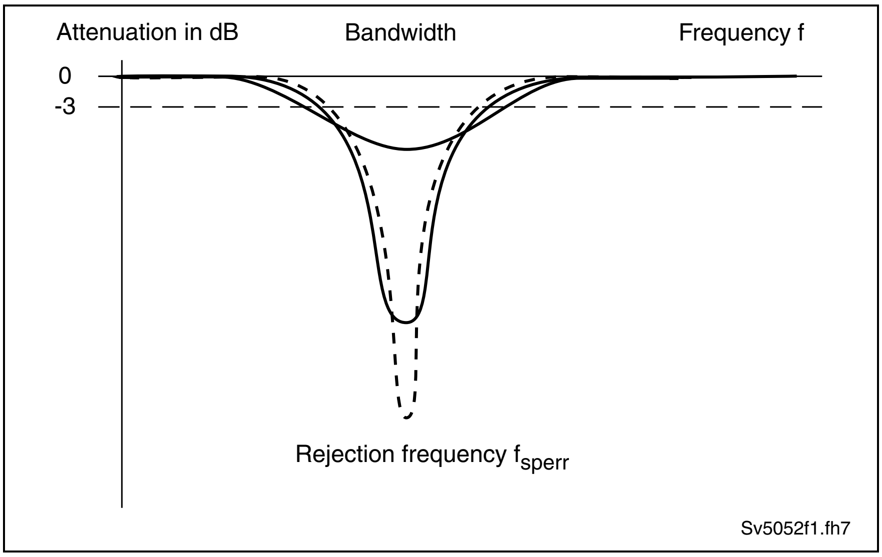


Fig. 8.61: Amplitude response of the rejection filter in terms of bandwidth, qualitative

To set the band filter, we recommend the following procedure:

Presetting

Set rejection filter inactive.

Enter the value "0" in parameter **P-0-0181 Rejection bandwidth velocity loop**.

Determine resonance frequency

Connect oscilloscope to analog output channels, assign velocity feedback value to analog output 1 (enter "S-0-0040" in **P-0-0420, Analog output 1, signal selection** and enter the desired scaling, e.g. 100 rpm/10 V in **P-0-0422, Analog output 1 scaling**).

- or -

Use the oscilloscope function of the drive to display velocity feedback value. This can be read out directly by an FFT of the frequency response.

Excite the drive mechanics, e.g. tap lightly and tangentially with a rubber hammer.

Record the time of the velocity oscillations with an oscilloscope or oscilloscope function and analyze for clearly salient frequencies. If the oscilloscope function is used, then the resonance frequency can be directly read out of the frequency readout.

Determining the initial state of the loop

Set the drive enable signal and optimize the velocity loop with inactive rejection filter (see "Setting the velocity controller").

Record step response of the velocity feedback value and the torque/force generating command current with a small velocity command step (the torque-generating command current is not allowed to reach the limit during this process).

Turn rejection filter on and check the effect

Enter the most salient frequency in Hz in parameter **P-0-0180, Rejection frequency velocity loop**.

Enter a minimum bandwidth in parameter **P-0-0181, Rejection bandwidth velocity loop** (e. g. 25 Hz).

Record the previous step response again.

If the step response features less overshoot and shorter periods of oscillation, then:

Check whether increasing the value of **P-0-0181, Rejection bandwidth velocity loop** causes an improvement.

- or -

Check whether a change in the value of **P-0-0180, Rejection frequency velocity loop** causes an improvement.

If the step response results in the same behavior, then:

Check the resonance frequency analysis

- or -

Clearly increase the value in **P-0-0181, Rejection bandwidth velocity loop**.

Optimize rejection filter or velocity loop

With the pre-optimized values of **P-0-0180, Rejection frequency velocity loop** and **P-0-0181, Rejection bandwidth velocity loop**, optimize the velocity controller again (see above).

The step response defined above must have a similar appearance with higher values for **S-0-0100, Velocity loop proportional gain** and / or smaller values for **S-0-0101, Velocity loop integral action time**.

An additional optimizing run may be necessary for **P-0-0180, Rejection frequency velocity loop** and **P-0-0181, Rejection bandwidth velocity loop** using the step response.

Filtering with double smoothing filter

Optimization of the control loop with a rejection filter does not always make the regulation good enough. This happens for example when the closed loop does not have significant resonance frequencies. Activation of a second smoothing filter (with PT1 characteristics) can, depending on the case, improve the regulation quality as desired.

To do this, set the parameter **P-0-0181, Rejection bandwidth velocity loop** to -1. The rejection filter as well as the assigned parameter **P-0-0180, Rejection frequency velocity loop** are deactivated. Instead of the rejection filter, a smoothing filter is activated in the control loop. This uses the same smoothing time constant (T_{gl}) as the smoothing filter **P-0-0004, Velocity loop smoothing time constant**. Together with the smoothing filter at the input of the velocity controller, you obtain a filter with PT2 characteristics. Frequencies greater than the cut-off frequency ($f_g = 1/2\pi T_{gl}$) are much more suppressed and cannot excite oscillations in the control loop any more.

The parameter for the filter is **P-0-0004, Velocity loop smoothing time constant**.

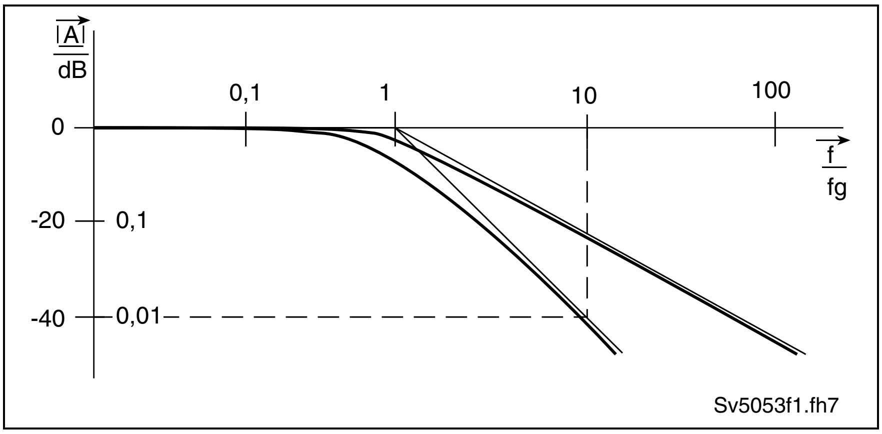


Fig. 8-62: Frequency response of a PT1 and PT2 filter

Note: The setting is the same as described under "Definition of the critical proportional gain and smoothing time constant".

Velocity control loop monitoring

If the velocity control loop monitor detects a fault in the velocity control loop, then error

- **F878 Error in velocity control loop**

is generated.

Note: The velocity control loop monitor is only active with operating modes with which the velocity control loop in the drive is closed (i.e. always except with torque control) and monitoring activated.

Activating the monitor

The velocity control loop monitor is activated with parameter **P-0-0538, Motor function parameter 1**.

The structure of the parameter:

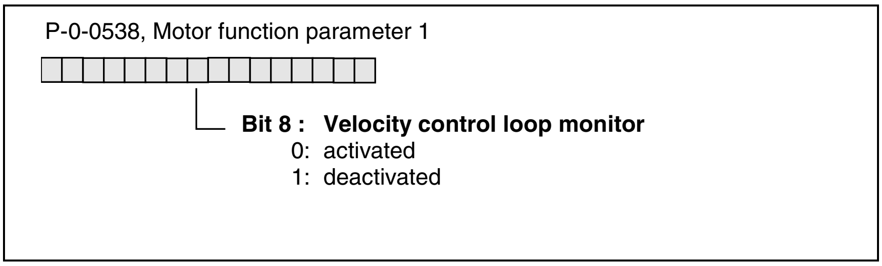


Fig. 8-63: P-0-0538, Motor function parameter 1

Note: It is highly recommended not to deactivate the velocity control loop monitor activated at the factory, as it represents a basic safety function of the drive!

Causes of a monitor trigger

The velocity control loop monitor is designed to be triggered in the case of those faults that lead to the wrong direction of rotation of the motor torque. The following options are basically possible:

- incorrect polarity with motor connection
- wrong commutation angle
- faults in the velocity encoder

Note: This prevents the "runaway effect" of the motor.

Criteria for triggering the monitor

One of the following criteria must be met for the velocity control loop monitor to be triggered:

- current command value limited to **P-0-4046, Active peak current**
- motor accelerating in the wrong direction
- actual velocity value is greater than 0.0125-times the maximum motor velocity.

Position controller

The position deviation is generated from the effective position command value, that is generated from the respective generator function of the active operating mode, and the position feedback value (encoder 1 or encoder 2) used for control.

The position deviation is transmitted to the position controller the gain of which is set via **S-0-0104, Position loop Kv-factor** (see chapter: "Setting the position controller").

Meaning of bit 3 of the operating mode parameters (S-0-0032...S-0-0035)

Bit 3 of the operating mode parameters (S-0-0032..35) indicates whether a path is to be traveled with lag distance or laglessly:

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

The following figure shows how the velocity feedforward works: By means of differentiation, a velocity value is calculated from the position command values. This value is a velocity command value with which the new position command value can be reached within one position controller cycle. One position controller cycle after this feedforward value has been transmitted to the velocity controller, the position command value is entered for the position controller. This means that the drive has already reached the new position command value, when it is entered for the position controller, and the lag is clearly reduced ("lagless").

With lagless position control, an acceleration-related feedforward proportion can be added by means of parameter **S-0-0348, Acceleration feedforward gain**. The feedforward proportion is generated with another differentiation according to the velocity feedforward.

(see also chapter: "Setting the acceleration feed forward")

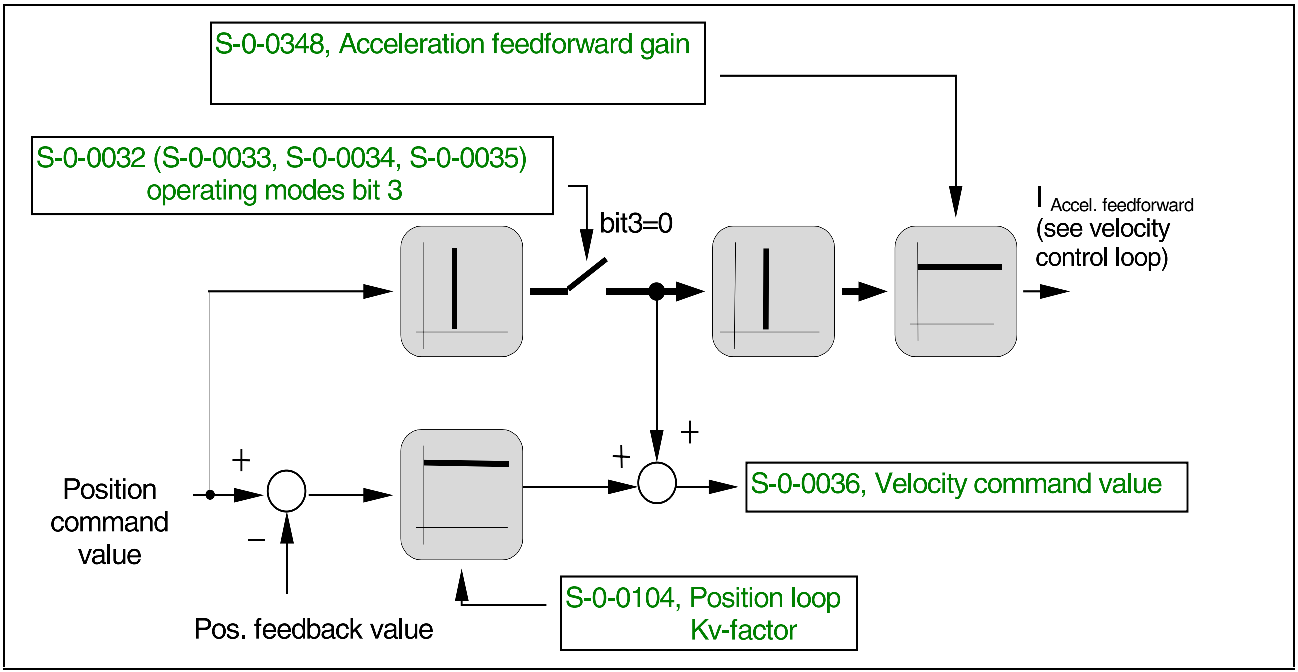


Fig. 8-64: Position controller

see also chapter: "Velocity controller"

see also chapter: "Current controller"

Rexroth Indramat

Setting the position controller

Pre-requisite In order to set the position controller correctly, current and velocity controller must be correctly set.

The position controller can be set with the parameter

- **S-0-0104, Position loop Kv-factor**

This can be set by either executing the "load default" feature once or by following the process below.

Preparations for setting the position control loop

A number of preparations must be made in order to be able to set the position controller properly:

- The mechanical system of the machine must be definitely assembled, in order to have original conditions for parameter definition.
- The drive controller must be properly connected.
- The safety limit switches (if available) must be checked for correct operation.
- Operate the drive in a mode that closes the position loop in the drive ("Operating mode: Position control").
- The outer velocity controller must be properly tuned. The start value chosen for the K_v factor should be relatively small (K_v = 1).
- For the determination of the position controller parameter, no compensation function should be activated.

Determining the critical position controller gain

- Move axis at a slow velocity, e. g. with a jog function at the connected NC Control (rotary motors: 10...20 Rpm, linear motors: 1...2 m/min).
- Raise the K_v factor until instability occurs.
- Reduce the K_v factor until the continuous oscillation stops by itself.

The K_v factor determined through this process is called the "Critical position control loop gain (K_{vcrit})**".**

Determining the position controller setting

In most applications, an appropriate position controller setting will lie between 50% ... 80% of the critical position controller loop gain.

This means:

S-0-0104, Position loop Kv-factor = 0.5...0.8 x K_{vcrit}

Position control loop monitoring

The position control loop monitor is used to diagnose errors in the position control loop.

Reasons for triggering the position control loop monitor can be:

- Exceeding the torque or acceleration capability of the drive.
- Blocking of the axis' mechanical system
- Failures in the position encoder

The position control loop monitor is only active when an operation mode with closed position loop in the drive is active.

To set and diagnose the monitoring function, two parameters are used:

- **S-0-0159, Monitoring Window**
- **P-0-0098, Max. Model Deviation**

If the position control loop monitor detects an error in the position control loop, the error message

- **F228 Excessive deviation**

is generated.

General operating characteristics of the position control loop monitor

To monitor the position control loop, a model position feedback value is computed in the drive while the position control loop is closed, which depends only on the preset position command value profile and the set control loop parameters. This model position feedback value is compared continuously to the position feedback value that is used for control. If the deviation exceeds **S-0-0159, Monitoring Window** during **4 ms** error **F228 Excessive deviation** will be generated.

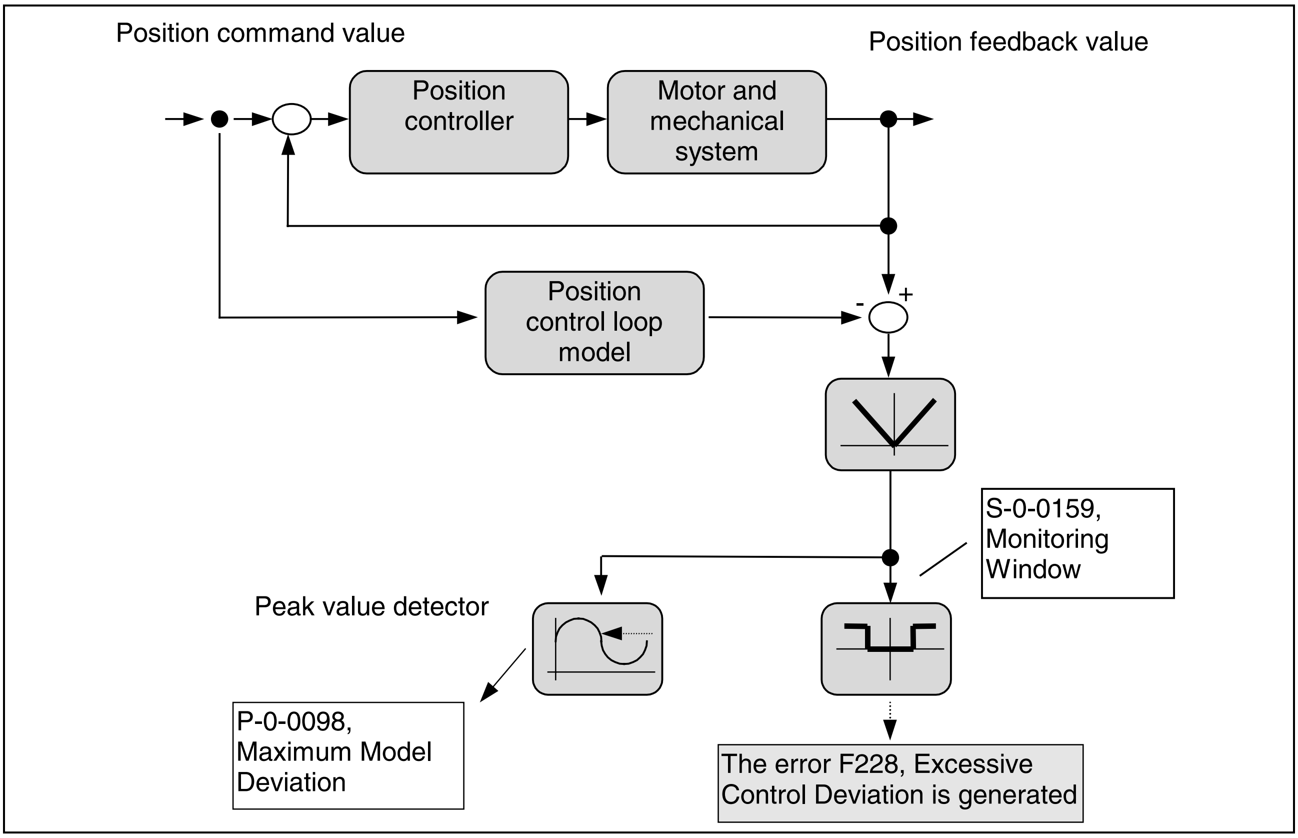


Fig. 8-65: Schematic of position control loop monitor

Note: For monitoring, the feedback value used for position control is always used, this means that for position control with the motor encoder, position feedback value 1 is used, and for position control with the external encoder, the position feedback value 2 is used.

Setting the position control loop monitor

Requirements

Requirements for the setup of the position loop monitoring are

- Check the velocity and position control loops for their appropriate settings before setting the position control loop.
- The respective axis should be checked mechanically.

Setting

The position control loop monitor setting should be carried out as follows:

- Through the connected control, you should proceed in a typical operation cycle. In this mode, move at the maximum projected velocity.
- Parameter **P-0-0098, Max. Model Deviation** always displays the maximum deviation between the position feedback value and the expected position feedback value.

Note: The contents of parameter P-0-0098 is saved in the volatile memory, i.e. after switching the drive on, the contents of this parameter equals zero.

- This value can be used to help set the monitoring window. Parameter **S-0-0159, Monitoring Window** is to be set to **P-0-0098, Max. Model Deviation** multiplied by a safety factor. A safety factor between 1.5 and 2.0 is recommended.

Example:

P-0-0098, Maximum Model Deviation = 0.1°

⇒ S-0-159, Monitoring Window = 0.2° (= 2 x 0.1°)

Deactivation of the position control loop monitor

It is strongly recommended to activate the position control loop monitor.

However, there are exceptions for which the position control loop monitor must be deactivated. You can do this by entering very high values for parameter **S-0-0159, Monitoring Window**.

Note: By default, the position control loop monitor is active.

Setting the acceleration feed forward

For Servo applications, where high precision at high speeds counts, you have the option to greatly improve the precision of an axis during acceleration and braking phases through activation of the acceleration feedforward.

Typical applications for the use of the acceleration feedforward:

- Free form surface milling
- Grinding

To set the acceleration feedforward, use the parameter

- **S-0-0348, Acceleration feedforward gain**

Requirements for a correct setting of the acceleration feedforward

- Velocity and position control loop have to be set appropriately.
- For the position controller, lagless operation mode must be selected.
- If frictional torque compensation is to be activated, you must do this before setting the acceleration feedforward, because a reversed procedure can limit the effect of the acceleration feedforward.

Setting the acceleration feed forward

Setting the correct acceleration feedforward can only be done by the user since it depends on inertia.

The setting is done in two steps:

Calculation of a guide value for acceleration feedforward

1. For the calculation of the guide value for the acceleration feedforward you need the value of the total inertia momentum translated to the motor shaft (J_{Motor}+J_{Load}) of the axis. This value is known approximately from the sizing of the axis. Additionally, you need the torque constant of the used motor. This data can be retrieved from the motor data sheet or the parameter **P-0-0051, Torque/force constant**. The guide value is calculated as:

$$\text{Acceleration feedforward} = \frac{J_{Motor} + J_{Load}}{Kt} \times 1000$$

Acceleration feedforward [mA\rad\s²]

J_{Motor}:	Inertia of the motor [kg m²]	(P-0-0510)
J_{Load}:	Inertia of the load [kg m²]	(P-0-4010)
Kt:	Torque constant of the motor [Nm/A]	(P-0-0051)

Fig.8-66: Guide value for the acceleration feedforward

The determined guide value is to be entered in parameter **S-0-0348, Acceleration feedforward gain**.

Checking the effect of the acceleration feedforward and, if necessary, fine tuning of parameter S-0-0348

2. The deviation of the position feedback value from the position command value can be displayed through the analog diagnostic outputs of the drive controller or the oscilloscope function. To check the effect of the acceleration feedforward, you must oscilloscope this signal during movement of the axis along the desired operation cycle. In acceleration and braking phases, the feedforward must reduce the dynamic control deviation drastically.

Setting the velocity mix factor

With the help of the velocity mix factor, you can combine the values of motor measuring system and external measuring system to obtain the velocity feedback value used for velocity control. This might be an advantage, when there is play or torsion between motor and load.

To set the mixing ratio, use the parameter

- **P-0-0121, Velocity mix factor feedback1 & 2**

Note: This function is only applicable when there is an external measuring system. If there is no external measuring system available, **P-0-0121** is automatically set to 0 %.

The mixture of the velocity feedback value can be continuously varied between:

100 % velocity feedback value of the motor encoder	...	0 % feedback value of the external encoder (P-0-0121 = 0)

AND

0 % velocity feedback value of the motor encoder	...	100 % feedback value of the external encoder (P-0-0121 = 100)

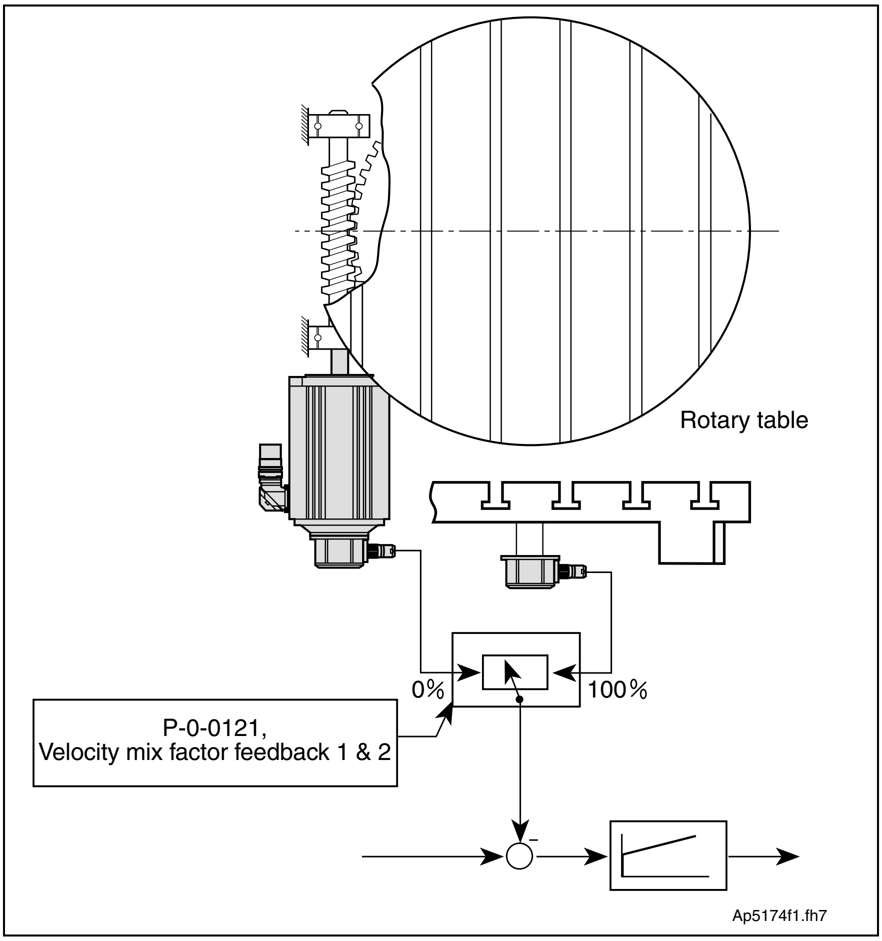


Fig. 8-67: Functional principle velocity mixing

8.8 Drive Stop

The drive halt feature serves to stop the axis with defined acceleration and defined jerk.

The feature is activated either through deletion of the /drive_halt bit (bit 13) in the master control word or through interruption of the drive control commands (i.e., drive-controlled homing).

The following parameters are used:

- **S-0-0138, Bipolar Acceleration Value**
- **S-0-0349, Jerk limit bipolar**

For diagnostics, the following parameters are used:

- **S-0-0124, Standstill Window**
- **S-0-0182, Manufacturer Class 3 Diagnostics**

Drive Halt Feature Description

If in the master control word bit 13 is changed from 1 to 0, then this feature will be activated. The drive no longer follows the command values of the active operating mode, but changes to position control and decelerates the axis with the parameters **S-0-0138, Bipolar Acceleration Value** and **S-0-0349, Jerk limit bipolar**. The LEDs display **AH**, and the diagnostic message in S-0-0095 is **A010 Drive HALT**.

If the actual velocity falls below the value of the parameter **S-0-0124, Standstill Window**, the bit "Drive Halt Confirmation" will be set in **S-0-0182, Manufacturer Class 3 Diagnostics**.

If bit 13 in the master control word is reset to 1, the selected operation mode will be reactivated.

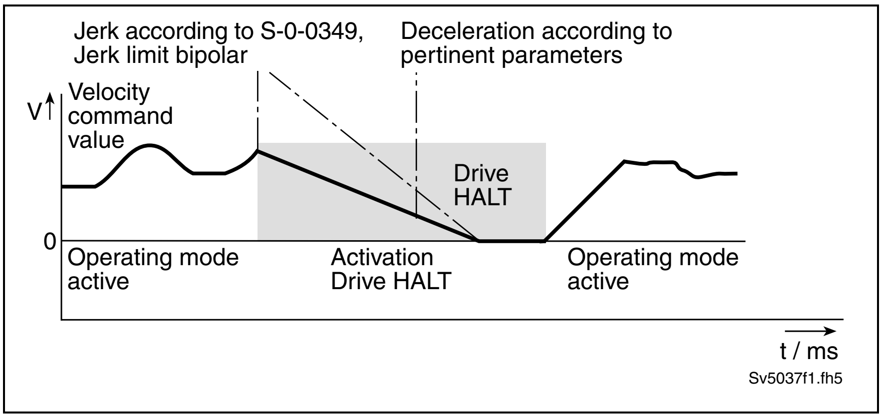


Fig. 8-68: Drive Halt Diagram

The position-controlled deceleration is done with lag, if the previous operating mode was with a lag. In the other case, this feature proceeds without lagless control.

8.9 Drive-Controlled Homing

The position feedback value of the measuring system to be referenced forms a coordinate system. This system does not comply with the machine coordinate system after the drive has been initialized, as long as no absolute encoders are used. To establish congruence between drive (measuring system) and machine coordinate system use the **S-0-0148, C600 drive-controlled homing procedure command**.

Drive-controlled homing means that the drive independently creates the necessary motion, which corresponds to the homing velocity settings and homing acceleration settings.

This feature can be executed for either the motor encoder or the optional encoder.

To run this feature, use the following parameters:

- **S-0-0148 C600 Drive-controlled Homing Command**
- **S-0-0147, Homing Parameter**
- **S-0-0298, Reference Cam Shifting**

- **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 also can be used:

- **S-0-0108, Feedrate Override**
- **S-0-0057, Positioning Window**
- **P-0-0099, Position Command Smoothing Time Constant**
- **S-0-0403, Position Feedback Value Status**

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
- evauation of the marker yes/no

The parameter is structured as follows:

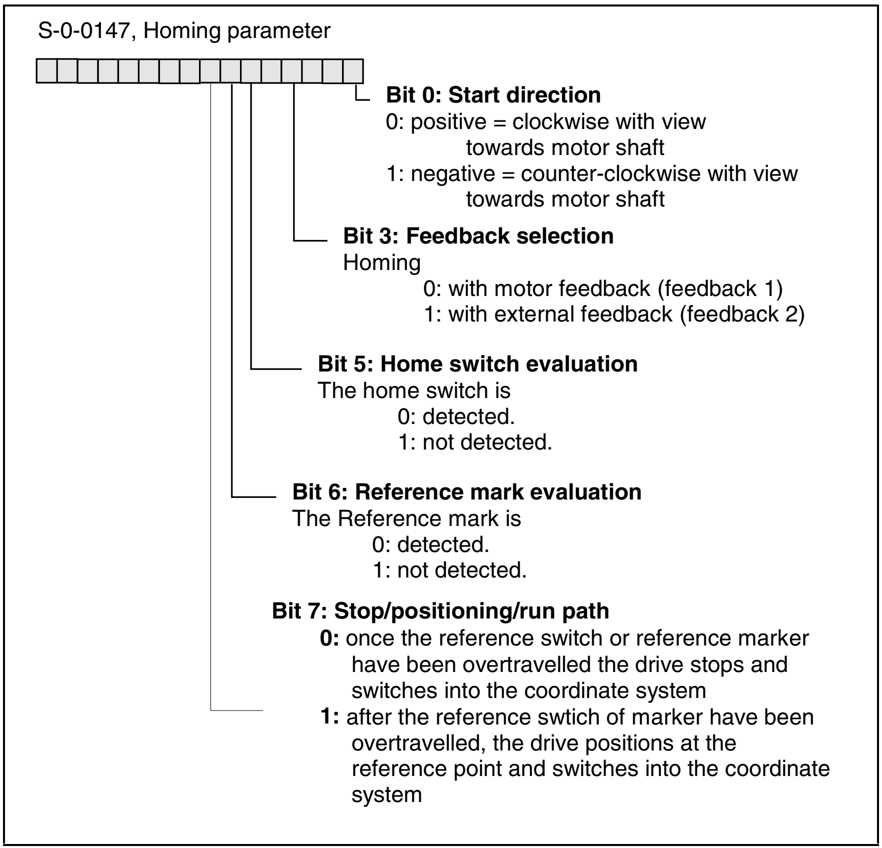


Fig. 8-69: Structure of parameter S-0-0147, Homing parameter

The sequence also depends on the type and arrangement of the reference markers in terms of the referenced encoder. For distance-coded reference marks (type 4), the reference switch is not evaluated, even if this is selected in S-0-0147.

Overview about Type and Configuration of Homing Marks in the Measurement System

For better 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 and the GDS measurement system.

- **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 parameter** (for motor encoder) or **S-0-0115, Position feedback 2 type parameter** (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.

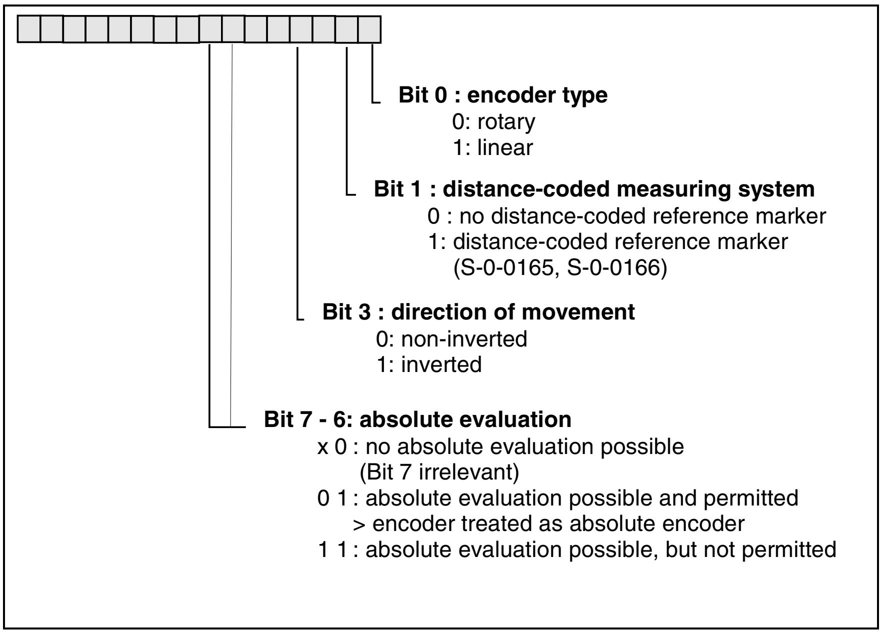


Fig. 8-70: Structure of the position feedback type parameters S-0-0115 / S-0-0277

For measurement systems with their own data memory (Type 1), this setting is done automatically.

See also "Setting the Measurement System".

Functional principle of drive-controlled referencing

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 compensation 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".

- 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 is in parameter S-0-0052/ S-0-0054.
- 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 comply.

By switching the position command and feedback value, **S-0-0403, Position feedack 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 p**arameter 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.

Sequence control "Drive-Controlled Homing"

The command profile depends on the parameters

- **S-0-0041 Homing velocity ,**
- **S-0-0108 Feed rate override and**
- **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 **P-0-0099, Position command smoothing time constant**.

The following diagram explains this:

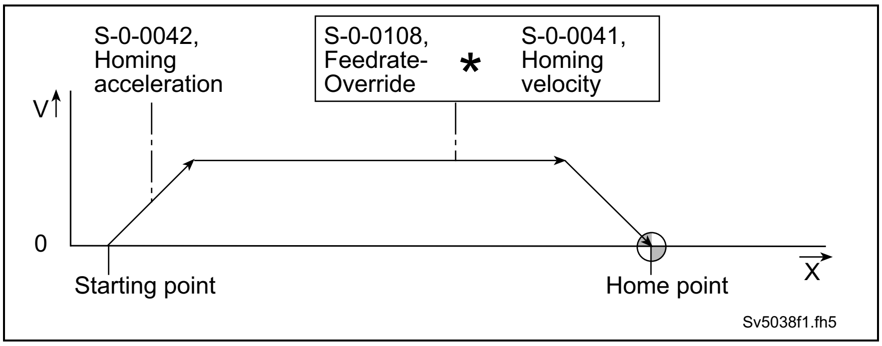


Fig. 8-71: Position command profile with homing velocity and homing acceleration

The maximum velocity is influenced, like 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**.

If the parameter S-0-0108, Feedrate-Override has been set to zero, the warning **E255 Feedrate-override S-0-0108 = 0** will be displayed.

The motional process during drive-controlled homing 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 edge is within the reachable travel range.

- If real 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).
- The further action depends on how bit 7 has been set in **S-0-0147, Homing parameter**. If 0 is programmed there ("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. If a 1 is set in bit 7, ("Drive travels to reference point“), then the drive positions to the reference point. The reference point in encoders of the types 1 to 3 is defined by the position of the reference mark plus the relevant reference offset (S-0-0150 / S-0-0151). In the case of distance-coded reference markers, the drive runs to the second detected mark. The coordinate system switch and the completion message of the command are generated as soon as the drive-internal position command has reached the target value and the difference between feedback and target value is less than the value set in **S-0-0057, Position window.**

The following illustrates the sequence for "Drive goes to reference point"

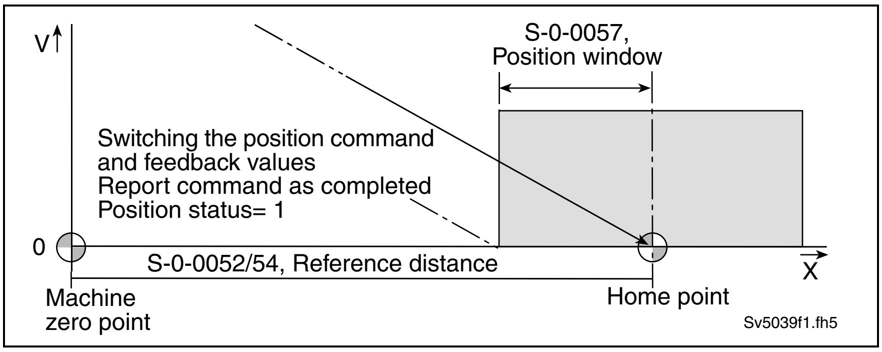


Fig. 8-72: Switching of position command and actual feedback values

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. 8-73: 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,

- 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 **S-0-0052, Reference distance 1** or **S-0-0054, Reference distance 2** as well as parameter **S-0-0150, Reference offset 1** or **S-0-0151, Reference offset 2** with 0.

⇒ 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!**

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 set 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)

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.

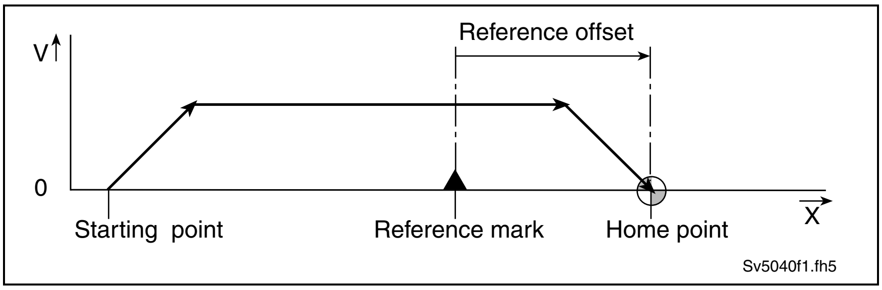


Fig. 8-74: Command value profile for positive reference offset and positive homing direction

If the reference direction is negative, then the drive can reverse the direction (with types 2 and 3) after passing the reference marker.

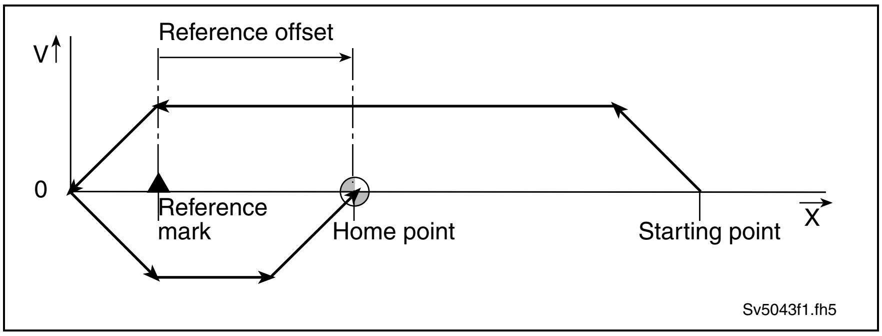


Fig. 8-75: Command profile for positive reference offset and negative homing direction

If the reference offset is negative, then its drive-internal direction is negative (see "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.

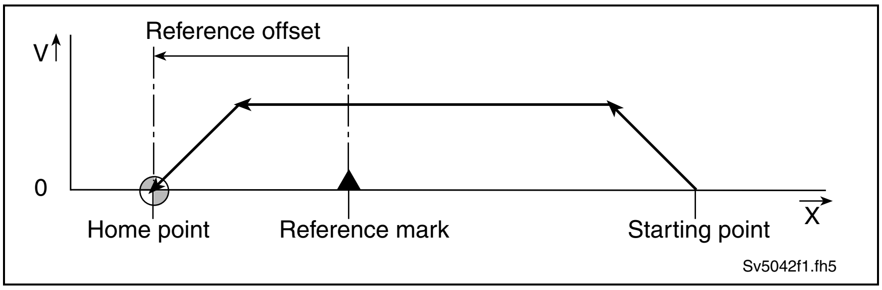


Fig. 8-76: Command profile with negative reference offset and negative homing direction

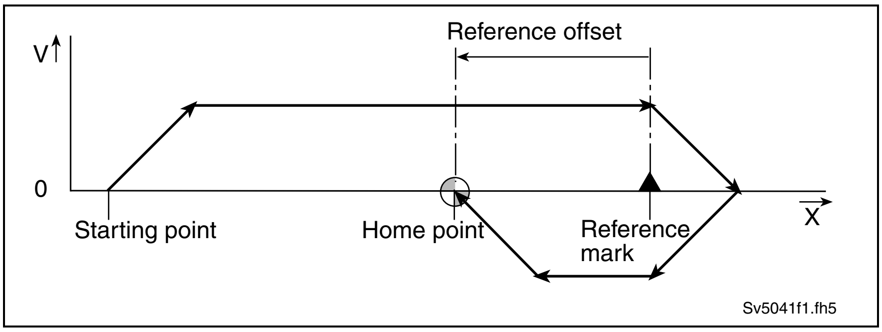


Fig. 8-77: Command profile with negative reference offset and positive homing direction

Evaluation of the Home Switch

A home switch can label a specific marker, if the configuration of several reference marks for the homing is ambiguous. If the home switch is evaluated (bit 5 in S-0-0147 = 0), then that reference mark will be evaluated, which follows the positive edge of the home switch (if the drive is moving towards the homing point).

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

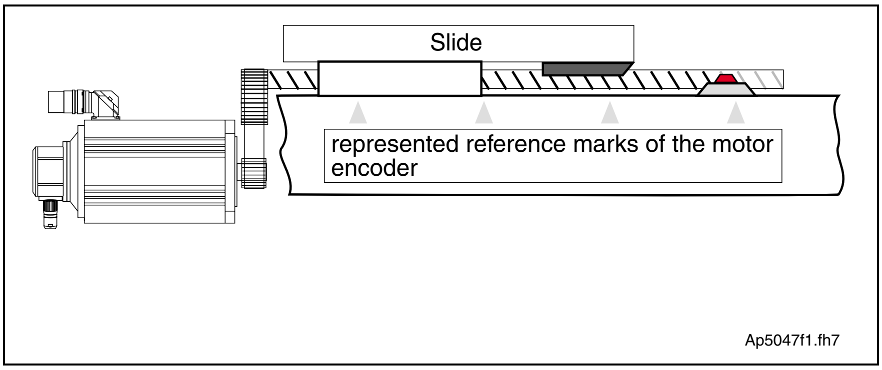


Fig. 8-78: Selection of a reference mark depending on the homing direction

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.

The homing direction must be set so that the positive edge can be found.

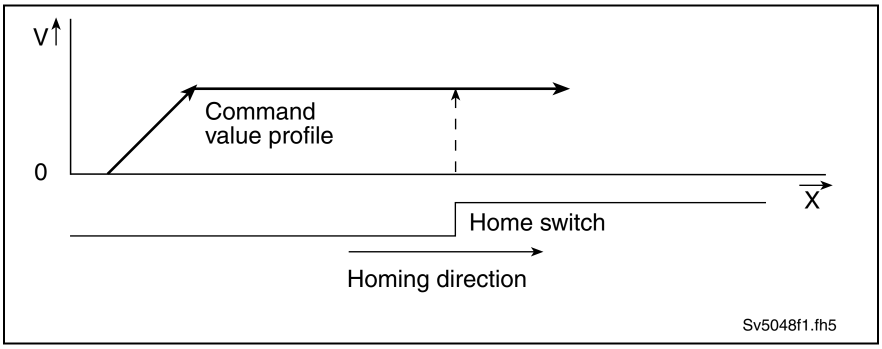


Fig. 8-79: Correct setting of homing direction

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!

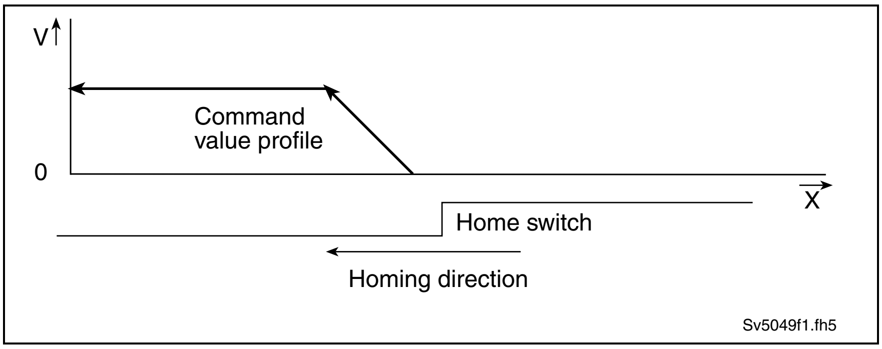


Fig. 8-80: Incorrectly set homing direction

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.

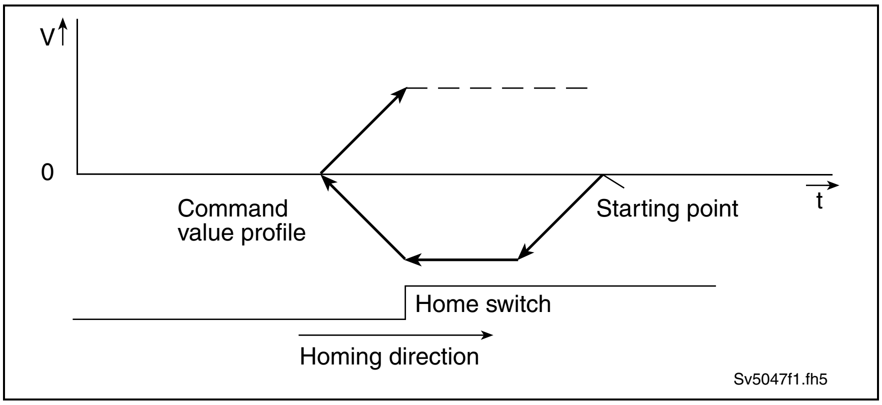


Fig. 8-81: Command profile with start position on the home switch

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 a detection of the following reference mark, and the reference mark detection becomes ambiguous.

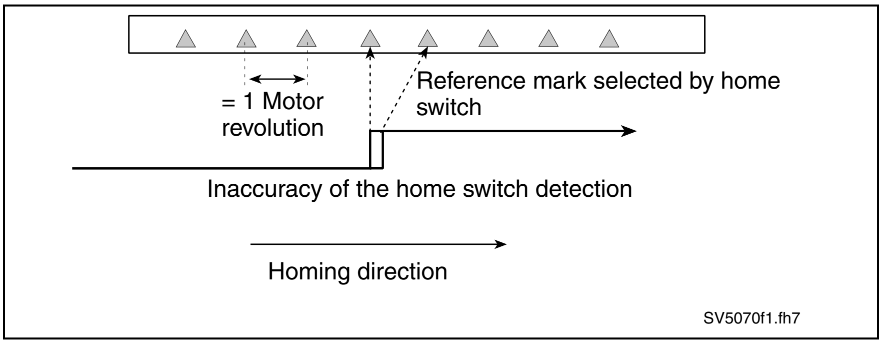


Fig. 8-82: Ambiguous detection of reference markers at small distances between home switch edge and reference mark

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

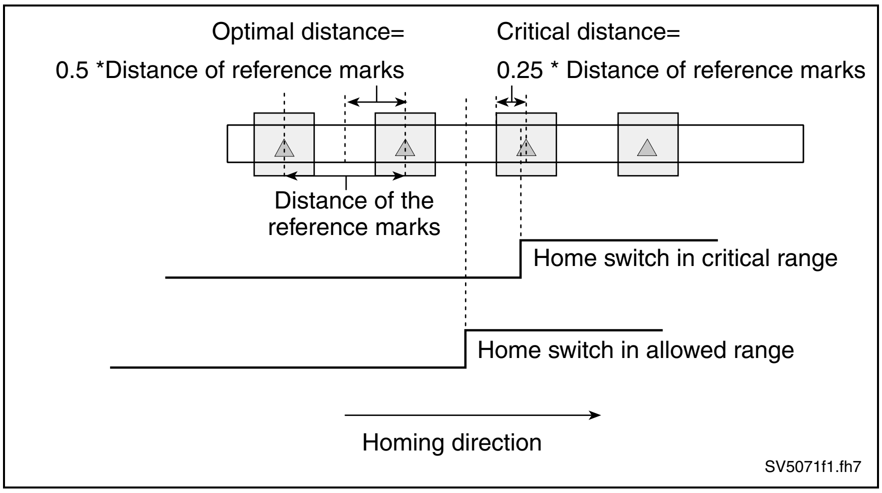


Fig. 8-83: Critical and optimal distance between home switch and reference mark

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, Optimal Distance Home Switch-Reference Mark	Function
Rotary	0	The distance home switch - 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, Resolution of motor feedback** for resolvers.
Rotary	x	The distance home switch - 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 home switch - 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 home switch - reference mark will be monitored. Half the reference mark spacing must be entered in **P-0-0153, Optimal Distance Home Switch - Reference Mark**.

Fig. 8-84: 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 Shifting**. 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 Shifting** is transferred to parameter **S-0-0299, Home Switch Offset**.

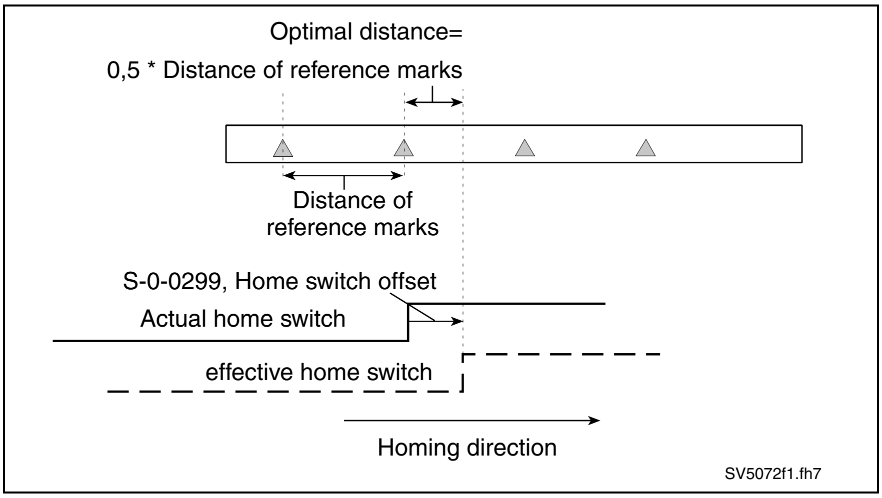


Fig. 8-85: Operation of parameter S-0-0299, Home Switch Offset

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 Shifting** into **S-0-0299, Home Switch Offset**.
- Check: You should see a 0 displayed in **S-0-0298, Reference Cam Shifting** when homing is restarted.

Commissioning with "Evaluation of distance-coded reference marker"

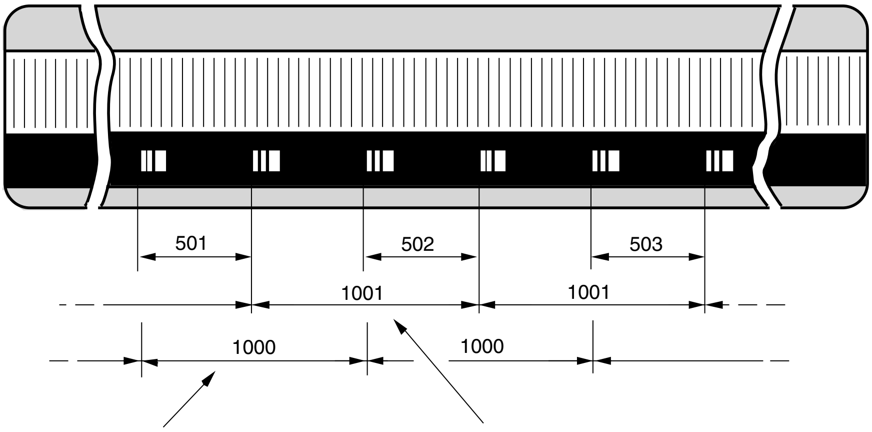
If the encoder has distance-coded reference markers (type 4), then set in **S-0-0147, Homing parameter**

- 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" ,
- whether the drive should to move to the second passed reference mark or not.

In the parameters

- **S-0-0165, Distance-coded reference offset 1** and
- **S-0-0166, Distance-coded reference offset 2**

the greater and smaller distance of the reference mark must be entered. These values can be retrieved from the encoder specification.



„Distance-coded reference dimension 2“
(smaller value) SERCOS-ID No.:S-0-0166;
Input unit: pitch

The manufacturer of the length measuring system indicates:
distance travelled up to the absolute position value: 20 mm
pitch unit: 20 µm (0-02 mm)

20 mm: 0.02 mm = 1000 pitch units

This value (1000 pitch units) is to be entered in parameter ID No. S-0-0166.

„Distance-coded reference dimension 1“
(greater value) SERCOS ID No. S-0-0165.
Input unit: pitch unit

For Heidenhain length measuring system the greater value is the product of:
(distance travelled + pitch unit):
pitch unit, therefore:
20.02 mm: 0.02 mm = 1001 pitch units

This value (1001 pitch units) is to be entered in parameter ID No. S-0-0165.

Setting up of distance-coded Heidenhain length measuring systems
(taken from: Catalog for NC length measuring systems, September 1993):

Length measuring system Type	Distance travelled: in mm	Pitch unit: in µm	Input in: ID No.: S-0-0166	Input in: ID No.: S-0-0165
LS 403C LS 406C LS 323C LS 623C LS 106C ULS 300C	20	20	1000	1001
LS 103C LS 405C ULS 300C	10	10	1000	1001
LID 311C LID351C	20	10	2000	2001

Pi5005f1.fh7

Fig. 8-86: Distance-coded measuring system specified with greater and smaller distance

In **S-0-0165, Distance-coded reference offset 1** the greater distance is entered, in **S-0-0166, Distance-coded reference offset 2** the smaller distance. The unit of these two parameters is (division) periods. Typical vaues 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 accelerating** must be set to smaller values (e.g., S-0-0041 = 10 rpm, S-0-0042 = 10 rad/s²).

⇒ Execute command drive-controlled reference

Note: **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!**

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 qualifying sign in **S-0-0177, Absolute offset 1** or **S-0-0178, Absolute offset 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 offset 1** or **S-0-0178, Absolute offset 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 is only for 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 with the selected homing direction the distance which is necessary to capture 2 adjacent marker positions. This distance is

$$s_{Re\,f\,max} = (S\text{-}0\text{-}0165 * S\text{-}0\text{-}0116 / 7) + \frac{v^2}{2 \times a}$$

S-0-0165: Value in the parameter S-0-0165, Distance coded reference offset 1
v : value in S-0-0041, Homing velocity
a : value in S-0-0042, Homing acceleration
$s_{Re\,f\,max}$: maximum travel distance for homing with distance coded reference markers
S-0-0116: Feedback 1 Resolution
S-0-0117: Feedback 2 Resolution

Fig. 8-87: 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, C6 Drive controlled homing** is greater than the max. necessary travel distance S_{Refmax}, or
- evaluate the home switch.

If the home switch is evaluated, the drive automatically starts in the opposite homing direction, if at command start the home switch is actuated (**S-0-0400, Home switch** = 1).

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.

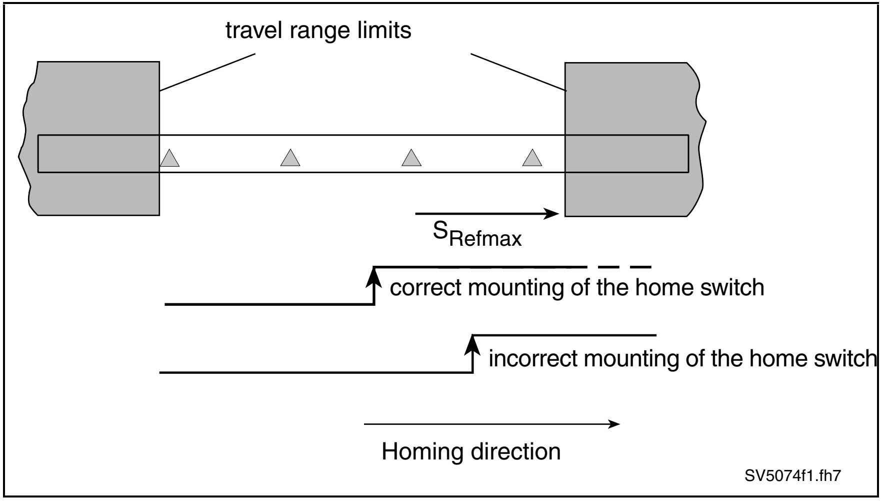


Fig. 8-88: Mounting the home switch with distance coded reference markers

Functions of the Control During "Drive-Controlled Homing"

Note: The control's interpolator must be set to the position command (S-0-0047) 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, C6 Drive-controlled homing** (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 = 111bin) to *command executed* (3 = 11bin) or to *command error* (0xF =1111bin).

If the command is interrupted (Input = 1) during processing (when confirmation = 7 = 111bin), the drive responds by activating the drive halt feature. The program continues if the interruption is canceled.

(See also "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 8-79
- **C603 Homing not permitted In this operation mode**
- **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 "Set Absolute Measuring".
- **C605 Homing velocity to high**

Configuration of the Home switch

Note: The home switch should be set up far enough that the "actuated" range covers more than the permissible motion range. Otherwise, the travel range may be overrun at command start if the start position is in an unfavorable position. Damage to the system is possible!

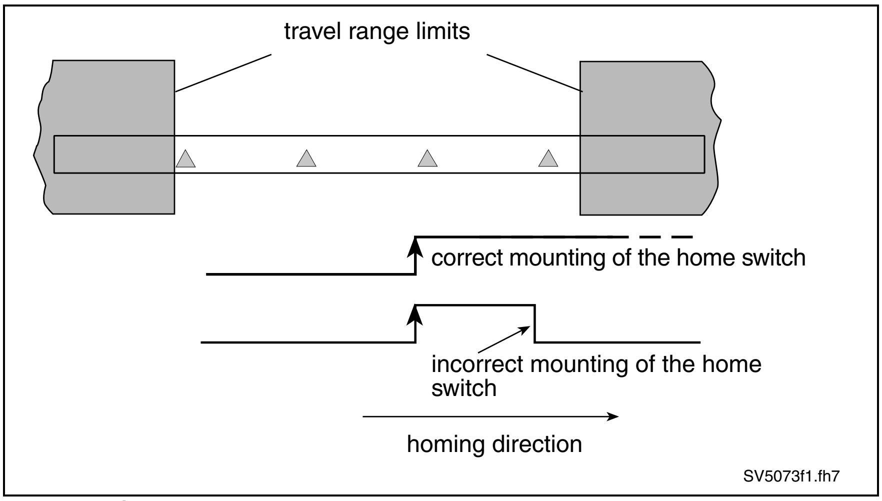


Fig. 8-89: Configuration of the home switch in reference to the travel range

Homing of Gantry axes

Gantry-type portal machines are used to process workpieces with large surfaces. To allow the axes to be moved without the danger of jamming, the digital AC servo drive with SERCOS interface is equipped with the "Gantry Axis" feature.

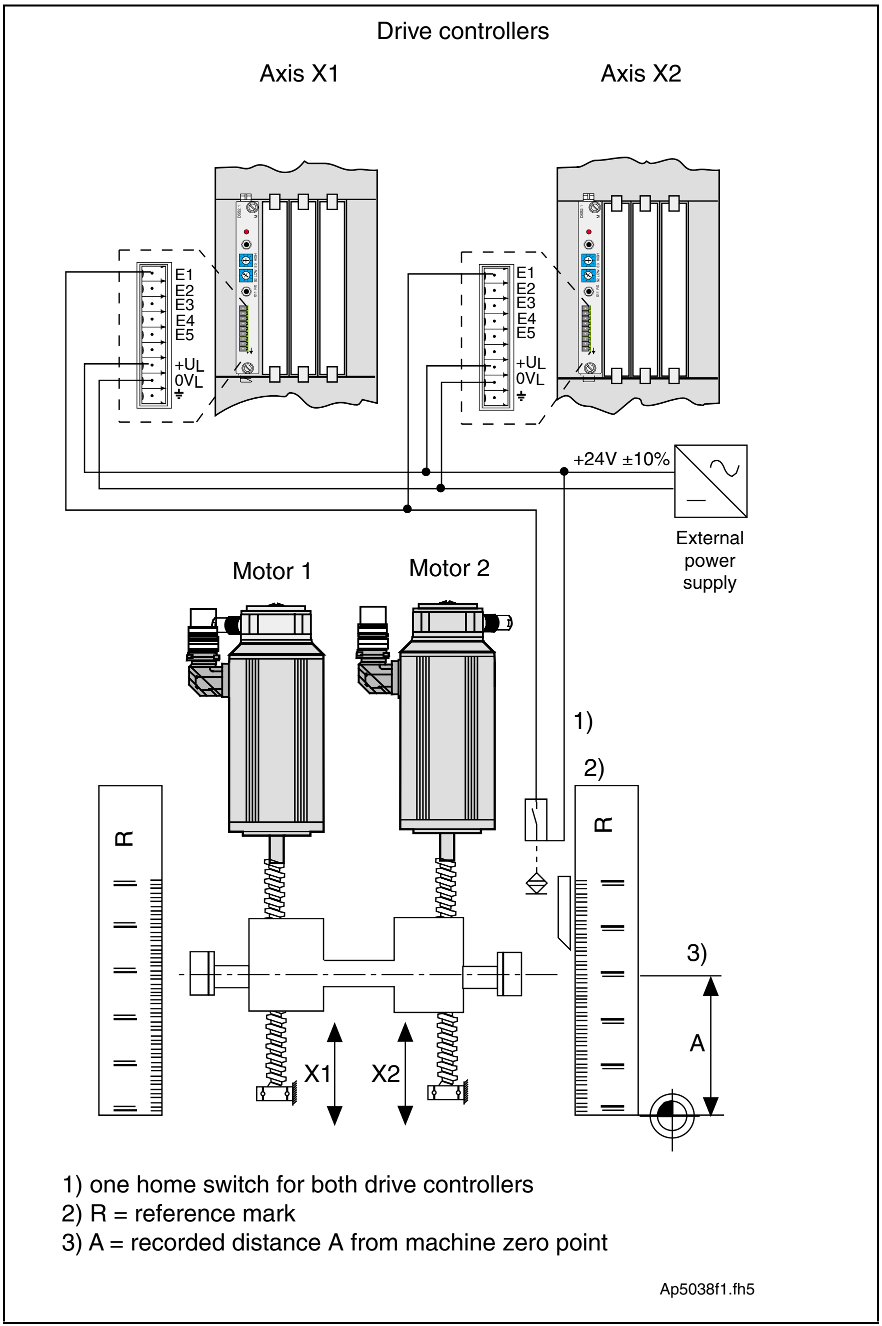


Fig. 8-90: Schematic of a Gantry axis with digital intelligent AC servo drives

CAUTION

Material damage caused by jamming of the Gantry axes!

The possibility of jamming must always be compensated by the mechanical structure in such a way that the machine will never under any circumstances be damaged.

Prerequisites for operating Gantry axes

- Both Gantry axes are registered as single axes in the control unit.
- The axes are identically parameterized.
- The Gantry drives are equipped with absolute encoders.
- The parallel guideways of the Gantry axes (X1; X2) are guaranteed.

Setting up Gantry axes

1. Align the Gantry axis at right angles with regard to the traversing direction.

Move the axis in jog mode or manually.

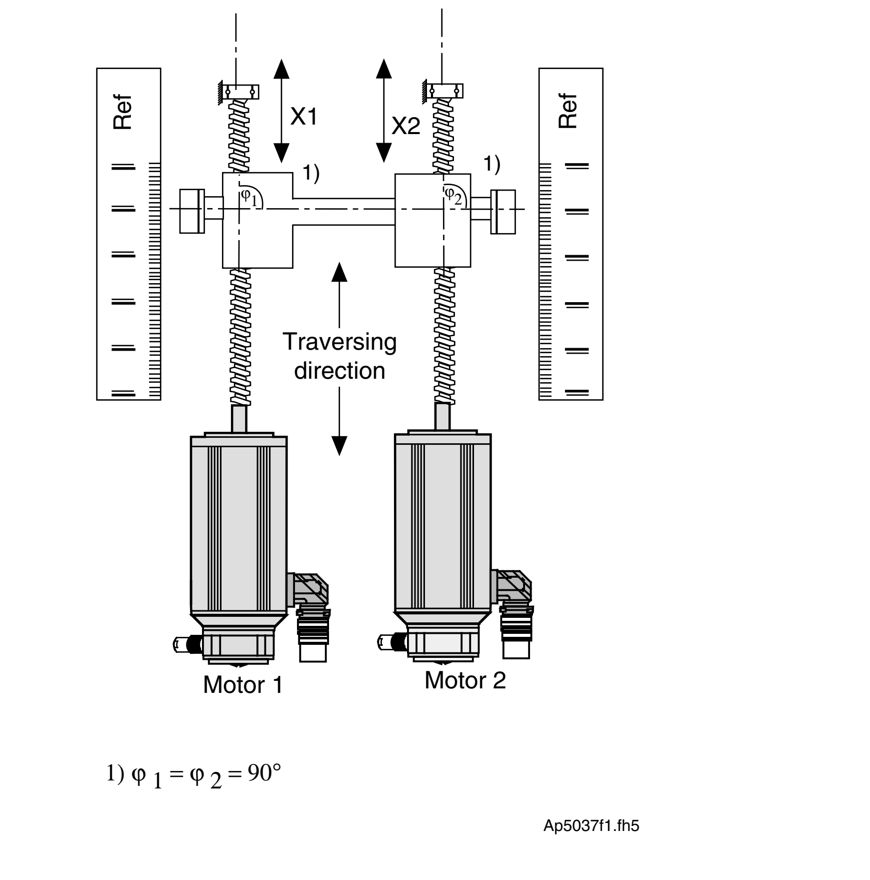


Fig. 8-91: Rectangular aligning of Gantry axis

2. Establish absolute reference dimension.

Determine the distance from the Gantry axis to the machine zero point.

Enter distance A to machine zero point in parameter **S-0-0052, Reference distance 1**.

Activate the **P-0-0012, C300 Command Set absolute measurement** command.

Deactivate the drive enable:
The value entered in the "Reference distance 1" parameter is transferred to parameter **S-0-0051, Position feedback 1 value**.

Reset the command.

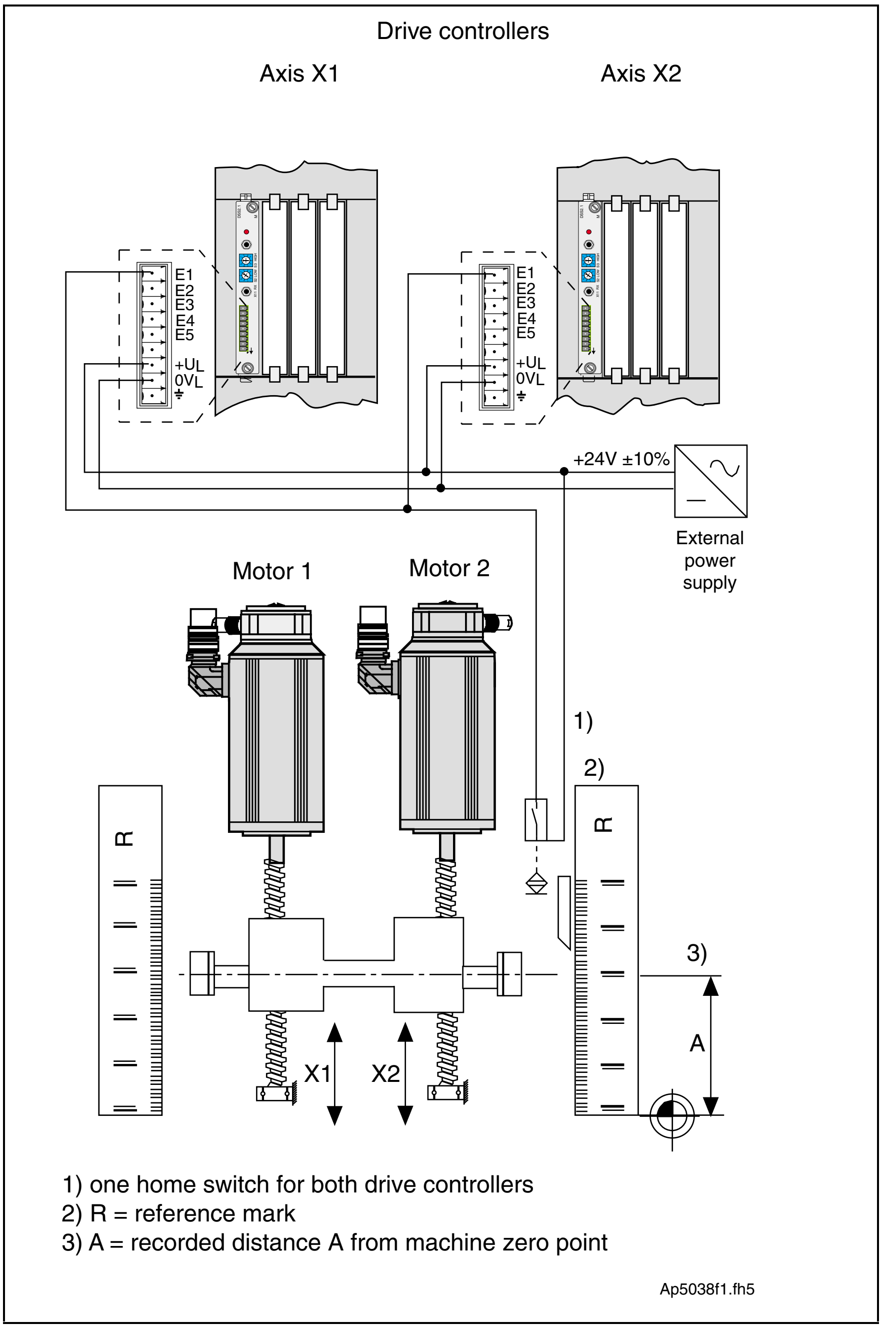


Fig. 8-92: Connecting the home switch to the drive controllers of Gantry axis X1/X2

3. Establish the reference distance of the direct position measuring system (if available).

Set the following homing procedure parameters to the same values in both axis:

- **S-0-0041, Homing velocity**
- **S-0-0042, Homing acceleration**
- **S-0-0147, Homing parameter**
- **S-0-0108, Feedrate override**

4. Check the connection/function of the home switch:

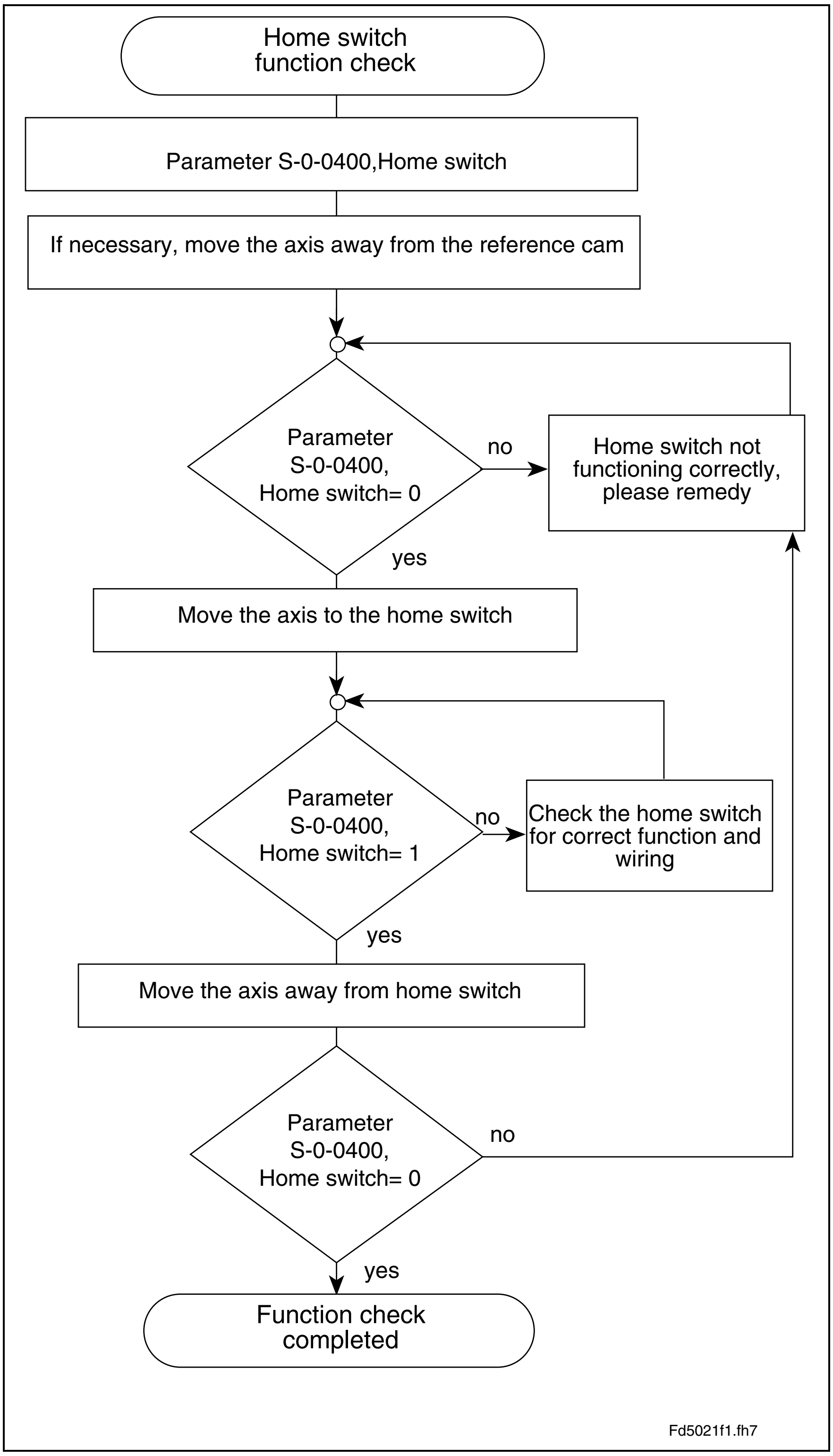


Fig. 8-93: Checking the function of the home switch

5. Detecting the reference mark positions of external encoder systems:

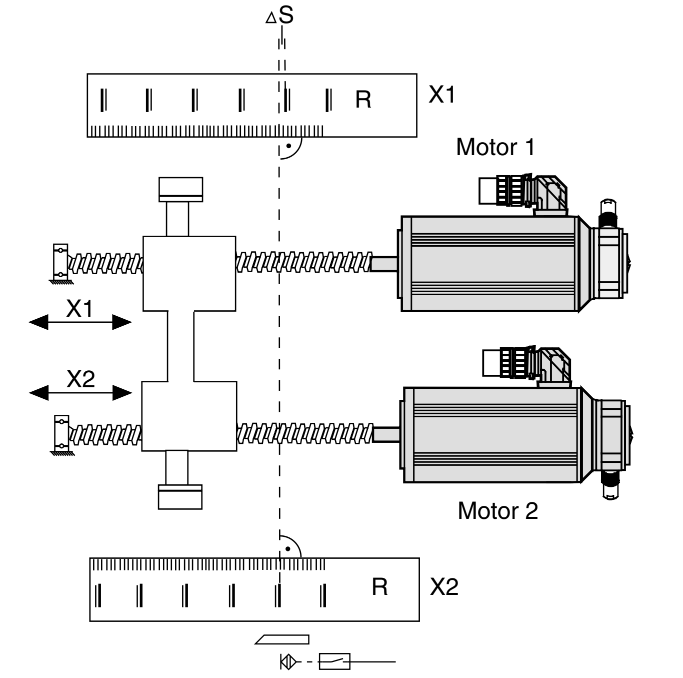


Fig. 8-94: Position offset of reference marks in the direct measuring systems of Gantry axes X1/X2

Activate command **P-0-0014, D500 Command determine marker position** in both axis (see control unit manual).

Move both axes towards the reference marks by presetting the same position command values through the control unit.

Note: The direction of travel must be the same as the subsequent homing direction (bit 0, **S-0-0147, Homing parameter**).

On reaching the relevant reference mark of the linear scale, each of the two drives stores the current actual position value 2 in the corresponding marker position (**S-0-0173, Marker position A**). Once the reference mark has been detected, the respective drive acknowledges the "Get mark position" command. When both Gantry axes have acknowledged the command, the control unit must decelerate the drives to a standstill.

Determine the distance between the reference marks (ΔS):

$$\Delta S = S-0-0173,\text{ Marker position A (axis X1)} - S-0-0173,\text{ Marker position A (axis X2)}$$

Fig. 8-95: Calculating the distance between the reference marks (ΔS)

6. Calculate and enter reference offset 2 of the respective axis.

For the axis the reference mark of which occurs first, the following applies:

$$S-0-0151,\text{ Reference offset 2} \geq \frac{V_{ref}^{2}}{2 * a_{ref}} + \Delta S$$

ΔS distance between reference marks
V_{ref} homing velocity
a_{ref} homing acceleration

Fig. 8-96: Calculating the S-0-0151, Reference offset 2 for the drive the reference mark of which occurs first

For the axis the reference mark of which occurs last, the following applies:

$$S-0-0151,\text{ Reference offset 2} \geq \frac{V_{ref}^{2}}{2 * a_{ref}}$$

V_{ref} homing velocity
a_{ref} homing acceleration

Fig. 8-97: Calculating the S-0-0151, Reference offset 2 for the drive the reference mark of which occurs last

CAUTION

Material damage caused by reversal of direction of one of the two drives!

For **S-0-0151, Reference offset 2**, do not enter values lower than the calculated ones.

The polarity of parameter **S-0-0151, Reference offset 2** must be selected in such a way that the reference point is offset in the homing direction; i.e. with negative homing direction in one or both axes, the reference offset must be entered with negative sign, too. This avoids a reversal of direction after passing the reference mark (see "Consideration of the Reference Offset").

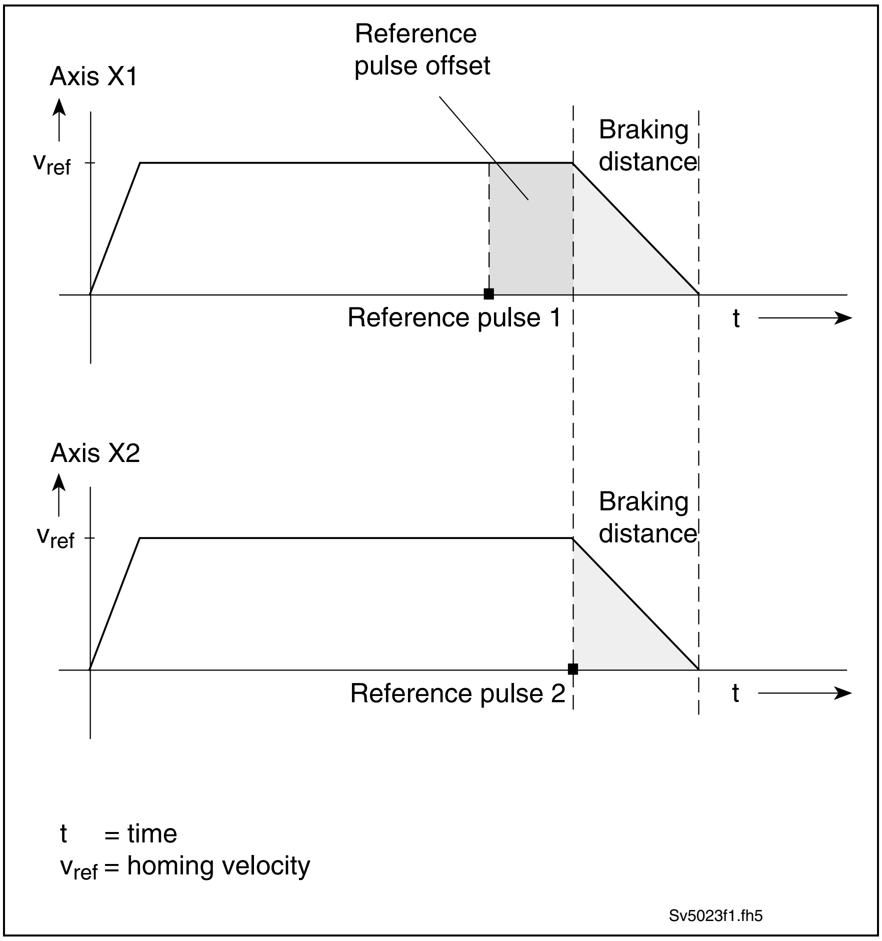


Fig. 8-98: Velocity curves of Gantry axes during homing

8.10 Set absolute measuring

When commissioningan absolute measuring system, its initial actual position value represents an arbitrary value which does not refer to the machine zero point.

Note: The value of **S-0-0403, Position feedback value status** is "0".

Establishing the absolute reference

In contrast to non-absolute measuring systems, the absolute reference of an absolute measuring system only has to be established once, at the initial commissioning of the axis.

By means of the **C300 Command Set absolute measuring** command the actual position value of this measuring system can be set to the desired value. After the "Set absolute measuring" procedure has been completed, the actual position value of the relevant encoder has a defined reference to the machine zero point.

Activating the function

The command is activated by writing data to the **P-0-0012, C300 Command Set absolute measuring** parameter.

Reference point of the command

If there is only one absolute measuring system available, then the command automatically refers to this measuring system. If 2 absolute measuring systems are connected, the selection must be set in **bit 3** of **S-0-0147, Homing parameter**.

Saving the data

By means of a backup of all required data of the absolute measuring system in the encoder data memory or parameter memory, all information is retained every time the machine is switched off and on again. The actual position value retains its reference to the machine zero point.

Pertinent parameters

The following parameters are relevant for the execution of the command:

- **P-0-0012, C300 Command Set absolute measuring**
- **S-0-0147, Homing parameter**
- **S-0-0052, Reference distance 1**
- **S-0-0054, Reference distance 2**
- **S-0-0403, Position feedback value status**

Functional principle

The motor is brought to a precisely measured position. The desired actual position value of the measuring system in this position is entered in parameters **S-0-0052, Reference distance 1** (for motor encoders) or **S-0-0054, Reference distance 2** (for optional encoders).

Upon successful completion of command **P-0-0012, C300 Command Set absolute measuring**, the actual position value is set to the value entered in the relevant **Reference distance** and bit 0 of **S-0-0403, Position feedback value status** is set to **"1"**.

Setting absolute measuring of master axis encoder

If the optional encoder was defined as a master axis encoder (**P-0-0185, Function of encoder 2** = 1), the scaling and the unit of parameter **S-0-0054, Reference distance 2** are switched. In parameter **S-0-0403, Position feedback value status** only bit 2 is set to **"1"**.

Unit: increments without decimal places.

"Set absolute measuring" without drive enable

The procedure is as follows:

- Move the axis to the to the measured position.
- The desired actual position value at this position has to be written to the respective reference distance.
- The command can then be started by writing "11b" to **P-0-0012, C300 Command Set absolute measuring**.
- The command immediately sets the actual position value of the measuring system to the reference distance and the position status becomes "1". The drive has completed the command which can now be cleared (**P-0-0012** ="0").

Setting absolute measuring with drive enable followed by "Drive-controlled homing"

If the application uses a so-called "vertical axis" or the position approached cannot, for another reason, be held without drive enable, then the command can also be executed with drive enable.

The procedure is as follows:

- Move the axis to the measured position.
- Enter the desired actual position value in the respective reference distance parameter.
- Start the **P-0-0012, C300 Command Set absolute measuring** command. The coordinate system is switched internally at this position. The actual position value (S-0-0051 or S-0-0053) is not changed yet.
- Start the **S-0-0148, C600 Drive controlled homing procedure command**. This command is required with drive enable having been set, in order to interrupt the acceptance of command values and enable a control unit to adjust the command values to the new coordinate system. When the command is started the drive completely switches over to the new coordinate system. The switching can be recognized by a positive command acknowledgment. The control unit, for example, can now read the new actual position value and take it over to the position command value for the drive.

CAUTION

⇒ Make sure that the encoder to be set was selected in bit 3 of **S-0-0147, Homing parameter**!

- Clear the **S-0-0148, C600 Drive controlled homing procedure command**.
- Clear the **P-0-0012, C300 Command Set absolute measurement** command.

Setting absolute measuring with drive enable followed by deactivation of drive enable

By setting absolute measuring with drive enable and afterwards deactivating drive enable it is possible to switch the actual position value of an axis that is in control. The actual position value is only switched when drive enable is deactivated.

The procedure is as follows:

- Move the axis to the measured position.
- Enter the desired actual position value in the respective reference distance parameter.
- Start the **P-0-0012, C300 Command Set absolute measuring** command. The coordinate system is switched internally at this position. The actual position value (S-0-0051 or S-0-0053) is not changed yet.
- Deactivate drive enable, the actual position value is also switched over to the new coordinate system and the drive has completed the command.
- Clear the **P-0-0012, C300 Command Set absolute measuring** command.

Actual position values after setting absolute measuring

The status of the actual position values of the motor encoder and, if available, of the optional encoder after the execution of the "Set absolute measuring" command, depends on bit 3 in **S-0-0147, Homing parameter** and the availability of an absolute encoder in the form of a motor or optional encoder. In addition, the actual position value of the encoder to which "Set absolute measuring" does **not** apply is only changed if this actual position value hasn't been homed yet.

Motor encoder	Opt. encoder	S-0-0147 bit 3	S-0-0403 before	Actual position value 1	Actual position value 2	S-0-0403 after
absolute	non-absolute	0	0x...0xx	reference distance 1	reference distance 1	0x...011
absolute	non-absolute	0	0x...1xx	reference distance 1	unchanged	0x...111
non-absolute	absolute	1	0x...x0x	reference distance 2	reference distance 2	0x...101
non-absolute	absolute	1	0x...x1x	unchanged	reference distance 2	0x...101
absolute	absolute	0	0x...1xx	reference distance 1	unchanged	0x...111
absolute	absolute	0	0x...0xx	reference distance 1	reference distance 1	0x...011
absolute	absolute	1	0x...x0x	reference distance 2	reference distance 2	0x...101
absolute	absolute	1	0x...x1x	unchanged	reference distance 2	0x...111

Fig. 8-99: Actual position values after setting absolute measuring

Note: If the optional, absolute encoder is used as a master axis encoder the actual position value 1 remains unchanged when this encoder is calibrated. Bit 0 of **S-0-0403, Position feedback value status** is not set.

Actual position values of absolute encoders after power on

(see also Functional Description "Actual Feedback Values of Absolute Measurement Systems After Initialization")

Diagnostic messages

While executing the command, the command error **C302 Absolute measuring system not installed** sometimes occurs when the **P-0-0012, C300 Command Set absolute measuring** command is started without an absolute measuring system having been installed.

9 Optional Drive Functions

9.1 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. 9-1: Example of a configurable signal status word

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!

9.2 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 250 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 analog.

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 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
FREE		
FREE		
...		
0x00000014	synchronous position command value	rot. => 360°/10V lin. => 1mm/10V
0x00000015	synchronous velocity	rot. => 1000rpm/10V lin. => 100m/min/10V
0x00000016	master axis position fine interpolation	2^20/10V
0x00000017	master axis speed in the NC cycle	rot. => 1000rpm/10V

Fig. 9-2: 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 project planning manualthe 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 the corresponding developer.

Activation of the bit and byte output The bit and byte output is only possible if the signal selection for the used channel (P-0-0420 or P-0-0423) is deactivated by inputting the ID number 0.

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 bit of the parameter inputs the storage address.

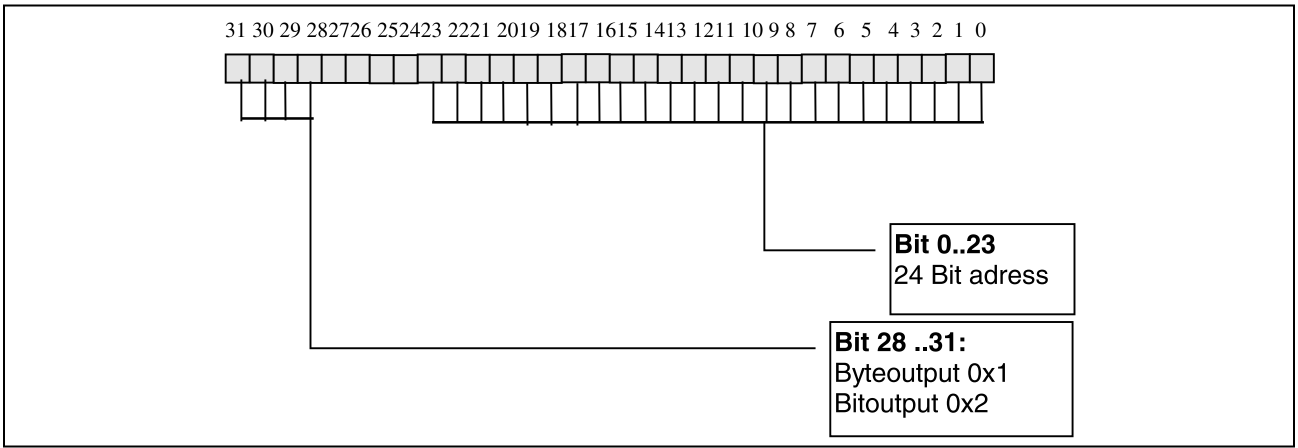


Fig. 9-3: Parametrizing bit or byte output

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 it can be determined from which (least signifiant) bit 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

The output of the analog signals uses connector X3 of the basic unit.

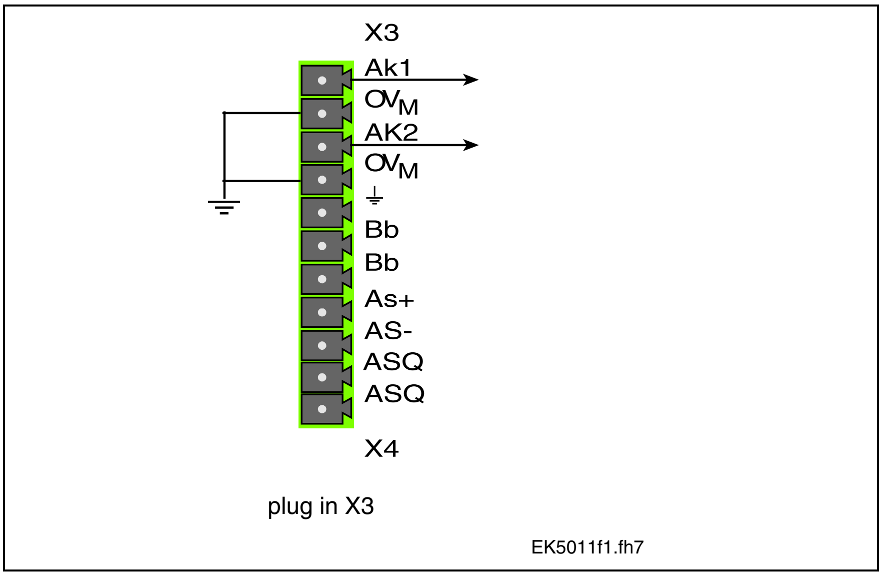


Fig. 9-4: Terminal assignment of analog output

9.3 Analog inputs

Using the function "Analog inputs", **2 analog inputs** can be mapped to one parameter each via an analog/digital converter. The analog voltage in the form these two parameters can then either be

- transmitted to the control and serves the control as an analog input function or
- assigned in the drive to a different parameter taking a settable scaling and a settable offset into account.

Note: With the help of analog inputs it is also possible to set command values for velocity control mode.

Pertinent parameters

The following parameters are available for the function:

- **P-0-0210, Analog input 1**
- **P-0-0211, Analog input 2**
- **P-0-0212, Analog inputs, IDN list of assignable parameters**
- **P-0-0213, Analog input 1, Assignment**
- **P-0-0214, Analog input 1, scaling per 10V full scale**
- **P-0-0215, Analog input 2, Assignment**
- **P-0-0216, Analog input 2, scaling per 10V full scale**
- **P-0-0217, Analog input 1, Offset**
- **P-0-0218, Analog input 2, Offset**

Functional principle of the analog inputs

The two analog inputs are connected via the two **differential inputs** E1+ / E1- and E2+ / E2-.

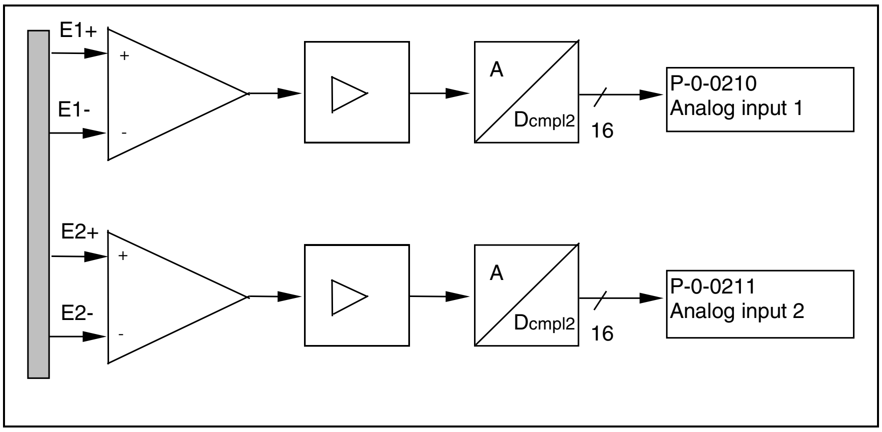


Fig. 9-5: Functional principle of the analog inputs

The digitized voltages of both differential inputs are displayed in the parameters **P-0-0210, Analog input 1** and **P-0-0211 Analog input 2**.

Assignment of analog inputs to parameters

Both parameters **P-0-0210, Analog input 1** and **P-0-0211 Analog input 2**, which depict the analog-to-digital converted voltages, can be assigned to other drive parameters, i.e. they can be cyclically copied while taking

- an offset and
- a selectable scaling

into account.

Processing of analog inputs

- Analog channel 1 **is processed every 250 µs**.
- Analog channel 2 **is processed every 8 ms**.

Exception: In modes "velocity control" or "torque/force control", the command values are scanned every 500 µs.

For assignment, the following principle is used:

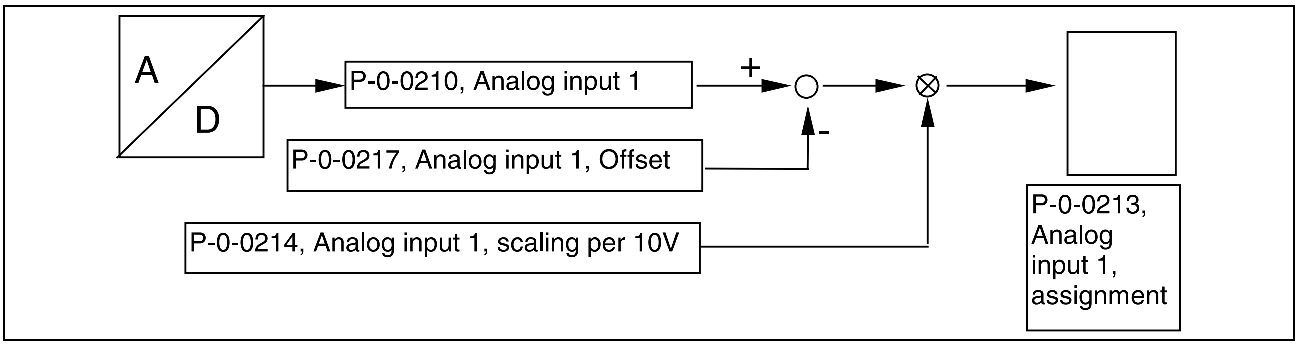


Fig. 9-6: Functional principle of the assignment of analog input 1 to a parameter

Displaying analog value 1

The digitized input voltage is stored in parameter **P-0-0210, Analog input 1**.

Configuring analog input 1

An assignment of an analog input to a parameter is activated, if in parameter **P-0-0213, Analog input 1, assignment** a value unequal S-0-0000 has been parameterized.

The contents of **P-0-0210, Analog input 1** minus the contents of **P-0-0217, Analog input 1, Offset** is scaled with the scaling factor set in **P-0-0214, Analog input 1, scaling per 10V full scale** and then copied to the parameter with the ID number set in **P-0-0213, Analog input 1, Assignment**.

Evaluation parameter unit

The unit of the parameter **P-0-0214, Analog input 1, Scaling per 10V full scale** complies with the unit of the assigned parameter.

Selection list

Only those parameters can be assigned that are listed in **P-0-0212, Analog inputs, IDN list of assignable parameters**.

Configuring analog input 2

Note: The configuration or assignment of analog input 2 can be conducted accordingly.

Example

Assignment of analog input 1 to

S-0-0036, Velocity command value with 10 V corresponds to 1000 rpm

Parameter setting:

- **P-0-0213, Analog input 1, assignment** = S-0-0036
- **P-0-0214, Analog input 1, evaluation per 10V** = 1000.0000 rpm

DIAX--Terminal assignment of analog inputs

The inputs of the analog signals use connector X75 of the plug-in module DAE02X.

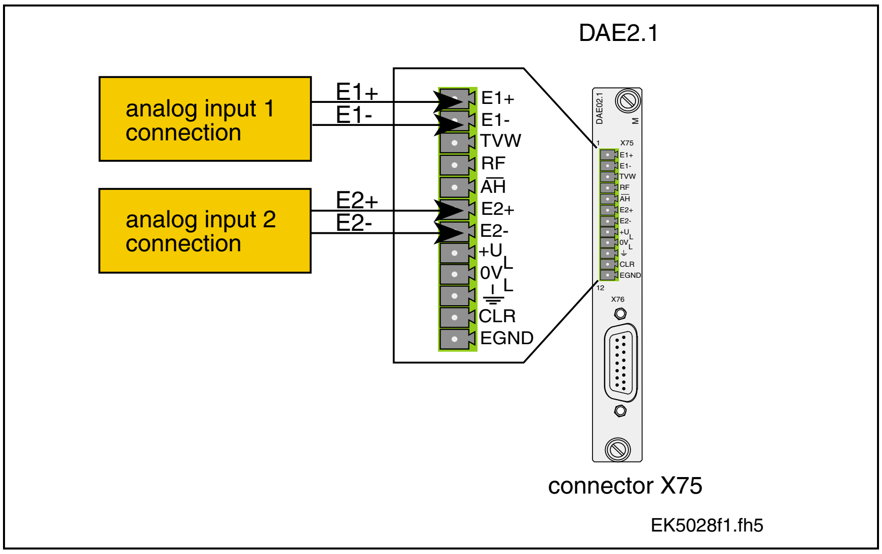


Fig. 9-7: Terminal assignment of analog inputs at plug-in module DAE02.X

9.4 Digital Input/Output

The "digital input/output" feature allows for binary inputs and outputs through the DEA plug-in modules. DEAs 4, 5 and 6 offer 15 binary inputs and 16 binary outputs each. DEAs 8, 9 and 10 have 32 inputs and 24 outputs each.

The following DEA modules are supported:

- DEA 4.1
- DEA 5.1
- DEA 6.1
- DEA 8.1
- DEA 9.1
- DEA 10.1

There may not be two interface cards of the same kind in a drive controller. Each drive controller can have a maximum of 96 inputs (3•32) and 72 outputs (3•24).

The following parameters are available for this feature:

- **P-0-0081, Parallel I/O Output 1**
- **P-0-0082, Parallel I/O Input 1**
- **P-0-0110, Parallel I/O Output 2**
- **P-0-0111, Parallel I/O Input 2**
- **P-0-0112, Parallel I/O Output 3**
- **P-0-0113, Parallel I/O Input 3**
- **P-0-0124, Assignment IDN -> DEA-Output**
- **P-0-0125, Assignment DEA-Input -> IDN**
- **P-0-0170, Parallel I/O Output 4**
- **P-0-0171, Parallel I/O Input 4**
- **P-0-0172, Parallel I/O Output 5**
- **P-0-0173, Parallel I/O Input 5**
- **P-0-0174, Parallel I/O Output 6**
- **P-0-0175, Parallel I/O Input 6**

It is also possible to assign a DEA output or DEA input to the current value of a parameter.

Digital I/O Functional Principle

The parameters "parallel input" and "parallel output" can be configured cyclically.

The binary in- and outputs are reflected in the parameters "Parallel input" and "Parallel output".

Two parameters are available for each DEA. The following assignment applies:

DEA Module:	Parameter for Input:	Parameter for Output:
DEA 4.1	P-0-0082	P-0-0081
DEA 5.1	P-0-0111	P-0-0110
DEA 6.1	P-0-0113	P-0-0112
DEA 8.1	P-0-0171	P-0-0170
DEA 9.1	P-0-0173	P-0-0172
DEA 10.1	P-0-0175	P-0-0174

Fig. 9-8: Digital Input/Output: Assigned Parameters

By reading the parameter "parallel input", you can obtain an image of the existing binary inputs of a DEA. By writing the parameter "parallel output", the binary outputs are updated.

The assignment of individual binary inputs and outputs to the bit numbers of the corresponding parameters for DEAs 4, 5 and 6 are defined as follows:

Pin No. Input:	Bit No. in the Parameter:	Pin No. Output:
1	0 (LSB)	16
2	1	17
3	2	18
4	3	19
5	4	20
6	5	21
7	6	22
8	7	23
9	8	24
10	9	25
11	10	26
12	11	27
13	12	28
14	13	29
15	14	30
--	15 (MSB)	31

Fig. 9-9: Digital Input/Output: Bit Output Assignment - DEA 4, 5, 6-Module

This applies for the DEAs 8 , 9 and 10:

Pin no. input:	Bin no. in parameter:	Pin no. output:
1	0 (LSB)	12
2	1	13
3	2	14
4	3	15
5	4	16
6	5	17
7	6	18
8	7	19

Pin no. input:	Bin no. in parameter:	Pin no. output:
9	8	33
10	9	34
11	10	35
22	11	36
23	12	37
24	13	38
25	14	39
26	15	40
27	16	53
28	17	54
29	18	55
30	19	56
31	20	57
32	21	58
43	22	59
44	23	60
45	24	-
46	25	-
47	26	-
48	27	-
49	28	-
50	29	-
51	30	-
52	31	-

Fig. 9-10: Digital input/output: Assigning bit output - DEA 8, 9, 10 module

The parameter "parallel output" is copied to the DEA port every 250 µs. Likewise, the DEA port is copied to the "parallel input" every 250 µs.

Note: An external power supply must be connected to operate a DEA card.

It applies to DEA 4, 5 and 6:

Pin 37: 24 Vext

Pin 35 0 Vext.

It applies to DEA 8, 9 and 10:

Pin 41, 61: 24 Vext

Pin 21, 42, 62 0 Vext.

If the power supply is missing, the **F233 External power supply error** will be generated.

Allocating ID Number - Parallel I/O

The current value of any desired parameter can be exported to the binary output of a DEA. Likewise, the binary inputs of a DEA can be mapped onto the current value of any desired parameter.

This feature is set with the parameters:

- **P-0-0124, IDN -> DEA-Output Assignment**
- **P-0-0125, DEA-Input -> IDN Assignment**

The parameters are structured as follows:

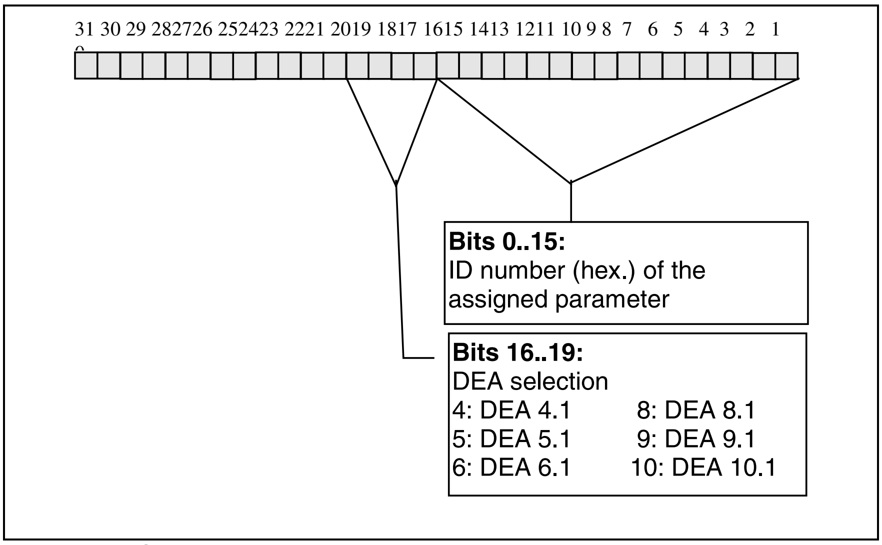


Fig. 9-11: Structure of Parameters P-0-0124 and P-0-0125

IDN -> DEA-Output Assignment

With the IDN -> DEA-Output Assignment, the current value of the assigned parameter is copied to the DEA output parameter; this is exported to the DEA outputs.

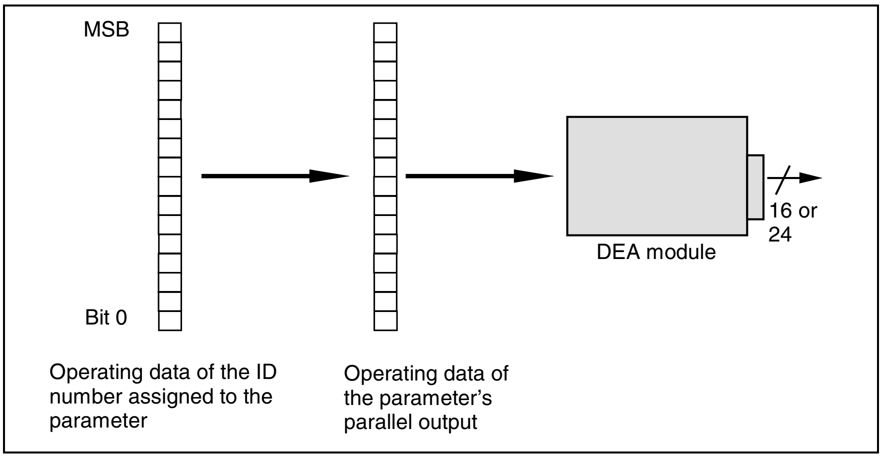


Fig. 9-12: Principle of assigning an ID number to a DEA output

If the data length of the current value for the assigned ID number is greater than 16 bits, then the upper bits of the current value will be truncated.

When the parameter **P-0-0124, Assignment IDN -> DEA-Output** is written, then the following will be checked:

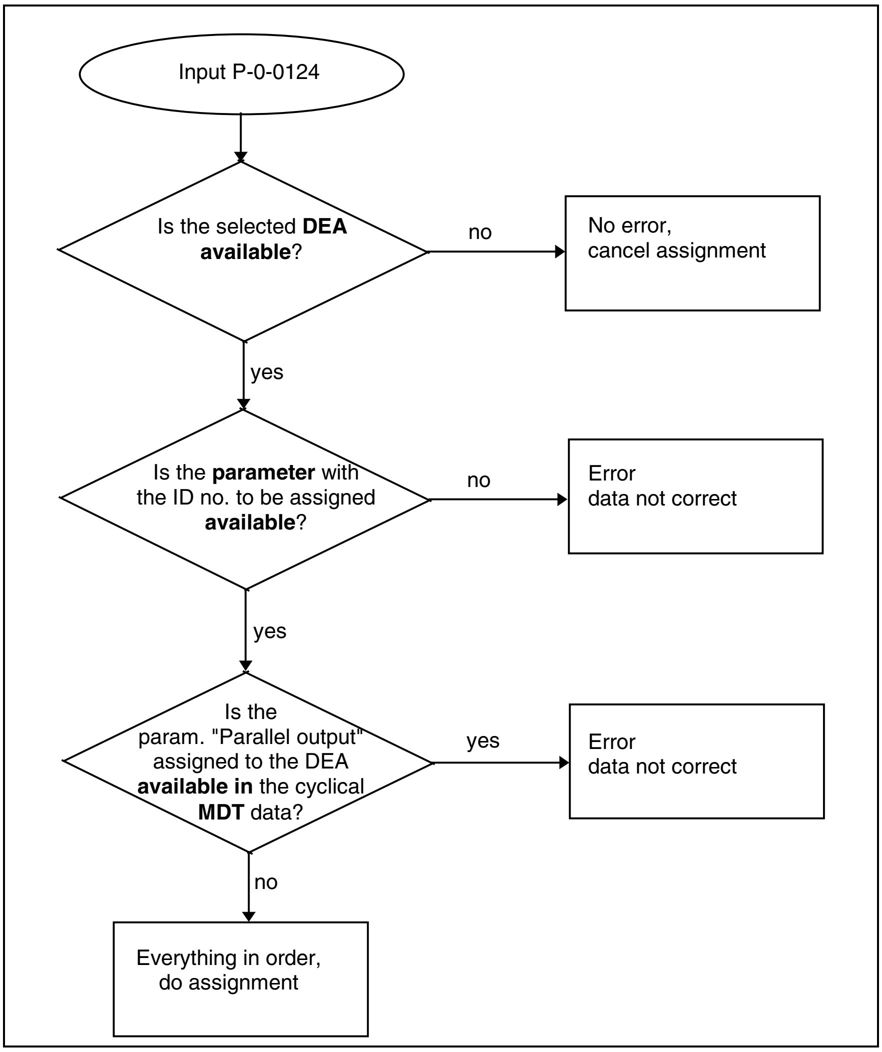


Fig. 9-13: Checks when inputting parameter P-0-0124, assigning ID number -> DEA- output

DEA-Input -> IDN Assignment

During the "DEA Input -> ID Number" assignment, all binary inputs of the DEA are mapped onto the "DEA Input" parameter; the parameter is then copied to the current value of the assigned parameter.

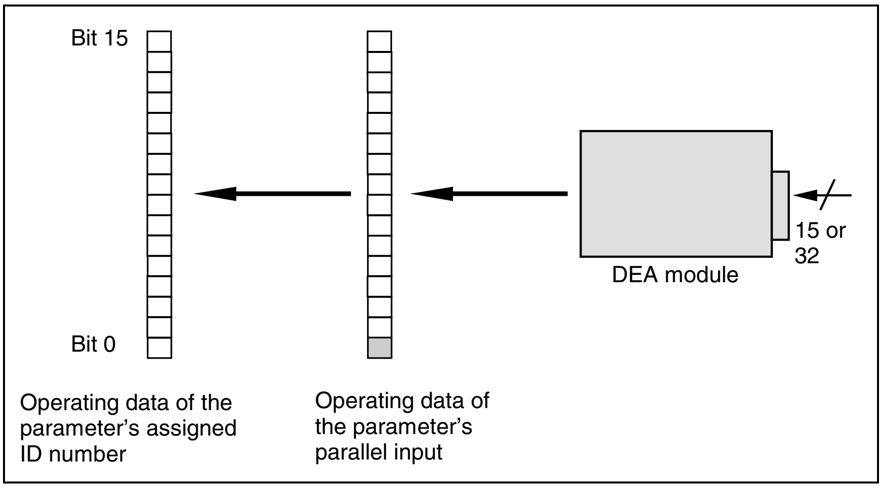


Fig. 9-14: Diagram for DEA-Input -> IDN Assignment

If data length of the current value for the assigned ID number exceeds 16 bits, then the upper bits of the operating data in DEA 4, 5 and 6 are cut off (truncated).

If the parameter **P-0-0125, Assignment DEA-Input -> IDN** is written, then the following will be checked:

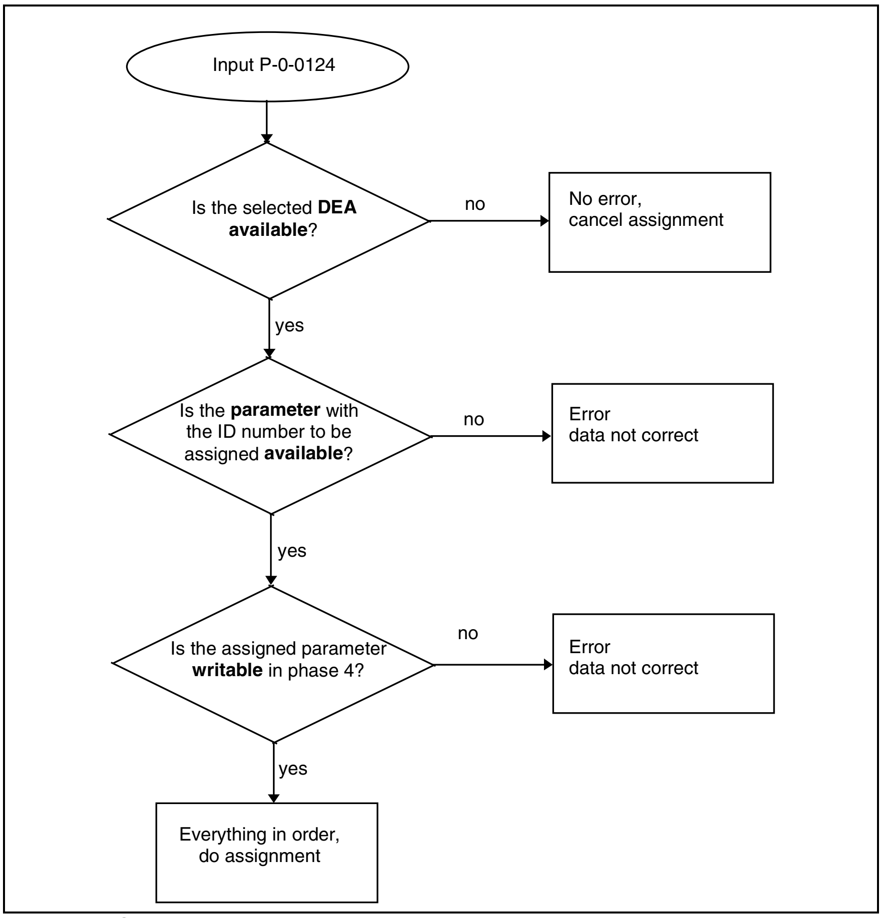


Fig. 9-15: Checks during input of the Parameter P-0-0125, Assignment DEA-Input -> IDN

9.5 Oscilloscope feature

The oscilloscope feature is used to record internal and external signals and state variables. Its function can be compared to a 2-channel oscilloscope. The following parameters are available to set the oscilloscope feature:

- **P-0-0021, List of Scope Data 1**
- **P-0-0022, List of Scope Data 2**
- **P-0-0023, Signal Select Scope Channel 1**
- **P-0-0024, Signal Select Scope Channel 2**
- **P-0-0025, Trigger Source**
- **P-0-0026, Trigger Signal Selection**
- **P-0-0027, Trigger Level for Position Data**
- **P-0-0028, Trigger Level for Velocity Data**
- **P-0-0029, Trigger Level for Torque/Force Data**
- **P-0-0030, Trigger Edge**
- **P-0-0031, Timebase**
- **P-0-0032, Size of Memory**
- **P-0-0033, Number of Samples after Trigger**
- **P-0-0035, Delay from Trigger to Start**
- **P-0-0036, Trigger Control Word**
- **P-0-0037, Trigger Status Word**
- **P-0-0145, Expanded Trigger Level**
- **P-0-0146, Expanded Trigger Address**
- **P-0-0147, Expanded Signal K1 Address**
- **P-0-0148, Expanded Signal K2 Address**
- **P-0-0149, List of selectable signals for oscilloscope function**
- **P-0-0150, Number of valid Samples for Oscilloscope Function**

Functional principle of the oscilloscope feature

Activating the oscilloscope feature

The oscilloscope feature can be activated with the parameter **P-0-0036, Trigger Control Word** by setting bit 2. From then on, all data will be recorded that were selected through the parameters **P-0-0023, Signal Selection Channel 1** and **P-0-0024, Signal Selection Channel 2**. The selection will be defined with numbers that are assigned to various signals.

Triggering

The triggering is activated by setting bit 1 in parameter **P-0-0036, Trigger Control Word**. The trigger conditions can be set with the parameters **P-0-0025, Trigger Source**, **P-0-0026, Trigger Signal Selection** and **P-0-0030, Trigger Edge**. The signal amplitude that releases the trigger can be set with the parameters P-0-0027 to P-0-0029.

If a trigger event is recognized, then the number of values in the parameter **P-0-0033, Number of Samples after Trigger** will be recorded and the feature will be completed. Parameters **P-0-0031, Timebase** and **P-0-0032, Size of Memory** can define the recording duration and the time intervals of the measured values.

The measured values are stored in parameters **P-0-0021** and **P-0-0022** and can be read by the control.

Parameterizing the oscilloscope feature

Oscilloscope feature with defined recording signals

Preset signals and state variables can be selected through parameters **P-0-0023, Signal Select Scope Channel 1** and **P-0-0024, Signal Select Scope Channel 2**. The selection can be made by entering the signal number (hex format) in the corresponding signal selection parameter. The selected signal number defines the unit of data stored in the list of scope data. The following signals are predefined with numbers.

Number	Signal selection	Unit of the measured value list
0x00	Channel not activated	--
0x01	Position feedback value dependent on operating mode S-0-0051 or S-0-0053	dependent on position scaling
0x02	Velocity feedback value parameter (S-0-0040)	velocity scaling dependent
0x03	Velocity control deviation (S-0-0347)	velocity scaling dependent
0x04	Following error parameter (S-0-0189)	dependent on position scaling
0x05	Torque/force command value parameter S-0-0080	Percent
0x06	Position feedback 1 value S-0-0051	dependent on position scaling
0x07	Position feedback 2 value S-0-0053	dependent on position scaling
0x08	Position command value S-0-0047	dependent on position scaling
0x09	Velocity command value parameter (S-0-0036)	velocity scaling dependent
0x0A	Master drive position P-0-0053	increments [2^20/rev.]
0x0B	Position feedback value 3 P-0-0052	increments [2^20/rev.]

Fig. 9-16: Selection of predefined signals

Note: Parameter **P-0-0149, List of selectable signals for oscilloscope function** was introduced so that the control can detect the number of preset numbers. This parameter has the structure of a list parameter and transmits the ID numbers of the possible signals.

Expanded oscilloscope recording feature

In addition to the oscilloscope feature with preset signals, the drive also allows for recording of any desired internal signals. Use of this feature makes sense only with information about the structure of the internal data memory; therefore, this feature can be used effectively only by the respective developer. The feature can be activated with parameters P-0-0023 and P-0-0024 by setting bit 12.

The format for the data to be saved can be defined with bit 13.

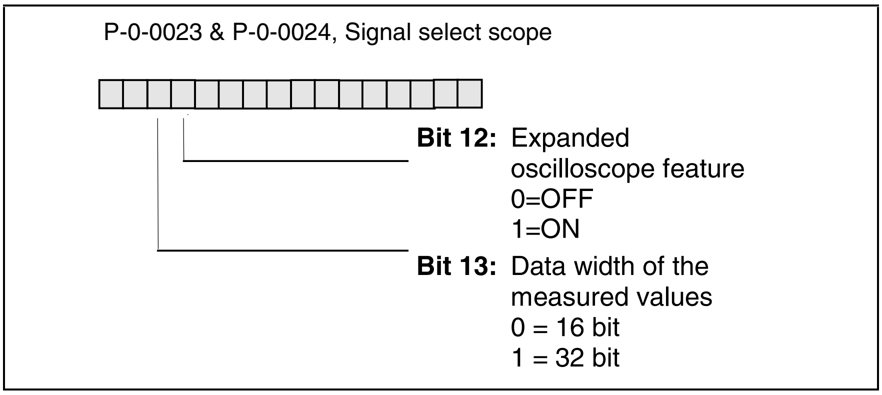


Fig. 9-17: Structure of parameters P-0-0023 and P-0-0024

If the expanded signal selection is parameterized, then the desired signal address can be defined in parameters **P-0-0147, Expanded signal K1 address** and **P-0-0148, Expanded signal K2 address**. During the recording process, the contents of the selected addresses are saved in the lists of scope data.

Note: If a 16-bit data width is selected, then the signal data will be stored as sign-extended 32-bit values.

Oscilloscope feature trigger source

The **P-0-0025, Trigger Source** parameter makes it possible to choose between two trigger types.

External trigger (P-0-0025=0x01)

The trigger is activated by the control through bit 0 in **P-0-0036, Trigger Control Word**. This makes it possible to transmit a trigger event to several drives. This parameterization supports parameter **P-0-0035, Delay from trigger to start** which is needed to visualize the recording data.

Internal trigger (P-0-0025 = 0x02)

Triggering occurs through the monitoring of the parameterized trigger signal. If the selected edge is recognized, then the trigger will be released. Parameter **P-0-0035, Delay from trigger to start** will be set to zero.

Selection of trigger edges

Various trigger edges can be selected with the parameter **P-0-0030, Trigger Edge**. The following options are available:

Number	Trigger edge
1	Triggering on the positive edge of the trigger signal
2	Triggering on the negative edge of the trigger signal
3	Triggering on both the positive and negative edge of the trigger signal
4	Triggering when the trigger signal equals the trigger level

Fig. 9-18: Trigger edge selection

Selection of fixed trigger signals

The parameter **P-0-0026, Trigger Signal Selection** determines the signal that is monitored for the parameterized edge reversal. Just as for the signal selection, there are drive-internal fixed trigger signals for the trigger signal selection. These are activated by entering the corresponding number.

The following signal numbers are possible:

Trigger signal number	Trigger signal	Associated trigger level
0x00	no trigger signal	not defined
0x01	Position feedback value according to active operating mode	Position data (P-0-0027)
0x02	Velocity feedback value Parameter S-0-0040	Velocity data (P-0-0028)
0x03	Velocity deviation Parameter S-0-0347	Velocity data (P-0-0028)
0x04	Following error Parameter S-0-0189	Position data (P-0-0027)
0x05	Torque command value Parameter S-0-0080	Torque data (P-0-0029)
0x06	Position feedback 1 value S-0-0051	Position data (P-0-0027)
0x07	Position feedback 2 value S-0-0053	Position data (P-0-0027)
0x08	Position command value S-0-0047	Position data (P-0-0027)
0x09	Velocity command value Parameter (S-0-0036)	Velocity data (P-0-0028)

Fig. 9-19: Selection of fixed trigger signals

Selection of expanded trigger signals

In addition to a trigger signal selection with preset signals, the drive also allows for triggering on any internal signal. Use of this feature makes sense only with information about the structure of the internal data memory; therefore, this feature can be used effectively only by the respective developer. This feature can be activated with the parameter **P-0-0026, Trigger Signal Selection** by setting bit 12.

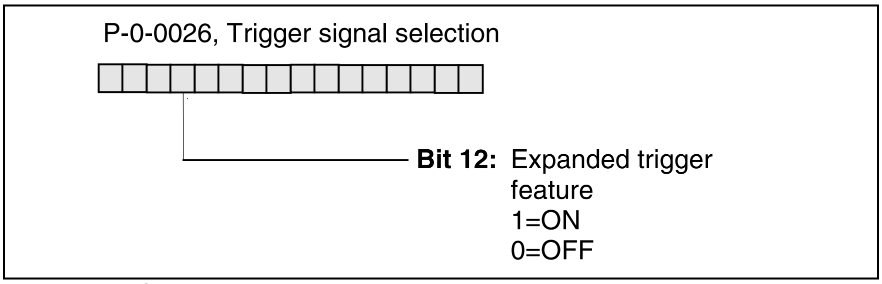


Fig. 9-20: Structure of parameter P-0-0026

If the expanded trigger feature is activated, then the trigger signal address must be defined via the parameter **P-0-0146, Expanded Trigger Address**. The associated trigger level is entered in the parameter **P-0-0145, Expanded Trigger Level**. This parameter is defined as follows:

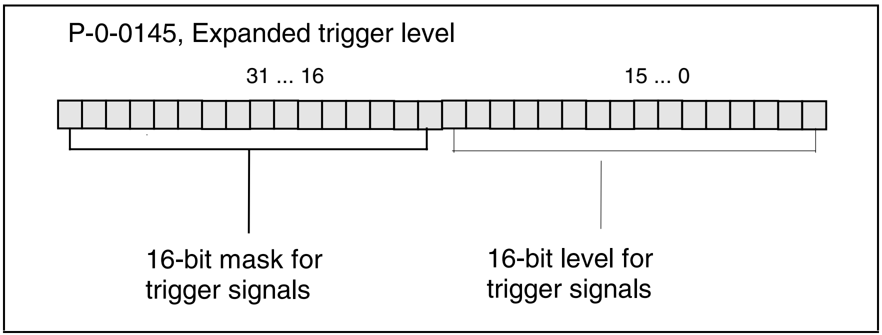


Fig. 9-21: Structure of parameter P-0-0145

The 16-bit value of the trigger level is monitored the trigger signal being ANDed before by means of the trigger signal mask.

Parameterizing time resolution and size of memory

The recording ranges for the oscilloscope feature can be defined with parameters **P-0-0031, Timebase** and **P-0-0032, Size of Memory**. The maximum size of memory defined is 512 measured values. If you need fewer measured values, you can change the value in the memory size parameter.

The time resolution can be set from 250 µs to 100 ms in steps of 250 µs. This determines the time intervals in which the measured values are recorded. The minimum recording duration is 128 ms, the maximum recording duration is 51.2 s.

In general:

$$\text{Recording duration} = \text{Time resolution} \times \text{Size of Memory}\,[\mu s]$$

Fig. 9-22: Determining the recording duration

Setting the trigger delay

By setting the parameter **P-0-0033, Number of Samples after Trigger**, it is possible to record measured values before the trigger event occurs (trigger delay function of an oscilloscope). The setting is made in units of the parameterized time resolution. The input value determines the number of probe values still recorded after a trigger event. By entering 0 [time resolution], only data available before a trigger event will be recorded. If the value of parameter **P-0-0032, Size of Memory** is entered, then only the measured values occurring after the trigger event will be recorded.

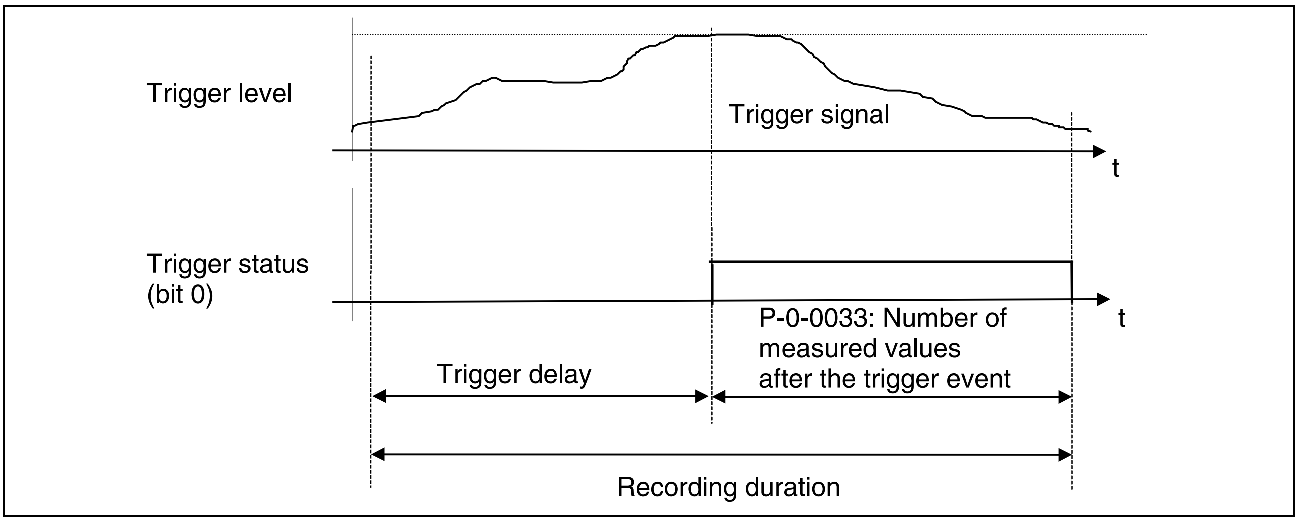


Fig. 9-23: Trigger delay - Number of measured values after trigger event

Activating the oscilloscope feature

The oscilloscope feature can be activated with the parameter **P-0-0036, Trigger Control Word**. The parameter is defined as follows:

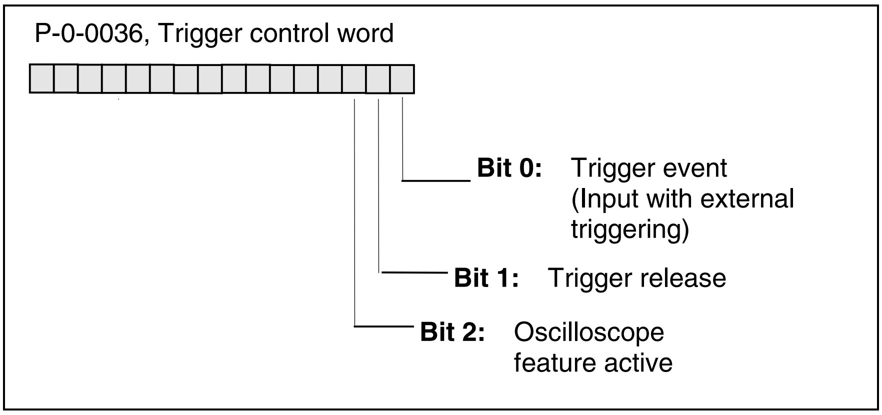


Fig. 9-24: Structure of parameter P-0-0036

The oscilloscope feature is activated by writing "1" to bit 2, i.e. the selected measurement signals are continuously written to the internal probe value memory. If bit 1 is set, then the trigger monitor is activated and the oscilloscope feature waits for the selected edge to occur. If a valid edge is recognized, then the probe value memory will be completed as set in parameter P-0-0033, and the oscilloscope feature will be deactivated by resetting bits 1 and 2 in the trigger control word.

Oscilloscope feature with external trigger and internal trigger condition

If triggering is selected in parameter **P-0-0025, Trigger Source** with the control bit of the trigger control word, then the trigger will only be released with the 0→1 (rising) edge of bit 0 in the trigger control word.

With this drive, it is also possible to monitor a trigger signal for the trigger condition. If the trigger condition is recognized, then bit 0 will be set in the trigger status, but the trigger will not be released. In this way, it is possible to signal the trigger event for several drives simultaneously using the real-time status and control bits via the control, and to release the trigger.

Since there is a delay between the recognition of the trigger event and the release of the trigger, caused by the transmission of the trigger event via the control, the delay is measured by the drive and stored in the parameter **P-0-0035, Delay from Trigger to Start**. A time-correct display of the signals can be guaranteed by using this parameter for the visualization of the measured values.

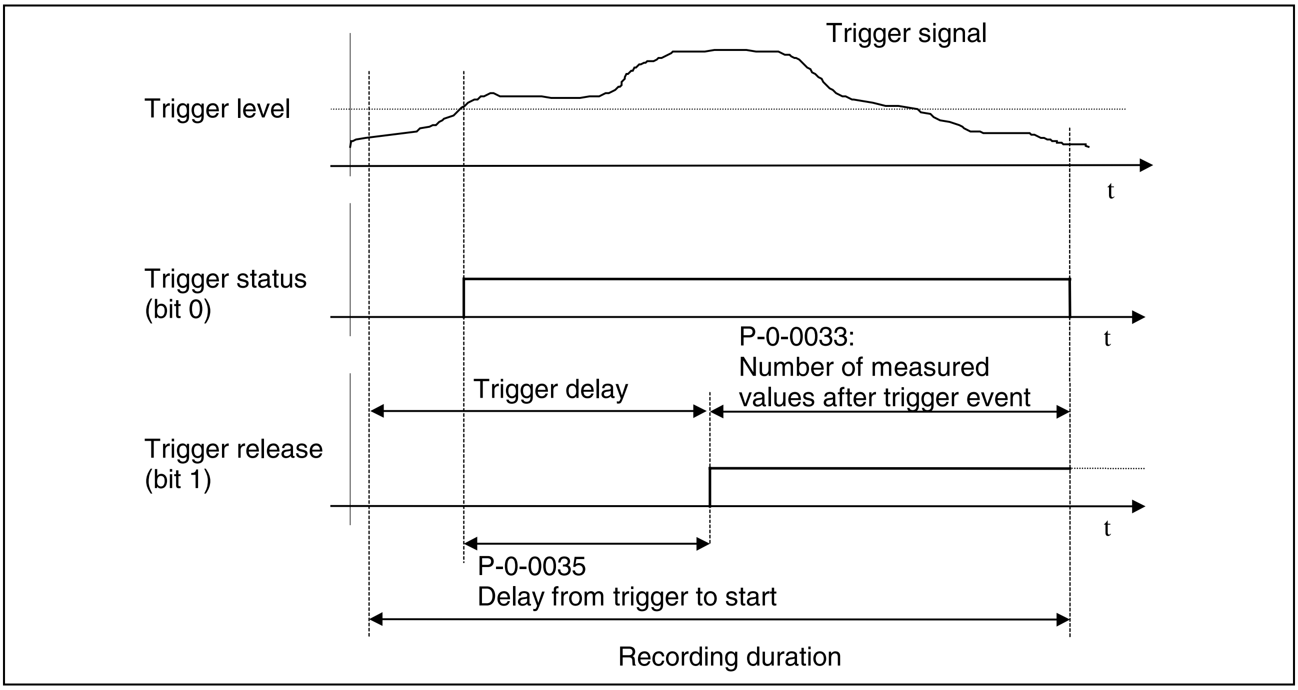


Fig. 9-25: Delay from trigger to start

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**.

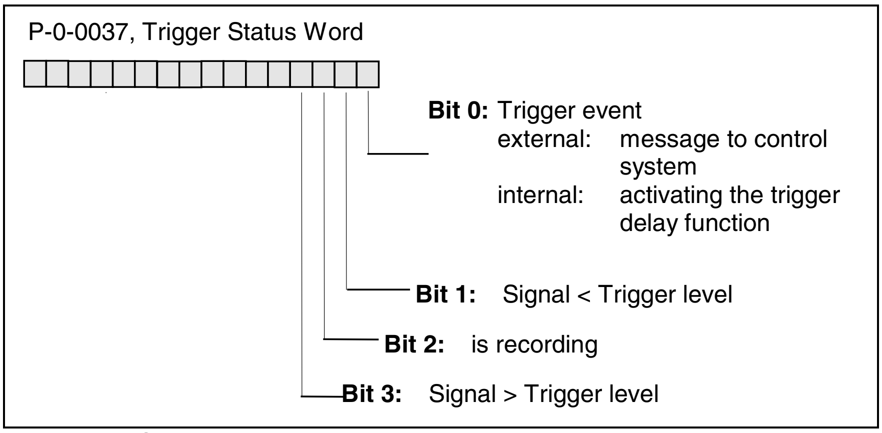


Fig. 9-26: Structure of parameter P-0-0037

Number of valid measured values

As soon as bit 2 is set by the **P-0-0036, Trigger Control Word**, the drive starts recording measured values.

If the trigger event is recognized after the bit is set, the oscilloscope feature records the number of measured values after the trigger event and then stops recording.

The total probe value memory for the current measurement will not always be written, dependent on the memory size setting, the time resolution, the number of measured values after the trigger event and the time when the trigger event occurs; this means that the memory contains measured values which are not valid for this measurement.

The parameter **P-0-0150, Number of valid Samples** indicates the number of valid measured values for the current recording.

9.6 Probe Input Feature

There are two digital inputs for measuring position and times. The measurands are fixed at the time of the positive and negative edges.

The following measured values can be determined:

- actual position value 1
- actual position value 2
- relative internal time in [usec]
- master axis position

Note: The probe inputs are probed every 1 usec. The measured signals are generated every 250 usec. Linear interim interpolation takes place between these two steps with an accuracy of 1 usec.

Both the absolute values at the time the positive or negative edges occur as well as their difference can be read out via parameter.

The following parameters support this function:

- **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**
- **P-0-0204, Start position for active probe**
- **P-0-0205, End position for active probe**
- **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**
- **P-0-0202, Difference probe values 1**
- **S-0-0132, Probe value 2 positive edge**
- **S-0-0133, Probe value 2 negative edge**
- **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 (KÄ) 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.

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.

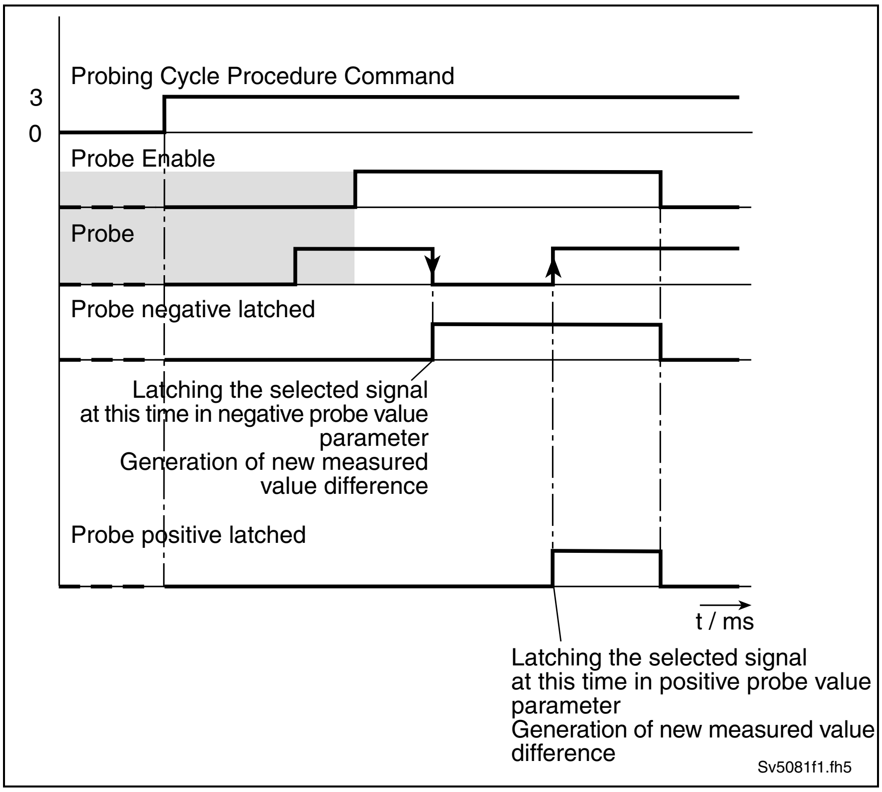


Fig. 9-27: Evaluation of probe signal edges, when positive and negative signal edge evaluation are set in the probe control parameter

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, Command Probing Cycle Procedure**. 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. The parameter is structured as follows:

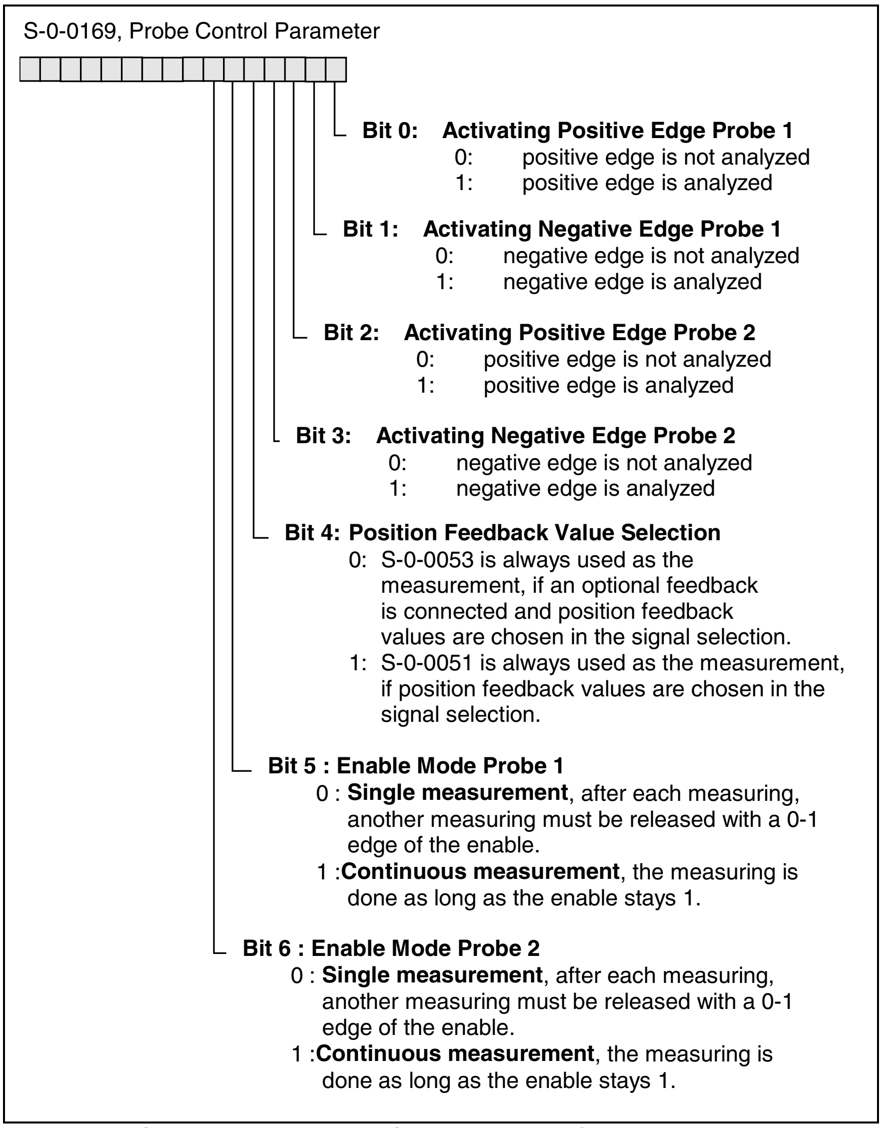


Fig. 9-28: Structure of Parameter S-0-0169, Probe Control

Signal Selection for the Probe Inputs

The signals to be measured are:

- actual position value 1 (motor encoder)
- actual position value 2 (option encoder, if mounted)
- internal time
- master axis position

The selection is made via parameters **P-0-0200, Signal select probe 1** and **P-0-0201, Signal select probe 2**, as well as bit 4 of **S-0-0169, Probe control parameter**.

It is possible with P-0-0200 and P-0-0201 to specify both probe inputs separately in terms of whether an actual position value or an internal time are to be measured.

Value of P-0-0200:	Signal:
0	actual position values 1/2
1	time
2	master axis position
3	actual position values 1 or 2 with activated window
4	master axis position with active window

Fig. 9-29: probe function determining signals for probe 1

Value of P-0-0201:	Signal:
0	actual position values 1/2
1	time
2	master axis position

Fig. 9-30: Probe function determining signals for probe 2

Depending on this choice, the units, decimal places of parameter measured value positive and negative, Measured value difference, Start position probe function active and End position probe function active of the relevant probe are switched.

If the actual position 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.

Probe 1 has the option of determining whether only master axis positions or actual position values within a fixed range are latched (signal selection 3 or 4). The range is defined with parameters **P-0-0204, Start position for active probe** and **P-0-0205, End position for active probe**.

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.

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.

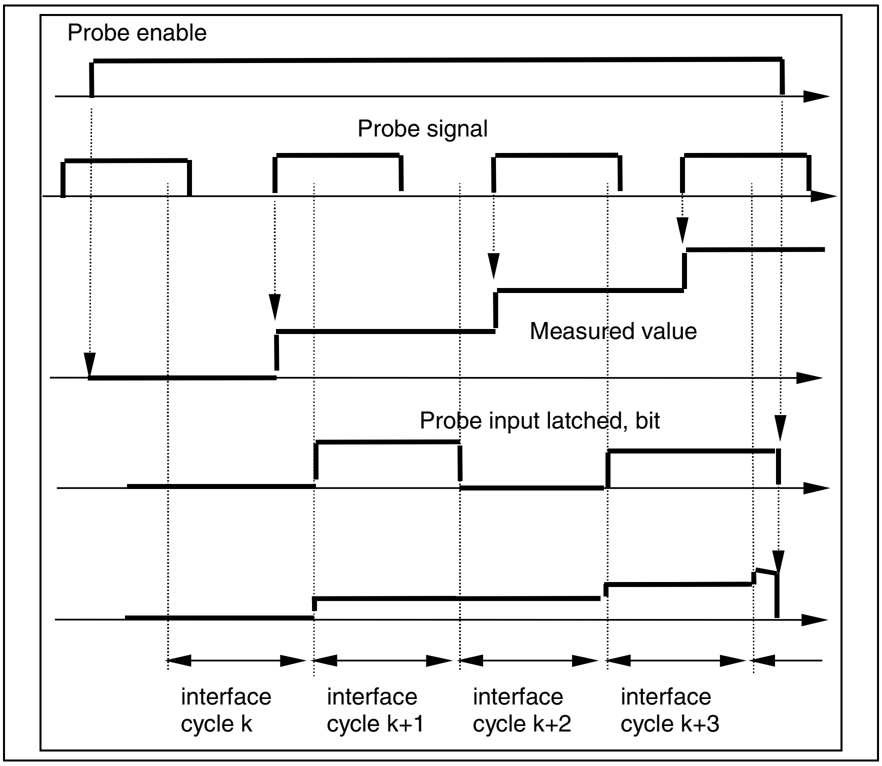


Fig. 9-31: Probe enable, probe signal, probe latched and measurand without overrun, for example a "positive probe flank"

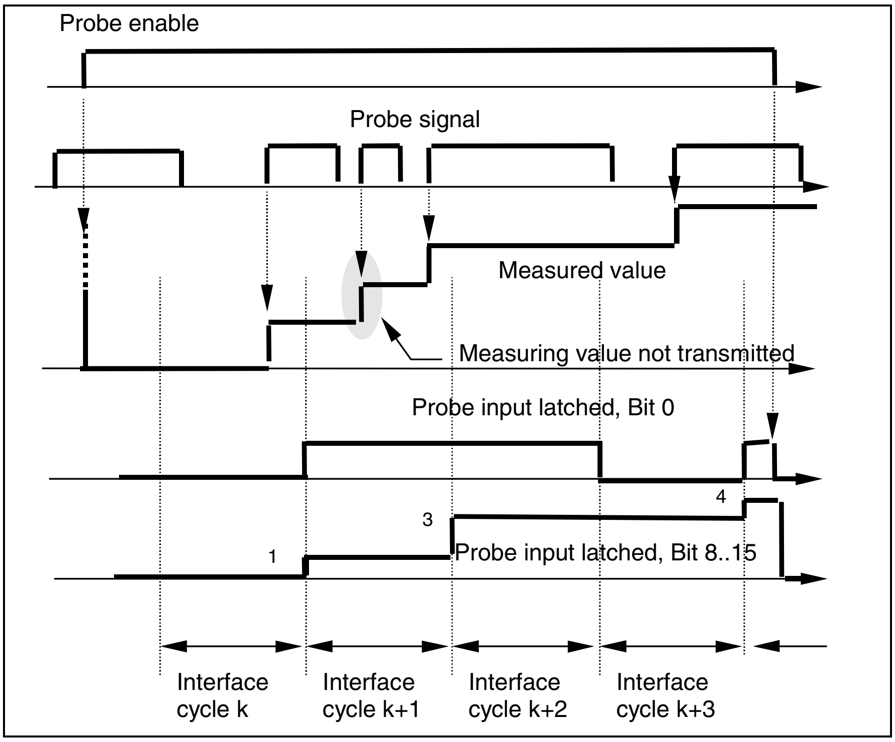


Fig. 9-32: Probe enable, probe signal, probe latched and measurand with overrun, for example a "positive probe flank"

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. 9-33: Relationship between measurand status and overrun counter

DIAX--Connecting the Probe Inputs

The probe can be connected to E4 or E5 at connector X12 on the DSS 2.1 plug-in module.

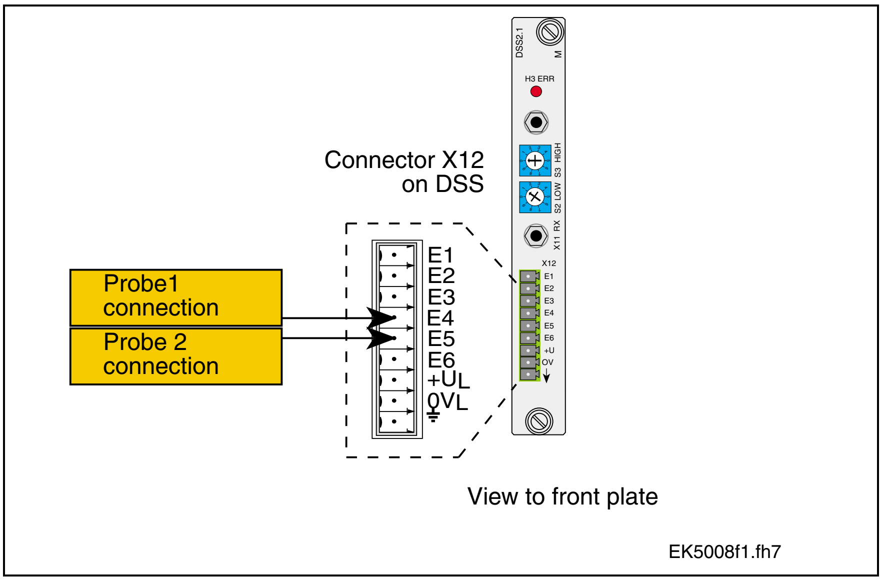


Fig. 9-34: Connecting the probes to the DSS

The following levels are valid for the probe inputs:

Low: 0..+6V

High: +14V..U_{ext}(max)

The inputs need an external power supply (with voltage U_{ext}) because they are electrically isolated.

The following applies:

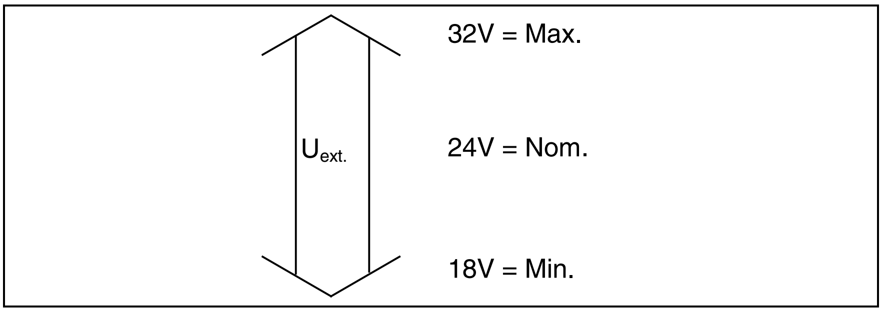


Fig. 9-35:Permissible input voltage range of the external power supply

If the external voltage is not in this range, then the error message:

F272 Error power supply probe input will be generated.

9.7 Masteraxis position output

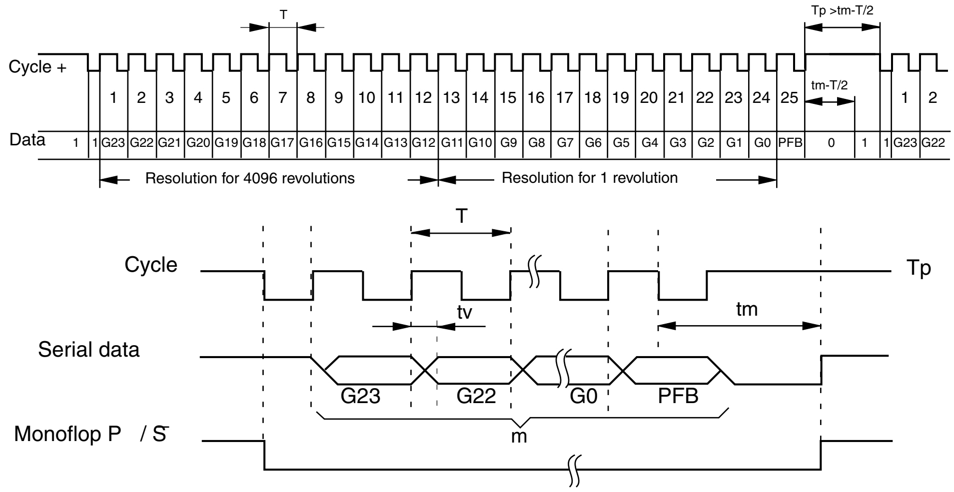
The drive control device offers the option to output the Master-drive position in SSI format. The Master-drive position is transmitted by the control with the parameter **P-0-0053, Master Drive Position**.

The DSA slide-in module is needed for that function.

The drive automatically recognizes that a DSA module is connected and activates the output of the Master-drive position.

Parameter **P-0-0059, SSI-Emulator-Solution** can be used to determine with how many increments per encoder rotation the Master-drive position will be exported in SSI format through the DSA interface.

The following displays an impulse diagram of a position output in SSI format.



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

Figure 9-36: SSI Format as an Impulse Diagram

9.8 Command - detect marker position

The command "Determine marker position" is used to check the correct detection of the reference markers of an incremental measuring system. This does not include an evaluation of the zero switch.

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 detect marker position** is activated, the following is done:

Only possible with incremental measuring systems

- The diagnosis **D500 detect marker position command** is generated.
- Check whether the encoder selected by bit 3 of **S-0-0147, Homing parameter** is an incremental measuring system. Incremental measuring systems are those connected via one of the encoder interfaces listed below. If this is not the case, then the command error message **D501 Incremental encoder required** is generated. The command cannot be executed any further.
- 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, then its position feedback value is stored in parameter **S-0-0173, marker position A.** This command is now signalled as completed.

Note: No command values are generated. The mode active at command start remains unchanged. To override the reference marker, the control must generate command values, e.g., by jogging.

Possible encoder interfaces of incremental measuring systems:

Encoder interface	Number
DLF01.1	2
DZF02.1	3
DEF011	5
DEF02.1	6
DZF03.1	9

Fig. 9-37: Possible encoder interfaces of incremental measuring systems

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 command drive-controlled homing**. This relates, however, to the "old" coordinate system (before the coordinate system was switched while performing a homing function).

9.9 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.

Pertinent Parameters

- **S-0-0139, D700 Command parking axis**

Functional principle

The command can only be started in parameter mode (communications phases 2 or 3). Once **S-0-0139, D700 command parking axis** is started:

- the measuring system monitors,
- the control loop monitors and
- the temperature monitors

are deactivated.

The measuring system initializations are not executed in command **S-0-0128, C200 communications phase 4 transition check**. "**PA**" appears at the 7-segment display. The drive no longer accepts the drive enable signal.

All active commands in the drive are cancelled when switching the communications phases back. If this command was activated, followed by a progression into communications phase 4 (operating mode), then there is no need to cancel the command, as the cancelling is only possible in communications phases 2 or 3, and any phase regression will also inevitably cancel all commands.

9.10 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 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.

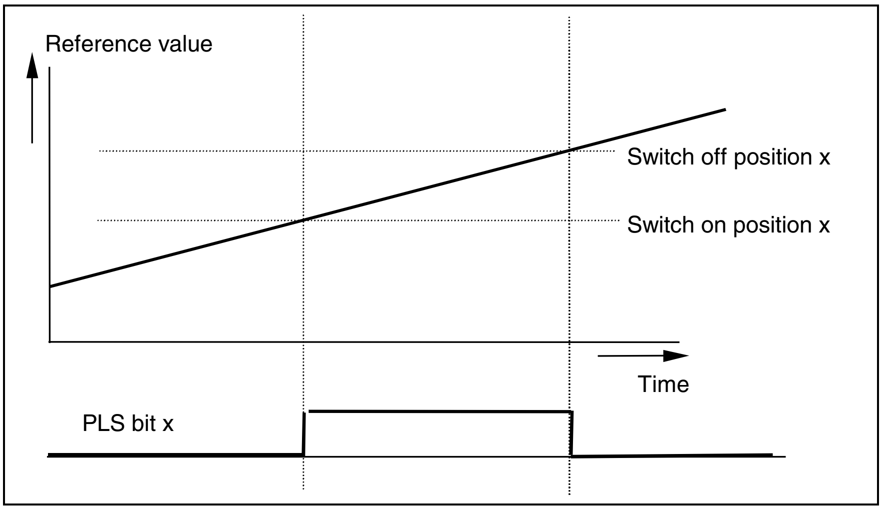


Fig. 9-38: General Function Diagram for the Programmable Limit Switch

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

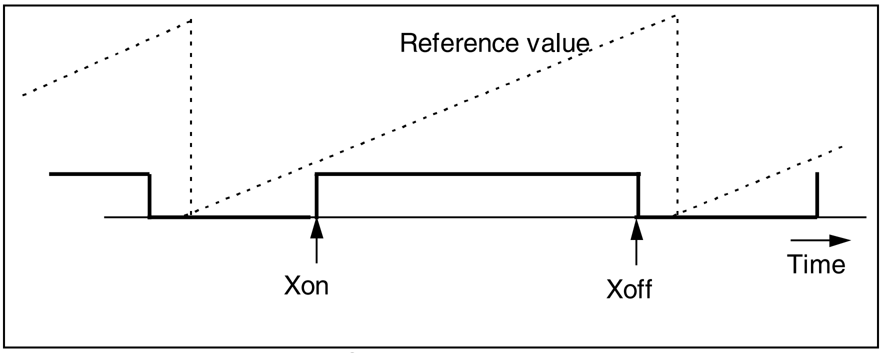


Fig. 9-39: Programmable Limit Switch With Xon < Xoff

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

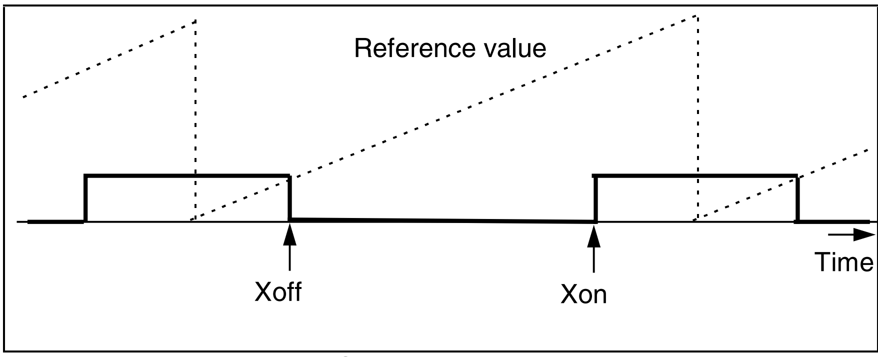


Fig. 9-40: Programmable Limit Switch With Xon > Xoff

A switch hysteresis is available to avoid position-switch flickering when the on- or off-switch level is reached.

Programmable Limit Switch Lead Time

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.

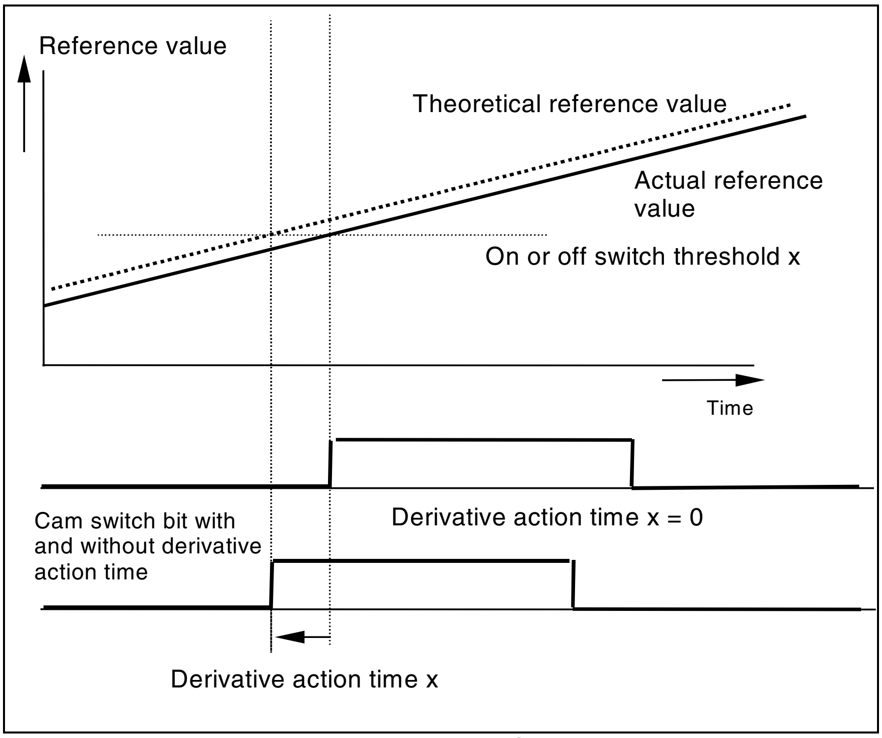


Fig. 9-41: Diagram for the Programmable Limit Switch Lead Time

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. 9-42: Programmable Limit Switch: Activation and Setting the ReferenceSignal

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.

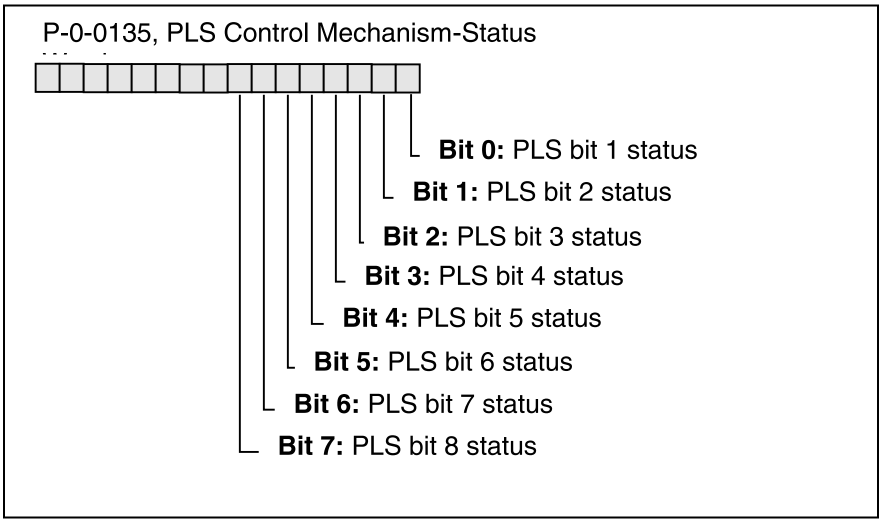


Fig. 9-43: Position Switch Status

9.11 Incremental Encoder Emulation

Incremental encoder emulation is a simulation by the drive controller of a real incremental encoder. It is possible to emulate either a master axis position or a motor position. The selected position is then output by means of incremental encoder compatible signals via the **DAE02.1M interface, connector** X76.

Note: If actual position feedback 1 is emulated then only the motor can be referenced the load cannot, i.e., a gear or a feed constant cannot be taken into account. Relevant inputs **S-0-0076, Position data scaling type** are not taken into consideration for the incremental encoder emulator.

Pertinent Parameters

- **P-0-0502, Encoder emulation, resolution**
- **P-0-0503, Marker pulse offset**
- **P-0-0505, Signal selection incremental encoder**

Functional principle and Hardware Prerequisites

A hardware prerequisite is **module DAE02.1M**.

The function can neither be used nor parameterized without the interface. Use parameter **P-0-0505, Signal selection incremental encoder** to select the position to be emulated:

0	no emulation
1	simulated master axis position
2	simulated motor position

Fig. 9-44: Selecting incremental encoder signal

Note: If emulation is not needed then an "0" must be entered here as the emulator needs execution time.

With parameter **P-0-0502, Encoder emulation, resolution** the resolution can be set, input ranges from 1 to 2^18. The unit of P-0-0502 depends on **S-0-0076, Position data scaling type.** It can be lines / revolutions or lines / mm or lines / inches.

Use parameter **P-0-0503, Marker pulse offset** to shift the zero pulse of the incremental encoder in the range of 0 to 360 degrees.

Note: If a motor is used and the motor position selected with a resolver feedback, then the emulator will generate as many pulses as there are resolver pole pairs. Note that the input for **P-0-0502**, **Encoder emulation, resolution** can be divided without remainder by the number of resolver pairs, otherwise the "the zero pulse will run away".

Diagnostic Messages

SS display	Diagnosis	Cause / Solution
F2/53	incremental encoder emulator or frequency too high	Number of lines to be generated in a 250µsec interval is too high => the incremental encoder can generate up to 253 lines/250µsec interval. • Decrease P-0-0502 input. • Reduce travel speed
F2/54	incremental encoder emulator hardware error	=> the output of all lines in the interval is monitored and was faulty here so that a position offset occurred • replace DAE

Fig. 9-45: Diagnostic message

Incremental Encoder Emulation Restrictions

In contrast to conventional incremental encoders in which the pulse output frequency can be altered practically infinitely closely stepped, in other words, the pulse edges are always allocated to fixed positions, an emulated incremental encoder signal is subject to certain restrictions. These are primarily the result of the digital way in which the encoder emulation card DAE01.2M and the drive controller work.

Number of Lines

The number of encoder lines generally equals between 16 and 262144 - taking the maximum output frequency into consideration, see below - which can be freely selected as needed.

Exception: When emulating actual position value 1, gained from a non-absolute resolver, the number of lines must be divisible by the number of resolver pole pairs.

Maximum Output Frequency

The pulse output register on the DAE02.1M has a width of ten (10) bits. This means that per control cycle (250µs) it can process a maximum of $2^{10}-1 = 1023$ increments. The maximum pulse frequency which can thus be output equals 1023/4 = 256 per 250µs = 1.023 MHz. If this frequency is exceeded, then pulses can fail. The non-fatal error **F253 Incr. encoder emulator: pulse frequency too high** is generated. A position offset of the emulated in contrast to the real position occurs.

$$I_{max} = \frac{1.023\text{MHz} * 60}{n_{max}}$$

I_{max}: maximum number of lines
n_{max}: required maximum speed

Fig. 9-46: Computing maximum number of lines

Running Time Between Real and Emulated Positions

If real position detection occurs at point in time t_n then an internal computation is initiated. Starting at point in time t_{n+1} the computer number of increments is generated. Output is completed no later than point in time t_{n+2}.

At present, there is no running time compensation.

Depending on control's sampling point, minimum running time thus equals 250µs, maximum 500µs (average 375µs).

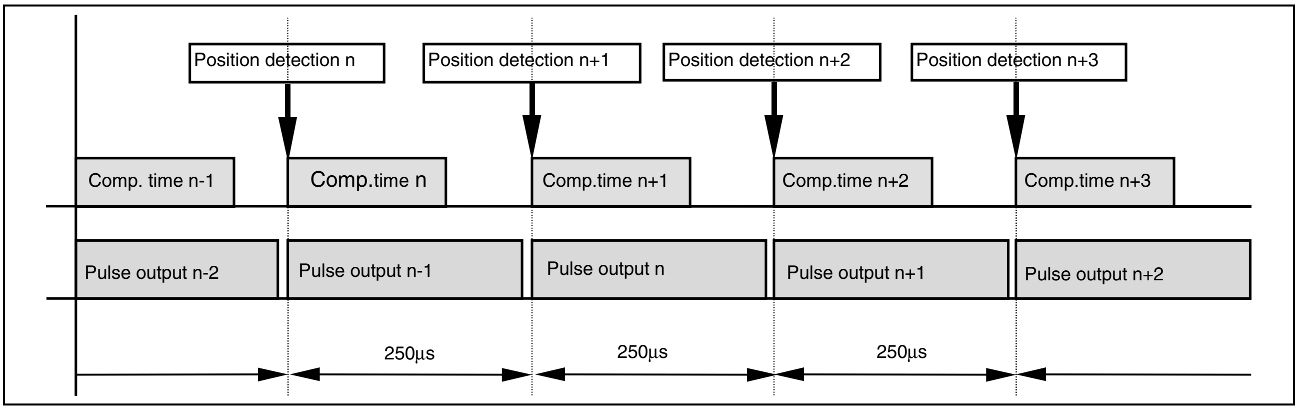


Fig. 9-47: Timing pulse output

Note: If the master axis position is emulated, then the lacking running time compensation of the emulation does not lead to a permanent error as the master axis position in the drives is also processed in the drives with a delay.

Rounding Off the Incremental Number in Short Intervals

In a short interval of 250µs (= internal control cycle) only one whole number of incrementals (1 increment = ¼ line) can be output. The remainder, which cannot be output, is added to the next interval. If another rest of 0 < rest < 1 follows this one, then it is added to the next interval and so on.

The results of this effect is that the „emulated speed" may be precise in its average but it can be a maximum of one incremental to small in each 250µs interval.

Pulse Breaks at the End of the Control Cycle

The duration of an increment can only be a whole multiple of the quartz oscillation period (T=50ns). This is why the number of increments of the current speed can be output prior to the end of the time interval of 250µs. This means that at the end of each interval, the signal levels for a specific period can remain constant. The output frequency cannot be changed during the interval of 250µs.

This effect is especially effective at high frequencies, i.e., with a high number of lines and/or high speeds.

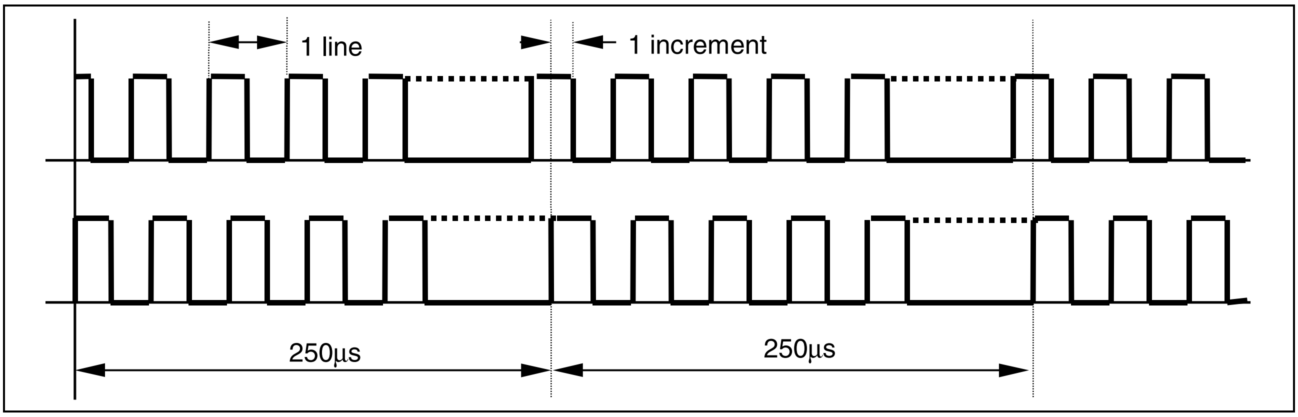


Fig. 9-48: Output signals of the incremental encoder emulator

The largest pulse break occurs if 1001 increments are generated per cycle. This equals an output frequency of 1.001 MHz.

Example:

Speed n = 3003 min-1, number of lines 20000

The required increment duration equals T = 0.2497µs. The duration which can be output equals T = 4 * 50ns = 0.2µs.

After T = 1001 increments * 0.2µs = 200.2µs output is completed. A pulse duration of 49.8µs thus remains.

Note: Pulse breaks can cause fluctuations in position detection especially if the system pulse of the control unit performing the sampling is not a whole number multiple of the system pulse of the drive controller. (This is always the case as the quartzes have tolerances and both systems are not synchronized.)

The following illustration clarifies the effects of the pulse breaks in a control unit.

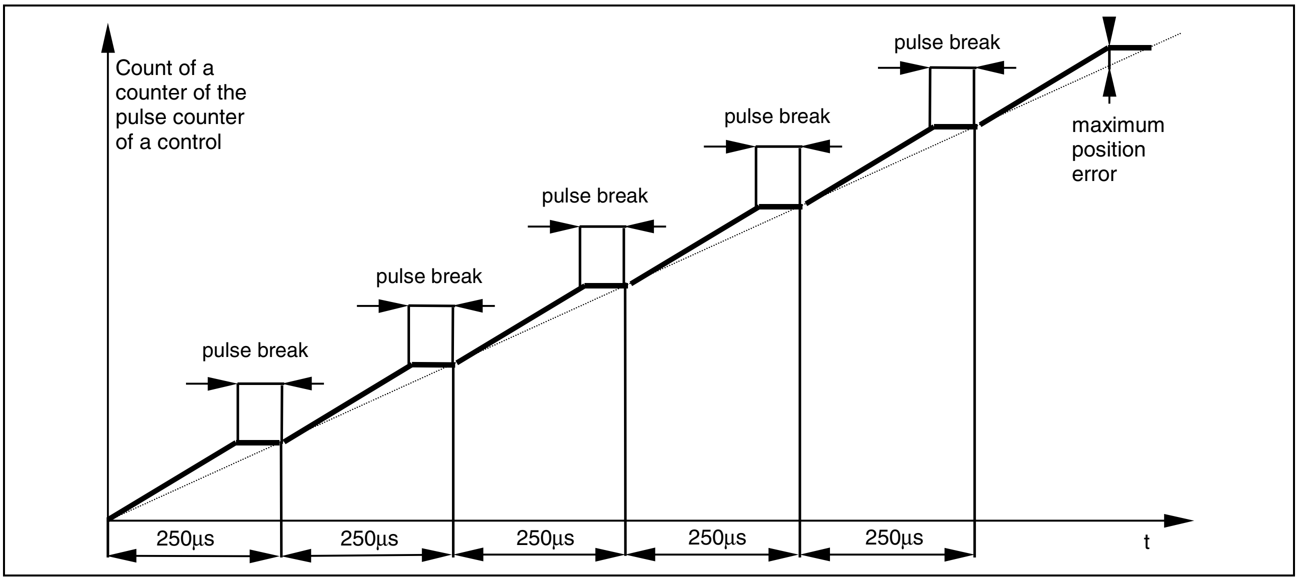


Fig. 9-49: Error during cyclical position detection caused by pulse breaks

Maximum output frequency without pulse breaks

If a pulse break exceeding one increment is to be prevented under all circumstances, then a specific maximum frequency may not be exceeded.

This maximum frequency equals **f = 76 kHz**.

A maximum speed, fixed by the application, equals the resulting maximum number of lines that can be input:

$$I_{max} = \frac{76kHz * 60}{n_{max}}$$

I_{max}: maximum number of lines without pulse breaks
n_{max}: application-dependent maximum speed

Fig. 9-50: Maximum number of lines without pulse breaks

Example:

Speed n = 1000 min-1, frequency f = 76 kHz

I = 4560 number of lines

10 Glossary

1MB

Rotary liquid-cooled asynchronous frameless motors.

2AD

Rotary asynchronous motors for main spindle applications.

Acceleration feedforward

In applications that require highest precision at high velocity it is possible to activate the acceleration precontrol and thereby significantly increase the precision of the axis in the acceleration and deceleration phases.

ADF

Rotary liquid-cooled asynchronous motor.

Analog inputs

By means of this function, two analog command values are mapped to one parameter via an analog/digital converter. The analog voltage can then be assigned to a parameter. This allows, for example, preselecting torque limit values or speed command values via analog inputs for the operating mode "Velocity control".

Analog outputs

The analog output function allows to output drive-internal signals and status variables in the form of analog voltage signals. In addition, the control unit can output cyclically transferred values.

AT

Abbreviation of "Antriebstelegramm" (German word for "drive telegram"). The drive telegram is sent from the slave to the master via the real time data channel.

Automatic control loop setting

In order to facilitate parameterization of an axis, the firmware types of the ECODRIVE03 and DURADRIVE product families include automatic control loop setting. After the user has specified the required axis dynamics, the drive controller automatically defines the control loop parameters for this kind of control loop setting.

Base parameters

Standard values for all drive parameters are stored in the drive controller. These values can be loaded anytime.

Basic load

Default control loop parameters are available for all digital drive controllers. These parameters are either contained in the motor feedback data memory (if available) and can be activated by executing the command "basic load", or can be read from a data base via the parameterization user interface of DriveTop.

Box set

If you order a box set from Rexroth Indramat, you get several books with related topics that are collected in a box.

CAN

Controller Area Network (CAN) is a serial bus system. This international standard network is particularly suitable for interconnecting units that are controlled by a micro controller. CAN is realtime-capable and highly reliable in data transfer.

CANopen

CANopen, a profile family for industrial automation, is based upon CAN and the CAN Application Layer (CAL). The CANopen specifications developed by the research groups of the international association of users and manufacturers *CAN in Automation (CiA)* allow installing cost-efficient decentralized control systems and input/output systems, as well as interconnected sensor/actuator systems.

Command "Drive-controlled homing procedure"

With this function the drive controller automatically carries out the homing procedure, i. e. it establishes a reference for the measurement system, in compliance with preset parameters.

Command "Get mark position"

The command "Get mark position" is used to check whether the reference marks of an incremental measuring system are recognized correctly.

Command "Parking axis"

The command "Parking axis" is used to uncouple an axis. This can be necessary, for example, for stopping an axis temporarily . The start of this command causes all monitoring functions of the measuring system and of the control loops to be switched off.

Command "Positive stop drive procedure"

The "Positive stop drive procedure" causes all controller monitoring functions to be switched off. When the drive is blocked by the positive stop, no error message is generated.

Command "Set absolute measurement"

By means of this function the actual position value of an absolute measuring system can be set to any value. The actual position value thereby gets a defined reference to the machine zero point.

Current limit

By internal monitoring of the thermal load of the drive controller and the motor it is possible to activate the reduction of the allowed output current.

Customer password

All important axis-specific parameters are stored in the programming module. In order to protect these parameters against accidental or unauthorized change, they can be write-protected by a customer password.

Diagnosis

Every status of the drive controller is identified by means of a diagnosis. The diagnosis is displayed on the drive controller as a combination of letters and numbers, as well as stored in parameters. In addition, the commissioning software DriveTop illustrates the diagnosis in the form of a short text. There are different diagnoses for error, warning, command and status (diagnoses that display the operating status).

DISC

This function allows integrating special drive functions, that are not "hard wired" in the drive firmware, in the drive controller in the form of drive macros.

DKC

Name of a drive controller developed by Rexroth Indramat. This drive controller belongs to the ECODRIVE03 product family.

DKCxx.3-016-7-FW

The devices of the DKCxx.3-016-7-FW type still were in their development phase at the time this documentation was compiled, i. e. the data in the documentation are preliminary. For further information on the availability and the definite functionality, please contact our service department.

Document typecode

The document typecode helps identify documents. It can be found at several places on a document: on the left bottom of the title page, on the reverse of the title page (marginal note: "Document Typecode") and in each footing.

Drive Halt

When the Drive Halt function is activated, the drive does not follow the command values of the active operating mode any longer. The values that are used for stopping depend on the operating mode that had been active before.

DSF

Abbreviation for the position encoder type "digital servo feedback".

Dynamic position switch

The function "dynamic position switch" allows realizing dynamic position switching points. For each position switching point there is an individual switch-on and switch-off position, as well as an individual rate time.

EcoX

EcoX is the name of an expansion interface. This expansion interface is a serial, cyclic bus.

Encoder emulation

The encoder emulation allows outputting the actual position value of the motor encoder or an external encoder, or the position command value in the TTL format (incremental encoder emulation) or in the SSI format (absolute encoder emulation).

Error memory and hours-run meter

Errors that occur during operation are stored in an error memory. This memory contains the last 19 errors that occurred and the time when they occurred. There are also hours-run meters for the control section and power section of the drive controller.

Error reaction to be parameterized

If an error status is recognized in the drive controller, a drive error reaction is automatically started. In the case of a non- fatal error status the kind of error reaction (best possible deceleration) can be predetermined. (There are up to four different possibilities available.)

E-Stop function

The E-Stop function is used to stop the drive via a hardware input at the drive controller. It is thereby possible to switch off the drive in parallel with the master communication in case of emergency. It is possible to select how to activate the E-Stop function and how to stop the drive.

Evaluation of absolute measuring systems

Measuring systems that provide absolute position information over one or several encoder revolutions (single or multi-turn encoder) or over a certain distance (absolute linear measuring systems) can be used as motor measuring systems and/or optional measuring systems. The information on the absolute encoder range within which the measuring system can provide position data, is stored in the data memory of the measuring system or in the drive software. After the initialization procedure (setting of the absolute position), the actual position value is available within the absolute encoder range, with reference to the machine zero point.

Evaluation of optional encoders for position and/or velocity control

Optional (load-side) encoders can be evaluated, in order to use their values for position and/or velocity control. The optional encoder can be used as a load-side motor encoder.

FGP

Part of a firmware name. This firmware is used for general automation and supports master communication via field bus interfaces.

GDS

Name of a digital single-turn encoder supplied by Rexroth Indramat.

IBS

Abbreviation of the German term "Inbetriebnahmeschritt(e)" ("commissioning step[s]").

Jerk

Jerk is the change in acceleration per time.

LAF

Asynchronous linear frameless motors with encapsulated standard construction.

LAR

Asynchronous linear housing motors for high acceleration and short travel distances.

LSB valence

Valence of the "least significant bit".

LSF

Synchronous linear frameless motors with encapsulated standard construction for automation.

- and -

Synchronous linear frameless motors with encapsulated thermo construction for precision processing.

MBS

Synchronous rotary frameless spindle motors.

MBW

Synchronous rotary frameless motor with stator and rotor.

MDT

Abbreviation for master data telegram. The master data telegram is sent from the master to the slave via the real time data channel.

Measuring probe function

The measuring probe function is used to measure positions (actual position value or master axis position) and times (relative internal time) by means of binary input signals.

MHD

High-performance synchronous rotary motors.

MKD

Synchronous rotary motors for standard applications.

MKE

Synchronous rotary motors for areas subject to explosion hazard.

Modulo function

The modulo function allows representing all position data within the range from 0 to the modulo value that has been parameterized. It is therefore possible to realize axes that move endlessly in one direction.

Multi-turn encoder

Position encoder that provides absolute position over several revolutions.

Oscilloscope function

The oscilloscope function is used to record internal and external signals and status variables. Its functional scope corresponds approximately to that of a 2-channel oscilloscope.

PDO

Process data objects. Objects that are transferred via the acyclic channel (real time data channel), in the case of master communication via CANopen interface.

Position control loop monitoring

The position control loop monitoring function is used to diagnose malfunction within the position control loop. This monitoring function can recognize, for example, transgression of the torque or acceleration capacity of the drive, blockage of the axis mechanism or failures in the position encoder.

RCD

Abbreviation for residual current-operated protective devices.

Scaling

Combination of the unit and the number of decimal places.

SDO

Service data objects. Objects that are transferred via the cyclic channel (process data channel), in the case of master communication via CANopen interface.

SGP

Part of a firmware name. This firmware is used for general automation.

Single-turn encoder

Position encoder, an absolute value is assigned to every angular position between 0° and 360°.

SMT

Part of a firmware name. This firmware is used for machine tool applications.

Torque/force limit to be parameterized

The torque/force limit value can be parameterized to values below the maximum possible value. This is useful, for example, when the drive moves to the end position of its travel range.

Travel range limit

In order to limit the working range, the firmware provides the following functions:

- position limit values and
- travel range limit switches

Typecode

see document typecode

Velocity control loop monitoring

The drive controller monitors the velocity control loop for correct function and causes immediate stop (torque disable) in case of error. This monitoring function allows recognizing, for example, incorrect polarity of the motor connection, incorrect commutation angle or failures in the velocity encoder.

The monitoring function avoids the "runaway effect".

Velocity limit

The parameterization of the drive controller can limit the velocity of a motor to values lower than the maximum possible velocity. The maximum velocity can therefore be variably limited as required by specific applications.

Velocity mix factor

By means of the velocity mix factor the actual velocity value used for velocity control can be calculated from a combination of motor measuring system and external measuring system. This can be advantageous if the coupling between motor and load has play or torsion.

Notes

11 Index

D

F

G

H

I

L

N

O

P

R

S

T

U

V

W

Notes

12 Service & Support

12.1 Helpdesk

Unser Kundendienst-Helpdesk im Hauptwerk Lohr am Main steht Ihnen mit Rat und Tat zur Seite. Sie erreichen uns

- telefonisch: **+49 (0) 9352 40 50 60**
  über Service Call Entry Center Mo-Fr 07:00-18:00
- per Fax: **+49 (0) 9352 40 49 41**
- per e-Mail: **service@indramat.de**

Our service helpdesk at our headquarters in Lohr am Main, Germany can assist you in all kinds of inquiries. Contact us

- by phone: **+49 (0) 9352 40 50 60**
  via Service Call Entry Center Mo-Fr 7:00 am - 6:00 pm
- by fax: **+49 (0) 9352 40 49 41**
- by e-mail: **service@indramat.de**

12.2 Service-Hotline

Außerhalb der Helpdesk-Zeiten ist der Service direkt ansprechbar unter

+49 (0) 171 333 88 26
oder **+49 (0) 172 660 04 06**

After helpdesk hours, contact our service department directly at

+49 (0) 171 333 88 26
or **+49 (0) 172 660 04 06**

12.3 Internet

Unter **www.indramat.de** finden Sie ergänzende Hinweise zu Service, Reparatur und Training sowie die **aktuellen** Adressen *) unserer auf den folgenden Seiten aufgeführten Vertriebs- und Servicebüros.

- ☐ Verkaufsniederlassungen
- ☐ Niederlassungen mit Kundendienst

Außerhalb Deutschlands nehmen Sie bitte zuerst Kontakt mit unserem für Sie nächstgelegenen Ansprechpartner auf.

*) http://www.indramat.de/de/kontakt/adressen
Die Angaben in der vorliegenden Dokumentation können seit Drucklegung überholt sein.

At **www.indramat.de** you may find additional notes about service, repairs and training in the Internet, as well as the **actual** addresses *) of our sales- and service facilities figuring on the following pages.

- ☐ sales agencies
- ☐ offices providing service

Please contact our sales / service office in your area first.

*) http://www.indramat.de/en/kontakt/adressen
Data in the present documentation may have become obsolete since printing.

12.4 Vor der Kontaktaufnahme... - Before contacting us...

Wir können Ihnen schnell und effizient helfen wenn Sie folgende Informationen bereithalten:

1. detaillierte Beschreibung der Störung und der Umstände.
2. Angaben auf dem Typenschild der betreffenden Produkte, insbesondere Typenschlüssel und Seriennummern.
3. Tel.-/Faxnummern und e-Mail-Adresse, unter denen Sie für Rückfragen zu erreichen sind.

For quick and efficient help, please have the following information ready:

1. Detailed description of the failure and circumstances.
2. Information on the type plate of the affected products, especially type codes and serial numbers.
3. Your phone/fax numbers and e-mail address, so we can contact you in case of questions.

12.5 Kundenbetreuungsstellen - Sales & Service Facilities

Deutschland – Germany

vom Ausland: (0) nach Landeskennziffer weglassen!
from abroad: don't dial (0) after country code!

Vertriebsgebiet Mitte Germany Centre Rexroth Indramat GmbH Bgm.-Dr.-Nebel-Str. 2 / Postf. 1357 97816 Lohr am Main / 97803 Lohr **Kompetenz-Zentrum Europa** Tel.: +49 (0)9352 40-0 Fax: +49 (0)9352 40-4885	**SERVICE** **CALL ENTRY CENTER** **MO – FR** **von 07:00 - 18:00 Uhr** **from 7 am – 6 pm** **Tel. +49 (0) 9352 40 50 60** service@indramat.de	**SERVICE** **HOTLINE** **MO – FR** **von 17:00 - 07:00 Uhr** **from 5 pm - 7 am** + SA / SO **Tel.: +49 (0)172 660 04 06** **oder / or** **Tel.: +49 (0)171 333 88 26**	**SERVICE** **ERSATZTEILE / SPARES** verlängerte Ansprechzeit - extended office time - ♦ nur an Werktagen - only on working days - ♦ von 07:00 - 18:00 Uhr - from 7 am - 6 pm - **Tel. +49 (0) 9352 40 42 22**
Vertriebsgebiet Süd Germany South Rexroth Indramat GmbH Landshuter Allee 8-10 80637 München Tel.: +49 (0)89 127 14-0 Fax: +49 (0)89 127 14-490	Vertriebsgebiet West Germany West Bosch Rexroth AG Regionalzentrum West Borsigstrasse 15 40880 Ratingen Tel.: +49 (0)2102 409-0 Fax: +49 (0)2102 409-406	Gebiet Südwest Germany South-West Bosch Rexroth AG Service-Regionalzentrum Süd-West Fellbacherstr.115 70736 Fellbach Tel.: +49 (0)711 54041–0 Fax: +49 (0)711 54041–147	Gebiet Südwest Germany South-West Bosch Rexroth AG Regionalzentrum Südwest Ringstrasse 70 / Postfach 1144 70736 Fellbach / 70701 Fellbach Tel.: +49 (0)711 57 61–100 Fax: +49 (0)711 57 61–125
Vertriebsgebiet Nord Germany North Bosch Rexroth AG Walsroder Str. 93 30853 Langenhagen Tel.: +49 (0) 511 72 66 57-0 Service: +49 (0) 511 72 66 57-256 Fax: +49 (0) 511 72 66 57-93 Service: +49 (0) 511 72 66 57-95	Vertriebsgebiet Mitte Germany Centre Bosch Rexroth AG Regionalzentrum Mitte Waldecker Straße 13 64546 Mörfelden-Walldorf Tel.: +49 (0) 61 05 702-3 Fax: +49 (0) 61 05 702-444	Vertriebsgebiet Ost Germany East Bosch Rexroth AG Beckerstraße 31 09120 Chemnitz Tel.: +49 (0)371 35 55-0 Fax: +49 (0)371 35 55-333	Vertriebsgebiet Ost Germany East Bosch Rexroth AG Regionalzentrum Ost Walter-Köhn-Str. 4d 04356 Leipzig Tel.: +49 (0)341 25 61-0 Fax: +49 (0)341 25 61-111

Europa (West) - Europe (West)

vom Ausland: (0) nach Landeskennziffer weglassen, Italien: 0 nach Landeskennziffer mitwählen
from abroad: don't dial (0) after country code, Italy: dial 0 after country code

Austria - Österreich Bosch Rexroth GmbH Bereich Indramat Stachegasse 13 1120 Wien Tel.: +43 (0)1 985 25 40 Fax: +43 (0)1 985 25 40-93	Austria – Österreich Bosch Rexroth G.m.b.H. Gesch.ber. Rexroth Indramat Industriepark 18 4061 Pasching Tel.: +43 (0)7221 605-0 Fax: +43 (0)7221 605-21	Belgium - Belgien Bosch Rexroth AG Electric Drives & Controls Industrielaan 8 1740 Ternat Tel.: +32 (0)2 5830719 - service: +32 (0)2 5830717 Fax: +32 (0)2 5830731 indramat@boschrexroth.be	Denmark - Dänemark BEC A/S Zinkvej 6 8900 Randers Tel.: +45 (0)87 11 90 60 Fax: +45 (0)87 11 90 61
Great Britain – Großbritannien Bosch Rexroth Ltd. Rexroth Indramat Division Broadway Lane, South Cerney Cirencester, Glos GL7 5UH Tel.: +44 (0)1285 863000 Fax: +44 (0)1285 863030 sales@boschrexroth.co.uk service@boschrexroth.co.uk	Finland - Finnland Bosch Rexroth Oy Rexroth Indramat division Ansatie 6 017 40 Vantaa Tel.: +358 (0)9 84 91-11 Fax: +358 (0)9 84 91-13 60	France - Frankreich Bosch Rexroth S.A. Division Rexroth Indramat Avenue de la Trentaine BP. 74 77503 Chelles Cedex Tel.: +33 (0)164 72-70 00 Fax: +33 (0)164 72-63 00 **Hotline:** +33 (0)608 33 43 28	France - Frankreich Bosch Rexroth S.A. Division Rexroth Indramat 1270, Avenue de Lardenne 31100 Toulouse Tel.: +33 (0)5 61 49 95 19 Fax: +33 (0)5 61 31 00 41
France - Frankreich Bosch Rexroth S.A. Division Rexroth Indramat 91, Bd. Irène Joliot-Curie 69634 Vénissieux – Cedex Tel.: +33 (0)4 78 78 53 65 Fax: +33 (0)4 78 78 53 62	Italy - Italien Bosch Rexroth S.p.A. Via G. Di Vittoria, 1 20063 Cernusco S/N.MI Tel.: +39 02 2 365 270 Fax: +39 02 700 408 252378	Italy - Italien Bosch Rexroth S.p.A. Via Paolo Veronesi, 250 10148 Torino Tel.: +39 011 224 88 11 Fax: +39 011 224 88 30	Italy - Italien Bosch Rexroth S.p.A. Via del Progresso, 16 (Zona Ind.) 35020 Padova Tel.: +39 049 8 70 13 70 Fax: +39 049 8 70 13 77
Italy - Italien Bosch Rexroth S.p.A. Via Mascia, 1 80053 Castellamare di Stabia NA Tel.: +39 081 8 71 57 00 Fax: +39 081 8 71 68 85	Italy - Italien Bosch Rexroth S.p.A. Viale Oriani, 38/A 40137 Bologna Tel.: +39 051 34 14 14 Fax: +39 051 34 14 22	Netherlands – Niederlande/Holland Bosch Rexroth B.V. Kruisbroeksestraat 1 (P.O. Box 32) 5281 RV Boxtel Tel.: +31 (0)411 65 19 51 Fax: +31 (0)411 65 14 83 indramat@hydraudyne.nl	Netherlands - Niederlande/Holland Bosch Rexroth Services B.V. Kruisbroeksestraat 1 (P.O. Box 32) 5281 RV Boxtel Tel.: +31 (0)411 65 19 51 Fax: +31 (0)411 67 78 14
Norway - Norwegen Bosch Rexroth AS Rexroth Indramat Division Berghagan 1 or: Box 3007 1405 Ski-Langhus 1402 Ski Tel.: +47 (0)64 86 41 00 Fax: +47 (0)64 86 90 62 jul.ruud@rexroth.no	Spain - Spanien Bosch Rexroth S.A. Divisiòn Rexroth Indramat Centro Industrial Santiga Obradors s/n 08130 Santa Perpetua de Mogoda Barcelona Tel.: +34 9 37 47 94 00 Fax: +34 9 37 47 94 01	Spain – Spanien Goimendi S.A. División Rexroth Indramat Parque Empresarial Zuatzu C/ Francisco Grandmontagne no.2 20018 San Sebastian Tel.: +34 9 43 31 84 21 - service: +34 9 43 31 84 56 Fax: +34 9 43 31 84 27 - service: +34 9 43 31 84 60 sat.indramat@goimendi.es	Sweden - Schweden Rexroth Mecman Svenska AB Rexroth Indramat Division - Varuvägen 7 (Service: Konsumentvägen 4, Älfsjö) 125 81 Stockholm Tel.: +46 (0)8 727 92 00 Fax: +46 (0)8 647 32 77
Sweden - Schweden Rexroth Mecman Svenska AB Indramat Support Ekvändan 7 254 67 Helsingborg Tel.: +46 (0) 42 38 88 -50 Fax: +46 (0) 42 38 88 -74	Switzerland West - Schweiz West Bosch Rexroth Suisse SA Département Rexroth Indramat Rue du village 1 1020 Renens Tel.: +41 (0)21 632 84 20 Fax: +41 (0)21 632 84 21	Switzerland East - Schweiz Ost Bosch Rexroth Schweiz AG Geschäftsbereich Indramat Hemrietstrasse 2 8863 Buttikon Tel. +41 (0) 55 46 46 111 Fax +41 (0) 55 46 46 222	

Europa (Ost) - Europe (East)

vom Ausland: (0) nach Landeskennziffer weglassen
from abroad: don't dial (0) after country code

Czech Republic - Tschechien Bosch -Rexroth, spol.s.r.o. Hviezdoslavova 5 627 00 Brno Tel.: +420 (0)5 48 126 358 Fax: +420 (0)5 48 126 112	Czech Republic - Tschechien DEL a.s. Strojírenská 38 591 01 Zdar nad Sázavou Tel.: +420 616 64 3144 Fax: +420 616 62 1657	Hungary - Ungarn Bosch Rexroth Kft. Angol utca 34 1149 Budapest Tel.: +36 (1) 364 00 02 Fax: +36 (1) 383 19 80	Poland – Polen Bosch Rexroth Sp.zo.o. ul. Staszica 1 05-800 Pruszków Tel.: +48 22 738 18 00 – service: +48 22 738 18 46 Fax: +48 22 758 87 35 – service: +48 22 738 18 42
Poland – Polen Bosch Rexroth Sp.zo.o. Biuro Poznan ul. Dabrowskiego 81/85 60-529 Poznan Tel.: +48 061 847 64 62 /-63 Fax: +48 061 847 64 02	Rumania - Rumänien Bosch Rexroth Sp.zo.o. Str. Drobety nr. 4-10, app. 14 70258 Bucuresti, Sector 2 Tel.: +40 (0)1 210 48 25 +40 (0)1 210 29 50 Fax: +40 (0)1 210 29 52	Russia - Russland Bosch Rexroth OOO Wjatskaja ul. 27/15 127015 Moskau Tel.: +7-095-785 74 78 +7-095 785 74 79 Fax: +7 095 785 74 77 laura.kanina@boschrexroth.ru	Russia - Russland ELMIS 10, Internationalnaya 246640 Gomel, Belarus Tel.: +375/ 232 53 42 70 +375/ 232 53 21 69 Fax: +375/ 232 53 37 69 elmis_ltd@yahoo.com
Turkey - Türkei Bosch Rexroth Otomasyon San & Tic. A..S. Fevzi Cakmak Cad No. 3 34630 Sefaköy Istanbul Tel.: +90 212 541 60 70 Fax: +90 212 599 34 07	Slowenia - Slowenien DOMEL Otoki 21 64 228 Zelezniki Tel.: +386 5 5117 152 Fax: +386 5 5117 225 brane.ozebek@domel.si		

Africa, Asia, Australia – incl. Pacific Rim

Australia - Australien	Australia - Australien	China	China
AIMS - Australian Industrial Machinery Services Pty. Ltd. Unit 3/45 Horne ST Campbellfield , VIC 3061 Melbourne Tel.: +61 393 590 228 Fax: +61 393 590 286 Hotline: +61 419 369 195 terryobrien@aimservices.com.au	Bosch Rexroth Pty. Ltd. No. 7, Endeavour Way Braeside Victoria, 31 95 Melbourne Tel.: +61 3 95 80 39 33 Fax: +61 3 95 80 17 33 mel@rexroth.com.au	Shanghai Bosch Rexroth Hydraulics & Automation Ltd. Waigaoqiao, Free Trade Zone No.122, Fu Te Dong Yi Road Shanghai 200131 - P.R.China Tel.: +86 21 58 66 30 30 Fax: +86 21 58 66 55 23 gf.zhu_sh@boschrexroth.com.cn	Bosch Rexroth China Ltd. 15/F China World Trade Center 1, Jianguomenwai Avenue Beijing 100004, P.R.China Tel.: +86 10 65 05 03 80 Fax: +86 10 65 05 03 79
China	**China**	**China**	**Hongkong**
Bosch Rexroth China Ltd. Guangzhou Repres. Office Room 1014-1016, Metro Plaza, Tian He District, 183 Tian He Bei Rd Guangzhou 510075, P.R.China Tel.: +86 20 8755-0030 +86 20 8755-0011 Fax: +86 20 8755-2387	Bosch Rexroth (China) Ltd. A-5F., 123 Lian Shan Street Sha He Kou District Dalian 116 023, P.R.China Tel.: +86 411 46 78 930 Fax: +86 411 46 78 932	Melchers GmbH BRC-SE, Tightening & Press-fit 13 Floor Est Ocean Centre No.588 Yanan Rd. East 65 Yanan Rd. West Shanghai 200001 Tel.: +86 21 6352 8848 Fax: +86 21 6351 3138	Bosch Rexroth (China) Ltd. 6th Floor, Yeung Yiu Chung No.6 Ind Bldg. 19 Cheung Shun Street Cheung Sha Wan, Kowloon, Hongkong Tel.: +852 22 62 51 00 Fax: +852 27 41 33 44 alexis.siu@boschrexroth.com.hk
India - Indien	**India - Indien**	**India - Indien**	**Indonesia - Indonesien**
Bosch Rexroth (India) Ltd. Rexroth Indramat Division Plot. A-58, TTC Industrial Area Thane Turbhe Midc Road Mahape Village Navi Mumbai - 400 701 Tel.: +91 22 7 61 46 22 Fax: +91 22 7 68 15 31	Bosch Rexroth (India) Ltd. Rexroth Indramat Division Plot. 96, Phase III Peenya Industrial Area Bangalore - 560058 Tel.: +91 80 41 70 211 Fax: +91 80 83 94 345 rexbang@bgl.vsnl.net.in	Bosch Rexroth (India) Ltd. 1st Floor, S-10 Green Park ext. Market New Delhi – 110016 Tel.: +91 1 16 56 68 88 Fax: +91 1 16 56 68 87	PT. Rexroth Wijayakusuma Building # 202, Cilandak Commercial Estate Jl. Cilandak KKO, Jakarta 12560 Tel.: +62 21 7891169 (5 lines) Fax: +62 21 7891170 - 71
Japan	**Japan**	**Korea**	**Korea**
Bosch Rexroth Automation Corp. Service Center Japan Yutakagaoka 1810, Meito-ku, NAGOYA 465-0035, Japan Tel.: +81 52 777 88 41 +81 52 777 88 53 +81 52 777 88 79 Fax: +81 52 777 89 01	Bosch Rexroth Automation Corp. Rexroth Indramat Division 1F, I.R. Building Nakamachidai 4-26-44, Tsuzuki-ku YOKOHAMA 224-0041, Japan Tel.: +81 45 942 72 10 Fax: +81 45 942 03 41	Bosch Rexroth-Korea Ltd. Electric Drives and Controls Bongwoo Bldg. 7FL, 31-7, 1Ga Jangchoong-dong, Jung-gu Seoul, 100-391 Tel.: +82 234 061 813 Fax: +82 222 641 295	Bosch Rexroth-Korea Ltd. 1515-14 Dadae-Dong, Saha-Ku Rexroth Indramat Division Pusan Metropolitan City, 604-050 Tel.: +82 51 26 00 741 Fax: +82 51 26 00 747 gyhan@rexrothkorea.co.kr
Malaysia	**Singapore - Singapur**	**South Africa - Südafrika**	**Taiwan**
Bosch Rexroth Sdn.Bhd. 11, Jalan U8/82 Seksyen U8 40150 Shah Alam Selangor, Malaysia Tel.: +60 3 78 44 80 00 Fax: +60 3 78 45 48 00 hockhwa@hotmail.com rexroth1@tm.net.my	Bosch Rexroth SDN BHD. No.11, Jalan Astaka U8/82 Seksyen U8 40150 Shah Alam Selangor Darul Ehsan Tel.: +65 3 7844 8000 Fax: +65 3 7845 4800 sanjay.nemade @boschrexroth.com.sg	TECTRA Automation (Pty) Ltd. 71 Watt Street, Meadowdale Edenvale 1609 Tel.: +27 11 971 94 00 Fax: +27 11 971 94 40 Hotline: +27 82 903 29 23 georgv@tectra.co.za	Rexroth Uchida Co., Ltd. No.17, Alley 24, Lane 737 Cheng Bei 1 Rd., Yungkang Tainan Hsien Tel.: +886 6 25 36 565 Fax: +886 6 25 34 754 indra.charlie@msa.hinet.net
Thailand			
NC Advance Technology Co. Ltd. 59/76 Moo 9 Ramintra road 34 Tharang, Bangkhen, Bangkok 10230 Tel.: +66 2 943 70 62 +66 2 943 71 21 Fax: +66 2 509 23 62 sonkawin@hotmail.com			

Nordamerika – North America

USA Hauptniederlassung - Headquarters	USA Central Region - Mitte	USA Southeast Region - Südwest	USA SERVICE-HOTLINE
Bosch Rexroth Corporation Rexroth Indramat Division 5150 Prairie Stone Parkway Hoffman Estates, IL 60192-3707 Tel.: +1 847 6 45 36 00 Fax: +1 847 6 45 62 01 servicebrc@boschrexroth-us.com repairbrc@boschrexroth-us.com	Bosch Rexroth Corporation Rexroth Indramat Division Central Region Technical Center 1701 Harmon Road Auburn Hills, MI 48326 Tel.: +1 248 3 93 33 30 Fax: +1 248 3 93 29 06	Bosch Rexroth Corporation Rexroth Indramat Division Southeastern Technical Center 3625 Swiftwater Park Drive Suwanee, Georgia 30124 Tel.: +1 770 9 32 32 00 Fax: +1 770 9 32 19 03	- 7 days x 24hrs - **+1-800-860-1055**
USA East Region –Ost	**USA Northeast Region – Nordost**	**USA West Region – West**	
Bosch Rexroth Corporation Rexroth Indramat Division Charlotte Regional Sales Office 14001 South Lakes Drive Charlotte, North Carolina 28273 Tel.: +1 704 5 83 97 62 +1 704 5 83 14 86	Bosch Rexroth Corporation Rexroth Indramat Division Northeastern Technical Center 99 Rainbow Road East Granby, Connecticut 06026 Tel.: +1 860 8 44 83 77 Fax: +1 860 8 44 85 95	Bosch Rexroth Corporation 7901 Stoneridge Drive, Suite 220 Pleasant Hill, California 94588 Tel.: +1 925 227 10 84 Fax: +1 925 227 10 81	
Canada East - Kanada Ost	**Canada West - Kanada West**	**Mexico**	**Mexico**
Bosch Rexroth Canada Corporation Burlington Division 3426 Mainway Drive Burlington, Ontario Canada L7M 1A8 Tel.: +1 905 335 55 11 Fax: +1 905 335-41 84 michael.moro@boschrexroth.ca	Bosch Rexroth Canada Corporation 5345 Goring St. Burnaby, British Columbia Canada V7J 1R1 Tel. +1 604 205-5777 Fax +1 604 205-6944 david.gunby@boschrexroth.ca	Bosch Rexroth Mexico S.A. de C.V. Calle Neptuno 72 Unidad Ind. Vallejo 07700 Mexico, D.F. Tel.: +52 5 754 17 11 +52 5 754 36 84 +52 5 754 12 60 Fax: +52 5 754 50 73 +52 5 752 59 43	Bosch Rexroth S.A. de C.V. Calle Argentina No 3913 Fracc. las Torres 64930 Monterrey, N.L. Tel.: +52 8 333 88 34...36 +52 8 349 80 91...93 Fax: +52 8 346 78 71 mario.quiroga@boschrexroth.com.mx

Südamerika – South America

Argentina - Argentinien	Argentina - Argentinien	Brazil - Brasilien	Brazil - Brasilien
Bosch Rexroth S.A.I.C. "The Drive & Control Company" Acassusso 48 41/47 1605 Munro Provincia de Buenos Aires Tel.: +54 11 4756 01 40 Fax: +54 11 4756 01 36 victor.jabif@boschrexroth.com.ar	NAKASE Servicio Tecnico CNC Calle 49, No. 5764/66 B1653AOX Villa Balester Provincia de Buenos Aires Tel.: +54 11 4768 36 43 Fax: +54 11 4768 24 13 nakase@usa.net nakase@nakase.com gerencia@nakase.com (Service)	Bosch Rexroth Ltda. Av. Tégula, 888 Ponte Alta, Atibaia SP CEP 12942-440 Tel.: +55 11 4414 56 92 +55 11 4414 56 84 Fax sales: +55 11 4414 57 07 Fax serv.: +55 11 4414 56 86 alexandre.wittwer@rexroth.com.br	Bosch Rexroth Ltda. R. Dr.Humberto Pinheiro Vieira, 100 Distrito Industrial [Caixa Postal 1273] 89220-390 Joinville - SC Tel./Fax: +55 47 473 58 33 Mobil: +55 47 9974 6645 prochnow@zaz.com.br
Columbia - Kolumbien			
Reflutec de Colombia Ltda. Calle 37 No. 22-31 Santafé de Bogotá, D.C. Colombia Tel.: +57 1 368 82 67 +57 1 368 02 59 Fax: +57 1 268 97 37 reflutec@neutel.com.co			

2 9 1 6 2 9

Printed in Germany

Rexroth
Indramat