Description of Functions 10/2003 Edition

sinumerik & simodrive

HLA Module
SINUMERIK 840D
SIMODRIVE 611 digital

SIEMENS

SIEMENS

SINUMERIK 840D
SIMODRIVE 611 digital

HLA module

Description of Functions

Valid for

Control	*Software Version*
SINUMERIK 840D	5, 6
SINUMERIK 840DE (export version)	5, 6
SINUMERIK 840Di	2
SINUMERIK 840DiE (export version)	2

10.03 Edition

SINUMERIK® Documentation

Revision history

Brief details of this edition and previous editions are listed below.

The status of each edition is indicated by the code in the “Remarks” column.

Status code in the “Remarks” column:

A . . . . . New documentation.
B . . . . . Unmodified reprint with new order number
C . . . . . Revised version with new edition status.
If the technical subject matter shown on the page has changed compared to the previous edition status, this is indicated by the changed edition status in the header of the respective page.

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Preface

Notes for the Reader

Structure of the documentation

The documentation for SIMODRIVE 611/SINUMERIK 840D is organized on the following levels:

- General Documentation
- Manufacturer/Service Documentation
- Electronic Documentation

The description of functions of the HLA module is part of the SIMODRIVE/SINUMERIK documentation.

For further information about the publications listed in the documentation overview and other available SIMODRIVE/SINUMERIK publications, please contact your local Siemens sales office.

This Description of Functions does not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in connection with installation, operation or maintenance.

The contents of this document shall neither become part of nor modify any prior or existing agreement, commitment or relationship. The Sales Contract contains the entire obligations of Siemens. The warranty contained in the contract between the parties is the sole warranty of Siemens. Any statements contained herein do not create new warranties or modify the existing warranty.

Target group

This documentation is intended for use by machine manufacturers and servicing personnel who use the “HLA modules”.

Objective

This Description of Functions provides the information required to configure and start up the hydraulic drive module.

- Chapter 2 describes the procedures for configuring the electric and hydraulic components.
- Chapter 3 shows how the hydraulic drive is started up with the support of a menu-driven user interface.
- The firmware and the HLA module hardware functionality are explained in Chapters 4 and 5.
- Chapter 6 explains how to check and interpret status displays and alarms (hydraulic diagnostics).
- Chapter 7 describes the accessories required, e.g. measuring systems and cables.
- Appendix A contains general information and an explanation of the hydraulic system functionality.

Note

Hydraulics In this document, information about specific hydraulic functions refers to functions provided by Bosch Rexroth AG.

How to use this manual

The following guide information is provided to help you reference information in this Description of Functions:

- General table of contents
- Header (as orientation aid):
  - The top line of the header is the main section number
  - The second line of the header is the subsection number
- Appendix with
  - abbreviations, terms and references
  - Glossary (index)

Definition of qualified persons

For the purpose of this manual and product labels, a “qualified person” is one who is familiar with the installation, mounting, start-up and operation of the equipment and the hazards involved.

- Training or instruction/permit for connecting electric circuits and devices in accordance with safety technology standards.
- Training and instruction in maintenance and use of adequate safety equipment according to safety regulations.
- Trained in rendering first aid.

Software version

The SW versions specified in this documentation refer to the SINUMERIK 840D control system and the HLA module.

The Description of Functions applies only to the software versions specified. When a new software version is released, the Description of Functions for that version must be ordered.

Explanation of symbols

The following danger and warning concept is used in this document:

Danger

This symbol appears whenever death, severe physical injury or substantial material damage **will** occur if appropriate precautions are not taken.

Warning

This symbol appears whenever death, severe physical injury or substantial material damage **may** occur if appropriate precautions are not taken.

Caution

This symbol appears whenever minor physical injury or material damage **may** occur if appropriate precautions are not taken.

Caution

This warning (without warning triangle) indicates that material damage **may** occur if appropriate precautions are not taken.

Notice

This warning indicates that an undesirable result or an undesirable state **may** occur if the information is ignored.

Note

In the context of this document, it is advisable to take note of the warning information.

Hotline

The hotline phone numbers appear in Chapter 8.

Should you have any questions about the documentation (suggestions, corrections), please fax them to:

Fax: +49 (9131) 98-2176

Fax form: See the reply form at the end of the brochure

Danger and warning notices

Danger

Commissioning should not start until you have ensured that the machine in which the components described here are to be installed complies with Directive 98/37/EC.

Only appropriately qualified personnel may commission/start-up this equipment.

The personnel must take into account the information provided in the technical customer documentation for the product, and be familiar with and observe the specified danger and warning notices.

When electrical devices are operated, the electrical circuits automatically conduct a dangerous voltage.

Dangerous mechanical movements may occur in the system during operation.

All work on the electrical system must be carried out when the system has been disconnected from the power supply.

Warning

Proper transportation, expert storage, installation and mounting, as well as careful operation and maintenance are essential for this device to operate correctly and reliably.

In addition to the danger and warning information provided in the technical customer documentation, applicable national, local, and system-specific regulations must be taken into account.

The information given in catalogs and quotations applies additionally to special versions of machines and equipment.

Caution

When attaching the connecting cables, you must ensure that:

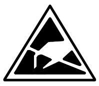
- They must not be damaged
- They must not be stressed
- They cannot come into contact with rotating parts

Caution

As part of routine tests, the devices undergo a voltage test in accordance with EN 50178. During voltage testing of electrical equipment on industrial machines in accordance with EN 60204-1, Section 19.4, all SIMODRIVE device connections must be disconnected/removed. This is necessary in order to avoid damaging the SIMODRIVE devices.

ESD notices

Electrostatic **S**ensitive **D**evices



Components which can be destroyed by electrostatic discharge are individual components, integrated circuits or boards which, when handled, tested or transported, could be destroyed by electrostatic fields or electrostatic discharge. These components are designated as **ESDS** (**E**lectro**S**tatic **D**ischarge **S**ensitive Devices).

Handling of modules containing devices sensitive to electrostatic discharge:

- When handling components which can be destroyed by electrostatic discharge, it must be ensured that personnel, the workstation and packaging are well grounded,.
- As a general principle, electronic modules should only be touched if this is absolutely unavoidable (owing to repair work, etc.).
- Touch components only if
  - you are constantly grounded by an antistatic armband,
  - you are wearing ESD boots or ESD boots with grounding strips in conjunction with ESD flooring.
- Modules may be placed only on electrically conductive surfaces (table with ESD top, conductive ESD foam plastic, ESD packing bags, ESD transport containers).
- Keep modules away from visual display units, monitors or TV sets (minimum distance from screen > 10 cm).
- Do not bring ESD-sensitive modules into contact with chargeable and highly-insulating materials, such as plastic, insulating table tops or clothing made of synthetic materials.
- Measurements on modules are allowed only if
  - the measuring instrument is properly grounded (e.g. equipment grounding conductor), or
  - before measuring, with an isolated measuring instrument, the measuring head is briefly discharged (e.g. touching a bare metal control housing).
- Closed-loop control modules, option modules and memory submodules may only be held by the front plate or on the board edges.

Table of Contents

General 1

1.1 Typical applications

Applications

The NCU 573.2 of the SINUMERIK 840D is capable of handling axis configurations of a maximum of 31 axes on up to 10 different channels. This functional sophistication makes the SINUMERIK 840D an increasingly popular system for the automation of rotary indexing machines. These machines are often highly compact in design and frequently equipped with hydraulic axes (cylinders and servo solenoid valves). The hydraulics (HLA) module provides a means of controlling hydraulic axes directly from the SINUMERIK 840D system via the digital drive bus.

The HLA module is a closed-loop control plug-in unit of the modular SIMODRIVE 611 converter system mounted in a 50 mm carrier module (universal empty housing).

The gating and closed-loop control electronics for operating controlled hydraulic drives are integrated on the HLA module.

From the point of view of the manufacturer of modern servo solenoid valves, an innovative step in the field of hydraulic drive systems has been taken by treating electric and hydraulic drives as equal partners and integrating them into a standard NC.

Objective

To place equal emphasis on the functional importance of both hydraulic and electric drives and make them available as a combined system within an interpolating axis grouping.

Interfaces

- **Firmware**

  The communications interface is compatible with the SIMODRIVE 611D SRM(FDD)/ARM(MSD) for supported services. Code and data management is analogous to the SIMODRIVE 611D SRM(FDD)/ARM(MSD). The hydraulics software is stored as a separate program code in the control system.

- **Hardware**

  The mode of integration into the SIMODRIVE 611 system is compatible with the SIMODRIVE 611 digital SRM(FDD)/ARM(MSD). This basically involves the following interfaces:

  - Drive bus
  - Device bus
  - Power supply system

1.2 Comparison of electric and hydraulic drive systems

Table 1-1 Comparison of electric and hydraulic drive systems

Criterion	Electric direct drive	Electric drive with leadscrew	Hydraulic drive
Power density / mounting space requirements	• Low weight and • reduced spatial requirements of the electric part on the machine table.	• Servomotor and leadscrew large and heavy. • Problematic with limited mounting space.	• Cylinder and servo solenoid valve are light-weight and compact. • Transfer of E motor to hydraulic power unit.
Mass inertia of moving parts	Electric part on machine table has low mass.	Servomotor and leadscrew have high mass moment of inertia.	Piston and piston rod have very low mass
Operational reliability, service life	Service life depends in principle only on linear guides.	• Shock-sensitive. • Service life limited by leadscrew. • Sudden failure possible.	• Protected against overload by pressure limitation. • Sturdy, insensitive to shocks. • Cylinder seals and valve control edges have long service life. • Warning of wear.
Servicing	Simple replacement	Expensive replacement and repair of leadscrew by specialists.	• Simple error diagnosis • Simple replacement and repair of valves and cylinders.
Energy storage	Peak requirement must be installed as no storage is possible.	Peak requirement must be installed as no storage is possible.	• Compensation of energy requirement peaks by hydraulic accumulator. • Rapid traverse in differential circuit. • Reduction of installed capacity.
Maximum forces	Peak thrust per unit area approx. 40 to 80 kN/m^2	Restriction with larger forces.	Practically unlimited (cylinderϕ, p_{max}=700 bar)
Load stiffness	Very good; Servo gain can be set to betw. 10-100 times higher than on the other two drives.	• Elasticity under large forces. • Elasticity of leadscrew is largely compensated as a control function.	• Oil compressibility is compensated as a control function (I component). • Good zero overlap quality of valve ensures very high rigidity under load.
maximum velocity	Up to 500 m/min	$v_{max}=h_s \cdot \omega_{max}/2\pi$ h_s=thread lead ω_{max}=max. motor speed	30...300 m/min (depending on which cylinder seal kit is used)
Maximum travel path	Unlimited	$\leq$ 6 m	$\leq$ 3 m
Collision protection	Mechanically difficult	Mechanically possible	Mechanically possible

Table 1-1 Comparison of electric and hydraulic drive systems

Criterion	Electric direct drive	Electric drive with leadscrew	Hydraulic drive
Noise	Noise produced by linear guides	Noise produced by servo-motor and leadscrew	• Flow through valve may produce noise. • Pump noise on hydraulic power unit.
Acceleration characteristics	max. 45 g	max. 1 g	max. 2 g
Drive cooling	Absolutely essential	Required only at high speeds	Required in some cases, in power unit only
Sensitivity to ferromagnetic swarf	High	Low	Low

Table 1-2 Analogy of characteristic data

Electric	Hydraulic
Spindle speed	-
Velocity	Velocity
Current	flowrate
DC link voltage	System pressure
Power	Flow rate · Valve pressure differential
Transistor/power section	Valve
Motor	Drive cylinder

1.3 Structure of an electro-hydraulically-controlled drive axis

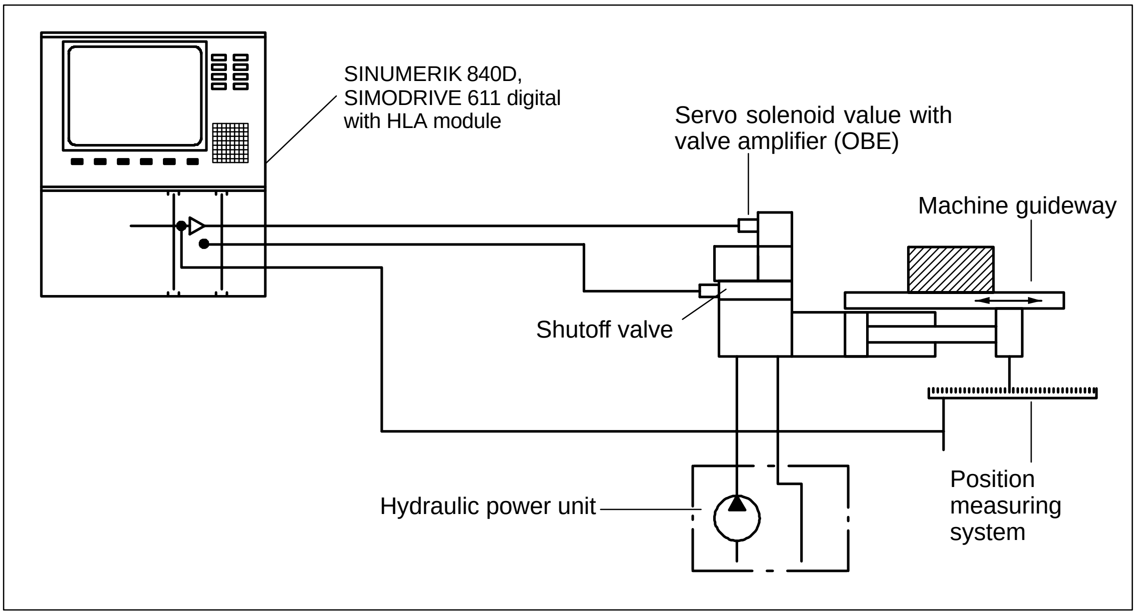


Fig. 1-1 Construction of an electro-hydraulically controlled drive axis

1.3.1 Machine guideway

Guide mechanism

Hydrodynamic and hydrostatic slideways or roller slideways allow machine slides and tables to move in straight lines with minimum friction and maximum precision.

Friction

A degree of friction can be very useful for damping oscillations.

However, excessive friction, especially pronounced transitions from static to sliding friction, have a negative effect on the control result and impair the control loop stability.

1.3.2 Cylinder

Construction

The cylinder represents the simplest form of linear motor and can be integrated easily into the machine guide. The cylinder normally has a piston rod at one end.

Quality criteria

The following are critical quality criteria:

- The surface quality of barrel and piston rod and
- The seals and guides (low-friction, servo quality...).

1.3.3 Servo solenoid valve

Task

This is the final control element in the closed control loop and forms the electro-hydraulic converter.

Function

The valve steplessly converts electrical signals into a hydraulic flow.

Its quality is defined by static and dynamic parameters, such as

- Zero overlap
- Hysteresis
- Limit frequency, etc.

1.3.4 Valve amplifier

This circuit contains the power electronics for the solenoid in the servo solenoid valve which adjusts the valve spool position.

The position controller in the valve amplifier (on-board electronics - OBE) controls the position of the valve spool proportionally to the output value (U=0... ± 10 V).

1.3.5 Shutoff valve

Shut-off valves are used to add safety functions to a valve control with servo solenoid valve. Shut-off valves can prevent uncontrolled motion of the cylinder.

1.3.6 Position measuring system

Task

The position measuring system supplies the actual value for the position of the moving machine element.

Function

The speed is acquired by continuous differentiation of the distance over time. Various systems are available depending on the level of accuracy required.

The highest accuracy requirements are fulfilled by digital systems (glass scale with photoelectric evaluation circuit) mounted directly on the machine.

The most widely used digital incremental systems require a reference point approach at the beginning of a machining operation.

1.3.7 SINUMERIK 840D/SIMODRIVE 611 digital

SINUMERIK controls and SIMODRIVE drive systems are specially designed for machine tools, manipulators and special-purpose machines.

The numerical control processes the machine program and converts it into control commands. It also monitors command execution continuously.

The control structures for the electrohydraulic control loop and the interfaces to

- the shutoff valve,
- the servo solenoid valve,
- the position measuring system and
- the central arithmetic logic unit

are all provided by the HLA module.

The HLA module is an integral component of the SINUMERIK 840D and SIMODRIVE 611 digital systems.

A range of different NCU modules with graded scope of functions is provided to allow the SINUMERIK 840D system to be tailored to the varying functional requirements of machines. The control can therefore be optimally adapted to individual machines and machining applications and is suitable for equipping standardized machine series.

1.3.8 Hydraulic power unit

This unit supplies hydraulic energy.

It is installed at a distance from the drive axis. Accumulators are employed to compensate for strongly fluctuating hydraulic energy requirements and to minimize the installed power.

■

Configuration 2

2.1 Configuring steps

2.1.1 Procedure for configuring electrical components

The procedure for configuring an HLA module is divided into steps in such a way that the user is guided through the full range of relevant settings, from the required force, to the hydraulics components, and finally the HLA and its encoder evaluation circuitry. This initial configuring phase may be followed by a second in some cases, in which the corresponding circuit recommendations and EMC measures are taken into account.

The functions of SIMODRIVE components are described with keywords in this Planning Guide. Limit values for functions may be specified in some cases. For further details (e.g. characteristics), please refer to the Installation and Start-Up Guides for SIMODRIVE 611 digital and SINUMERIK 840 digital.

Further configuring instructions and detailed ordering information can be found in Catalogs NC 60 and NC Z.

Phase 1

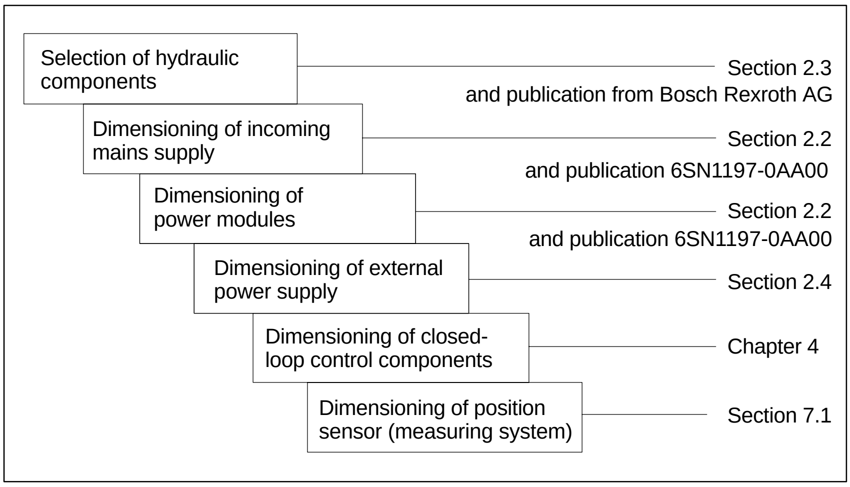


Fig. 2-1 Configuring steps in start-up sequence

Phase 2

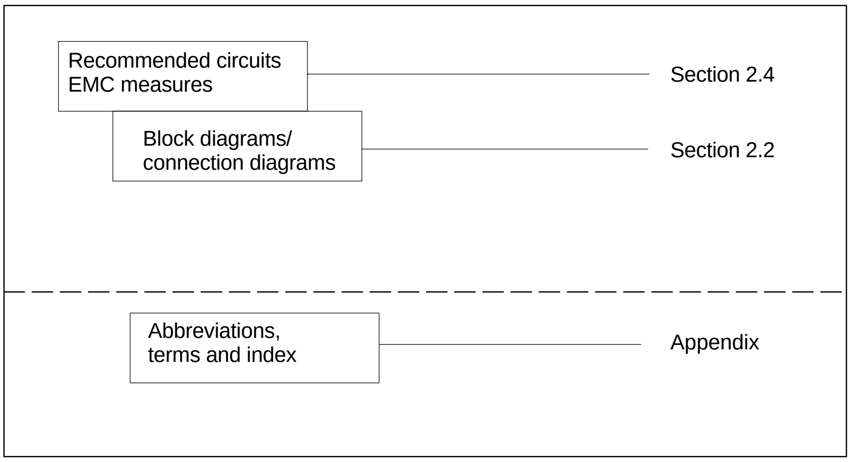


Fig. 2-2 2. configuring phase

2.1.2 Procedure for configuring hydraulic components

Hydraulically controlled drives are normally configured by the technical sales and marketing personnel of the hydraulics supplier (e.g. Bosch Rexroth, see Chapter 8) in close co-operation with the machine manufacturer.

This configuring phase is divided into the following steps:

- Selection of the cylinder on the basis of forces and velocities required and the cylinder mounting conditions in the machine (see Subsection 2.3.1).
- Selection of the servo solenoid valves on the basis of the cylinder data, forces, velocities and dynamic requirements (see Subsection 2.3.2, 2.3.3).
- Selection of the position measuring system and optionally the pressure sensors with regard to the measuring range, accuracy and linearity (see Section 7.1, 7.3).
- Dimensioning of the hydraulic power unit, taking all loads into account (see Subsection 2.3.5).
- Calculation of the natural frequency of the drive for an initial assessment of whether the expected control result can be achieved (see Subsection 2.3.4).
- In difficult cases, it may be worthwhile carrying out a dynamic simulation of the drive as an aid to configuration.

  The basic data required to design a system are obtained from a questionnaire.

Questionnaire Design of hydraulic NC axes

Hydraulic NC axes

Dimensioning of systems with linear motions

Company: ____________________ Contact person: ____________________

Address: ____________________ Department: ____________________

____________________ Phone: ____________________

Machine: ____

Axis: Function/designation: ____________________

Straight-cut control: ☐ Continuous-path control: ☐

Drive specification

Cylinder dimensions [mm]		Accuracy requirements	
Piston diameter:	______	Positioning precision [µm]	______
1st rod diameter:	______	from rapid traverse:	______
2nd rod diameter:	______	from feedrate:	______
Stroke:	______	Path accuracy:	______
Cylinder mounting position:		Velocity tolerance [mm/min]:	______

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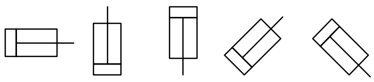

Connection: ☐ ☐ ☐ ☐ ☐

Valve - cylinder	______	Position measuring system	incremental, output signal ...
Pipe/hose length [mm]:	______	Make:	______
Pipe/hose diameter [mm]:	______	Type:	______
Moved mass [kg]:	______	Other:	______
Machining forces [N]	______	Resolution [µm]:	______
Piston advance:	______		
Piston retraction:	______		
Slide guide friction		Numerical control	
µ:	______	Make:	SIEMENS
F_R [N]:	______	Type:	840D
Pump pressure [bar]:	______		
Velocities [m/min]	______		
Rapid traverse advance:	______		
Rapid traverse retract:	______		
Machining feed advance:	______		
Machining feed retract:	______		
Acceleration rates [m/s^2]	______		
Max. acceleration:	______		
Max. delay:	______		

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2.2 Integration in SINUMERIK 840D/SIMODRIVE 611 digital

2.2.1 System overview

Components

A complete SINUMERIK 840 digital control system with HLA module consists of various individual components. These are listed below.

Table 2-1 Components of SINUMERIK 840 digital control with HLA module (number, component, description)

No.in Fig. 2-3	Component	Description
O	NCU box	• Enclosure for NC CPU
B	NC CPU	• Central processing unit of 840D • Execution of NC program, • Contains modules with e.g. PLC, communications functions • NCU 573.2 includes a fan module
B1	Cable distributor	• For insertion in NCU
C1)	Operator panel	• Display, keyboard, power supply unit and operator controls for NC
D1)	MMC module	• Operator panel calculator (integrated in panel), • MMC 103 with hard disk
I	Mains supply module (MS)	**References:** /PJ1/ SIMODRIVE 611
F1)	Machine control panel	• Machine operation
G11)	ISA adapter	• Allows AT modules to be used in conjunction with the MMC module MMC103 (mounted in operator panel)
G2 1)	Full CNC keyboard	• Full keyboard for connection to MMC module
G3	Memory card (PCMCIA)	• Contains the system program, • can be slotted into the NCU 561.2, 571.2, 572.2, 573.2
G4	Diskette unit (accessory)	• Built-in unit for connection to MMC module
H1 to H 9	Cable	**References:** /Z/, Catalog of Accessories NC Z
H10 to H12	Cable	See Chapter 7, Peripherals/Accessories
I	SIMODRIVE hydraulics module (HLA module)	• Closed-loop control of hydraulic drive • Actuation of servo solenoid valve
	50 mm carrier module (universal empty housing)	Holder for HLA closed-loop control plug-in module (see Fig. 2-6)
I1	Phoenix cable connection	• Shutoff valve • External 24 V supply • BERO input • “Power enable”
J	SIMATIC components	**References:** /S7H/, Manual
K	Terminator	Terminator for drive bus (inserted in last module in drive grouping)

Table 2-1 Components of SINUMERIK 840 digital control with HLA module (number, component, description)

No.in Fig. 2-3	Component	Description
L[1)]	Handheld unit	• Connect HHU to K bus via MPI • Handwheel, EMERGENCY STOP button, key-actuated switch, override, agreement buttons, display, unassigned keys
M[1)]	Distribution box	• For linking the hand-held unit to the MPI bus • Connection for EMERGENCY STOP circuit, enable keys, handwheel, 24 V DC
N	Cable distributor	• 24V supply for connection to MPI connector
O	Hydraulic Drive	**References:** /BR1/, "Servo solenoid valves" catalog /BR2/, "Sensors and electronics" catalog /BR3/, "Adapter plate valves" catalog
P	External 24 V supply	• SITOP stabilized power supply modules **References:** SITOP catalog Order No. E860060-K2410-A101-A4

1) A description of these components can be found in:

References: /BH/, Operator Components Manual

Note

An HLA module must never be operated directly on a SIMODRIVE monitoring module, i.e. it must always be connected via a mains infeed module.

For information about connecting further additional SIMODRIVE monitoring modules in configurations with several HLA modules, please refer to the Planning Guide for SIMODRIVE 611 Converters /PJU/.

In a multi-tier configuration, all the infeed supply units must be connected simultaneously.

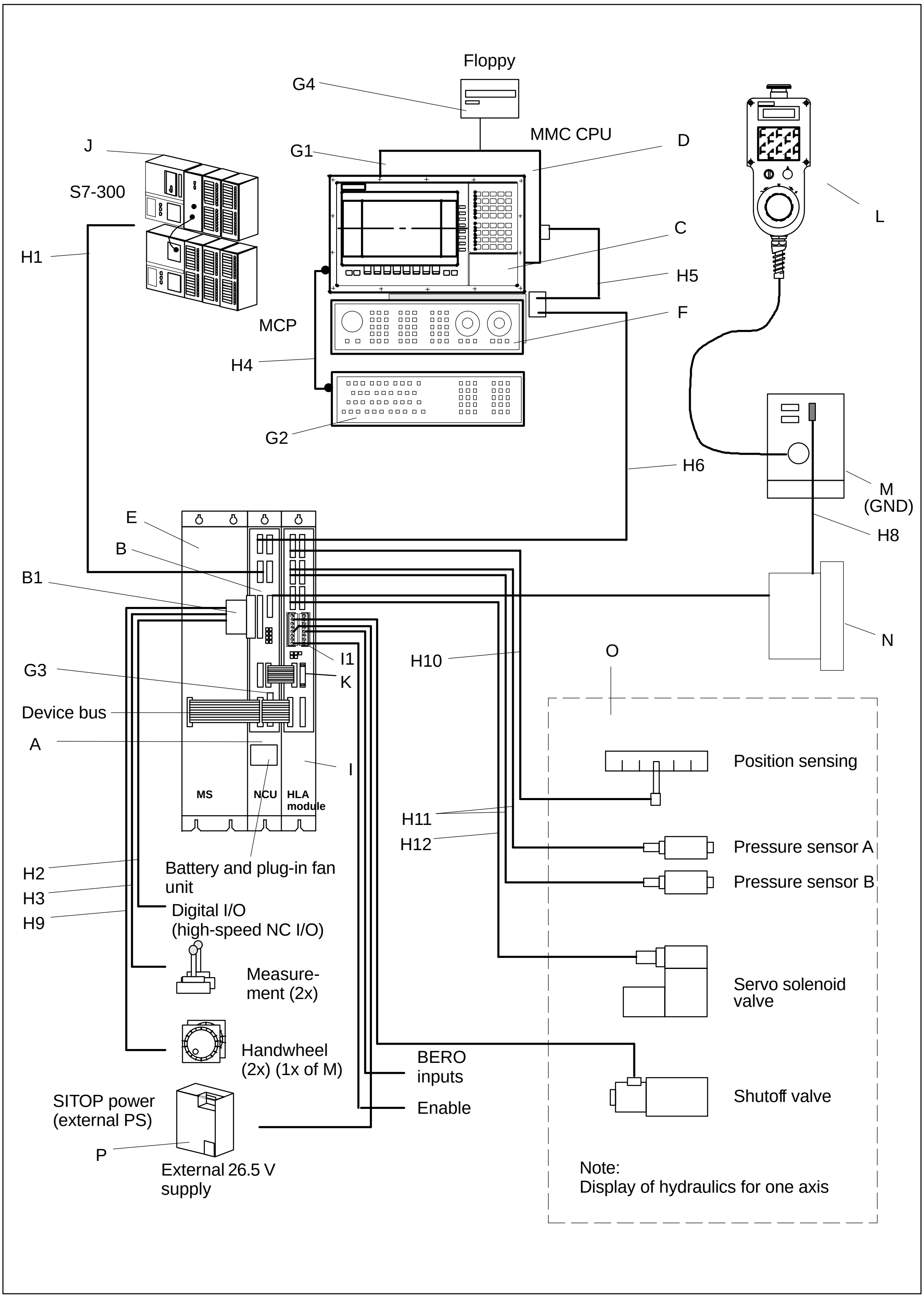


Fig. 2-3 System components

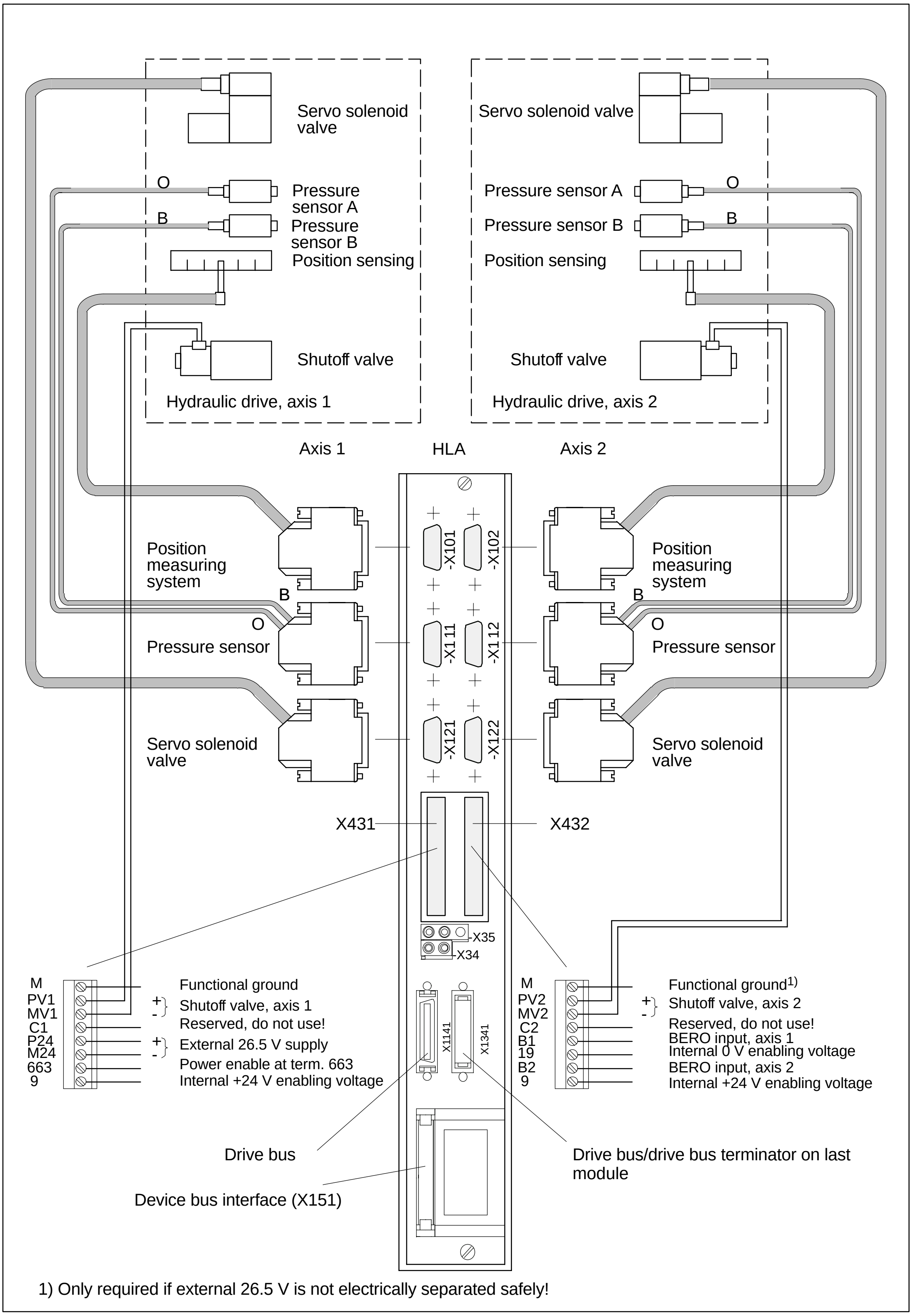


Fig. 2-4 Connection configuration for HLA module

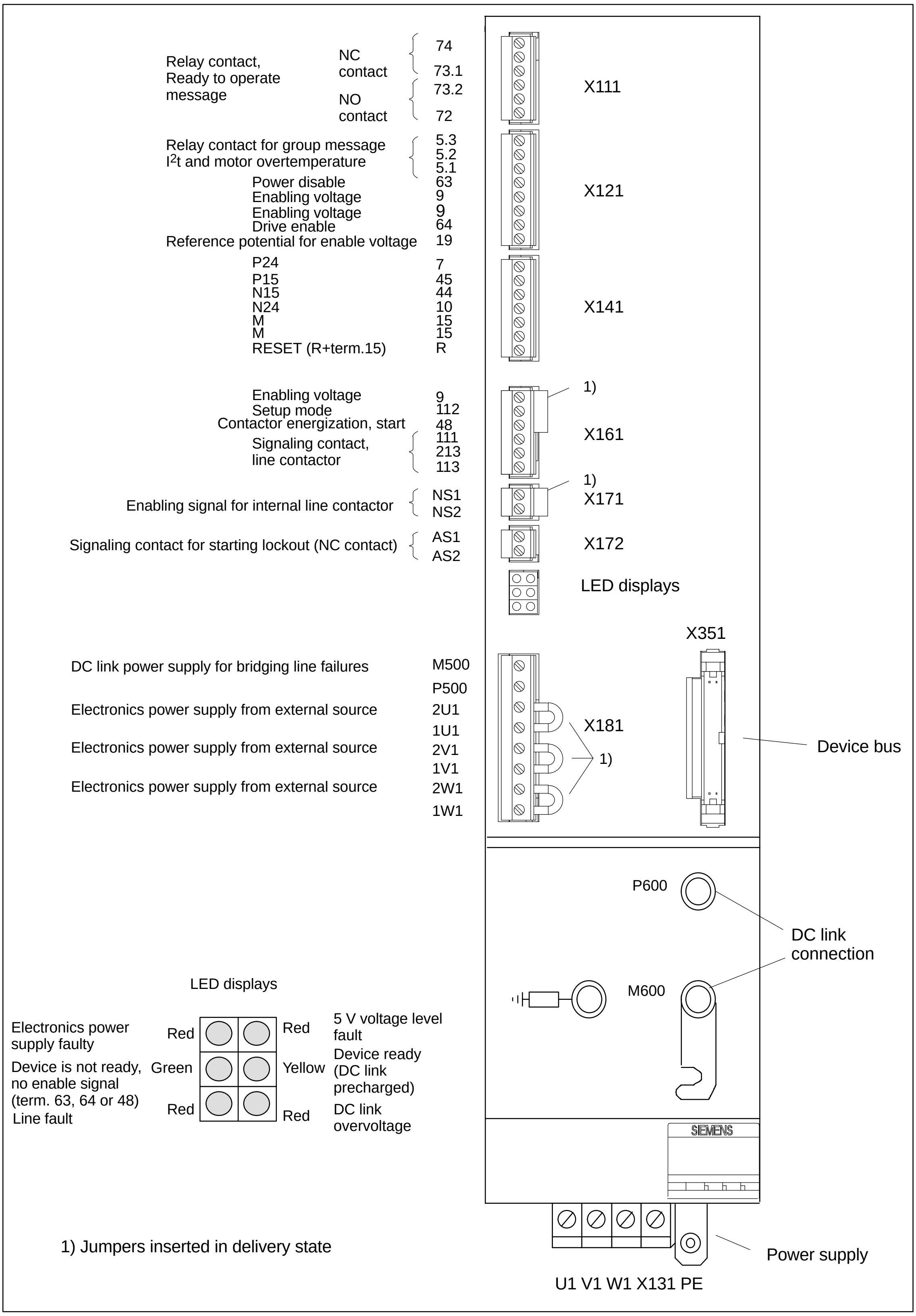


Fig. 2-5 Interfaces on mains supply module (OI and I/RF module)

Mounting the HLA closed-loop control plug-in module

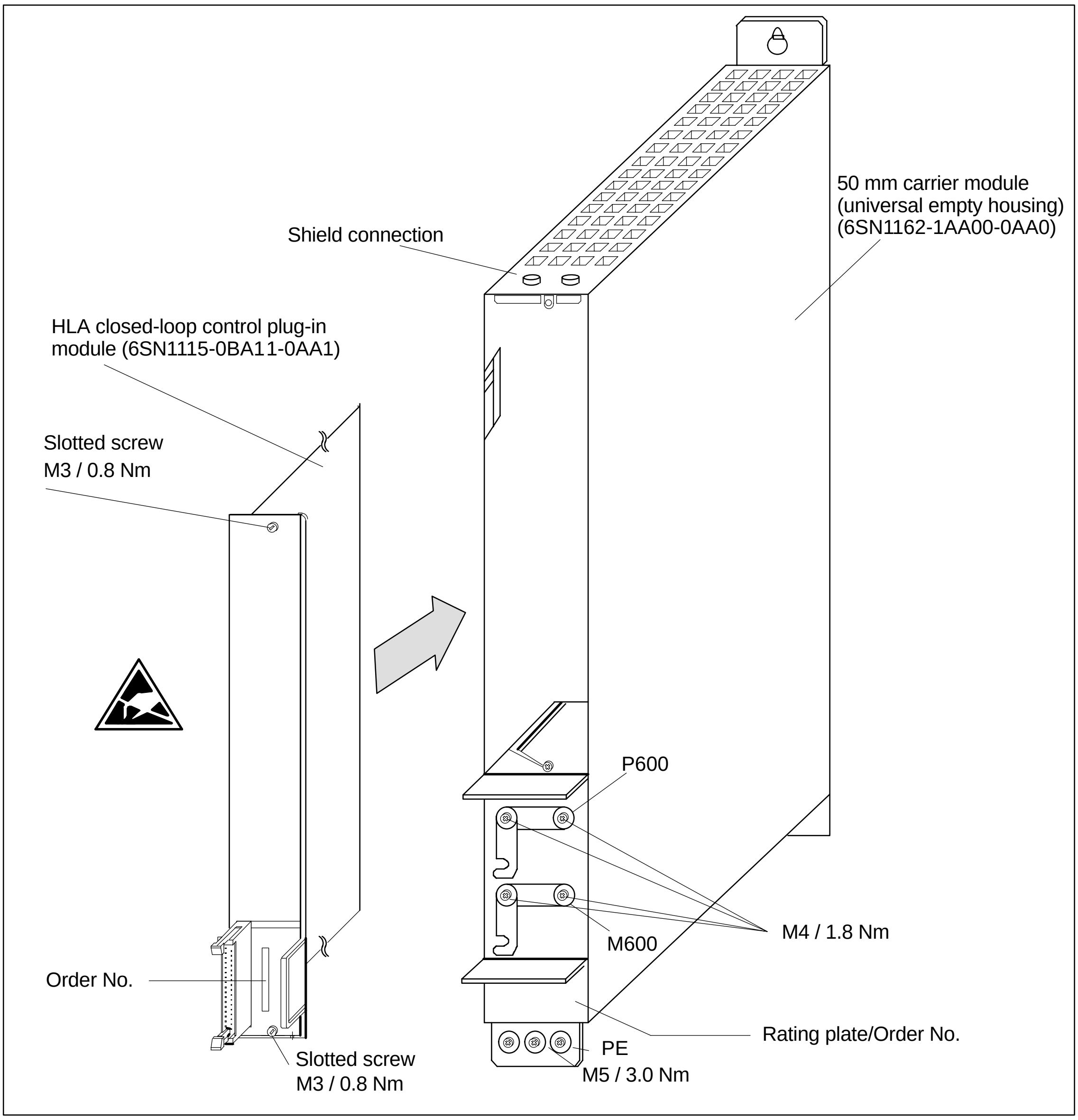


Fig. 2-6 Mounting the HLA closed-loop control plug-in module in 50 mm carrier module (universal empty housing)

2.2.2 Required FW packages

- SINUMERIK 840D NCK SW ≥ 5.1
  including SIMODRIVE 611 digital HLA module ≥ 1.0
- SINUMERIK 840D MMC SW > 5.1
  or
  SINUMERIK 840D HMI SW ≥ 6

2.2.3 Hardware requirements

- NCU 561.2, 571.2, 572.2, 573.2

2.3 Configuring the hydraulic drive

General

Hydraulic drives are generally configured by technical sales personnel from the hydraulics supplier, Rexroth.

The configuration is based on the data from the questionnaire in Subsection 2.1.2 .

Please refer to Appendix A for a description of hydraulic components.

The hydraulic drive is configured in the sequence of steps described below.

2.3.1 Cylinder selection

Piston and rod diameter

The piston and rod diameters are calculated according to Pascal's theorem on the basis of the necessary compressive and tensile forces F and a standard pressure value of P=40...100 bar for machine tools (a maximum pressure setting of 350 bar is permitted).

$$p = \frac{F}{O}$$

The force value calculation must include friction and acceleration forces as well as the actual feed force. Pistons and rods with the following standard diameter dimensions are available:

Table 2-2 Typical cylinder data

Description	Diameter							
Piston ∅	25	32	40	50	63	80	100	125
Rod ∅ Standard	12	14	18	22	28	36	45	56
Rod ∅ Optional	18	22	28	36	45	56	70	90

Stroke length

The stroke is identical to the working stroke of the drive except that it includes a few additional safety reserves.

Mounting

In order to ensure good control quality, backlash-free mountings, e.g. base or flange mountings, must be used.

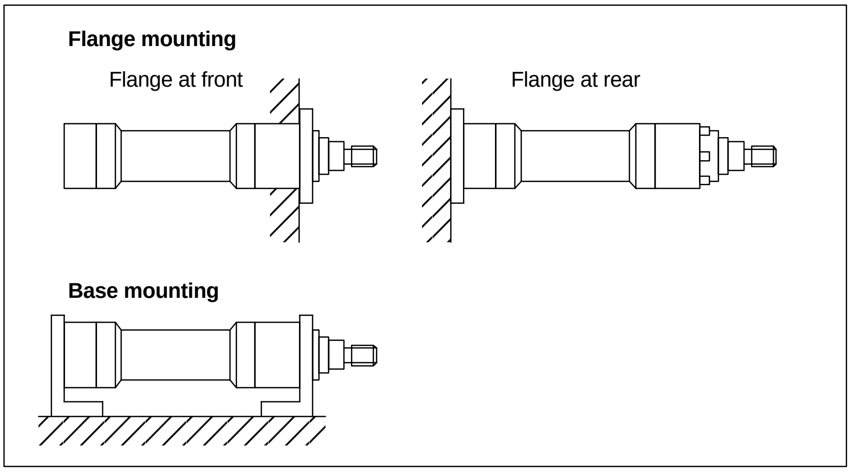


Fig. 2-7 Cylinder mounting methods

Mounting position

This is will depend on the machine's situation and affects the choice of shutoff valves (see Subsection 2.3.3). Vertical loads must be protected via poppet valves. Forces due to weight must be taken into account in the final calculation of the operating pressure (MD 5151: CYLINDER_A_ORIENTATION).

See Fig. 4-17 in Section 4.9 for the possible cylinder mounting positions.

Seal, friction

Suitable seals must be used to minimize friction. Transitions from static to sliding friction have a particularly adverse affect on the control result.

The slide guide friction must be added to the cylinder friction. A friction compensation setting has been provided in the HLA module (MD 5460: FRICTION_COMP_GRADIENT) for the purpose of counteracting initial friction.

Cylinder pipes

The distance between the cylinder and servo solenoid valve must be kept as short as possible for the sake of the drive's natural frequency (compressibility of the oil volume). In ideal cases, the servo solenoid valve is flange-mounted directly on the cylinder.

Position measuring system

The incremental and absolute position measuring systems supported by the HLA module are mounted on the machine slide. It is also possible to use position measuring systems (SSI encoders) integrated in the cylinder.

2.3.2 Selection of servo solenoid valves

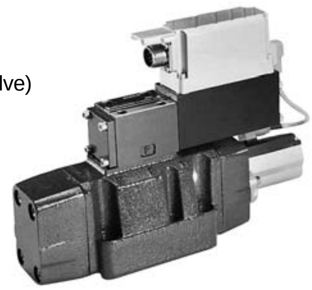
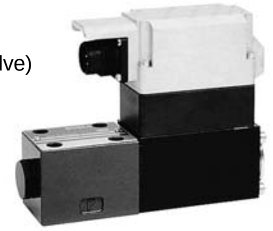
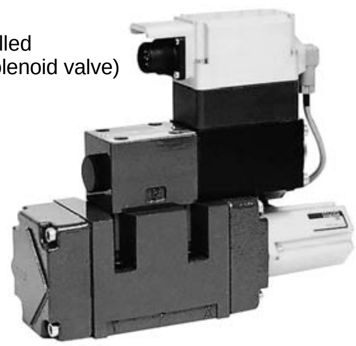
References: /BR1/, “Servo solenoid valves” catalog

Valve types (overview)

The HLA module supports servo solenoid valves with on-board electronics (OBE) supplied by Bosch Rexroth AG. The technical data for these valves and valves supplied by other manufacturers is stored in the HLA module software. The drive is parameterized automatically when the order number is entered. The following table lists the various types of servo solenoid valve and HR (= High Response) servo solenoid valves available from Bosch Rexroth AG.

For a complete list, please see Tables 2-4 to 2-10.

Table 2-3 Overview of servo solenoid and HR servo solenoid valves from Bosch Rexroth AG

Title	Nominal size	Nominal flowrate (l/min) for nominal pressure drop per control edge (bar)	curve	Limit frequency [1] (Hz)
4WRPEH (directly-controlled servo solenoid valve) 	6	up to 40 / 35 bar	linear and with knee	110
	10	up to 100 / 35 bar	linear and with knee	85
4WRPE (pilot-controlled servo solenoid valve) 	10	up to 70 / 5 bar	with knee	40
	16	up to 150 / 5 bar	with knee	40
4WRPEH (directly-controlled HR servo solenoid valve) 	6	up to 40 / 35 bar	linear and with knee	210
4WRVE (pilot-controlled HR servo solenoid valve) 	10	up to 70 / 35 bar	with knee	80
	16	up to 150 / 5 bar	with knee	80

1) The characteristic values specified for the valve limit frequencies relate to an amplitude of ± 5% and a phase offset in the Bode diagram of -90°, see also data in catalog supplied by Bosch Rexroth AG.

The choice of valve for a particular application is made with reference to the following criteria.

Servo solenoid or HR servo solenoid valves

HR (**H**igh **R**esponse) valves are characterized by their improved dynamic quality, i.e. by a higher limit frequency compared to servo solenoid valves. They react with greater sensitivity to setpoint changes especially in the small-signal range. The use of HR servo solenoid valves is recommended in the following cases:

1. When extremely high contour precision is required in high-speed continuous-path control machining operations.
2. When very high response sensitivity is required to achieve the best possible positioning accuracy.

Note that HR servo solenoid valves do not generally have a fail-safe position. The connector is also 12-pin, rather than 7-pin as with servo solenoid valves.

Valve size

The valve size is determined by the maximum flowrate Q_X. This maximum flowrate is calculated according to the law of flow:

$$Q_X = v \cdot A$$

v: Maximum drive speed for extension and retraction
A: associated cylinder surface area

The calculated maximum flow rate must not exceed the limit for use of the valve. This limit is generally specified in the catalog by the valve manufacturer (e.g. Rexroth: /BR1/, “Servo solenoid valves” catalog).

Within the limits for use, the flow rate that can be achieved with the valve is calculated by

$$Q = Q_{nom} \cdot \sqrt{\frac{\Delta p}{\Delta p_{nom}}}$$

In practice, the cylinder speeds that can actually be achieved depend on the operating pressure, the load pressure and flow-specific characteristics of the drive. The dimensioning is left to the hydraulic configuration engineer, who has access to a number of design calculation and simulation programs.

Linear/knee-shaped flowrate characteristic

Values with either a **linear** or **knee-shaped characteristic** can be selected. The latter are suitable for obtaining a higher resolution in the low signal range (machining) and sufficient flow in the high signal range (rapid traverse).

The definition of the knee-point position as 40% or 60% means that only 10% of the nominal opening cross-section (nominal flowrate) is released at 40% or 60% of the nominal control signal (i.e. at U=4 V or 6 V).

The knee-shaped characteristic of the valve must be linearized in the HLA module to adapt it to the closed-loop control of the entire drive (cylinder).

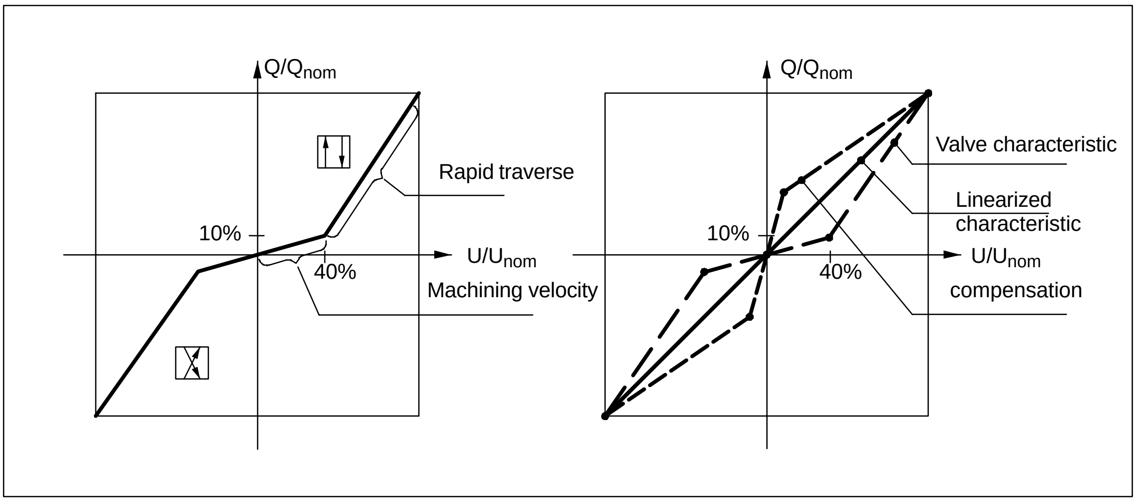


Fig. 2-8 Diagram of a knee-shaped servo solenoid valve characteristic and its correction in the HLA module

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Note

Recommended selection:

Servo solenoid valves are generally recommended for applications where there is a clear separation between machining operation and rapid traverse.

Asymmetrical flowrate characteristics

It is a good idea to use valves with asymmetrical restriction cross-sections for differential cylinders or for cylinders that are not arranged horizontally and move large loads. This improves the hydraulic clamping of the cylinder and adjusts the controlled system gain of the hydraulic servo-drive for both directions of travel.

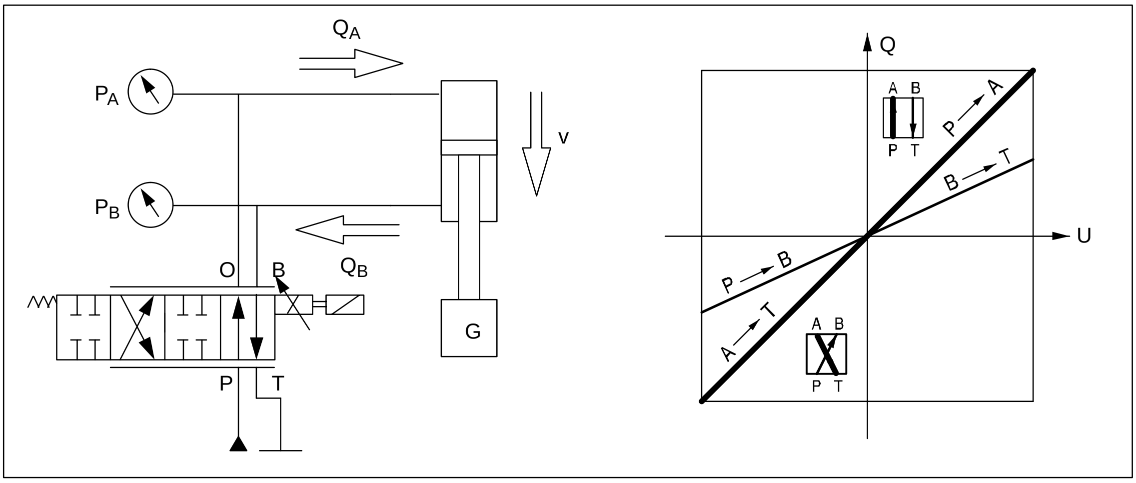


Fig. 2-9 Asymmetrical characteristics

Fail-safe position

Directly-controlled servo solenoid valves have a fail-safe position, i.e. the control spool moves to a safe position when the valve is disconnected from the power supply. The fail-safe position is either “closed” (A, B, P, T disabled) or “open” (A, B and T connected and P disabled). It should be noted that the “crossed” switching position is necessarily passed when the valve is switched on and off, and there can be temporary responses from the cylinder at these moments. Separate shut-off valves are therefore required in order to implement safety functions, such as a totally safe cylinder stop.

Pilot-controlled servo solenoid valves, pilot-controlled HR servo solenoid valves and directly-controlled HR servo solenoid valves do not have a fail-safe position and thus do not have a safe basic position when switched off. Any safety functions nmust therefore be implemented via separate shut-off valves.

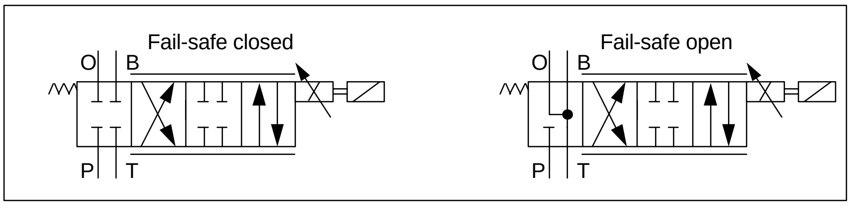


Fig. 2-10 Fail-safe position in the valve graphical symbol

Pin assignments

A distinction must be made between servo solenoid valves and HR servo solenoid valves.

- Servo solenoid valves (directly and pilot-actuated): 7-pin round connector

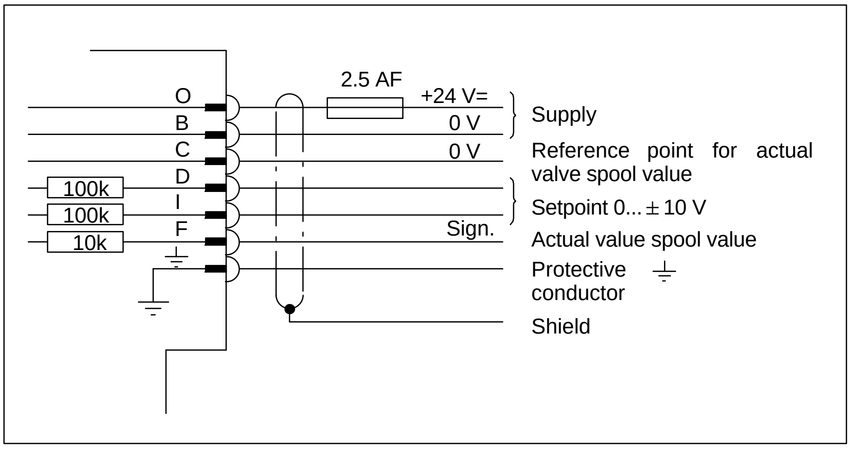


Fig. 2-11 Connector pin assignment on servo solenoid valves

- HR servo solenoid valves (directly and pilot-controlled); 12-pin round connector

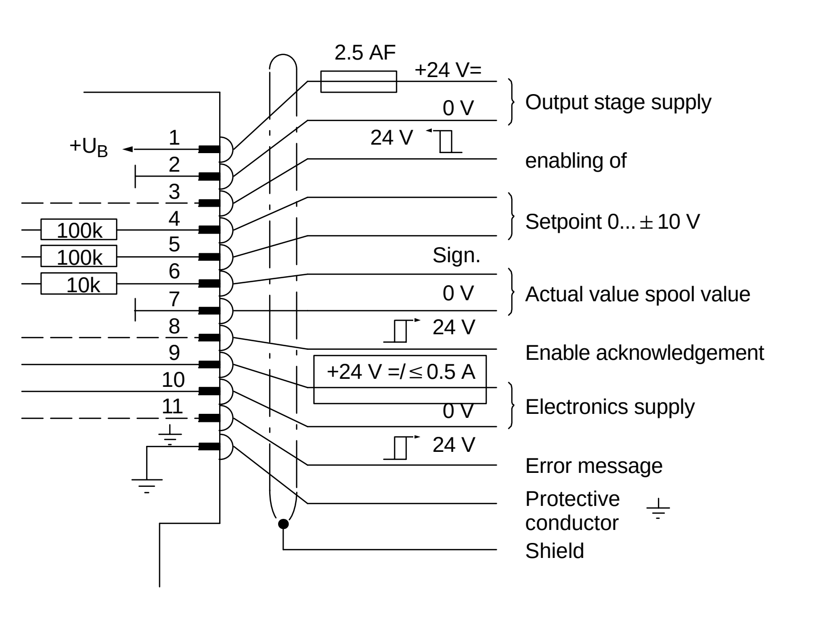


Fig. 2-12 Connector assignment for HR servo solenoid valves

Preferred range of servo solenoid valves

The following tables list all the servo solenoid valves and HR servo solenoid valves supplied by Bosch Rexroth AG for which technical data is stored in the HLA module.

Table 2-4 NG6 directly-controlled servo solenoid valves; model code 4WRPEH 6

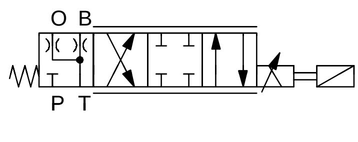
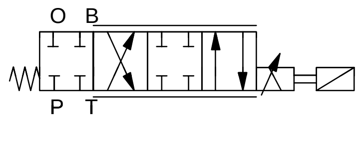
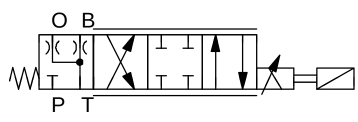
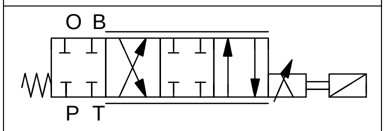
HLA code no.	Rexroth order number	Q_{nom} (l/min) for Δp / edge = 35 bar	Characteristic kneepoint (%)	No. of connector pins	Graphic symbol	Rexroth catalog
9	0 811 404 600	4	Linear.	7-pin		/BR1/
10	0 811 404 601	12	Linear.			
11	0 811 404 602	24	Linear.			
12	0 811 404 603	40	Linear.			
13	0 811 404 610	4	Linear.			
14	0 811 404 611	12	Linear.			
15	0 811 404 612	24	Linear.			
16	0 811 404 613	40	Linear.			
17	0 811 404 642	15	60			
18	0 811 404 747	25	60			
19	0 811 404 644	40	40			
20	0 811 404 645	15	60			
21	0 811 404 646	25	60			
22	0 811 404 647	40	40			

Table 2-4 NG6 directly-controlled servo solenoid valves; model code 4WRPEH 6

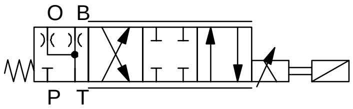
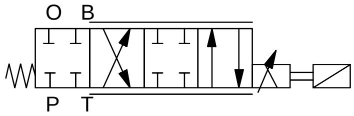
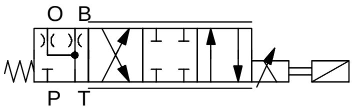
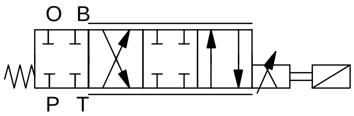
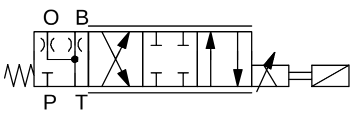
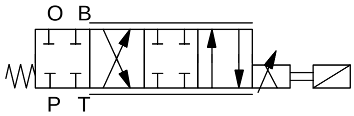
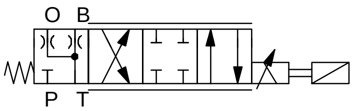
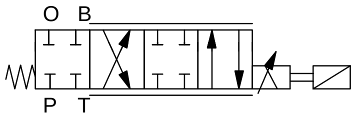
HLA code no.	Rexroth order number	Q_{nom} (l/min) for Δp / edge = 35 bar	Characteristic kneepoint (%)	No. of connector pins	Graphic symbol	Rexroth catalog
23	0 811 404 648	A:40; B:20[1)]	40	7-pin		/BR1/
24	0 811 404 649	A:40; B:20[1)]	40			

Table 2-5 NG10 directly-controlled servo solenoid valves; model code 4WRPEH 10

HLA code no.	Rexroth order number	Q_{nom} (l/min) for Δp / edge = 35 bar	Characteristic kneepoint (%)	No. of connector pins	Graphic symbol	Rexroth catalog
41	0 811 404 800	50	Linear.	7-pin		/BR1/
42	0 811 404 801	100	Linear.			
43	0 811 404 802	50	Linear.			
44	0 811 404 803	100	Linear.			
45	0 811 404 822	50	40			
46	0 811 404 823	100	40			
47	0 811 404 824	50	40			
48	0 811 404 825	100	40			
49	0 811 404 826	A:50; B:25[1)]	40			
50	0 811 404 827	A:100; B:50[1)]	40			
51	0 811 404 828	A:50; B:25[1)]	40			
52	0 811 404 829	A:100; B:50[1)]	40			

1) Asymmetrical characteristic

Table 2-6 NG10 pilot-controlled servo solenoid valves; model code 4WRLE 10

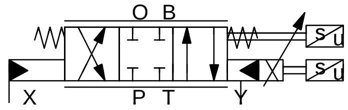
HLA code no.	Rexroth order number	Q_{nom} (l/min) for Δp / edge = 5 bar	Characteristic kneepoint (%)	No. of connector pins	Graphic symbol	Rexroth catalog
25	0 811 404 686	40	40	7-pin		/BR1/
26	0 811 404 687	70	40			
27	0 811 404 688	A:40; B:20[1]	40			
28	0 811 404 689	A:70; B:40[1]	40			

Table 2-7 NG16 pilot-controlled servo solenoid valves; model code 4WRLE 16

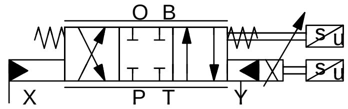
HLA code no.	Rexroth order number	Q_{nom} (l/min) for Δp / edge = 5 bar	Characteristic kneepoint (%)	No. of connector pins	Graphic symbol	Rexroth catalog
1	0 811 404 263	90	40	7-pin		/BR1/
2	0 811 404 264	150	40			
3	0 811 404 265	A:90; B:50[1]	40			
4	0 811 404 266	A:150; B:90[1]	40			

Table 2-8 NG6 directly-controlled HR servo solenoid valves; model code 4WRREH 6

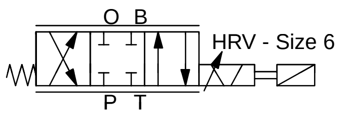
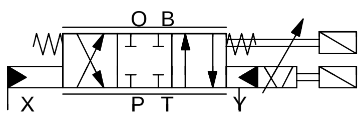
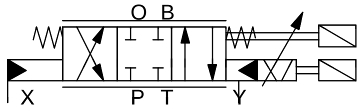
HLA code no.	Rexroth order number	Q_{nom} (l/min) for Δp / edge = 35 bar	Characteristic kneepoint (%)	No. of connector pins	Graphic symbol	Rexroth catalog
33	0 811 404 720	40	Linear.	12-pin		/BR1/
34	0 811 404 721	24	Linear.			
35	0 811 404 722	12	Linear.			
36	0 811 404 723	8	Linear.			
37	0 811 404 725	15	60			
38	0 811 404 726	25	60			
39	0 811 404 727	40	40			
40	0 811 404 728	A:40; B:20[1]	40			

Table 2-9 NG10 pilot-controlled HR servo solenoid valves; model code 4WRVE 10

HLA code no.	Rexroth order number	Q_{nom} (l/min) for Δp / edge = 5 bar	Characteristic kneepoint (%)	No. of connector pins	Graphic symbol	Rexroth catalog
29	0 811 404 693	40	40	12-pin		/BR1/
30	0 811 404 694	70	40			
31	0 811 404 695	A:40; B:20[1]	40			
32	0 811 404 696	A:70; B:40[1]	40			

1) Asymmetrical characteristic

Table 2-10 NG16 pilot-controlled HR servo solenoid valves; model code 4WRVE 16

HLA code no.	Rexroth order number	Q_{nom} (l/min) for Δp / edge = 5 bar	Characteristic kneepoint (%)	No. of connector pins	Graphic symbol	Rexroth catalog
5	0 811 404 296	90	40	12-pin		/BR1/
6	0 811 404 297	150	40			
7	0 811 404 298	A:90; B:50[1]	40			
8	0 811 404 299	A:150; B:90[1]	40			

1) Asymmetrical characteristic

2.3.3 Selection of shutoff valves

References:/BR3/, “Adapter plate valves” catalog

General

The shutoff valves are automatically enabled and disabled in the correct switching sequence by the HLA module.

Start condition: The hydraulic pressure must be available before the system is switched on.

Warning

In the event of sudden failure (e.g. open circuit) of the external 24 V supply, an axial storage capacitor on the HLA module provides energy to supply the servo solenoid valve until such time as the pressure supply for a configured shutoff valve is disabled.

The machine manufacturer must verify the interaction between valves, making allowance for all tolerances in the controlled system.
The energy content of the storage capacitors is dependent upon

- the tolerances of the capacitors,
- the voltage level of the external supply and
- the charging time of the integrated capacitors (instant of voltage failure).

The available response time is mainly defined by

- the power required for the current machining step,
- the response time of the shutoff valves and
- the trip threshold of the servo solenoid valves.

Examples

Figure 2-13 shows an electrically-switched sandwich-type shut-off valve used to shut off the system pressure at the servo solenoid valve.

Interruption of the hydraulic power circuit upstream of the servo solenoid valve is sufficient to meet simple safety requirements. When a servo solenoid valve in the closed fail-safe position is switched off, then approximate shut-off of the consumer connections with respect to the cylinder is guaranteed.

There are some safety limitations, however, since the servo solenoid valve's fail-safe position is not totally free of leakage oil, and thus does not work without some cylinder drift. In addition, when the servo solenoid valve is switched on and off, the "crossed" position is necessarily passed, which can result in cylinder movement.

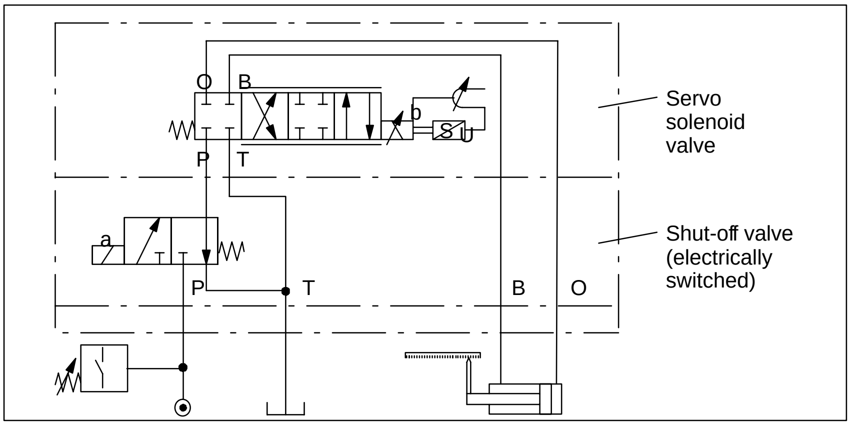


Fig. 2-13 A typical example for an electrically-controlled shut-off valve

The circuit in Figure 2-14 achieves a high level of safety. In this case, an additional barrier block closes the consumer connections to the cylinder safely and with no leakage of oil. This means that even heavy loads on non-horizontal axis can be quickly stopped and held safely, regardless of the state of the servo solenoid valve. Totally safe scenarios for switching the drive on and off can thus be implemented.

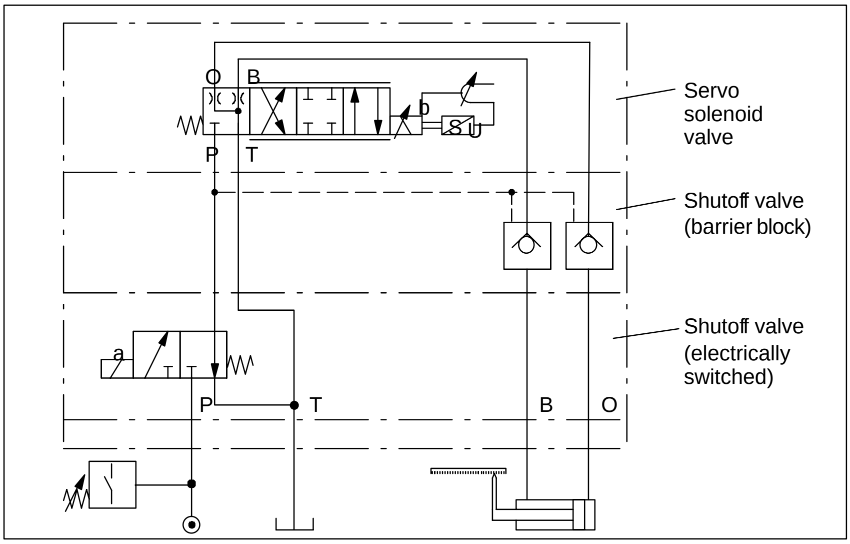
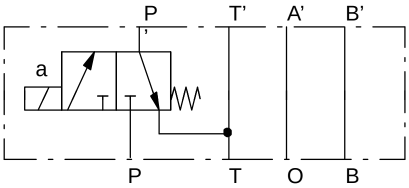
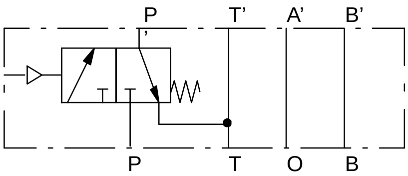
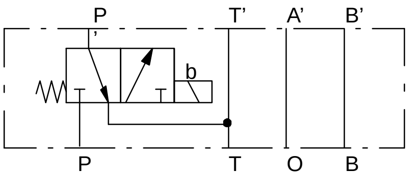
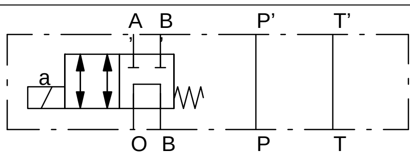
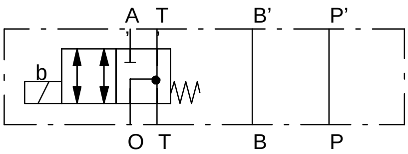
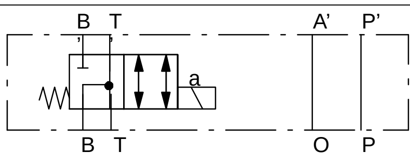
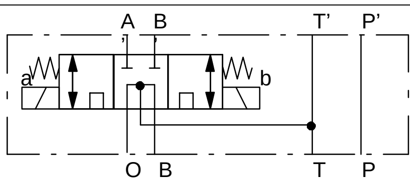
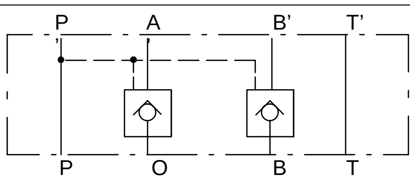


Fig. 2-14 Typical example for the combination of an electrically-switched shut-off valve with an additional barrier block

Preferred range of shut-off valves

Bosch Rexroth shut-off valves from the following table should ideally be used in conjunction with the HLA module. These are sandwich-plate valves in sizes 6 and 10. Additional shut-off valves are available upon request from Bosch Rexroth.

Table 2-11 Shutoff valves

Rexroth order number	Nominal size	Graphic symbol	Rexroth catalog
0 811 024 120	6		/BR3/
0 811 020 040	10		
0 811 024 125	6		
0 811 024 123	6		
0 811 004 102	6		
0 811 004 103	6		
0 811 004 104	6		
0 811 024 122	6		
0 811 024 121	6		

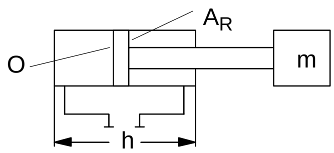
2.3.4 Natural frequency of the hydraulic drive

Servo gain

The possible servo gain is essentially determined by the natural frequency of the cylinder and its load ω_0 and the limit frequency of the servo solenoid valve ω_V.

The cylinder and its load constitute a spring/mass attenuation system whose natural frequency is calculated using the following formula:

$$w_o \sim \sqrt{\frac{4 \cdot E \cdot A}{m \cdot h} \left(\frac{1+\alpha}{2}\right)}$$



Where: E=modulus of elasticity (N/m^2)
A=piston area (m^2)
A_R=ring surface (m^2)
h=stroke (m)
α=surface ratio A_R/A
m=mass (kg)

Oil volumes in the cylinder pipes must also be taken into account.

The minimum natural frequency occurs only at a particular mid-position about the middle and increases as the end positions are approached.

Natural frequency

The natural frequency of the hydraulic drive is automatically calculated by the HLA module and applied in the controller once the corresponding data parameters have been set. See machine data, Sections 4.8 and 4.9:

- MD 5131: CYLINDER_PISTON_DIAMETER
  ...
  MD 5136: CYLINDER_DEAD_VOLUME_B
- MD 5140: VALVE_CYLINDER_CONNECTION
  ...
  MD 5143: PIPE_INNER_ DIAMETER_A_B
- MD 5150: DRIVE_MASS
  ...
  MD 5152: CYLINDER_FASTENING
- MD 5160: PISTON_POS_MIN_NAT_FREQ
  ...
  MD 5163: DRIVE_NATURAL_FREQUENCY

Possible dynamic response

The dynamic response of the servo solenoid valves thus depends on the amplitude of the valve modulation. For valves that are used in controlled axes, the natural frequency is typically determined for a modulation amplitude of $\pm$10% and a phase offset of -180°. The relevant information is given in the valve manufacturer's catalog, e.g. /BR1/.

For pilot-controlled servo solenoid valves, the dynamic response is determined by the pilot pressure p_{pilot}, in addition to the valve type:

$$f_0 \sim \sqrt{p_{before}}$$

The Rexroth catalog data relates to a pilot pressure of 100 bar.

Servo valves can reach corner frequencies of up to 1000 Hz, but are very sensitive to contamination.

2.3.5 Hydraulic power unit

The hydraulic power is supplied by a hydraulic power unit installed separately or integrated in the machine. The power unit is configured individually to meet the requirements of all hydraulic loads. The following factors are of particular importance:

Pressure p

The pressure is determined from the cylinder geometry, hydraulic characteristics of the servo solenoid valve and other data such as load forces or flow resistance values in the hydraulic circuit due to the drive speeds and forces required. The standard value for the system pressure for machine tool feed drives is around 40... 100 bar.

Flow rate Q

The maximum flowrate is calculated from the rapid traverse velocity.

If several cylinders are operating simultaneously, the sum of all loads must be taken into account.

Maximum flow is often reached for only brief periods and can be supplied by an accumulator.

The pump capacity is selected to satisfy the mean flow rate.

Drive power P

The power P output by the electric motor to the pump drive is calculated as the product of pressure p, flow rate Q and efficiency η.

$$P = p \cdot Q \cdot \eta$$

Pump type

Variable displacement pumps with pressure regulators in combination with an accumulator are generally employed in order to prevent power losses and to match the energy supply to the fluctuating delivery requirement during the cycle.

Vane pumps have proven successful in the normal pressure range for these applications of 70 to 210 bar.

Axial piston pumps are commonly used for high-pressure applications up to 350 bar.

Filtration

Classic servo-valves with fluid converters as initial stages are extremely sensitive to contamination. However, even the control edges of modern servo solenoid valves require filtration.

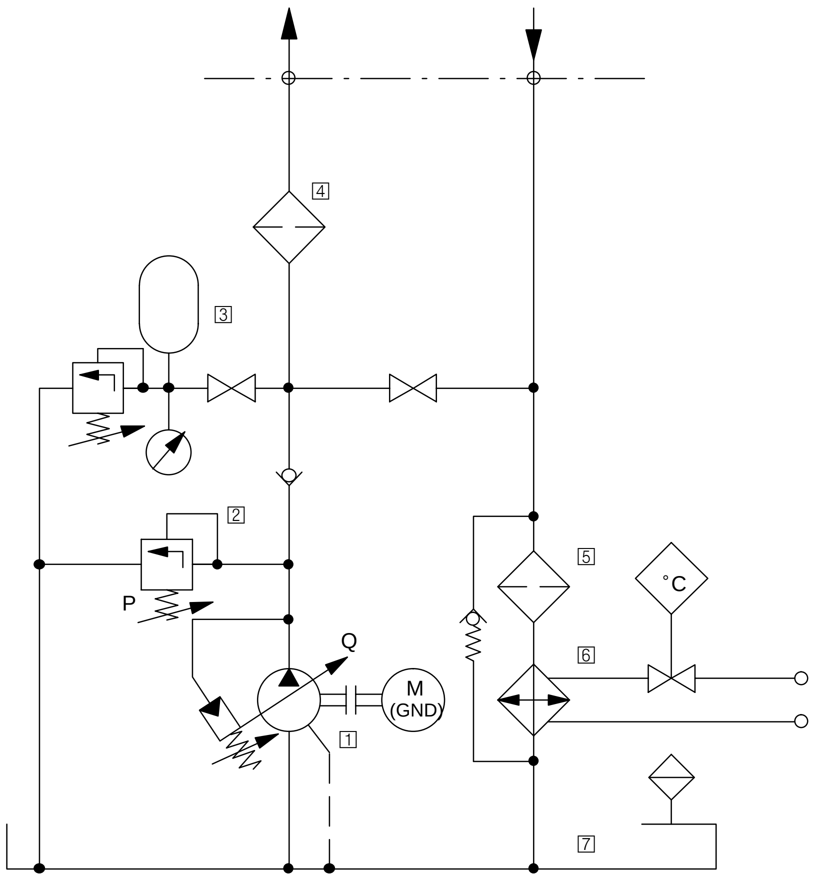
To ensure general operational reliability, but more importantly, to protect the control edges against premature erosion and to maintain the quality of zero overlap, the oil contamination must be limited in compliance with
Class 7...9 according to NAS 1638.

This is achieved by using class β_{10}=75 full flow filters, which must be positioned in the pressure line directly upstream of the servo solenoid valve.

The most critical phase is start-up, since contamination which has “accumulated” prior to installation often causes failures. For this reason, it is advisable to purge the system before the servo solenoid valves are fitted.

Cooling

Since considerable power losses that cannot be compensated for solely through oil reservoir dissipation occur when the flow is throttled via the control edges on the valve, additional oil/air or oil/water heat exchangers must be provided in most cases.



1 Variable displacement pump with pressure regulator
2 Pressure-relief valve (protection)
3 Accumulator with fail-safe circuit
4 Filters in pressure line
5 Filters in return line
6 Oil/water heat exchanger
7 Oil reservoir

Fig. 2-15 Overview of typical hydraulic power unit

2.4 Connection

2.4.1 Internal power supply

Comments

Note

The NC CPU is supplied by the SIMODRIVE power supply via the device bus. No provision has been made for any other type of voltage supply and failure to use the supply provided could damage the unit.

Connection and power loss calculation for the NCU

The HLA module is integrated as a single module into the network of SIMODRIVE modules (power supply or incoming supply module, possibly feed modules and/or main spindle modules) and 840D. The power supply is fed in via the device bus.

The total power requirement for the entire network must be calculated. This must not exceed the power supplied by the power supply module.

To make the calculation easier, each module has a weighting factor.

This can be found in Chapter 9 of the following reference material:

References: NC 60 catalog

The sum of electronic and control points must not be larger than stated in the data sheet of the power supply module.

2.4.2 External power supply

Requirements of external 26.5 V supply

The purpose of the external power supply is to switch and supply the hydraulic components

- closed-loop proportional valves
- Shutoff valves
- pressure sensors

via the closed-loop control.

In principle, stabilized or unstabilized power supplies and switched-mode or in-phase-controlled supplies can be used.

The following points must, however, be noted:

- The required voltage tolerance can only be achieved in practice with stabilization and preferably switched for the existing currents. The ripple associated with an unstabilized power supply may cause tripping at the lower monitoring threshold.
- The stabilization has 24000 µF input capacity per module, which can best be charged up with a stabilized power supply (with current limitation).

Warning

- The DC supply must be **safely electrically isolated**.
  See also:

  References: /PHD/, Configuration NCU 561.2-573.2

- The DC supply must be connected to the functional ground of the control at **one** point (e.g. X131 on I/RF module). As a rule, the connection is provided as standard in the S7-300 I/Os. See also:

  References: /EMC/, SINUMERIK, SIROTEC, SIMODRIVE, EMC Installation Guideline

- The input for the 26.5 V supply is protected against polarity reversal.

  26.5 V ± 2% must be fed from the external 26.5 V supply to connector X431 to supply the hydraulics components (servo solenoid valves, shut-off valves, and pressure sensors). The power requirements is calculated from the power required by external components plus 0.1 A for the internal circuit.

  The input voltage tolerance relates to the input terminals of the closed-loop control; the voltage drops on the supply leads are **not** negligible.

  The external 26.5 V supply is monitored for violation of a lower limit in the control.

Caution

After the external 26.5 V supply has powered up, terminal X431 may no longer be inserted or switched since the high charging currents can irreparably damage the module or external switch.

- If the external 26.5 V supply has to be switched, then an external “precharging circuit” (e.g. relay with timer and resistor) must be used.
- The 26.5 V outputs are short-circuit-proof or protected by fuses.

  The outputs for the shutoff valves are designed as electronic switches with integrated zener diodes for disconnecting inductive loads. The zener diodes are located between the 24 V input and the output, with a typical zener voltage of 58 V.

  On supply disconnection, the energy produced by the coil inductance and the valve spool spring, plus the energy supplied from the 24 V source in the zener diode and ohmic resistance in the solenoid coil is converted to heat. This energy must not exceed 1.7 J during one power OFF process or else the zener diode will be destroyed; no electronic protection against this type of overload is available.

- Other requirements of the external 26.5 V supply:
  - Voltage range (mean value) 25.97 V to 27.03 V DC
  - Ripple 240 mVpp
  - No voltage dips, otherwise disconnection

Recommended power supply

The **SITOP power** product range supplied by SIEMENS is recommended for use as the external 26.5 V power supply.

References: SITOP catalog
Order no. E86060-K2410-A101-A4

- **SITOP power for line supply connection**

  The SITOP power product types shown in the tables are recommended for the line supply connection:

Table 2-12 SITOP power for line supply connection

Input	Output		Order No.
Voltage range [v]	**Voltage U_a**	**Current $I_{a\ Nom}$**	
2AC 85...132/176...550	24 V DC (24...28.8 V) tol. ±1%	5 A	6EP1333-3BA00
		10 A	6EP1334-3BA00
3AC 320...550		20 A	6EP1436-3BA00
		40 A	6EP1437-3BA00

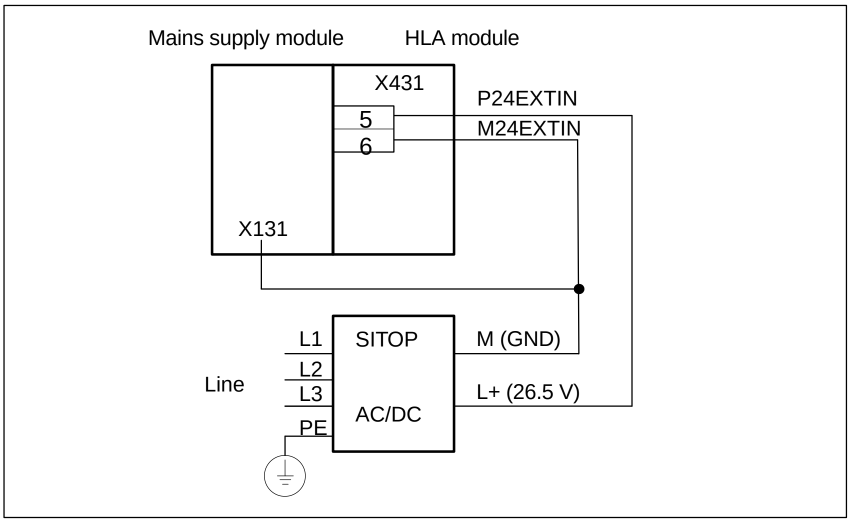


Fig. 2-16 Connection of external 26.5 V SITOP power for line connection

2.4.3 Grounding concept/Electromagnetic compatibility (EMC)

The 840D system with HLA module consists of a number of individual components. The individual system components are:

- I/RF infeed/regenerative feedback module
- NCU box
- HLA module
- Machine control panel MCP
- Qwerty keyboard
- Operator panel components (various monitors with different MMC CPUs)
- Terminal block (NCU and L2 DP)
- Distributor box and handheld unit

The individual modules are attached to a metal cabinet panel by means of screws. Make sure that near the screws a low-impedance contact of the NCU box with the cabinet wall can be made. Insulating varnishes must be avoided where possible.

The electronic grounding points of the modules are interconnected via the device and drive bus and at the same time conducted to the X131 terminal of the I/RF module.

The internal electronics ground of the HLA module is directly connected to the metal front (module) plate.

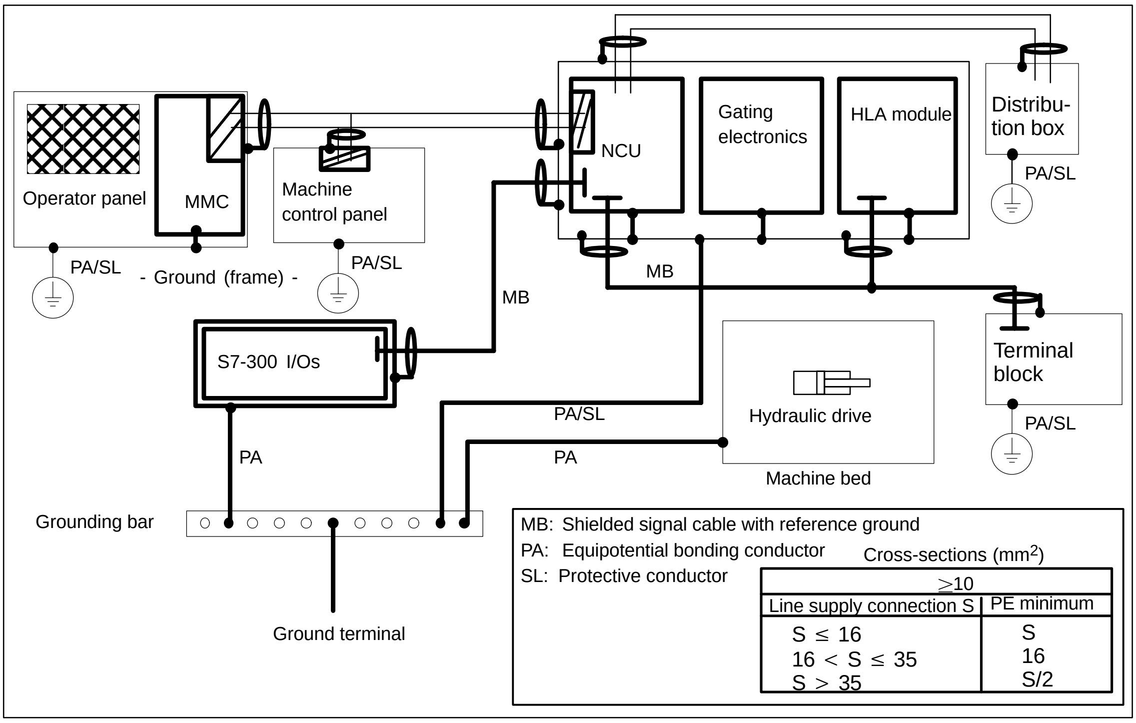


Fig. 2-17 Grounding concept

Please note the following in relation to electromagnetic compatibility:

References: /EMC/, EMC Installation Guidelines
Standards according to Declaration of Conformity (Appendix E)

■

Installation and Start-Up

3

3.1 Overview of start-up process

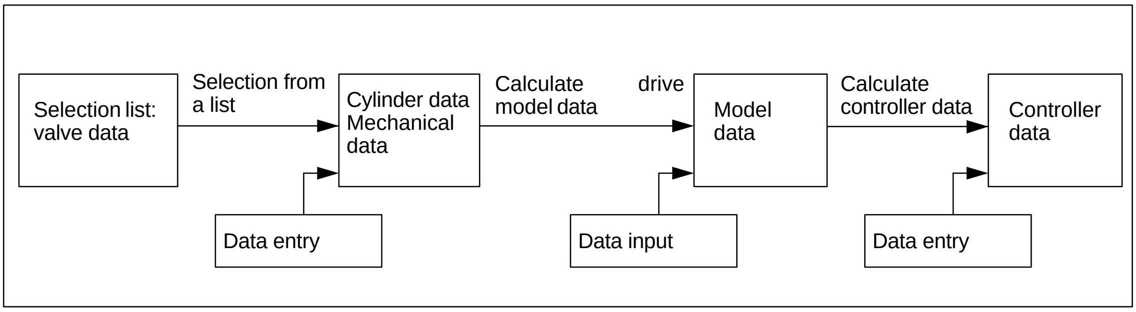


Fig. 3-1 Overview of start-up process

Specially designed start-up menu displays are provided by the SINUMERIK 840D control system.

Instructions for calling menu displays can be found in:

References: /IAD/, Installation and Start-Up Guide

Machine Configuration

The hydraulic linear drive (HLA) is displayed as follows next to the electric drives (SRM, ARM and SLM) in the “Machine Configuration” screen (basic start-up display):

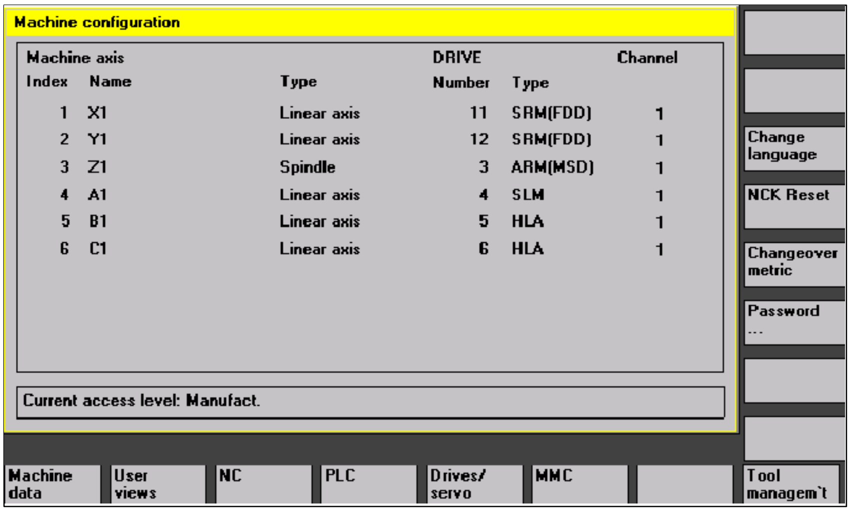


Fig. 3-2 Machine Configuration (basic start-up display)

Machine Data

Hydraulic linear drives (HLA) are adapted to suit the machine using the machine data.

In addition to the following soft keys:

- General MD
- Channel MD
- Axis MD
- Display MD

Softkey “Drive MD”.

Start-up sequence

The following list shows the general steps to be taken to start up an HLA module.

1. Select a valve → Select a valve from the list
2. Enter cylinder data
3. Mounting/supply data
4. Measuring system data
5. Calculate controller data, save boot file, NCK reset.
6. MD 5474: OUTPUT_VOLTAGE_POS_LIMIT and
   MD 5475: OUTPUT_VOLTAGE_NEG_LIMIT
   to low values to check the control direction.
7. Approach reference point and adjust position;
   Position adjustment if piston is in A position at end stop.
8. Adjust pressure sensors (MD 5550, MD 5551, MD 5552, MD 5553, MD 5704, MD 5705, MD 5708). Adjust “manually” using this machine data or automatically via MD 5650. Enter *1000 Hex* in MD 5650. The data is reset to 0 after approximately 2 s and the sensors are then adjusted. The sensors must be unpressurized during adjustment.
9. Run offset compensation MD 5470.
   Automatic offset compensation can be run via MD 5650 if *2000 Hex* is entered in MD 5650. Automatic offset compensation takes approximately 30 s and functions only if the P and I components of the velocity controller are active and all enabling signals are set (see Service Drive).
10. Reduce valve knee-point voltage in MD 5111 by 2...3% if necessary.
11. Area adaptation in MD 5462, set MD 5463 such that the control difference in the positive and negative traversing directions is almost identical.
12. Force limitation and friction torque compensation, see Section 4.4.

3.2 Drive configuration

You must configure the drive bus before you can start up the drives. Do this by pressing softkey “Drive configuration”.

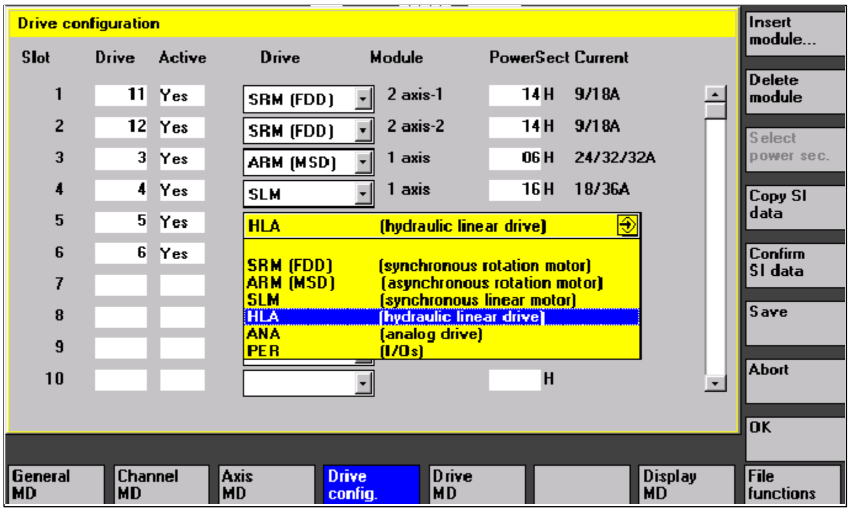


Fig. 3-3 “Drive Configuration” menu display

The selected drive type (hydraulic linear drive in this example) is stored in NC machine data MD 13040: DRIVE_TYPE stored.

Table 3-1 Abbreviations of drive types

Drive	Motors	Contents of MD 13040 DRIVE_TYPE
SRM (FDD)	Synchronous rotating motor (1FT6...)	1
ARM (MSD)	Asynchronous rotating motor (1PH...)	2
SLM	Synchronous linear motor (1FN...)	3
HLA	Hydraulic linear drive	5
ANA	Analog drive	4
PER	I/Os	0

Once (at least) the following axis-specific machine data:

- MD 30110: CTRLOUT_MODULE_NR
- MD 30130: CTRLOUT_TYPE
- MD 30220: ENC_MODULE_NR
- MD 30240: ENC_TYPE

has been entered and an NCK power ON reset has been carried out (taking you to the “Drive Machine Data” menu display), the drive can be started up.

3.3 Modify drive machine data

You can use softkeys “Drive +” and “Drive -” to scroll through all digital (SRM, ARM, SLM and HLA) drives listed in the drive machine data.

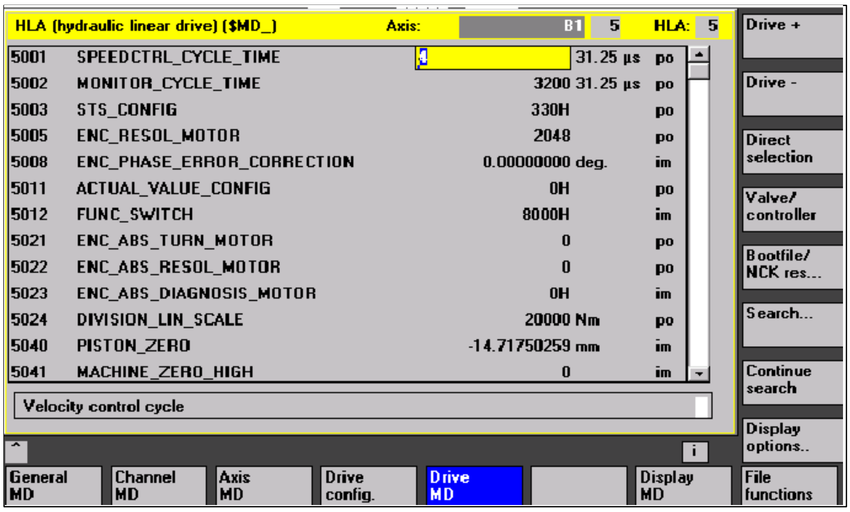


Fig. 3-4 “Drive machine data” menu display

The softkey “Motor/Controller...” is renamed “Valve/Controller...” for the HLA.

Softkey “Valve/Controller...” changes the keys of the vertical softkey menu for the HLA as follows:

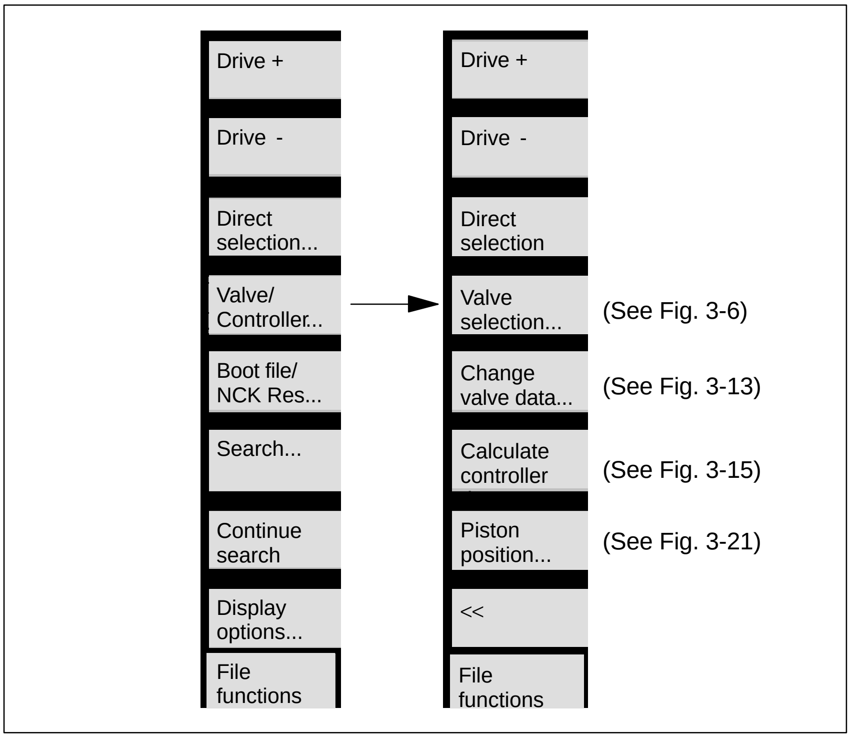


Fig. 3-5 Rearrangement of vertical softkey menu for HLA

3.4 Valve selection

General

You can select the servo solenoid valve from a list when you start up the SIMODRIVE 611 for the first time. Once you have made your selection, the valve machine data defaults are overwritten.

If the valve you want to use is not included in the list, you must enter the valve machine data manually.

"Valve selection..." soft key

This soft key starts the user-prompted start-up process for the HLA module.

You can select a valve from a list stored in the module software, or a non-listed valve, in the following menu display.

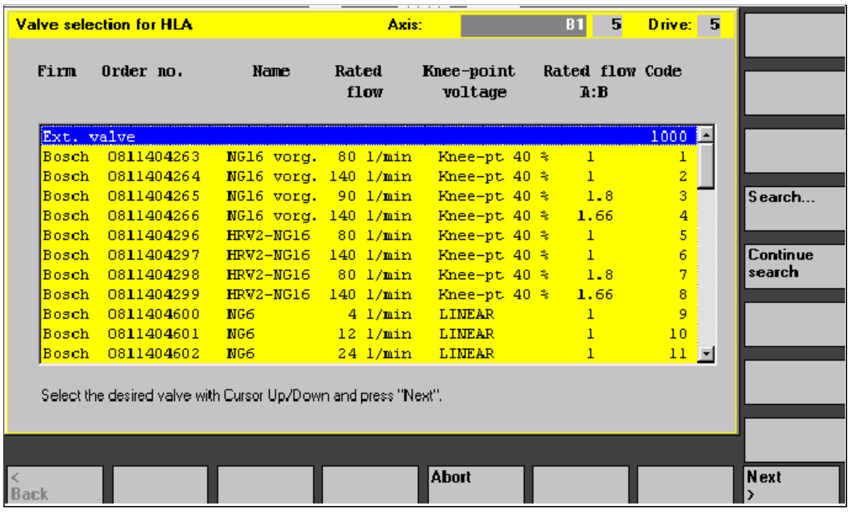


Fig. 3-6 "Valve selection for HLA" menu display

Enter "Unlisted valve" to call a new menu display (see Fig. 3-7) in which the corresponding machine data can be entered manually.

Choose softkeys "Search..." and "Continue search" to look for any character string within the list.

Select softkey "Back" to return to the previously displayed menu. This softkey is disabled in the menu display 3-6.

Note

When you select "Abort", the program branches back to the drive machine data display (see Fig. 3-5), both in this screen and the following menu displays for user-prompted start-up. The "Abort" soft key also activates a prompt box in which you must confirm that you really want to abort start-up for this drive.

No data is ever changed when you select "Abort". This also applies to the following menu displays.

From 10.03 onwards, the name of the company will be changed from Bosch to Rexroth in the menu displays. The order numbers will remain unchanged.

If the “Unlisted valve” entry is selected, press the “Continue” soft key to go to the “Unlisted Valve Data for HLA” menu display (see Fig. 3-7). If you press softkey “Continue” otherwise, the machine data assigned to the entry are written to a buffer whose contents are transferred to the drive at the end of the start-up process. The “Cylinder data” menu display then appears (see Fig. 3-9).

Valve selection from a list

The following data appears in the MMC list display for a stored valve when you select one:

- Company — e.g.: Rexroth
- Order No. — e.g.: 0811404829
- Type — e.g.: 4WRPEH 10
- Nominal flow rate — e.g: 100 l/min.
- Knee-point voltage — e.g.: Knee 40%
- Nominal flow rate A:B — e.g.: 2.0
- Code — e.g.: 52

Loaded valve data

If you select a valve from the list, the following machine data is preset (i.e. the default value is overwritten):

- MD 5106: VALVE_CODE (valve code no.)
- MD 5107: VALVE_NOMINAL_FLOW (nominal flow rate of valve)
- MD 5108: VALVE_NOMINAL_PRESSURE (nominal pressure drop of valve)
- MD 5109: VALVE_NOMINAL_VOLTAGE (nominal valve voltage)
- MD 5110: VALVE_DUAL_GAIN_FLOW (knee-point flow rate of valve)
- MD 5111: VALVE_DUAL_GAIN_VOLTAGE (knee-point voltage of valve)
- MD 5112: VALVE_FLOW_FACTOR_A_B
  (ratio of flow rate at the A end to the B end of valve)
- MD 5113: VALVE_CONFIGURATION (valve configuration)
- MD 5114: VALVE_NATURAL_FREQUENCY
  (natural frequency of valve in small-signal range)
- MD 5115: VALVE_DAMPING (valve damping)

Unlisted valve data

You must enter the valve machine data manually for an unlisted valve. You can also preset the machine data to the settings of a similar valve.

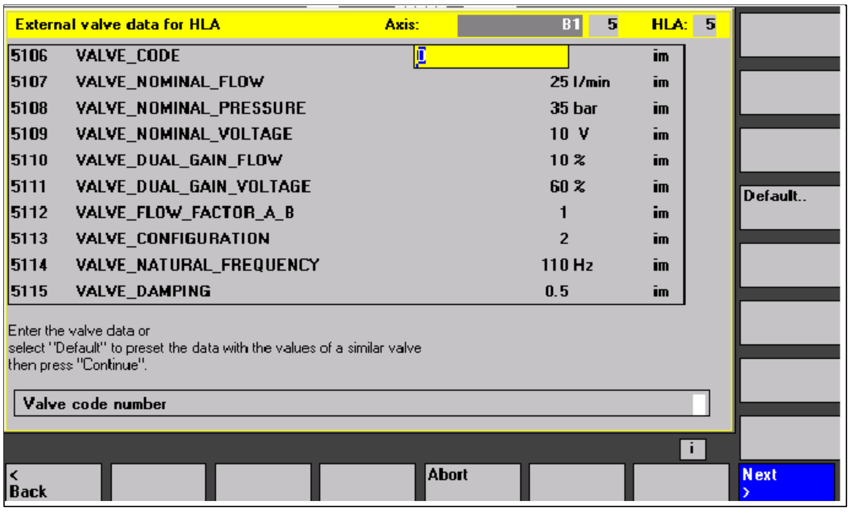


Fig. 3-7 “Unlisted valve data for HLA” menu display

Press the “Continue” softkey to call menu display “Cylinder data”. This data is not written to the drive until start-up has ended.

By pressing vertical softkey “Preset”, you can go to the corresponding menu display in which you can preset machine data by selecting “OK”. You then return to menu display “Unlisted valve data for HLA”.

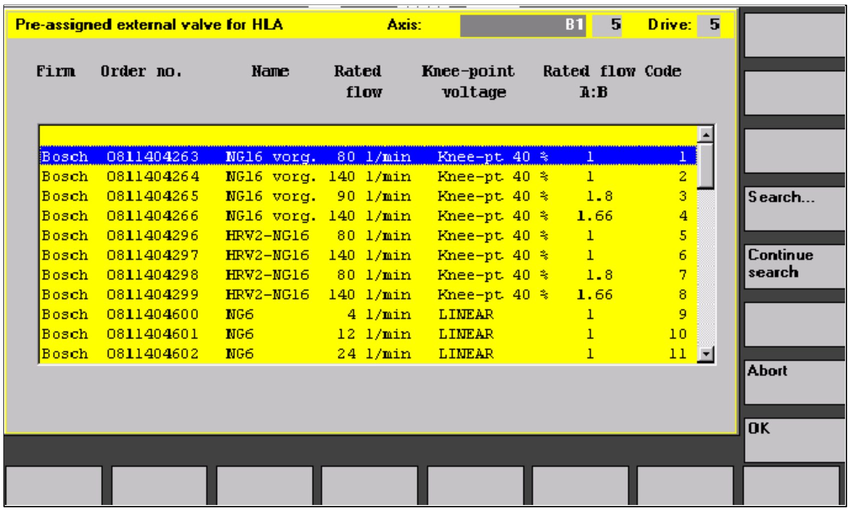


Fig. 3-8 “Preset Unlisted Valve for HLA” menu display

When you press “OK”, the machine data in menu display “Preset unlisted valve for HLA” are preset. You then return to this menu display.

3.5 Cylinder selection

The following cylinder data must be entered manually:

- MD 5131: CYLINDER_PISTON_DIAMETER
  (piston diameter of cylinder)
- MD 5132: CYLINDER_ROD_A_DIAMETER
  (cylinder piston rod diameter at A end)
- MD 5133: CYLINDER_ROD_B_DIAMETER
  (cylinder piston rod diameter at B end)
- MD 5134: PISTON_STROKE
  (piston stroke)
- MD 5135: CYLINDER_DEAD_VOLUME_A
  (cylinder dead volume at A end)
- MD 5136: CYLINDER_DEAD_VOLUME_B
  (cylinder dead volume at B end)

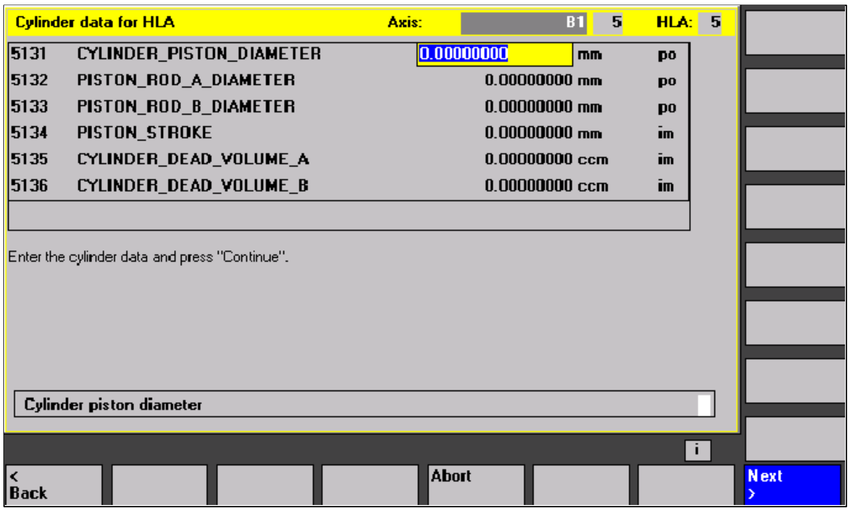


Fig. 3-9 “Cylinder data for HLA” menu display

3.6 Mounting/supply data

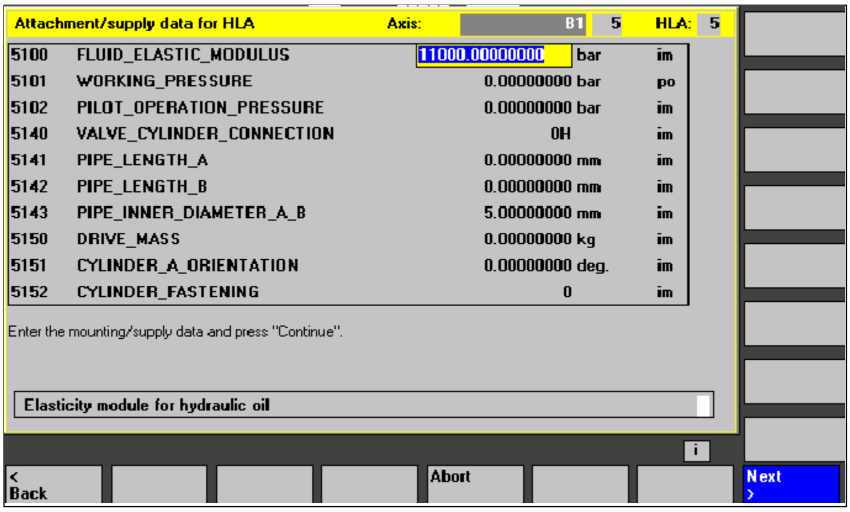


Fig. 3-10 “Mounting/supply data for HLA” menu display

Select the “Back” softkey to return to the “Cylinder data for HLA” menu display. Then press “Continue” to go to the “Measuring system data for HLA” menu display.

The following mounting and supply data must be entered manually.

Supply unit

- MD 5100: FLUID_ELASTIC_MODULUS (modulus of elasticity of hydraulic fluid)
- MD 5101: WORKING_PRESSURE (system pressure)
- MD 5102: PILOT_OPERATION_PRESSURE (pilot pressure, for pilot-actuated valves only)

Connection

- MD 5140: VALVE_CYLINDER_CONNECTION (valve-cylinder connection configuration)
- MD 5141: PIPE_LENGTH_A (pipe length at A end)
- MD 5142: PIPE_LENGTH_B (pipe length at B end)
- MD 5143: PIPE_INNER_DIAMETER_A_B (internal pipe diameter A-B (nominal diameter))
- MD 5530: CYLINDER_SAFETY_CONFIG (protection circuit)

Drive data

- MD 5150: DRIVE_MASS (moved mass of drive)
- MD 5151: CYLINDER_A_ORIENTATION (mounting position A end of cylinder)
- MD 5152: CYLINDER_FASTENING (cylinder mounting)

3.7 Measuring system data

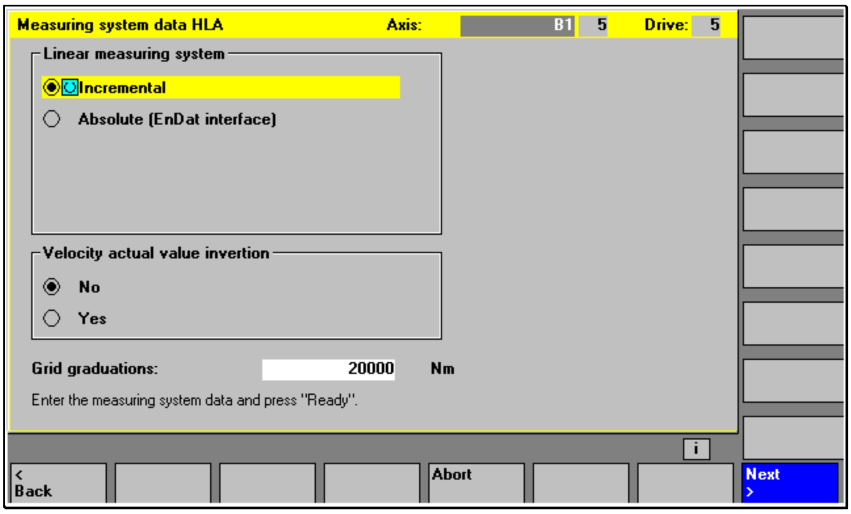


Fig. 3-11 “Measuring System Data HLA, Incremental” menu display

To set the encoder parameters, select either the “Incremental” or the “Absolute (EnDat interface/SSI interface)” option.

The value of the associated machine data is displayed as the scale graduation. You can return to menu display “Mounting/supply data for HLA” by selecting softkey “Back”.

Softkey “Ready”

Select the “Ready” softkey to conclude the start-up for this drive.

A dialog message then appears. This must be acknowledged with “Abort” or “OK”.

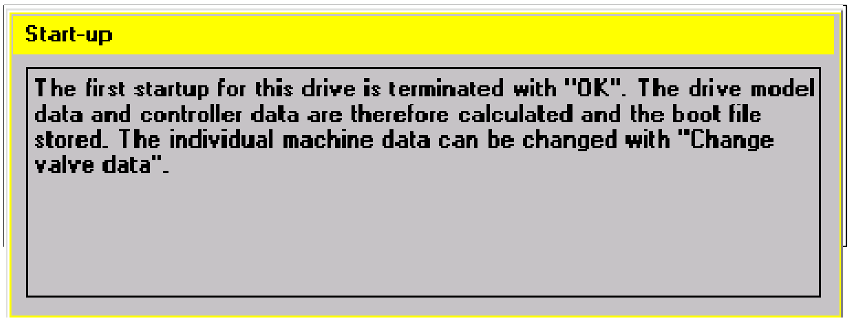


Fig. 3-12 Dialog message “Start-up ready”

You can return to menu display “Measuring system data for HLA” by selecting softkey “Abort”.

Press “OK”, to write the machine data to the drive. The drive model and controller data are then calculated and the boot file saved. The program then jumps to the “Valve/Controller...” menu display (see Fig. 3-5), where data can be checked and/or modified using “Change valve data”.

The remaining drives can then be started up.

Activation of data

The entered/calculated data can be activated by an NCK power On/Reset.

3.8 Modifying data

Changing valve data

The following menu display appears when you press the “Change valve data...” softkey (see Fig. 3-5):

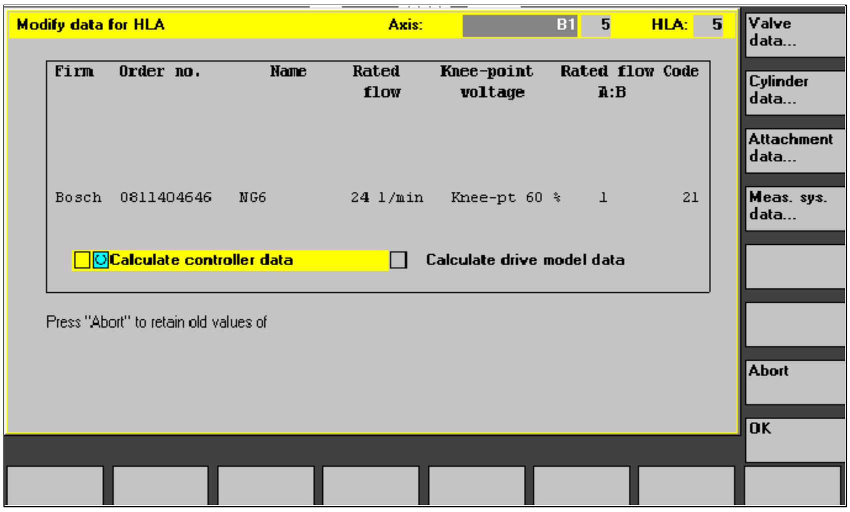


Fig. 3-13 Menu display “Change data for HLA”

If you press “Abort”, the old machine data settings are retained and you return to the initial menu display (see Fig. 3-5).

Softkeys “Valve data...”, “Cylinder data...” and “Mounting data...” each call a display that has the same format as the following screenshot except for display header and contents (e.g. valve data for HLA):

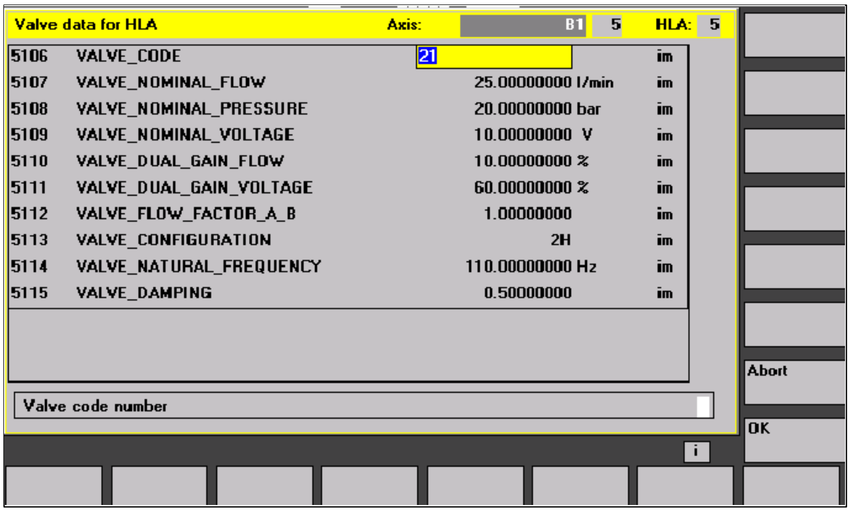


Fig. 3-14 Menu display “Valve data for HLA”

You can return to menu display “Change data for HLA” (see Fig. 3-13) by pressing “Abort” or “OK”.

The valve and cylinder data and the mounting/supply data are used to preset the following data when you activate “Calculate drive model data”. These settings can be changed manually afterwards. It is advisable to confirm the calculated model data by carrying out tests on the drive and correct them in accordance with the test results.

- MD 5401: DRIVE_MAX_SPEED (maximum useful velocity)
- MD 5440: POS_DRIVE_SPEED_LIMIT (positive velocity setpoint limit)
- MD 5441: NEG_DRIVE_SPEED_LIMIT (neg. velocity setpoint limit)
- MD 5160: PISTON_POS_MIN_NAT_FREQ (min. natural frequency, piston position)
- MD 5161: DRIVE_DAMPING (drive damping)
- MD 5162: DRIVE_NATURAL_FREQUENCY_A (natural freq. of drive A)
- MD 5163: DRIVE_NATURAL_FREQUENCY (natural frequency of drive)
- MD 5164: DRIVE_NATURAL_FREQUENCY_B (natural freq. of drive B)
- MD 5231: FORCE_LIMIT_WEIGHT (weight force limitation)
- MD5240: FORCECONTROLLED_SYSTEM_GAIN (controlled system gain force controller)
- MD 5435: CONTROLLED_SYSTEM_GAIN (controlled system gain)
- MD 5462: AREA_FACTOR_POS_OUTPUT (fact. area adaptation pos.)
- MD 5463: AREA_FACTOR_NEG_OUTPUT (fact. area adaptation neg.)

The data entered for valve, cylinder, mounting/supply and drive model are used to preset the following data when you activate “Calculate drive model data”. These settings can be changed manually afterwards.

- MD 5242: FORCECTRL_GAIN (P-gain of force controller)
- MD 5243: FORCECTRL_GAIN_RED (reduction of force controller P gain)
- MD 5244: FORCECTRL_INTEGRATOR_TIME (force controller reset time)
- MD 5245: FORCECTRL_PT1_TIME (smoothing time constant of force contr.)
- MD 5246: FORCECTRL_DIFF_TIME (force controller D-action time)
- MD 5476: OUTPUT_VOLTAGE_INVERSION (manip. variable inversion)
- MD 5464: POS_DUAL_GAIN_COMP_FLOW (knee compensation pos. flow rate)
- MD 5465: POS_DUAL_GAIN_COMP_VOLTAGE (knee comp. pos. voltage)
- MD 5467: NEG_DUAL_GAIN_COMP_FLOW (knee comp. neg. flow rate)
- MD 5468: NEG_DUAL_GAIN_COMP_VOLTAGE (knee comp. neg. voltage)
- MD 5406: SPEEDCTRL_GAIN_A (P gain, P gain
- MD 5407: SPEEDCTRL_GAIN (velocity controller P gain)
- MD 5408: SPEEDCTRL_GAIN_B (P gain, P gain
- MD 5409: SPEEDCTRL_INTEGRATOR_TIME[n] (vel. controller reset time)
- MD 5413: SPEEDCTRL_ADAPT_ENABLE (selection of vel. c. adaptation)
- MD 5414: SPEEDCTRL_REF_MODEL_FREQ[n] (natural freq. of ref.model)
- MD 5415: SPEEDCTRL_REF_MODEL_DAMPING[n] (damping of velocity controller reference model)
- MD 5430: SPEEDCTRL_PT1_TIME (smoothing time constant vel. lead time)
- MD 5431: SPEEDCTRL_DIFF_TIME_A[n] (velocity controller A derivative-action time)
- MD 5432: SPEEDCTRL_DIFF_TIME[n] (velocity controller lead time)
- MD 5433: SPEEDCTRL_DIFF_TIME_B[n] (velocity controller B)

Calculate controller data/drive model data

Press “OK” (in Fig. 3-13) to transfer the modified machine data is transferred to the drive and, depending on the option settings

- calculate drive model data and/or
- Calculate controller data

the “Calculate controller/drive model data” dialog box appears with the corresponding text (see Fig. 3-15; in this case, for both options).

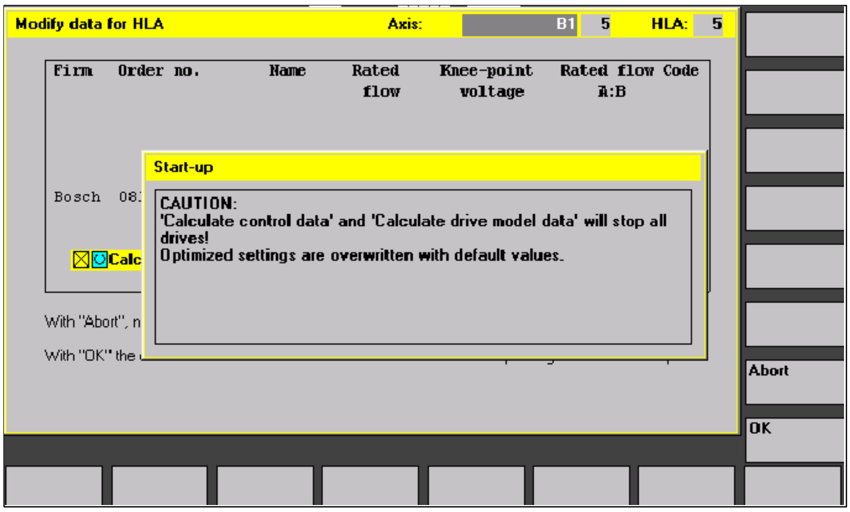


Fig. 3-15 Menu display “Dialog box for calculate controller/drive data”

Press “Abort” to return to the “Change Data for HLA” menu display (see Fig. 3-13).

Press “OK”, to recalculate the drive model data and/or controller data and then return to the initial menu display (see Fig. 3-5).

The filters, friction compensation and limitation parameters can then be set to suit the application.

Softkey “Help” displays a list of those machine data that are changed with softkey “OK”. In this case as well, the texts are dependent on the set options.

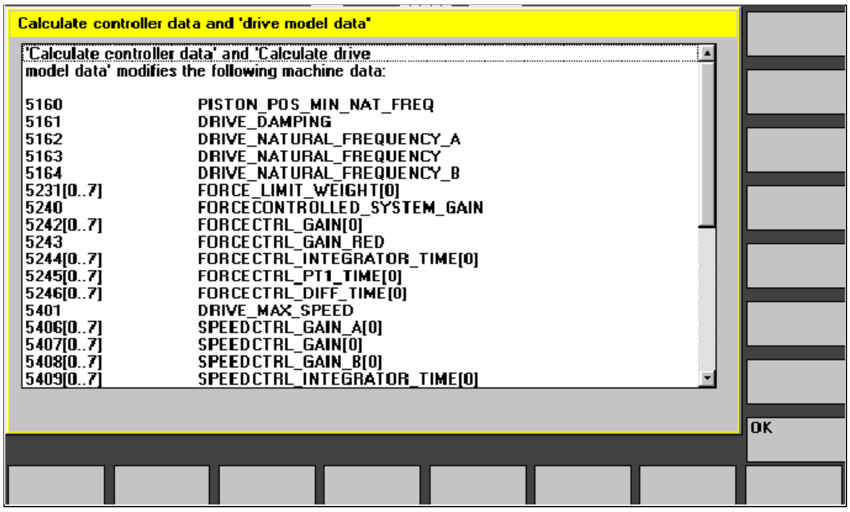


Fig. 3-16 Help screen for changing controller/drive model data

3.9 Fine adjustment and optimization

On completion of start-up, the control loop settings must be checked.

3.9.1 Control direction, travel direction

General

The control direction can be reversed by the following methods:

- Inversion of the manipulated voltage
- Actual value inversion
- Scale rotation
- Pipes A → A to A → B (inversion)

Any adjustment in the hydraulic piping can be canceled by inversion of the manipulated voltage.

If the scale is rotated or attached at the wrong point (jacket or rod of cylinder), the control direction can be adjusted by means of actual value inversion.

Limitation of manipulated voltage

The manipulated voltage must be limited before the system is first switched on for a control direction check.

MD 5474: OUTPUT_VOLTAGE_POS_LIMIT ≈ 1 V
MD 5475: OUTPUT_VOLTAGE_NEG_LIMIT ≈ 1 V

Determine control direction (step 1)

Note

It is not necessary to determine the control direction if the drive can already operate in JOG mode. In this case, the control direction is already set correctly (MD 32110). The control direction of the velocity controller still needs to be checked (MD 5011 bit 0). The control direction must be set identically: both “inverted” or both “not inverted”.
Continue from step 2.

When the enabling signals are set, the axis may move in an uncontrolled manner.

Causes:

- Incorrect control direction of velocity controller
  - Actual value encoder mounting
  - Connections combining servo solenoid valve and cylinder
  - Manipulated voltage polarity reversed
- Incorrect control direction of position controller
  - Actual value encoder mounting

Fig. 3-17 shows the methods which can be used to adjust any uncontrolled traversing movements.

Note

If valve end A is connected to cylinder end B (MD 5140=1), inversion of the valve manipulated variable (MD 5476) is preset by “Calculate controller data”.

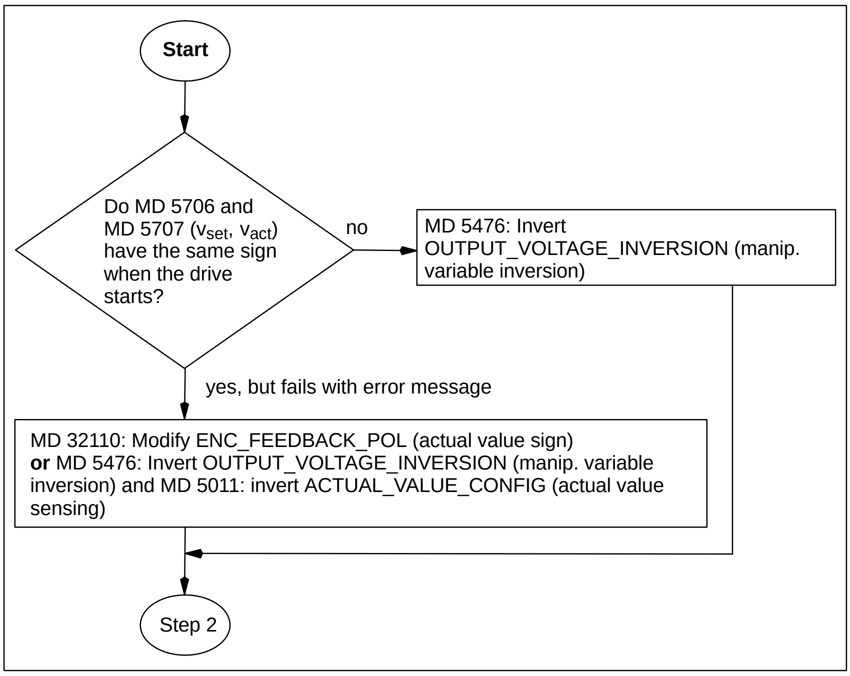


Fig. 3-17 Start-up flow chart, determine control direction

Definition of drive travel direction (step 2)

When the cylinder piston moves in the A → B direction (flow rate Q > 0) , the actual velocity value V_{act} must be positive.

This definition MUST be made in the drive for the associated functionality of

- velocity controller adaptation and
- force limitation

absolutely essential.

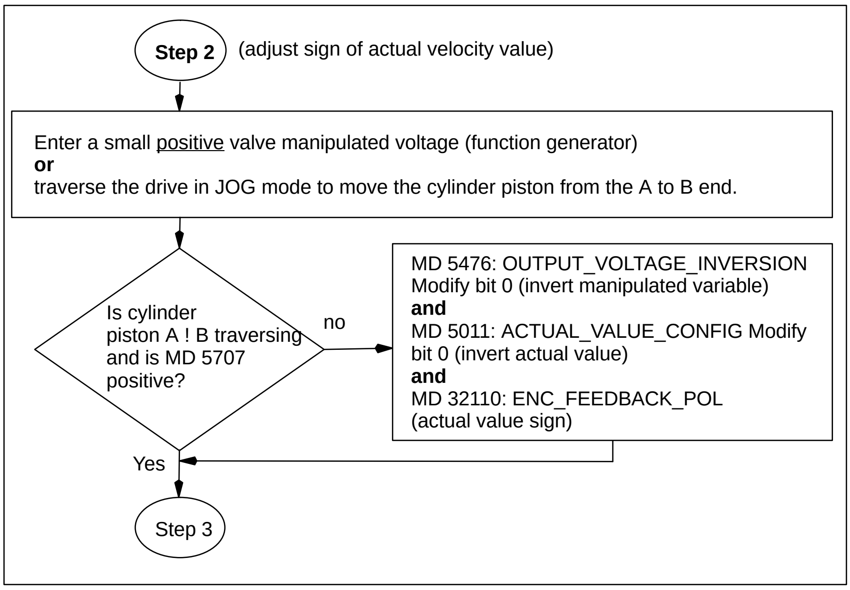


Fig. 3-18 Start-up flow chart, definition of drive travel direction

Definition of travel direction in NC (Step 3)

The positive direction of travel of the machine is defined by the user.

With adjustment of travel direction with setpoint MD 32100: AX_MOTION_DIR.

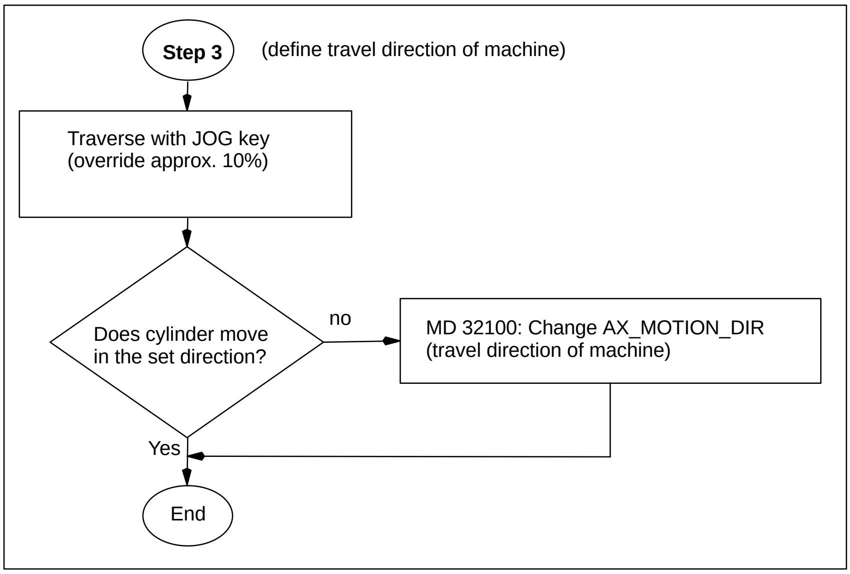


Fig. 3-19 Start-up flow chart, definition of travel direction in NC

Cancel manipulated voltage limitation

The setpoint limitation must be set to 10 V in the following MDs:

MD 5474: OUTPUT_VOLTAGE_POS_LIMIT
MD 5475: OUTPUT_VOLTAGE_NEG_LIMIT

3.9.2 Offset adjustment

Offset of pressure sensors

Note

Only in combination with pressure sensing function.

Condition: Sensors are pressure-free!

Ideal: The pressure indicator should also display 0 bar at zero pressure.

Adjustment:

- MD 5650: Set DIAGNOSIS_CONTROL_FLAGS bit 12 (canceled automatically after 2 s).
- Pressure sensor A: MD 5551: PRESSURE_SENS_A_OFFS is automatically adjusted.
- Pressure sensor B: MD 5553: PRESSURE_SENS_B_OFFS is automatically adjusted.

For unpressurized pressure sensors, the display must read approximately 0.0 bar for both pressures (MD 5704, MD 5705).

Reference value for pressure sensors

Note

Only in combination with pressure sensing function.

Pressure sensor characteristic data in

- MD 5550: PRESSURE_SENS_A_REF (ref. value for pressure sensor A)
- MD 5552: PRESSURE_SENS_B_REF (ref. value for pressure sensor B)

according to data sheet.

Offset of valve manipulated voltage

Ideal: Adjustment of electro-hydraulic zero point

The voltage is adjusted automatically by the following sequence of operations:

- Preset velocity controller with I component (e.g. V_p=-10%, T_N=30 ms) (see Subsection 4.3.2).
- In position-controlled mode at zero speed with all enabling signals applied (drive can be traversed with JOG keys).
- Set MD 5650 bit 13. (Bit 13 is automatically reset after about 30 s.)
- MD 5470: OFFSET_COMPENSATION offset compensation is set automatically.

3.9.3 Velocity adjustment

Target

Owing to the tolerances of the valves and drive units with

- real areas
- real valve control edges

it is advisable to readjust the controlled system gain for the purpose of obtaining a symmetrical actual velocity.

$$\Delta \mathbf{v}_{\textbf{move out}} = \Delta \mathbf{v}_{\textbf{move in}}$$

The gain is adjusted via machine data

- MD 5435: CONTROLLED_SYSTEM_GAIN (stage 1)
  and
- MD 5462: AREA_FACTOR_POS_OUTPUT/
  MD 5463: AREA_FACTOR_NEG_OUTPUT (stage 2).

is substituted.

Controller parameters

- P: P gain of velocity controller (MD 5406/MD 5407/MD 5408)
- I: reset time of velocity controller (MD 5409)
- D: D-action time of velocity controller (MD 5431/MD 5432/MD 5433)

must be set to 0.

Adjustment of controlled system gain

Use function generator to enter a velocity setpoint of v_{set}, offset=0.

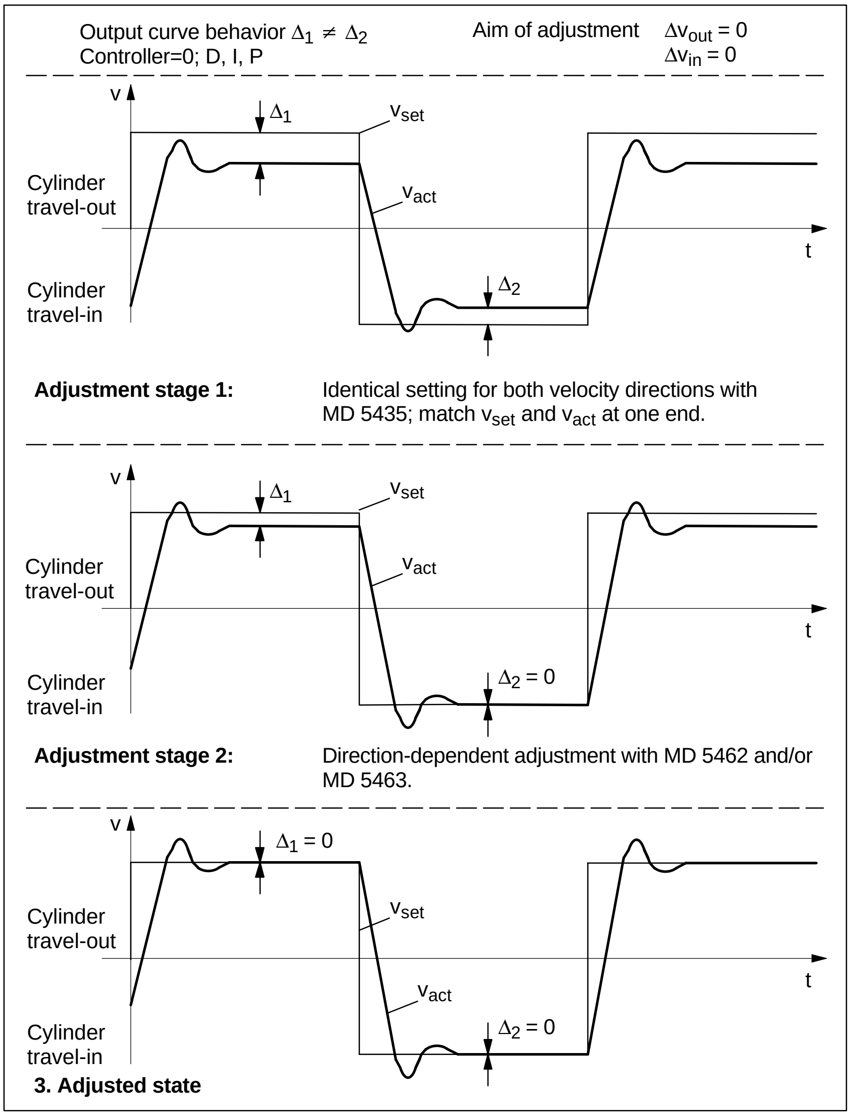


Fig. 3-20 Adjustment of controlled system gain

Note

- V_{set} is not represented by the "servo trace" function if the setpoint is defined by the function generator.
- The setting must be checked at different velocities.
  - Generally speaking, the average value of the calculated controlled system gain must be set or
  - the gain can be adjusted to match the relevant operating range.
- Both adjustment are equivalent, i.e. adjustment by the stage 2 method via MD 5462 and MD 5463 produces equivalent results when the preset value (setting) of the controlled system gain (MD 5435) is applied.

3.9.4 Referencing data for HLA

Piston zeroing

The position of the cylinder piston is required for the “Force controller” and “Velocity controller adaptation” functions. For this purpose, the piston position must be adjusted once after referencing.

This is done by the following sequence of operations:

- Reference Point Approach
- Press the “Piston position” soft key (see Fig. 3-5)
- Move cylinder piston to limit stop at A end
- Press softkey “Position adjust.” (see Fig. 3-21) to transfer the value set in MD 5740: ACTUAL_POSITION to MD 5040: PISTON_ZERO.
- Saving the boot file

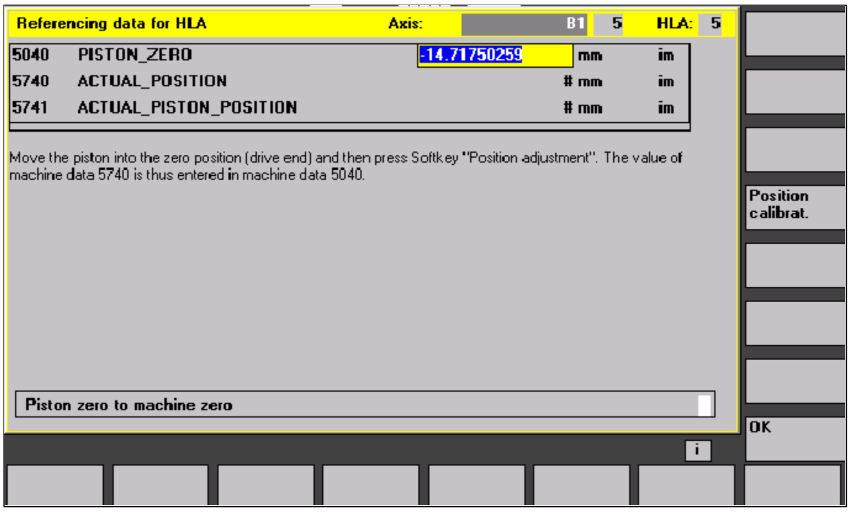


Fig. 3-21 Menu display “Referencing data for HLA”

Press the “OK” soft key to return to the initial menu display for HLA.

The following machine data affects the position adjustment:

- MD 5040: PISTON_ZERO (piston zero in relation to machine zero))
- MD 5740: ACTUAL_POSITION (actual position in relation to machine zero)
- MD 5741: ACTUAL_PISTON_POSITION (piston position in relation to piston zero)

Note

The piston position adjustment must be repeated if the control direction, reference point offset or travel direction (MD 32110, MD 34090 or MD 32100) in the axis-specific machine data is changed.

3.9.5 Controller optimization

General

The most important travel motions are implemented via the feedforward control path.

The function of the controller parameters is to damp the oscillation characteristics of the valve/cylinder grouping.

In this respect, we distinguish between three different scenarios relating to the corner frequency (f):

1. $f_{valve} << f_{cylinder}$ (f_{1})

   The valve cannot actively influence any cylinder frequency that is higher than the valve corner frequency.

   Disturbances with frequencies $f_{St} > f_{valve}$ cannot be damped.

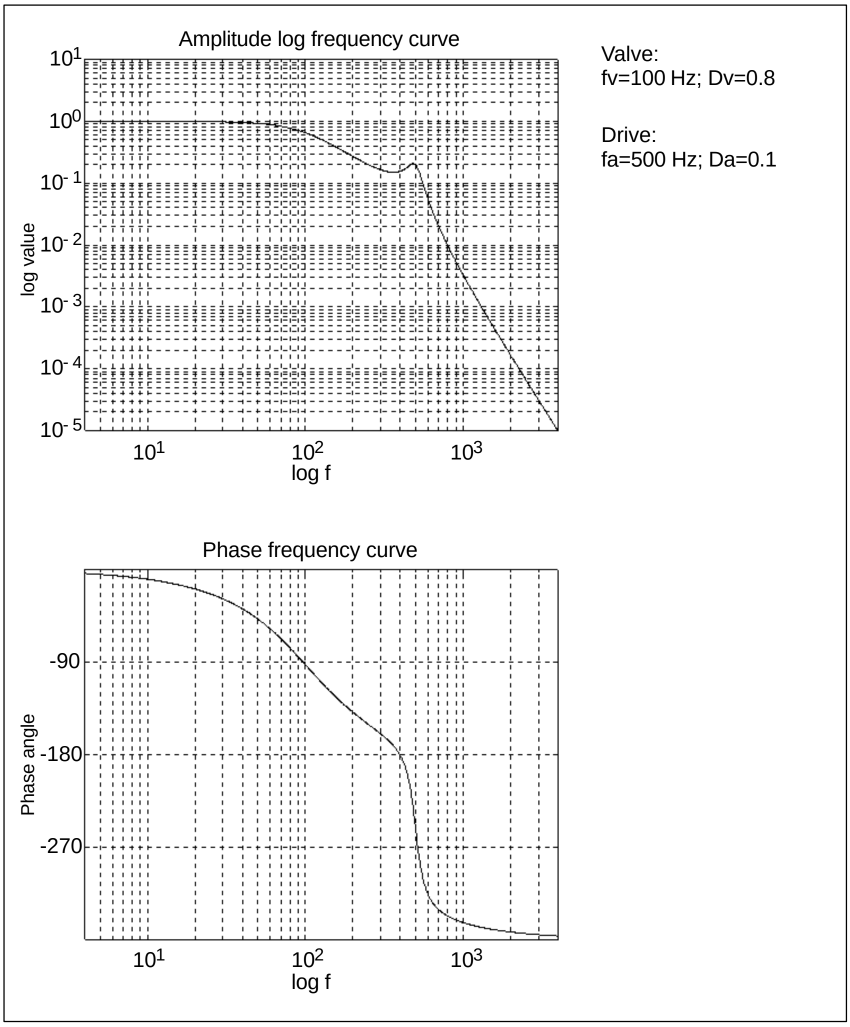


Fig. 3-22 Frequency response of controlled system ($f_{valve} << f_{cylinder}$)

2. $f_{valve} \approx f_{cylinder}$ (f_{2})

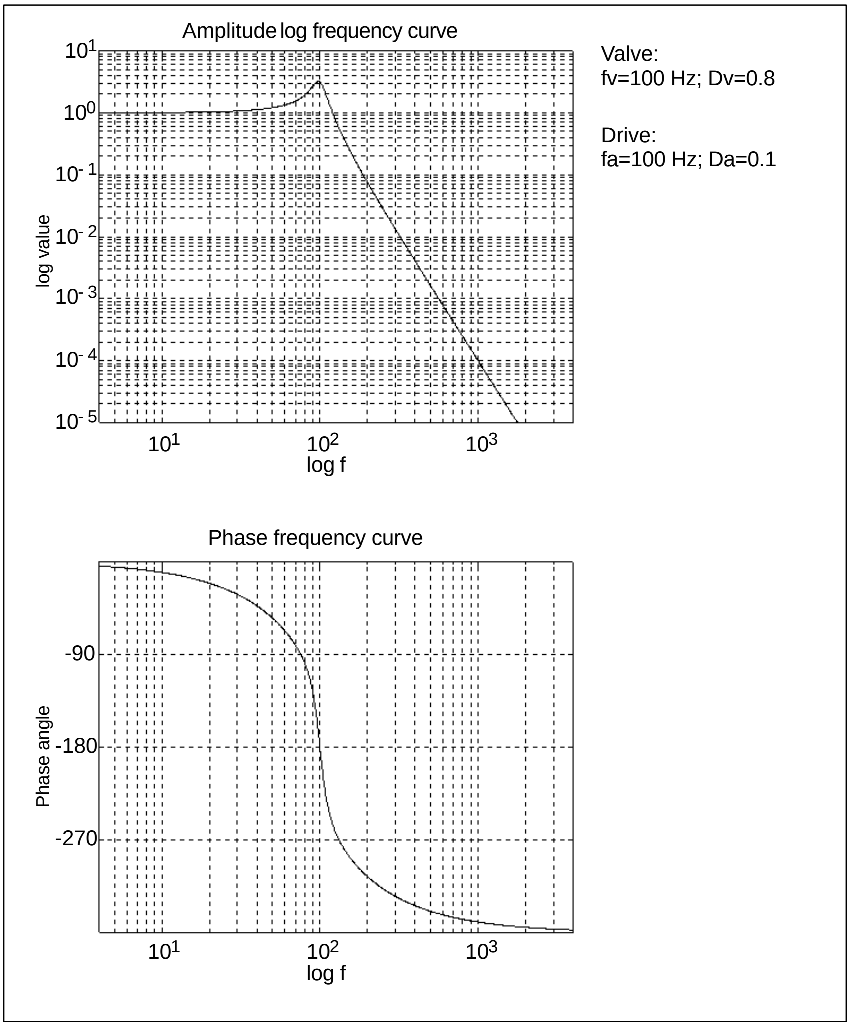


Fig. 3-23 Frequency response of controlled system ($f_{valve} \approx f_{cylinder}$)

3. $f_{valve} >> f_{cylinder}$ (f_{3})

   The valve can actively influence all natural frequencies of the drive.

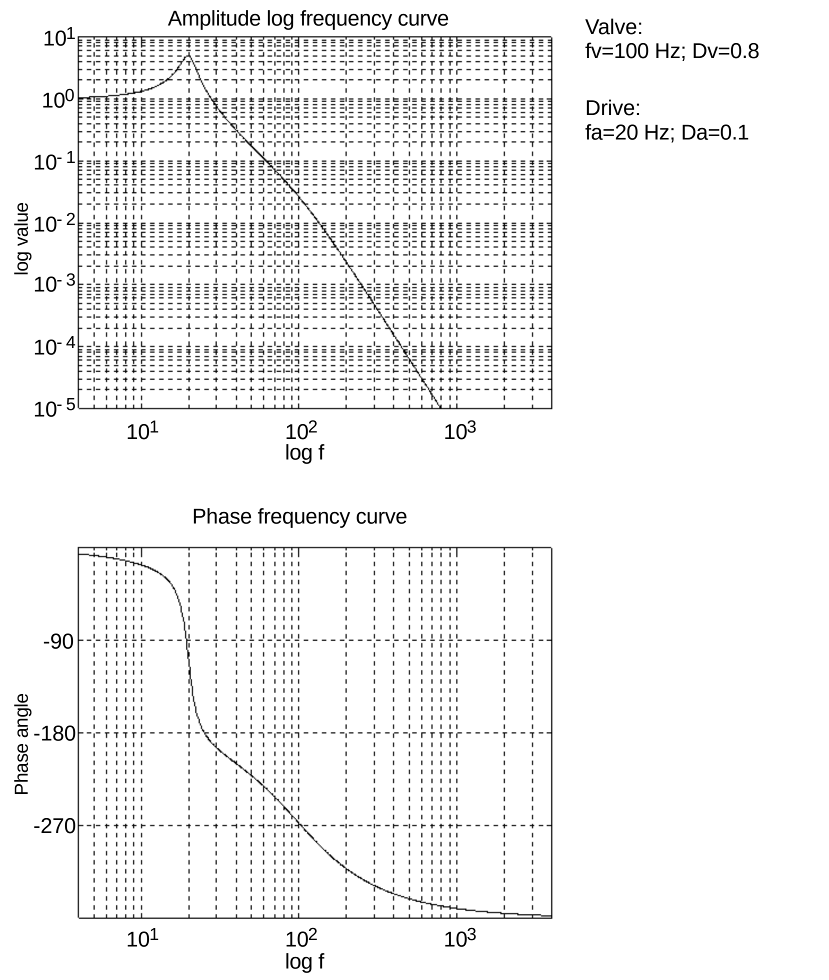


Fig. 3-24 Frequency response of controlled system ($f_{valve} >> f_{cylinder}$)

The controller components are optimized in the following order:

1. P component (proportional component)
2. D component (derivative component)
3. I component (integral component)

The preferred method of optimization uses unit step functions (step response) with the function generator (FG) after entering a velocity setpoint v_{set}.

The measuring function with noise signals (FFT, PBRS) may be difficult to interpret owing to non-linearities in the controlled system.

Differences in the characteristic data may be caused as follows:

- Theor. valve: Real valve
- Pipes: Control pressure = f(Q)
- Additional valves; shut-off valves; filters; throttles (pressure measuring plates)

Optimization of controller P component

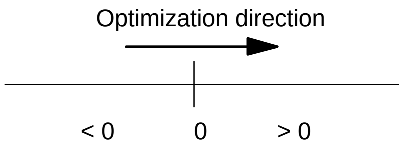
Relevant machine data:

MD 5406: SPEEDCTRL_GAIN_A (P gain of velocity controller A)
MD 5407: SPEEDCTRL_GAIN (P gain of velocity controller)
MD 5408: SPEEDCTRL_GAIN_B (P gain of velocity controller B)

The theoretical characteristic data of the valve and cylinder are used to calculate a suggested P gain value. The positive feedback area (MD 5406...MD 5408 <0) is included in the calculation to damp the drive system.

The adjustment to real conditions on the machine (special damping requirements) should be made according to the following criteria:

1. P component must be as positive as possible.



MD 5406
MD 5407
MD 5408

2. The acceptable overshoot behavior represents the upper limit for the setting.

Note

P<0 (positive feedback) may be necessary to achieve the required damping behavior. However, this setting will degrade the control quality. Friction in particular causes prolonged settling times.

Threshold values (typical):

- f_{1} P>0
- f_{2} P<0, or around zero
- f_{3} P>0

(f_{1}...f_{3} see section 3.9.5 point 1...3)

Note

The P gain is indicated as a % of MD 5435: CONTROLLED_SYSTEM_GAIN. P=-100% compensates the feedforward control.

Optimization of controller D component

Relevant machine data:

MD 5431: SPEEDCTRL_DIFF_TIME_A (derivative-action time T_V of velocity controller A)
MD 5432: SPEEDCTRL_DIFF_TIME (derivative-action time T_V of velocity controller)
MD 5433: SPEEDCTRL_DIFF_TIME_B (derivative-action time T_V of velocity controller B)

MD 5430: SPEEDCTRL_PT1_TIME (velocity controller smoothing time constant)

The positive phase displacement of the derivative term can be used to actively damp the controlled system for f_{3} type.

The derivative-action time constant/corner frequency parameters must be set to values higher than the minimum natural frequency of valve and drive.

Test run:

- As long as the damping effect improves, the the D-action time value can be raised further:
- Leave D-action time at its old value if the damping effect does not improve.

(see Fig. 3-22 - $f_{\boxed{1}}$)

The smoothing time constant is set to values $\geq$ 1 ms as a function of the controlled system for “Calculate controller”.

Owing to the fact that a derivative action amplifies the actual value noise, it is necessary in this case to find a compromise between

- the derivative action (and thus vibration damping)

  (MD 5430: SPEEDCTRL_PT1_TIME as low as possible, i.e. high corner frequency of D-action component or wide D-action frequency range)

  and

- the noise of the manipulated variable.

Like the P component setting, the optimization criterion here is the maximum acceptable overshoot of the closed velocity control loop.

The main area of application is the valve/cylinder combination $f_{\boxed{3}}$ (see Fig. 3-24) with values T_V>>0.

For applications $f_{\boxed{1}}$ + $f_{\boxed{2}}$ (see Figs. 3-22, 3-23) improvements of the damping characteristics are only to be expected at specific points when $T_V \gtrsim 0$. In most cases T_V=0 is the best choice.

Note

A second iteration loop (optimize P and D components) with further improvements can be connected in series downstream.

Optimization of controller I component

- Integrator/reset time (T_N)

Objective:	Elimination of errors in feedforward control channel.
Implementation:	T_N>5 ms taking the overshoot of the valve frequency response into account.

Note

The I component is deactivated if T_N=0 (MD 5409) or if the P component is zero (MD 5406=0, MD 5407=0, MD 5408=0).

3.9.6 Controller adaptation

General

Since the natural frequency of the cylinder changes as a function of position, it may be useful to adapt the position of the velocity controller. The maximum values coincide with the limits, and the minimum approximately with the center (MD 5160), of the traversing range.

Implementation

Requirement:

- NC end has been referenced.
- Cylinder piston in neutral position has been adjusted as described in Section 3.9.4.
- Control parameters have been processed according to the relevant operating range.

Procedure:

- Optimize the velocity controller (P and D components) with the associated machine data at the limits and at position set in MD 5160.

  Example: (see Fig. 4-11) operating range = total piston stroke

Interpolation point 1	Optimization to A end of cylinder	
	→ MD 5406: SPEEDCTRL_GAIN_A	(P gain)
	→ MD 5431: SPEEDCTRL_DIFF_TIME_A	(D gain)
Interpolation point 2	Optimization to piston position as set in MD 5160: PISTON_POS_MIN_NAT_FREQ	
	→ MD 5407: SPEEDCTRL_GAIN	(P gain)
	→ MD 5432: SPEEDCTRL_DIFF_TIME	(D gain)
Interpolation point 3	Optimization to B end of cylinder	
	→ MD 5408: SPEEDCTRL_GAIN_B	(P gain)
	→ MD 5433: SPEEDCTRL_DIFF_TIME_B	(D gain)

Note

If one end of a cylinder cannot be approached, then the adaptation process can be limited to two interpolation points.

- Velocity controller adaptation active
  MD 5413: SPEEDCTRL_ADAPT_ENABLE=1

Note

SPEEDCTRL_ADAPT_ENABLE=1 (MD 5413) is switched through only when the axis has been referenced and adjusted.

For f_{1} (see section 3.9.5), adaptation is deactivated in “Calculate controller data”.

3.9.7 Hydraulic/electrical interpolation

Target

Contour accuracy between hydraulic and electric drives is achieved when the drive dynamic response is set identically on the axes involved.

In addition to identical servo gain settings, it must be ensured that the step response of the closed speed controller is "identical".

Implementation

A velocity setpoint filter of the faster axis (e.g. electric) must be set to the difference between the time constants of the closed velocity control loop (Tv, eqv).

$T_{filter, el} = Tv_{eqv, hyd} - Tv_{eqv, el}$

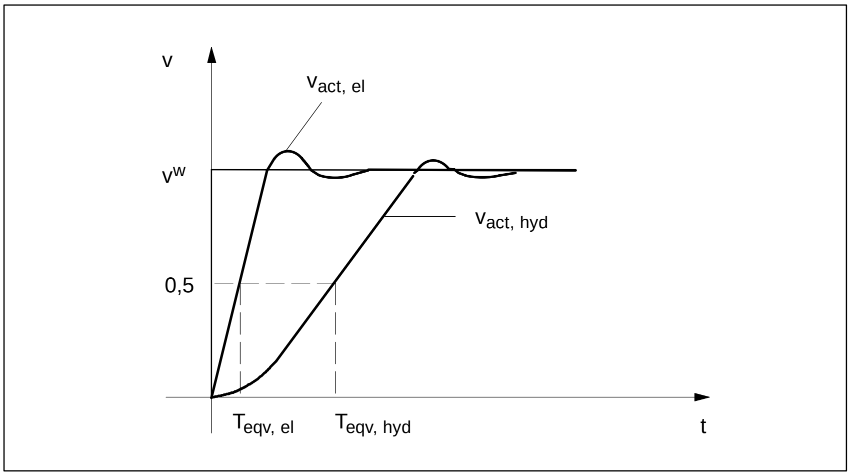


Fig. 3-25 Hydraulic/electrical interpolation

If dynamic stiffness control (DSC) is active, the DSC function must be activated on all interpolating axes.

3.10 File functions

Save data

The drive type is recorded in the MD files when drive machine data is saved. Thus, the comment is inserted only if the entry “MdFileDriveType=TRUE” has been set in the [Compatibility] section of INI file “ib.ini”. This setting is the default.

Load data

Only MD files that are suitable for a particular drive type may be downloaded to that drive. If you attempt, for example, to load an MD file for SLM to an HLA module, the following message will be displayed:

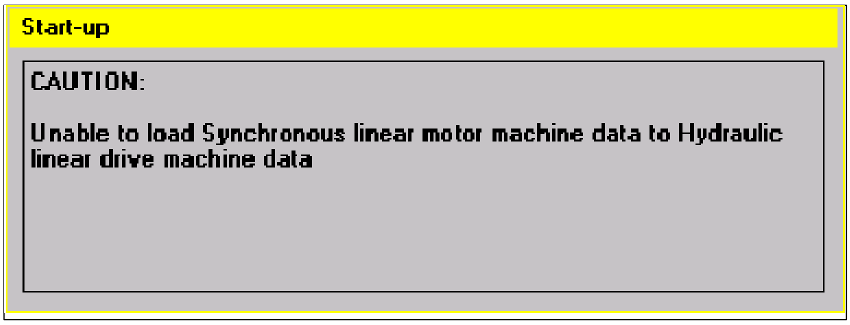


Fig. 3-26 Menu display “Dialog box Load machine data”

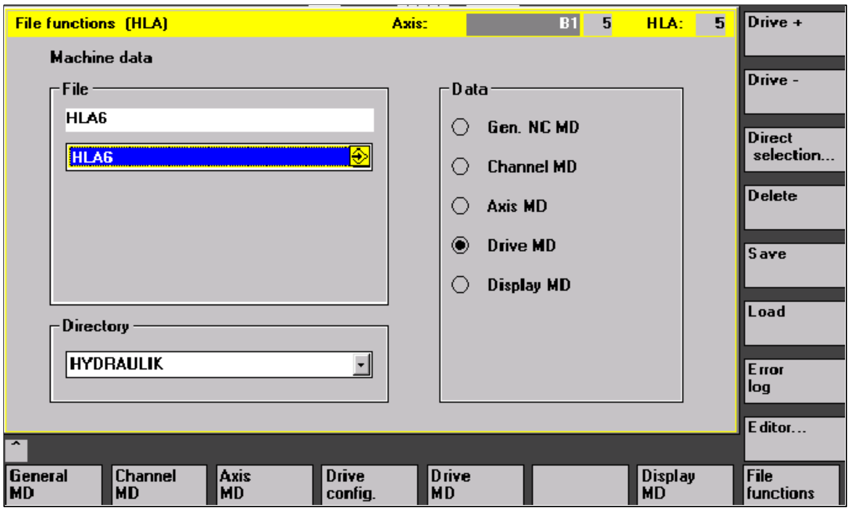


Fig. 3-27 Menu display “File functions”

3.11 Start-up functions

The following start-up functions are implemented for axes with HLA:

- Measuring functions
  - Measurement of valve control loop
  - Measurement of velocity control loop
  - Position control measurement
- Function generator
- Circularity test
- Servo trace
- DAC configuration

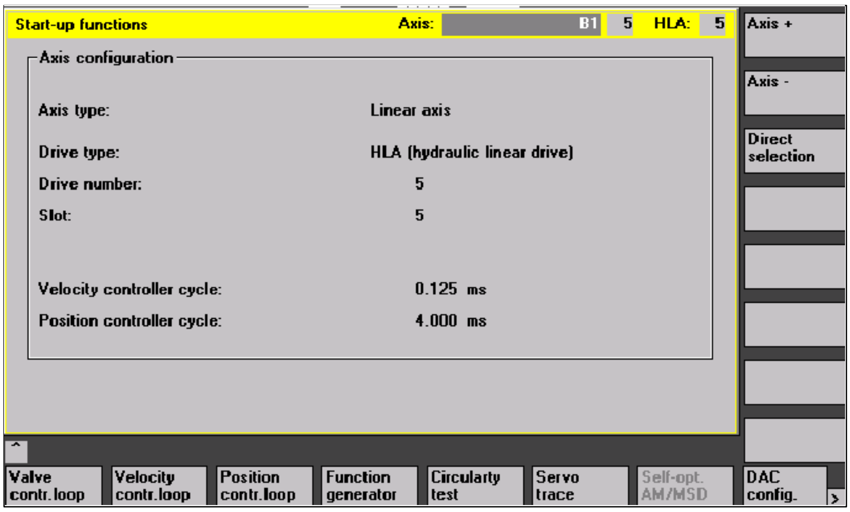


Fig. 3-28 Menu display “Start-up functions”

Disabled softkeys

The softkey “Self-opt.AM/MSD” in the “Start-up functions” menu is also disabled for axes with HLA since this is a special function for AM/MSD.

The “Aut. Controller setting” in the “Startup functions” menu is disabled for axes with HLA since the algorithms it uses are designed for automatic controller setting for electric digital drives.

3.11.1 Measurement function

The measurement functions can be used to evaluate the most important speed and position control loop variables in the time and frequency range on screen without having to use external measuring devices.

An overview of the measurement functions provided for HLA is given below. Only the hydraulic-specific functionality for HLA is described in detail.

The following measurement functions can be performed in conjunction with the HLA:

- Valve control loop measurement
  - Valve frequency response
- Velocity control loop measurement
  - Reference frequency response
  - Setpoint step change
  - Interference frequency response
  - Disturbance step change
  - Velocity path
  - Velocity path + controller
- Position control loop measurement
  - Reference frequency response
  - Setpoint step change
  - Setpoint ramp

Valve control loop measurement

Table 3-2 Measurement types and measured variables for the valve control loop measurement

Measurement	Trigger	Measured quantities
Valve frequency response	Valve spool setpoint in velocity controller cycle, valve control loop closed, velocity control loop open	Actual valve spool value/ valve spool setpoint

Table 3-3 Valve control loop measurement parameter settings

Parameters		Physical unit
Amplitude	Typ. 1 V	V
Bandwidth	typ. 1000 Hz	Hz
Averaging operations	typ. 10	-
Settling time	typ. 100	ms
Offset	typ. 0	V

Note

It must be ensured that the drive is adequately lubricated before PBRS/FFT is applied (high-frequency movement at one position).

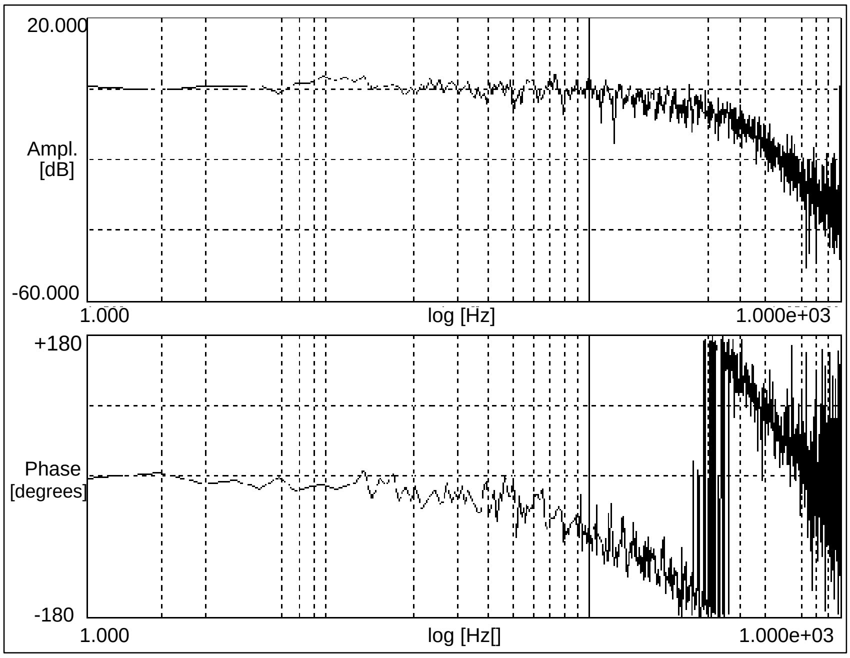


Fig. 3-29 Sample valve frequency response for type 4WRREH 6 HR servo solenoid valves from Bosch Rexroth AG
Note: For setting the valve data, see Section 4.7.

Measurement of velocity control loop

Table 3-4 Measurement types and measured variables for the velocity control loop measurement

Measurement	Trigger	Measured quantities
Reference frequency response	Velocity setpoint in velocity controller cycle, valve control loop closed, velocity control loop closed	Actual velocity value/ velocity setpoint
Setpoint step change	Velocity setpoint in velocity controller cycle, valve control loop closed, velocity control loop closed	**Measured variable 1:** • Velocity setpoint • valve spool setpoint **Measured variable 2:** Actual velocity
Interference frequency response	Valve spool setpoint in velocity controller cycle, valve control loop closed, velocity control loop closed	Actual velocity value/ valve spool setpoint
Disturbance step change	Valve spool setpoint in velocity controller cycle, valve control loop closed, velocity control loop closed	**Measured variable 1:** Valve spool setpoint **Measured variable 2:** Actual velocity
Velocity controller path	Valve spool setpoint in velocity controller cycle, valve control loop closed, velocity control loop closed	Actual velocity value/ actual valve spool value
Velocity controller path + controller	Velocity setpoint in velocity controller cycle, valve control loop closed, velocity control loop closed	Actual velocity value/ control deviation

Table 3-5 Parameter settings for measurement of velocity control loop

Parameters	Physical unit
Reference frequency response	
Amplitude (linear axis)	mm/min | inch/min
Bandwidth	Hz
Averaging operations	-
Settling time	ms
Offset (linear axis)	mm/min | inch/min
Setpoint step change	
Amplitude (linear axis)	mm/min | inch/min
Measurement time	ms
Settling time	ms
Offset (linear axis)	mm/min | inch/min
Disturbance step change	
Amplitude	V
Measurement time	ms
Settling time	ms
Offset (linear axis)	mm/min | inch/min
Velocity controller path	
Amplitude	V
Bandwidth	Hz
Averaging operations	-
Settling time	ms
Offset (linear axis)	mm/min | inch/min
Velocity controller path + controller	
Amplitude (linear axis)	mm/min | inch/min
Bandwidth	Hz
Averaging operations	-
Settling time	ms
Offset (linear axis)	mm/min | inch/min

The following functional response in the diagrams were recorded with the equipment combination below:

Valve: Type 4WRREH 6 HR servo solenoid (15 l/min, knee 60 %) from Bosch Rexroth AG

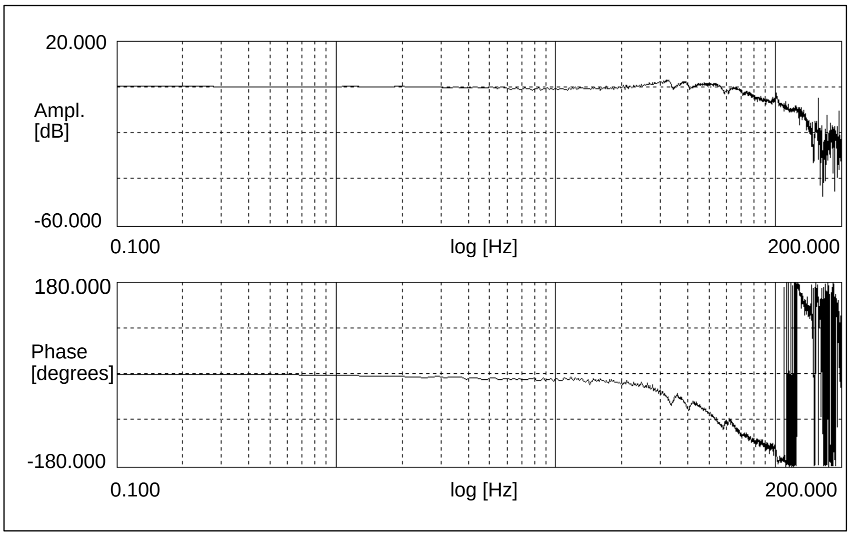


Fig. 3-30 Oscillogram showing reference frequency response of velocity control loop

Amplitude: 20 mm/min.

Offset: 100 mm/min.

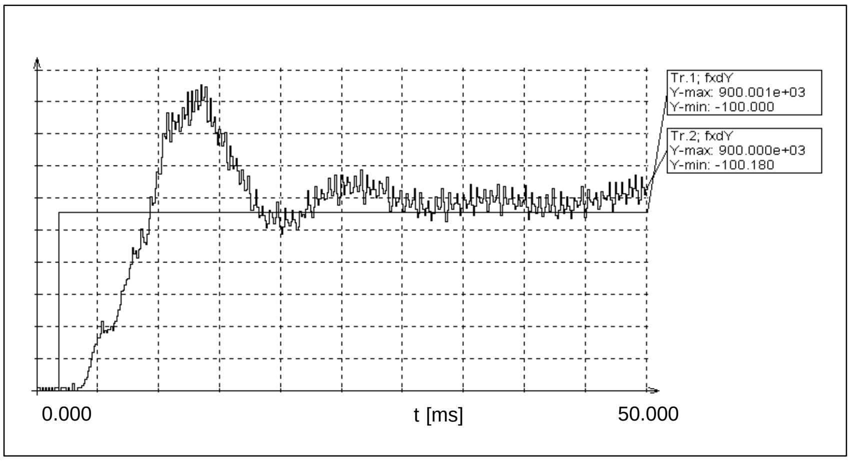


Fig. 3-31 Timing of setpoint step change in velocity control loop

Step change: 0 → 100 mm/min without closed-loop force control, real friction conditions

Trace 1: Velocity setpoint

Trace 2: Actual velocity value

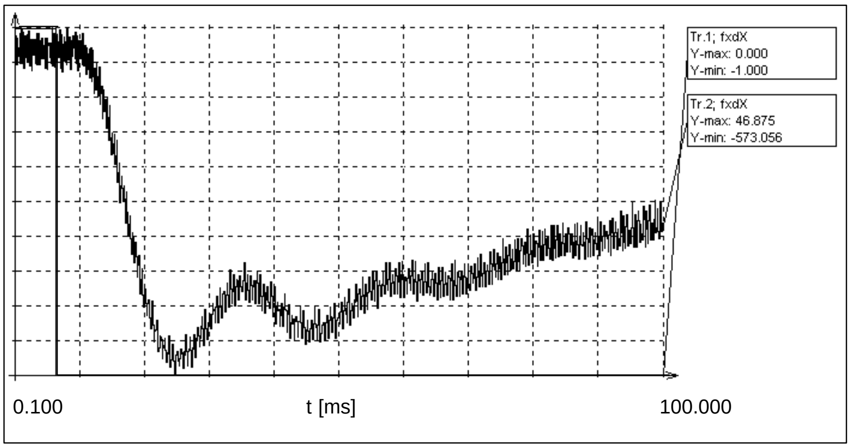


Fig. 3-32 Timing of disturbance step change, integral branch of velocity controller deactivated

Trace 1: valve spool setpoint

Trace 2: Actual velocity value

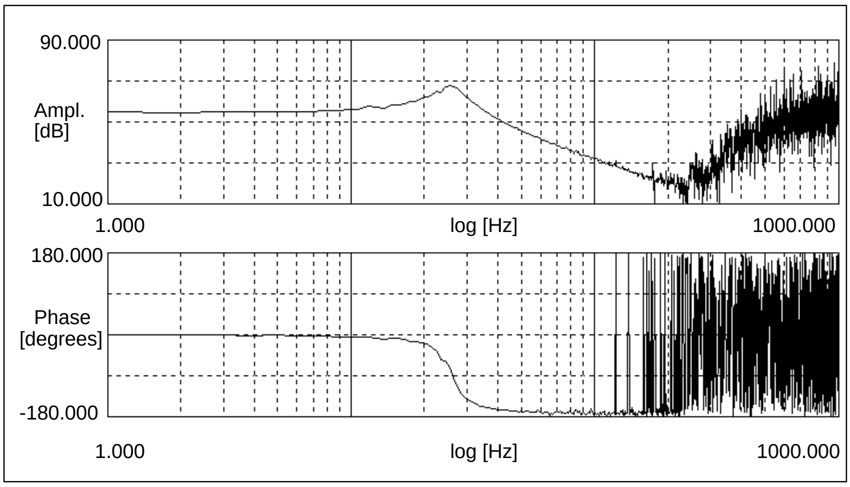


Fig. 3-33 Oscillogram showing velocity controlled system v_{act}/Q_{act}

Note: Phase crossover -90 degrees essentially characterizes the cylinder natural frequency

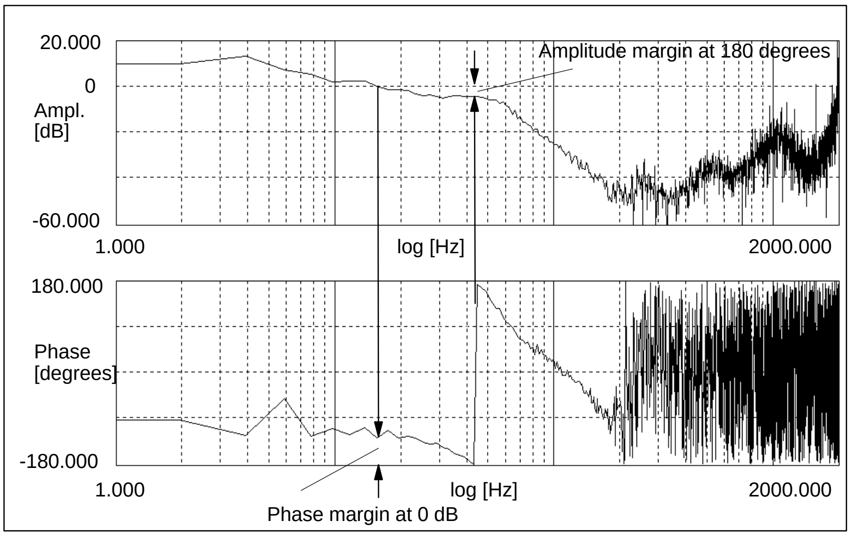


Fig. 3-34 Oscillogram for velocity controller path + controller

Note: Measurement of open velocity controlled system, indicative of the stability of the control loop.

Target values for stability of control loop:

- At least 3 dB amplitude margin at 180 degrees
- At least 60 degrees phase margin at 0 dB

Position control measurement

Table 3-6 Measurement types and measured variables for position feedback loop measurement

Measurement	Trigger	Measured quantities
Reference frequency response	Position setpoint in position controller cycle, position control loop closed, velocity control loop closed	Actual position/position setpoint
Setpoint step change	Position setpoint in position controller cycle, position control loop closed, velocity control loop closed	**Measured variable 1:** Position setpoint **Measured variable 2:** • Actual position value • Control deviation • Following error • Actual velocity value
Setpoint ramp		

Table 3-7 Parameter settings for measurement of position control loop

Parameters	Physical unit
Reference frequency response	
Amplitude (linear axis)	mm | inch
Bandwidth	Hz
Averaging operations	-
Settling time	ms
Offset (linear axis)	mm/min | inch/min
Setpoint step change	
Amplitude (linear axis)	mm | inch
Measurement time	ms
Settling time	ms
Offset (linear axis)	mm/min | inch/min
Setpoint ramp	
Amplitude (linear axis)	mm | inch
Measurement time	ms
Ramp time	ms
Settling time	ms
Offset (linear axis)	mm/min | inch/min

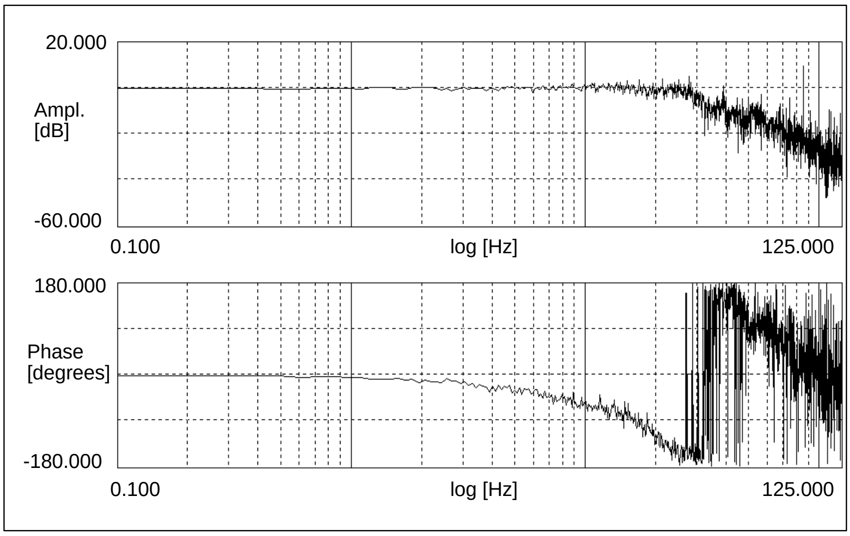


Fig. 3-35 Example of measurement of position control loop

3.11.2 Function generator

The function generator for HLA is based on the existing functionality provided for other drive types integrated to date. The funct. for HLA, which is not especially designed for hydraulic drives, is based on the SLM range of functions.

The function generator excites the drive with a periodic signal. The signal type is a modifiable parameter. External measuring instruments such as oscillographs can record the system responses via DAC output jacks.

The following signals (operating modes) and signal types are available on the HLA:

- Signals (operating modes)
  - valve spool setpoint
  - Velocity setpoint
  - Position setpoint
- Signal type
  - Square-wave
  - Noise signal (only for signal output via DAC and external evaluation equipment for frequency response analyses)

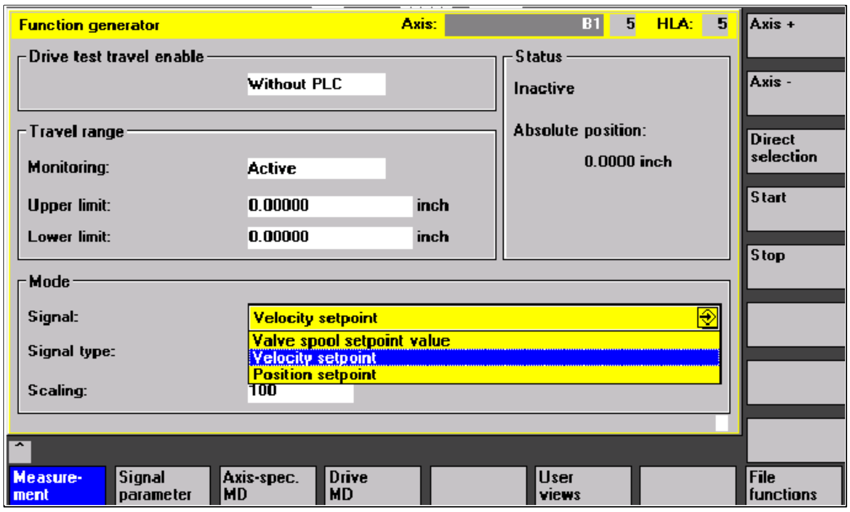


Fig. 3-36 Menu display “Function generator selection signal”

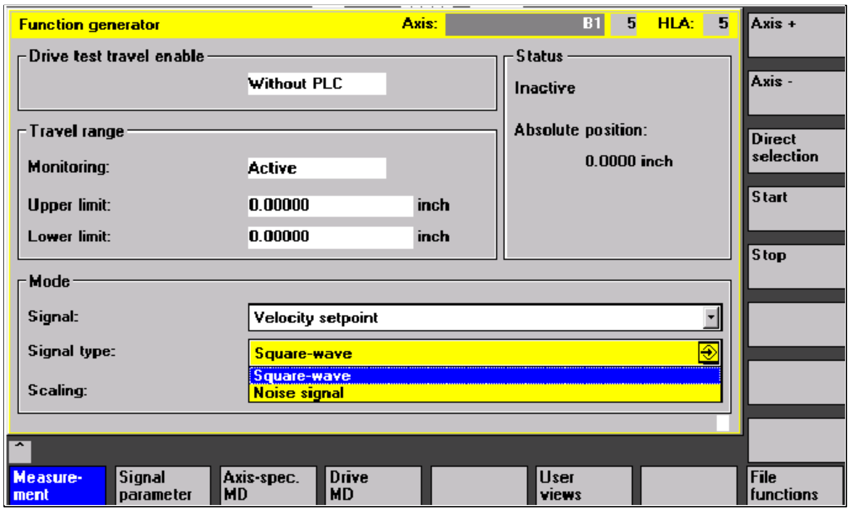


Fig. 3-37 Menu display “Function generator selection signal type”

For an explanation of how to use the function generator, please refer to

References: /FBA/, DD2 “Speed control loop”
/SHM/, SIMODRIVE 611 “Manual for MCU 172A”

An overview of the function generator functions provided for HLA is given below, with only the purely hydraulic-specific functionality for HLA described in detail.

Valve spool setpoint (manipulated voltage)

Table 3-8 Signal (operating mode) for valve spool setpoint

Trigger	Signal type
Valve spool setpoint in velocity controller cycle, valve control loop closed, velocity control loop open	Square-wave

Table 3-9 Signal (operating mode) for valve spool setpoint parameter settings

Parameters	Physical unit
Signal type: Square-wave	
Amplitude	V
Period	ms
Pulse width	ms
Offset	V
limitation	V

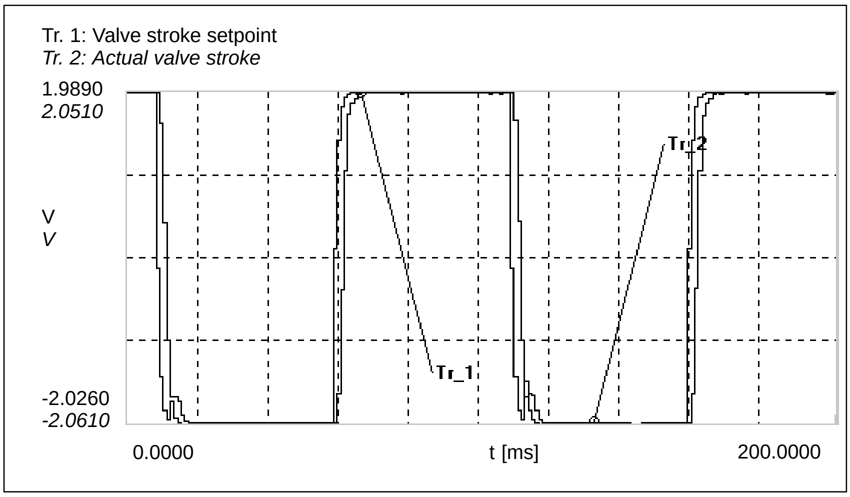


Fig. 3-38 Servo trace of actual valve value with square-wave signal type to valve setpoint

Velocity setpoint

Table 3-10 Signal (operating mode) for velocity setpoint

Trigger	Signal type
Velocity setpoint in velocity controller cycle, valve control loop closed, velocity control loop closed	Square-wave

Table 3-11 Signal (operating mode) for velocity setpoint parameter settings

Parameters	Physical unit
Signal type: Square-wave	
Amplitude (linear axis)	mm/min | inch/min
Period	ms
Pulse width	ms
Offset (linear axis)	mm/min | inch/min
Limitation (linear axis)	mm/min | inch/min

Note

The following diagram was created using a servo trace.

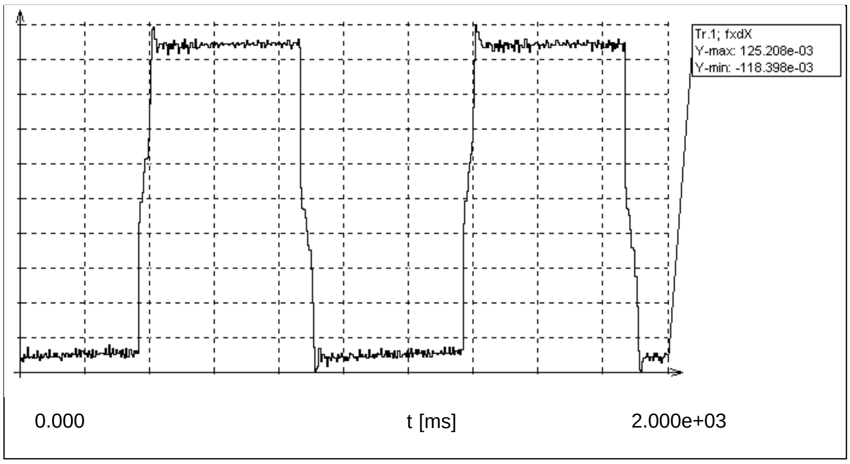


Fig. 3-39 Servo trace of actual velocity with square-wave signal type to velocity setpoint

Amplitude: 100 mm/min.

Position setpoint

Table 3-12 Signal (operating mode) for position setpoint

Trigger	Signal type
Position setpoint in position controller cycle, position control loop closed, velocity control loop closed	Square-wave

Table 3-13 Signal (operating mode) for position setpoint parameter settings

Parameters	Physical unit
Signal type: Square-wave	
Amplitude (linear axis)	mm | inch
Period	ms
Pulse width	ms
Offset (linear axis)	mm/min | inch/min
Limitation (linear axis)	mm | inch

Note

The following diagram was created using a servo trace.

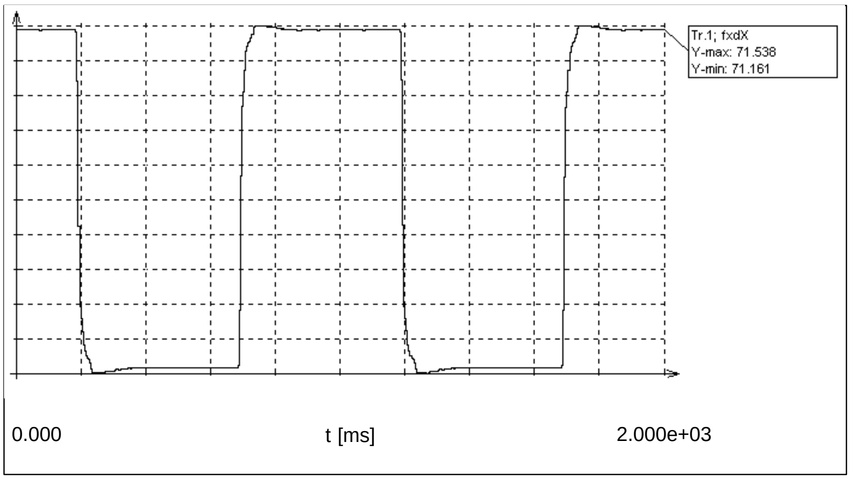


Fig. 3-40 Servo trace of actual position with square-wave signal type to position setpoint

Amplitude: 100 mm

3.11.3 Circularity test

The circularity test is used among other things as a way of checking the resulting contour precision. It works by measuring the actual positions during a circular movement and displaying the deviations from the programmed radius as a diagram (especially at the quadrant transitions). For detailed information, see:

References: /FB/Part 2, K3, Sect. 2.7 “Circularity test”

Example: The following example refers to a drive with an HRV.

X1 axis: Horizontal movement by electric drive
Y1 axis: Vertical movement by hydraulic drive

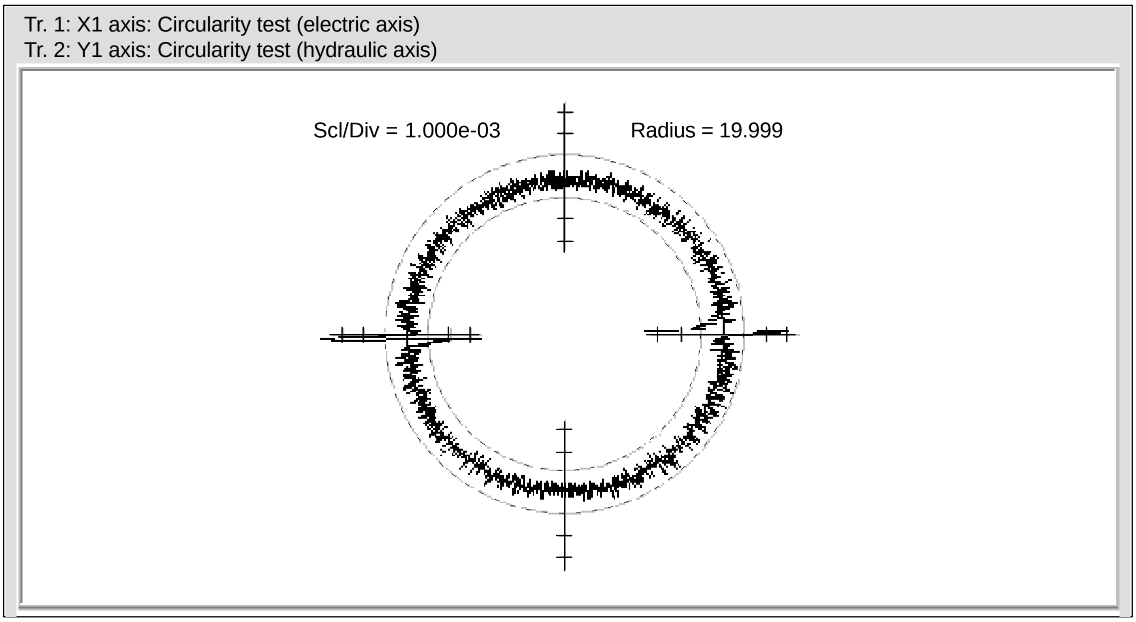


Fig. 3-41 Example of circularity test on HRV size 06, 15 l/min, knee-point 60%; V=400 mm/min (traversing velocity)

3.11.4 Servo trace

The servo trace function is used for graphic representation of signals and operating conditions.

A hydraulic-specific signal list (servo and drive signals) is available as a support function for axes with HLA module.

The following hydraulic-specific drive signals are supported by the servo trace:

- Active power (with pressure sensing)
- Actual force (with pressure sensing)
- Actual velocity value
- Valve stroke setpoint
- Actual valve stroke
- Actual pressure cylinder A end
- Actual pressure cylinder B end

3.11.5 DAC parameter settings

For DAC measuring sockets see subsection 5.1.5.

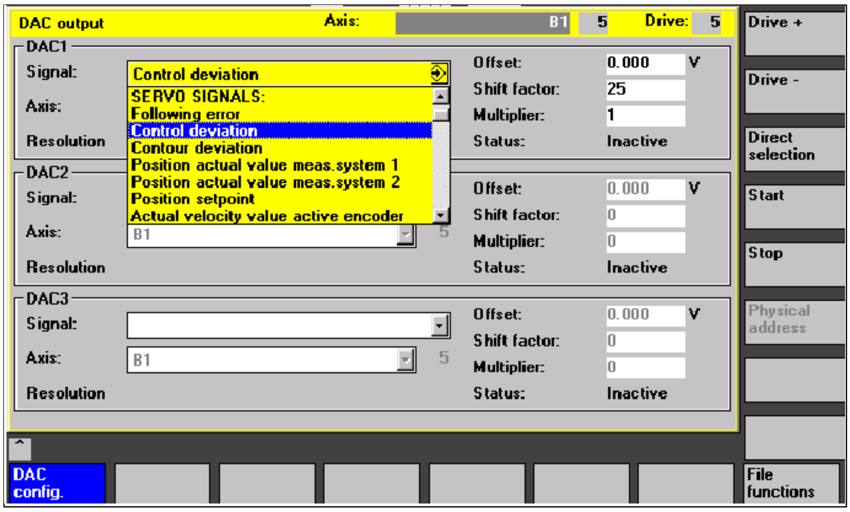


Fig. 3-42 Menu display “DAC parameter settings”

DAC selection list

Table 3-14 DAC selection list

Description	Unit
Pressure p(A) (with pressure sensing)	bar
Pressure p(B) (with pressure sensing)	bar
Actual value spool value	V
valve spool setpoint	V
Actual velocity value	mm/min
velocity Setpoint (upstream of filter)	mm/min
velocity Setpoint (limited at filter output)	mm/min
velocity Reference model setpoint	mm/min
Actual force (with pressure sensing)	N
Active power (with pressure sensing)	kW
Control deviation of velocity controller	mm/min
Velocity controller P component	V
Velocity controller I component	V
Velocity controller D component	V
Feedforward control component velocity controller	V
Friction feedforward control component velocity controller	V
Velocity controller output before filter	V
Velocity controller output after filter	V
Actual position value	mm
Force setpoint	N
Force controller control deviation	N

Table 3-14 DAC selection list

Description	Unit
P component of force controller	V
I component of force controller	V
D component of force controller	V
Feedforward control component force controller	V
Force controller output	V
Zero mark signal	-
BERO signal	-
Physical address (drive)	-

3.12 User views

The horizontal softkey HLA is used under menu items “User Views/Edit View/Insert Date”.

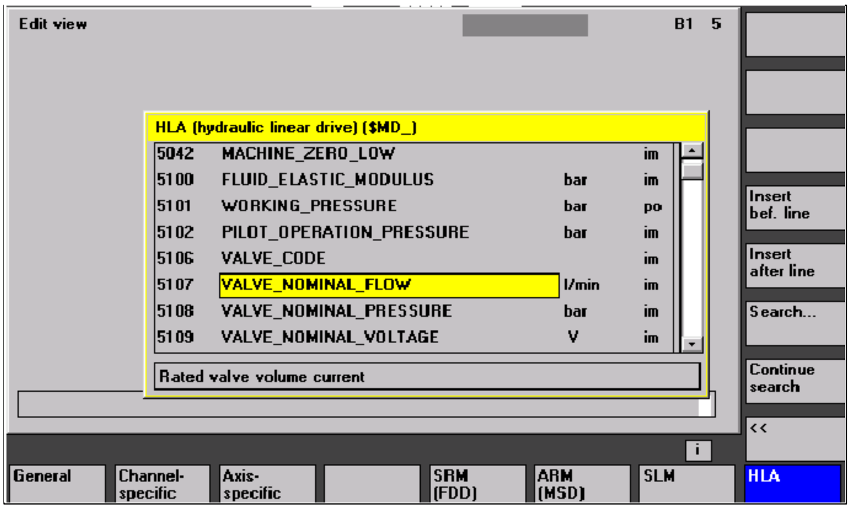


Fig. 3-43 Menu display “Edit view”

3.13 Display options

The display options allow the user to selectively reduce the amount of machine data that is displayed.

Machine data groups

The machine data is grouped for display purposes is similarly to the machine data display for electric drives.

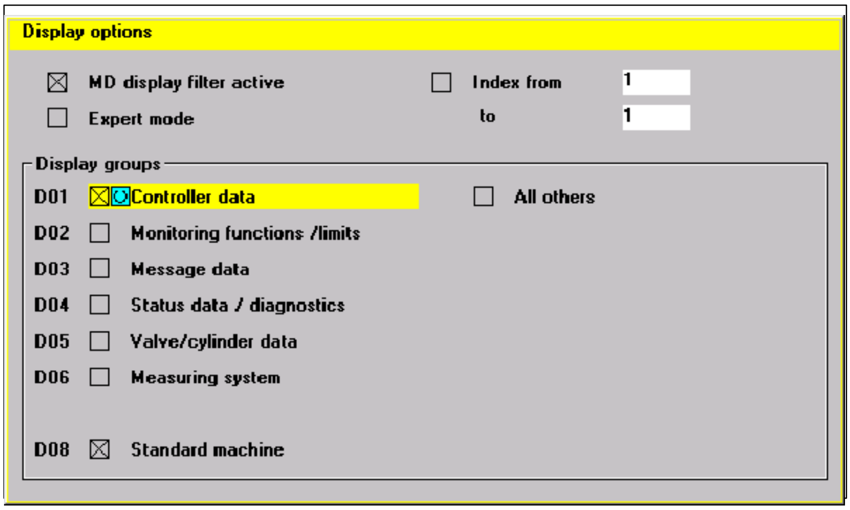


Fig. 3-44 Menu display “Display options”

3.14 Configuring an OEM valve list

General

OEM users can add their own valves to the valve list by copying file **ibhlvlvo.ini** to the “\oem” directory. This list is added as a separate item under the heading “OEM valves” at the end of the system list (Siemens list).

The syntax of the valve list is identical to that of a Windows INI file. The list may be created under “Start-up”, “MMC” or “Editor”.
Select C:\OEM, then “New”. Enter the filename **ibhlvlvo.ini**, followed by “OK”.

Structure

This file must have the following structure:

[DATA]
Column1 = Column2, Column3, ... , Column15,
.
.
.

Example of an OEM valve list

[DATA]

;5106	,	,	,	5107,	5108,	5109,	5110,	5111,	5112,	5113,	5114,	5115,	,	,
1001=	OEM,	01,	abc type,	90.1,	5,	10,	10,	39.8,	1,	0001B,	35,	1.0,	90,	$T7⊔40,
1050=	OEM,	02,	xyz type,	40.2,	5,	10,	10,	40.1,	1,	0001B,	35,	1.0,	40,	$T7⊔40,
1051=	OEM,	03,	def type,	8.1,	35,	10,	10,	10,	1,	0000B,	200,	0.8,	8,	$T8,
1030=	OEM,	04,	gkl type,	100.1,	35,	10,	10,	38.5,	2,	0010B,	70,	0.8,	100,	$T7⊔40,
$L=			“End of list”											
$L=		“- - - - - - - - - -”												

Note

Columns 1 and 2 are separated by a “=” character. All other columns are separated by a comma. Column 15 ends with a comma.

An MMC Reset must be performed to make changes effective.

Table 3-15 Meaning of individual columns

Column in OEM valve list	Description	Column in MMC display / max. characters	Reference to MD		Unit
			Name	No.	
1	Valve code number	7 / 5	VALVE_CODE	5106	
2	Manufacturer's name	1 / 7			
3	Order Number	2 / 13			
4	Type	3 / 11			
5	Nominal valve flow		VALVE_NOMINAL_FLOW	5107	[l/min]
6	Nominal pressure drop of valve		VALVE_NOMINAL_PRESSURE	5108	[bar]
7	Nominal voltage of valve		VALVE_NOMINAL_VOLTAGE	5109	[V]
8	Knee-point flow rate of valve		VALVE_DUAL_GAIN_FLOW	5110	[%]
9	Knee-point voltage of valve		VALVE_DUAL_GAIN_VOLTAGE	5111	[%]
10	Nominal flow rate ratio between A and B ends of valve	6 / 10	VALVE_FLOW_FACTOR_A_B	5112	
11	Valve configuration		VALVE_CONFIGURATION	5113	
12	Natural frequency of valve		VALVE_NATURAL_FREQUENCY	5114	[Hz]
13	Valve damping		VALVE_DAMPING	5115	
14	Nominal valve flow rate for display	4 / 9			[l/min]
15	Valve knee-point voltage for display	5 / 15			[%]

The valve code is entered in the first column and must be a number. Numbers 1 to 1000 are reserved for Siemens. Individual values are separated by commas. Columns 1 and 2 are separated by an equals signal (=). Comments are preceded by a semicolon.

Different numeric formats may be used.

- The following applies to the display (selection list) on the MMC:
  The character strings used are identical to those stored in the INI file.
- The following applies to writing machine data:
  - Unless otherwise specified, the decimal format is always used. If the number is followed by a capital B, it is interpreted as a binary number. If a capital H is inserted after the number, it is interpreted as a hexadecimal value.
  - Floating-point numbers must be specified in US format (decimal point=".") and **without** the separator symbol for 1000s (",").
  - The individual fields in this section can be left empty, i.e. they contain 2 commas one after the other or two blanks between the 2 commas. Empty fields are not written to the drive, i.e. the default setting of the machine data is transferred unchanged. The number of blanks is optional. The maximum permitted number of characters is shown in Table 3-15.

Language-dependent texts

Any language-dependent texts can be inserted in the OEM valve list. These all start with $T.

Syntax: $T<X> (no semicolon)
<X> refers to a text in the language-dependent text files
(see also language-dependent OEM texts)

Subheadings can also be inserted in the OEM valve list by adding the instruction “$L=<any text>;” at the beginning of a line. $T<X> can be used to insert other language-dependent texts within this optional text instruction.

Language-dependent system texts

The following language-dependent texts are predefined by the system and can be used in OEM valve lists.

$T1=Order No.;
$T2=Type;
$T3=Nominal flow rate;
$T4=Knee-point voltage;
$T5=Nominal flow rate A:B;
$T6=Code;
$T7=“ Knee”;
$T8=“ Linear”;
$T9=Company;
$T10=Unlisted valve;
$T11=l/min;

Language-dependent OEM texts

Language-dependent OEM display texts are stored in the **\oem\language** directory in **\ibdrv_<SPRACHE>.ini** files

<LANGUAGE> stands for the appropriate language code. This file would be called **ibdrv_gr.ini** for German. The codes for all languages installed in a system are listed in the **\mmc2\mmc.ini** file, [LANGUAGE] section, LanguageList entry. Language-dependent OEM text files must be formatted as follows:

[TEXT]
$T<X>=<any text>;
:<X> is any number ≥ 1000 and ≤ 32767, which must only occur once.

The number range from 1 to 999 is reserved for the system.

3.15 System variables

The NC control can use system variables to read in the measuring signals applied to connectors X121/X122 or X111/X112.

Table 3-16 Assignment of system variables

Name	Male connector	Pin
$VA_VALVELIFT[X]	X121/X122	14 and 15
$VA_PRESSURE_A[X]	X111/X112	11 and 12
$VA_PRESSURE_B[X]	X111/X112	14 and 15

■

4 Firmware Drive Functions

4.1 Block diagram of closed-loop control

Integration in overall system

The following diagram shows how the HLA module is embedded between the control system and the hydraulic drive. The control functions of the module are shown in greatly simplified form. They are shown in more detail in the diagram on the following page.

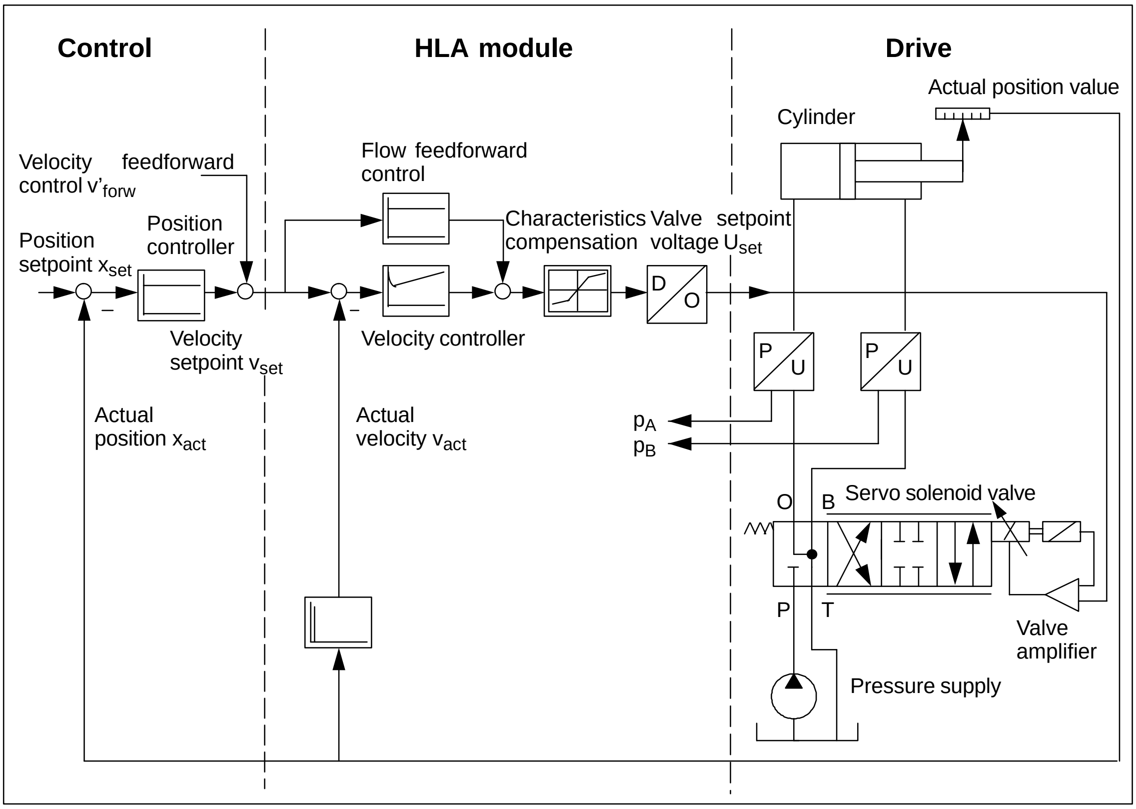


Fig. 4-1 General block diagram of NC - HLA module - drive system

Possible dynamic response

The dynamic response is dependent on:

- Natural frequency of the servo solenoid valve (see Subsection 2.3.2)
- Natural frequency of the drive (see Subsection 2.3.4)

The greater the natural frequency, the better the achievable dynamic response.

For the purpose of oscillation damping, the natural frequency of the servo solenoid valve must be greater than that of the drive.

Block diagram of control functions

Fig.4-2 shows the functionality for velocity and closed-loop force control plus characteristics implemented in the HLA module.

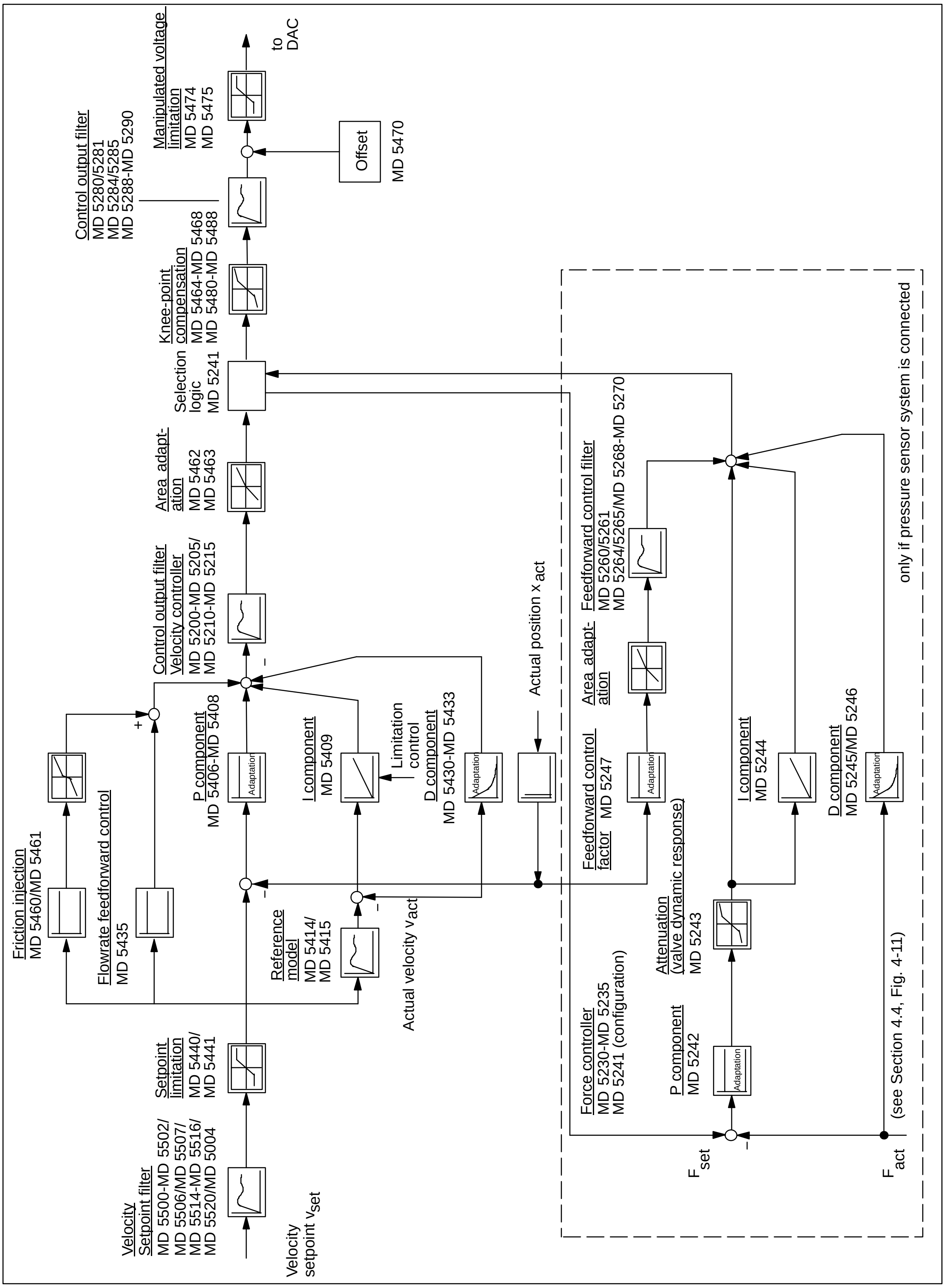


Fig. 4-2 Controller and characteristic functions of the HLA module

4.2 Functions

4.2.1 Overview of functions

The document has been organized under the following main topics with reference to Fig. 4-2:

- Velocity feedforward control (Subsection 4.3.1)
  - Servo gain
  - Velocity setpoint filter
  - Setpoint limitations
- Velocity controller (Subsection 4.3.2)
  - P/D/I components
  - Deactivate adaptation
  - Integrator feedback
  - Reference model
  - Control output filter in velocity controller
- Force control (Section 4.4)
  - P/D/I components
  - Force limitations
  - Servo gain
- Manipulated voltage output (Section 4.5)
  - Characteristic compensation
  - Control output filter
  - Manipulated voltage limitations

4.2.2 Parameter set changeover

It is possible to switch between 8 different parameter sets. Data which are assigned to specific parameter sets are identified by an [n] in the string code [0-7].

The request is made from the PLC by means of IS “Select drive parameter set” DB 31-61 DBB 21 bits 0-2. They are predominantly controller and filter data that can be switched over as a function of parameter set.

The status is interrogated by means of IS “Active drive parameter set” DB 31-61 DBB 93 bits 0-2.

Section 4.15 contains a complete parameter list with the attributes for each parameter.

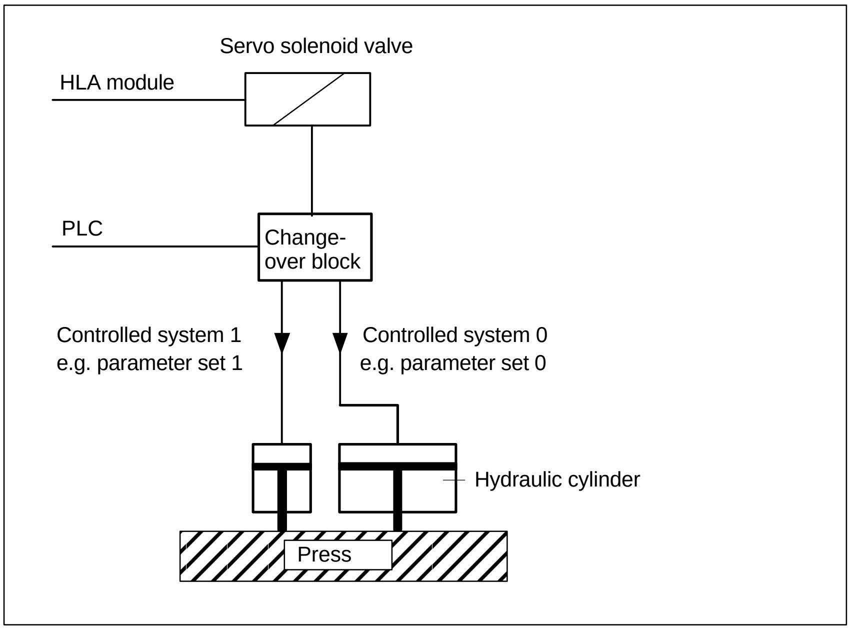


Fig. 4-3 Example of a parameter set changeover

4.3 Closed-loop velocity control

4.3.1 Velocity adaptation/feedforward control

Velocity setpoint

The NC → drive transfer interface is normalized to the maximum velocity set in data MD 5401: DRIVE_MAX_SPEED.

5401	DRIVE_MAX_SPEED				Cross reference: -
	Maximum useful velocity			Related to: HLA	Protection level: 3/3
Unit: mm/min	Default: 0.0	Minimum: 0.0	Maximum: 120 000.0	Data type: FLOAT	Active: Power On

The velocity limit is defined by the settings in MD 5440: POS_DRIVE_SPEED_LIMIT and MD 5441: NEG_DRIVE_SPEED_LIMIT, but not with MD 5401: DRIVE_MAX_SPEED.

Velocity setpoint interpolation

5004	CTRL_CONFIG				Cross reference: -
	Configuration structure			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 1000	Minimum: 0	Maximum: 1000	Data type: UNS.WORD	Active: Power On

Velocity setpoints are preset in the position controller cycle.
In order to prevent rigorous drive positioning motions at the beginning of each position controller cycle, the current and previous velocity setpoint are interpolated linearly in the drive.

Bit 12=0: no interpolation, velocity setpoint only changes in the position controller cycle.
Bit 12=1: linear interpolation of the velocity setpoint over one position controller cycle. The default setting is active.

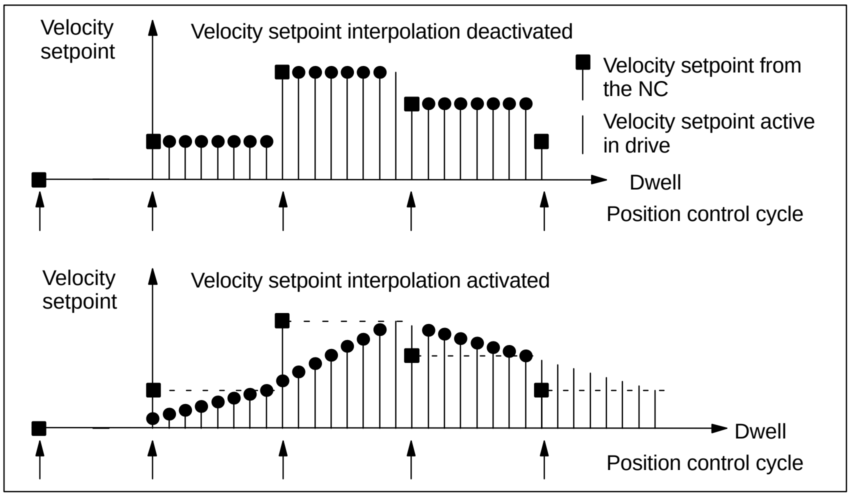


Fig. 4-4 Velocity setpoint interpolation

Velocity setpoint filter

The complexity of applying velocity setpoint filters means that it is not possible to provide generally-applicable, definitive guidelines for their use. However, criteria for selecting filters and their parameters are defined below.

The velocity setpoint filters are used to adapt the velocity-controlled drive grouping to the higher-level position control loop. You can choose between bandstop filters and low passes (PT2/PT1).

The task of a filter is to

- smooth the control response characteristic,
- damp mechanical resonance and
- symmetrize axes with different dynamic responses, especially the response of interpolating axes.

Note

Low-pass filters can be employed on interpolating axis groupings to compensate for differences in dynamic response in velocity control loops.

The total equivalent time constant (equivalent time constant of velocity control loop + equivalent time constant of velocity setpoint filter) must be set to an identical value for all mutually interpolating axes.

Entering damping values close to the minimum input limits results in overshoots up to a factor of 2 in the time range.

5500	**NUM_SPEED_FILTERS** [n] 0...7 index of the parameter set				**Cross reference: -**
	No. of velocity filters 0: No velocity filters active 1: Velocity filter activated			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 1	Data type: UNS.WORD	Active: Immediately
5501	**SPEED_FILTER_TYPE** [n] 0...7 index of the parameter set				**Cross reference: -**
	Type of velocity filter Bit 0= 0: Low-pass (see MD 5502, MD 5506, MD 5507) 1: Bandstop (see MD 5514 - MD 5516, MD 5520) Bit 8= 0: PT2 low-pass (see MD 5506, MD 5507) 1: PT1 low-pass (see MD 5502)			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 257	Data type: UNS.WORD	Active: Immediately
5502	**SPEED_FILTER_1_TIME** [n] 0...7 index of the parameter set				**Cross reference: -**
	PT1 time constant for velocity filter 1			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 0.0	Minimum: 0.0	Maximum: 500.0	Data type: FLOAT	Active: Immediately

The filter is activated via MD 5500 (1) and deactivated via (0). The default setting is deactivated. The type of velocity filter can be defined by setting MD 5501 to PT1 or PT2 low-pass or to band-stop filter. The key data for the filter is defined in MD 5502 to MD 5520.

The filter is deactivated if machine data MD 5502 is set to 0.

5506	**SPEED_FILTER_1_FREQUENCY** [n] 0...7 index of the parameter set				**Cross reference: -**
	PT2 natural frequency for velocity filter 1			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 2000.0	Minimum: 10.0	Maximum: 8000.0	Data type: FLOAT	Active: Immediately
5507	**SPEED_FILTER_1_DAMPING** [n] 0...7 index of the parameter set				**Cross reference: -**
	PT2 damping for velocity filter 1			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0.7	Minimum: 0.2	Maximum: 1.0	Data type: FLOAT	Active: Immediately

Setting the machine data to a value of < 10 Hz as the low-pass natural frequency deactivates the filter.

Note

For interpolating axes, please read Subsection 3.9.7.

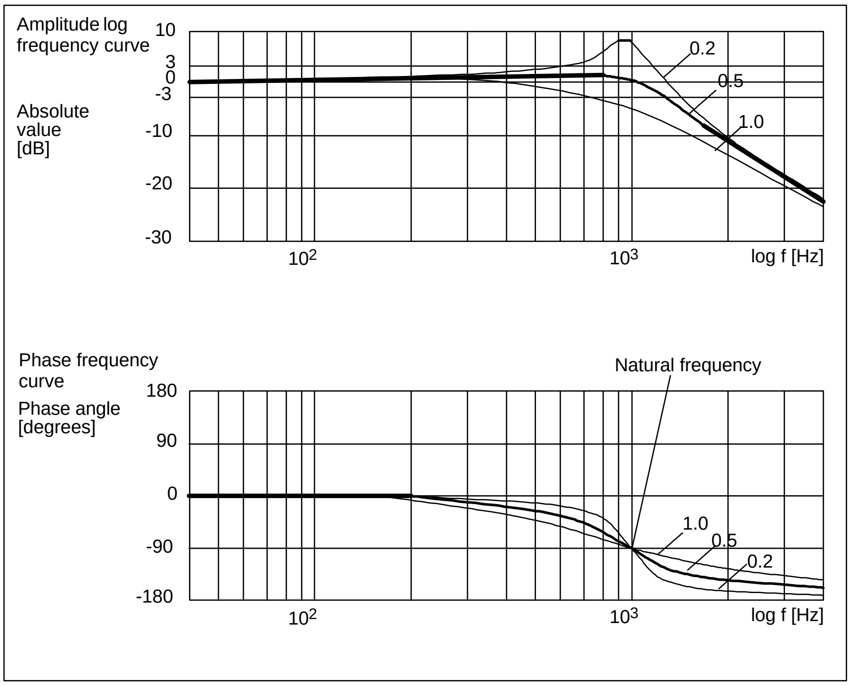


Fig. 4-5 Low-pass filter (PT2) operation at natural frequency (MD 5506) of 1000 Hz and variations in damping (MD 5507) of 0.2, 0.5 and 1.0

5514	**SPEED_FILTER_1_SUPPR_FREQ** [n] 0...7 index of the parameter set				**Cross reference: -**
	Band-stop filter blocking frequency for velocity filter 1			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 3500.0	Minimum: 10.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately

5515	**SPEED_FILTER_1_BANDWIDTH** [n] 0...7 index of the parameter set				**Cross reference: -**
	Band-stop filter bandwidth for velocity filter 1			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 500.0	Minimum: 5.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately

Note

The bandwidth must be less than or equal to 2 x MD 5514 x MD 5520.

5516	**SPEED_FILTER_1_BW_NUMERATOR** [n] 0...7 index of the parameter set				**Cross reference: -**
	Bandwidth numerator of velocity filter 1			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 0.0	Minimum: 0.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately

Note

Setting a value of 0 (MD 5516) initializes the filter as an undamped band-stop.

The value set in MD 5516 must not exceed twice the value set in MD 5515.

5520	**SPEED_FILTER_1_BS_FREQ** [n] 0...7 index of the parameter set				**Cross reference: -**
	Band-stop filter natural frequency for velocity filter 1			Related to: HLA	Protection level: 3/3
Unit: %	Default: 100.0	Minimum: 1.0	Maximum: 141.0	Data type: FLOAT	Active: Immediately

The natural frequency for the general band-stop is set in MD 5520 as a percentage of MD 5514 (blocking frequency).

Note

Setting MD 5520=100% initializes the filter as an undamped band-stop.

The natural frequency in Hz of the filter must be less than the reciprocal of two velocity controller cycles
(MD 5520 · 0.01 · MD 5514<1/(2 · MD 5001 · 31.25 µs).

5522	**ACT_SPEED_FILTER_TIME**				**Cross reference: -**
	Time constant for actual velocity filter 1			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 0	Minimum: 0	Maximum: 0	Data type: UNS.WORD	Active: Power On

Note

MD 5522 performs no function and is only compatible with the electric drives.

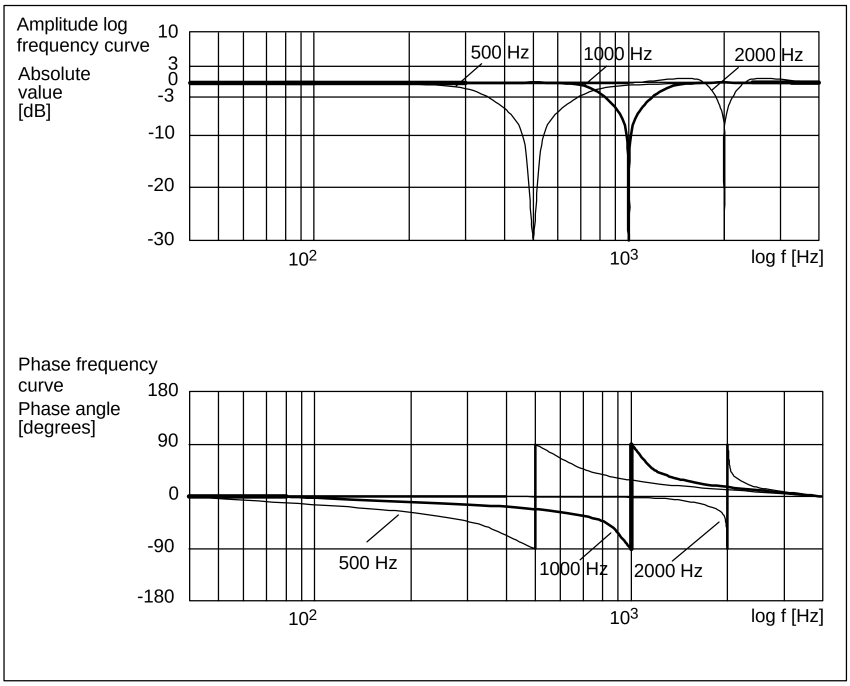


Fig. 4-6 Frequency response of undamped band-stop with a bandwidth of 500 Hz and variations in blocking frequency (MD 5514) of 500 Hz, 1000 Hz, 2000 Hz

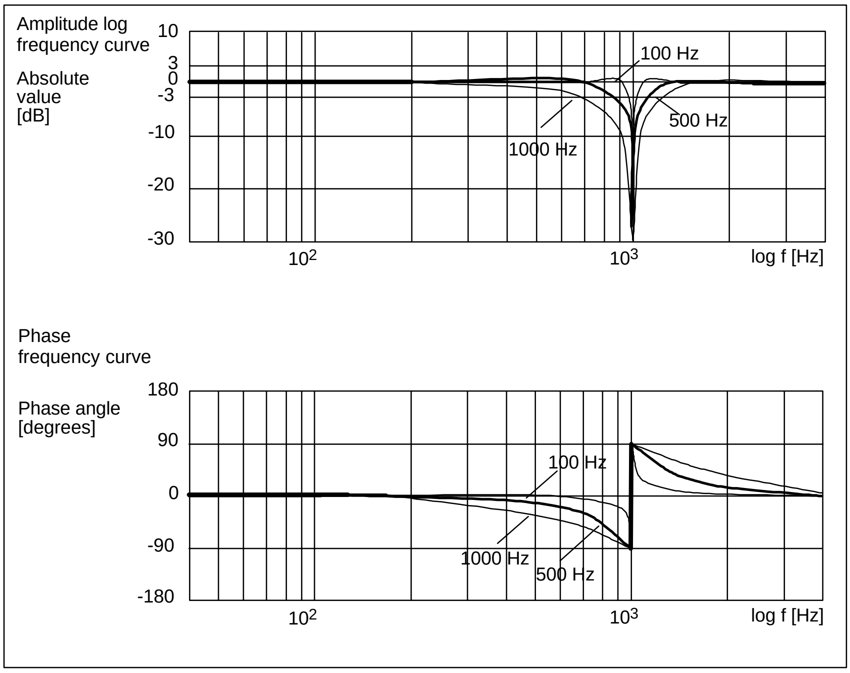


Fig. 4-7 Frequency response of undamped band-stop at a blocking frequency of 1000 Hz and variations in bandwidth (MD 5515) of 100 Hz, 500 Hz, 1000 Hz.
The bandwidth is the difference between the two frequencies with 3 dB drop in amplitude.

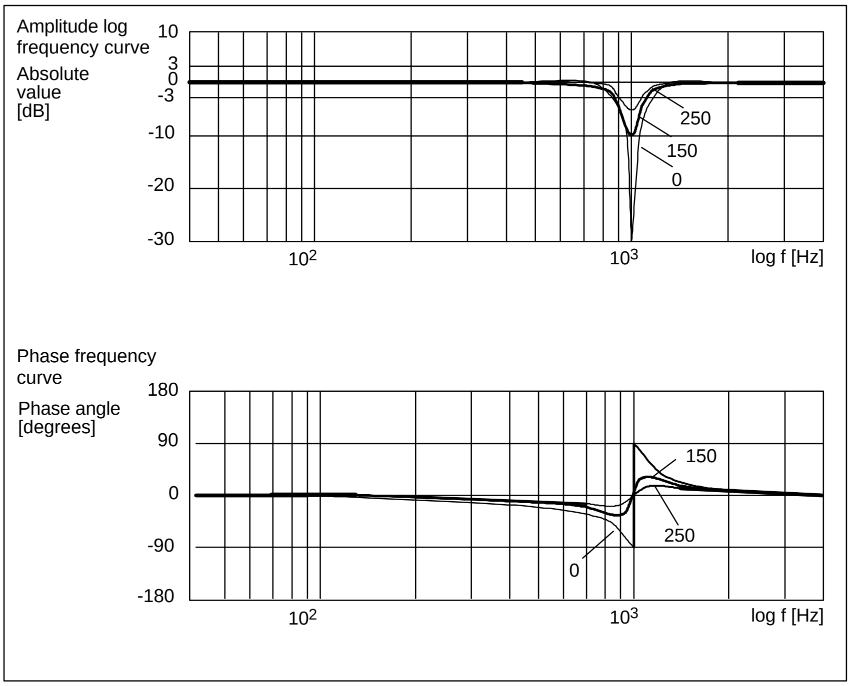


Fig. 4-8 Band-stop behavior with bandwidth of 500 Hz, blocking frequency of 1000 Hz and variation in numerator bandwidth (MD 5516) of 0, 150 and 250 Hz.

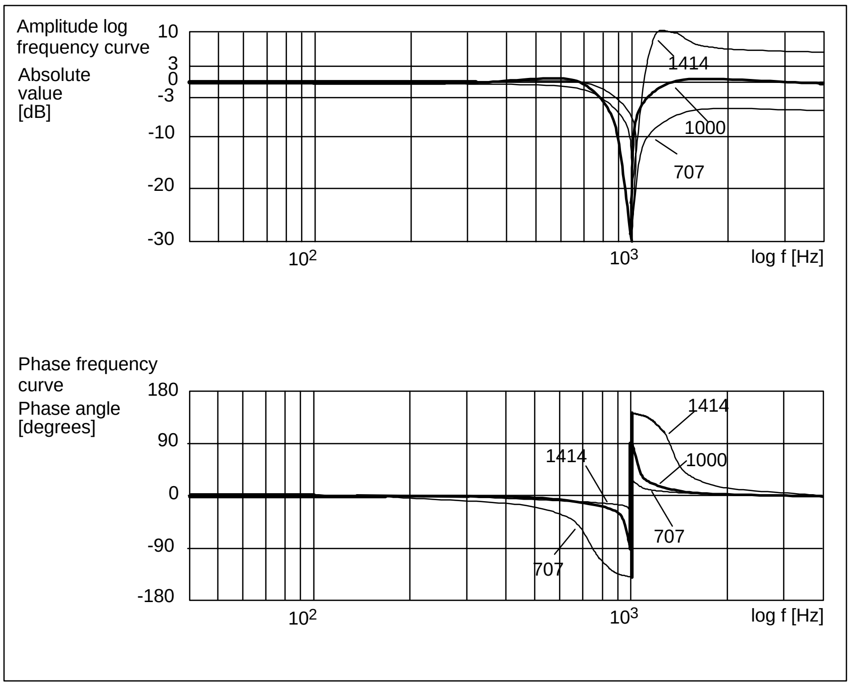


Fig. 4-9 Frequency response of general band-stop at a blocking frequency of fz=1000 Hz, bandwidth fBn=500 Hz, numerator bandwidth fBz=0 Hz and variation in natural frequency of (MD 5520) fn=70.7%, 1000% and 141.4%

Velocity setpoint limitation

The velocity setpoint is limited in the positive and negative directions.

Note

The maximum rapid traverse velocity of the drive (G0 function) is determined by NC machine parameter 32000.

5420	DRIVE_MAX_SPEED_SETUP				Cross reference: -
	Max. velocity for setup mode			Related to: HLA	Protection level: 3/3
Unit: mm/min	Default: 10.0	Minimum: 0.0	Maximum: 120 000.0	Data type: FLOAT	Active: Immediately
5440	**POS_DRIVE_SPEED_LIMIT**				**Cross reference: -**
	Positive velocity setpoint limit			Related to: HLA	Protection level: 3/3
Unit: mm/min	Default: 0.0	Minimum: 0.0	Maximum: 120 000.0	Data type: FLOAT	Active: Immediately
5441	**NEG_DRIVE_SPEED_LIMIT**				**Cross reference: -**
	Negative velocity setpoint limit			Related to: HLA	Protection level: 3/3
Unit: mm/min	Default: 0.0	Minimum: 0.0	Maximum: 120000.0	Data type: FLOAT	Active: Immediately

With a differential cylinder, the physically possible velocities for piston travel-out and travel-in are asymmetrical. For this reason, it is advisable to set asymmetrical limitations. A message is sent to the PLC if the limit is violated.

If setup mode is selected, then the velocity setpoint is set to the value in MD 5420 for both directions. The velocity setpoint limitation is calculated as part of the “Calculate drive model data” operation and
MD 5440 and MD 5441 are preset accordingly.

Acceleration limitation

To protect mechanical components against excessive wear and damage, the drive acceleration setpoints can be limited **by the NC**. Linear interpolation of the velocity setpoints (see MD 5004: CTRL_CONFIG, bit 12; velocity setpoint interpolation) ensures that the drive accelerates at the rate specified by the control. A function for limiting the acceleration in the drive has **not** been implemented. (A braking ramp is operative only if the velocity controller is disabled, see MD 5402: SPEED_CTRL_DISABLE_STOPTIME).

Servo gain

The controlled system gain is entered in MD 5435 after “Calculate drive model data” and should not be altered unless it is incorrect. The value in MD 5435 is the reference for the P gain of the velocity controller.

5435	**CONTROLLED_SYSTEM_GAIN** [n] 0...7 index of the parameter set				Cross reference: -
	Controlled system gain			Related to: HLA	Protection level: 3/3
Unit: mm/Vmin	Default: 0.0	Minimum: 0.0	Maximum: 20000.0	Data type: FLOAT	Active: Immediately

Friction

5460	FRICTION_COMP_GRADIENT				Cross reference: -
	Gradient of friction compensation characteristic			Related to: HLA	Protection level: 3/3
Unit: %	Default: 0.0	Minimum: 0.0	Maximum: 400.0	Data type: FLOAT	Active: Immediately
5461	**FRICTION_COMP_OUTPUT_RANGE**				**Cross reference: -**
	Effective range of friction compensation (at output)			Related to: HLA	Protection level: 3/3
Unit: %	Default: 0.1	Minimum: 0.1	Maximum: 10.0	Data type: FLOAT	Active: Immediately

In order to reduce the effects of friction, the characteristic gradient is made steeper around the zero point in the flow rate feedforward control path (see Fig. 4-2). The differential pressure is thus boosted with the velocity setpoint sign. Fig. 4-10 shows an example of this characteristic and the way that the associated machine data works (see also Subsection 2.3.1 and Appendix A).

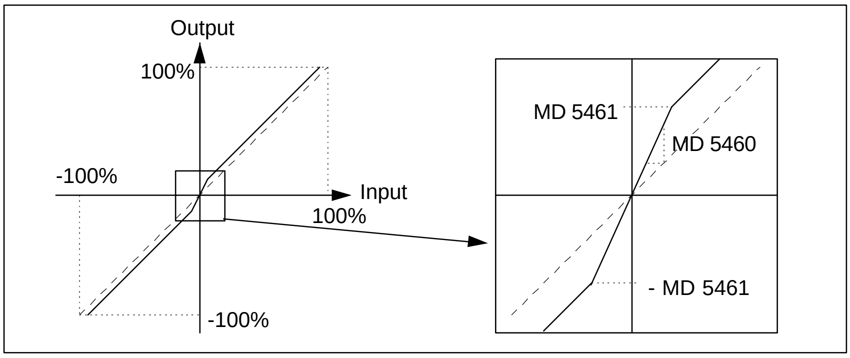


Fig. 4-10 Friction compensation characteristic; see also static friction injection in Subsection 4.4.2.

4.3.2 Velocity controller

Velocity controller cycle

Sampling time with which the velocity control loop is calculated.

5001	SPEEDCTRL_CYCLE_TIME				Cross reference: -
	Velocity controller cycle			Related to: HLA	Protection level: 3/3
Unit: 31.25 µs	Default: 4	Minimum: 2	Maximum: 16	Data type: UNS.WORD	Active: Power On

- Short cycle: Good dynamic response, but measurement noise from actual velocity increases.
- Long cycle: Poor dynamic response, actual velocity values are not noisy

Recommended setting:
Increase cycle time for measuring system with wide scale graduations or large derivative action time of D component.

Adaptation of P and D components

Adaptation of the P and D components is recommended where the natural frequency of the servo solenoid valve is higher than that of the drive.

5413	**SPEEDCTRL_ADAPT_ENABLE**				**Cross reference: -**
Selection of velocity controller adaptation				Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 1	Data type: UNS.WORD	Active: Immediately

Requirement: Adaptation can only be selected following zero calibration of cylinder piston, see Subsection 3.9.4.

With MD 5413: SPEEDCTRL_ADAPT_ENABLE can be used to activate (bit 0=1)/deactivate (bit 0=0) adaptation. If adaptation is deactivated, MD 5407 applies: SPEEDCTRL_GAIN and MD 5430: SPEEDCTRL_PT1_TIME apply.

- Adaptation ON (see Fig. 4-11)

  With MD 5406: SPEEDCTRL_GAIN_A and MD 5408:
  SPEEDCTRL_GAIN_B are programmed to define the P gain and MD 5431:
  SPEEDCTRL_DIFF_TIME_A,
  MD 5433: SPEEDCTRL_DIFF_TIME_B to define the derivative-action time (D component)
  at the A and B ends of the cylinder.

  MD 5407: SPEEDCTRL_GAIN and MD 5432: SPEEDCTRL_DIFF_TIME act on the position set in MD 5160: PISTON_POS_MIN_NAT_FREQ.

- Adaptation OFF

  MD 5407: SPEEDCTRL_GAIN and MD 5432: SPEEDCTRL_DIFF_TIME are active over the entire range,

The natural frequency of the drive varies as a function of distance. Extreme values occur at the two limits and in the approximate center (MD 5160) of the traversing range. It may therefore be useful to adapt the velocity controller position (P and D components), with the extreme range limits specified as interpolation points.

The adaptation function can be activated or deactivated.

If the piston zero has not been calibrated, the adaptation will not be operative, even if it is activated.

When adaptation is active, the P gain and D-action component of the velocity controller are interpolated linearly between two points.

“Calculate controller data” alters the settings for the controllers and the adaptation selection.

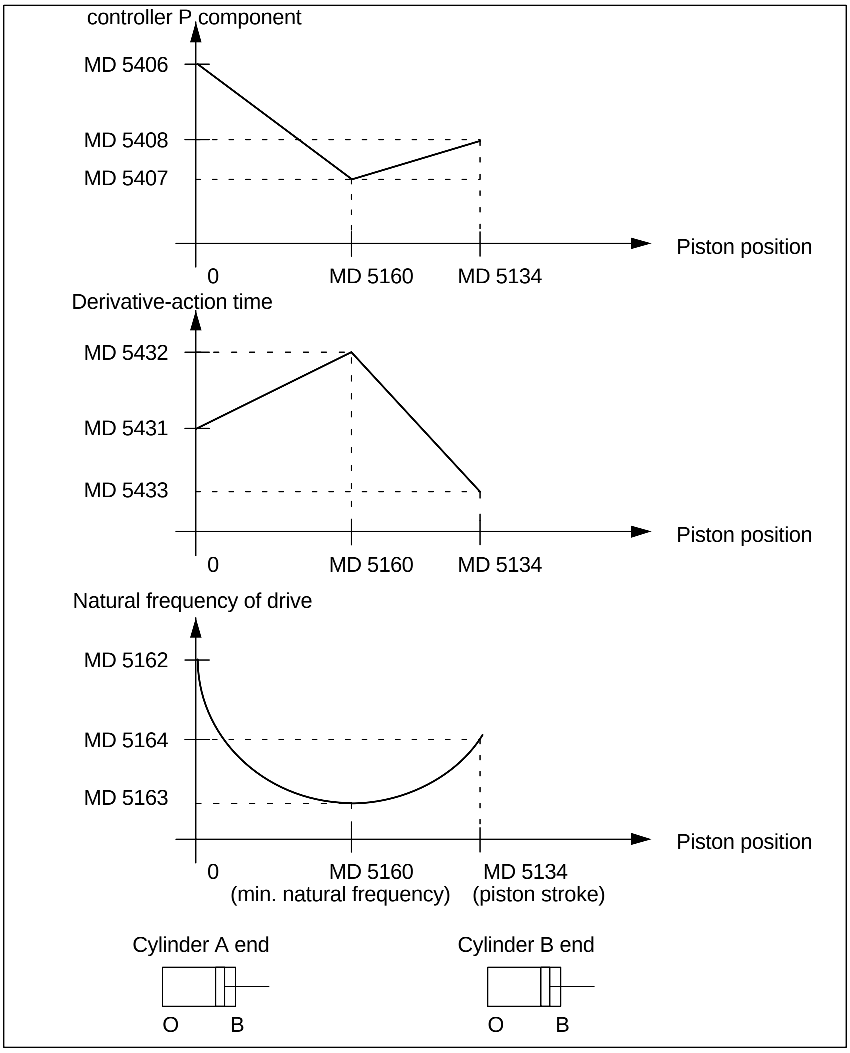


Fig. 4-11 Deactivate adaptation

P component

5406	**SPEEDCTRL_GAIN_A** [n] 0...7 index of the parameter set				**Cross reference: -**
	P gain of velocity controller A			Related to: HLA	Protection level: 3/3
Unit: %	Default: 0.0	Minimum: -100.0	Maximum: 1000.0	Data type: FLOAT	Active: Immediately
5407	**SPEEDCTRL_GAIN** [n] 0...7 index of the parameter set				**Cross reference: -**
	P gain of velocity controller			Related to: HLA	Protection level: 3/3
Unit: %	Default: 0.0	Minimum: -100.0	Maximum: 1000.0	Data type: FLOAT	Active: Immediately
5408	**SPEEDCTRL_GAIN_B** [n] 0...7 index of the parameter set				**Cross reference: -**
	P gain of velocity controller B			Related to: HLA	Protection level: 3/3
Unit: %	Default: 0.0	Minimum: -100.0	Maximum: 1000.0	Data type: FLOAT	Active: Immediately

A negative P gain setting may be useful for oscillation damping. Negative gain settings are permissible. The gain is specified in relation to the drive servo gain setting. 100% means that if the distance-to-go is equal to the maximum speed (MD 5440: POS_DRIVE_SPEED_LIMIT, MD 5441: NEG_DRIVE_SPEED_LIMIT), the full nominal valve voltage will be output as the P component.

The P gain set in MD 5407 SPEEDCTRL_GAIN is referred to the controlled system gain set in MD 5435: CONTROLLED_SYSTEM_GAIN.

I component

5409	**SPEEDCTRL_INTEGRATOR_TIME** [n] 0...7 index of the parameter set				**Cross reference: -**
Reset time of velocity controller				Related to: HLA	Protection level: 3/3
Unit: ms	Default: 50.0	Minimum: 0.0	Maximum: 2000.0	Data type: FLOAT	Active: Immediately

The integral-action component can be deactivated by setting the reset time to zero. For a negative P gain setting, the reset time is interpreted as a negative value so that the compensation always acts as negative feedback.

The integrator can be activated/deactivated via the PLC. The current status is returned to the PLC.

Integrator feedback

5421	**SPEEDCTRL_INTEGRATOR_FEEDBK** [n] 0...7 index of the parameter set				**Cross reference: -**
Time constant of integrator feedback				Related to: HLA	Protection level: 3/3
Unit: ms	Default: 0.0	Minimum: 0.0	Maximum: 1000.0	Data type: FLOAT	Active: Immediately

The integrator of the velocity controller loop is reduced to a 1st order low-pass action with the configured time constant via a weighted feedback.

- **Effect:**
  The output of the velocity controller integrator is limited to a value proportional to the difference between setpoint and actual values (steady-state proportional action).
- **Applications:**
  Machining motions for position setpoint zero and dominant static friction can be suppressed but result in a permanent distance-to-go, e.g. oscillation of the position-controlled axis at zero speed (stick-slip effect) or overshooting in the µm-step method.
- **Setting notes:**
  Optimize this data starting from a high value until you find the best compromise.

If the time constant integrator feedback ≤ 1 ms is set, feedback is disabled.

Integrator feedback threshold

Velocity below which the integrator feedback takes effect.

5422	**FEEDBK_SPEED_THRESHOLD**				**Cross reference: -**
	Velocity threshold for integrator feedback			Related to: HLA	Protection level: 3/3
Unit: mm/min	Default: 10.0	Minimum: 0.0	Maximum: 120000.0	Data type: FLOAT	Active: Immediately

The integrator feedback function is mainly used when static friction problems are encountered, i.e. so as to suppress undesirable movements caused by static friction (slip-stick effect) in position-controlled operation and at zero speed.

MD 5422 can be set to ensure that the integrator feedback is activated only for low velocity setpoints and stabilizes the axis at zero speed. At high velocities, however, the effect of the I component is not restricted.

D component (acceleration feedback)

A derivative-action component (acceleration feedback) is implemented in the controller in addition to the P component. This derivative-action component is located in the feedback branch. It is set via the derivative-action time. It may be a negative or positive setting. No D component is active if the D-action time is set to zero.

5430	**SPEEDCTRL_PT1_TIME**[n] 0...7 index of the parameter set				**Cross reference: -**
	Velocity controller smoothing time constant			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 0.25	Minimum: 0.25	Maximum: 100.0	Data type: FLOAT	Active: Immediately
5431	**SPEEDCTRL_DIFF_TIME_A**[n] 0...7 index of the parameter set				**Cross reference: -**
	Derivative-action time of velocity controller A (D component)			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 0.0	Minimum: -100.0	Maximum: 100.0	Data type: FLOAT	Active: Immediately
5432	**SPEEDCTRL_DIFF_TIME**[n] 0...7 index of the parameter set				**Cross reference: -**
	Derivative-action time of velocity controller (D component)			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 0.0	Minimum: -100.0	Maximum: 100.0	Data type: FLOAT	Active: Immediately
5433	**SPEEDCTRL_DIFF_TIME_B**[n] 0...7 index of the parameter set				**Cross reference: -**
	Derivative-action time of velocity controller B (D component)			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 0.0	Minimum: -100.0	Maximum: 100.0	Data type: FLOAT	Active: Immediately

Similar to the P component setting, it is possible to set a D component at the A and B ends of the cylinder.

Since precise differentiation is not possible, an additional denominator component must be provided. This component is set by means of a smoothing time constant (MD 5430: SPEEDCTRL_PT1_TIME). If the D component is deactivated, then the smoothing constant also ceases to function.

Reference model

5414	**SPEEDCTRL_REF_MODEL_FREQ** [n] 0...7 index of the parameter set				**Cross reference: -**
	Natural frequency of reference model			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 150.0	Minimum: 0.0	Maximum: 1000.0	Data type: FLOAT	Active: Immediately
5415	**SPEEDCTRL_REF_MODEL_DAMPING** [n] 0...7 index of the parameter set				**Cross reference: -**
	Reference model damping			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0.9	Minimum: 0.4	Maximum: 1.0	Data type: FLOAT	Active: Immediately

The dynamic response of the velocity control loop to control commands without an I component in the velocity controller is simulated in the reference model. In the ideal case of exact simulation, there is no deviation after the setpoint/actual value comparison on the integrator under no-load conditions. In practice, velocity overshoots in the response to control commands can be reduced in this way.

The reference model is defined by setting the natural frequency (MD5414) and damping (MD 5415) parameters.

Control output, velocity controller

Two control output filters have been implemented. As compared to the current setpoint filter on electrical drives, the scope of functions has been extended by the general band stop.

5200	**NUM_OUTPUT_VCTRL_FILTERS** [n] 0...7 index of the parameter set				**Cross reference: -**
	Number of control output filters in velocity controller			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 2	Data type: UNS.WORD	Active: Immediately

The number of control output filters in the velocity controller is set in MD 5200. No filters are active by default. Bandstop filters and 2nd-order low pass filters can be selected and set in MD 5201: OUTPUT_FILTER_CONFIG.

Table 4-1 Selection of number of control output filters in velocity controller

0	No control output filter active
1	Filter 1 active
2	Filters 1 and 2 active

Enter the configuration for 2 control output filters. Bandstops (BS) and low-pass filters can be selected. The variable filter parameters are entered in the associated machine data.

Note

The filter machine data must be assigned before the filter type is configured.

5201	**OUTPUT_VCTRL_FILTER_CONFIG** [n] 0...7 index of the parameter set				**Cross reference: -**
Control output filter type in velocity controller				Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 3	Data type: UNS.WORD	Active: Immediately

Table 4-2 Control output filter type in velocity controller

1st filter	Bit 0	0	Low-pass (see MD 5202/5203)
		1	Bandstop filter (refer to MD 5210/5211/5212)
2nd filter	Bit 1	0	Low-pass (see MD 5204/5205)
		1	Bandstop filter (refer to MD 5213/5214/5215)

Table 4-3 Filter combinations

Filter 2	Filter 1	MD 5201: OUTPUT_VCTRL_FILTER_CONFIG
PT2	PT2	0
PT2	BS	1
BS	PT2	2
BS	BS	3

5202	**OUTPUT_VCTRL_FIL_1_FREQ**[n] 0...7 index of the parameter set				**Cross reference: -**
Natural frequency output filter 1 velocity controller				Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 1000.0	Minimum: 10.0	Maximum: 8000.0	Data type: FLOAT	Active: Immediately
5204	**OUTPUT_VCTRL_FIL_2_FREQ**[n] 0...7 index of the parameter set				**Cross reference: -**
Natural frequency output filter 2 velocity controller				Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 1000.0	Minimum: 10.0	Maximum: 8000.0	Data type: FLOAT	Active: Immediately

The filter key data is defined in MD 5202 to MD 5205 and MD 5210 to MD 5215.

Enter the natural frequency for control output filters 1...2 (PT2 low-pass) in the velocity controller.
The filters are activated in MD 5200: NUM_OUTPUT_VCTRL_FILTERS and MD 5201: OUTPUT_VCTRL_FILTER_CONFIG.

5203	**OUTPUT_VCTRL_FIL_1_DAMP**[n] 0...7 index of the parameter set				**Cross reference: -**
	Damping control output filter 1 velocity controller			Related to: HLA	Protection level: 3/3
Unit: -	Default: 1.0	Minimum: 0.05	Maximum: 1.0	Data type: FLOAT	Active: Immediately
5205	**OUTPUT_VCTRL_FIL_2_DAMP**[n] 0...7 index of the parameter set				**Cross reference: -**
	Damping control output filter 2 velocity controller			Related to: HLA	Protection level: 3/3
Unit: -	Default: 1.0	Minimum: 0.05	Maximum: 1.0	Data type: FLOAT	Active: Immediately

Enter the damping for control output filters 1...2 (PT2 low-pass) in the velocity controller. The filters are activated in MD 5200: NUM_OUTPUT_VCTRL_FILTERS and MD 5201: OUTPUT_VCTRL_FILTER_CONFIG.

5210	**OUTPUT_VCTRL_FIL_1_SUP_FREQ**[n] 0...7 index of the parameter set				**Cross reference: -**
	Blocking frequency output filter 1 velocity controller			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 3500.0	Minimum: 1.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately
5213	**OUTPUT_VCRTL_FIL_2_SUP_FREQ**[n] 0...7 index of the parameter set				**Cross reference: -**
	Blocking frequency output filter 2 velocity controller			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 3500.0	Minimum: 1.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately

Enter the blocking frequency for control output filters 1...2 (bandstop) in the velocity controller. The filters are activated in MD 5200: NUM_OUTPUT_VCTRL_FILTERS and MD 5201: OUTPUT_VCTRL_FILTER_CONFIG.

5211	**OUTPUT_VCTRL_FIL_1_BW**[n] 0...7 index of the parameter set				**Cross reference: -**
	Bandwidth control output filter 1 velocity controller			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 500.0	Minimum: 5.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately
5214	**OUTPUT_VCTRL_FIL_2_BW**[n] 0...7 index of the parameter set				**Cross reference: -**
	Bandwidth control output filter 2 velocity controller			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 500.0	Minimum: 5.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately

Enter the -3dB bandwidth for control output filters 1...2 (bandstop filter) in the velocity controller.

The filters are activated in MD 5200: NUM_OUTPUT_VCTRL_FILTERS and MD 5201: OUTPUT_VCTRL_FILTER_CONFIG.

5212	**OUTPUT_VCTRL_FIL_1_BW_NUM** [n] 0...7 index of the parameter set				**Cross reference: -**
Numerator bandwidth output filter 1 velocity controller				Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 0.0	Minimum: 0.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately
5215	**OUTPUT_VCTRL_FIL_2_BW_NUM** [n] 0...7 index of the parameter set				**Cross reference: -**
Numerator bandwidth output filter 2 velocity controller				Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 0.0	Minimum: 0.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately

Enter the numerator bandwidth for control output filters 1...2 (damped bandstop) in the velocity controller. Entering a value of 0 initializes the filter as an unattenuated bandstop filter.

The filters are activated in MD 5200: NUM_OUTPUT_VCTRL_FILTERS and MD 5201: OUTPUT_VCTRL_FILTER_CONFIG.

4.3.3 Dynamic stiffness control (DSC)

DSC

The DSC (dynamic stiffness control) function is supported, allowing higher P gain settings in the position controller. The function is implemented in the same way as on an electrical drive. It is also activated via the control system (as on an electrical drive).

4.4 Closed-loop force control

Requirements

- Pressure sensors must be installed
- Force limitation and/or static friction injection activated (MD 5241: FORCECTRL_CONFIG)
- Piston position must have been calibrated (see Subsection 3.9.4)

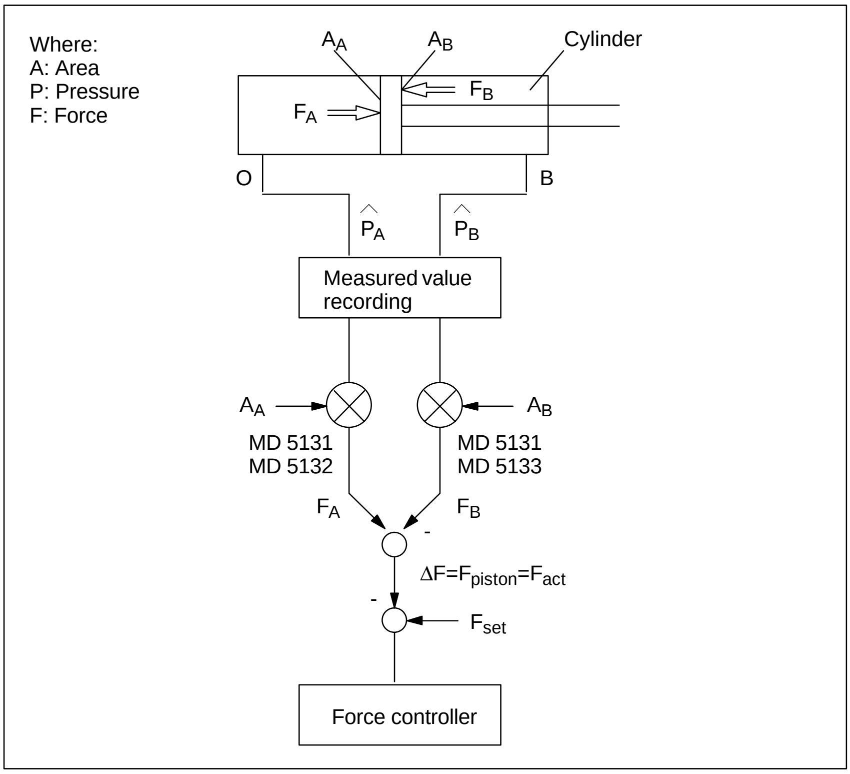


Fig. 4-12 Actual force measurement sensing

Starting up the force controller

To start up the force controller, the measuring functions and function generator can be redirected from the velocity controller to the force controller by setting bit 8 in MD 5650. In this setting, velocity setpoints are interpreted as force setpoints in units of kN. This mode is deactivated by clearing MD 5650, bit 8 (mm/min $\rightarrow$ kN).

Force limitation

Force limitation is required

- in certain machining processes for which the “Travel to fixed stop” function must be implemented or
- to work material in the machining of force profiles.

Static friction compensation

This compensation function is needed to compensate the effects of static friction occurring when the traversing direction changes (reduction of contour errors, see e.g. circularity test).

Force controller configuration

Enter configuration for force controller:

5241	**FORCECTRL_CONFIG** [n] 0...7 index of the parameter set				Cross reference: -
	Force controller configuration Bit 0= 0: Force limitation 1 from 1: Force limitation 1 ON Bit 1= 0: Static friction injection OFF 1: Static friction injection ON Bit 2= 0: Force limitation 2 OFF 1: Force limitation 2 ON			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: 6	Data type: UNS.WORD	Active: Immediately

If a pressure sensor is installed and connected for the pressures at A and B, the force limitation and/or static friction injection functions in MD 5241 can be switched on.

Before the force limitation and/or static friction injection is activated, the associated machine data for force limitation (MD 5230, MD 5231) or friction force (MD 5234, MD 5235) should be set. These data may contain the force of weight values and might not be preset correctly by the defaults.

If the cylinder load changes and the force of weight must be held by the cylinder, then the static friction injection function cannot be utilized, as the values in MD 5234 and MD 5235 vary depending on the load.

- **Static friction injection** (MD 5241 bit 1=1), see Subsection 4.4.2.
- **Force limitation 1** (MD 5241 bit 0=1)

  Force limitation 1 is always effective, even without FFA (NC function “Travel to fixed stop”). The force limit is specified in MD 5230. If FFA is active, the lowest force limitation always takes effect (MD 5230 or MD 37010 or value from FXST[x]). Reference value (100% value) of force limit for NC is MD 5725.

  If the current force limitation is exceeded, the speed controller will remain active, even if FFA has been activated. This may lead to faults if FFA is active. At higher velocities, this can also cause continuous alternation between the force and velocity controller. This mode is therefore only suitable for low velocities (<0.1 · maximum velocity).

- **Force limitation 2** (MD 5241 bit 2=1)

  Force limitation 2 becomes active when the force limit value is exceeded **and** FFA is active. In each case, the lowest force limitation becomes active (MD 5230 or MD 37010 or value from FXST[x]). Reference value (100% value) of force limit for NC is MD 5725.

  Force limitation remains active until the function FFA is deactivated, even if the force has already fallen below the current force limitation.

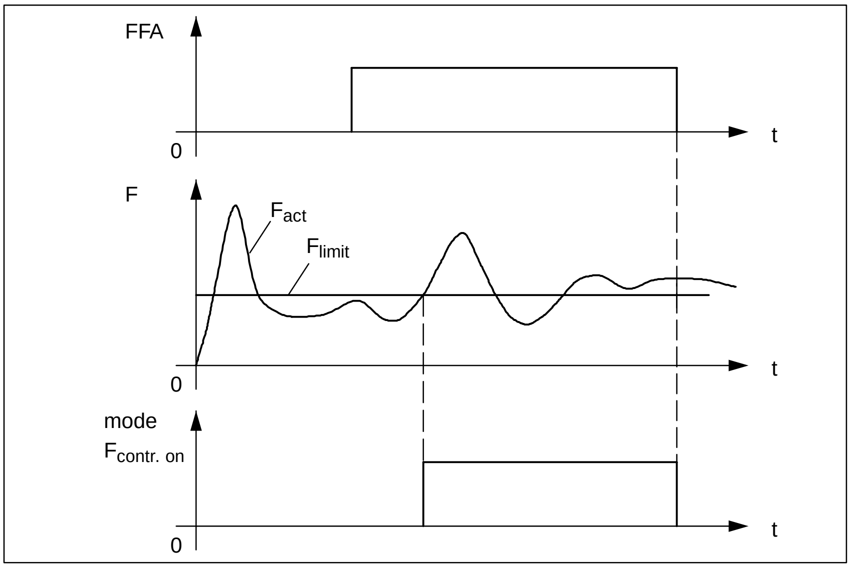


Fig. 4-13 Force limitation 2

Deselection of closed-loop force control by deactivating function “Travel to fixed stop” bit.

4.4.1 Force limitation

Force limitation tolerance band (plus/minus) about force of weight and weight force limitation.

5230	**FORCE_LIMIT_THRESHOLD** [n] 0...7 index of the parameter set				**Cross reference: -**
	Force limitation tolerance threshold about weight			Related to: HLA	Protection level: 3/3
Unit: N	Default: 10000.0	Minimum: 0.0	Maximum: 100000000.0	Data type: FLOAT	Active: Immediately
5231	**FORCE_LIMIT_WEIGHT** [n] 0...7 index of the parameter set				**Cross reference: -**
	Weight force limitation			Related to: HLA	Protection level: 3/3
Unit: N	Default: 0.0	Minimum: -100000000.0	Maximum: 100000000.0	Data type: FLOAT	Active: Immediately

If a pressure sensor is installed and connected for the pressures at A and B, the force limitation in MD 5241 can be activated.

The force controller then ensures that the cylinder force is limited to the relevant values if it is threatening to exceed the value set in MD 5230 plus force of weight (MD 5231) or to drop below the force of weight value (MD 5231) minus the setting in MD 5230.

Since only the cylinder force is measured and regulated, it may be necessary to allow for the force of weight in MD 5231 and the friction force in MD 5230.

An additional force limitation value with the same effect as MD 5230 can be preset by the NC, e.g. when traveling onto a fixed stop. The lower of the two force limitation values is then applied.

4.4.2 Static friction injection

If a pressure sensor is installed and connected for the pressures at A and B, the static friction injection function in MD 5241 can be activated.

Static force injection should not be activated if the cylinder is required to hold a varying force of weight. In addition, the offset of the valve manipulated voltage and the piston position must already have been adjusted. Machine data MD 5232...MD 5235 can be adjusted by means of a circularity test.

Velocity threshold

Velocity below which zero speed and thus static friction is detected.

5232	**STICTION_SPEED_THRESHOLD**				**Cross reference: -**
	Velocity threshold for static friction			Related to: HLA	Protection level: 3/3
Unit: mm/min	Default: 10.0	Minimum: 0.0	Maximum: 500.0	Data type: FLOAT	Active: Immediately

The force controller ensures that the force is limited to the value set in MD 5234 or MD 5235 when the velocity drops below the setting in MD 5232 for as long as the drive is stationary.

Which of the two force setpoints is applied (MD 5234 or MD 5235) is determined by the sign of the velocity setpoint.

Cutoff limit

5233	**STICTION_COMP_THRESHOLD**				**Cross reference: -**
	Cutoff limit static friction			Related to: HLA	Protection level: 3/3
Unit: %	Default: 40.0	Minimum: 3.0	Maximum: 100.0	Data type: FLOAT	Active: Immediately

The force controller is deactivated just before the setpoint is reached via the cutoff limit (MD 5233) to prevent overshoots occurring during servo solenoid valve actuation.

If MD 5233 is set to 100%, then the force controller is not switched off until the force setpoint (MD 5234 or MD 5235) is reached or unless the drive moves beforehand. This setting results in overshoots in the actual velocity value.

Cylinder friction force

The cylinder friction force at a positive or negative velocity is set in MD 5234 and 5235 respectively.

5234	STICTION_FORCE_POS				Cross reference: -
	Friction force at velocity > 0			Related to: HLA	Protection level: 3/3
Unit: N	Default: 100.0	Minimum: -100000000.0	Maximum: 100000000.0	Data type: FLOAT	Active: Immediately

Allowance must be made for the force of weight applied to the cylinder in MD 5234 (e.g. with a cylinder mounting position other than 0 degrees, MD 5151). The value to be set can be read in MD 5708 when the cylinder is moved slowly (e.g. in JOG mode) in the **positive** direction.

If the force of weight applied to the cylinder varies as a function of load, then static force injection cannot be utilized.

5235	STICTION_FORCE_NEG				Cross reference: -
	Friction force at velocity < 0			Related to: HLA	Protection level: 3/3
Unit: N	Default: -100.0	Minimum: -100000000.0	Maximum: 100000000.0	Data type: FLOAT	Active: Immediately

Allowance must be made for the force of weight applied to the cylinder in MD 5235 (e.g. with a cylinder mounting position other than 0 degrees, MD 5151). The value to be set can be read in MD 5708 when the cylinder is moved slowly (e.g. in JOG mode) in the **negative** direction.

If the force of weight applied to the cylinder varies as a function of load, then static force injection cannot be utilized.

4.4.3 Force controller

Feedforward control gain of force controller

Factor for setting the feedforward control gain in the force controller.

5247	FORCE_FFW_WEIGHT				Cross reference: -
	Feedforward control factor for force controller			Related to: HLA	Protection level: 3/3
Unit: %	Default: 100.0	Minimum: 0.0	Maximum: 120.0	Data type: FLOAT	Active: Immediately

Operative only if force limitation or static friction injection is activated in MD 5241.

The more accurate the feedforward control setting, the more effective the force limitation at high velocities.

An excessively high setting can result in continuous switching between force and velocity controllers.

The area adaptation (MD 5462 and MD 5463) and controlled system gain (MD 5435) are taken into account by the feedforward control.

Controlled system gain of force controller

5240	FORCECONTROLLED_SYSTEM_GAIN				Cross reference: -
	Force controlled controlled-system gain			Related to: HLA	Protection level: 3/3
Unit: N/V	Default: 0.0	Minimum: 0.0	Maximum: 1000000000.0	Data type: FLOAT	Active: Immediately

MD 5240 contains the controlled system proportional gain for the force control loop.

Since the force control loop has an integral action, a unit integrator (I-action time of 1 second) was subtracted from the controlled system to calculate the gain.

MD 5240 is preset by the “Calculate drive model data” routine.

The controlled system gain depends on the volume of oil in the cylinder and the nominal volumetric flow of the servo solenoid valve. The value should not generally be altered.

The value in MD 5240 is the reference for the P gain of the force controller.

MD 5240 makes allowance for the effects of geometric dimensions.

The effect of the valve dynamic response is taken into account in MD 5242, which means that the same gain value can always be set for an identical valve dynamic response on different cylinders.

P component of force controller

5242	**FORCECTRL_GAIN** [n] 0...7 index of the parameter set				Cross reference: -
	Force controller P gain			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0.0	Minimum: 0.0	Maximum: 10000.0	Data type: FLOAT	Active: Immediately

If force limitation and/or static friction injection is activated in MD 5241, the P gain of the force controller is entered in this machine data.

The P gain reference is MD 5240, which contains a value representing the effects of the geometric dimensions.

The effect of the valve dynamic response is taken into account in MD 5242, which means that the same gain value can always be set for an identical valve dynamic response on different cylinders.

5243	FORCECTRL_GAIN_RED				Cross reference: -
	Reduction of force controller P gain			Related to: HLA	Protection level: 3/3
Unit: %	Default: 40.0	Minimum: 0.1	Maximum: 100.0	Data type: FLOAT	Active: Immediately

If force limitation and/or static friction injection are activated in MD 5241, the reduction in the force controller P gain in response to large setpoint/actual value deviations (large-signal operation) is entered in MD 5243. The P component of the force controller must be reduced since the dynamic limitations of the actuator in large-signal operation also reduce the potential dynamic response of the control loop.

Small-signal operation is set in MD 5242.

The factor in MD 5243 specifies as a percentage the value to which a P component of 10 V is reduced.

I component of force controller

5244	**FORCECTRL_INTEGRATOR_TIME** [n] 0...7 index of the parameter set				**Cross reference: -**
	Force controller reset time			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 40.0	Minimum: 0.0	Maximum: 2000.0	Data type: FLOAT	Active: Immediately

If force limitation and/or static friction injection is activated in MD 5241, the reset time of the force controller is entered in this machine data.

Enter a value of 0 for the reset time deactivates the I-action component.

D component of force controller

5245	**FORCECTRL_PT1_TIME** [n] 0...7 index of the parameter set				**Cross reference: -**
	Force controller smoothing time constant			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 0.5	Minimum: 0.25	Maximum: 100.0	Data type: FLOAT	Active: Immediately
5246	**FORCECTRL_DIFF_TIME** [n] 0...7 index of the parameter set				**Cross reference: -**
	Force controller D-action time			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 0.0	Minimum: -10000.0	Maximum: 10000.0	Data type: FLOAT	Active: Immediately

If force limitation and/or static friction injection is activated in MD 5241, a smoothing time constant of the force controller for derivative action is set in MD 5245 and, in addition to the force controller P component (MD 5242), a D-action component (jerk feedback) in MD 5246.

If the D-action component of the force controller is deactivated (MD 5246), then the smoothing function (MD 5245) is also rendered inoperative.

The D-action time setting (MD 5246) can be negative or positive. No D component is active if the D-action time is set to zero.

Feedforward control filter for force controller

5260	**NUM_FFW_FCTRL_FILTERS** [n] 0...7 index of the parameter set				**Cross reference: -**
	No. of force controller feedforward control filters			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 1	Data type: UNS.WORD	Active: Immediately

The number of feedforward control filters in the force controller are entered in this machine data.

Table 4-4 Selection of number of feedforward control filters

0	No feedforward control filter active (default)
1	Filter(s) activated

Note

The filter machine data must be assigned before the filter type is configured.

5261	**FFW_FCTRL_FILTER_TYPE** [n] 0...7 index of the parameter set				**Cross reference: -**
	Type of feedforward control filter in force controller			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 1	Data type: UNS.WORD	Active: Immediately

The type of feedforward control filter in the force controller is entered in this machine data.

Table 4-5 Type of feedforward control filter

Bit 0	0	Low-pass (see MD 5264/5265)
	1	Bandstop filter (refer to MD 5268/5269/5270)

5264	**FFW_FCTRL_FIL_1_FREQ** [n] 0...7 index of the parameter set				**Cross reference: -**
	PT2 natur. freq. feedforward control filter1			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 2000.0	Minimum: 10.0	Maximum: 8000.0	Data type: FLOAT	Active: Immediately

The filter key data is defined in MD 5264, MD 5265 and MD 5268 to MD 5270.

5265	**FFW_FCTRL_FIL_1_DAMP** [n] 0...7 index of the parameter set				Cross reference: -
	PT2 damping for feedforward control filter 1			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0.7	Minimum: 0.2	Maximum: 1.0	Data type: FLOAT	Active: Immediately

Enter damping for feedforward control filter 1 (PT2 low-pass) in force controller.

5268	**FFW_FCTRL_FIL_1_SUP_FREQ** [n] 0...7 index of the parameter set				Cross reference: -
	Blocking frequency of feedforward control filter 1			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 3500.0	Minimum: 10.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately

Enter the blocking frequency for feedforward control filter 1 (band-stop) in force controller.

5269	**FFW_FCTRL_FIL_1_BW** [n] 0...7 index of the parameter set				Cross reference: -
	Bandwidth of feedforward control filter 1			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 500.0	Minimum: 5.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately

Enter the -3 dB bandwidth for feedforward control filter 1 (band-stop) in force controller.

5270	**FFW_FCTRL_FIL_1_BW_NUM** [n] 0...7 index of the parameter set				Cross reference: -
	Numerator bandwidth feedforward control filter 1			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 0.0	Minimum: 0.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately

Enter numerator bandwidth for feedforward control filter 1 (damped band-stop) in force controller.

Entering a value of 0 initializes the filter as an unattenuated bandstop filter. The value set in MD 5270 must not exceed twice the value set in MD 5269.

4.5 Manipulated voltage output

4.5.1 Characteristic compensation

Area adaptation

Various non-linear effects of valve or drive can be compensated by means of characteristics. The characteristics are cascaded so that they can be set separately.

5462	**AREA_FACTOR_POS_OUTPUT** [n] 0...7 index of the parameter set				Cross reference: -
	Piston surface adaptation factor, positive			Related to: HLA	Protection level: 3/3
Unit: %	Default: 100.0	Minimum: 50.0	Maximum: 200.0	Data type: FLOAT	Active: Immediately
5463	**AREA_FACTOR_NEG_OUTPUT** [n] 0...7 index of the parameter set				**Cross reference: -**
	Piston surface adaptation factor, negative			Related to: HLA	Protection level: 3/3
Unit: %	Default: 100.0	Minimum: 50.0	Maximum: 200.0	Data type: FLOAT	Active: Immediately

In order to compensate the direction-dependent controlled-system gain on differential cylinders, a characteristic with a gradient that is variable as a function of direction has been implemented. Fig. 4-14 shows a sample characteristic and illustrates how the associated machine data works. In practice, only one of the two gradients is weighted with a factor not equal to 100%. Normally, it is the gradient that causes the cylinder piston to travel out that is weighted with a factor of less than 100% (see also Subsection 2.3.1 and Appendix A).

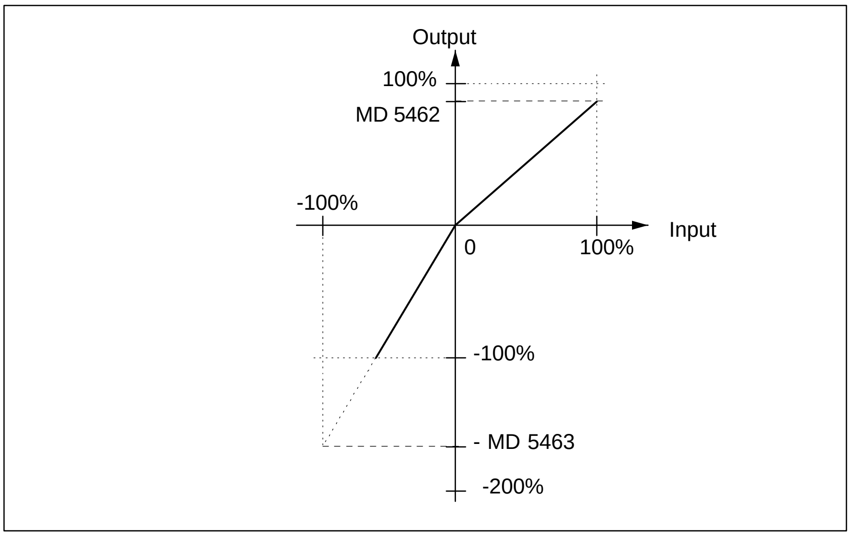


Fig. 4-14 Example of piston surface adaptation characteristic

Linearization of valve

Valves with a fine control range are described in Section 4.7. An inverse characteristic is applied to compensate the nonlinear characteristic of these valves. The breakpoint on real valves is rounded. For this reason, the breakpoint range in the compensation characteristic is also rounded. The rounding is based on a root characteristic in such a way that the intersection points lie on a continuous tangent; the rounding range can be set as required. Fig. 4-15 shows a sample characteristic and illustrates how the associated machine data works.

The knee point is defined by the percentage for input (voltage) and output (flow).

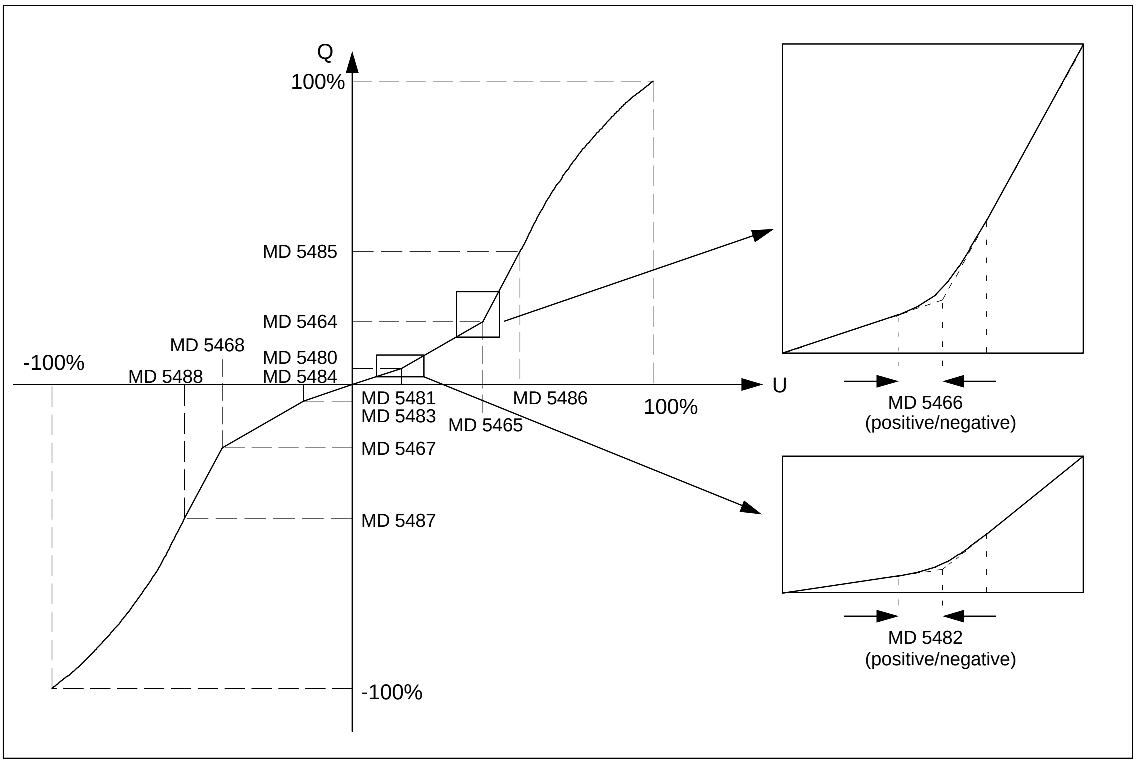


Fig. 4-15 Valve characteristic with breakpoint in zero, fine control and saturation ranges

- **Valve characteristic with breakpoint in zero range**

5480	**POS_DUAL_GAIN_COMP_Z_FLOW**[n] 0...7 index of the parameter set				**Cross reference: -**
	Knee-point compensation pos. flowrate in zero range			Related to: HLA	Protection level: 3/3
Unit: %	Default: 0.01	Minimum: 0.01	Maximum: 95.0	Data type: FLOAT	Active: Immediately
5481	**POS_DUAL_GAIN_COMP_Z_VOLT** [n] 0...7 index of the parameter set				**Cross reference: -**
	Knee-point compensation pos. voltage in zero range			Related to: HLA	Protection level: 3/3
Unit: %	Default: 0.0	Minimum: 0.0	Maximum: 95.0	Data type: FLOAT	Active: Immediately

5482	**DUAL_GAIN_COMP_SMOOTH_Z_R** [n] 0...7 index of the parameter set				Cross reference: -
	Knee-point compensation rounding in zero range			Related to: HLA	Protection level: 3/3
Unit: %	Default: 0.0	Minimum: 0.0	Maximum: 10.0	Data type: FLOAT	Active: Immediately
5483	**NEG_DUAL_GAIN_COMP_Z_FLOW** [n] 0...7 index of the parameter set				**Cross reference: -**
	Knee-point compensation neg. flow in zero range			Related to: HLA	Protection level: 3/3
Unit: %	Default: 0.01	Minimum: 0.01	Maximum: 95.0	Data type: FLOAT	Active: Immediately
5484	**NEG_DUAL_GAIN_COMP_Z_VOLT** [n] 0...7 index of the parameter set				**Cross reference: -**
	Knee-point compensation neg. voltage in zero range			Related to: HLA	Protection level: 3/3
Unit: %	Default: 0.0	Minimum: 0.0	Maximum: 95.0	Data type: FLOAT	Active: Immediately

To calculate the inverse characteristic, a knee-point is defined in the positive zero range of the valve characteristic with MD 5480 and MD 5481 and in the negative zero range with MD 5483 and MD 5484.

The positive and negative valve flows at the knee-point in relation to the nominal flow (MD 5107) are entered in 5483 and MD 5480 respectively.

The valve voltage at the knee-point in relation to the nominal valve voltage (MD 5109) is entered in MD 5481.

When MD 5481 is set to default zero, there is no breakpoint in the positive zero range.

When MD 5484 is set to default zero, there is no breakpoint in the negative zero range.

The rounding range is parameterized in MD 5482.

- **Valve characteristic with breakpoint in fine control range**

5464	**POS_DUAL_GAIN_COMP_FLOW** [n] 0...7 index of the parameter set				Cross reference: -
	Knee-point compensation pos. flow			Related to: HLA	Protection level: 3/3
Unit: %	Default: 10.0	Minimum: 0.2	Maximum: 95.0	Data type: FLOAT	Active: Immediately
5465	**POS_DUAL_GAIN_COMP_VOLTAGE** [n] 0...7 index of the parameter set				**Cross reference: -**
	Knee-point compensation pos. voltage			Related to: HLA	Protection level: 3/3
Unit: %	Default: 10.0	Minimum: 0.2	Maximum: 95.0	Data type: FLOAT	Active: Immediately
5466	**DUAL_GAIN_COMP_SMOOTH_RANGE** [n] 0...7 index of the parameter set				**Cross reference: -**
	Rounding range for knee-point compensation			Related to: HLA	Protection level: 3/3
Unit: %	Default: 2.5	Minimum: 0.0	Maximum: 10.0	Data type: FLOAT	Active: Immediately

5467	**NEG_DUAL_GAIN_COMP_FLOW** [n] 0...7 index of the parameter set				**Cross reference: -**
	Knee-point compensation neg. flow			Related to: HLA	Protection level: 3/3
Unit: %	Default: 10.0	Minimum: 0.2	Maximum: 95.0	Data type: FLOAT	Active: Immediately
5468	**NEG_DUAL_GAIN_COMP_VOLTAGE** [n] 0...7 index of the parameter set				**Cross reference: -**
	Knee-point compensation neg. voltage			Related to: HLA	Protection level: 3/3
Unit: %	Default: 10.0	Minimum: 0.2	Maximum: 95.0	Data type: FLOAT	Active: Immediately

To calculate the inverse characteristic, the knee-point in the positive quadrant of the valve characteristic is defined in MD 5464 and MD 5465 and in the negative quadrant with MD 5467 and MD 5468.

The positive and negative valve flows at the knee-point in relation to the nominal flow (MD 5107) are entered in 5467 and MD 5464 respectively.

The positive and negative valve voltages at the knee-point in relation to the nominal valve voltage (MD 5109) are entered in MD 5465 and MD 5468 respectively.

When the same values (defaults) are set in MD 5464 and MD 5465, the characteristic is linear (without breakpoint in the zero range (default) and without saturation (default)).

This breakpoint data is preset from the valve data (MD 5110, MD 5111) during the “Calculate controller data” operation. The presettings can be altered later. The rounding range is not a valve data and is therefore only preset to a default value. It can however be changed later by the user (MD 5466). If necessary, a measurement can be taken to obtain a precise setting.

Note

A constant machining velocity of the drive directly at the knee-point of the valve is not recommended.

- **Valve characteristic with breakpoint at the start of a saturation range**

5485	**POS_DUAL_GAIN_COMP_S_FLOW** [n] 0...7 index of the parameter set				**Cross reference: -**
	Knee-point compensation pos. flow saturation			Related to: HLA	Protection level: 3/3
Unit: %	Default: 100.0	Minimum: 0.2	Maximum: 100.0	Data type: FLOAT	Active: Immediately
5486	**POS_DUAL_GAIN_COMP_S_VOLT** [n] 0...7 index of the parameter set				**Cross reference: -**
	Knee-point compensation pos. voltage saturation			Related to: HLA	Protection level: 3/3
Unit: %	Default: 100.0	Minimum: 0.2	Maximum: 100.0	Data type: FLOAT	Active: Immediately

5487	**NEG_DUAL_GAIN_COMP_S_FLOW** [n] 0...7 index of the parameter set				**Cross reference: -**
	Knee-point compensation neg. flow saturation			Related to: HLA	Protection level: 3/3
Unit: %	Default: 100.0	Minimum: 0.2	Maximum: 100.0	Data type: FLOAT	Active: Immediately
5488	**NEG_DUAL_GAIN_COMP_S_VOLT** [n] 0...7 index of the parameter set				**Cross reference: -**
	Knee-point compensation neg. voltage saturation			Related to: HLA	Protection level: 3/3
Unit: %	Default: 100.0	Minimum: 0.2	Maximum: 100.0	Data type: FLOAT	Active: Immediately

To calculate the inverse characteristic, the beginning of a saturation range with parabolic rounding in the positive quadrant of the valve characteristic is defined in MD 5485 and MD 5486 and in the negative quadrant with MD 5487 and MD 5488.

The positive and negative valve flow rates at the start of the saturation range in relation to the nominal valve flow rate (MD 5107) are entered in MD 5485 and MD 5487 respectively.

The positive and negative valve voltages in relation to the nominal voltage (MD 5109) are entered in MD 5486 and MD 5488 respectively.

The saturation range is compensated by a root characteristic such that the intersection point lies on a continuous tangent and the characteristic ends at the point (100%, 100%).

If the default of 100% is set in MD 5485 and MD 5486 or MD 5487 and MD 5488, there is no saturation range in the positive or negative quadrant.

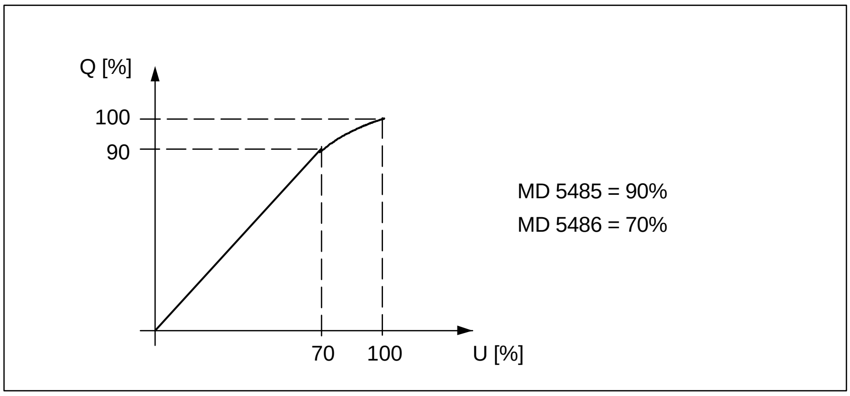


Fig. 4-16 Example

For a more detailed explanation, see also Subsection 2.3.1 and Appendix A.

Offset

5470	OFFSET_COMPENSATION				Cross reference: -
	Offset compensation			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: -4000	Maximum: 4000	Data type: WORD	Active: Immediately

Since the valves are operated under analog control, an offset voltage of the D/A converter or valve amplifier may cause a zero point error and thus a position deviation (if no I-action component has been activated). By adding a compensation value, the offset error can be largely eliminated.

An automatic offset adjustment can be triggered with MD 5650 (see Subsection 3.9.2).

Note

When closed-loop force control is active (MD 5241), offset compensation is absolutely necessary because the I component of the velocity controller is deactivated with closed-loop force control.

4.5.2 Control output filter

5280	**NUM_OUTPUT_FILTERS** [n] 0...7 index of the parameter set				Cross reference: -
	Number of control output filters			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 1	Data type: UNS.WORD	Active: Immediately

The number of control output filters must be set in this machine data.

Table 4-6 Selecting the number of control output filters

0	No filter(s) active (default)
1	Filter(s) activated

Note

The filter machine data must be assigned before the filter type is configured.

5281	**OUTPUT_FILTER_TYPE** [n] 0...7 index of the parameter set				Cross reference: -
	Type of control output filter			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 1	Data type: UNS.WORD	Active: Immediately

The type of control output filter is entered in this machine data.

Table 4-7 Type of control output filter

Bit 0	0	Low-pass (see MD 5284/5285)
	1	Bandstop filter (refer to MD 5288/5289/5290)

5284	**OUTPUT_FIL_1_FREQ** [n] 0...7 index of the parameter set				Cross reference: -
	Natural frequency of control output filter 1			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 1000.0	Minimum: 10.0	Maximum: 8000.0	Data type: FLOAT	Active: Immediately

The filter key data is defined in MD 5284, MD 5285 and MD 5288 to MD 5290.

Enter the natural frequency for control output filter 1 (PT2 low-pass). Setting a value of <10 Hz for the natural frequency of the low pass initializes the filter as a proportional element with a gain of 1, irrespective of the associated damping.

5285	**OUTPUT_FIL_1_DAMP** [n] 0...7 index of the parameter set				**Cross reference: -**
	Damping of control output filter 1			Related to: HLA	Protection level: 3/3
Unit: -	Default: 1.0	Minimum: 0.05	Maximum: 1.0	Data type: FLOAT	Active: Immediately

Enter damping for control output filter 1 (PT2 low-pass).

5288	**OUTPUT_FIL_1_SUP_FREQ** [n] 0...7 index of the parameter set				**Cross reference: -**
	Blocking frequency of control output filter 1			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 3500.0	Minimum: 1.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately

Enter blocking frequency for control output filter 1 (bandstop)

5289	**OUTPUT_FIL_1_BW** [n] 0...7 index of the parameter set				**Cross reference: -**
	Bandwidth of control output filter 1			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 500.0	Minimum: 5.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately

Enter -3dB bandwidth for control output filter 1 (bandstop).

5290	**OUTPUT_FIL_1_BW_NUM** [n] 0...7 index of the parameter set				**Cross reference: -**
	Numerator bandwidth for control output filter 1			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 0.0	Minimum: 0.0	Maximum: 7999.0	Data type: FLOAT	Active: Immediately

Enter the numerator bandwidth for control output filter 1 (damped bandstop).

Entering a value of 0 initializes the filter as an unattenuated bandstop filter. The value set in MD 5290 must not exceed twice the value set in MD 5289.

4.5.3 Manipulated voltage limitation

5474	**OUTPUT_VOLTAGE_POS_LIMIT** [n] 0...7 index of the parameter set				**Cross reference: -**
	Manipulated voltage limitation positive			Related to: HLA	Protection level: 3/3
Unit: V	Default: 10.0	Minimum: 1.0	Maximum: 10.0	Data type: FLOAT	Active: Immediately

The manipulated variable setpoint is limited in the positive direction to the value set in MD 5474 before the D/A conversion. A message is sent to the PLC if the limit is violated.

5475	**OUTPUT_VOLTAGE_NEG_LIMIT** [n] 0...7 index of the parameter set				**Cross reference: -**
	Manipulated voltage limitation negative			Related to: HLA	Protection level: 3/3
Unit: V	Default: 10.0	Minimum: 1.0	Maximum: 10.0	Data type: FLOAT	Active: Immediately

The manipulated variable setpoint is limited in the negative direction to the value set in MD 5475 before the D/A conversion. A message is sent to the PLC if the limit is violated.

Output value inversion

5476	**OUTPUT_VOLTAGE_INVERSION**				**Cross reference: -**
	Manipulated variable inversion Bit 0= 0: No inversion 1: Inversion			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 1	Data type: UNS.WORD	Active: Immediately

The voltage output (manipulated variable) can be inverted in machine data MD 5476 in order to compensate for differences in sign in the piping or wiring. Alternatively, the wiring of the manipulated variable for the valve could be altered.

Definition of direction: See Subsection 3.9.1.

4.6 Supply unit data

The supply unit is defined by

- the modulus of elasticity of the hydraulic fluid,
- the system pressure and
- on pilot-actuated valves by the pilot pressure
- at the cylinder working temperature.

are programmed.

These data influence the limit data (maximum velocity, maximum force...) as well as the dynamic response characteristics of the drive system (corner frequencies).

5100	**FLUID_ELASTIC_MODULUS**				**Cross reference: -**
	Modulus of elasticity of hydraulic fluid			Related to: HLA	Protection level: 3/3
Unit: bar	Default: 11000	Minimum: 1000	Maximum: 21000	Data type: FLOAT	Active: Immediately
5101	**WORKING_PRESSURE**				**Cross reference: -**
	System pressure			Related to: HLA	Protection level: 3/3
Unit: bar	Default: 0.0	Minimum: 0.0	Maximum: 350.0	Data type: FLOAT	Active: Power On
5102	**PILOT_OPERATION_PRESSURE**				**Cross reference: -**
	Pilot pressure			Related to: HLA	Protection level: 3/3
Unit: bar	Default: 0.0	Minimum: 0.0	Maximum: 250.0	Data type: FLOAT	Active: Immediately

MD 5102 is used for “Calculate controller data” if MD 5113 bit 0=1.

Note

The elasticity of oil variable as a function of the temperature can be ignored for industrial hydraulics.

MD 5100 defines the compressibility of the hydraulic fluid.

MD 5101 defines the pressure supplied by the hydraulic power unit.

MD 5102 defines the pressure for a pilot-actuated valve. Zero must be entered valves without pilot actuation.

4.7 Valve

Valve data

The nominal valve data defines the key valve data at the nominal operating point. The latter is defined by the

- Nominal flow rate,
- nominal pressure drop and
- nominal voltage.

5106	**VALVE_CODE**				**Cross reference: -**
	Valve code number			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 2000	Data type: UNS.WORD	Active: Immediately
5107	**VALVE_NOMINAL_FLOW**				**Cross reference: -**
	Nominal valve flow rate			Related to: HLA	Protection level: 3/3
Unit: l/min	Default: 0.0	Minimum: 0.0	Maximum: 1000	Data type: FLOAT	Active: Immediately
5108	**VALVE_NOMINAL_PRESSURE**				**Cross reference: -**
	Nominal pressure drop of valve (per control edge)			Related to: HLA	Protection level: 3/3
Unit: bar	Default: 35.0	Minimum: 1.0	Maximum: 200.0	Data type: FLOAT	Active: Immediately
5109	**VALVE_NOMINAL_VOLTAGE**				**Cross reference: -**
	Nominal voltage of valve			Related to: HLA	Protection level: 3/3
Unit: V	Default: 10.0	Minimum: 0.5	Maximum: 15.0	Data type: FLOAT	Active: Immediately

Valves with the associated data are included in the valve selection list (see Subsection 2.3.2).

Other valve data includes:

- Knee characteristic,
- Flow ratio,
- Dynamic definition with natural frequency and damping and
- Valve configuration.

For a more detailed explanation of valves, see Section 2.3 and Appendix A.

5110	**VALVE_DUAL_GAIN_FLOW**				**Cross reference: -**
Knee-point flow rate of valve Note: MD 5464 and MD 5467 are preset				Related to: HLA	Protection level: 3/3
Unit: %	Default: 10.0	Minimum: 0.2	Maximum: 95.0	Data type: FLOAT	Active: Immediately
5111	**VALVE_DUAL_GAIN_VOLTAGE**				**Cross reference: -**
Knee-point voltage of valve Note: MD 5465 and MD 5468 are preset				Related to: HLA	Protection level: 3/3
Unit: %	Default: 10.0	Minimum: 0.2	Maximum: 95.0	Data type: FLOAT	Active: Immediately

A valve characteristic as shown in Fig. 2-8 results in an entry of 10% in MD 5110 and 40% in MD 5111. Entering the same value in both machine parameters produces a linear characteristic (default setting).

5112	**VALVE_FLOW_FACTOR_A_B**				**Cross reference: -**
	Valve flow rate ratio between A and B ends of valve			Related to: HLA	Protection level: 3/3
Unit: -	Default: 1.0	Minimum: 0.5	Maximum: 2.0	Data type: FLOAT	Active: Immediately

The flow ratio specifies the ratio between the nominal flow towards the A end and the nominal flow towards the B end.

5114	**VALVE_NATURAL_FREQUENCY**				**Cross reference: -**
	Natural frequency of valve			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 150.0	Minimum: 1.0	Maximum: 1000.0	Data type: FLOAT	Active: Immediately
5115	**VALVE_DAMPING**				**Cross reference: -**
	Valve damping			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0.8	Minimum: 0.4	Maximum: 1.0	Data type: FLOAT	Active: Immediately

To dimension the velocity controller, the transmission behavior of the valve on conversion of the voltage setpoint to the spool position is approximated as a PT2 low-pass.

The valve's natural frequency can be read for a phase shift of -180°. The valve's natural frequency for a valve modulation of ± 10% in relation to 100 bar pilot pressure is specified in MD 5114.

The valve damping can be calculated from the amplitude overshoot at resonant frequency for values of less than 0.7. The valve damping for a valve modulation of ± 20% in relation to 100 bar pilot pressure is specified in MD 5115.

Special points to be noted

Machine parameter MD 5113 with control bits has been introduced to allow special valve features to be taken into account.

5113	**VALVE_CONFIGURATION**				**Cross reference: -**
	Valve configuration Bit 0= 0: Directly-controlled valve 1: Pilot-controlled valve Bit 2/Bit 1= 00: No fail-safe 01: Fail safe closed 10: Fail-safe open 11: - Bit 3= 0: No differential circuit 1: Differential circuit Bit4= 0: 7-pin connector 1: 12-pin connector			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: 1	Data type: UNS.WORD	Active: Immediately

4.8 Cylinder drive

Cylinder data

5131	**CYLINDER_PISTON_DIAMETER**				**Cross reference: -**
	Cylinder piston diameter			Related to: HLA	Protection level: 3/3
Unit: mm	Default: 0.0	Minimum: 0.0	Maximum: 500.0	Data type: FLOAT	Active: Power On
5132	**CYLINDER_ROD_A_DIAMETER**				**Cross reference: -**
	Cylinder piston rod diameter at A end			Related to: HLA	Protection level: 3/3
Unit: mm	Default: 0.0	Minimum: 0.0	Maximum: 500.0	Data type: FLOAT	Active: Power On
5133	**CYLINDER_ROD_B_DIAMETER**				**Cross reference: -**
	Cylinder piston rod diameter at B end			Related to: HLA	Protection level: Immediate
Unit: mm	Default: 0.0	Minimum: 0.0	Maximum: 500.0	Data type: FLOAT	Active: Power On
5134	**PISTON_STROKE**				**Cross reference: -**
	Piston stroke			Related to: HLA	Protection level: 3/3
Unit: mm	Default: 0.0	Minimum: 0.0	Maximum: 3000.0	Data type: FLOAT	Active: Immediately
5135	**CYLINDER_DEAD_VOLUME_A**				**Cross reference: -**
	Cylinder dead voltage A end			Related to: HLA	Protection level: 3/3
Unit: ccm	Default: 0.0	Minimum: 0.0	Maximum: 200000.0	Data type: FLOAT	Active: Immediately
5136	**CYLINDER_DEAD_VOLUME_B**				**Cross reference: -**
	Cylinder dead voltage B end			Related to: HLA	Protection level: 3/3
Unit: ccm	Default: 0.0	Minimum: 0.0	Maximum: 200000.0	Data type: FLOAT	Active: Immediately

Apart from the piston diameter (MD 5131), the rod diameters at the A and B ends must also be specified (5132, MD 5133). On a differential cylinder, both rod diameters are different, one of the rods might even have a zero diameter. The maximum piston stroke (MD 5135) and cylinder dead volume (MD 5135, MD 5136) are also required.

The cylinder dead volume is the liquid volume between the cylinder and servo solenoid valve which cannot be displaced by the piston.

The dead volume attributable to the pipework is separately parameterized (MD 5141 to MD 5143).

For a more detailed explanation of the cylinder data, see also Subsection 2.3.1 and Appendix A.

4.9 Drive data

Valve-to-drive connection

5140	VALVE_CYLINDER_CONNECTION				Cross reference: -
	Valve-cylinder connection configuration Bit 0 = 0: Valve A on cylinder A 1: Valve A on cylinder B			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 1	Data type: UNS.WORD	Active: Immediately
5141	PIPE_LENGTH_A				Cross reference: -
	Pipe length at A end			Related to: HLA	Protection level: 3/3
Unit: mm	Default: 0.0	Minimum: 0.0	Maximum: 10000.0	Data type: FLOAT	Active: Immediately
5142	PIPE_LENGTH_B				Cross reference: -
	Pipe length at B end			Related to: HLA	Protection level: 3/3
Unit: mm	Default: 0.0	Minimum: 0.0	Maximum: 10000.0	Data type: FLOAT	Active: Immediately
5143	PIPE_INNER_ DIAMETER_A_B				Cross reference: -
	Internal pipe diameters at A and B			Related to: HLA	Protection level: 3/3
Unit: mm	Default: 5.0	Minimum: 0.0	Maximum: 100.0	Data type: FLOAT	Active: Immediately

These machine data provide information about the valve-to-drive connection. They are used to preset other machine data during the “Calculate drive model data” and “Calculate controller data” routines. If there is a pipe between the valve and cylinder, then the dead volume of the pipe can be calculated from the pipe length (A and B ends) and the inner pipe diameter. If the valve is mounted directly on the cylinder, then zero must be entered for the pipe length at each end. The dead volume affects the natural frequency of the drive.

For more detailed explanation of the drive data, see also Subsection 2.3.4 and Appendix A.

Mechanical design of drive

5150	DRIVE_MASS				Cross reference: -
	Moved drive mass			Related to: HLA	Protection level: 3/3
Unit: kg	Default: 0.0	Minimum: 0.0	Maximum: 20000.0	Data type: FLOAT	Active: Immediately

The movement of the piston rod is transmitted to other mechanical components (e.g. table, tools, ...). The total moved mass must be specified as a machine data (MD 5150).

Note

The mass of the drive is a critical parameter and should be calculated as exactly as possible!

5151	CYLINDER_A_ORIENTATION				Cross reference: -
	Cylinder mounting position referred to A end			Related to: HLA	Protection level: 3/3
Unit: Degrees	Default: 0.0	Minimum: -90.0	Maximum: 90.0	Data type: FLOAT	Active: Immediately
5152	**CYLINDER_FASTENING**				**Cross reference: -**
	Cylinder fixing (fixed part of HLA) Bit 0= 0: Cylinder 1: Piston rod			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 1	Data type: UNS.WORD	Active: Immediately

The mounting position of the cylinder (MD 5151) specifies to what degree the force due to weight of the moved mass (MD 5150) is taken into account in calculating the servo gain and maximum piston travel-in/travel-out speed.

It is assumed that the moved mass will act in the direction of the cylinder axis. If the weight of the moved mass does not act in this direction, however, MD 5151 must be converted accordingly.

A distinction is made between two different mounting methods in the HLA:

1. The cylinder is stationary, the moved mass is attached to the piston rod (MD 5152 bit 0=0).
2. The piston is stationary, the moved mass is attached to the cylinder (MD 5152 bit 0=1).

The Calculate drive model data routine calculates the weight force applied to the cylinder from MD 5150...MD 5152 and enters the result in MD 5231.

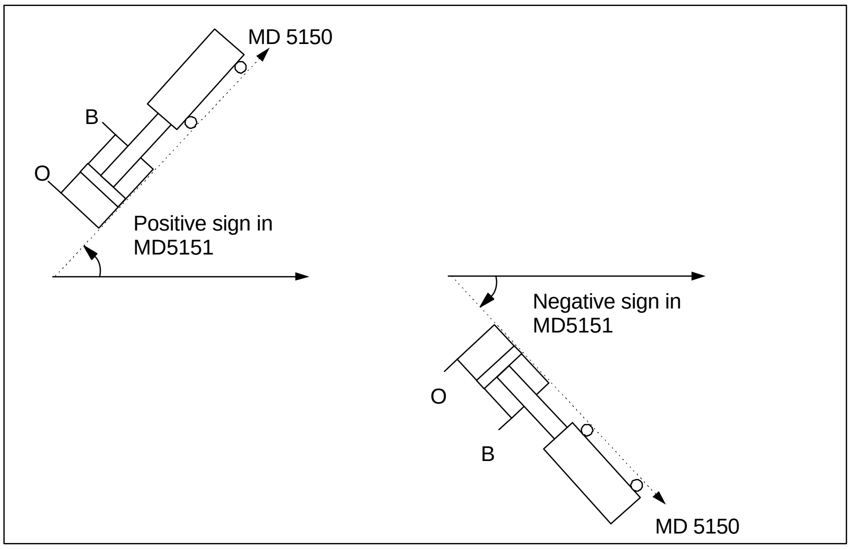


Fig. 4-17 Mounting position of drive referred to A end

Dynamic drive model data

5160	PISTON_POS_MIN_NAT_FREQ				Cross reference: -
	Min. natural frequency piston position			Related to: HLA	Protection level: 3/3
Unit: mm	Default: 0.0	Minimum: 0.0	Maximum: 3000.0	Data type: FLOAT	Active: Immediately
5161	**DRIVE_DAMPING**				**Cross reference: -**
	Drive damping			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0.1	Minimum: 0.01	Maximum: 1.0	Data type: FLOAT	Active: Immediately
5162	**DRIVE_NATURAL_FREQUENCY_A**				**Cross reference: -**
	Natural frequency of drive A			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 1.0	Minimum: 1.0	Maximum: 2000.0	Data type: FLOAT	Active: Immediately
5163	**DRIVE_NATURAL_FREQUENCY**				**Cross reference: -**
	Natural frequency of drive			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 1.0	Minimum: 1.0	Maximum: 2000.0	Data type: FLOAT	Active: Immediately
5164	**DRIVE_NATURAL_FREQUENCY_B**				**Cross reference: -**
	Natural frequency of drive B			Related to: HLA	Protection level: 3/3
Unit: Hz	Default: 1.0	Minimum: 1.0	Maximum: 2000.0	Data type: FLOAT	Active: Immediately
5180	**CLOSED_LOOP_SYSTEM_DAMPING**				**Cross reference: -**
	Selected damping for closed-loop system			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0.7	Minimum: 0.2	Maximum: 1.0	Data type: FLOAT	Active: Immediately
corresponds to: MD 5414, MD 5415, MD 5431, MD 5433					

The drive is approximated as a PT2 low pass for the purpose of dimensioning the closed-loop velocity control. The characteristic values “natural frequency” and “damping” are calculated and preset from other drive data by the “Calculate drive model data” function.

With MD 5180: CLOSED_LOOP_SYSTEM_DAMPING can be set to specify the degree of damping to be applied in calculating the control loop during “Calculate controller data”.

Example: Damping of 0.9
Slow closed-loop system with infrequent overshoots

Damping of 0.5
Fast closed-loop system with frequent overshoots

4.10 Position measuring system

Description

One measuring system can be connected per axis as a piston rod position sensor.

Suitable measuring systems

- Incremental encoder with sinusoidal-cosine voltage signals
- Absolute measuring systems with EnDat interface and sinusoidal-cosine voltage signals
- Absolute measuring systems with SSI interface

Incremental encoder

Linear and rotary measuring systems with two 1 Vpp sinusoidal voltage signals in quadrature. The internal interpolation factor of the HLA module is 2048 (high resolution per sine period).

The sign of the actual-value sensing circuit can be reserved.
Signs are reversed by a software function.

Absolute encoder EnDat

Linear and rotary measuring systems with two 1 Vpp sinusoidal voltage signals in quadrature. The internal interpolation factor of the HLA module is 2048 (high resolution per sine period).

The sign of the actual-value sensing circuit can be reserved.
Signs are reversed by a software function.

An additional serial interface for transmitting the absolute position according to the EnDat protocol.

SSI absolute value encoder [1)]

Linear and rotary measuring systems with serial interface for transmitting the absolute position using the SSI protocol.

The connection for measuring systems with a 24V voltage supply must be made using signal lead 6FX8002-2CC80-1□□□ via which the 24V DC encoder power supply can be fed in. The filter module 6SN1161-1DA00-0AA0 must be used in combination with this lead. No other type of filter may be used.

Encoders supplied by other manufacturers must be connected via adapter leads supplied by the relevant manufacturer.

Encoders from the following manufacturers may be used, for example:
MTS: Temposonics 25-bit
Balluff Micropulse 25-bit
Visolux: EDM

Notice

The products recommended above are not manufactured by Siemens, but we know that they are suitable for the purpose in principle. However, we can never guarantee the quality of products supplied by other manufacturers.

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1) SSI encoders are likely to have lower noise immunity due to the encoder and the 24 V power supply. The immunity to interference can be improved as follows: By using a separate and immune 24V power supply for the measuring systems

Minimum and maximum velocity

The minimum or maximum possible velocity depends on the position measuring system.

- V_{max}: of the position measuring system must not be exceeded.

  The maximum measuring velocity must be set in MD 5609: ENC_SPEED_LIMIT (see Subsection 4.13.1).

  V_{max} must not exceed the 350 kHz bar frequency of the connected measuring system.

  $$V_{max,bar} = \text{scale graduation} \cdot 350000\ s^{-1}$$

- V_{min}: The number of crossed graduations per velocity controller cycle is small at low velocities. In extreme cases, this can result in uneven movements at low velocities, large scale graduation and short velocity controller cycle.

  Solution: Select another position measuring system with smaller scale graduations or increase the velocity controller cycle.

Phase error compensation

A phase error on tracks A and B can be corrected with the phase error compensation function.

5008	**ENC_PHASE_ERROR_CORRECTION**				**Cross reference: -**
	Encoder phase error compensation			Related to: HLA	Protection level: 3/3
Unit: Degrees	Default: 0.0	Minimum: -20.0	Maximum: 20.0	Data type: FLOAT	Active: Immediately
5011	**ACTUAL_VALUE_CONFIG**				**Cross reference: -**
	Actual-value sensing configuration Bit 0= 0: No inversion 1: Actual value inversion Bit 1= 0: No phase error compensation activated 1: Phase error compensation activated Bit 3= 0: No absolute value encoder 1: Absolute value encoder (EnDat or SSI encoder) Bit 4= 0: Rotary measuring system 1: Linear or rotary measuring system Bit7= 0: No distance-coded measuring system 1: Distance-coded measuring system Bit 8= 0: No zero marker selection by NC 1: Zero marker selection by NC Bit 14=0: 100 kHz data transfer rate (absolute value encoder) 1: 500 kHz data transfer rate (absolute value encoder)			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: 65535	Data type: UNS.WORD	Active: Power On

Linear scale graduations

5024	DIVISION_LIN_SCALE				Cross reference: -
	Linear scale graduations			Related to: HLA	Protection level: 3/3
Unit: nm	Default: 20000	Minimum: 1000 (0)	Maximum: 5000000	Data type: UNS.DWORD	Active: Power On

The standard parameterizing machine data provided support only linear measuring systems. ROD encoders must be converted by the user, i.e. the distance traversed by the drive between two (coarse) increments must be entered. Value 0 is automatically entered if MD 5011 bit 4 is set to 0 (no linear measuring system).

Rotary absolute value encoders cannot be implemented until software version HLA 01.01.11 and beyond

5021	ENC_ABS_TURNS_MOTOR				Cross reference: -
	Multi-turn resolution, absolute encoder, motor			Related to: HLA	Protection level: 3/3
Unit: U	Default: 4096	Minimum: 0000	Maximum: 65535	Data type: WORD	Active: Power On

Number of displayable revolutions of absolute value encoder in motor measuring system. The value is read-only.

5022	ENC_ABS_RESOL_MOTOR				Cross reference: -
	Measuring steps of absolute track in motor			Related to: HLA	Protection level: 3/3
Unit: -	Default: 8192	Minimum: 0000	Maximum: 65535	Data type: WORD	Active: Power On

Resolution of motor absolute value encoder in measuring pulses per revolution. The value is read-only.

5023	ENC_ABS_DIAGNOSIS_MOTOR				Cross reference: -
Diagnostic bits of absolute value encoder, measuring system Bit 0=1: “Lighting failed” Bit 1=1: “Signal amplitude too small” Bit 2=1: “Faulty code connection” Bit 3=1: “Overvoltage” Bit 4=1: “Undervoltage” Bit 5=1: “Overcurrent” Bit 6=1: “Battery change necessary” Bit 7=1: “Control check error” Bit 8=1: “EnDat encoder cannot be used” Bit 9=1: CDtrack on encoder ERN1387 defective Bit 10=1: “Protocol cannot be interrupted” Bit 11=1: “SSI level on data line detected” Bit 12=1: “TIMEOUT reading measured values” Bit 13=1: “CRC error” Bit 14=1: SSI encoder returned alarm Bit 15=1: “Encoder faulty” Bit 12 and 15: SSI zero level monitoring Bit 14 and 15: SSI idle level monitoring				Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: BFFF	Data type: UNS.WORD	Active: Immediately

Diagnostic bits of absolute value encoder, motor measuring system

5025	SERIAL_NO_ENCODER				Cross reference: -
	Serial number of motor measuring system (HLA 01/02/04 or later)			Related to: HLA	Protection level: 1/1
Unit: -	Default: 0	Minimum: 0	Maximum: 4294967295	Data type: UNS. DWORD	Active: Power On

The serial number of the indirect, absolute measuring system is read from the encoder in set state 3 at boot and entered in MD 5025. (Exception: Linear encoder.) 0 is entered if an incremental measuring system is installed. This encoder ID notifies the NC if the encoder has been replaced and, if it has been replaced, the NC resets the calibration identifier.

5027	ENC_CONFIG				Cross reference: -
	Configuration of IM encoder (HLA 01/02/04 or later)			Related to: HLA	Protection level: 2/4
Unit: -	Default: 0	Minimum: 0000H	Maximum: FFFFH	Data type: WORD	Active: Power On

Table 4-8 Configuration of SSI encoder

Bit	0 or 1	Description
7 7	= 00	100 kHz
	= 01	500 kHz
	= 10	1 MHz
	= 11	2 MHz
9	= 0	SSI encoder with incremental signal (not permitted)
	= 1	SSI encoder without incremental signal
10	= 0	Gray code
	= 1	Dual (binary code)
11	= 0	Right-justified format
	= 1	Fir-tree format (not permitted)
12	= 0	Without parity bit
	= 1	With parity bit
13	= 0	Odd parity
	= 1	Even parity
14	= 0	No alarm bit
	= 1	With alarm bit
15	= 1	With SSI encoder

5028	NO_TRANSMISSION_BITS				Cross reference: -
	Message frame length SSI (HLA 01/02/04 or later)			Related to: HLA	Protection level: 2/4
Unit: -	Default: 25	Minimum: 0	Maximum: 25	Data type: WORD	Active: Power On

The length defines the total transferred message frame length including all parity or alarm bits.

Example: 24 bits + 1 alarm bit; 25 must be entered.

Every encoder manufacturer has a different name for the alarm bit, e.g. Power Failure Bit.

Actual position value

5040	PISTON_ZERO				Cross reference: -
Piston zero in relation to machine zero				Related to: HLA	Protection level: 3/3
Unit: mm	Default: 0.0	Minimum: -1000000.0	Maximum: 100000.0	Data type: FLOAT	Active: Immediately

In the machine data 5040: between the piston zero (end stop at A end) and machine zero must be set in MD 5040: PISTON_ZERO.

If the actual position is available in machine coordinates in the drive after the reference point approach, it can be applied to calculate the piston position (e.g. for adaptation).

4.11 Pressure sensing system

Sensor adjustment

5550	PRESSURE_SENS_A_REF				Cross reference: -
	Reference value of pressure sensor A at 10 V			Related to: HLA	Protection level: 3/3
Unit: bar	Default: 200.0	Minimum: 50.0	Maximum: 400.0	Data type: FLOAT	Active: Immediately
5552	PRESSURE_SENS_B_REF				Cross reference: -
	Reference value of pressure sensor B at 10 V			Related to: HLA	Protection level: 3/3
Unit: bar	Default: 200.0	Minimum: 50.0	Maximum: 400.0	Data type: FLOAT	Active: Immediately

In MD 5550: PRESSURE_SENS_A_REF and MD 5552: PRESSURE_SENS_B_REF, the pressure at which the pressure sensor outputs 10 V at the A and B ends of the cylinder is entered in bar.

The pressure sensor should have a range of 0 to 10 V, with 0 bar pressure represented by 0 V and the reference value (MD 5550 or. MD 5552) by 10 V.

Offset adjustment

5551	PRESSURE_SENS_A_OFFS				Cross reference: -
	Offset adjustment for pressure sensor A			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: -32760	Maximum: 32760	Data type: WORD	Active: Immediately
5553	PRESSURE_SENS_B_OFFS				Cross reference: -
	Offset adjustment for pressure sensor B			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: -32760	Maximum: 32760	Data type: WORD	Active: Immediately

Bits set to 1 in MD 5551: PRESSURE_SENS_A_OFFS and MD 5553: PRESSURE_SENS_B_OFFS, the pressure sensor offset at the A or B end of the cylinder is adjusted in ADC increments.

The pressure indicator should also display 0 bar at zero pressure. If the velocity controller cycle is altered, the offset must be adjusted again.

Note

For automatic offset adjustment, see Subsection 3.9.2.

4.12 Terminals

ON/OFF sequence

Terminals are provided on connectors X431/X432 of the HLA module and X121 of the MS module for the purpose of implementing the ON/OFF conditions for the HLA module.

The following overview shows the hierarchy of signals for enabling and disabling the HLA.

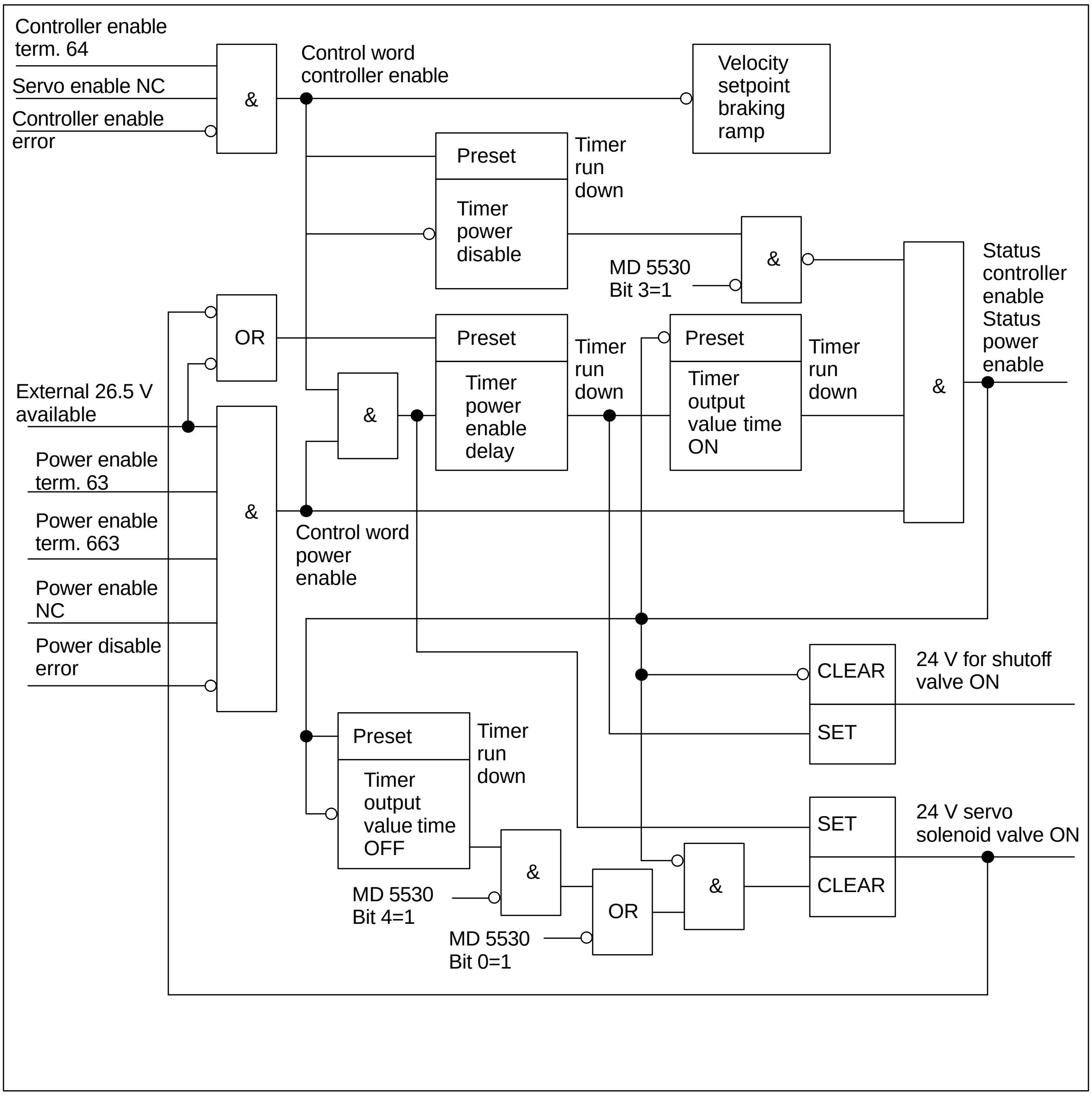


Fig. 4-18 Enabling logic on HLA module

External 26.5 V supply

The 24 V voltage for the shut-off valve and valve electronics is supplied from an external source connected via the HLA module.

This voltage source is monitored by the HLA module such that an internal signaling bit “24 V valve supply voltage missing” is set by the hardware when the voltage drops below a specific threshold. While the “Valve supply voltage missing” bit is set, any power enable command will be rejected, thus setting the “velocity controller enable” status bit to zero.

- **Failure of 26.5 V supply during operation**

  The power is disabled and status bit “Velocity controller enable” canceled. The module does not output an error message.

- **Recovery of 26.5 V supply voltage or after initial connection of the 26.5V supply voltage**

  The power is not enabled until the power enabling delay set in MD 5532 has expired.

Warning

In the event of sudden failure (e.g. open circuit) of the external 26.5 V supply, an axial storage capacitor on the HLA module provides energy to supply the servo solenoid valve until such time as the pressure supply for a configured shut-off valve is disabled.

The machine manufacturer must verify the interaction between valves, making allowance for all tolerances in the controlled system.

The energy content of the storage capacitors is dependent upon

- the tolerances of the capacitors,

The available response time is mainly defined by

- the power required for the current machining step,
- the response time of the shut-off valves and
- the trip threshold of the servo solenoid valves.

5532	**POWER_ENABLE_DELAY**				**Cross reference: -**
	Power enable delay time			Related to: HLA	Protection level:
Unit: ms	Default: 100	Minimum: 0	Maximum: 300	Data type: UNS.WORD	Active: Immediately

If a shut-off valve is connected (MD 5530, bit 0=1), the switch remains open for that time, i.e. the shut-off valve is closed.

This gives the servo solenoid valve enough time to move into the mid-position from the fail-safe position without pressure. In such cases, the power enabling delay period must be set to the time required by the valve to move from fail-safe to mid-position.

If this operation were to take place under pressure, the drive would move. If no shut-off valve is connected, zero can be entered as the power enabling delay period.

Figs. 4-19 and 4-20 show the system response to 24 V ON and OFF for a configuration with and without shut-off valve.

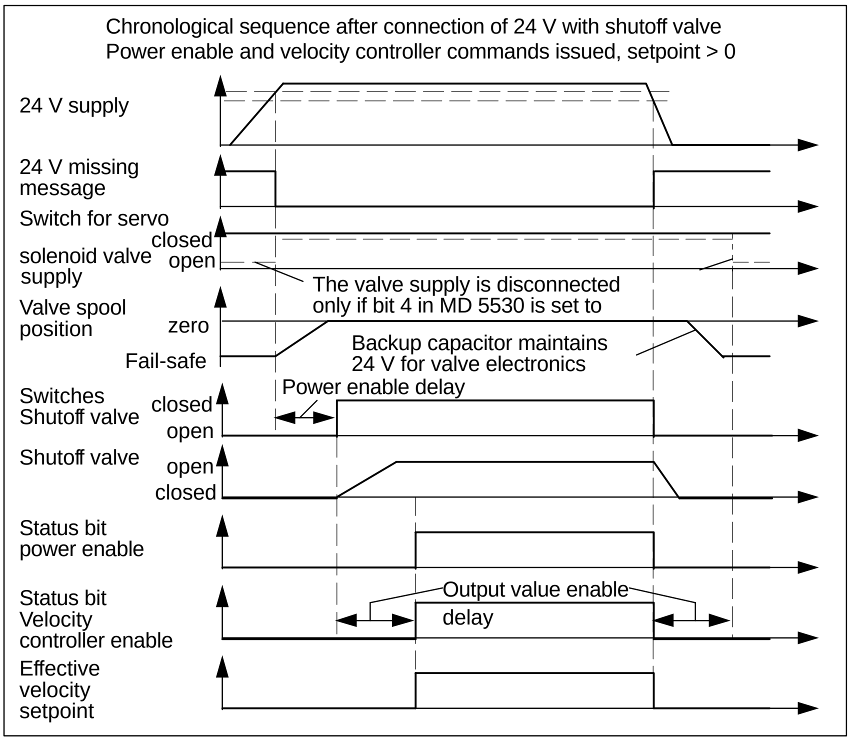


Fig. 4-19 Chronological sequence after connection of 24 V supply, with shut-off valve

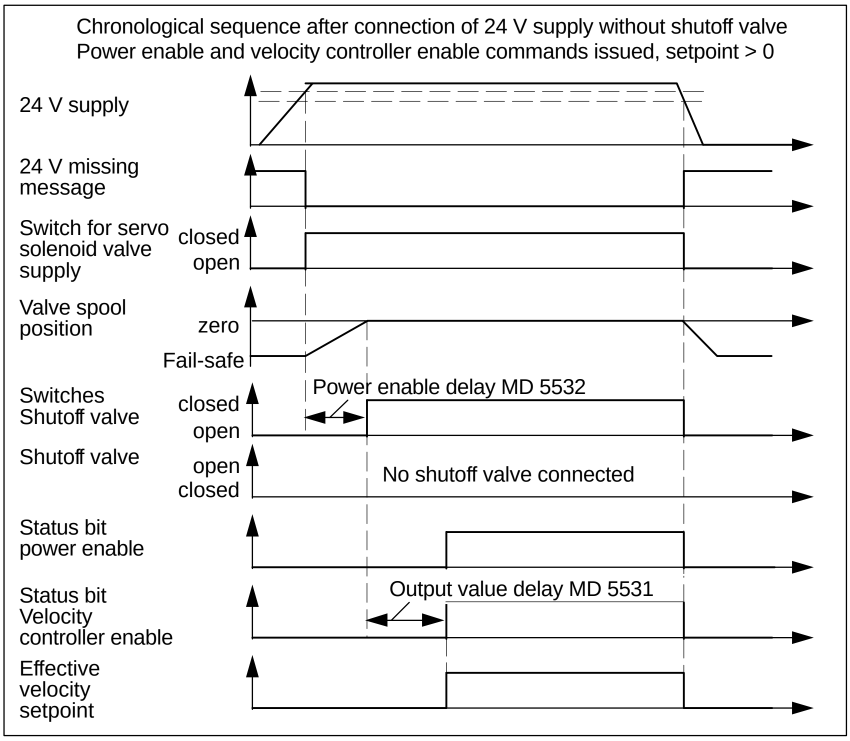


Fig. 4-20 Chronological sequence after connection of 24 V supply, without shut-off valve

Power enable

The power enabling command (corresponding to pulse enable on an electrical drive) can be issued and/or canceled via the following paths:

- Term. 63 (central power enable)
- Term. 663 (module-specific power enable)
- Control word (from NC)
- Error (ZK1, watchdog)

5530	CYLINDER_SAFETY_CONFIG				Cross reference: -
Safety configuration Bit 0= 0: Without shut-off valve 1: With shut-off valve Bit 1= 0: Central shut-off valve 1: Axis-specific shut-off valve Bit 2= 0: No valve spool checkback 1: Valve spool checkback present Bit 3= 0: Velocity controller disable with power disable (PD) 1: Velocity controller disable without power disable (PD) Bit 4= 0: Servo solenoid valve supply disconnected with PS with shut-off valve (irrelevant without shut-off valve) 1: Servo solenoid valve supply remains connected with PS with shut-off valve (irrelevant without shut-off valve) (PD ≙ Power disable)				Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 4	Minimum: 0	Maximum: 31	Data type: UNS.WORD	Active: Immediately
5531	**OUTPUT_ENABLE_DELAY**				**Cross reference: -**
Manipulated variable enable delay				Related to: HLA	Protection level: 3/3
Unit: ms	Default: 300	Minimum: 0	Maximum: 500	Data type: UNS.WORD	Active: Immediately

The manipulated variable delay time is the time which the velocity controller enable continues to disable after the power enable delay time (MD 5532) has expired. This delay time is needed to allow the shut-off valve to open or, in systems without shut-off valve, to allow the valve spool to move from the fail-safe to the zero position.

Disconnecting the shut-off valve supply
If a shut-off valve is set in MD 5530 (bit 0 or bit 1 = 1) and the supply voltage of the servo solenoid valve is to be disconnected when the power is disabled (MD 5530 bit=0), the manipulated variable delay (MD 5531) is the time it takes until the voltage supply of the servo solenoid valve is interrupted. The shut-off valve can be closed during this period.

Actions on PE (ext. 24 V supply available, controllers enabled):

- 24 V supply for servo solenoid valve is switched on immediately (if it is not already connected).
- If 24 V supply for servo solenoid valve was available, then 24 V supply for shut-off valve is switched on immediately, otherwise it is not switched on until power enable delay period has run down.
- After the 24 V supply for the shut-off valve has been switched on, the status word “Velocity controller enable” is not set until the manipulated variable enable delay has run down.

Operating sequence for PD (power disable):

- 24 V supply for shut-off valve is disconnected immediately (shut-off valve closes).
- If MD 5530 bit 4=0 is set, the 24 V supply for the servo solenoid valve is also switched off when the manipulated variable enable delay (MD 5531) runs down (servo solenoid valve moves to fail-safe position).

  If MD 5530 bit 4=1 is set, the 24 V supply for the servo solenoid valve remains connected.
- If MD 5530 bit 0=0 is set (no shut-off valve), then the 24 V supply for the servo solenoid valve is switched off immediately (servo solenoid valve moves to fail-safe position).
- Velocity controller enable status bit is reset immediately.
  - Valve setpoint=0 V is output
  - Controller I-components are cleared.
  - Valve spool monitoring is deactivated
- If a **central shut-off valve** is installed, it is left to the user to gate the signals (e.g. using the PLC) such that the central shut-off valve is actuated when the power is disabled.

  To prevent errors on other axes, it should be ensured that all axes whose pressure is supplied via the central shut-off valve also receive the power disable command when the central shut-off valve is actuated.
- If a **separate shut-off valve** (axis-specific shut-off valve) is installed for each axis, this need only be connected to the "shut-off valve" relay output of the relevant axis.

After the power has been disabled, the switch for the 24 V supply is either opened or not (depending on the setting of bit 4 in MD 5530) at the end of the manipulated variable enable delay. The default setting has been selected such that the 24 V valve supply voltage is disconnected (bit 4 =0), thus moving the valve into the fail-safe position.

This will not be necessary if a shut-off valve is installed and actuated. This function has been integrated for cases where a shut-off valve has been set, but is not actually connected. In such cases, this function prevents the drive from being able to drift after a power disable. After a function test, bit 4 in MD 5530 can be set to 1.

Velocity controller enable

A velocity controller enable/disable can be requested via the following paths:

- Terminal 64 (central velocity controller enable)
- Control word (from NC)
- Error (ZK1)

If a velocity controller enable is requested and all the relevant enable conditions are fulfilled, i.e.

- manipulated variable enable delay run down,
- 24 V supply for shut-off and SS valves ON,
- power enable signal set and
- No error

then the "Velocity controller enable" status bit is set.

Mode of operation when “Velocity controller enable” bit is set:

- Valve setpoint is output by the velocity controller
- I-component is enabled
- Valve spool monitor is activated

If a velocity controller disable is requested, a zero velocity setpoint is output.

- The braking time set in MD 5402 acts as a speed setpoint adjustment ramp (acceleration limitation).
- The setting in MD 5402 corresponds to the time required by the braking ramp to decelerate the cylinder from the speed in MD 5401 down to zero. This ramp is effective only when the velocity controller is disabled since, in this case, the acceleration limits programmed in the control are ignored. Otherwise, the control system has the responsibility of limiting acceleration rates.
- If velocity controller disable followed by a power disable is requested (MD 5530 bit 3=0), then the delay set in MD 5404: POWER_DISABLE_DELAY is left to run down after the velocity controller disable request until the power disable signal is set. If MD 5530, bit 3=1, MD 5404 has no meaning (drive continues to operate under closed-loop control with a zero velocity setpoint following a velocity controller disable request).

Velocity controller disable

5402	SPEED_CTRL_DISABLE_STOPTIME				Cross reference: -
	Braking time for controller disable			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 0.0	Minimum: 0.0	Maximum: 120000.0	Data type: FLOAT	Active: Immediately
5404	POWER_DISABLE_DELAY				Cross reference: -
	Power disable timer			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 100	Minimum: 0	Maximum: 100000	Data type: FLOAT	Active: Immediately

Setup mode

If the setup mode terminal (term. 112 on mains supply module) is selected, the velocity setpoint is limited to the value programmed in MD 5420.

Function switch

5012	FUNC_SWITCH				Cross reference: -
	Status word (PLC readable) Drive ready Bit 2=0: Drive signaled as ready if not drive alarm is pending Bit 2=1: Drive signaled as ready if not drive alarm is pending and terminals 63, 64, 48 and 663=1 Bit 4=1: ZK2 parameterization error Bit 14=1: Valid offset between machine zero and actual value zero Bit 15=1: Valid offset between piston zero and machine zero			Related to: HLA	Protection level: 3/3
Unit: -	Default: 4	Minimum: 0	Maximum: 65535	Data type: UNS.WORD	Active: Immediately

Only bits 2 and 4 are relevant for the user.

SIMRDY

This LED indicates that the drive unit is ready (SIMODRIVE Ready terminal 72/73 -> device bus; cannot be changed by MD 5012).

4.13 Monitoring functions

4.13.1 Alarms

Power On alarms

5600	ALARM_MASK_POWER_ON				Cross reference: -
	Concealable alarms (Power On) Bit 4: "Measuring circuit measuring system" Bit 5: Measuring circuit absolute track (incl. SSI encoder) Bit 8: "Zero marker error"			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately
5612	ALARM_REACTION_POWER_ON				Cross reference: -
	Config. shutdown response to PO alarms Bit 0= 0: No enable signal cancellation in response to internal errors 1: Enable signal cancellation in response to internal errors			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately
5731	CL1_PO_IMAGE				Cross reference: -
	Image ZK1_PO register			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately

With MD 5600: ALARM_MASK_POWER_ON can be set to conceal Power On alarms. If the relevant bit is set to 0, the corresponding error monitoring function is active. If the bit=1, the error monitoring function is suppressed. The default setting is active for all monitoring functions.

With MD 5612: ALARM_REACTION_POWER_ON is set to configure change-over of the relevant Power On alarm.

Alarm messages, see Chapter 6, numbers 300500...300599.

RESET alarms

5601	ALARM_MASK_RESET				Cross reference: -
	Concealable alarms (Reset) Bit 7: "Valve controller not responding" Bit 8: "Velocity controller at limit" Bit 9: "Encoder limit frequency exceeded" Bit 10: "Piston position negative" Bit 11: "Pressure sensing failed" Bit 12: "Force limitation OFF" Bit 13: "External valve voltage supply check Off" ("26.5 V monitoring""			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately

5613	ALARM_REACTION_RESET				Cross reference: -
	Config. shutdown response to RESET alarms Bit 0= 0: No enable signal cancellation in response to configuration errors 1: Enable signal cancellation in response to configuration errors			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately
5732	CL1_RES_IMAGE				Cross reference: -
	Image ZK1_RES register			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately

With MD 5601: ALARM_MASK_RESET can be set to conceal Reset alarms. If the relevant bit is set to 0, the corresponding error monitoring function is active. If the bit=1, the relevant error message is suppressed. The default setting is active for all monitoring functions.

With MD 5613: ALARM_REACTION_RESET is set to configure changeover of the relevant Reset alarm.

Alarm messages, see Chapter 6, numbers 300600...300699.

"Limit frequency reached" measuring circuit

5609	ENC_SPEED_LIMIT				Cross reference: -
	Max. measuring velocity of linear scale			Related to: HLA	Protection level: 3/3
Unit: mm/min	Default: 240 000.0	Minimum: 1.0	Maximum: 240 000.0	Data type: FLOAT	Active: Immediately

The limit frequency of the measured-value conditioning hardware is monitored with respect to A/B signals. The limit frequency is calculated from machine data MD 5005 and MD 5609. It is approximately 100 kHz and is normally specified by the measuring system manufacturer.

Maximum measuring velocity (MD 5609) / increments (MD 5005) = encoder limit frequency

Example: 120 000 mm/min / 20 µm = 100 kHz

Velocity controller at limit

5605	SPEEDCTRL_LIMIT_TIME				Cross reference: -
	Time for velocity controller at limit			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 200.0	Minimum: 20.0	Maximum: 1000.0	Data type: FLOAT	Active: Immediately

5606	SPEEDCTRL_LIMIT_THRESHOLD				Cross reference: -
	Threshold for velocity controller at limit			Related to: HLA	Protection level: 3/3
Unit: mm/min	Default: 120 000.0	Minimum: 0.0	Maximum: 120 000.0	Data type: FLOAT	Active: Immediately

A message is activated if the manipulated voltage at the D/A converter is continuously for at the limit a set period and, at the same time, the actual velocity is lower than a set threshold (MD 5606).

Valve spool not responding

5614	VALVE_ERROR_TIME				Cross reference: -
	Valve spool monitoring timer			Related to: HLA	Protection level: 3/3
Unit: ms	Default: 50	Minimum: 1	Maximum: 100	Data type: UNS.WORD	Active: Immediately

The valve spool position is returned for all Rexroth servo solenoid valves from the preferred range (see Subsection 2.3.2). The message “Valve spool is not responding” is output if the valve spool position exits the tolerance field of 10% of maximum stroke around the setpoint for longer than the time set in MD 5614 when the power is enabled. This error message cannot be output if no check-back signal is configured for the valve spool position (MD 5530).

4.13.2 Variable signaling functions

Input bit field for controlling the variable signaling function.

5620	PROG_SIGNAL_FLAGS				Cross reference: -
	Variable signaling function bits Bit 0= 0: Variable signaling function; not active 1: Variable signaling function; active Bit1= 0: Variable signaling function segment; address space X 1: Variable signaling function segment; address space Y Bit 2=0: Compar. var. sign. fct.; compare without sign 1: Compar. var. sign. fct.; compare with sign			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: 7	Data type: UNS.WORD	Active: Immediately

---

Note

Bit 1 is **only** effective, if the signal number 0 is selected in MD 1651:PROG_SIGNAL_NR.

Any memory location from address space X or Y in the data RAM can be monitored for violation of a set threshold for the variable signaling function. A tolerance band can be set around this threshold; this is taken into account when the threshold is scanned for violation in either direction. Any violation of the tolerance band is signaled to the PLC. This violation message can be linked to a pickup and/or dropout delay. The signaling function operates in a 4 ms cycle.

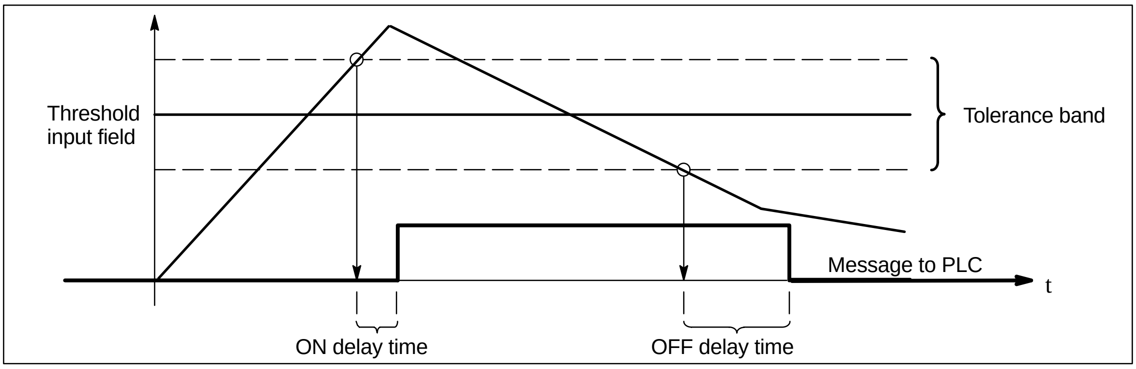


Fig. 4-21 Variable signaling function

Note

The quantity to be monitored can be selected through specification of either a signal number or a physical address, the physical address having relevance **only** for Siemens servicing activities.

The following machine data corresponds to MD 5620:

- MD 5621: PROG_SIGNAL_NR
- MD 5622: PROG_SIGNAL_ADDRESS
- MD 5623: PROG_SIGNAL_THRESHOLD
- MD 5624: PROG_SIGNAL_HYSTERESIS
- MD 5625: PROG_SIGNAL_ON_DELAY
- MD 5626: PROG_SIGNAL_OFF_DELAY

Note

If changes are made to machine data MD 5621 to MD 5624 while monitoring is already active (≙ MD 5620, Bit 0 = 1), they do not automatically reinitialize the PLC message, i.e. reset it to 0. If the message must be re-initialized, the monitoring function must be switched off and on again via MD 5620, bit 0, after the MD setting has been changed.

5621	PROG_SIGNAL_NR				Cross reference: -
Signal number of variable signaling function				Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 100	Data type: UNS. WORD	Active: Immediately

Enter the signal number of the memory location to be monitored by the variable signaling function.

Table 4-9 Signal number variable signal function

Signal number	Signal designation	Normalization (LSB corresponds to:)
0	No signal	-
1	No signal	-
2	Pressure p(A) (with pressure sensing)	MD 5710[1)]
3	Pressure p(B) (with pressure sensing)	MD 5710[1)]
4	Actual valve spool value	MD 5709[1)]
5	Valve spool setpoint	MD 5709[1)]
6	Actual velocity value	MD 5711[1)]
7	Velocity setpoint (before filter, limitation)	MD 5711[1)]
8	Velocity setpoint (downstream of filter, limitation)	MD 5711[1)]
9	Velocity setpoint reference model	MD 5711[1)]
10	Actual force (with pressure sensing)	MD 5713[1)]
11	Active power	1 inc → 0.01 kW
12	Velocity controller differential	MD 5711[1)]
13	Velocity controller P component	MD 5709[1)]
14	Velocity controller I component	MD 5709[1)]
15	Velocity controller D component	MD 5709[1)]
16	Velocity controller feedforward control component	MD 5709[1)]
17	Friction feedforward control component velocity controller	MD 5709[1)]
18	Velocity controller output (before filter)	MD 5709[1)]
19	Velocity controller output (after filter)	MD 5709[1)]
20	Actual position value	MD 5714[1)]
21	Force setpoint	MD 5713[1)]
22	Force controller control deviation	MD 5713[1)]
23	P component of force controller	MD 5709[1)]
24	I component of force controller	MD 5709[1)]
25	D component of force controller	MD 5709[1)]
26	Feedforward control component force controller	MD 5709[1)]
27	Force controller output	MD 5709[1)]
28	Zero mark signal	-
29	BERO signal	-

1) See Subsection 4.14.3

5622	PROG_SIGNAL_ADDRESS				Cross reference: -
	Address of variable signaling function			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFFFF	Data type: UNS.DWORD	Active: Immediately

Enter the address of the memory location to be monitored by the variable signaling function.

Note

This machine data is effective **only** if the signal number is set to 0 (see MD 5621).

5623	PROG_SIGNAL_THRESHOLD				Cross reference: -
	Threshold of variable signaling function			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFFFF	Data type: UNS.DWORD	Active: Immediately

Enter the threshold for the memory location address entered in MD 5622: PROG_SIGNAL_ADDRESS which is to be monitored by the variable signaling function. In combination with MD 5624: PROG_SIGNAL_HYSTERESIS, this defines the actual value to be checked by the monitoring function (see diagram under MD 5620, Fig. 4-21).

Note

Depending on machine data MD 5620: PROG_SIGNAL_FLAGS, the numerical value entered in MD 5624 is interpreted as an unsigned value (bit 2 = 0) or a signed value (bit 2 = 1).

5624	PROG_SIGNAL_HYSTERESIS				Cross reference: -
	Hysteresis of variable signaling function			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFFFF	Data type: UNS.DWORD	Active: Immediately

Enter the hysteresis (tolerance band) for the memory location address entered in MD 5622: PROG_SIGNAL_ADDRESS which is to be monitored by the variable signaling function. In combination with MD 5623: PROG_SIGNAL_THRESHOLD, this defines the actual value to be checked by the monitoring function (see diagram under MD 5620, Fig. 4-21).

Note

Depending on MD 5620: PROG_SIGNAL_FLAGS, the numerical value entered in MD 5624 is interpreted as an unsigned value (bit 2 = 0) or a signed value (bit 2 = 1).

5625	PROG_SIGNAL_ON_DELAY				Cross reference: -
	Pickup delay of variable signaling function			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 10 000	Data type: UNS.DWORD	Active: Immediately

Enter the pickup delay for setting the message if the monitored quantity exceeds the set threshold (with hysteresis) (see diagram under MD 5620, Fig. 4-21).

Note

Changing the settings in MD 5625: PROG_SIGNAL_ON_DELAY and MD 5626: PROG_SIGNAL_OFF_DELAY affects a time watchdog that is already running. The monitor is initialized with the new time settings.

5626	PROG_SIGNAL_OFF_DELAY				Cross reference: -
	Dropout delay of variable signaling function			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: 10 000	Data type: UNS.WORD	Active: Immediately

Enter the dropout delay for resetting the message if the monitored quantity drops below the set threshold (with hysteresis) (see diagram under MD 5620, Fig. 4-21).

Note

Changing the settings in MD 5625: PROG_SIGNAL_ON_DELAY and MD 5626: PROG_SIGNAL_OFF_DELAY affects a time watchdog that is already running. The monitor is initialized with the new time settings.

4.14 Service functions

For explanations regarding the

- Measuring functions
  - Measurement of valve control loop
  - Measurement of velocity control loop
  - Position control measurement
- Function generator
- Circularity test
- Servo trace
- DAC configuration

see Subsection 3.11, Start-up functions.

5650	DIAGNOSIS_CONTROL_FLAGS				Cross reference: -
Diagnostic control Bit 0: Min/max memory Bit 1: Min/max memory segment Bit 2: Compare signed Bit 8: Conversion of velocities to forces Measuring functions, function generator Bit 9: Conversion of function generator to valve characteristic identification Bit 12: Offset adjustment P_a, P_b Bit 13: Offset adjustment valve spool setpoint				Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately

MD 5650 is important for diagnostic and start-up purposes.

For information about adjusting the pressure sensor and valve setpoint offsets, see Subsection 3.9.2.

To start up the force controller, it is possible to redirect the measuring functions and function generator from the velocity controller to the force controller by setting bit 8 (see Section 4.4).

4.14.1 Min/max display

Note

Machine data MD 5651 to MD 5654 are relevant **only** for internal Siemens functions and **must not be changed**.

5651	MINMAX_SIGNAL_NR				Cross reference: -
Signal number of min/max memory				Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately
5652	**MINMAX_ADDRESS**				**Cross reference: -**
Memory location in min/max memory				Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFFFF	Data type: UNS.DWORD	Active: Immediately

5653	MINMAX_MIN_VALUE				Cross reference: -
	Minimum value of min/max memory			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFFFF	Data type: UNS.DWORD	Active: Immediately
5654	**MINMAX_MAX_VALUE**				**Cross reference: -**
	Maximum value of min/max memory			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFFFF	Data type: UNS.DWORD	Active: Immediately

4.14.2 Monitor

Note

Machine data MD 5655 to MD 5659 are relevant **only** for internal Siemens functions and **must not be changed**.

5655	MONITOR_SEGMENT				Cross reference: -
	Monitor memory location segment			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately
5656	**MONITOR_ADDRESS**				**Cross reference: -**
	Monitor memory location address			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFFFF	Data type: UNS.DWORD	Active: Immediately
5657	**MONITOR_DISPLAY**				**Cross reference: -**
	Monitor value display			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFFFF	Data type: UNS.DWORD	Active: Immediately
5658	**MONITOR_INPUT_VALUE**				**Cross reference: -**
	Monitor value input			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFFFF	Data type: UNS.DWORD	Active: Immediately
5659	**MONITOR_INPUT_STROBE**				**Cross reference: -**
	Monitor value transfer			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately

4.14.3 Diagnostic machine data

Various machine data is provided in the HLA module for diagnostic purposes. NC diagnostic displays are available in a similar way to those used on electrical drives.

5700	**TERMINAL_STATE**				**Cross reference: -**
	Status of binary inputs Bit 0: 26.5 V supply available Bit 1: Term. 663 available Bit 2: Term. 63 available Bit 3: HW enable aggregate signal set Bit 5: Setup mode selected Bit 6: Term. 64 available Bit 12: 24 V servo solenoid valve ON Bit 13: 24 V shutoff valve ON			Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately
5704	**ACTUAL_PRESSURE_A**				**Cross reference: -**
	Actual pressure A			Related to: HLA	Protection level: 3/3
Unit: bar	Default: 0.0	Minimum: -10000.0	Maximum: 10000.0	Data type: FLOAT	Active: Immediately
5705	**ACTUAL_PRESSURE_B**				**Cross reference: -**
	Actual pressure B			Related to: HLA	Protection level: 3/3
Unit: bar	Default: 0.0	Minimum: -10000.0	Maximum: 10000.0	Data type: FLOAT	Active: Immediately
5706	**DESIRED_SPEED**				**Cross reference: -**
	Velocity setpoint			Related to: HLA	Protection level: 3/3
Unit: mm/min	Default: 0.0	Minimum: -240000.0	Maximum: 240000.0	Data type: FLOAT	Active: Immediately
5707	**ACTUAL_SPEED**				**Cross reference: -**
	Actual velocity value			Related to: HLA	Protection level: 3/3
Unit: mm/min	Default: 0.0	Minimum: -240000.0	Maximum: 240000.0	Data type: FLOAT	Active: Immediately
5709	**VOLTAGE_LSB**				**Cross reference: -**
	Significance of voltage representation Defines how many volts [V] correspond to 1 increment of the internal voltage format (valve spool setpoint/actual value).			Related to: HLA	Protection level: 3/3
Unit: V	Default: 0.0	Minimum: -100000.0	Maximum: 100000.0	Data type: FLOAT	Active: Immediately
5710	**PRESSURE_LSB**				**Cross reference: -**
	Significance of pressure representation Defines the pressure in [bar] corresponding to 1 increment of the internal pressure format.			Related to: HLA	Protection level: 3/3
Unit: bar	Default: 0.0	Minimum: -240000.0	Maximum: 240000.0	Data type: FLOAT	Active: Immediately

5711	**SPEED_LSB**				**Cross reference: -**
	Significance of velocity representation Defines the velocity in [mm/min] corresponding to 1 increment of the internal velocity format.			Related to: HLA	Protection level: 3/3
Unit: mm/min	Default: 0.0	Minimum: -240000.0	Maximum: 240000.0	Data type: FLOAT	Active: Immediately
5713	**FORCE_LSB**				**Cross reference: -**
	Significance of force representation Defines the force in [µN] corresponding to 1 increment of the internal force format.			Related to: HLA	Protection level: 3/3
Unit: µN	Default: 0.0	Minimum: -10000000.0	Maximum: 10000000.0	Data type: FLOAT	Active: Immediately
5714	**POSITION_LSB**				**Cross reference: -**
	Significance of position representation Defines the position in [nm] corresponding to 1 increment of the internal position format.			Related to: HLA	Protection level: 3/3
Unit: nm	Default: 0.0	Minimum: -1000000.0	Maximum: 1000000.0	Data type: FLOAT	Active: Immediately
5715	**DESIRED_VALVE_SPOOL_POS**				**Cross reference: -**
	Voltage for valve spool position setpoint			Related to: HLA	Protection level: 3/3
Unit: V	Default: 0.0	Minimum: -10.0	Maximum: 10.0	Data type: FLOAT	Active: Immediately
5716	**ACTUAL_VALVE_SPOOL_POS**				**Cross reference: -**
	Voltage for actual valve spool position value			Related to: HLA	Protection level: 3/3
Unit: V	Default: 0.0	Minimum: -10.0	Maximum: 10.0	Data type: FLOAT	Active: Immediately
5725	**MAX_FORCE_FROM_NC**				**Cross reference: -**
	Normalization of force setpoint interface in high-speed PLC data channel. 4000hex corresponds to value in MD 5725.			Related to: HLA	Protection level: 3/3
Unit: N	Default: 0.0	Minimum: 0.0	Maximum: 10000000.0	Data type: FLOAT	Active: Immediately

The value in MD 5725 equals 100% of the set value from the NC program (FXST[X]=100).

5740	**ACTUAL_POSITION**				**Cross reference: -**
	Actual position in relation to machine zero			Related to: HLA	Protection level: 3/3
Unit: mm	Default: 0.0	Minimum: -10000000.0	Maximum: 10000000.0	Data type: FLOAT	Active: Immediately
5741	**ACTUAL_PISTON_POSITION**				**Cross reference: -**
	Piston position in relation to piston zero			Related to: HLA	Protection level: 3/3
Unit: mm	Default: 0.0	Minimum: -10000000.0	Maximum: 10000000.0	Data type: FLOAT	Active: Immediately

5730	OPERATING_MODE				Cross reference: -
Operating mode display Bit 0=1: Velocity controller active Bit 1=1: Force limitation active Bit 2=1: Friction torque compensation active Bit 3=1: Velocity controller adaptation active (MD 5413=1) Bit 4=1: Piston position known Bit 8=1: Force limitation 1 set (MD 5241 Bit 0=1) Bit 9=1: Friction torque compensation set (MD 5241 Bit 1=1) Bit 10=1: Force limitation 2 set (MD 5241 Bit 2=1)				Related to: HLA	Protection level: 3/3
Unit: HEX	Default: 1	Minimum: 1	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately
5790	**ENC_TYPE**				**Cross reference: -**
Measuring circuit type of measuring system 0: IPU (V) unconditioned voltage signals 1...15: Reserved 16: EnDat encoder 48: SSI encoder				Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: -1	Maximum: 32767	Data type: WORD	Active: Immediately
5720	**CRC_DIAGNOSIS**				**Cross reference: -**
CRC diagnostic parameter				Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS. WORD	Active: Immediately

The purpose of machine data MD 5720 is to display any detected CRC errors (cyclic redundancy check). The counter information is displayed on every read request and is 5 bits wide (bit 4...bit 0 or count 0...31).

Note

The assignment of CRC errors to the respective drives is not assured in all cases. The “wrong” module (if installed) displays the error when the address is incorrect.

5708	ACTUAL_CYL_FORCE				Cross reference: -
Actual cylinder force				Related to: HLA	Protection level: 3/3
Unit: N	Default: 0.0	Minimum: -10000000.0	Maximum: 10000000.0	Data type: FLOAT	Active: Immediately

The cylinder force is calculated from the actual pressures in A and B (provided that pressure sensors are connected at X111/X112) and displayed in MD 5708. This value is irrelevant if no pressure sensor is connected.

5717	DESIRED_CYL_FORCE				Cross reference: -
Cylinder force setpoint				Related to: HLA	Protection level: 3/3
Unit: N	Default: 0.0	Minimum: -10000000.0	Maximum: 10000000.0	Data type: FLOAT	Active: Immediately

If the force controller (force limitation or friction injection) has been activated in MD 5241, the effective force setpoint is displayed here. This can be specified by:

- the force limitation (MD 5230 or 5231)
- the friction injection (MD 5234 or MD 5235)
- the NC via the "Travel to fixed stop" function

It must be noted that the force controller is activated only in conjunction with friction injection and zero speed or with force limitation and violation of the upper force limit. The voltage setpoint of the velocity controller is otherwise applied, in which case the force setpoint is irrelevant.

Software version

5797	**PBL_VERSION**				**Cross reference: -**
	Data version			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately

Output of current data version (machine data list).

5798	**FIRMWARE_DATE**				**Cross reference: -**
	Firmware date			Related to: HLA	Protection level: 3/3
Unit: -	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS.WORD	Active: Immediately

Output of coded software release. The display is decimal. The character string has the following format:

DDMMY, in which DD stands for day, MM for month and Y = last digit of year.

Example: The code for 01.06.1993 is 1063_{dec}

5799	**FIRMWARE_VERSION**				**Cross reference: -**
	Firmware version			Related to: HLA	Protection level:
Unit: -	Default: 0	Minimum: 0	Maximum: FFFFFF	Data type: UNS.DWORD	Active: Read-only

Output of current software release. The display is decimal, e.g. 21000. This is the code for SW version 2.10/00.

Processor capacity utilization

5735	PROCESSOR_UTILIZATION				Cross reference: -
	Processor capacity utilization			Related to: HLA	Protection level: 3/3
Unit: %	Default: 0	Minimum: 0	Maximum: FFFF	Data type: UNS. WORD	Active: Read-only

The processor capacity utilization display provides online information about available computing capacity.

4.15 Parameters table

Default value

The machine data is preset to this value during start-up.

Range of values (minimum and maximum)

Specifies the input limits. If no range of values is specified, the data type determines the input limits and the field is marked “∗∗∗”.

Changes take effect

- POWER ON (po) “RESET” key on front panel of NCU module or disconnection and reconnection of power supply or “NCK reset” soft key
- NEW_CONF (cf)
  - “Set MD active” soft key on HMI
  - “RESET” key on control unit,
  - Changes at block ends possible in program mode
- RESET at end of program M2/M30
- RESET (re) “RESET” key on control unit or
- Immediately (im) after entry of the value

The levels of effectiveness have been listed above in order of priority.

Protection level

Protection levels 0 to 7 have been used. The lock for protection levels 0 to 3 (4 to 7) can be canceled by entering the correct password (correct keyswitch position). The operator only has access to information protected by one particular level and the levels below it.

Meanings of numbers
0 or 10: SIEMENS
1 or 11: OEM-HIGH
2 or 12: OEM-LOW
3 or 13: End user
4 or 14: Keyswitch position 3
5 or 15: Keyswitch position 2
6 or 16: Keyswitch position 1
7 or 17: Keyswitch position 0

Unit	The unit relates the the machine data default SCALING_FACTOR_USER_DEF_MASK and SCALING_FACTOR_USER_DEF. The field is identified with “-” if the MD is not based on a physical unit.
Index	Selectable data sets associated with one parameter.
Data type	The following data types are used in the control system:

- BOOLEAN — Machine data bit (1 or 0)
- BYTE — Integers (from -128 to +127)
- DOUBLE — Real values or integers (from +/-4.19*10^{-307} to +/-1.67*10^{308})
- DWORD — Integers (from -2.147*10^{9} to +2.147*10^{9})
- STRING — Character string (max. 16 characters) consisting of capital letters with digits and underscore
- UNSIGNED WORD — Integers (from 0 to 65536)
- SIGNED WORD — Integers (from -32768 to 32767)
- UNSIGNED DWORD — Integers (from 0 to 4294967300)
- SIGNED DWORD — Integers (from -2147483650 to 2147483649)
- WORD — Hex values (from 0000 to FFFF)
- DWORD — Hex values (from 00000000 to FFFFFFFF)
- FLOAT DWORD — Real values (from “8.43*10^{-37} to ”3.37*10^{38})

Version	HLA firmware 1.02.12

MD no.	Name in plaintext	Name in NC	Version	Min.	Max.	Unit	Data type	Attribute		Sec-tion	Firm-ware-Version
								Index	Active		
5001	Velocity controller cycle	SPEEDCTRL_CYCLE_TIME	4	2	16	31.25µs	UNS.WORD		Power On	4.3.2	1.01
5002	Monitoring cycle	MONITOR_CYCLE_TIME	3200	128	3200	31.25µs	UNS.WORD		Power On	-	1.01
5003	Configuration STS	STS_CONFIG	0330	0	07F0	HEX	WORD		Power On	-	1.01
5004	Configuration structure	CTRL_CONFIG	1000	0	1000	HEX	UNS.WORD		Power On	4.3.1	1.01
5005	Encoder resolution for rotary measuring system	ENC_RESOL_MOTOR	2048	128	65535	-	UNS.WORD		Power On	-	1.01
5008	Encoder phase error correction	ENC_PHASE_ERROR_CORRECTION	0.0	-20.0	20.0	Degrees	FLOAT		immediately	4.10	1.01
5011	Actual-value sensing configuration	ACTUAL_VALUE_CONFIG	0	0	65535	HEX	UNS.WORD		Power On	4.10	1.01
5012	Function switch	FUNC_SWITCH	4	0	65535	HEX	UNS.WORD		immediately	4.12	1.01
5021	Multi-turn resolution absolute value enc. in motor	ENC_ABS_TURNS_MOTOR	0	0000	65535	U	WORD		Power On	4.10	1.01
5022	Measuring steps of absolute track in motor	ENC_ABS_RESOL_MOTOR	8192	0000	524287	-	DWORD		Power On	4.10	1.01
5023	Diagnosis meas. circ. motor abs. track	ENC_ABS_DIAGNOSIS_MOTOR	0	0	BFFF	-	UNS.WORD		immediately	4.10	1.01
5024	Linear scale graduations	DIVISION_LIN_SCALE	20000	1000	5000000	nm	UNS.WORD		Power On	4.10	1.01
5025	Serial number of motor measuring system	SERIAL_NO_ENCODER	0	0	4294967295	-	UNS.WORD		Power On	4.10	1.02.04
5027	Configuration of encoder IM	ENC_KONFIG	0	0000H	FFFFH	-	WORD		Power On	4.10	1.02.04
5028	IM message frame length SSI	NO_TRANSMISSION_BITS	25	0	25	-	WORD		Power On	4.10	1.02.04
5040	Piston zero in relation to machine zero	PISTON_ZERO	0.0	-1000000.0	100000.0	mm	FLOAT		immediately	4.10	1.01
5041	Machine zero in relation to actual position zero	MACHINE_ZERO_HIGH	0	-2147483647	7FFFFFFF	HEX	SIGN.DWORD		immediately	-	1.01
5042	Machine zero in relation to actual position zero	MACHINE_ZERO_LOW	0	0	FFFFFFFF	HEX	UNS.WORD		immediately	-	1.01
5100	Modulus of elasticity of hydraulic fluid	FLUID_ELASTIC_MODULUS	11000	1000	21000	bar	FLOAT		immediately	4.6	1.01
5101	System pressure	WORKING_PRESSURE	0.0	0.0	700.0	bar	FLOAT		Power On	4.6	1.01
5102	Pilot pressure	PILOT_OPERATION_PRESSURE	0.0	0.0	350.0	bar	FLOAT		immediately	4.6	1.01
5106	Valve code number	VALVE_CODE	0	0	2000	-	UNS.WORD		immediately	4.7	1.01
5107	Nominal valve flowrate	VALVE_NOMINAL_FLOW	0.0	0.0	1000.0	l/min	FLOAT		immediately	4.7	1.01
5108	Nominal pressure drop of valve	VALVE_NOMINAL_PRESSURE	35.0	1.0	200.0	bar	FLOAT		immediately	4.7	1.01
5109	Nominal voltage of valve	VALVE_NOMINAL_VOLTAGE	10.0	0.5	15.0	V	FLOAT		immediately	4.7	1.01
5110	Knee-point flow rate of valve	VALVE_DUAL_GAIN_FLOW	10.0	0.2	95.0	%	FLOAT		immediately	4.7	1.01
5111	Knee-point voltage of valve	VALVE_DUAL_GAIN_VOLTAGE	10.0	0.2	95.0	%	FLOAT		immediately	4.7	1.01
5112	Valve flow ratio betw. A and B ends	VALVE_FLOW_FACTOR_A_B	1.0	0.5	2.0		FLOAT		immediately	4.7	1.01

MD no.	Name in plaintext	Name in NC	Version	Min.	Max.	Unit	Data type	Attribute		Sec-tion	Firm-ware-Version
								Index	Active		
5113	Valve configuration	VALVE_CONFIGURATION	0	0	1	HEX	UNS.WORD		immediately	4.7	1.01
5114	Natural frequency of valve	VALVE_NATURAL_FREQUENCY	150.0	1.0	1000.0	Hz	FLOAT		immediately	4.7	1.01
5115	Valve damping	VALVE_DAMPING	0.8	0.4	1.0	-	FLOAT		immediately	4.7	1.01
5131	Cylinder piston rod diameter	CYLINDER_PISTON_DIAMETER	0.0	0.0	2500	mm	FLOAT		Power On	4.8	1.01
5132	Cylinder piston rod diameter A	CYLINDER_ROD_A_DIAMETER	0.0	0.0	2400	mm	FLOAT		Power On	4.8	1.01
5133	Cylinder piston rod diameter B	CYLINDER_ROD_B_DIAMETER	0.0	0.0	2400	mm	FLOAT		Power On	4.8	1.01
5134	Piston stroke	PISTON_STROKE	0.0	0.0	3000.0	mm	FLOAT		immediately	4.8	1.01
5135	Cylinder dead voltage A end	CYLINDER_DEAD_VOLUME_A	0.0	0.0	200000.0	ccm	FLOAT		immediately	4.8	1.01
5136	Cylinder dead voltage B end	CYLINDER_DEAD_VOLUME_B	0.0	0.0	200000.0	ccm	FLOAT		immediately	4.8	1.01
5140	Valve-cylinder connection configuration	VALVE_CYLINDER_CONNECTION	0	0	1	HEX	UNS.WORD		immediately	4.9	1.01
5141	Pipe length at A end	PIPE_LENGTH_A	0.0	0.0	10000.0	mm	FLOAT		immediately	4.9	1.01
5142	Pipe length at B end	PIPE_LENGTH_B	0.0	0.0	10000.0	mm	FLOAT		immediately	4.9	1.01
5143	Internal pipe diameters at A and B	PIPE_INNER_ DIAMETER_A_B	5.0	0.0	100.0	mm	FLOAT		immediately	4.9	1.01
5150	Moved drive mass	DRIVE_MASS	0.0	0.0	50000.0	kg	FLOAT		immediately	4.9	1.01
5151	Cylinder mounting position referred to A end	CYLINDER_A_ORIENTATION	0.0	-90.0	90.0	Degrees	FLOAT		immediately	4.9	1.01
5152	Cylinder mounting method	CYLINDER_FASTENING	0	0	1	-	UNS.WORD		immediately	4.9	1.01
5160	Min. natural frequency piston position	PISTON_POS_MIN_NAT_FREQ	0.0	0.0	3000.0	mm	FLOAT		immediately	4.9	1.01
5161	Drive damping	DRIVE_DAMPING	0.1	0.01	1.0	-	FLOAT		immediately	4.9	1.01
5162	Natural frequency of drive A	DRIVE_NATURAL_FREQUENCY_A	1.0	1.0	2000.0	Hz	FLOAT		immediately	4.9	1.01
5163	Natural frequency of drive	DRIVE_NATURAL_FREQUENCY	1.0	1.0	2000.0	Hz	FLOAT		immediately	4.9	1.01
5164	Natural frequency of drive B	DRIVE_NATURAL_FREQUENCY_B	1.0	1.0	2000.0	Hz	FLOAT		immediately	4.9	1.01
5180	Selected damping for closed-loop system	CLOSED_LOOP_SYSTEM_DAMPING	0.7	0.2	1.0	-	FLOAT		immediately	4.9	1.01
5200	Number of control output filters in velocity controller	NUM_OUTPUT_VCTRL_FILTERS	0	0	2	-	UNS.WORD	0...7	immediately	4.3.2	1.01
5201	Control output filter type in velocity controller	OUTPUT_VCTRL_FILTER_CONFIG	0	0	3	-	UNS.WORD	0...7	immediately	4.3.2	1.01
5202	Natur. freq. control output filter 1 velocity controller	OUTPUT_VCTRL_FIL_1_FREQ	1000.0	10.0	8000.0	Hz	FLOAT	0...7	immediately	4.3.2	1.01
5203	Damping control output filter 1 velocity controller	OUTPUT_VCTRL_FIL_1_DAMP	1.0	0.05	1.0	-	FLOAT	0...7	immediately	4.3.2	1.01
5204	Natur. freq. control output filter 2 velocity controller	OUTPUT_VCTRL_FIL_2_FREQ	1000.0	10.0	8000.0	Hz	FLOAT	0...7	immediately	4.3.2	1.01
5205	Damping control output filter 2 velocity controller	OUTPUT_VCTRL_FIL_2_DAMP	1.0	0.05	1.0		FLOAT	0...7	immediately	4.3.2	1.01

MD no.	Name in plaintext	Name in NC	Version	Min.	Max.	Unit	Data type	Attribute		Sec-tion	Firm-ware-Version
								Index	Active		
5210	Blocking freq. control output filter 1 vel. controller	OUTPUT_VCTRL_FIL_1_SUP_FREQ	3500.0	1.0	7999.0	Hz	FLOAT	0...7	immediately	4.3.2	1.01
5211	Bandwidth control output filter 1 velocity controller	OUTPUT_VCTRL_FIL_1_BW	500.0	5.0	7999.0	Hz	FLOAT	0...7	immediately	4.3.2	1.01
5212	Num. bandwith contr. output filter vel. controller	OUTPUT_VCTRL_FIL_1_BW_NUM	0.0	0.0	7999.0	Hz	FLOAT	0...7	immediately	4.3.2	1.01
5213	Blocking freq. control output filter 2 vel. controller	OUTPUT_VCTRL_FIL_2_SUP_FREQ	3500.0	1.0	7999.0	Hz	FLOAT	0...7	immediately	4.3.2	1.01
5214	Bandwidth control output filter 2 velocity controller	OUTPUT_VCTRL_FIL_2_BW	500.0	5.0	7999.0	Hz	FLOAT	0...7	immediately	4.3.2	1.01
5215	Num. bandwith contr. output filter 2 veloc. controller	OUTPUT_VCTRL_FIL_2_BW_NUM	0.0	0.0	7999.0	Hz	FLOAT	0...7	immediately	4.3.2	1.01
5230	Force limitation tolerance threshold about weight	FORCE_LIMIT_THRESHOLD	10000.0	0.0	100000000.0	N	FLOAT	0...7	immediately	4.4.1	1.01
5231	Weight force limitation	FORCE_LIMIT_WEIGHT	0.0	-100000000.0	100000000.0	N	FLOAT	0...7	immediately	4.4.1	1.01
5232	Velocity threshold for static friction	STICTION_SPEED_THRESHOLD	10.0	0.0	500.0	mm/min	FLOAT		immediately	4.4.2	1.01
5233	Cutoff limit static friction	STICTION_COMP_THRESHOLD	40.0	3.0	100.0	%	FLOAT		immediately	4.4.2	1.01
5234	Friction force at velocity >0	STICTION_FORCE_POS	100.0	-100000000.0	100000000.0	N	FLOAT		immediately	4.4.2	1.01
5235	Friction force at velocity <0	STICTION_FORCE_NEG	-100.0	-100000000.0	100000000.0	N	FLOAT		immediately	4.4.2	1.01
5240	Force controlled controlled-system gain	FORCECONTROLLED_SYSTEM_GAIN	0.0	0.0	100000000.0	N/V	FLOAT		immediately	4.4.3	1.01
5241	Force controller configuration	FORCECTRL_CONFIG	0	0	6	HEX	UNS.WORD	0...7	immediately	4.4	1.01
5242	Force controller P gain	FORCECTRL_GAIN	0.0	0.0	10000.0	-	FLOAT	0...7	immediately	4.4.3	1.01
5243	Reduction of force controller P component	FORCECTRL_GAIN_RED	40.0	0.1	100.0	%	FLOAT		immediately	4.4.3	1.01
5244	Force controller reset time	FORCECTRL_INTEGRATOR_TIME	40.0	0.0	2000.0	ms	FLOAT	0...7	immediately	4.4.3	1.01
5245	Force controller smoothing time constant	FORCECTRL_PT1_TIME	0.5	0.25	100.0	ms	FLOAT	0...7	immediately	4.4.3	1.01
5246	Force controller D-action time	FORCECTRL_DIFF_TIME	0.0	-10000.0	10000.0	ms	FLOAT	0...7	immediately	4.4.3	1.01
5247	Feedforward control factor for force controller	FORCE_FFW_WEIGHT	100.0	0.0	120.0	%	FLOAT		immediately	4.4.3	1.01
5260	No. of force controller feedforward control filters	NUM_FFW_FCTRL_FILTERS	0	0	1	-	UNS.WORD	0...7	immediately	4.4.3	1.01
5261	Type of feedforward control filter in force controller	FFW_FCTRL_FILTER_TYPE	0	0	1	-	UNS.WORD	0...7	immediately	4.4.3	1.01
5264	PT2-natur. freq. feedforward control filter1	FFW_FCTRL_FIL_1_FREQ	2000.0	10.0	8000.0	Hz	FLOAT	0...7	immediately	4.4.3	1.01
5265	PT2 damping for feedforward control filter 1	FFW_FCTRL_FIL_1_DAMP	0.7	0.2	1.0	-	FLOAT	0...7	immediately	4.4.3	1.01
5268	Blocking frequency of feedforward control filter 1	FFW_FCTRL_FIL_1_SUP_FREQ	3500.0	10.0	7999.0	Hz	FLOAT	0...7	immediately	4.4.3	1.01
5269	Bandwidth of feedforward control filter 1	FFW_FCTRL_FIL_1_BW	500.0	5.0	7999.0	Hz	FLOAT	0...7	immediately	4.4.3	1.01
5270	Numerator bandwidth feedforward control filter 1	FFW_FCTRL_FIL_1_BW_NUM	0.0	0.0	7999.0	Hz	FLOAT	0...7	immediately	4.4.3	1.01
5280	Number of control output filters	NUM_OUTPUT_FILTERS	0	0	1	-	UNS.WORD	0...7	immediately	4.5.2	1.01

MD no.	Name in plaintext	Name in NC	Version	Min.	Max.	Unit	Data type	Attribute		Sec-tion	Firm-ware-Version
								Index	Active		
5281	Type of control output filter	OUTPUT_FILTER_TYPE	0	0	1	-	UNS.WORD	0...7	immediately	4.5.2	1.01
5284	Natural frequency of control output filter 1	OUTPUT_FIL_1_FREQ	1000.0	10.0	8000.0	Hz	FLOAT	0...7	immediately	4.5.2	1.01
5285	Damping of control output filter 1	OUTPUT_FIL_1_DAMP	1.0	0.05	1.0	-	FLOAT	0...7	immediately	4.5.2	1.01
5288	Blocking frequency of control output filter 1	OUTPUT_FIL_1_SUP_FREQ	3500.0	1.0	7999.0	Hz	FLOAT	0...7	immediately	4.5.2	1.01
5289	Bandwidth of control output filter 1	OUTPUT_FIL_1_BW	500.0	5.0	7999.0	Hz	FLOAT	0...7	immediately	4.5.2	1.01
5290	Numerator bandwidth control output filter 1	OUTPUT_FIL_1_BW_NUM	0.0	0.0	7999.0	Hz	FLOAT	0...7	immediately	4.5.2	1.01
5401	Maximum useful velocity	DRIVE_MAX_SPEED	0.0	0.0	120000.0	mm/min	FLOAT		Power On	4.3.1	1.01
5402	Braking time for controller disable	SPEED_CTRL_DISABLE_STOPTIME	0.0	0.0	120000.0	ms	FLOAT		immediately	4.12	1.01
5404	Power disable timer	POWER_DISABLE_DELAY	100	0	100000	ms	FLOAT		immediately	4.12	1.01
5406	P gain of velocity controller A	SPEEDCTRL_GAIN_A	0.0	-100.0	1000.0	%	FLOAT	0...7	immediately	4.3.2	1.01
5407	P gain of velocity controller	SPEEDCTRL_GAIN	0.0	-100.0	1000.0	%	FLOAT	0...7	immediately	4.3.2	1.01
5408	P gain of velocity controller_B	SPEEDCTRL_GAIN_B	0.0	-100.0	1000.0	%	FLOAT	0...7	immediately	4.3.2	1.01
5409	Reset time of velocity controller	SPEEDCTRL_INTEGRATOR_TIME	0.0	0.0	2000.0	ms	FLOAT	0...7	immediately	4.3.2	1.01
5413	Selection of velocity controller adaptation	SPEEDCTRL_ADAPT_ENABLE	0	0	1	-	UNS.WORD		immediately	4.3.2	1.01
5414	Natural frequency of reference model	SPEEDCTRL_REF_MODEL_FREQ	150.0	0.0	1000.0	Hz	FLOAT	0...7	immediately	4.3.2	1.01
5415	Reference model damping	SPEEDCTRL_REF_MODEL_DAMPING	0.9	0.4	1.0	-	FLOAT	0...7	immediately	4.3.2	1.01
5420	Max. velocity for setup mode	DRIVE_MAX_SPEED_SETUP	10.0	0.0	120000.0	mm/min	FLOAT		immediately	4.3.1	1.01
5421	Time constant of integrator feedback	SPEEDCTRL_INTEGRATOR_FEEDBK	0.0	0.0	1000.0	ms	FLOAT	0...7	immediately	4.3.2	1.01
5422	Velocity threshold for integrator feedback	FEEDBK_SPEED_THRESHOLD	10.0	0.0	120000.0	mm/min	FLOAT		immediately	4.3.2	1.01
5430	Velocity controller smoothing time constant	SPEEDCTRL_PT1_TIME	0.25	0.25	100.0	ms	FLOAT	0...7	immediately	4.3.2	1.01
5431	Velocity controller A D-action time	SPEEDCTRL_DIFF_TIME_A	0.0	-100.0	100.0	ms	FLOAT	0...7	immediately	4.3.2	1.01
5432	Velocity controller D-action time	SPEEDCTRL_DIFF_TIME	0.0	-100.0	100.0	ms	FLOAT	0...7	immediately	4.3.2	1.01
5433	Velocity controller B D-action time	SPEEDCTRL_DIFF_TIME_B	0.0	-100.0	100.0	ms	FLOAT	0...7	immediately	4.3.2	1.01
5435	Servo gain	CONTROLLED_SYSTEM_GAIN	0.0	0.0	20000.0	mm/Vmin	FLOAT	0...7	immediately	4.3.1	1.01
5440	Positive velocity setpoint limit	POS_DRIVE_SPEED_LIMIT	0.0	0.0	120000.0	mm/min	FLOAT		immediately	4.3.1	1.01
5441	Neg. velocity setpoint limit	NEG_DRIVE_SPEED_LIMIT	0.0	0.0	120000.0	mm/min	FLOAT		immediately	4.3.1	1.01
5460	Gradient of friction compensation characteristic	FRICTION_COMP_GRADIENT	0.0	0.0	400.0	%	FLOAT		immediately	4.3.1	1.01
5461	Effective range of friction compensation	FRICTION_COMP_OUTPUT_RANGE	0.1	0.1	10.0	%	FLOAT		immediately	4.3.1	1.01

MD no.	Name in plaintext	Name in NC	Version	Min.	Max.	Unit	Data type	Attribute		Sec-tion	Firm-ware-Version
								Index	Active		
5462	Piston surface adaptation factor, positive	AREA_FACTOR_POS_OUTPUT	10.0	10.0	200.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5463	Piston surface adaptation factor, negative	AREA_FACTOR_NEG_OUTPUT	10.0	10.0	200.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5464	Knee-point compensation pos. flow	POS_DUAL_GAIN_COMP_FLOW	10.0	0.2	95.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5465	Knee-point compensation pos. voltage	POS_DUAL_GAIN_COMP_VOLTAGE	10.0	0.2	95.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5466	Rounding range for knee-point compensation	DUAL_GAIN_COMP_SMOOTH_RANGE	2.5	0.0	20.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5467	Knee-point compensation neg. flow	NEG_DUAL_GAIN_COMP_FLOW	10.0	0.2	95.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5468	Knee-point compensation neg. voltage	NEG_DUAL_GAIN_COMP_VOLTAGE	10.0	0.2	95.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5470	Offset compensation	OFFSET_COMPENSATION	0	-4000	4000	-	WORD		immediately	4.5.1	1.01
5474	Manipulated voltage limitation positive	OUTPUT_VOLTAGE_POS_LIMIT	10.0	0.0	10.0	V	FLOAT	0..7	immediately	4.5.3	2.04
5475	Manipulated voltage limitation negative	OUTPUT_VOLTAGE_NEG_LIMIT	10.0	0.0	10.0	V	FLOAT	0..7	immediately	4.5.3	1.01
5476	Manipulated variable inversion	OUTPUT_VOLTAGE_INVERSION	0	0	1	-	UNS.WORD		immediately	4.5.3	1.01
5480	Knee-point compensation pos. flow in zero range	POS_DUAL_GAIN_COMP_Z_FLOW	0.01	0.01	95.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5481	Knee-point compensation pos. volt. in zero range	POS_DUAL_GAIN_COMP_Z_VOLT	0.0	0.0	95.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5482	Knee-point compensation rounding in zero range	DUAL_GAIN_COMP_SMOOTH_Z_R	0.0	0.0	10.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5483	Knee-point compensation neg. flow in zero range	NEG_DUAL_GAIN_COMP_Z_FLOW	0.01	0.01	95.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5484	Knee-point compensation neg. volt. in zero range	NEG_DUAL_GAIN_COMP_Z_VOLT	0.0	0.0	95.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5485	Knee-point compensation pos. flow saturation	POS_DUAL_GAIN_COMP_S_FLOW	100.0	0.2	100.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5486	Knee-point compensation pos. voltage saturation	POS_DUAL_GAIN_COMP_S_VOLT	100.0	0.2	100.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5487	Knee-point compensation neg. flow saturation	NEG_DUAL_GAIN_COMP_S_FLOW	100.0	0.2	100.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5488	Knee-point compensation neg. voltage saturation	NEG_DUAL_GAIN_COMP_S_VOLT	100.0	0.2	100.0	%	FLOAT	0..7	immediately	4.5.1	1.01
5500	Number of velocity filters	NUM_SPEED_FILTERS	0	0	1	-	UNS.WORD	0...7	immediately	4.3.1	1.01
5501	Type of velocity filter	SPEED_FILTER_TYPE	0	0	257	-	UNS.WORD	0...7	immediately	4.3.1	1.01
5502	PT1 time constant for velocity filter 1	SPEED_FILTER_1_TIME	0.0	0.0	500.0	ms	FLOAT	0...7	immediately	4.3.1	1.01
5506	PT2 natural frequency for velocity filter 1	SPEED_FILTER_1_FREQUENCY	2000.0	10.0	8000.0	Hz	FLOAT	0...7	immediately	4.3.1	1.01
5507	PT2 damping for velocity filter 1	SPEED_FILTER_1_DAMPING	0.7	0.2	1.0	-	FLOAT	0...7	immediately	4.3.1	1.01
5514	Band-stop filter blocking frequency for vel. filter 1	SPEED_FILTER_1_SUPPR_FREQ	3500.0	10.0	7999.0	Hz	FLOAT	0...7	immediately	4.3.1	1.01
5515	Band-stop filter bandwidth for velocity filter 1	SPEED_FILTER_1_BANDWIDTH	500.0	5.0	7999.0	Hz	FLOAT	0...7	immediately	4.3.1	1.01
5516	Numerator bandwidth for velocity filter 1	SPEED_FILTER_1_BW_NUMERATOR	0.0	0.0	7999.0	Hz	FLOAT	0...7	immediately	4.3.1	1.01

MD no.	Name in plaintext	Name in NC	Version	Min.	Max.	Unit	Data type	Attribute		Sec-tion	Firm-ware-Version
								Index	Active		
5520	Band-stop filter natural frequency for vel. filter 1	SPEED_FILTER_1_BS_FREQ	100.0	1.0	141.0	%	FLOAT	0...7	immediately	4.3.1	1.01
5522	Time constant for velocity actual value filter	ACT_SPEED_FILTER_TIME	0	0	0	-	FLOAT		Power On	-	1.01.08
5530	Safety configuration	CYLINDER_SAFETY_CONFIG	4	0	3F	HEX	UNS.WORD		immediately	4.12	1.01
5531	Manipulated variable enable delay	OUTPUT_ENABLE_DELAY	300	0	500	ms	UNS.WORD		immediately	4.12	1.01
5532	Power enable delay time	POWER_ENABLE_DELAY	100	0	300	ms	UNS.WORD		immediately	4.12	1.01
5550	Reference value of pressure sensor A at 10 V	PRESSURE_SENS_A_REF	200.0	50.0	6000.0	bar	FLOAT		immediately	4.11	1.01
5551	Offset adjustment for pressure sensor A	PRESSURE_SENS_A_OFFS	0	-32760	32760	-	WORD		immediately	4.11	1.01
5552	Reference value of pressure sensor B at 10 V	PRESSURE_SENS_B_REF	200.0	50.0	6000.0	bar	FLOAT		immediately	4.11	1.01
5553	Offset adjustment for pressure sensor B	PRESSURE_SENS_B_OFFS	0	-32767	32767	-	WORD		immediately	4.11	1.01
5600	Concealable alarms (Power On)	ALARM_MASK_POWER_ON	0	0	FFFF	HEX	UNS.WORD		immediately	4.13	1.01
5601	Concealable alarms (Reset)	ALARM_MASK_RESET	0	0	FFFF	HEX	UNS.WORD		immediately	4.13	1.01
5605	Time for velocity controller at limit	SPEEDCTRL_LIMIT_TIME	200.0	20.0	1000.0	ms	FLOAT		immediately	4.13	1.01
5606	Threshold for velocity controller at limit	SPEEDCTRL_LIMIT_THRESHOLD	120000.0	0.0	120000.0	mm/min	FLOAT		immediately	4.13	1.01
5609	Max. measuring speed of linear scale	ENC_SPEED_LIMIT	240000.0	1.0	240000.0	mm/min	FLOAT		immediately	4.13	1.01
5610	Diagnostic functions	DIAGNOSIS_ACTIVATION_FLAGS	0	0	3	HEX	UNS.WORD		Power On	-	1.01
5612	Config. shutdown response to PO alarms	ALARM_REACTION_POWER_ON	0	0	FFFF	HEX	UNS.WORD		immediately	4.13	1.01
5613	Config. shutdown response to RESET alarms	ALARM_REACTION_RESET	0	0	FFFF	HEX	UNS.WORD		immediately	4.13	1.01
5614	Valve spool monitoring timer	VALVE_ERROR_TIME	50	1	100	ms	UNS.WORD		immediately	4.13	1.01
5620	Bits of variable signaling functions	PROG_SIGNAL_FLAGS	0	0	7	HEX	UNS.WORD		immediately	4.13	1.01
5621	Signal number of variable signaling functions	PROG_SIGNAL_NR	0	0	100	-	UNS.WORD		immediately	4.13	1.01
5622	Address to be monitored by variable sign. funct.	PROG_SIGNAL_ADDRESS	0	0	FFFFFF	HEX	UNS.WORD		immediately	4.13	1.01
5623	Threshold for variable signaling functions	PROG_SIGNAL_THRESHOLD	0	0	FFFFFF	HEX	UNS.WORD		immediately	4.13	1.01
5624	Hysteresis for variable signaling functions	PROG_SIGNAL_HYSTERESIS	0	0	FFFFFF	HEX	UNS.WORD		immediately	4.13	1.01
5625	Dropout delay for variable signaling function	PROG_SIGNAL_ON_DELAY	0	0	10000	-	UNS.WORD		immediately	4.13	1.01
5626	Dropout delay for variable signaling function	PROG_SIGNAL_OFF_DELAY	0	0	10000	-	UNS.WORD		immediately	4.13	1.01
5648	Valve identification parameter 1	VALVE_ID_PARAMS1	0	0	7999	-	UNS.WORD		immediately	-	1.01.12
5649	Valve identification parameter 2	VALVE_ID_PARAMS2	0	0	7999	-	UNS.WORD		immediately	-	1.01.12
5650	Diagnostic control	DIAGNOSIS_CONTROL_FLAGS	0	0	FFFF	HEX	UNS.WORD		immediately	4.14	1.01

MD no.	Name in plaintext	Name in NC	Version	Min.	Max.	Unit	Data type	Attribute		Sec-tion	Firm-ware-Version
								Index	Active		
5651	Signal number of min/max memory	MINMAX_SIGNAL_NR	0	0	FFFF	-	UNS.WORD		immediately	4.14	1.01
5652	Memory location of min/max memory	MINMAX_ADDRESS	0	0	FFFFFF	HEX	UNS.WORD		immediately	4.14	1.01
5653	Minimum value of min/max memory	MINMAX_MIN_VALUE	0	0	FFFFFF	HEX	UNS.WORD		immediately	4.14	1.01
5654	Maximum value of min/max memory	MINMAX_MAX_VALUE	0	0	FFFFFF	HEX	UNS.WORD		immediately	4.14	1.01
5655	Monitor memory location segment	MONITOR_SEGMENT	0	0	FFFF	HEX	UNS.WORD		immediately	4.14	1.01
5656	Monitor memory location address	MONITOR_ADDRESS	0	0	FFFFFF	HEX	UNS.WORD		immediately	4.14	1.01
5657	Monitor value display	MONITOR_DISPLAY	0	0	FFFFFF	HEX	UNS.WORD		immediately	4.14	1.01
5658	Monitor value input	MONITOR_INPUT_VALUE	0	0	FFFFFF	HEX	UNS.WORD		immediately	4.14	1.01
5659	Monitor value transfer	MONITOR_INPUT_STROBE	0	0	FFFF	HEX	UNS.WORD		immediately	4.14	1.01
5700	Status of binary inputs	TERMINAL_STATE	0	0	FFFF	HEX	UNS.WORD		immediately	4.14	1.01
5704	Actual pressure A	ACTUAL_PRESSURE_A	0.0	-10000.0	10000.0	bar	FLOAT		immediately	4.14	1.01
5705	Actual pressure B	ACTUAL_PRESSURE_B	0.0	-10000.0	10000.0	bar	FLOAT		immediately	4.14	1.01
5706	Velocity setpoint	DESIRED_SPEED	0.0	-240000.0	240000.0	mm/min	FLOAT		immediately	4.14	1.01
5707	Actual velocity value	ACTUAL_SPEED	0.0	-240000.0	240000.0	mm/min	FLOAT		immediately	4.14	1.01
5708	Actual cylinder force	ACTUAL_CYL_FORCE	0.0	-10000000.0	10000000.0	N	FLOAT		immediately	4.14	1.01
5709	Significance of voltage representation	VOLTAGE_LSB	0.0	-100000.0	100000.0	V	FLOAT		immediately	4.14	1.01
5710	Significance of pressure representation	PRESSURE_LSB	0.0	-240000.0	240000.0	bar	FLOAT		immediately	4.14	1.01
5711	Significance of velocity representation	SPEED_LSB	0.0	-240000.0	240000.0	mm/min	FLOAT		immediately	4.14	1.01
5713	Significance of force representation	FORCE_LSB	0.0	-10000000.0	10000000.0	µN	FLOAT		immediately	4.14	1.01
5714	Significance of position representation	POSITION_LSB	0.0	-1000000.0	1000000.0	nm	FLOAT		immediately	4.14	1.01
5715	Voltage for valve spool position setpoint	DESIRED_VALVE_SPOOL_POS	0.0	-10.0	10.0	V	FLOAT		immediately	4.14	1.01
5716	Voltage for actual valve spool position	ACTUAL_VALVE_SPOOL_POS	0.0	-10.0	10.0	V	FLOAT		immediately	4.14	1.01
5717	Cylinder force setpoint	DESIRED_CYL_FORCE	0.0	-10000000.0	10000000.0	N	FLOAT		immediately	4.14	1.01
5720	CRC diagnostic parameter	CRC_DIAGNOSIS	0	0	FFFF	-	UNS.WORD		immediately	4.14	1.01
5725	Normalization of force setpoint interface	MAX_FORCE_FROM_NC	0.0	0.0	10000000.0	N	FLOAT		immediately	4.14	1.01
5730	Operating mode display	OPERATING_MODE	1	1	FFFF	HEX	UNS.WORD		immediately	4.14	1.01
5731	Image ZK1_PO register	CL1_PO_IMAGE	0	0	FFFF	HEX	UNS.WORD		immediately	4.14	1.01
5732	Image ZK1_RES register	CL1_RES-IMAGE	0	0	FFFF	HEX	UNS.WORD		immediately	4.14	1.01

MD no.	Name in plaintext	Name in NC	Version	Min.	Max.	Unit	Data type	Attribute		Sec-tion	Firm-ware-Version
								Index	Active		
5735	Processor capacity utilization	PROCESSOR_UTILIZATION	0	0	FFFF	%	UNS.WORD		immediately	4.14	1.01
5740	Actual position in relation to machine zero	ACTUAL_POSITION	0.0	-10000000.0	10000000.0	mm	FLOAT		immediately	4.14	1.01
5741	Piston position in relation to piston zero	ACTUAL_PISTON_POSITION	0.0	-10000000.0	10000000.0	mm	FLOAT		immediately	4.14	1.01
5790	Measuring circuit type of measuring system	ENC_TYPE	0	-1	32767	-	WORD		immediately	4.14	1.01
5797	Data version	PBL_VERSION	0	0	FFFF	-	UNS.WORD		immediately	4.14	1.01
5798	Firmware date	FIRMWARE_DATE	0	0	FFFF	-	UNS.WORD		immediately	4.14	1.01
5799	Firmware version	FIRMWARE_VERSION	0	0	FFFFFF	-	UNS.WORD		immediately	4.14	1.01

5 Hardware Drive Functions

5.1 Interface overview

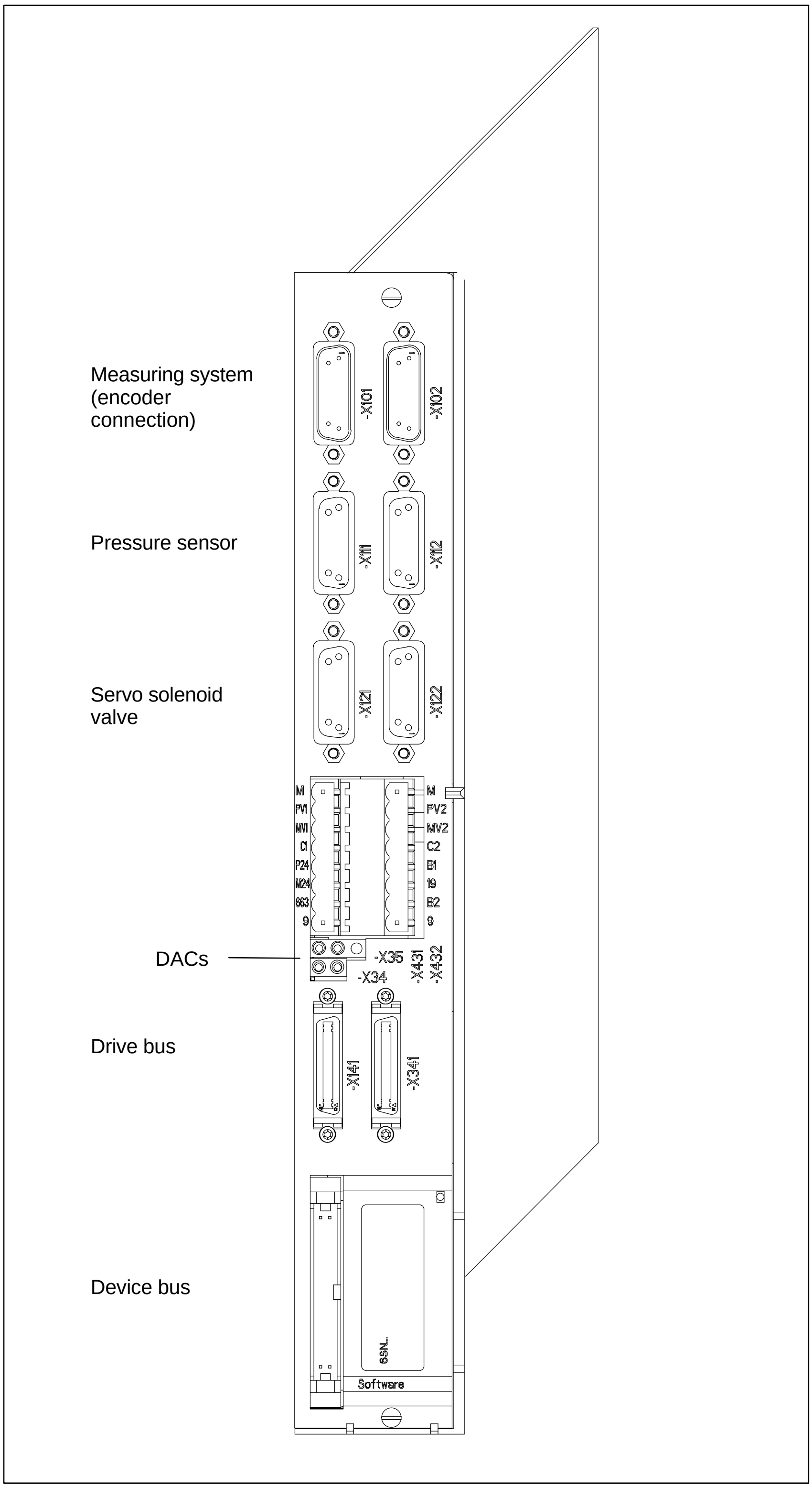


Fig. 5-1 HLA closed-loop control plug-in module (2-axis)

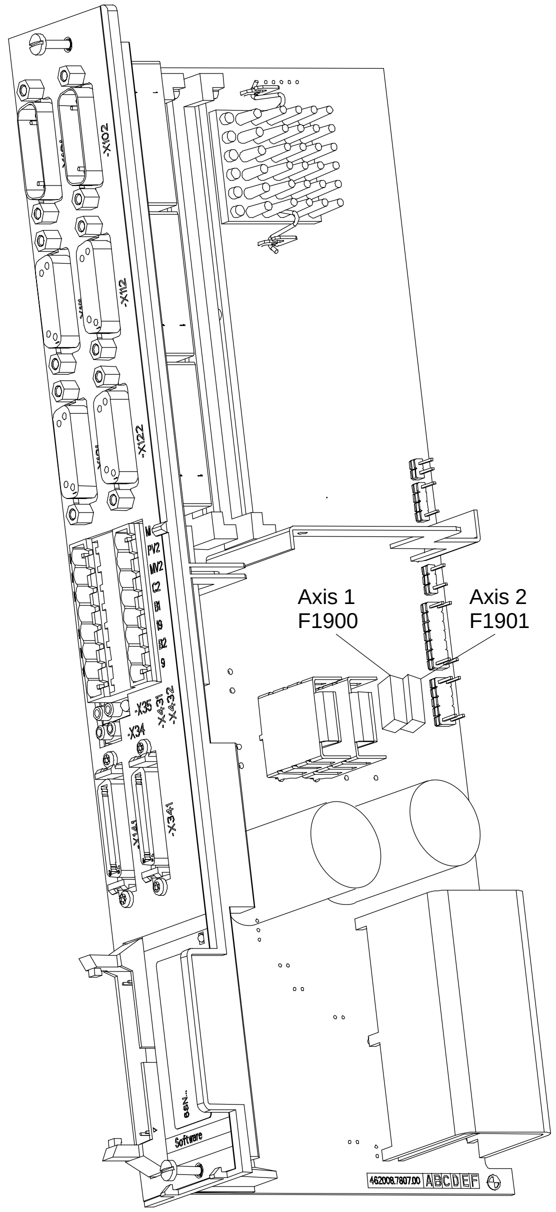


Fig. 5-2 Location diagram of HLA closed-loop control module

5.1.1 Measuring system

Measuring systems

One position encoder for each axis can be evaluated on the module.

- X101: Axis 1
- X102: Axis 2

The measuring system must always be plugged into the connector of the associated axis.

See Section 7.1 for further details.

Table 5-1 Connectors X101, X102; 15-pole male sub D connector (two-tier) in each case

Pin	X101	X102	Function
1	PENC0	PENC2	Encoder power supply
2	M (GND)	M (GND)	Encoder power supply ground
3	AP0	AP2	Incremental signal A
4	AN0	AN2	Inverse incremental signal A
5	BMIDAT0	BMIDAT2	Data signal EnDat or SSI interface
6	BP0	BP2	Incremental signal B
7	BN0	BN2	Inverse incremental signal B
8	XBMIDAT0	XBMIDAT2	Inverse data signal EnDat or SSI interface
9	PSENSE0	PSENSE2	Remote Sense encoder power supply (P)
10	RP0	RP2	Incremental signal R
11	MSENSE0	MSENSE2	Remote Sense encoder power supply (M)
12	RN0	RN2	Inverse incremental signal R
13	M (GND)	M (GND)	Ground (for internal shields)
14	BMICLK0	BMICLK2	Clock signal EnDat or SSI interface
15	XBMICLK0	XBMICLK2	Inverse clock signal, EnDat interface

5.1.2 Pressure sensor system

Connection for 2 pressure sensors per axis

- X111: Axis 1 (sensor 1A, 1B)
- X112: Axis 2 (sensor 2A, 2B)

Table 5-2 Connectors X111, X112; 15-pin female sub D connector in each case

Pin	X111	X112	Function
1	P24DS	P24DS	Supply of pressure sensor with external +24 V voltage
2	P24DS	P24DS	Supply of pressure sensor with external +24 V voltage
3	-	-	Not assigned
4	-	-	Not assigned
5	M24EXT	M24EXT	Supply of pressure sensor with external 0 V voltage
6	-	-	Not assigned
7	-	-	Not assigned
8	-	-	Not assigned
9	M24EXT	M24EXT	Supply of pressure sensor with external 0 V voltage
10	M24EXT	M24EXT	Extra pin for jumper between pins 10-11 with 3-wire connection
11	PIST1BN	PIST2BN	Analog actual-value signal, reference ground
12	PIST1BP	PIST2BP	Analog actual-value signal, max. range 0...10 V
13	M24EXT	M24EXT	Extra pin for jumper between pins 13-14 with 3-wire connection
14	PIST1AN	PIST2AN	Analog actual-value signal, reference ground
15	PIST1AP	PIST2AP	Analog actual-value signal, max. range 0...10 V

The inputs are differential with 40 kΩ input resistance.
The input voltage range is 0...+10 V.

The supply output has an electronic short-circuit protector.
The supply output is designed for a total current (4 sensors) of 200 mA.

Pressure sensor power supply via 26.5 V ± 2% according to external supply.

5.1.3 Servo solenoid valve

- X121: Axis 1
- X122: Axis 2

Table 5-3 Connectors X121, X122; both are 15-pin subminiature D female connectors

Pin	X121	X122	Function
1	P24RV1	P24RV2	+24 V switched
2	P24RV1	P24RV2	+24 V switched
3	P24RV1	P24RV2	+24 V switched
4	P24RV1	P24RV2	+24 V switched
5	M (GND)	M (GND)	Functional ground
6	USOLL1N	USOLL2N	Analog setpoint output, reference ground
7	USOLL1P	USOLL2P	Analog setpoint output +/-10 V
8	M (GND)	M (GND)	Functional ground
9	M24EXT	M24EXT	24 V external ground
10	M24EXT	M24EXT	24 V external ground
11	M24EXT	M24EXT	24 V external ground
12	-	-	Not assigned
13	M (GND)	M (GND)	Functional ground
14	UIST1N	UIST2N	Analog valve actual-value input, reference ground
15	UIST1P	UIST2P	Analog valve actual-value input, +/-10 V

The analog valve actual value inputs are differential with 100 kΩ input resistance.

The current ratings of the 24 V outputs on the servo solenoid value are

- for an ambient temperature of 40 °C 2.0 A
- for an ambient temperature of 55 °C 1.5 A

for the mean current value with a load cycle of 10 s duration.

The temperature corner points may be interpolated linearly.

The short-term current rating of the servo solenoid valve outputs is 3.0 A (200 ms).

In the event of overload, fuse F1900 or F1901 on the HLA closed-loop control plug-in module (for position, see Fig. 5-2) will blow.

Fuse

The switched 24 V outputs for axes 1 and 2 are protected by miniature fuses; fuse type F1900 for axis 1 and F1901 for axis 2.

Value: 2.5 AF/250 V; 5x20 mm UL

From: Wickmann-Werke GmbH
Annenstraße 113
58453 Witten
or
PO Box 2520
58415 Witten

Order No.: 194

5.1.4 Terminals

Shut-off valves (axis-specific), external 26.5 V supply, enabling, BERO inputs

- X431: Axis 1
- X432: Axis 2

Table 5-4 Connector X431; 8-pin Phoenix Combicon connector

Pin	X431	Type[1)]	Function	Typ. voltage/ Limit values
1	M (GND)	I	Functional ground	
2	PV1	O	+24V shut-off valve axis 1	max. 2.0 A
3	MV1	O	Ground for shut-off valve for axis 1	
4	C1	-	Reserved, do not use!	
5	P24	I	Input for +24 V external	26.5 V ± 2%
6	M24	I	Input for 0 V external	
7	663	I	Module-specific enable signal	21 V...30 V
8	9	O	Internal +24 V enable voltage, term. 9	

Table 5-5 Connector X432; 8-pin Phoenix Combicon connector

Pin	X432	Type[1)]	Function	Typical voltage/ limit values
1	M (GND)	I	Functional ground	
2	PV2	O	+24V shut-off valve axis 2	max. 2.0 A
3	MV2	O	Ground for shut-off valve for axis 2	
4	C2	-	Reserved, do not use!	
5	B1	I	BERO input, axis 1	13 V...30 V
6	19	O	Internal enable voltage ground, term.19	
7	B2	I	BERO input, axis 2	13 V...30 V
8	9	O	Internal +24 V enable voltage, term. 9	

Max. terminal cross-section 2.5 mm^2.

The +24 V outputs for shut-off valves for axes 1 and 2 are short-circuit-proof. The energy absorbed when inductive loads are disconnected must be limited to 1.7 J by the user (see also Subsection 2.4.2). When the supply polarity is reversed, the outputs are not protected against overload.

Warning

If the polarity of the 24 V supply is reversed, then the shut-off valves will open immediately, even if the NC or closed-loop control is not in operation!

1) I=Input; O=Output

Note

Each of the shut-off valves must be connected directly via 2 leads to pins 2/3 of X431 or X432!

A current-compensated interference suppression coil is inserted at the input for the external incoming supply terminal P24, terminal M24 (pins 5 and 6 of X431).

Terminal M24 and terminal MV1/MV2 must therefore not be reversed or short-circuited.

The internal enabling voltage (terminal 9) is provided in order to supply the BEROs and terminal 663, and must **not** be used to supply hydraulics components. The hydraulics components must be supplied via incoming supply P24. The voltages may not be connected in parallel.

Enabling inputs

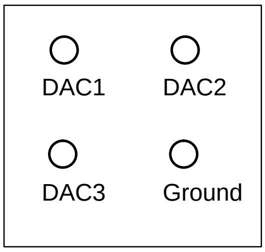
Module-specific enabling commands are issued by terminal 663. As no power section is installed, no relay is available. The input is therefore evaluated via optocouplers in the HLA module and also acts on the shut-off valves.
The enable voltage can be picked off at terminal 9.

Terminal 663 is referenced to the internal enabling voltage (ground, terminal 19).

5.1.5 Test sockets (diagnostics)

Test sockets

The start-up tool or an MMC102/103 can be used to assign internal signals to the test sockets on the 611D drive (in conjunction with SINUMERIK 840D), where the signals are then available as analog values (see also Section 3.11).



Functionality

Three 8-bit digital/analog converter (DAC) channels are available on the 611D hydraulics module. An analog image of various drive signals can be connected through to a test socket via these converters.

Only a window of the 24-bit wide drive signals can be displayed with the 8 bits (=1 byte) of the DAC, see Fig. 5-3. For this reason, the shift factor must be set to determine how fine the quantization of the selected signal must be. The normalization factor is calculated as the parameters are set and displayed as user info, e.g. 1V = 22.5A.

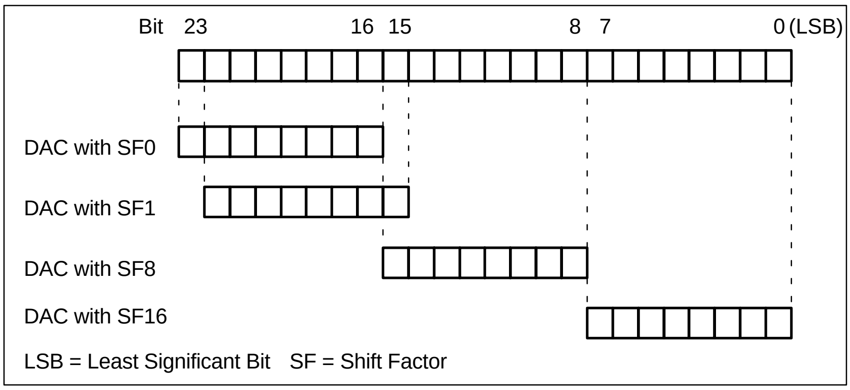


Fig. 5-3 Representation of the shift factor

Activating the analog output

The display for activating and setting the parameters of the DAC outputs is called up from the basic machine display by pressing the **Start-up** / **Drive/Servo** / **Configur. DAC** soft keys.

Use the **Start** soft key.to activate the configuration. Active DACs are identified (active/inactive) on the left of the display. The output is ended with **Stop** (active/ inactive).

The selected signals are active after POWER ON.

Output voltage range

The DAC operates on a voltage of between 0 V and +5 V. The 2.5 V output voltage corresponds to the zero point of the displayed signal. A two's complement is used in the digital/analog conversion, see Fig. 5-3.

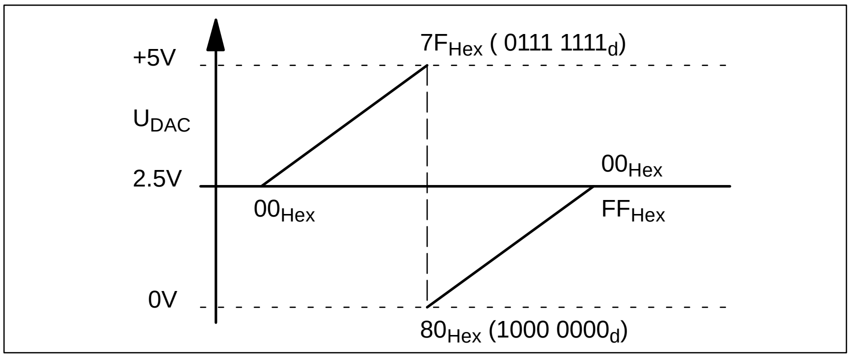


Fig. 5-4 Analog output voltage range

5.1.6 Bus interfaces

Drive bus

(see SIMODRIVE 611A/D)

- X141: Input
- X341: Output

A bus terminator must be plugged into the last module.

Device bus

(see SIMODRIVE 611A/D)

- X151: Device bus

5.2 System environment

Mains connection

The SINUMERIK 840D and HLA module are supplied via the device bus from the SIMODRIVE mains supply module or the SIMODRIVE monitoring module (may only be installed in conjunction with a mains supply module as an extended power supply). No provision has been made for any other type of voltage supply and failure to use the supply provided could damage the unit.

Note

It is not permissible to operate an HLA module on its own on a SIMODRIVE monitoring module!

Power is supplied to downstream electrical axes via the DC link busbars (40 mm^2) of the carrier module.

For information about the electrical supply conditions for the power supply or monitoring module, as well as recommended circuits, technical data and setting options, please see Chapter 2 and

References: /PJ2/ SIMODRIVE Planning Guide

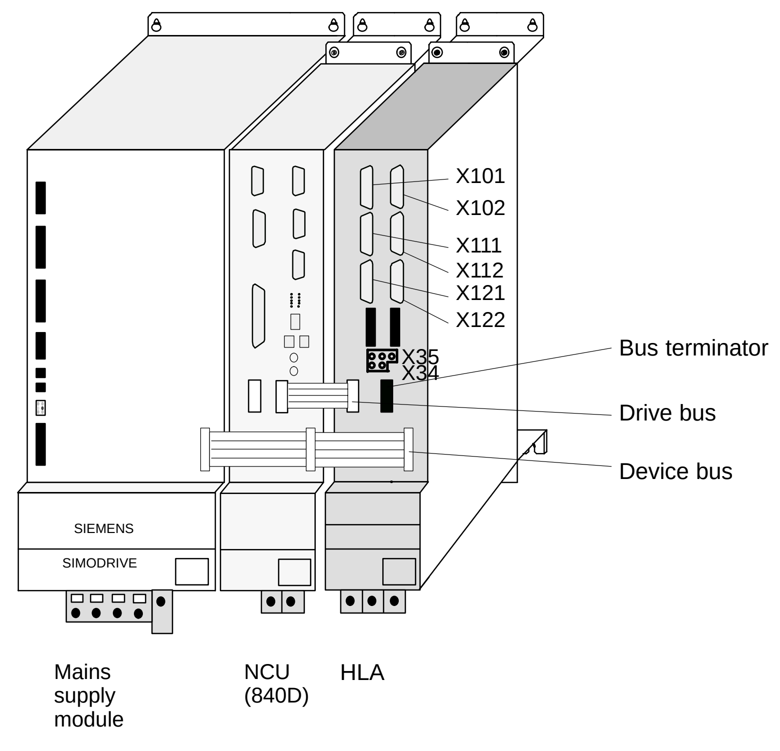


Fig. 5-5 Component layout for hydraulic drive

5.3 Notes

5.3.1 Climatic and mechanical environmental conditions in operation

Note

The following information refers to the electrical section of the HLA.

Relevant standards

IEC 68-2-1, IEC 68-2-2, IEC 68-2-3

Climatic ambient conditions

If the specified values cannot be maintained, then a heat exchanger or air conditioner must be provided.

Table 5-6 Climatic ambient conditions

Temperature range	Lower limit temperature	0°C
	Upper limit temperature	+55°C 1)
Dew-point temperature td and relative air humidity U	Annual average	U = 75%, td = 17°C
	On 30 days (24 hours) in year (days distributed over the annual period)	U = 95%, td = 24°C
	On other days (<24 hours) (observing the yearly average)	U = 85%, td = 20°C
Condensation		not permissible
Temperature rate of change	Within one hour	10 K
	Within three minutes	1 K
Atmospheric pressure	When operated at an altitude of 1500m above mean sea level. For greater altitudes, the upper limit temperature must be reduced by 3.5°C/500m.	86 kPa to 108 kPa

Table 5-7 Mechanical environmental conditions

Vibration resistance (to IEC 68-2-6)	Frequency range 10 - 58 Hz Over 58 - 500 Hz	Constant deflection 0.075 mm Ampl. of acceleration 9.8 m/s^2
Shock resistance in operation (test group E, test Ea to IEC 68, part 2-27)	Acceleration	5 g
	Duration of nominal shock	11 ms for device without disk drive 30 ms for device with disk drive

1) Current reduction above 40°C at the servo solenoid valve output, see Subsection 5.1.3.

5.3.2 Transport and storage conditions

Note

The following information refers to the electrical section of the HLA.

Relevant standards

IEC 68-2-1, IEC 68-2-2, IEC 68-2-3

Originally packaged modules

The following data applies to modules in their original packaging:

Table 5-8 Climatic conditions

Temperature range	Lower limit temperature	-40 °C
	Upper limit temperature	+70°C
Dew-point temperature td and relative air humidity U	Annual average	U = 75%, td = 17°C
	On 30 days (24 hours) in year (days distributed over the annual period)	U = 95%, td = 24°C
	On 30 days (24 hours) in year (days distributed over the annual period)	U = 85%, td = 20°C
Condensation	As regards condensation, the following conditions may apply simultaneously:	Seldom, brief, slight
	Max. condensation period	3 hours
	Frequency of condensation	Annual average 3/Max.: 10
	Shortest sequence of condensation cycles	1 day
Temperature rate of change	Within one hour	20 K
Air pressure	The specified values apply to a transportation altitude of up to 3265 m above sea level	66 kPa to 108 kPa

Table 5-9 Mechanical conditions during transportation in original packaging

Vibration resistance (to IEC 68-2-6)	Frequency range 5 - 9 Hz Over 9 - 500 Hz	Const. Deflection 3.5 mm Ampl. of acceleration 10 m/s^2

5.3.3 Stress caused by contaminants

Relevant standards

DIN 40046, parts 36 and 37

Table 5-10 Function-impairing gases

Sulfur dioxide (SO_2) Test conditions:	Degree of severity	10 cm^3/m^3 ± 0.3 cm^3/m^3
	Temperature	25 °C ± 2 °C
	Relative humidity	75% ± 5%
	Test duration	4 days
Hydrogen sulfide (H_2S) Test conditions:	Degree of severity	1 cm^3/m^3 ± 0.3 cm^3/m^3
	Temperature	25 °C ± 2 °C
	Relative humidity	75% ± 5%
	Test duration	4 days

Function-impairing dust

When working in areas where there is an unacceptably high dust hazard, the control must be operated in a cabinet with a heat exchanger or in a cabinet with a suitable air intake.

■

Notes

Hydraulics Diagnostics 6

Fault responses.

When a fault occurs, the system responds with either a power disable or velocity controller disable depending on the type of fault.

The power is disabled in response to errors which might make operation under closed-loop control impossible, such as

- velocity controller at limit,
- measuring system faults,
- RAM check error,
- drive computer crash, etc.

Scope

The following alarms relate specifically to the hydraulics module:

Other alarms may also occur and are described in:

References: /DA/, Diagnostics Guide

For special cases arising in conjunction with an integrated PLC, please refer to documentation of the SIMATIC S7-300 System.

Sorting

The alarms are listed in ascending order of alarm number. There are gaps in the sequence.

Structure of alarm description

Each alarm, consisting of an alarm number and alarm text, is described with 4 categories:

- Explanation
- Response
- Remedy
- Program continuation.

Safety

Danger

Please check the situation in the plant on the basis of the description of the active alarm(s). Eliminate the causes for the occurrence of the alarms and acknowledge in the manner indicated. Failure to observe this warning will place your machine, workpiece, stored settings and possibly even your own safety at risk.

300 000 to 300 499

For a description of the **alarms with error numbers 300 000 to 300 499**, please refer to documentation

References: /DA/, Diagnostics Guide

300 500

Axis %1, drive %2 system error, error codes %3, %4

Explanation

%1 = NC axis number
%2 = drive number
%3 = error code 1
%4 = error code 2

The drive has signaled a system error. For an exact breakdown of error codes, see /FBA/ DB1, Operational Messages/Alarm Responses.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Please inform the authorized personnel/service department.
Reinitialize the drive.

The search for the precise cause of error can only be performed by the development team. The displayed error codes are always needed for this.

SIEMENS AG, After-Sales Support for A&D MC Products, Hotline.

Continue program

Switch control system OFF and ON again.

300 504

Axis %1, drive %2 measuring circuit fault in motor measuring system

Explanation

%1 = NC axis number
%2 = drive number

Signal level of motor encoder too small or noisy. SSI encoder: Parameter setting error (bit 9 of MD 5027 Bit 9 not set)

Response

Mode group not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC start disable.
NC stopped in response to alarm.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Please inform the authorized personnel/service department.
Check encoder, encoder leads and connectors between drive motor and 611D module: check for temporary interruptions (loose contact) - e.g. caused by movements in cable tow.

- Replace motor, encoder and/or cable if necessary
- Check shield bond to front plate of closed-loop plug-in module (top screw)
- Replace the control module.
- Check distance between gear wheel and sensor on gear wheel encoders (The HLA module does not feature a gear wheel encoder. This is a measuring system connected to the hydraulic equipment.).

Continue program

Switch control system OFF and ON again.

300 506 Axis %1, drive %2, no sign of life from NC

Explanation

%1 = NC axis number
%2 = drive number

Upon servo enable, the NC must update the sign-of-life monitoring in each position control cycle. In case of error, sign-of-life monitoring has not been updated.

Cause:
a) NC no longer updates its sign of life in response to an alarm (e.g. 611D alarm)
b) Communication error on drive bus
c) Hardware error on drive module
d) NC error
e) On the 840D: Value of the machine data MD10082: MN_CTRLOUT_LEAD_TIME (offset in setpoint transfer time) is too high

The alarm can be reconfigured using MD 11412: ALARM_REACTION_CHAN_NOREADY (channel not ready).

Response

Mode group not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Please inform the authorized personnel/service department.

For a) Determine whether the sign-of-life monitoring failure is a sequential fault. A sequential fault is caused by: A fault/alarm on axis x in an n-axis structure, for example. If this error description has occurred, the above error message is output for all n axes, even though the fault/alarm has only occurred on axis x.
==>Rectify error on axis x
==>The signs of life for the other axes are irrelevant.

For b) Check plug-in connection, take measures to suppress RI (check shielding/ground connections)

For c) Replace closed-loop control module

For d) See NC error diagnosis, replace NC hardware if necessary

For e) Set machine data 840D MD10082: CTRLOUT_LEAD_TIME (offset in setpoint transfer time) to correct value using machine data MD10083: CTRLOUT_LEAD_TIME_MAX (maximum settable offset in setpoint transfer time).

Continue program

Switch control system OFF and ON again.

300 508 Axis %1, drive %2 zero mark monitoring motor measuring system

Explanation

%1 = NC axis number
%2 = drive number

Error in modulo (16/10) incrementation of encoder mark number on zero marker crossings. Increments have been lost or extra increments trapped.

The alarm can be reconfigured using MD 11412:
ALARM_REACTION_CHAN_NOREADY (channel not ready).

Response

Mode group not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Please inform the authorized personnel/service department. Use original Siemens pre-assembled encoder cables (high degree of shield protection). Check encoder, encoder cable for cable break and shield bonding point. Check shielding surface on front panel (top screw), replace closed-loop control module. Check distance between gear wheel and sensor on gear wheel encoders. If a BERO is installed, it is not the BERO signal which is monitored, but the zero marker of the encoder.

Continue program

Switch control system OFF and ON again.

300 511 Axis %1, drive %2 measuring function active

Explanation

%1 = NC axis number
%2 = drive number

The measuring function (e.g. frequency response measurement) was active as the power supply was switched on (power-up). The measuring function may be have been started illegally internally.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Stop the measuring function
Reset NCK

Continue program

Switch control system OFF and ON again.

300 701 **Start-up required for axis %1, drive %2**

Explanation

%1 = NC axis number
%2 = drive number

This alarm occurs during initial start-up when there is no valid 611D machine data available.

Response

NC not ready.
Mode group not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Please inform the authorized personnel/service department.

- Reset motor data.
- Back up boot drive.
- Power up system again

Continue program

Switch control system OFF and ON again.

300 702 **Axis %1, drive %2 drive basic clock cycle invalid**

Explanation

%1 = NC axis number
%2 = drive number

The drive basic clock cycle set on the NC is too high for the drive.

Response

NC not ready.
Mode group not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

No remedial action is required. After the system has powered up again, the NCK machine data relevant to the drive basic clock cycle, i.e.
MD 10050: SYSCLOCK_CYCLE_TIME (basic system cycle) and MD 10080: SYSCLOCK_SAMPL_TIME_RATIO (scale factor of position controller cycle for actual value sensing) are automatically altered so that the relevant limits are applied.

Continue program

Switch control system OFF and ON again.

300 707 **Axis %1, drive %2 drive basic clock cycle axially unequal**

Explanation

%1 = NC axis number
%2 = drive number

The drive basic clock cycle is different for the two axes on a 2-axis module.

This alarm can only occur with OEM users who have the 611D drive without the standard NCK interface. In this instance, it is possible to transfer different axial drive clock cycles to the 611D modules.

Response
NC not ready.
Mode group not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy
Please inform the authorized personnel/service department.
Set the drive basic clock cycle to the same value for both axes.

Continue program
Switch control system OFF and ON again.

300 710 **Axis %1, drive %2 position controller clock cycle axially unequal**

Explanation
%1 = NC axis number
%2 = drive number

The position controller clock cycle is different for the two axes on a 2-axis module.

This alarm can only occur with OEM users having the 611D drives without the standard NCK interface. In this instance, it would be possible to transfer different axial position controller clock cycles to the 611D module.

Response
NC not ready.
Mode group not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy
Please inform the authorized personnel/service department.
Set the position controller cycle to the same value for both axes.

Continue program
Switch control system OFF and ON again.

300 713 **Axis %1, drive %2 lead time for position controller invalid**

Explanation
%1 = NC axis number
%2 = drive number

The position controller computing time reduction specified by the NC must be shorter than the position controller cycle. The offset must be an integer multiple of the speed controller cycle.

Response
NC not ready.
Mode group not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy
Please inform the authorized personnel/service department.
MD 10082: CTROUT_LEAD_TIME (offset in setpoint transfer time).

Continue program
Switch control system OFF and ON again.

300 754 Axis %1, drive %2 signal number var. signaling function invalid

Explanation

%1 = NC axis number
%2 = drive number

The signal number for output of the appropriate signaling function is illegal. The permissible signal number range starts at 0 and ends at 29.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Please inform the authorized personnel/service department.
Enter the correct signal number.

Continue program

Clear alarm on all channels by pressing RESET. Restart part program.

300 770 Axis %1, drive %2 format error

Explanation

%1 = NC axis number
%2 = drive number

The calculated filter coefficients of a bandstop filter are beyond the range of the internal format.

The alarm can be reconfigured using MD 11412:
ALARM_REACTION_CHAN_NOREADY (channel not ready).

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Please inform the authorized personnel/service department. Change the filter setting. The hotline can help you to trace the exact cause of the fault. Call the SIEMENS AG, SIMODRIVE Hotline.

Continue program

Cancel alarm in all channels by pressing RESET. Restart part program.

300 799 Axis %1, drive %2 save and boot necessary

Explanation

%1 = NC axis number
%2 = drive number

After drive machine data have been modified, parameters need to be re-calculated. Press the **CALCULATE** soft key to start the calculation routine. After calculating the control parameters, it is necessary to save the machine data and to reboot.

The alarm can be reconfigured using MD 11412:
ALARM_REACTION_CHAN_NOREADY (channel not ready).

Response
Under certain circumstances it can be switched over across the entire channel via MD.
NC not ready.
Mode group not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy
The newly calculated data must be saved (soft key: **SAVE).**
The new parameter settings become operative when the system is next booted!

Continue program
Switch control system OFF and ON again.

300 854

Axis %1, drive %2 signal number var. signaling function invalid

Explanation
%1 = NC axis number
%2 = drive number

The signal number for output of the appropriate signaling function is illegal. The signal number range is between 0 and 29.

Response
Alarm display
Interface signals are set

Remedy
Enter the correct signal number.

Continue program
Alarm display with cause of the alarm disappears. No further operator action required.

310 505

Axis %1, drive %2 meas. circuit error abs. track, code %3

Explanation
%1 = NC axis number
%2 = drive number
%3 = detailed error code

Absolute encoder (EQN 1325)
Monitoring of encoder hardware and EnDat or SSI interface.

- Error in SSI encoder parameters (MD 5028)
- SSI encoder: Fault in 24 V voltage supply
- SSI encoder: Break in data or clock pulse cable

More precise diagnosis via error code MD 5023: ENC_ABS_DIAGNOSIS_MOTOR (diagnosis of absolute track in motor meas. circuit):

Bit no.	**Meaning**	**Note**
Bit 0	Lighting failed	
Bit 1	Signal amplitude too small	
Bit 2	Faulty code connection	
Bit 3	overvoltage	
Bit 4	Undervoltage	
Bit 5	Overcurrent	
Bit 6	Battery change necessary	
Bit 7	CRC error (evaluate bit 13 as well)	See 1)

Bit no.	Meaning	Note
Bit 8	Encoder cannot be used Illegal assignment between absolute and incremental tracks	
Bit 9	C/D track on ERN1387 encoder faulty or EQN encoder connected	
Bit 10	Protocol cannot be interrupted	
Bit 11	SSI level in data line detected	
Bit 12	TIMEOUT while reading measured value	See 2)
Bit 13	CRC error (evaluate bit 7 as well)	See 1)
Bit 14	Incorrect IPU submodule for direct measuring signal	See 3)
Bit 15	Encoder faulty	see 2) 3)

1)

CRC error: Bits 7 and 13		Meaning:
0	1	CRC error from SIDA-ASIC
1	0	Check byte error
1	1	Error in correction of absolute track via increment track

2) Bit 12 and Bit 15: Zero-level monitoring SSI

3) Bit 14 and Bit 15: Idle-level monitoring SSI

Response

Mode group not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC start disable.
NC stopped in response to alarm.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Please inform the authorized personnel/service department.

- Check encoder, encoder leads and connectors between drive motor and 611D module: check for temporary interruptions (loose contact) - e.g. caused by movements in cable tow.
- Replace motor and cable if necessary
- Incorrect cable type
- Controller hardware not suitable for EnDat interface (e.g. closed-loop control module with EPROM)

Continue program

Switch control system OFF and ON again.

310 606 Axis %1, drive %2 No external voltage supply to valve

Explanation

%1 = NC axis number
%2 = drive number

The external 26.5 V supply (X431: P24, M24) is monitored for violation of a lower limit in the control.

Cause: Voltage dips or voltage outside the permissible range.

Response

Mode group not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Check the following monitoring criteria:

- Voltage range (average) 26.0 V to 27.0 V
- Ripple factor 240 mVp-p
- No voltage dips

Continue program

310 607 Axis %1, drive %2 valve is not responding

Explanation

%1 = NC axis number
%2 = drive number

The valve is not responding to the valve slide setpoint.

Cause: Valve is not connected or has no valve spool checkback signal.

Response

Mode group not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Valve without valve spool checkback: MD 5530: Reset bit 2;
Check valve connection.

Continue program

Cancel alarm in all channels of this mode group by pressing RESET. Restart part program.

310 608 Axis %1, drive %2 velocity controller at limit

Explanation

%1 = NC axis number
%2 = drive number

The speed controller output has been at its limit for an impermissibly long time (MD 5605: SPEEDCTRL_LIMIT_TIME (speed controller limit threshold).

Monitoring function is active only if the velocity setpoint is lower than MD 5606: SPEEDCTRL_LIMIT_THRESHOLD (speed controller limit threshold).

Response

Mode group not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

- Is the drive blocked?
- Is the encoder connected? (check encoder cable).
- Check shield on the encoder cable.
- Encoder defective?
- Check the encoder bar number.
- Replace the control module.
- Modify machine data MD 5605: SPEEDCTRL_LIMIT_TIME and MD 5606: SPEEDCTRL_LIMIT_THRESHOLD to match the mechanical and dynamic features of the axis.

Continue program

Cancel alarm in all channels of this mode group by pressing RESET. Restart part program.

310 609

Axis %1, drive %2 encoder limit frequency exceeded

Explanation

%1 = NC axis number
%2 = drive number

Actual velocity is exceeding encoder limit frequency fg,max = 650 kHz.

Response

Mode group not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

- The wrong encoder may be in use.
- Does MD 5005: ENC_RESOL_MOTOR (encoder resolution for motor measuring system) tally with the encoder resolution?
- Is the encoder cable connected correctly?
- Is the shield of the encoder cable bonded over a large area?
- Replace the encoder.
- Replace the 611D hydraulics module.

Continue program

Cancel alarm in all channels of this mode group by pressing RESET. Restart part program.

310 610

Axis %1, drive %2 incorrect piston position

Explanation

%1 = NC axis number
%2 = drive number

Error is triggered when actual position value of drive is negative.
Cause: Position actual value on drive side is counted in the wrong direction.
Incorrect piston zero adjustment.
If the drive is referenced and the offset between the piston zero (piston stop at A end) and machine zero positions has been entered for MD 5040, then the piston position in MD 5741 must only display positive values (from zero to maximum piston stroke).

Response

Mode group not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Correct counting direction of actual position value at drive end if:

1. Pos. setpoint voltage (e.g. function generator) →Cylinder piston moves from A to B
   If not: Invert control signal (change MD 5476 bit 0)
2. Cylinder piston moves from A to B →v_act (MD 5707) > 0
   If not: Invert actual value (change MD 5011 bit 0)
3. Check piston zero position adjustment and correct if necessary:
   Set MD 5012 bits 14 and 15 to zero, save boot file, perform NCK Reset followed by reference point approach and then adjust the piston position.

Continue program

Cancel alarm in all channels of this mode group by pressing RESET. Restart part program.

310 611 Axis %1, drive %2 pressure sensor has failed

Explanation

%1 = NC axis number
%2 = drive number

Power limitation or friction compensation is activated: MD 5241: bit 0 or bit 1 is set and both actual pressure values are less than 2% of the system pressure in MD 5101: WORKING_PRESSURE.
Cause: Defect in pressure sensor or connecting lead.

Response

Mode group not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Check connections for both pressure sensors.
If there are no pressure sensors:

- Deactivate force limitation: MD 5241: Reset bit 0
- Deactivate friction compensation: MD 5241: Reset bit 1

Continue program

Cancel alarm in all channels of this mode group by pressing RESET. Restart part program.

310 612 Axis %1, drive %2 force limitation off

Explanation

%1 = NC axis number
%2 = drive number

The force limitation is switched off.
Cause: The force limitation is switched off, even though

- The NC has defined a force limit or
- Travel to fixed stop is selected.

Response

Mode group not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Activate force limitation: MD 5241: Set bit 0

Continue program

Cancel alarm in all channels of this mode group by pressing RESET. Restart part program.

310 701 **Axis %1, drive %2 invalid velocity controller cycle**

Explanation

%1 = NC axis number
%2 = drive number

An illegal value was entered for the velocity controller cycle for drive MD 5001: SPEEDCTRL_CYCLE_TIME.

Response

NC not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Permissible: 62,5 µs ≤ T ≤ 500 µs

Continue program

Switch control system OFF and ON again.

310 702 **Axis %1, drive %2 invalid position controller clock cycle**

Explanation

%1 = NC axis number
%2 = drive number

The monitoring function on the 611D module has detected a position controller clock cycle that is not within the permissible tolerance range.

The general conditions for obtaining a permissible clock cycle are:

1. Minimum cycle period: 250 µs
2. Maximum pulse rate: 4 s
3. The position controller pulse rate must be a multiple of the speed controller cycle given in the drive MD 5001: SPEEDCTRL_CYCLE_TIME.

Response

NC not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Change the position controller clock cycle on the NC

Continue program

Switch control system OFF and ON again.

310 703 **Axis %1, drive %2 invalid monitoring cycle**

Explanation

%1 = NC axis number
%2 = drive number

Monitoring cycle MD 5002: MONITOR_CYCLE_TIME (monitoring cycle) is invalid.

Response
NC not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy
See drive functions “FB / DB1” MD1002

Continue program
Switch control system OFF and ON again.

310 704 Axis %1, drive %2 velocity controller clock cycle axially unequal

Explanation
%1 = NC axis number
%2 = drive number

The speed controller cycle MD 5001: SPEEDCTRL_CYCLE_TIME must be identical for both axes.

Response
NC not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy
Set velocity controller clock cycle in MD 5001: SPEEDCTRL_CYCLE_TIME to an identical value for both axes.

Continue program
Switch control system OFF and ON again.

310 705 Axis %1, drive %2 monitoring cycle axially unequal

Explanation
%1 = NC axis number
%2 = drive number

On 2-axis modules, the monitoring cycle set in MD 5002: MONITOR_CYCLE_TIME (monitoring cycle) must be identical for both axes.

Response
NC not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy
MD 5002: MONITOR_CYCLE_TIME (monitoring cycle) to an identical value for both axes.

Continue program
Switch control system OFF and ON again.

310 706 Axis %1, drive %2 maximum useful velocity invalid

Explanation

%1 = NC axis number
%2 = drive number

Because of the high maximum motor speed in the drive MD 5401: DRIVE_MAX_SPEED and the velocity controller clock cycle in MD 5001: SPEEDCTRL_CYCLE_TIME may cause a format overflow.

Response

NC not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Reduce maximum useful velocity setting in MD 5401: DRIVE_MAX_SPEED or set a smaller speed controller cycle in MD 5001: SPEEDCTRL_LIMIT_TIME.
MD 5024: Scale graduations: enter a higher value

Continue program

Switch control system OFF and ON again.

310 707 Axis %1, drive %2 STS configuration axially unequal

Explanation

%1 = NC axis number
%2 = drive number

The configuration of the control block MD 5003: STS_CONFIG (STS configuration) must be set to an identical value for both axes.

Response

NC not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Check drive MD 5003: STS_CONFIG (STS configuration) and set the bits for the two axes on the module identically. (Do not change the default setting - it represents the optimum configuration).

Continue program

Switch control system OFF and ON again.

310 708 Axis %1, drive %2 no. of encoder marks motor measuring system invalid

Explanation

%1 = NC axis number
%2 = drive number

The number of encoder marks of the motor measuring system in the drive MD 5005: ENC_RESOL_MOTOR (no. of encoder marks motor measuring system) is either zero or greater than the maximum input limit.

Response

NC not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Match the number of encoder marks for the motor measuring system set in MD 5005: ENC_RESOL_MOTOR (no. of encoder marks motor measuring system) to the bar number of the connected encoder. (Default setting for motor measuring system: (Default setting for motor measuring system: 2048 incr./rev.).

Continue program

Switch control system OFF and ON again.

310 709

Axis %1, drive %2 error in piston diameter or piston rod diameter

Explanation

%1 = NC axis number
%2 = drive number

The piston diameter in drive MD 5131: CYLINDER_PISTON_DIAMETER is less than zero

Or

the piston rod diameter set in drive MD 5132: CYLINDER_PISTON_ROD_A_DIAMETER is greater than the piston diameter set in drive MD 5131: CYLINDER_PISTON_DIAMETER

Or

the piston rod diameter set in drive MD 5133: CYLINDER_PISTON_ROD_B_DIAMETER is greater than the piston diameter set in drive MD 5131: CYLINDER_PISTON_DIAMETER

Response

NC not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Enter a valid piston diameter setting in drive MD 5131:
Enter CYLINDER_PISTON_DIAMETER ($0 < D \leq 500$ mm).

Or

set the piston rod diameter in drive MD 5132: CYLINDER_PISTON_ROD_A_DIAMETER to a lower value than the piston diameter in drive MD 5131: CYLINDER_PISTON_DIAMETER.

Or

set the piston rod diameter in drive MD 5133: CYLINDER_PISTON_ROD_B_DIAMETER to a lower value than the piston diameter in drive MD 5131: CYLINDER_PISTON_DIAMETER.

Continue program

Switch control system OFF and ON again.

310 710

Axis %1, drive %2 distance-coded scale is set incorrectly

Explanation

%1 = NC axis number
%2 = drive number

When a distance-coded scale (MD 5011 bit 7=1) is selected, a linear measuring system must also be configured (MD 5011 bit 4=1).

Response

Mode group not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
Alarm display.
Interface signals are set.

Remedy

MD 5011: ACTUAL_VALUE_CONFIG (configuration of actual-value sensing) and configure if necessary.

Continue program

Switch control system OFF and ON again.

310 750

Axis %1, drive %2 feedforward control gain too high

Explanation

%1 = NC axis number
%2 = drive number

The feedforward control gain is calculated from the reciprocal of the controlled system gain in drive MD 5435: CONTROLLED_SYSTEM_GAIN.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

- Increase the speed controller cycle time in MD 5001: SPEEDCTRL_CYCLE_TIME.
- Reduce the force controller feedforward factor in MD 5247: FORCE_FFW_WEIGHT.
- Increase the controlled system gain setting in MD 5435: CONTROLLED_SYSTEM_GAIN.

Continue program

Cancel alarm in all channels by pressing RESET. Restart part program.

310 751

Axis %1, drive %2 proportional gain of velocity controller too high

Explanation

%1 = NC axis number
%2 = drive number

The P gain for the velocity controller is too high:

- MD 5406: SPEEDCTRL_GAIN_A (gain at cylinder edge A end)
  Or
- MD 5407: SPEEDCTRL_GAIN (gain for piston position with lowest natural frequency)
  Or
- MD 5408: SPEEDCTRL_GAIN_B (gain at cylinder edge B end)

Response
NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy
Enter a lower value for the P gain of the velocity controller:

- MD 5406: SPEEDCTRL_GAIN_A (gain at cylinder edge A end)

  Or

- MD 5407: SPEEDCTRL_GAIN (gain for piston position with lowest natural frequency)

  Or

- MD 5408: SPEEDCTRL_GAIN_B (gain at cylinder edge B end)

Continue program
Cancel alarm in all channels by pressing RESET. Restart part program.

310 752 **Axis %1, drive %2 I-action gain of velocity controller invalid**

Explanation
%1 = NC axis number
%2 = drive number

The integral gain in MD 5409: SPEEDCTRL_INTEGRATOR_TIME cannot be represented.

Response
NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Continue program
Cancel alarm in all channels by pressing RESET. Restart part program.

310 753 **Axis %1, drive %2 D component of velocity controller invalid**

Explanation
%1 = NC axis number
%2 = drive number

The D component of the velocity controller is too high:

- MD 5431: SPEEDCTRL_DIFF_TIME_A (gain at cylinder edge A end) or
- MD 5432: SPEEDCTRL_DIFF_TIME (gain for piston position with lowest natural frequency) or
- MD 5433: SPEEDCTRL_DIFF_TIME_B (gain at cylinder edge B end)

Response
NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy
Enter a lower value for the D component of the velocity controller:

- MD 5431: SPEEDCTRL_DIFF_TIME_A (gain at cylinder edge A end) or
- MD 5432: SPEEDCTRL_DIFF_TIME (gain for piston position with lowest natural frequency) or
- MD 5433: SPEEDCTRL_DIFF_TIME_B (gain at cylinder edge B end)

Continue program
Cancel alarm in all channels by pressing RESET. Restart part program.

310 754

Axis %1, drive %2 friction compensation gradient too high

Explanation
%1 = NC axis number
%2 = drive number

Reduce the friction compensation gradient component MD 5460: FRICTION_COMP_GRADIENT is too high.

Response
NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy
Reduce the friction compensation gradient component MD 5460: FRICTION_COMP_GRADIENT.

Continue program
Cancel alarm in all channels by pressing RESET. Restart part program.

310 755

Axis %1, drive %2 area adaptation too high

Explanation
%1 = NC axis number
%2 = drive number

- The positive area adaptation factor set in drive MD 5462: AREA_FACTOR_POS_OUTPUT is too high or
- the negative area adaptation factor set in drive MD 5463: AREA_FACTOR_NEG_OUTPUT is too high.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

- Select a lower setting for the positive area adaptation factor in MD 5462 AREA_FACTOR_POS_OUTPUT or
- select a lower setting for the negative area adaptation factor in MD 5463 AREA_FACTOR_NEG_OUTPUT.

Continue program

Cancel alarm in all channels by pressing RESET. Restart part program.

310 756 **Axis %1, drive %2 controlled-system gain is less than/equal to zero**

Explanation

%1 = NC axis number
%2 = drive number

The controlled system gain setting in drive MD 5435: CONTROLLED_SYSTEM_GAIN is less than or equal to zero.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Enter a valid controlled system gain setting in drive MD 5435: CONTROLLED_SYSTEM_GAIN (see drive model data calculation).

Continue program

Cancel alarm in all channels by pressing RESET. Restart part program.

310 757 **Axis %1, drive %2 blocking frequency > Shannon frequency**

Explanation

%1 = NC axis number
%2 = drive number

The bandstop frequency set for a velocity or control output filter is higher than the Shannon sampling frequency defined by the sampling theorem.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

The blocking frequency

- drive MD 5514: SPEED_FILTER_1_SUPPR_FREQ or
- drive MD 5210: OUTPUT_VCTRL_FIL_1_SUP_FREQ or
- drive MD 5213: OUTPUT_VCTRL_FIL_2_SUP_FREQ or
- drive MD 5268: FFW_FCTRL_FIL_1_SUP_FREQ or
- drive MD 5288: OUTPUT_FIL_1_SUP_FREQ

must be lower than the reciprocal of two velocity controller clock cycles in MD 5001: SPEEDCTRL_CYCLE_TIME, i.e. less than 1/(2*MD 5001*31.25 microsec).

Continue program

Cancel alarm in all channels by pressing RESET. Restart part program.

310 758 Axis %1, drive %2 natural frequency > Shannon frequency

Explanation

%1 = NC axis number
%2 = drive number

The natural frequency of a velocity filter is higher than the Shannon sampling frequency defined by the sampling theorem.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

The natural frequency in Hz of a velocity must be less than the reciprocal of two velocity controller clock cycles.

Speed filter:

MD 5520 * 0.01 * MD 5514 < 1 / (2 * MD 5001 * 31.25 microsec)

- BSF natural frequency MD 5520: SPEED_FILTER_1_BS_FREQ
- BSF blocking frequency MD 5514: SPEED_FILTER_1_SUPPR_FREQ
- Set an identical speed controller cycle MD 5001: SPEEDCTRL_CYCLE_TIME

Continue program

Cancel alarm in all channels by pressing RESET. Restart part program.

310 759 **Axis%1, drive%2 numerator bandwidth exceeds double blocking frequency**

Explanation

%1 = NC axis number
%2 = drive number

The numerator bandwidth of a velocity or control output filter is greater than 2x the blocking frequency.

The error message is only generated for the general bandstop if the following applies:

- Speed filter 1:

  MD 5516 > 0.0 or

  MD 5520 <> 100.0

- Control output filter 1 in velocity controller:

  MD 5212 > 0.0

- Control output filter 2 in velocity controller:

  MD 5215 > 0.0

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

The numerator bandwidth must be less than twice the blocking frequency.

- Speed filter 1:
  - BSF bandwidth numerator drive MD 5516: SPEED_FILTER_1_BW_NUMERATOR
  - BSP blocking frequency drive MD 5514: SPEED_FILTER_1_SUPPR_FREQ

  MD 5516 $\leq$ 2 * MD 5514

- Control output filter 1 in velocity controller:
  - BSF numerator bandwidth drive MD 5212: OUTPUT_VCTRL_FIL_1_BW_NUM
  - BSP blocking frequency drive MD 5210: OUTPUT_VCTRL_FIL_1_SUP_FREQ

  MD 5212 $\leq$ 2 * MD 5210

- Control output filter 2 in velocity controller:
  - BSF numerator bandwidth drive MD 5215: OUTPUT_VCTRL_FIL_2_BW_NUM
  - BSP blocking frequency drive MD 5213: OUTPUT_VCTRL_FIL_2_SUP_FREQ

  MD 5215 $\leq$ 2 * MD 5213

Continue program

Cancel alarm on all channels by pressing RESET. Restart part program.

310 760

Axis %1, drive %2 denominator bandwidth exceeds double natural frequency

Explanation

%1 = NC axis number
%2 = drive number

The denominator bandwidth of a velocity filter is greater than 2x the natural frequency.

The error message is only generated for the general bandstop if the following applies:

Speed filter 1:

MD 5516 > 0.0 or

MD 5520 <> 100.0

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

The denominator bandwidth of a velocity filter must be less than twice the natural frequency.

Speed filter 1:

- BSP bandwidth drive MD 5515: SPEED_FILTER_1_BANDWIDTH
- BSP blocking frequency drive MD 5514: SPEED_FILTER_1_SUPPR_FREQ
- BSP natural frequency drive MD 5520: SPEED_FILTER_1_BS_FREQ

MD 5515 $\leq$ 2 * MD 5514 * 0.01 * MD 5520

Continue program

Cancel alarm on all channels by pressing RESET. Restart part program.

310 761

Axis %1, drive %2 proportional gain of force controller too high

Explanation

%1 = NC axis number
%2 = drive number

The P gain of the force controller in MD 5242: FORCECTRL_GAIN is too high.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Enter a lower value for the force controller P gain in MD 5242: FORCECTRL_GAING.

Continue program

Cancel alarm on all channels by pressing RESET. Restart part program.

310 762

Axis %1, drive %2 I-action gain of force controller invalid

Explanation

%1 = NC axis number
%2 = drive number

The integral gain in MD 5244: FORCECTRL_INTEGRATOR_TIME cannot be represented.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Continue program

Cancel alarm on all channels by pressing RESET. Restart part program.

310 763

Axis %1, drive %2 D component of force controller invalid

Explanation

%1 = NC axis number
%2 = drive number

The D component of the force controller MD 5246: FORCECTRL_DIFF_TIME is too high.

Response

NC not ready.
Under certain circ. it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Enter a smaller value for the D component of the force controller MD 5246: FORCECTRL_DIFF_TIME.

Continue program

Cancel alarm on all channels by pressing RESET. Restart part program.

310 764

Axis %1, drive %2 force controller controlled-system gain is less than/ equal to zero

Explanation

%1 = NC axis number
%2 = drive number

The controlled-system gain setting for the force controller in drive MD 5240 FORCECONTROLLED_SYSTEM_GAIN is less than or equal to zero.

Response

NC not ready.
Under certain circ. it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

Enter a valid controlled-system gain setting in drive MD 5240 FORCECONTROLLED_SYSTEM_GAIN (see Calculate Model Data).

Continue program

Cancel alarm on all channels by pressing RESET. Restart part program.

310 771

Axis %1, drive %2 gradient in fine range of valve characteristic is less than/equal to zero

Explanation

%1 = NC axis number
%2 = drive number

The gradient in the fine area of the valve characteristic is less than or equal to zero.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

The gradient in the fine area is calculated as follows:

- positive quadrant: (MD 5464-MD 5480)/(MD 5465-MD 5481)
- negative quadrant: (MD 5467-MD 5483)/(MD 5468-MD 5484)

Enter a valid combination in the above drive MD.

Continue program

Cancel alarm on all channels by pressing RESET. Restart part program.

310 772

Axis %1, drive %2 gradient in coarse range of valve characteristic is less than/equal to zero

Explanation

%1 = NC axis number
%2 = drive number

The gradient in the coarse area of the valve characteristic is less than or equal to zero.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

The gradient in the coarse range is calculated according to the:

- positive quadrant: (MD 5485-MD 5464)/(MD 5486-MD 5465)
- negative quadrant: (MD 5487-MD 5467)/(MD 5488-MD 5468)

Enter a valid combination in the above drive MD.

Continue program

Cancel alarm on all channels by pressing RESET. Restart part program.

310 773

Axis %1, drive %2 gradient at end of saturation range of valve characteristic is less than/equal to zero

Explanation

%1 = NC axis number
%2 = drive number

The gradient at the end of the saturation range of the valve characteristic is less than/equal to zero. The saturation range is rounded by a parabola function. The parabola has a maximum in the saturation region and therefore cannot be inverted.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

The gradient at the end of the saturation region is calculated according to the:

- Positive quadrant: 2·(1.0-MD 5485)/(1.0-MD 5486)
  -(MD 5485-MD 5464)/(MD 5486-MD 5465)
- Negative quadrant: 2·(1.0-MD 5487)/(1.0-MD 5488)
  -(MD 5487-MD 5467)/(MD 5488-MD 5468)

Enter a valid combination in the above drive MD.

Continue program

Cancel alarm on all channels by pressing RESET. Restart part program.

310 774

Axis %1, drive %2 overlap between zero and breakpoint ranges of valve characteristic

Explanation

%1 = NC axis number
%2 = drive number

The zero range and breakpoint range of the valve characteristic are overlapping.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

The zero and breakpoint ranges overlap if:

- positive quadrant: (MD 5481+MD 5482)>(MD 5465-MD 5466)
- negative quadrant: (MD 5484+MD 5482)>(MD 5468-MD 5466)

Enter a valid combination in the above drive MD.

Continue program

Cancel alarm on all channels by pressing RESET. Restart part program.

310 775

Axis %1, drive %2 overlap between breakpoint range and saturation region of valve characteristic

Explanation

%1 = NC axis number
%2 = drive number

The breakpoint range and saturation region of the valve characteristic are overlapping.

Response

NC not ready.
Under certain circumstances it can be switched over across the entire channel via MD.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
The NC switches to follow-up mode.
Alarm display.
Interface signals are set.

Remedy

The breakpoint range and saturation region overlap if:

- positive quadrant: (MD 5465+MD 5466)>MD 5486
- negative quadrant: (MD 5468+MD 5466)>MD 5488

Enter a valid combination in the above drive MD.

Continue program

Cancel alarm on all channels by pressing RESET. Restart part program.

311 710

Axis %1, drive %2 resolution invalid for SSI motor measuring system

Explanation

%1 = NC axis number
%2 = drive number

The motor measuring system is incorrectly configured for an SSI encoder:

MD 5022 ENC_ABS_RESOL_MOTOR must not be zero.

Response

NC not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
Alarm display.
Interface signals are set.

Remedy

Set MD 5022 to the correct value

Rotary encoder: Single-turn resolution (increments per revolution)
Linear encoder: Resolution of one increment (in nanometers)

Continue program

Switch control system OFF and ON again.

311 711

Axis %1, drive %2 message frame length invalid for SSI motor measuring system

Explanation

%1 = NC axis number
%2 = drive number

The motor measuring system is incorrectly configured for an SSI encoder.

Response

Mode group not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
Alarm display.
Interface signals are set.

Remedy

Check the following MD and correct if necessary

MD 5028
MD 5021 (Multi-turn): Number of resolvable revolutions
MD 5022 (Single-turn): Number of increments per revolution
MD 5027 Bit 12: Parity bit
MD 5027 Bit 14 Alarm bit

Example:
SSI encoder with 25-bit long message frame, 12 bits multi-turn, 12 bits single-turn, 1 alarm bit, no parity bit:
MD 5028 = 25
MD 5021 = 4096
MD 5028= 4096
MD 5027 bit 12 = 0
MD 5027 bit 14 = 1

Continue program

Switch control system OFF and ON again.

311 712

Axis %1, drive %2 Invalid multi-turn SSI motor measuring system

Explanation

%1 = NC axis number
%2 = drive number

The motor measuring system is incorrectly configured for a linear SSI motor measuring system. A linear measuring system cannot have any multiturn information.

Response

Mode group not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
Alarm display.
Interface signals are set.

Remedy

Set MD 5021 to 0.

Continue program

Switch control system OFF and ON again.

311 716

Axis %1 drive %2 SSI measuring system not possible without incremental signals

Explanation

%1 = NC axis number
%2 = drive number

SSI encoders without incremental signals cannot be used with the existing module.

Response

Mode group not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
Alarm display.
Interface signals are set.

Remedy

Use a new module (order no.: 6SN1115-0BA1 1-0AA1)

Continue program

Switch control system OFF and ON again.

311 717

Axis %1, drive %2 SSI transmission time-out

Explanation

%1 = NC axis number
%2 = drive number

The SSI transmission must be able to complete within one position controller cycle. It cannot do so.

Response

Mode group not ready.
Channel not ready.
NC stopped in response to alarm.
NC start disable.
Alarm display.
Interface signals are set.

Remedy

Increase the position controller cycle or the SSI data transfer rate, MD 5011 bits 14 and 15.

Transfer rates of 100 kHz, 500 kHz, 1 MHz and 2 MHz are possible.

Attention:
It might not be possible to increase the frequency with the length of encoder cable used.

Continue program

Switch control system OFF and ON again.

■

Peripherals/Accessories

7

7.1 Measuring systems

7.1.1 Encoders, linear scales

Note

For connector assignments, see Subsection 5.1.1.

Encoder specification

The HLA module is designed to evaluate

- **Incremental measuring systems** with sinusoidal signals (A, B) and a reference signal (R)

  Or

- **Absolute measuring systems** with sinusoidal signals (A, B) and EnDat interface for absolute position sensing

with the following signal limit data:

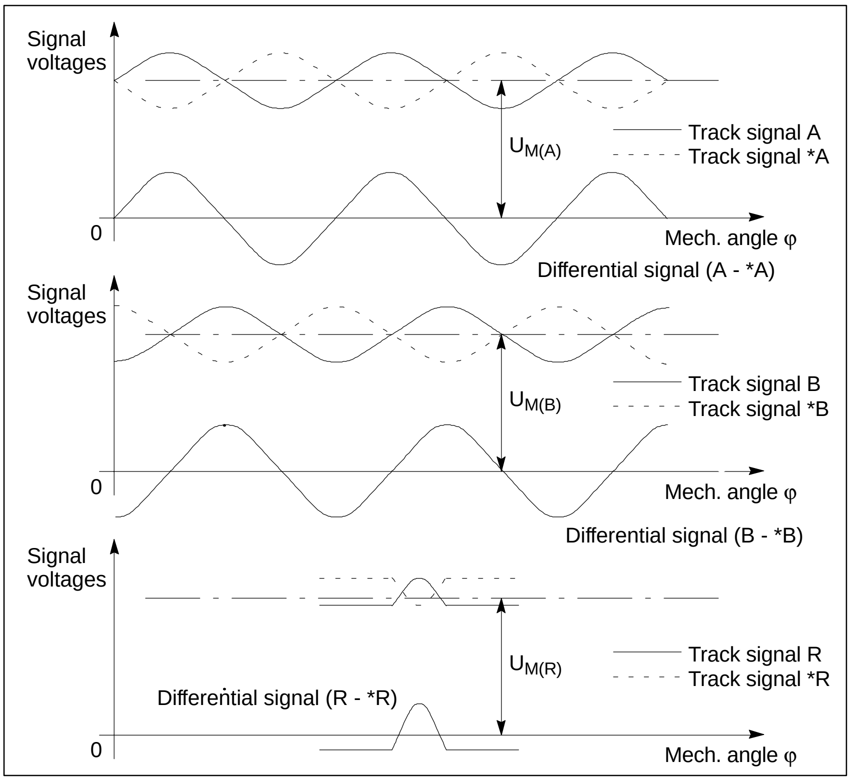


Fig. 7-1 Required signal chart of measuring system signals for data definition

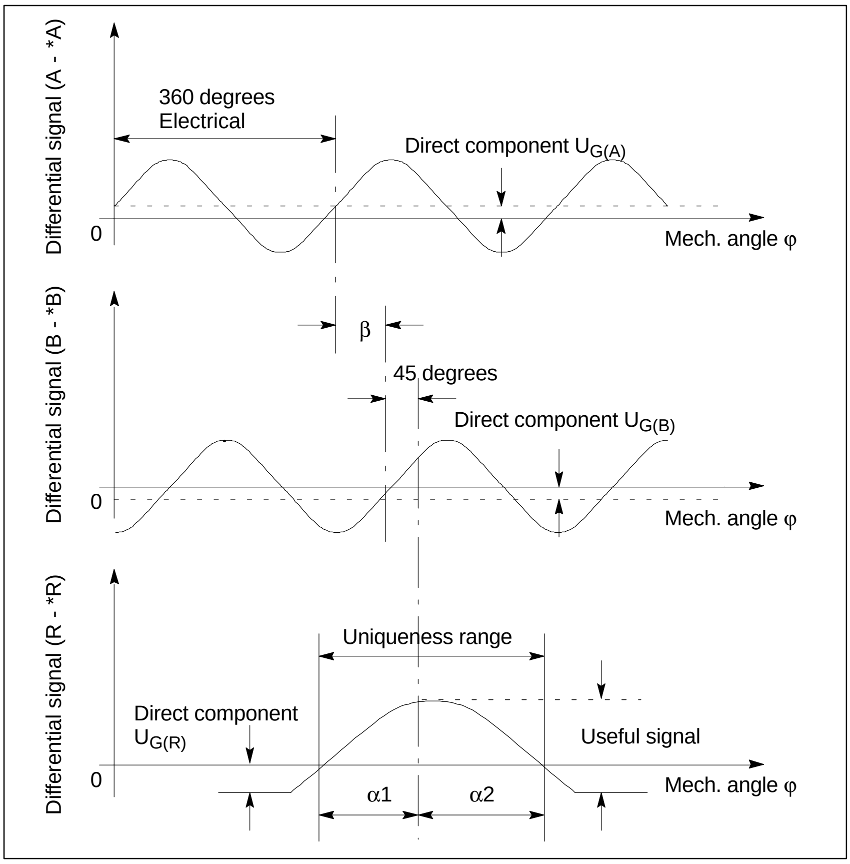


Fig. 7-2 Required signal chart of measuring system signals (incremental and reference) after differential amplification for data function

Table 7-1 Limit data for measuring system signals

Parameters	Description	min.	typ.	max.	Unit
Mean voltage	$U_{M(A)}$; $U_{M(B)}$; $U_{M(R)}$	1.75		3.25	V
Amplitude	A - *A; B - *B	350	500	600	mv
Ratio	(A - *A)/(B - *B)	0.9	1.0	1.1	-
Dynamic change in amplitude	Δ(A - *A)/360° el.; Δ(B - *B)/360° el.	-	-	0.3	mV/360° el.
Direct component	$U_{G(A)}$/amplitude (A - *A); $U_{G(B)}$/amplitude (B - *B);	-0.2	0	+0.2	
Dynamic change in direct component	$\Delta U_{G(A)}$/360° el.; $\Delta U_{G(B)}$/360° el.	-	-	1	mV/360° el.
Signal frequency	fs	-	-	200	kHz
Phase shift	β	85	90	95	Degrees
Harmonic distortion[1)]	k	-	-	1	%
Useful signal	R - *R	300	-	1500	mV
DC voltage	$U_{direct(R)}$	-150	-	-500	mV
Uniqueness range	α1; α2	50	-	270	Degrees

1) Definition for harmonic distortion: $k = \frac{\sqrt{U1^2+U2^2+...Un^2}}{\sqrt{U0^2+U1^2+...Un^2}}$

U0: Fundamental component
U1...Un: Harmonic components

Note

If signals which do not conform to this specification are used, problems such as speed ripple, positioning inaccuracy or other malfunctions may be encountered.

7.1.2 Connection diagrams

Connection options

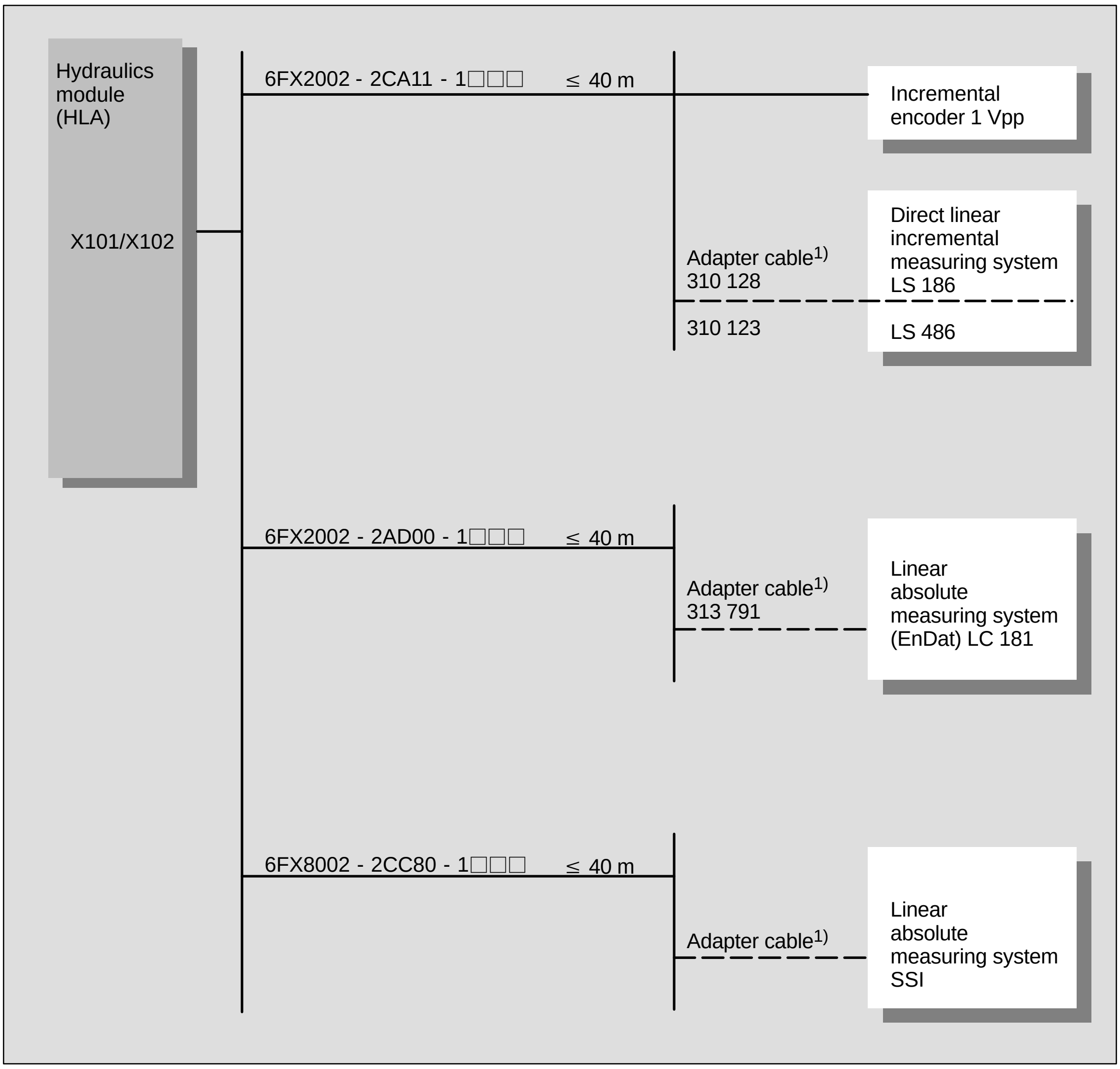


Fig. 7-3 Example showing connection options for measuring system cable

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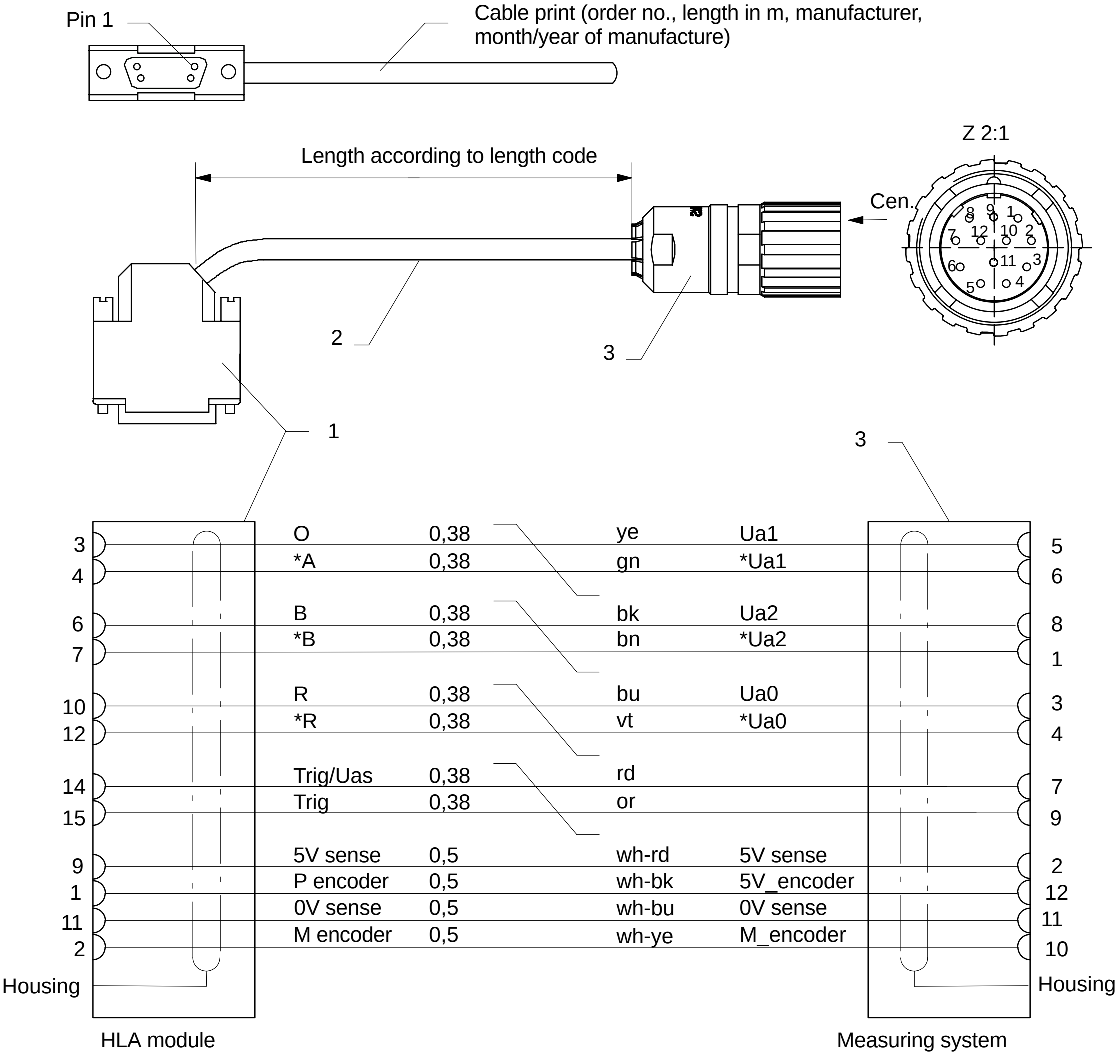
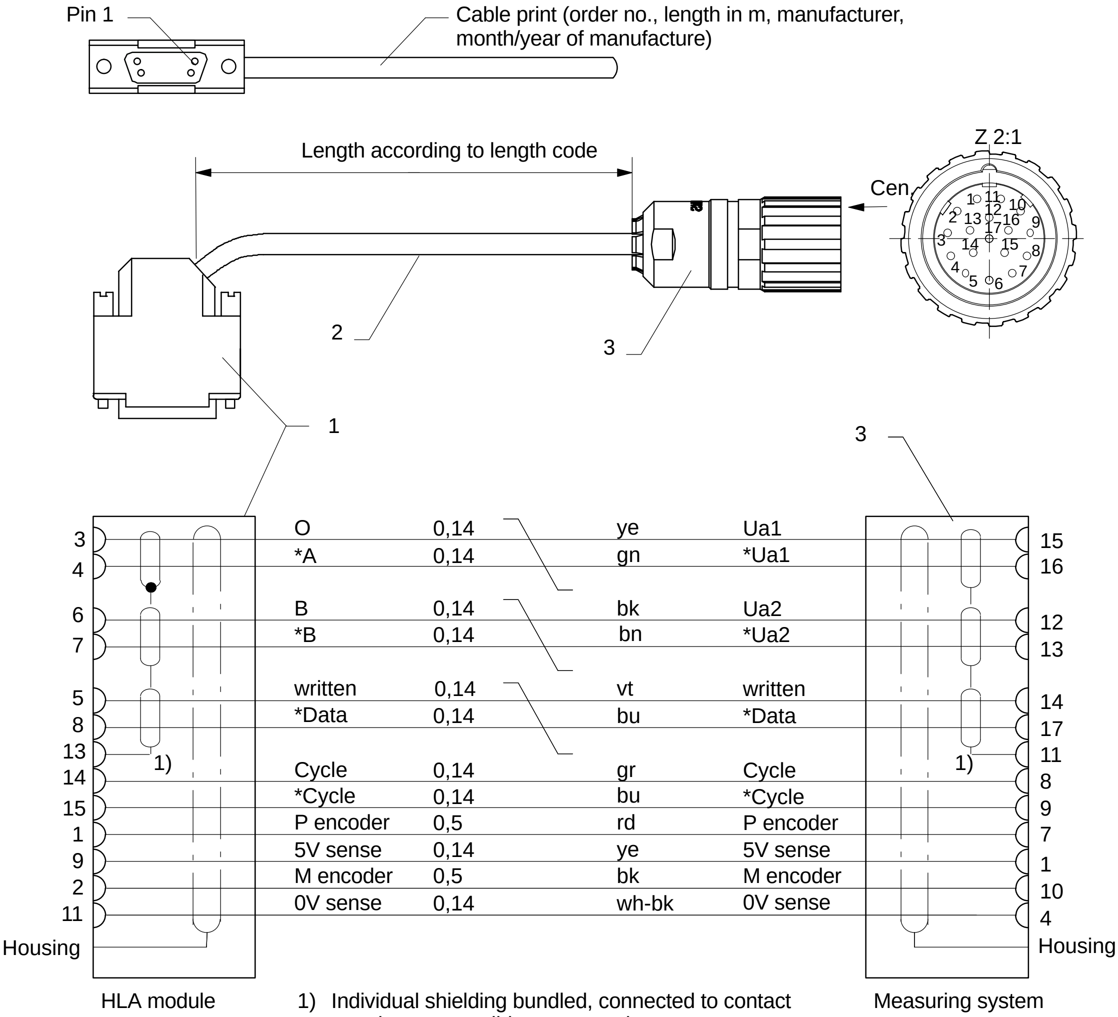
1) Adapter cable can be ordered from supplier of linear scale.
MTS: Order code 252 882
Balluff: BKS-S 32M/SA1-□□
Visolux: ASK EDM-SSI-SIMODRIVE



Item	Meaning
1	Male sub D connector, 15-pin, female connector, with screw interlocking 6FC9348-7HX
2	Signal lead 4x2x0.38+4x0.5 6FX2008-1BD21
3	12-pin connector 6FX2003-0CE12

Order No. (MLFB) of measuring system lead: **6FX2002-2CA11-1** □□□

Fig. 7-4 Measuring system lead for encoder with voltage signals (X101/X102)



1) Individual shielding bundled, connected to contact over largest possible cross-section.

Item	Meaning
1	Male sub D connector, 15-pin, female connector, with screw interlocking 6FC9348-7HX
2	Signal lead 3x2x0.14+4x0.14+2x0.5 6FX2008-1BD41
3	17-pin connector 6FX2003-0CE17

Order No. (MLFB) of lead: **6FX2002-2AD00-1** □□□

Fig. 7-5 Measuring system lead for encoder with voltage signals + EnDat (X101/X102)

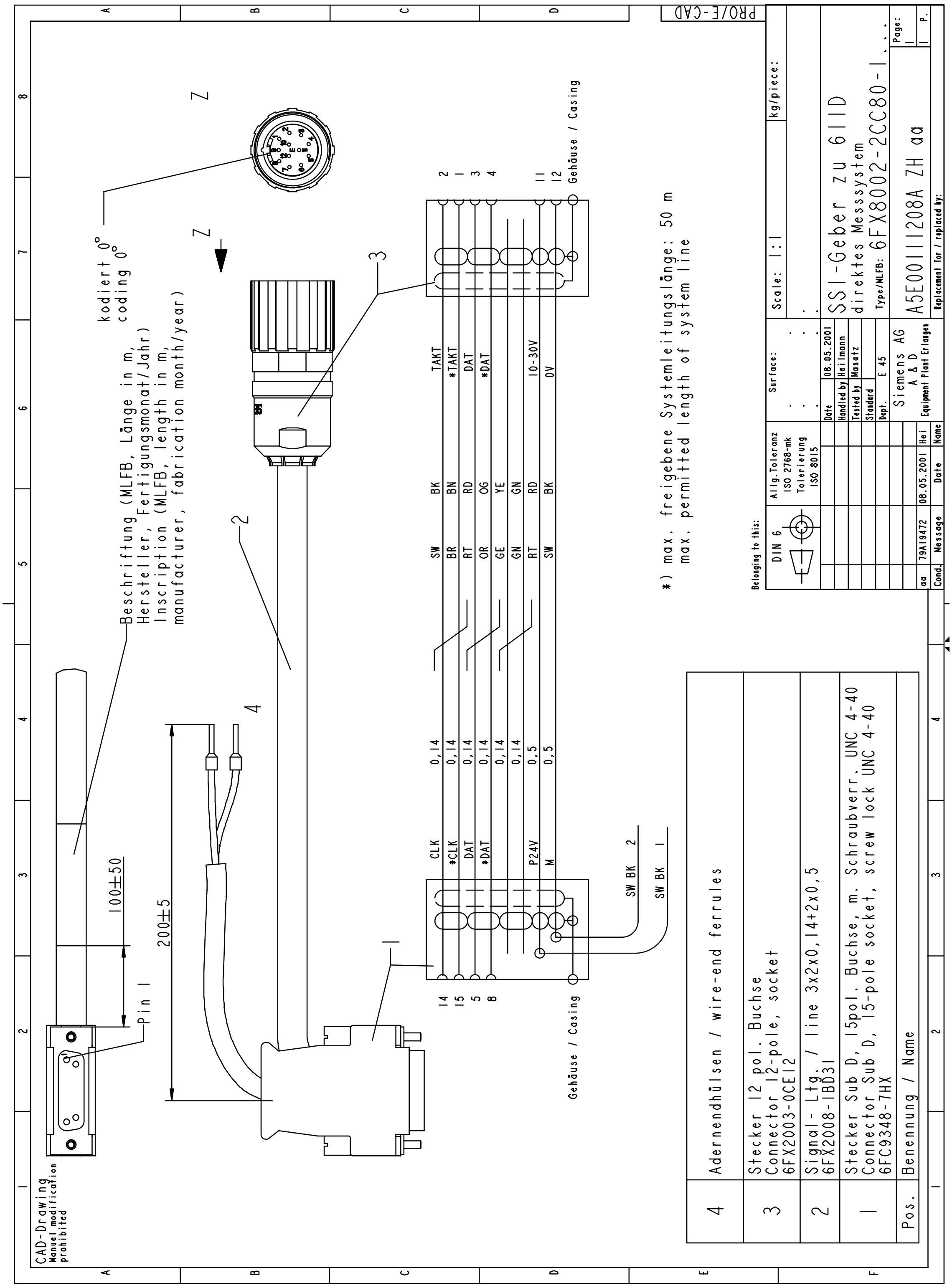


Fig. 7-6 Measuring system lead for SSI encoder

7.2 BERO (X432)

Only BEROs of type 3-wire PNP NO contact may be used.

We recommend the following BERO models:

SIEMENS BERO M30 3RG 4014-0AG01

BERO M12 3RG 4012-3AG01

Note

The BERO cable must be shielded.

Table 7-2 Pin assignment X432

Terminal name	Type1)	Signal designation
B1/B2	I	BERO (external reference system) axis 1/2
19	O	Power supply for BERO ground external
9	O	Power supply for BERO 24 V external

1) I: Input, O: Output

7.3 Pressure sensor

7.3.1 Sensor equipment

Note

For connector assignments, see Subsection 5.1.2.

General

The task of pressure sensors is to convert the mechanical “pressure” variable into the electrical “voltage” or “current” variable.

The pressure sensors from the Bosch Rexroth product range are suitable for pressure monitoring and control applications in mechanical engineering, injection molding machines, presses and many other areas.

The most important features of the sensors are

- pressure sensor element consisting of high-quality steel membrane (spring material), coated with thin-layer strain gauges in full-bridge connection.
- integrated electronic circuitry with temperature compensation
- signal output proportional to pressure
- zero point and sensitivity are calibrated exactly by manufacturer

Note

Pressure sensor cables with pre-assembled sensor end are not available. The following cable information is intended only as an example.

Instructions for use

- Sensor must be mounted in vertical position with connector pointing downwards.
- The sensor must be installed in the hydraulic system in such a way as to prevent air cushions developing between the sensor membrane and the pressure medium.
- Pressure medium: Hydraulic fluid;
 other fluids only after consultation with Bosch Rexroth.

Selection of pressure sensor (recommended types)

Sensors with a signal voltage of U=0...10 V are available in the following variants for the HLA module:

Table 7-3 Recommended types of pressure sensor

Signal	Pressure range	Male connector	Rexroth order no.
0...10 V	100 bar	Rectangular connector, 4-pin	0811 405 554
	210 bar		0811 405 540
	350 bar		0811 405 547
	210 bar	7-pin circular connector	0811 405 531
	350 bar		0811 405 532

Dimensions/terminal assignments

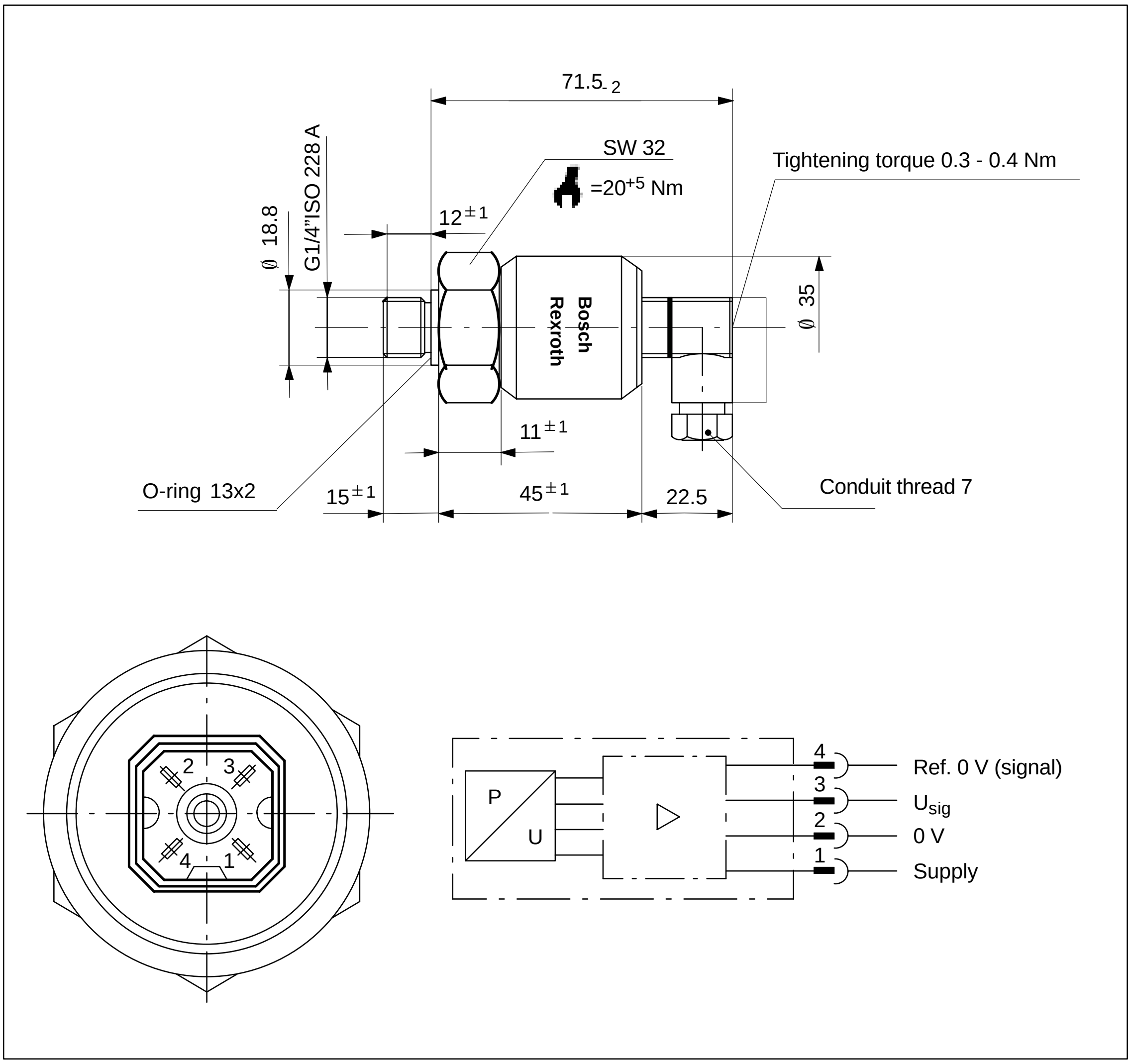


Fig. 7-7 Rexroth pressure sensors, order nos. 0811 405 540, 0811 405 547 and 0811 405 554

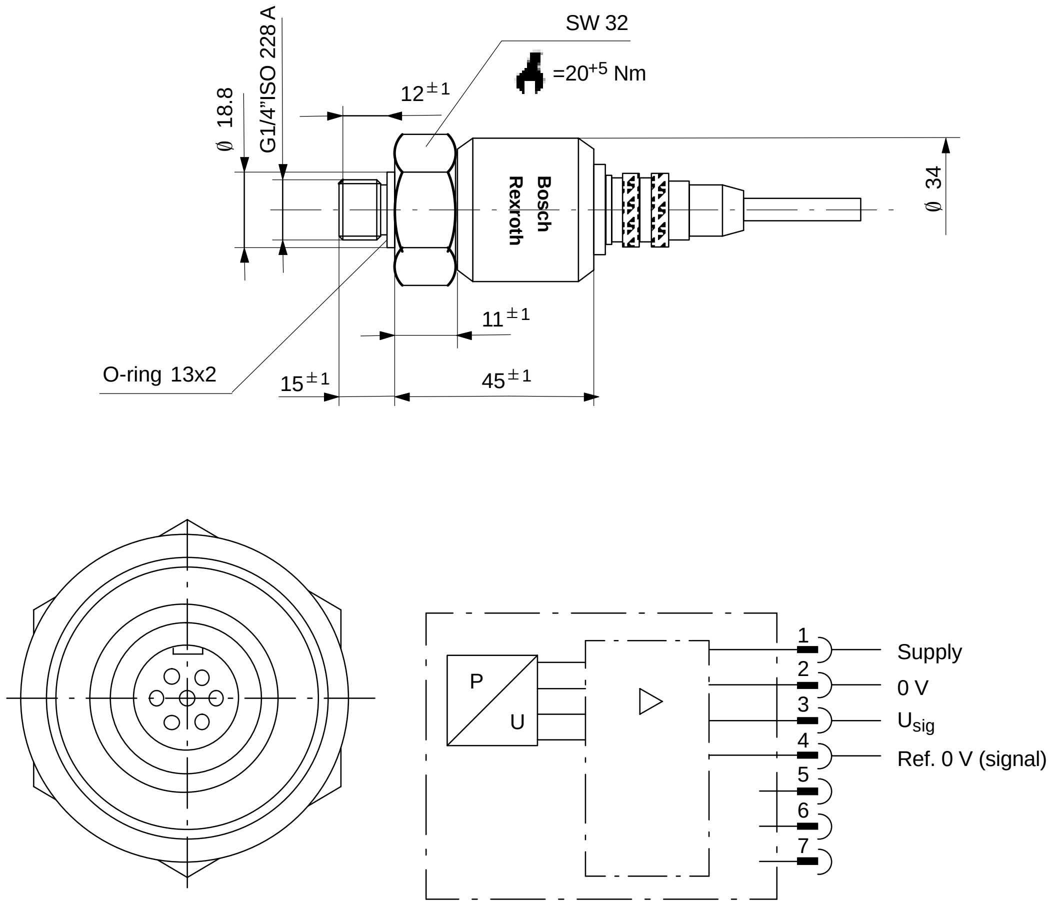


Fig. 7-8 Rexroth pressure sensors, order nos. 0811 405 531 and 0811 405 532

Rexroth order no. 1 834 484 141

Fig. 7-9 Accessories for pressure sensors with order nos. 0811 405 531 and 0811 405 532

Characteristics

Table 7-4 Characteristics of pressure sensors

Characteristic	Value range
Signal voltage	0...10 V
Supply voltage 0811 405 540 0811 405 547 0811 405 5554 0811 405 531 0811 405 532	 13...28 V DC 13...28 V DC 13...28 V DC 12...28 V DC 12...28 V DC
“Dynamic” overload capability	2 x p_{nom} (up to 20 x 10^6 load cycle)
“Static” overload capability	3 x p_{nom} (up to 10 x 0.5 sec each)
Burst pressure	>1500 bar
Linearity deviation with hysteresis Zero point scatter Sensitivity scatter Temperature coefficient of zero point Temperature coefficient of sensitivity	$< \pm 0.5\%$ $< \pm 0.5\%$ $< \pm 0.5\%$ $< \pm 0.2\%/10$ °C $< \pm 0.25\%/10$ °C
Measurement temperature range (compen-sated) Operating temperature range Storage temperature range	+10 to +70 °C -10 to +80°C -30 to +90°C
Hydraulic dead volume Measuring frequency (-3 dB) Natural frequency Max. acceleration	Approx. 0.5 cm^3 $\approx$1 kHz $\geq$10 kHz $\approx$25 g (g=9.81 ms^2)
Connecting piece material (hydraulic) Membrane material	X 5 Cr Ni 18 10 X 5 Cr Ni Cu Nb 17 4
Hydraulic connection	G 1/4 (ISO 228)

Accessories

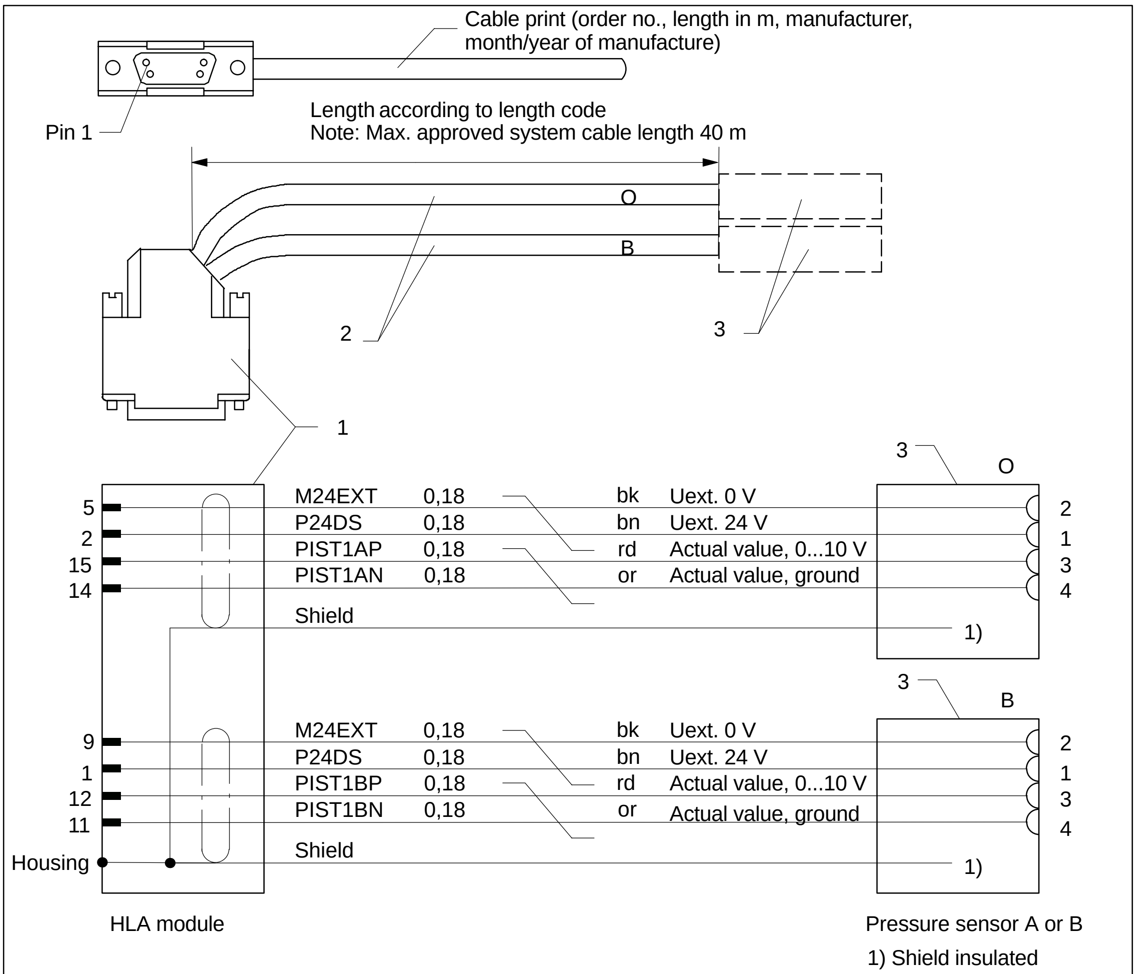
A 4-pin square connector is supplied with the following pressure sensors with order nos.: 0811 405 540
0811 405 547
0811 405 554.

For replacement purposes, it can be ordered under order no.: 1 834 484 061 or 1 834 484 063 from Bosch Rexroth AG.

7.3.2 Connection diagrams

Note

The following cable data for hydraulic systems is tailored specifically to Bosch Rexroth products. If hydraulics components supplied by other manufacturers are used, the pin assignments of the hydraulic-end connections might be different!



Item	Meaning
1	Sub D male connector, 15-pin, with screw lock UNC 4-40 6FC9341-1HC
2	Signal lead 2x(2x0.18) C 6FX2008-1BD71
3	Male connector • 4-pin socket included with pressure sensor Bosch Rexroth order no.: 1 834 484 061 or 1 834 484 063 • 7-pin socket not included with pressure sensor Bosch Rexroth order no.: 1 834 484 141

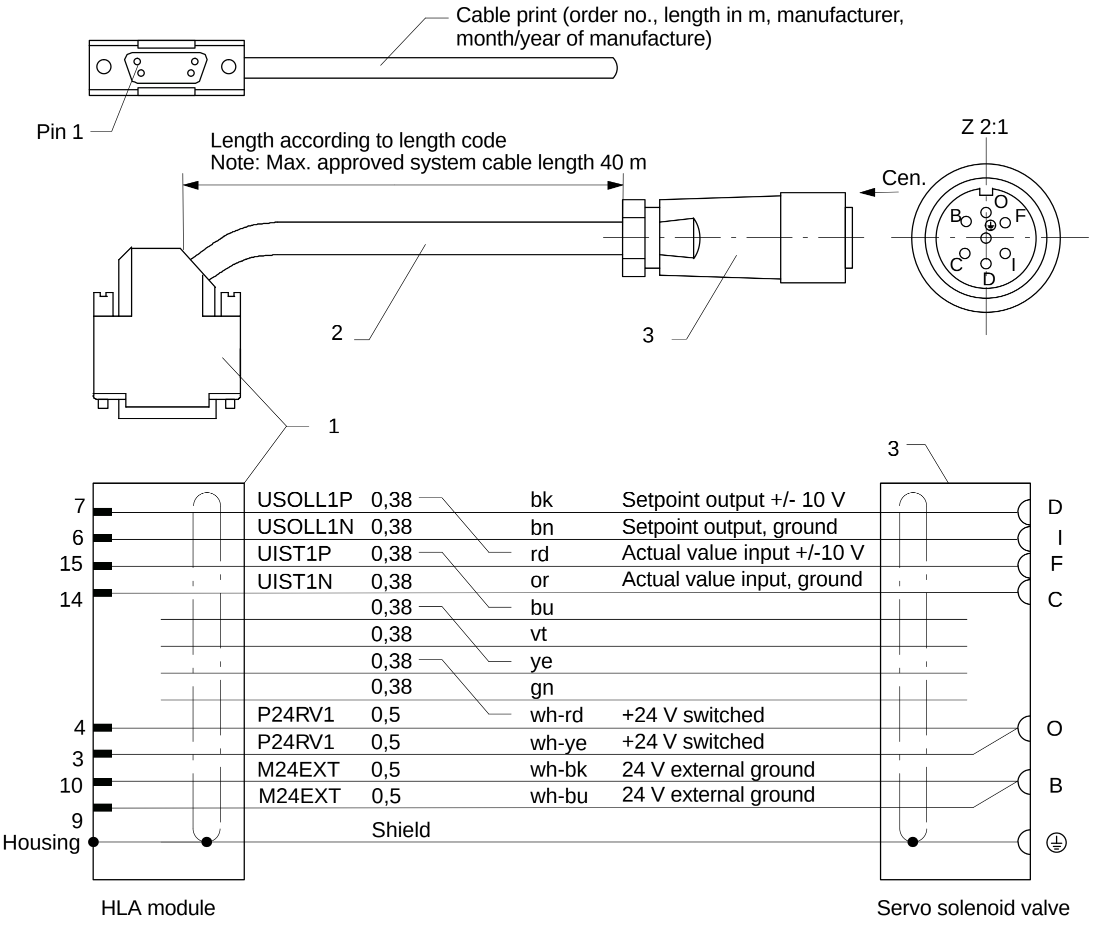
Order No. (MLFB) of signal lead for pressure sensors: **6FX2002-2AD00-1** □□□

Fig. 7-10 Signal lead for pressure sensors (X111/X112)

7.4 Connection diagrams for servo solenoid valves

Note

The following cable data for hydraulic systems is designed for directly and pilot actuated Bosch Rexroth servo solenoid valves (see Subsection 2.3.2).



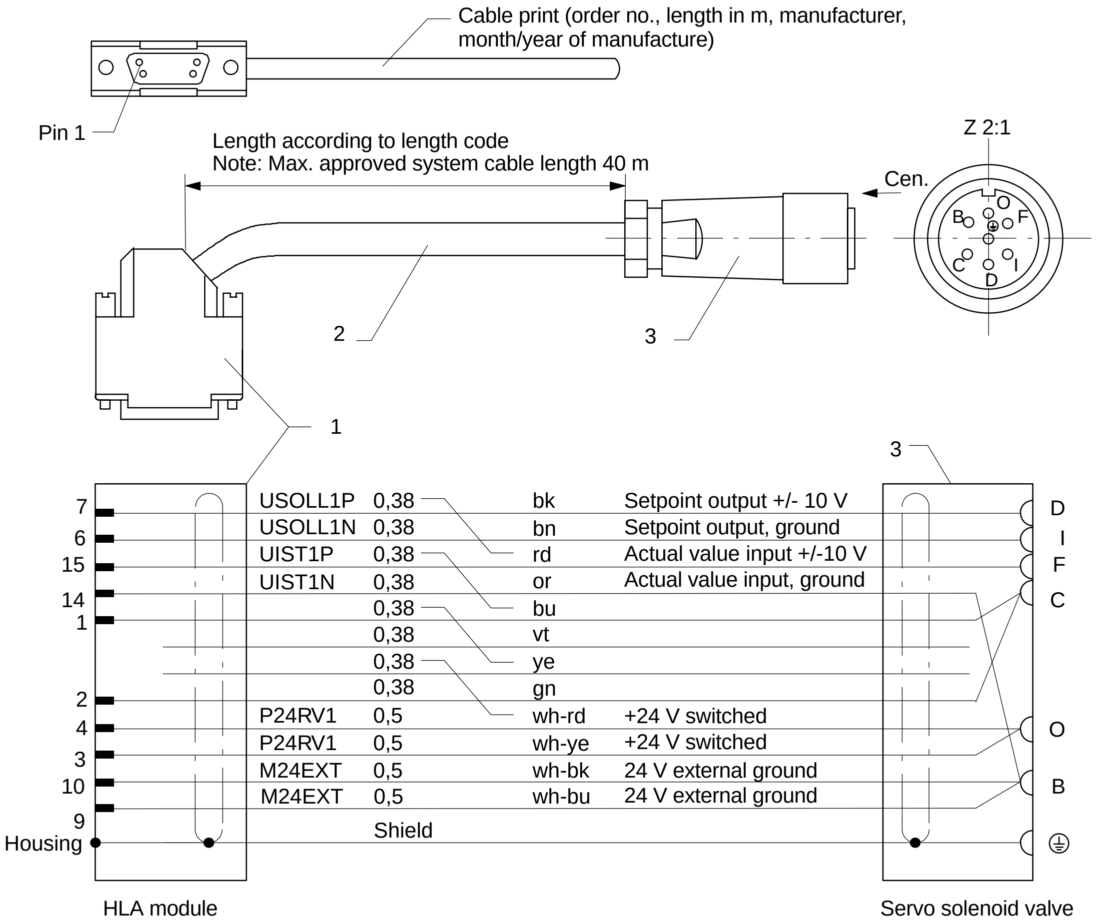
Item	Meaning
1	Sub D male connector, 15-pin, with screw lock UNC 4-40 6FC9341-1HC
2	Signal lead 4x(2x0.38) + 4x0.5 C 6FX2008-1BD21
3	7-pin socket connector GE.570102.0144.00

Order No. (MLFB) of signal lead for 7-pin servo solenoid valve: **6FX2002-2BA00-1 □□□**

Fig. 7-11 7-pin signal lead for servo solenoid valve (X121/X122) - standard version

Note

The pin assignments on valves supplied by other manufacturers may deviate from the assignments shown in Fig. 7-11. Cables must be assembled by the customer!

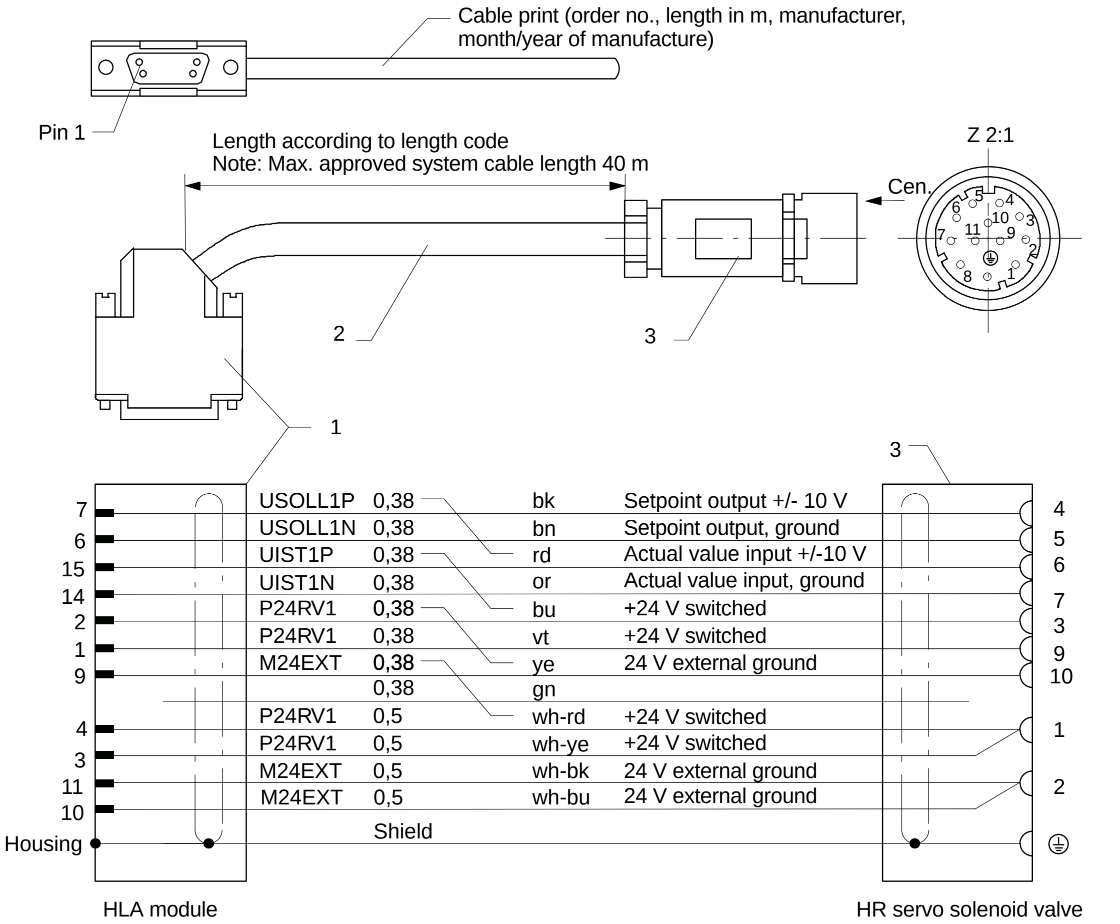


Item	Meaning
1	Sub D male connector, 15-pin, with screw lock UNC 4-40 6FC9341-1HC
2	Signal lead 4x(2x0.38) + 4x0.5 C 6FX2008-1BD21
3	7-pin socket connector Valve-specific

Fig. 7-12 Interconnection diagram for 7-pin servo solenoid valve (X121/X122) - connection option 2 (customized)

Note

The following cable data for hydraulic systems is designed for directly and pilot actuated Bosch Rexroth HR servo solenoid valves (see Subsection 2.3.2).



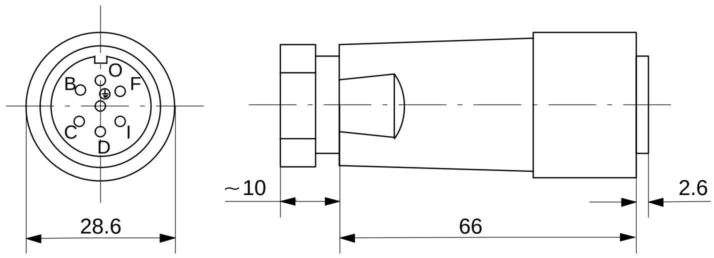
Item	Meaning
1	Sub D male connector, 15-pin, with screw lock UNC 4-40 6FC9341-1HC
2	Signal lead 4x(2x0.38) + 4x0.5 C 6FX2008-1BD21
3	12-pin socket connector GE.570102.0145.00

Order No. (MLFB) of signal lead for 12-pin HR servo solenoid valve: **6FX2002-2BA10-1 □□□**

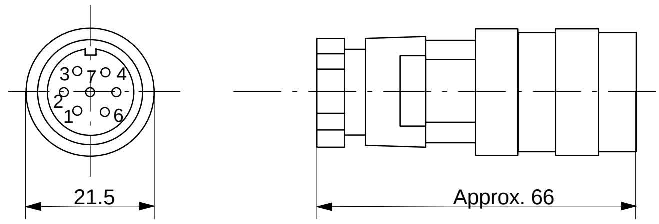
Fig. 7-13 12-pin signal lead for HR servo solenoid valve (X121/X122)

Note

The following data for the connectors on the servo solenoid or HR servo solenoid valve signal leads only applies to spare parts orders or where the cables are to be made up by the customer. The cables are normally supplied fully pre-assembled by Siemens.

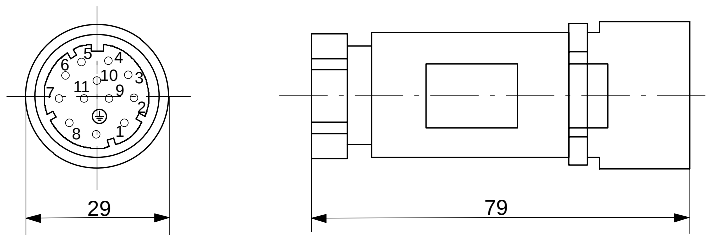


Metal	Crimp connection	0.08	Rexroth 1 834 482 023
Plastic	Crimp connection	0.05	Rexroth 1 834 482 026
Plastic	Soldered connection	0.05	Rexroth 1 834 482 022 Hirschmann CM 06 EA 14S-61S
Design	Contacts	kg	Order No.



Plastic	Soldered connection	0.05	Rexroth 1 834 484 140 Binder 723-2-09-0126-25-07
Design	Contacts	kg	Order No.

Fig. 7-14 Dimension diagram of circular, 7-pin connector



Plastic	Crimp connection	0.05	Rexroth 1 834 484 142 Hirschmann NIIR EF K B0
Design	Contacts	kg	Order No.

Fig. 7-15 Dimension diagram of circular, 12-pin connector

■

Notes

Service 8

8.1 Areas of responsibility at Siemens/Bosch Rexroth

The areas of responsibility with respect to Sales and Servicing as shown in Table 8-1 below have been agreed between Siemens AG and Bosch Rexroth AG.

Table 8-1 Areas of responsibility for sales and servicing

Siemens	Bosch Rexroth
“Electrical” equipment/ configuring	**“Hydraulic” equipment/ configuring**
HMI/MMC	Power units
NC/PLC	Valves
Mains supply module	Cylinder
Closed-loop control modules	Hydraulic connections
Power sections	Pressure sensing system
Motors	Encoder sensors
Cabling	
Hydraulic drive module	
Connecting cable for valves and pressure switches (see Subsection 7.3.2)	

Note

Neither company bears sole responsibility for the overall installation.

Siemens and Bosch Rexroth shall not be responsible unless they have actually supplied the components listed in Table 8-1 or have explicitly certified that components supplied by other manufacturers are compatible with the system.

8.2 Hotline and contacts

Siemens AG

Configuration and servicing for SIMODRIVE, central hotline

Europe and Africa time zone

Phone.: +49 (0) 180 5050-222

FAX: +49 (0) 180 5050-223

E-mail: techsupport@ad.siemens.de

America time zone

Phone.: +1 800 333-7421

FAX: +1 423 262-2200

E-mail: isd-callcenter@sea.siemens.com

Asia/Australia time zone

Phone.: +65 740-7000

FAX: +65 740-7001

E-mail: drives.support@sae.siemens.com.sg

Internet address

Up-to-date information about the products can be found on the Internet at the following address:

http://www.siemens.com

Bosch Rexroth AG

Servicing

7.00 am - 5.00 pm	Phone: +49 (0)9352 / 18-1164 FAX: +49 (0)9352 / 18-3363
5.00 pm - 7.00 am	Phone: +49 (0)173 / 3636036 (standby)

E-mail: support.bri@boschrexroth.de

Internet address

Up-to-date information about the products can be found on the Internet at the following address:

http://www.boschrexroth.de

■

Hydraulics

A

A.1 Servo solenoid valves

A.1.1 General

The servo solenoid valve is the final control element in the electro-hydraulic control loop. It converts the electrical manipulated variable U=-10...+10 V into the hydraulic variables pressure p and flow rate Q, and thus into a cylinder movement.

Sliding spool principle

These valves are of the sliding-spool type. A valve spool with 4 control edges moves inside a steel sleeve, the control bore of which is connected to the 4 ports in the valve casing. The main stages of pilot-controlled valves do not typically have the steel sleeve, in which case the control geometry is represented directly by the valve casing.

The ports in the valve casing are:

- P: Pressure port (inlet)
- T: Tank port (return)
- A and B: Working ports (cylinder)

The valve spool slides steplessly through 3 switching positions (continuous valve).

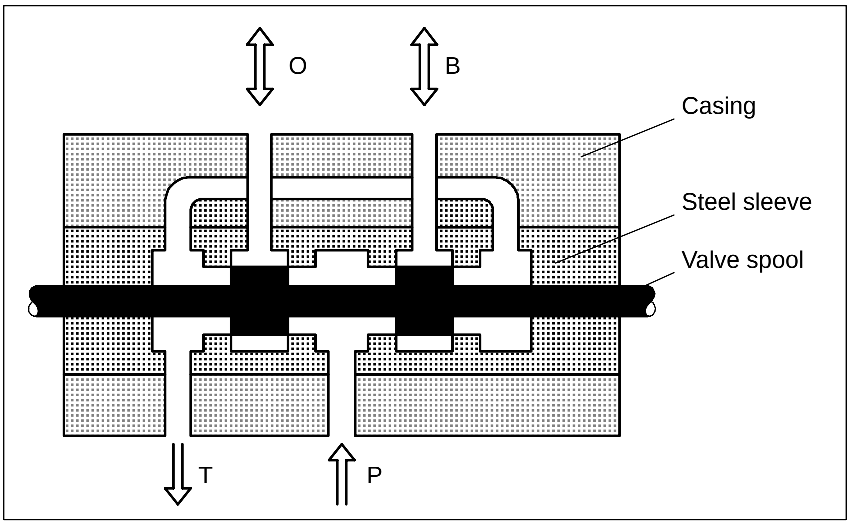


Fig. A-1 Sliding spool principle

Solenoid actuation with valve spool position control

On size 6 and 10 standard servo solenoid valves, the valve spool is actuated directly by a stepless actuating solenoid. This converts a current I into a force F, which is compared to the force of the reset spring. This comparison of forces finally produces a travel s, and thus an opening cross-section at the control edges of the valve spool.

To compensate for disturbance forces acting on the valve spool (flow forces) and to reduce the hysteresis and response sensitivity or range of inversion, the position of the armature, and therefore the spool travel, is scanned and applied to a position control loop as an actual value. Any deviations from the spool position setpoint are thus continuously corrected. This method is particularly successful in reducing the valves' sensitivity to dirt.

Very small control deviations, such as those caused when the valve spool sticks, can be corrected by mobilizing the entire available magnetic force.

A wear-resistant, proximity-type differential transformer (LVDT) is used as the spool travel sensor.

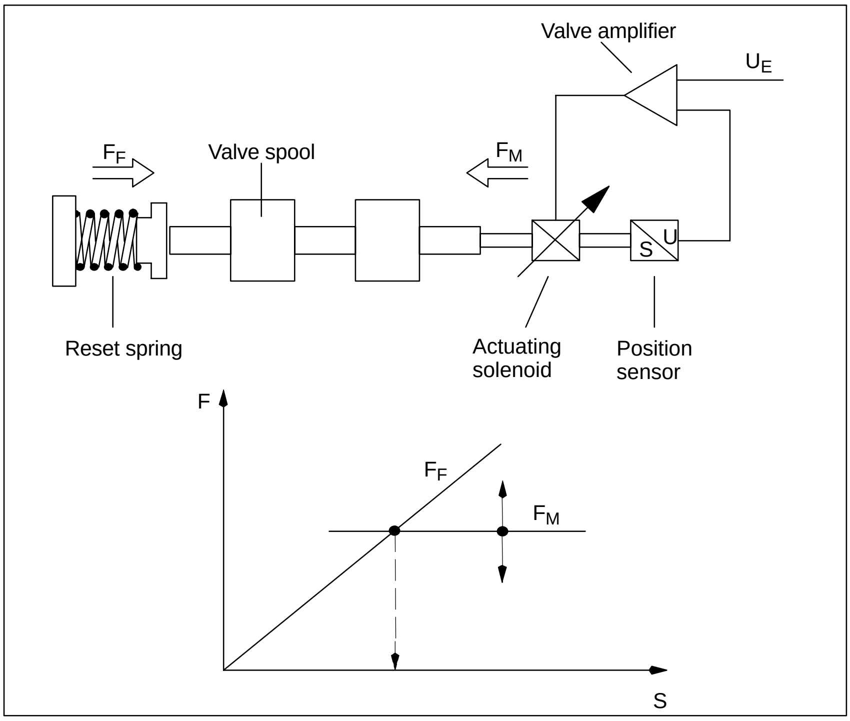


Fig. A-2 Solenoid actuation with valve spool position control

Graphical symbol

The operating principle of the servo solenoid valve is represented by a symbol in the hydraulic circuit diagram. The symbol comprises a series of different boxes denoting the valve positions.

The three stepless-transition valve positions are represented by additional lines. The symbol also indicates how the valve is actuated. In this case, by direct solenoid actuation with spring return at one end.

If the valve has a fail-safe position, then the valve spool moves into a fourth (safety) position when the valve is not powered. There are two alternative positions.

The symbol also illustrates the principle of position control applied to the valve spool.

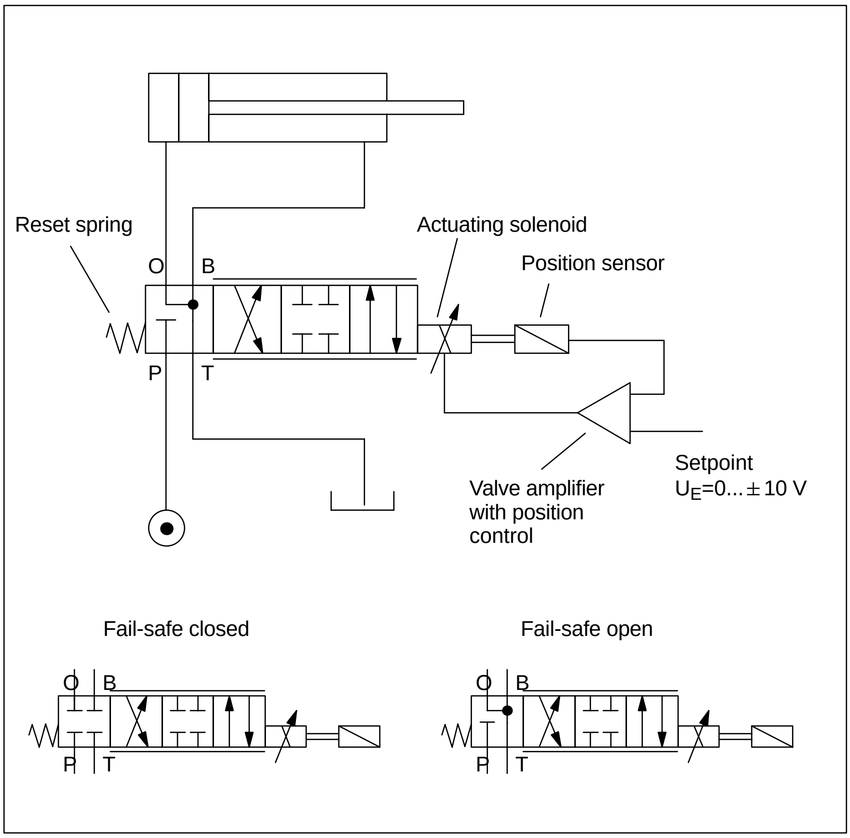


Fig. A-3 Graphical symbol

Zero overlap in mid-position

A continuous valve must have zero overlap around its mid-position if it is to be used in a position control loop.

A positive overlap will be perceived negatively in the form of a dead zone of the final control element.

In contrast, a negative overlap results in a marked increase in oil leakage.

To achieve zero overlap, valve spools, spool housings and spool sleeves must be manufactured with extreme precision and made of wear-resistant materials. The production costs incurred are correspondingly high.

To maintain the zero overlap over prolonged operating periods, it is essential to ensure that a clean pressure medium is used (to prevent erosion of control edges).

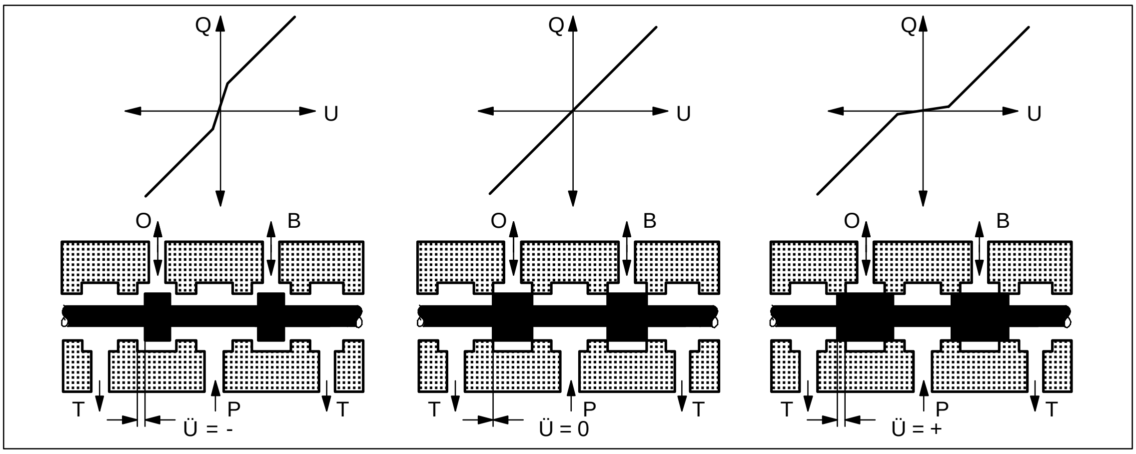


Fig. A-4 Zero overlap in mid-position

Pressure intensification

The quality of zero overlap in the mid-position is represented by the pressure intensification characteristic.

This states what percentage of the control spool deflection from the hydraulic zero point is needed to achieve a pressure differential of 80% system pressure at the closed load ports. The values of this characteristic are typically in the 1...3% range.

The following graphical representation of the measurement, which covers all 4 control edges, shows this clearly.

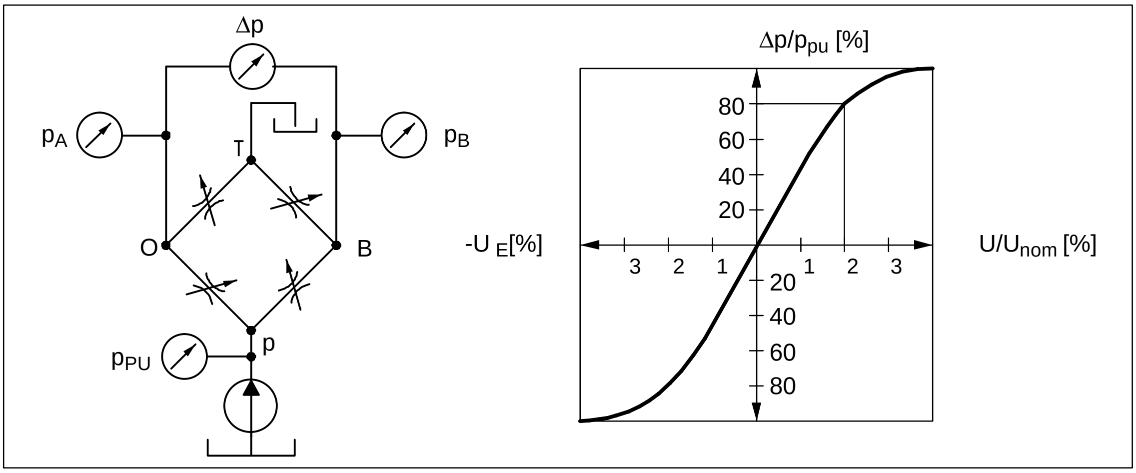


Fig. A-5 Pressure amplification

Flow characteristic, linear

The stepless spool movement, and thus the change in throttle cross-section at the control edges, results in a corresponding flowrate, which is represented as a function of the spool travel s or of the electrical input signal U (manipulated variable). The flow is dependent on the on the pressure drop, in addition to the opening cross-section,

$$Q \sim \sqrt{\Delta p}$$

as defined by the law of flow.

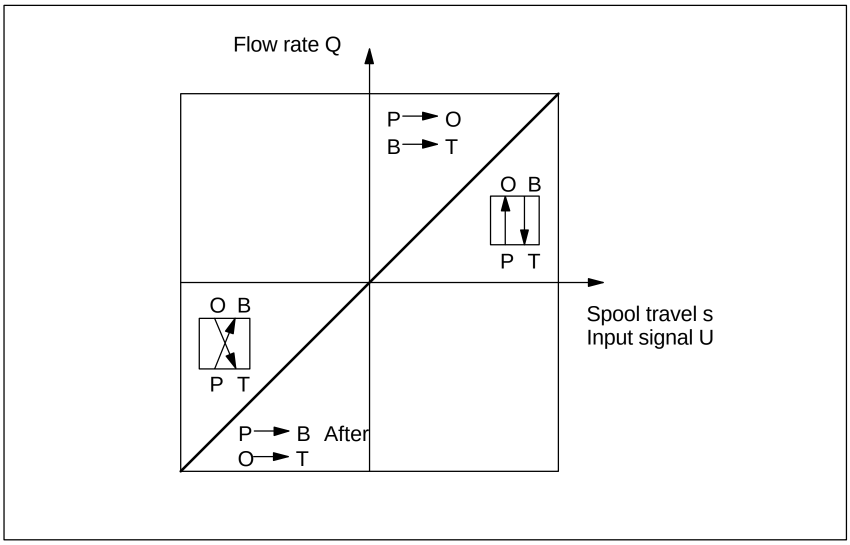


Fig. A-6 Linear flow rate characteristic

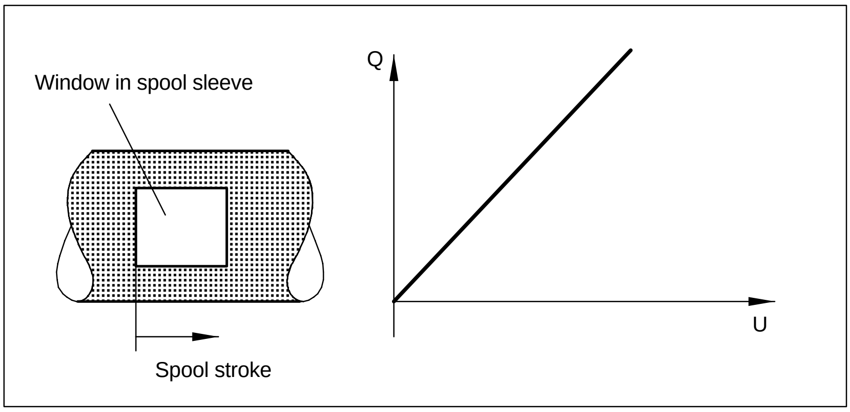


Fig. A-7 Control window in spool sleeve

Flow characteristic, with knee

Valves with a knee-shaped flow characteristic give the drive greater manipulated variable resolution in the lower signal range (better processing quality) and, at the same time, offer sufficient flow rate in the upper range (high rapid traverse velocity).

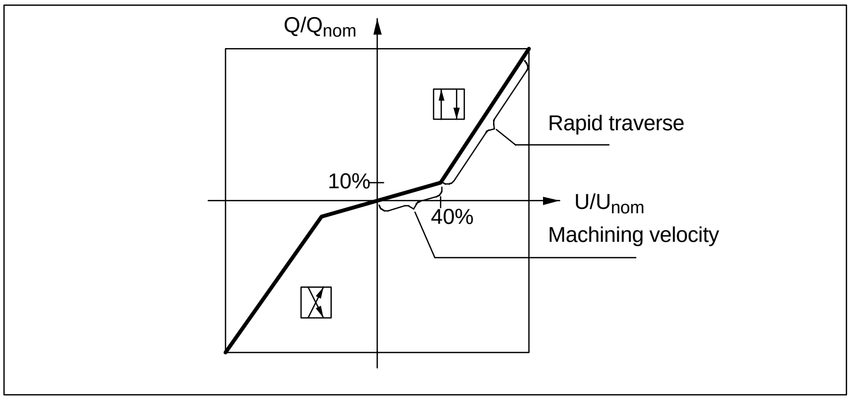


Fig. A-8 Flow characteristic with knee, example 40% - knee

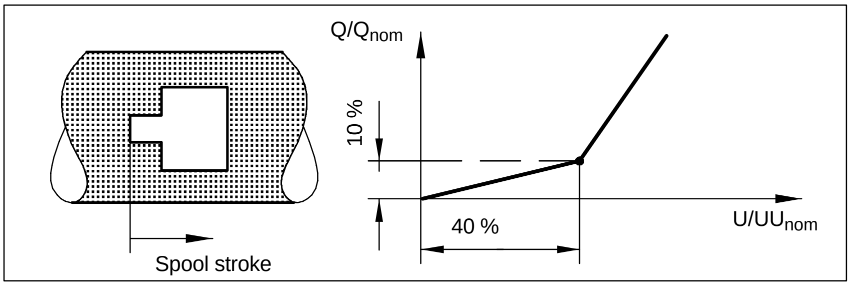


Fig. A-9 Stepped control window in spool sleeve, example 40% - knee

Linearization of knee-shaped flow characteristic

The knee-shaped characteristic of the valve is linearized in the HLA module to match it to the closed-loop control of the overall drive (cylinder). No steady-state operating point should be defined in the knee-point area.

The corresponding valve data are stored in the HLA module and automatically parameterized when the order number is entered.

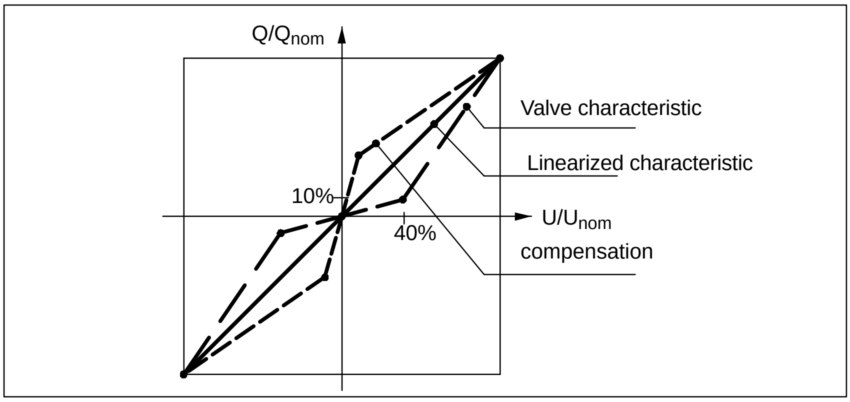


Fig. A-10 Electrical valve knee compensation

Nominal flowrate

This expresses the flow rate with fully opened valve in relation to a specific pressure drop per control edge.

Typical nominal flow rate for directly-controlled servo solenoid valves (nominal pressure drop of 35 bar per control edge):

- Size 6: Q=4...40 l/min
- Size 10: Q=50...100 l/min

Typical nominal flow rate for pilot-controlled servo solenoid valves (nominal pressure drop of 5 bar per control edge):

- Size 10: Q=55...85 l/min
- Size 16: Q=120...200 l/min

The flow under other pressure conditions is calculated according to the law of flow by the following formula:

$$Q_X = Q_{nom} \cdot \sqrt{\frac{\Delta p_X}{\Delta p_{nom}}}$$

Asymmetric flow characteristic

See Subsection 2.3.2 for a description.

Dynamic response

The dynamic characteristics provide information on the servo solenoid valve's ability to respond to rapid signal changes.

One simple expression of the dynamic response is the actuating time. This is the time that the valve spool requires in order to adjust to a jump in the valve spool setpoint of typically 0 to 100%.

More exact information about the dynamic response is provided by the Bode diagram or frequency response. In this case, a sinusoidal setpoint is applied to the valve. The amplitude ratio and phase shift curves are then determined via the frequency from the actual and setpoint values of the valve spool. The valve frequency response is highly dependent on the setpoint amplitude, which should therefore be specified as a parameter. The dynamic response of servo solenoid valves is of particular interest in the range of smaller signal amplitudes of 5 to 20% * U_{nom}.

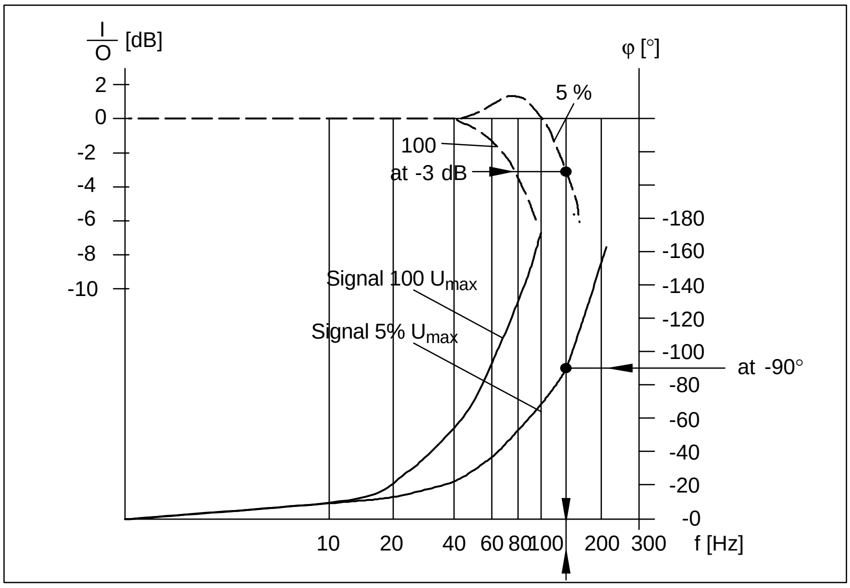


Fig. A-11 Dynamic response of valve

Hysteresis, response sensitivity, range of inversion

These three terms define similar properties.

Hysteresis means the greatest difference in the input signal for identical output signals on passing through a complete signal range.

For a servo solenoid valve, the hysteresis is caused by:

- mechanical friction,
- magnetic hysteresis of the electromagnetic signal transducer and
- the play between transmission elements.

The position control corrects the hysteresis.

The hysteresis for Rexroth servo solenoid valves is less than 0.2% and is compensated for in the closed control loop.

The terms Response sensitivity and Range of inversion refer to the signal level required to set a valve in motion again after it has stopped. The values of these characteristics correspond to about half the hysteresis.

To overcome residual hysteresis or initial valve friction, a friction compensation function can be activated in the HLA module.

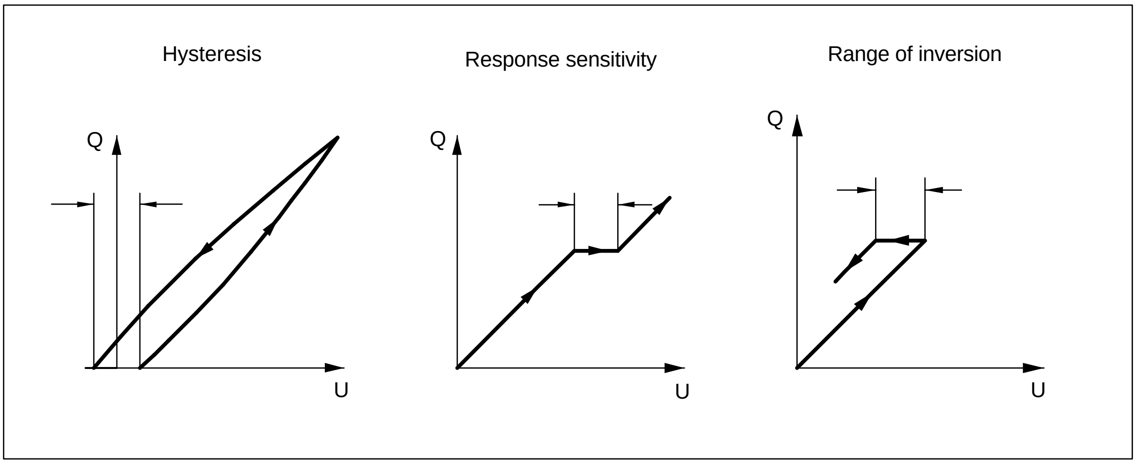


Fig. A-12 Hysteresis, response sensitivity and range of inversion of servo solenoid valve

Filtration grade

To maximize the service life of the control edges, thus ensuring the quality of zero overlap, a degree of purity of the hydraulic medium (fluid) must be maintained.

The objective is contamination class 7...9 to NAS 1638. This can normally be achieved with a pressure filter β_{10}=75.

A.1.2 Directly-controlled servo solenoid valves, sizes 6 and 10

Mechanical structure

The standard series of Bosch Rexroth size 6 and 10 servo solenoid valves shown in the following diagram are based on the same principle.

The valve spool in its steel sleeve is pushed against the reset spring directly by the actuating solenoid. The armature axis of the solenoid is mechanically coupled to the ferrite core of the position sensor integrated in the solenoid.

This sensor is a proximity-type, wear-resistant differential transformer (LVDT).

The housing of the integrated valve amplifier (On Board Electronic OBE) is bolted directly onto the solenoid/position sensor module.

Electrical power is supplied and the setpoint injected via a 7-pin connector.

If the valve is operating around the mid-position, the solenoid is energized by about 50%. When the power supply is switched off, it assumes a 4th position, known as the fail-safe position. On connection and disconnection of the supply, it slides through the crossed position.

The valves are available with a variety of nominal flow rates and two different fail-safe positions.

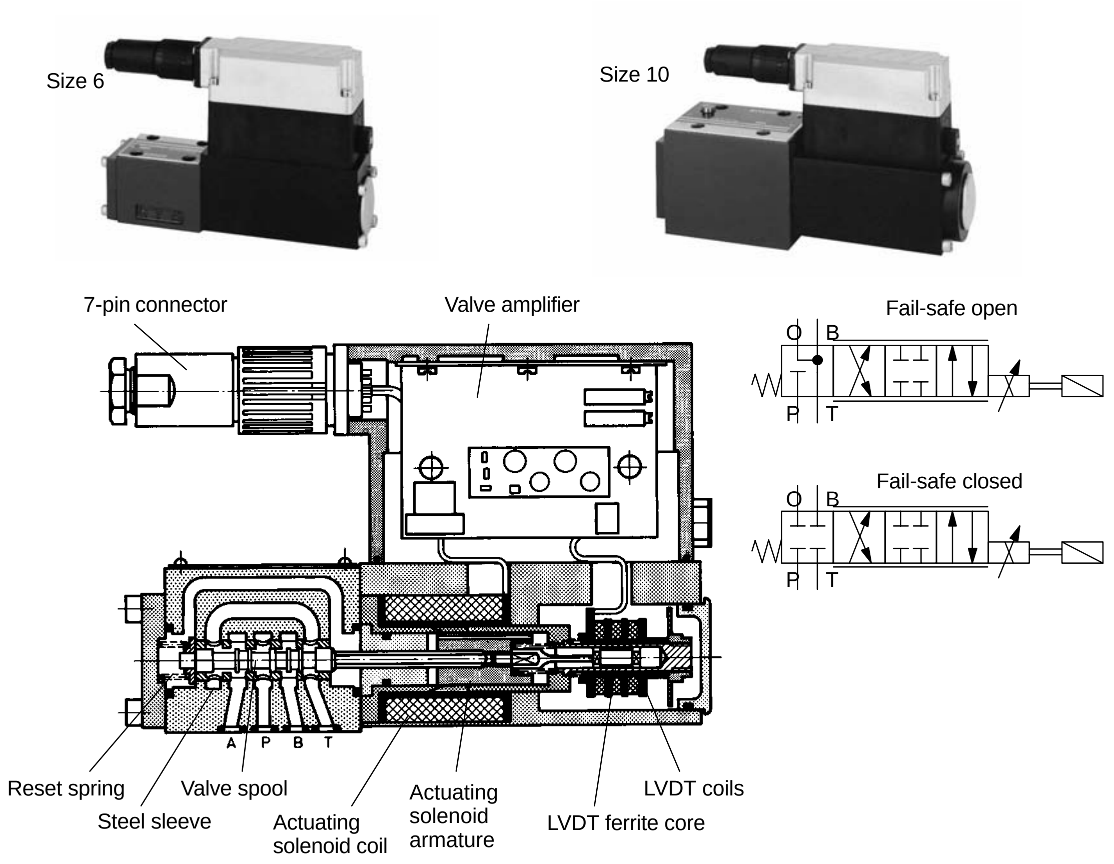


Fig. A-13 Directly-controlled servo solenoid valves, sizes 6 and 10 (Rexroth)

Valve amplifier

The functions of the integral valve amplifier are implemented with analog circuits, and are illustrated in the block diagram (see Fig. A-14).

The main amplifier functions are:

- Supply and evaluation of the position sensor (AC/DC converter)
- Comparison of setpoint input signal with spool actual value
- Formation of manipulated variable via a PID controller for the output stage
- Timing output stage with pulse length modulation

The amplifier is calibrated to match the valve at the factory. The zero-point is adjusted via the NC during start-up.

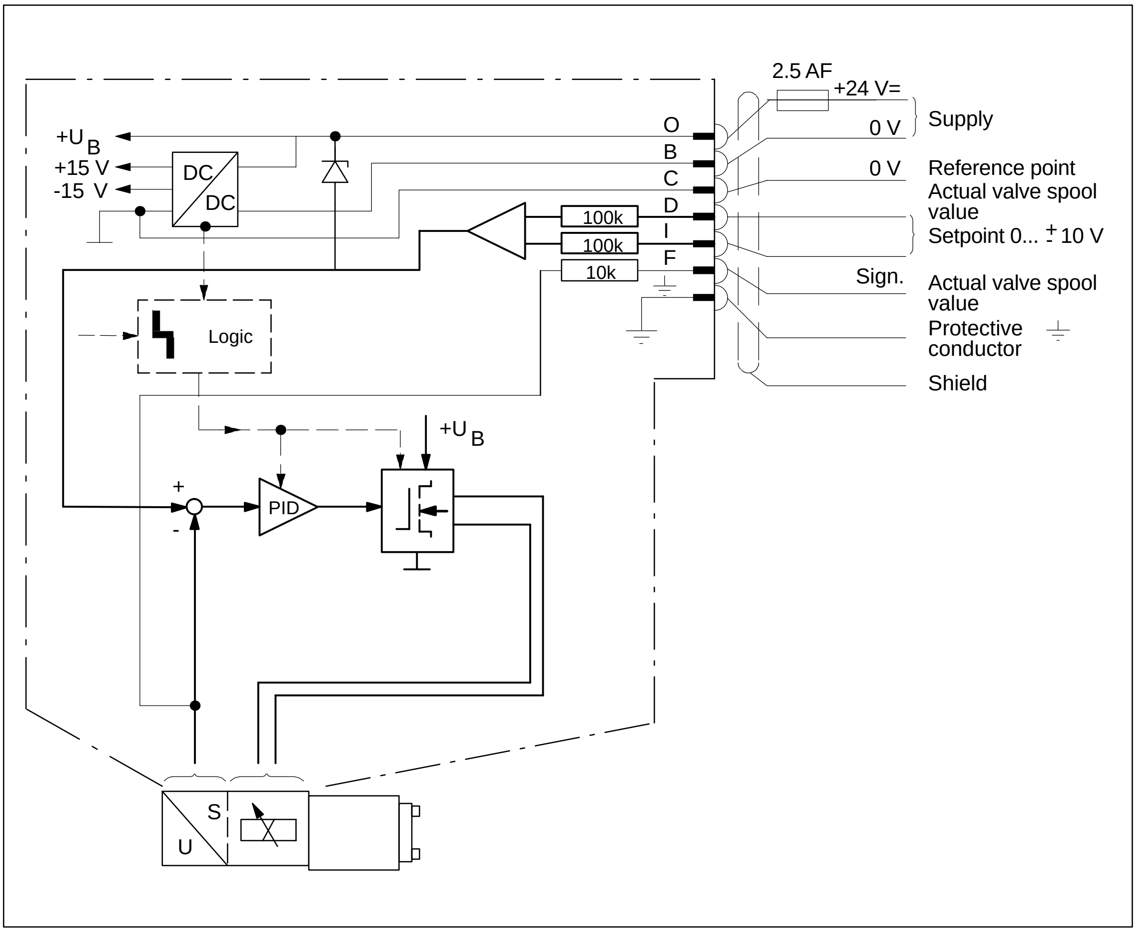


Fig. A-14 Valve amplifier block diagram for directly-controlled servo solenoid valves, sizes 6 and 10 (Rexroth)

A.1.3 Pilot-controlled servo solenoid valves, sizes 10 and 16

The principle of pilot control is applied in order to control higher flow rates.

Mechanical structure

A size 10 or 16 directional control valve with suitable control edges is used as the main stage on the valve spool. Like the piston rod of a cylinder, this stage is hydraulically clamped and positioned by a size 6 pilot valve (see Subsection A.1.2).

The position of the main spool is scanned by another position sensor and the corresponding actual value applied to a second, subordinate position control loop.

Inlet and outlet of hydraulic fluid

The control fluid can be supplied and removed either internally via ports P and T or, as often is the case in practice, externally via additional ports X and Y. The unit is converted using suitable plugs.

Valve positions

Pilot-actuated servo solenoid valves have only three stepless-transition valve positions.

The 4th fail-safe position is omitted. If the supply voltage is disconnected, the spring force of the main spool causes the valve to assume an indifferent mid-position.

Valve amplifier

The integral valve amplifier is mounted on the pilot valve assembly and contains both position control loops. A cable is used to connect the position sensor on the main stage to the amplifier.

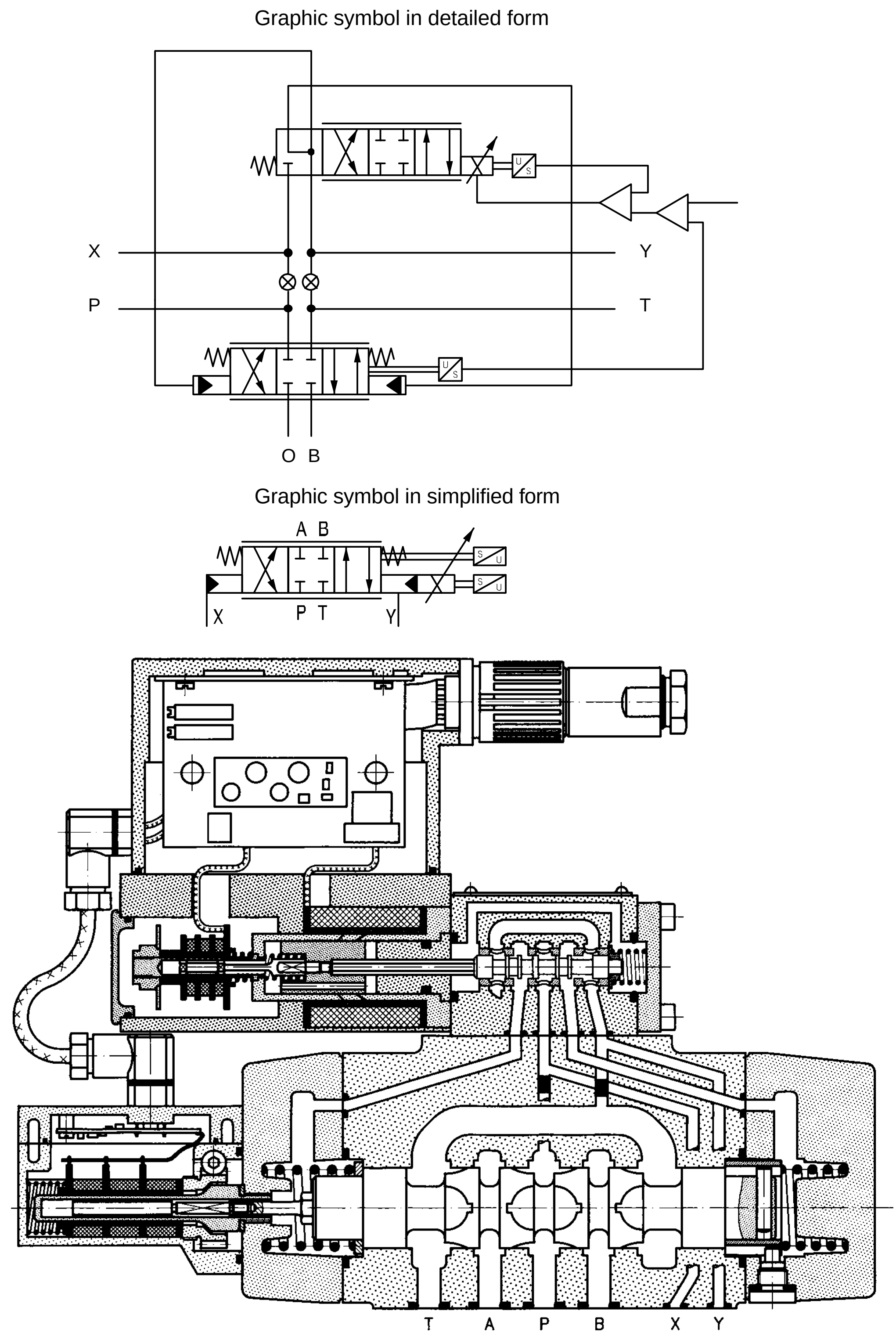


Fig. A-15 Directly-controlled servo solenoid valves, sizes 10 and 16 example of an external control fluid port (Rexroth)

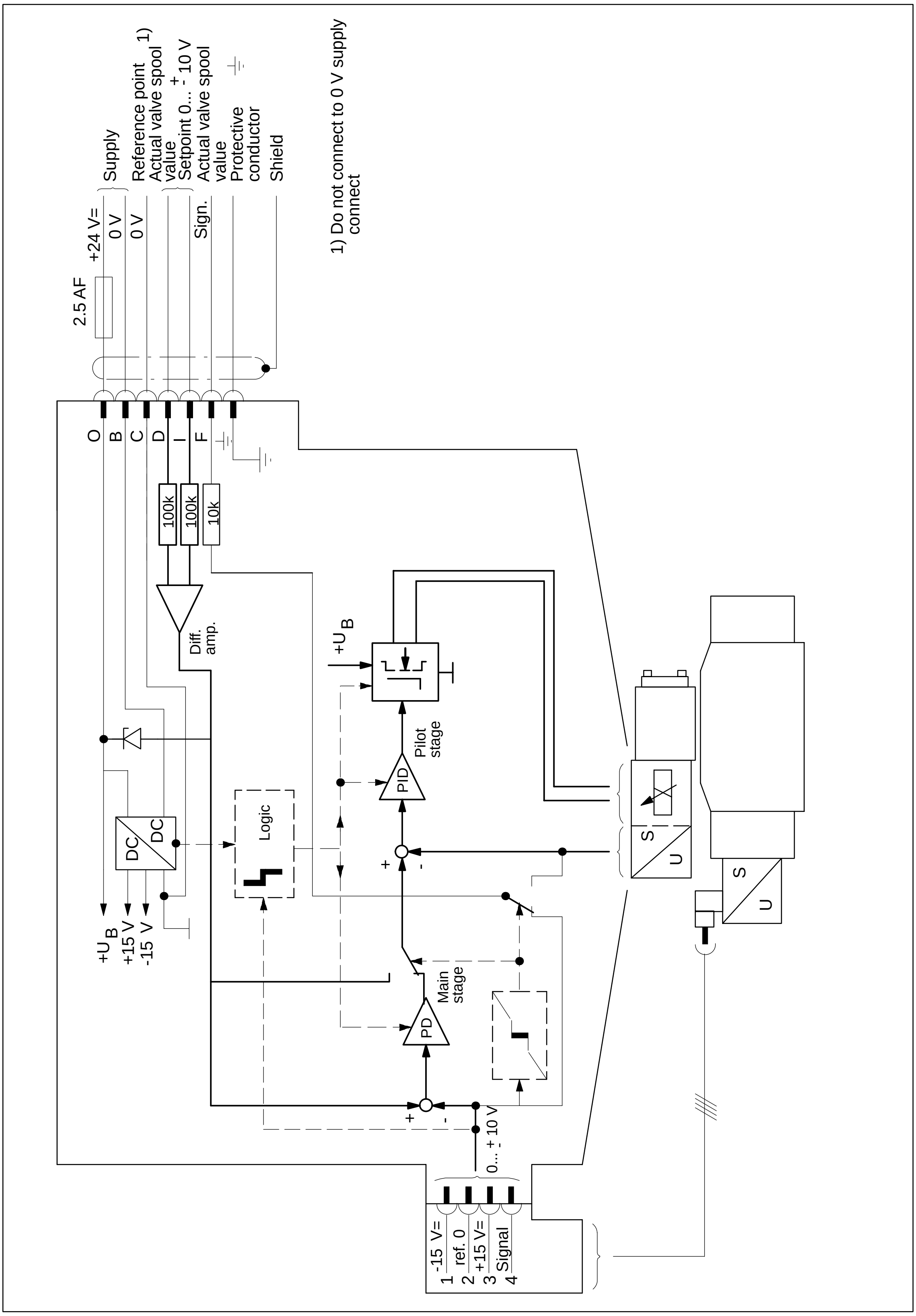


Fig. A-16 Valve amplifier block diagram for pilot-controlled servo solenoid valves, sizes 10 and 16 (Rexroth)

A.1.4 HR servo solenoid valves

General

The HR (High Response) series of servo solenoid valves from Bosch Rexroth offers particularly good dynamic and static characteristics, making it the ideal addition to the range for highly sophisticated applications.

At the heart of the series is the 4WRREH 6 valve. This is also used as a pilot valve in type 4WRVE pilot-controlled HR servo solenoid valves.

Both valve stages on pilot-actuated valves operate under position control.

Features

In contrast to the other valves, the HR servo solenoid valve has the following features:

- Significantly better dynamic response
- More compact dimensions
- A higher hydraulic switching capacity.

The HR valve comprises the following components:

- Flow-force-compensated hydraulic section with wear-resistant steel sleeve and spring centered control spool
- Double-stroke solenoid with inductive position encoder (LVDT) and
- Integrated electronics (OBE)

HR valves do not have the fail-safe position provided on other servo solenoid valves. Many applications therefore require external non-return valves, such as those available as sandwich-plate valves.

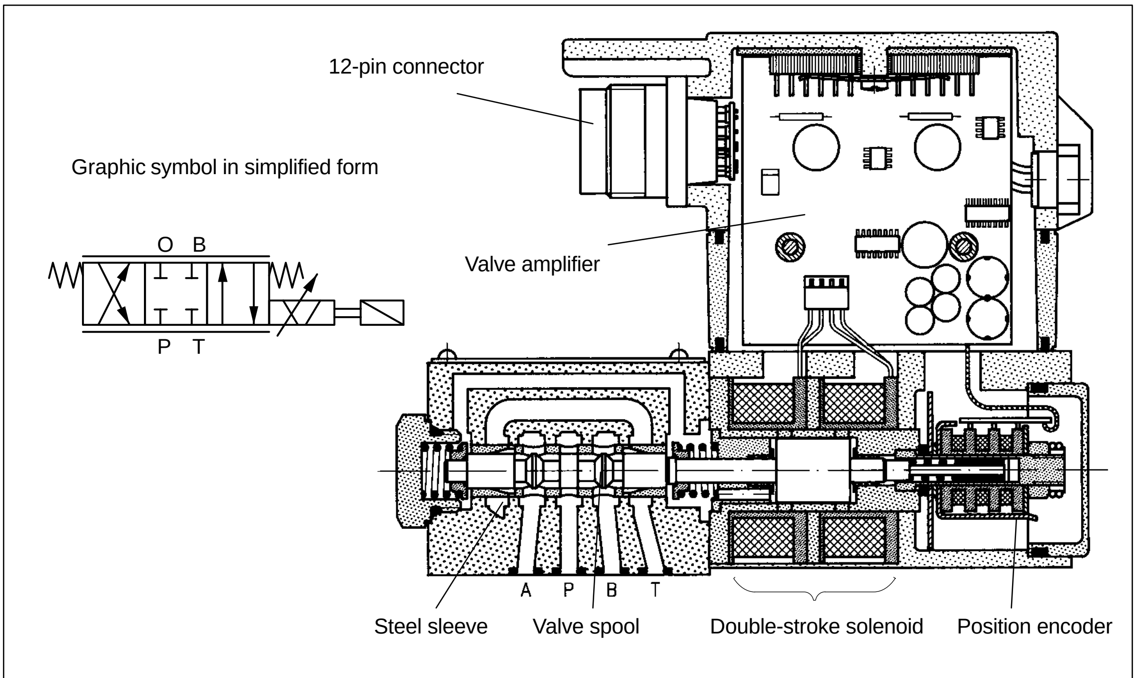


Fig. A-17 Directly-controlled HR servo solenoid valve (Rexroth)

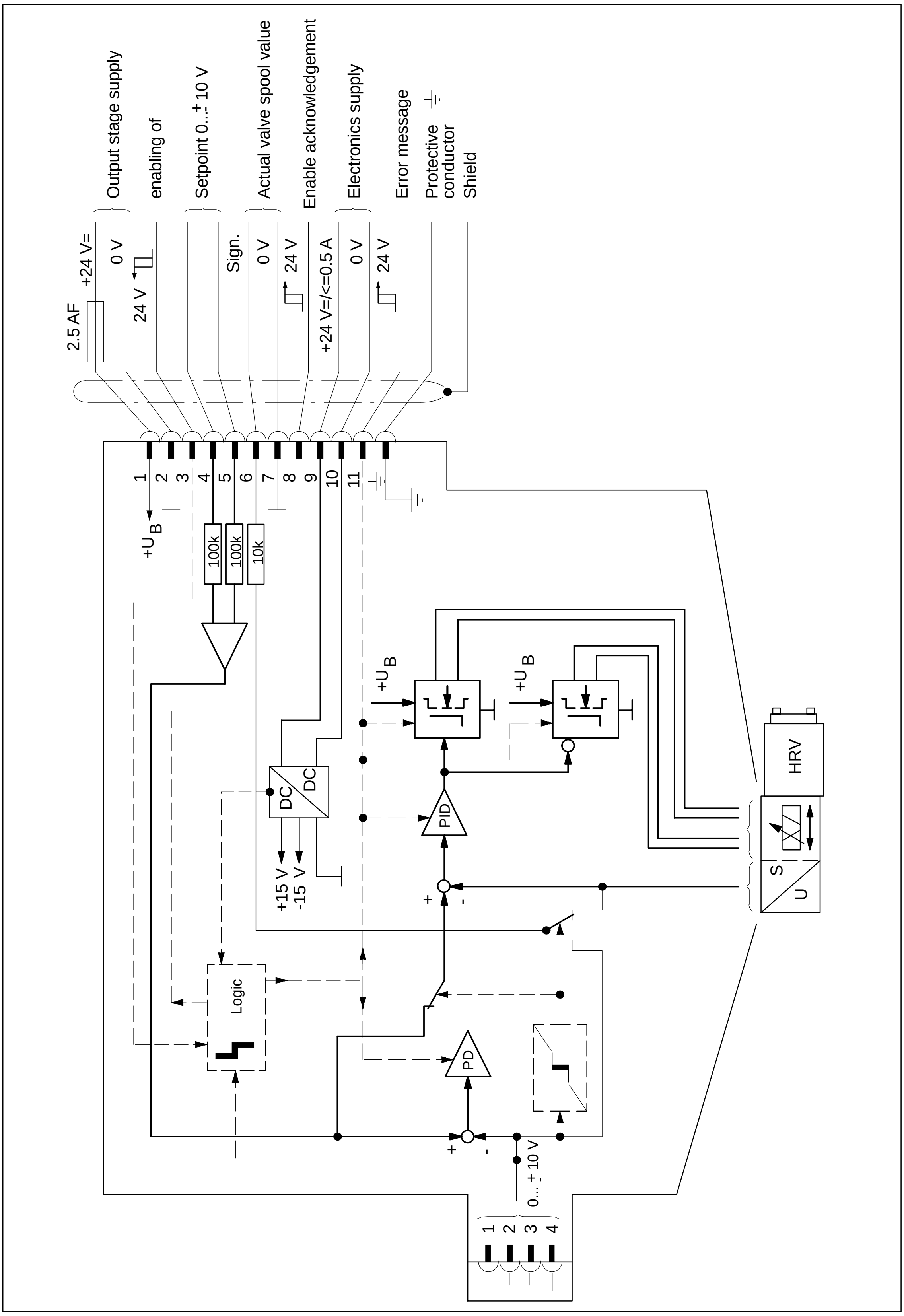


Fig. A-18 Valve amplifier block diagram for directly-controlled HR servo solenoid valves (Rexroth)

A.2 Cylinder

General

The cylinder acts as the drive element in the electro-hydraulic control loop.

It converts the flowrate into rectilinear motion. In this case, high velocities are required for rapid traverse movements as well as slow velocities for machining operations

Through-rod or differential cylinder

On a through-rod cylinder, a piston rod of the same diameter is mounted at both ends as a power transmission element. Consequently, the piston areas at the A and B ends are identical. Likewise, at a constant piston speed, the incoming flow is equal to the displaced flow in the settled state. The through-rod cylinder acts symmetrically both when traveling in and when traveling out.

In contrast to the through-rod cylinder, a differential cylinder has either a power-transmission piston rod at one end only or the piston rods at its two ends have different diameters. In the latter case, the piston areas at the A and B ends are different. Furthermore, at a constant piston speed, the displaced flow is not the same as the incoming flow. The maximum piston travel-in and travel-out speeds are not the same on a differential cylinder (see Section 4.7).

This asymmetry can, however, be compensated by means of the piston area adaptation function (MD 5112: VALVE_FLOW_FACTOR_A_B) on the HLA module.

Apart from the piston diameter, it is necessary to specify the rod diameters at the A and B ends. On a differential cylinder, both rod diameters are different, one of the rods might even have a zero diameter. The maximum piston stroke and cylinder dead volume are also required.

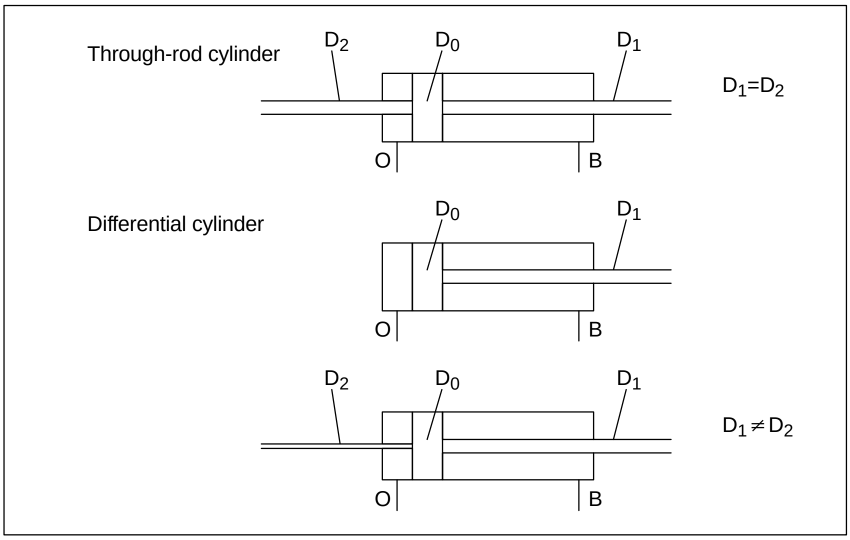


Fig. A-19 Cylinder principle

Quality of seals

The quality of the seals and guides on the piston, and the piston rod itself, must be particularly high in order to minimize the friction.

Transitions from static to sliding friction have a particularly adverse affect on the quality of control accuracy. A friction compensation setting has been provided in the HLA module (MD 5460: FRICTION_COMP_RADIENT).

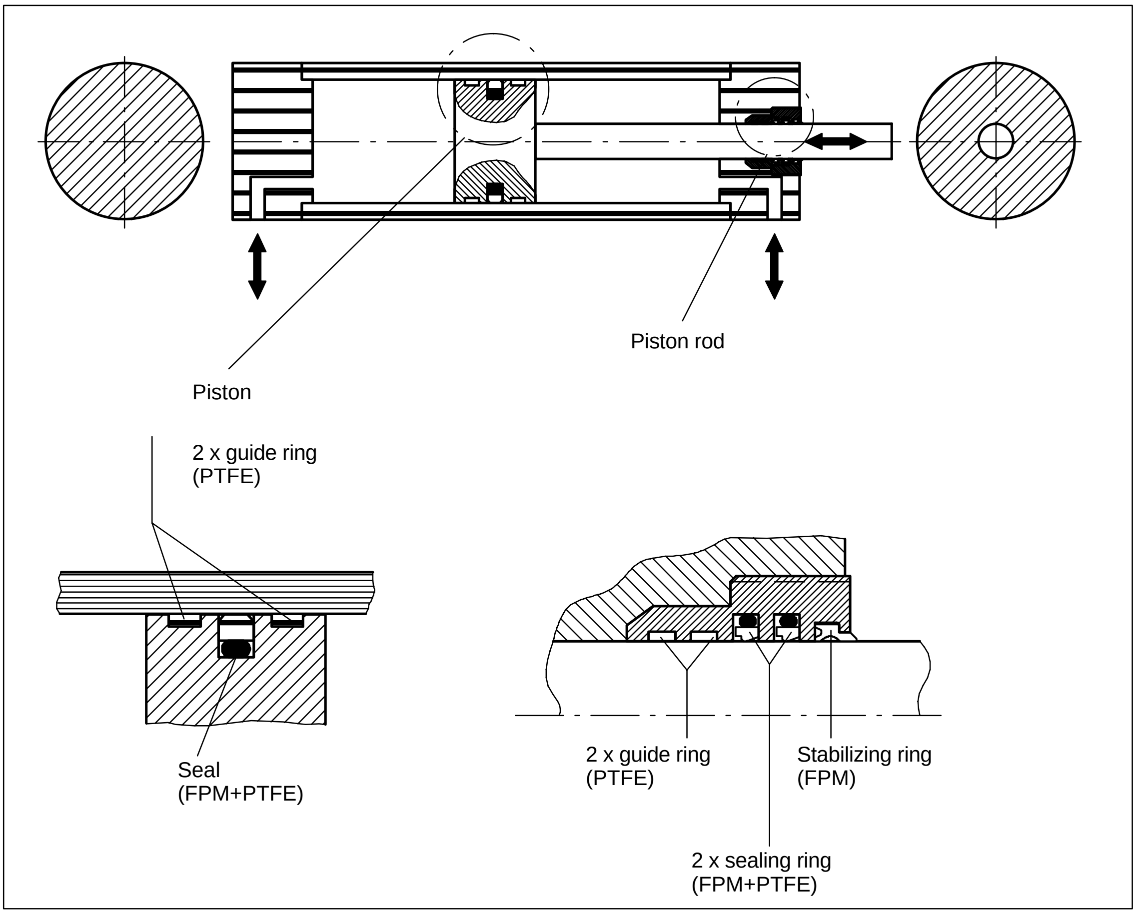


Fig. A-20 Cylinder

Dead volume

The dead volume is the volume between the cylinder and servo solenoid valve that is not displaced by one piston stroke. It reduces the natural frequency of the drive and should be avoided wherever possible.

Cylinder pipework should be kept as short as possible, i.e. the servo solenoid valve should be mounted directly on the cylinder.

The dead volume is set in the HLA module (MD 5135, MD 5136 and MD 5141...5143).

■

Notes

Abbreviations

B

ANA	Analog drive (drive configuration)
ARM (MSD)	Asynchronous Rotary Motor
AS	Automation System
AT	Advanced Technology
B	Cylinder working port
BERO	Proximity limit switch
C Bus	Communication bus
COM	Communication module
DAC	Digital/analog converter channel
D/A	Digital to analog
DP	Distributed I/Os
DRV	Driver module
DSC	Dynamic Stiffness Control
EMC	Electromagnetic compatibility
ESD	Electrostatic Sensitive Device
EUI	End User Interface
FFT	Fast Fourier Transform
FRM	Enable voltage, internal, ground
FRP	Enable voltage, internal, +24 V
FSD	Feed drive (drive bus configuration)
HD	Hard Disk
HHU	Handheld unit
HLA	Hydraulic Linear Drive (drive bus configuration)
HR servo solenoid valve	High Response servo solenoid valve
HYD	Hydraulic drive
I/RF	Infeed/regenerative feedback unit
IM	Interface Module (SIMATIC S7-300)
IM Address	Interface Module Address
ISA	Industry Standard Architecture
LED	Light Emitting Diode
LVDT	Linear Variable Differential Transducer
M24EXTIN	Input for 0 V external
MCP	Machine Control Panel

MD	Machine Data
MMC	Human Machine Communication
MON	Monitoring
MPI	Multi-Point Interface
MS	Mains Supply
MSD	Main Spindle Drive
NC	Numerical Control
NCU	Numerical Control Unit
NMI	Non-Maskable Interrupt
O	Cylinder working port
OBE	On-Board Electronics
OP	Operator Panel
OPI	Operator Panel Interface
Order No.	Machine-Readable Product Designation (order no.)
P	Pressure port (inlet), servo solenoid valve
P24EXTIN	Input for +24 V external
P bus	I/O (peripheral) bus
PBL	Parameter Basic List
PCL	Position Control Loop
PCMCIA	Personal Computer Memory Card International Association
PER	I/O (peripheral) module
PG	Programming device
PI	Program Invocation
PID	Controller with Proportional, Integral and Differential components
PLC	Programmable Logic Control
PS	Power Supply (SIMATIC S7-300)
SC	Status Class
SCI	Serial Communication Interface
SL	Servo Loop
SLM	Synchronous Linear Motor (drive configuration)
SM	SIMATIC S7-300 Signal Module, e.g. I/O modules
SRM (FDD)	Synchronous Rotary Motor (drive configuration)
SW	Software
T	Tank port (return), servo solenoid valve
Term.	Terminal
UI	Unstabilized power supply
VCL	Velocity control loop
VGA	Video graphics adapter

Definition of Terms

C

D1, D2 Cylinder piston diameter

d1, d2 Cylinder piston rod diameter

$\mathbf{f_{0drive}}$ Natural frequency (resonant frequency) of hydraulic drive

$\mathbf{f_{0control}}$ Limit frequency that can be achieved by velocity-controlled drive

$\mathbf{f_{0valve}}$ Natural frequency of servo solenoid valve

$\mathbf{f_v}$ Limit frequency of servo solenoid valve

h Cylinder stroke

m Mass on piston rod

O Cylinder piston area

$\mathbf{p_A}$ Pressure at A end of cylinder

$\mathbf{p_B}$ Pressure at B end of cylinder

$\mathbf{p_p}$ Pump pressure

$\mathbf{\Delta p}$ Pressure difference (nominal pressure drop)

$\mathbf{Q_{nom}}$ Nominal flowrate of servo solenoid valve

$\mathbf{Q_{valve}}$ Flow rate of servo solenoid valve

$U_{set\ valve}$	Valve setpoint
v_{set}	Velocity setpoint
v_{act}	Actual velocity value
x_{set}	Position setpoint
x_{act}	Actual position value
x_{valve}	Valve spool position

References

D

D.1 Electrical applications

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Order No.: (an integral part of the online help for the start-up tool)

/PJE/ SINUMERIK 840D/810D (08.01 Edition)
Description of Functions **Configuring Package HMI Embedded**
Software Update, Configuration Installation
Order No.: 6FC5297-6EA10-0BP0
(the document PS Configuring Syntax is supplied with the software and available as a pdf file)

/POS1/ SIMODRIVE **POSMO A** (05.03 Edition)
User's Guide **Distributed Positioning Motor on PROFIBUS DP**
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/POS2/ SIMODRIVE **POSMO A** (04.02 Edition)
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/POS3/ SIMODRIVE **POSMO SI/CD/CA** (07.03 Edition)
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/POS4/ SIMODRIVE **POSMO SI** (04.02 Edition)
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/POS5/ SIMODRIVE **POSMO CD/CA** (04.02 Edition)
Installation Guide (enclosed with POSMO CD/CA)

/S7H/ SIMATIC S7-300 (2002 Edition)
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- Reference Manual: **Module Data**
- Manual: **Technological Functions**
- Installation Manual

Order No.: 6ES7398-8FA10-8BA0

/S7HT/ SIMATIC S7-300 (03.97 Edition)
Manual: STEP 7, **Fundamentals**, V. 3.1
Order No.: 6ES7 10-4CA02-8BA0

/S7HR/ SIMATIC S7-300 (03.97 Edition)
Manual: STEP 7, **Reference Manuals**, V. 3.1
Order No.: 6ES7810-4CA02-8BR0

/S7S/ SIMATIC S7-300 (04.02 Edition)
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Order together with configuring package

/S7L/ SIMATIC S7-300 (04.02 Edition)
FM 354 Positioning Module for Servo Drive
Order together with configuring package

/S7M/ SIMATIC S7-300 (01.03 Edition)
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Order together with configuring package

/SP/ SIMODRIVE **611-A/61 1-D**
SimoPro 3.1
Program for Configuring Machine-Tool Drives
Order No.: 6SC6111-6PC00-0BA□, Order from: WK Fürth

d) Installation and Start-Up

/BS/ SIMODRIVE 611 analog (10.00 Edition)
Description **Start-Up Software for Main Spindle and Asynchronous Motor Modules**
Version 3.20
Order No.: 6SN1197-0AA30-0BP1

/IAA/ SIMODRIVE 611A (10.00 Edition)
Installation and Start-Up Guide
Order No.: 6SN1197-0AA60-0BP6

/IAC/ SINUMERIK 810D (11.02 Edition)
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/IAD/ SINUMERIK 840D/SIMODRIVE 611 digital (11.02 Edition)
Installation and Start-Up Guide
(incl. description of SIMODRIVE 611 digital start-up software)
Order No.: 6FC5297-6AB10-0BP2

/IAM/ SINUMERIK 840D/840Di/810D (09.03 Edition)
Installation and Start-Up Guide HMI/MMC
Order No.: 6FC5297-6AE20-0BP3

AE1 Updates/Supplements
BE1 Expanding the Operator Interface
HE1 Online Help
IM2 Starting up HMI Embedded
IM4 Starting up HMI Advanced
TX1 Creating Foreign Language Texts

D.2 Hydraulic applications

/BR1/ Bosch Rexroth AG,
“Servo solenoid valves” catalog
Rexroth Order no.: 1 987 761 323

/BR2/ Bosch Rexroth AG,
“Sensors and Electronics” catalog
Rexroth Order no.: 1 987 761 327

/BR3/ Bosch Rexroth AG,
“Sandwich-plate valves” catalog
Rexroth Order no.: 1 987 761 012

/BR4/ Robert Bosch GmbH,
“Electro-hydraulic Proportional and Closed-loop Control Systems” book
ISBN 3-933698-00-6

E EC Declaration of Conformity

Note

An extract from the EC Declaration of Conformity No. E002 V 25/02/99 is shown below. A complete copy of the EC Declaration of Conformity can be found in the “EMC Installation Guidelines” for the SINUMERIK, SIROTEC and SIMODRIVE controls.

SIEMENS

EG-Konformitätserklärung
EC Declaration of Conformity

No. E002 V 25/02/99

Hersteller: Siemens AG
Manufacturer:

Anschrift: Siemens AG A&D MC
Address: Frauenauracherstraße 80
91056 Erlangen

Produkt-bezeichnung: *Product description*	SINUMERIK	805, 805SM-P, 805SM-TW, 810, 810D 820, 840C, 840CE, 840D, 840DE, FM NC
	SIMATIC	FM 353, FM 354, FM 357
	SIROTEC	RCM1D, RCM1P
	SIMODRIVE	610, 611A, 611D, 611U, MCU, FM STEPDRIVE

Das bezeichnete Produkt stimmt in der von uns in Verkehr gebrachten Ausführung mit den Vorschriften folgender Europäischer Richtlinie überein:
The product described above in the form as delivered is in conformity with the provisions of the following European Directives:

89/336/EWG Richtlinie des Rates zur Angleichung der Rechtsvorschriften der Mitgliedstaaten über die elektromagnetische Verträglichkeit
(geändert durch 91/263/EWG, 92/31/EWG, 93/68/EWG und 93/97/EWG).

Council Directive on the approximation of the laws of the Member States relating to electromagnetic compatibility (amended by 91/263/EEC, 92/31/EEC, 93/68/EEC and 93/97/EEC)

Die Einhaltung dieser Richtlinie setzt einen EMV-gerechten Einbau der Produkte gemäß EMV-Aufbaurichtlinie für SINUMERIK, SIROTEC, SIMODRIVE (Best. Nr. 6FC 5297-0AD30-0AP0) in die Gesamtanlage voraus. Anlagenkonfigurationen, bei der die Einhaltung dieser Richtlinie nachgewiesen wurde, sowie angewandte Normen, siehe:
For keeping the directive, it is required to install the products according to "EMC Mounting regulation for SINUMERIK, SIROTEC, SIMODRIVE" (Order No. 6FC 5297-0AD30-0BP0). For details of the system configurations, which meet the requirements of the directives, as well as for the standards applied see:

- Anhang A1 - A14 (Anlagenkonfigurationen) *- Annex A1 – A14 (system configurations)*
- Anhang B1 - B7 (Komponenten) *- Annex B1 – B7 (components)*
- Anhang C (Normen) *- Annex C (standards)*

Siemens AG

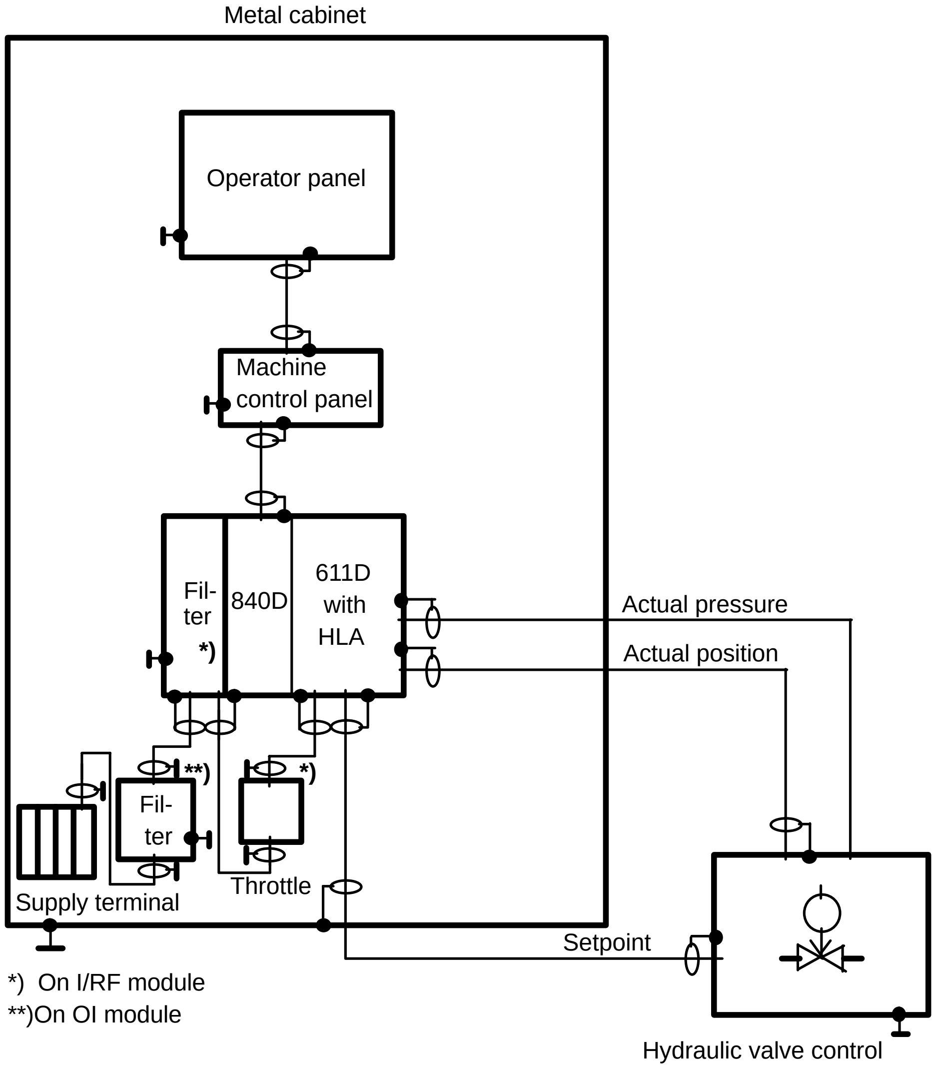
Erlangen, den 25.02.1999

R. Müller	K. Krause
Entwicklungsleitung	Qualitätsmanagement
Name, Funktion / *Name, function* — Unterschrift / *signature*	Name, Funktion / *Name, function* — Unterschrift / *signature*

Diese Erklärung bescheinigt die Übereinstimmung mit der genannten Richtlinie, ist jedoch keine Zusicherung von Eigenschaften.
Die Sicherheitshinweise der mitgelieferten Produktdokumentation sind zu beachten.
This declaration certifies the conformity to the specified directives but contains no assurance of properties. The safety documentation accompanying the product shall be considered in detail..

Appendix A to EC Declaration of Conformity No. E002 V 25/02/99

A16: Typical plant configuration SINUMERIK 840D/SIMODRIVE 611D with closed-loop hydraulics module (HLA)



- All components which are designated in the Ordering Information as approved for operation in a combined SINUMERIK 840D/SIMODRIVE 611D installation comply with Directive 89/336/EEC when operated in an installation of this type.
- For conformity to the standards, see Appendix C.

Note:
The sketch of the system configuration shows only the basic measures required to ensure that a typical system configuration conforms to directive 89/336/EEC.
In addition, and especially if the system configuration deviates from this typical model, the installation guidelines for EMC-compliant system design in the product documentation and the EMC design guidelines for SINUMERIK, SIROTEC and SIMODRIVE
(order no.: 6FC5297-0AD30-0BP0) must be carefully observed and implemented.

Appendix C to EC Declaration of Conformity No. E002 V 25/02/99

C: Conformity of the products with Council Directive 89/336/EEC has been verified by inspection and testing in accordance with the following product standard, basic technical specifications and the basic standards contained therein. Product categories SINUMERIK, SIROTEC, SIMODRIVE and SIMATIC are subject to the requirements of different standards.

C1 Product categories SINUMERIK*), SIMATIC, SIROTEC:

Basic specification: EN 50081-2 dated 8/93 1)

Basic standards:		Test topic:
EN 55011	2)	Radio interference

Basic specification: EN 50082-2 dated 3/95 3)

Basic standards:		Test topic:
EN 61000-4-3	4)	High-frequency irradiation (amplitude-modulated)
ENV 50204	5)	High-frequency irradiation (pulse-modulated)
EN 61000-4-6	6)	Conducted HF disturbance
EN 61000-4-8	7)	Magnetic fields
EN 61000-4-2	8)	Static discharge
EN 61000-4-4	9)	Fast transients (burst)

*) except for SINUMERIK 810D

C2 Product categories SIMODRIVE, SINUMERIK 810D:

Product standard: EN 61800-3 10)

C3 Other standards complied with:

1)	VDE 0839 part 81-2	6)	IEC 801-6, VDE 0847 part 4-6 IEV 1000-4-6 ENV 50141
2)	VDE 0875 part 11	7)	VDE 0847 part 4-8 IEC 1000-4-8
3)	VDE 0839 part 82-2	8)	VDE 0847 part 4-2 EN 60801 part 2 IEC 801-2 VDE 0843 part 2
4)	VDE 0847 part 4-3 ENV 50140	9)	VDE 0843 part 4 VDE 0847 part 4-4 IEC 801-4
5)	VDE 0847 part 204	10)	VDE 0160 part 100

■

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Notes

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SIEMENS AG
A&D MC BMS
P.O. Box 3180

D-91050 Erlangen Germany
Phone: +49 (0) 180 / 5050 - 222 [Service Support]
Fax: +49 (0) 9131 / 98 - 2176 [Documentation]
E-mail: motioncontrol.docu@erlf.siemens.de</td><td>Suggestions

Corrections
For
Publication/Manual:

SINUMERIK 840D
SIMODRIVE 611 digital
Description of Functions
HLA Module

Manufacturer/Service Documentation</td></tr>
<tr><td>From

Name
Company/Dept.
Address
Zip code: Town:
Phone: /
Fax: /</td><td>Description of Functions

Order no.: 6SN1197-0AB60-0BP3
Edition: 10/03

Should you come across any printing errors when reading this publication, please notify us using this form.

Suggestions for improvement are also welcome.</td></tr>
</table>

Suggestions and/or corrections

Documentation Overview SINUMERIK 840D/840Di/810D

General Documentation

- *SINUMERIK* 840D/810D — Brochure
- *SINUMERIK* 840D/840Di/ 810D/ — Catalog NC 60 ***)**
- *SINUMERIK SIROTEC SIMODRIVE* Accessories — Catalog Accessories NC-Z

User Documentation

- *SINUMERIK* 840D/810D/ FM-NC — **AutoTurn**
  - Product Brief
  - Programming /Setup
- *SINUMERIK* 840D/840Di 810D — Operating Instructions
  - **HT 6**
- *SINUMERIK* 840D/840Di/ 810D — Diagnostics Guide *)
- *SINUMERIK* 840D/840Di/ 810D — **Operating Instructions *)**
  - Product Brief
  - HMI Embedded
  - HMI Advanced

User Documentation

- *SINUMERIK* 840D/840Di/ 810D — **Programming Guide**
  - Product Brief
  - Fundamentals ***)**
  - Production Planning ***)**
  - Cycles
  - Measuring Cycles
  - ISO Turning/Milling
- *SINUMERIK* 840D/810D — Operating Instructions
  - **ManualTurn**
  - Product Brief ManualTurn
  - **ShopMill**
  - Product Brief ShopMill
  - **ShopTurn**
  - Product Brief ShopTurn
- *SINUMERIK* 840Di — **System Overview**

Manufacturer/Service Documentation

- *SINUMERIK* — **Configuring** (HW) ***)**
  - 810D
  - 840D
- *SINUMERIK* 840D/840Di/ 810D — **Operator Components** (HW) ***)**
- *SINUMERIK* 840D/810D — Description of Functions
  - **ManualTurn**
  - **ShopMill**
  - **ShopTurn**
- *SINUMERIK* 840D/840Di/ 810D — Description of Functions **Synchronized actions**

Manufacturer/Service Documentation

- *SINUMERIK SIMODRIVE* 611D 840D/810D — Description of Functions **Drive Function *)**
- *SINUMERIK* 840D/840Di/ 810D — **Description of Functions**
  - Basic Machine ***)**
  - Extended Funct.
  - Special Functions
- *SINUMERIK* 840D/840Di/ 810D — Description of Functions **Tool Management**
- *SINUMERIK* 840D/810D — **Configuration Point** HMI Embedded
- *SINUMERIK* 840D/810D — Description of Functions Project User interface **OP 030**
- *SINUMERIK* 840D/810D — **IT Solutions**
  - Computer Link
  - Tool Data Information System
  - NC Data Management
  - NC Data Communication
  - Tool Data Communica.

Manufacturer/Service Documentation

- *SINUMERIK SIMODRIVE* — Description of Functions SINUMERIK **Safety Integrated**
- *SINUMERIK* 840D — Description of Functions **Digitizing**
- *SINUMERIK SIMODRIVE* — **Installation & Start-Up Guide *)**
  - 810D
  - 840D/611D
  - HMI
- *SINUMERIK SIMODRIVE* 840D/840Di 810D 611D — Lists *)
- *SINUMERIK SIMODRIVE* 840D 611D — Description of Functions **Linear Motor**
- *SINUMERIK SIMODRIVE* 840D 611D — Description of Functions
  - **Hydraulics Module**
  - **Analog Module**
- *SINUMERIK SIMODRIVE SIROTEC* — EMC Installation Guide.

Electronic Documentation

- *SINUMERIK SIMODRIVE* 840D/840Di/ 810D 611, Motors — **DOC ON CD *)** The SINUMERIK System

Manufacturer/Service Documentation

- *SINUMERIK* 840D/840Di/ 810D — Description of Functions **ISO Dialects** for SINUMERIK
- *SINUMERIK* 840Di — **Manual** (HW + Installation)
- *SINUMERIK* 840D/810D — Description of Functions **Remote Diagnosis**
- *SINUMERIK* 840D/840Di/ 810D — **Manual @Event**

***)** Recommended minimum scope of documentation

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