SIEMENS

SIMATIC

FM 453 Positioning Module for Servo and Stepper Drives

Manual

This manual has the order number:

6ES7453-3AH00-8BG0

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Safety Information

This Manual contains information which you should carefully observe to ensure your own personal safety and the prevention of damage to the system. This information is highlighted by a warning triangle and presented in one of the following ways depending on the degree of risk involved:

Danger

indicates that death or severe personal injury damage **will** result if proper precautions are not taken.

Warning

indicates that death or severe personal injury damage **can** result if proper precautions are not taken.

Caution

indicates that minor personal injury can result if proper precautions are not taken.

Caution

without warning sign means that material damage can occur if the appropriate precautions are not taken.

Attention

means that an undesired result or a condition may occur if the appropriate note is not observed.

If more than one level of hazard can occur, the warning note of the correspondingly highest level is used in all cases. If a warning note with a warning triangle warns of personal injury, an additional warning of material damage can be included in the same warning note.

Qualified personnel

The unit may only be started up and operated by **qualified personnel.** Qualified personnel as referred to in the safety guidelines in this document are those who are authorized to start up, earth and label units, systems and circuits in accordance with relevant safety standards.

Proper use

Please note the following:

Warning

The unit may be used only for the applications described in the catalog or the technical description, and only in combination with the equipment, components and devices of other manufacturers as far as this is recommended or permitted by Siemens.

It is assumed that this product be transported, stored and installed as intended and maintained and operated with care to ensure that the product functions correctly and safely.

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Automation & Drives
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Exclusion of liability

We have checked that the contents of this publication agree with the hardware and software described herein. Nonetheless, differences might exist and therefore we cannot guarantee that they are completely identical. The information given in this publication is reviewed at regular intervals and any corrections that might be necessary are made in the subsequent printings.

Preface

Purpose of this Document

This manual contains all information about the FM 453 module:

- Hardware and functions
- Parameter definition
- Man-machine interface
- S7 function blocks
- Safe setup

Information Blocks in this Manual

The following information blocks describe the purpose and uses of this manual:

- Product overview of the module (Chapter 1)

  This section explains the purpose and possible applications of the module. It provides introductory information about the FM 453 and its functions.
- Basic principles of positioning (Chapter 2)

  Here you will find introductory information on positioning methods and associated definitions of terms.
- Installing and removing the FM 453 (Chapter 3)

  Explains the installation and removal of the FM 453.
- Wiring the FM 453 (Chapter 4)

  Describes the connection and wiring of drives, encoders and digital input/output modules.
- Defining parameters of the FM 453 (Chapter 5)

  Describes the parameterization and functions of "Parameterize FM 453."
- Programming the FM 453 (Chapter 6)

  Describes how to program the FM 453 with STEP 7.
- Starting up the FM 453 (Chapter 7)

  Describes startup procedures for the FM 453.
- Human-machine interface (Chapter 8)

  Describes the various options for operating and monitoring the FM 453, and which data and signals can be used and monitored.

- Reference information and appendices for finding factual information (module functions, programming guide, interface signals, error handling, technical specifications, standard HMI user interface)
- List of abbreviations and index for looking up information.

User Requirements

The present manual describes the hardware and functions of the FM 453.

To set up, program and start up a SIMATIC S7-400 with the FM 453, you will need a knowledge of:

- The SIMATIC S7

  S7-400/M7-400 Programmable Controllers, Hardware and Installation manual
- Your programming device (PG)
- How to perform programming with STEP 7
- How to configure an operator panel interface.

FM 453 Users

The structure and presentation of the information in the manual are oriented to the intended uses of the FM 453, and the user's own activity.

It distinguishes among the following:

- Installation

  These activities include installation and wiring of the FM 453.
- Programming

  These activities include parameterizing and programming the FM 453.
- Troubleshooting and diagnostics

  These activities include detecting and correcting faults and errors
  - in the hardware setup of the module and its components
  - and in the programming, handling and control of module functions.
- Operation

  These users operate the FM 453. The operator accordingly deals only with the control of positioning tasks.

Standards and approvals

Our products are in compliance with the EU Guideline 89/336/EEC "Electromagnetic Compatibility" and the harmonized European standards (EN) which it embodies.

The current version of the EC Declaration of Conformity can be found on the Internet at

http://support.automation.siemens.com/WW/view/de/15257461

Recycling and disposal

For recycling in an environmentally compatible manner and for the disposal of your old SIMATIC in line with prsent state of technology, please contact your appropriate Siemens contact partner:

http://www.automation.siemens.com/partner

Technical support

If you have any technical question, please do no hesitate to contact our hotline:

Time zone:	Europe/Africa	Asia/Australia	America
Telephone	+49 (0) 180 5050 222	+86 1064 719 990	+1 423 262 2522
Fax	+49 (0) 180 5050 223	+86 1064 747 474	+1 423 262 2289
Internet	http://www.siemens.com/automation/support-request		
E-mail	adsupport@siemens.com		

Note

The country−specific telephone numbers for technical consultation can be found on the Internet at: **http://www.siemens.com/automation/service&support**

Questions regarding this Manual

If you have any questions regarding this Documentation (suggestions, corrections), please send a fax or an e−mail to the following address:
Fax: +49 (0) 9131 98 63 315
E-mail: docu.motioncontrol@siemens.com

Siemens Internet address

For currently updated information on the SIMATIC products, vitsit us on the Internet at: **http://www.siemens.de/simatic**.

Further support

We are offering courses to help you familiarize yourself with the operation of the SIMATIC S7 programmable controller system.

Please contact your regional or the central training center in D-90027 Nürnberg, Germany under tel. +49 911-89 53 202.

Table of Contents

Product Summary

1

Chapter Overview

What Can the FM 453 Do?

The FM 453 is a microprocessor-controlled positioning module for controlling servo and/or stepper motors.

The module has three mutually independent channels (axes).

The control mode for each channel is specified by the parameterization.

The FM 453 is a high-performance module for servo-controlled positioning and for positioning with step drives.

The module works autonomously and is controlled by way of the user program in the SIMATIC S7-400 system.

It can operate rotary and linear axes by servo or open-loop control with actual-value tracking.

The FM 453 has a variety of operating modes.

The module has a non-volatile data memory to store parameterization data.

- The FM 453 is low-maintenance (no battery).
- It can be linked and adapted to user circumstances by parameterizing it as required by the system.

Where Can the FM 453 Be Used?

The FM 453 can be used for both simple positioning and complex traversing profiles demanding superior dynamic response, accuracy and speed. It is also suitable for positioning tasks in machinery with high clock-pulse rates.

Typical uses for the positioning module might include:

- Transfer lines
- Assembly lines
- Presses
- Woodworking machines
- Manipulators
- Loaders
- Auxiliary movements in milling and turning machines
- Packaging machines
- Conveyor equipment

Its standard range of functions per channel is comparable to that of the WF 721 module in the SIMATIC S5 system, and the FM 353/354 in the SIMATIC S7-300 system.

1.1 The FM 453 in the S7-400 Programmable Controller

How Is the FM 453 Linked Up with the S7-400?

The FM 453 is designed as a function module of the SIMATIC S7-400 controller.

The S7-400 programmable controller consists of a CPU and a variety of I/O modules mounted in a rack.

Depending on requirements, the configuration of the programmable controller can comprise one central controller (CC) and up to 21 expansion units (EUs).

The FM 453, however, can only be operated in the central controller or in expansion units 1 to 6.

The CPU is installed in the central controller.

For further details on the basic requirements for the layout of a programmable controller, please refer to the *S7-400/M7-400 Programmable Controller, Hardware and Installation manual*.

System Overview

A positioning controller using the FM 453 consists of a variety of individual components, which are shown in Figure 1-1.

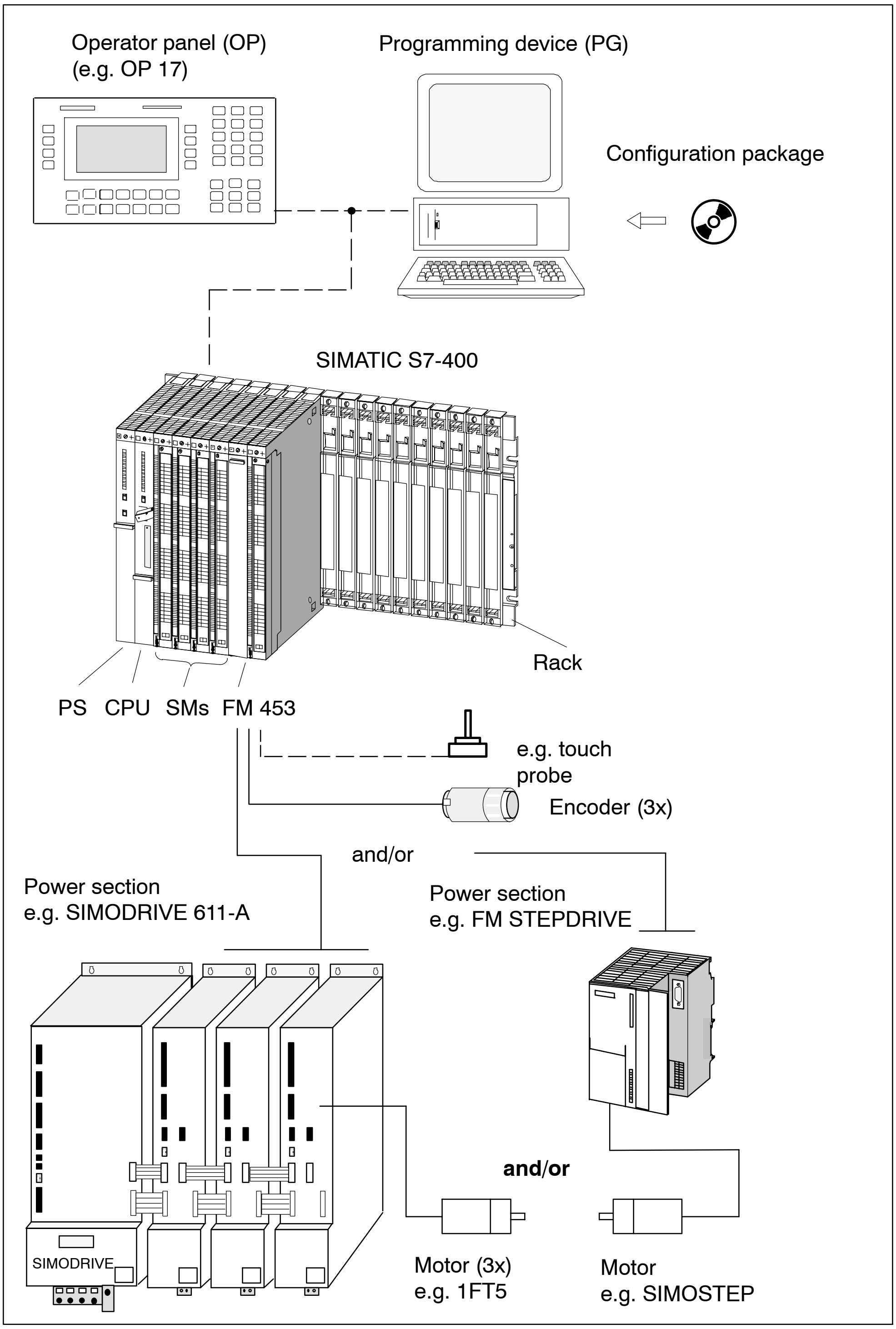


Fig. 1-1 System Overview (schematic)

MPI

The FM can service as many as three MPI nodes (PC, PG or OP) simultaneously.

Components

The most important components and their functions are listed in Table 1-1 .

Table 1-1 Components of a Positioning Controller

Component	Function
Rack	... establish the mechanical and electrical connections between the S7-400 modules.
FM 453	... the positioning module. It is controlled by the S7-400 CPU.
CPU	... executes the user program; and communicates with the programming device and the operator panel via the MPI interface and with the FM 453 via the backplane bus.
Power supply (PS)	... converts line voltage (120/230 V AC) to 5 V and (24 V)[1)] DC operating voltage to power the S7-400 and performs monitoring functions.
Signal modules (SM)	... adapts various process-signal levels to the S7-400.
Programming device (PG)	... configures, parameterizes, programs and tests the S7-400 and the FM 453.
Operator panel (OP)	... the interface to the machine. It serves for operation and monitoring. It is not an absolute prerequisite for operation of an FM 453.
Power section	... actuates the motor.
Motor	... drives the axis.
Encoder	... the path measurement system that detects the current position of the axis in servo control mode. By comparing the actual position with the applicable setpoint position, the FM 453 immediately detects discrepancies and attempts to compensate for them.
Configuration package	... A CD-ROM containing: • An FC block package • MD-DBs (for putting a stepper motor into operation) • The parameterization tool for “Parameterize FM 453” • A preconfigured operator interface for OPs • A manual in PDF format • Getting Started in PDF format

1) Only for internal use in S7-400 modules

System Overview of Data Handling

The following figure gives you an overview of the data storage concept.

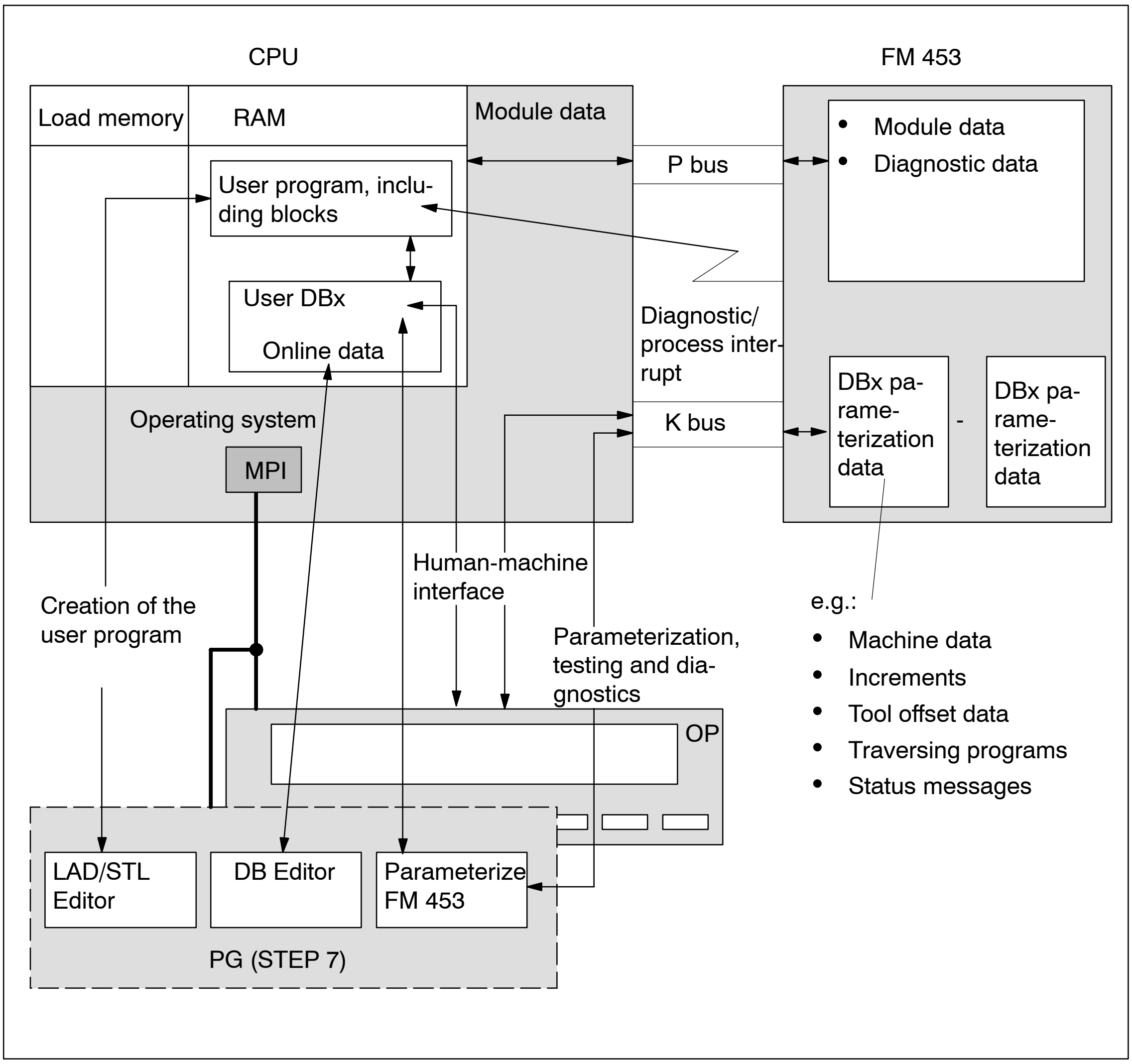


Fig. 1-2 Data Storage Concept

1.2 Module Description

View of the FM 453

Figure 1-3 shows the FM 453 module, its interfaces and front-panel elements (including fault and status displays).

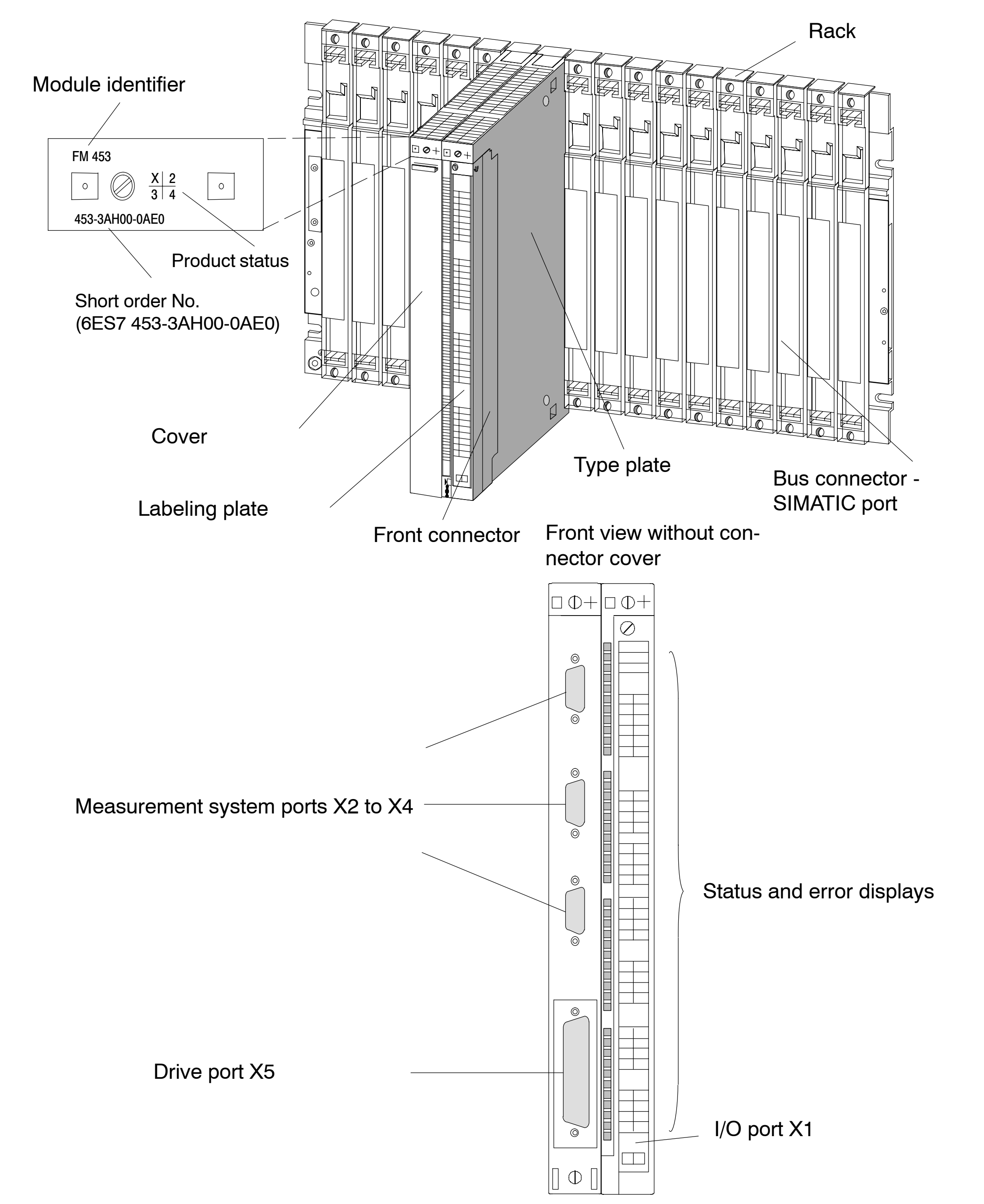


Fig. 1-3 View of the Ports and Front-Panel Elements

Ports

A description of the ports is provided in Table 1-2 .

Table 1-2 Ports

Ports	Description
Bus connector - SIMATIC port	Rear connectors to continue the S7 buses (P and K buses) to each module
Drive port	50-pin male Sub-D connector (X5) to connect the power sections for up to three analog or step drives
Measurement system port	15-pin female sub-D connector (X2 to X4) to connect the encoder
I/O port	48-pin male front connector (X1) to connect the auxiliary power supply and for digital input and output wiring

LED Indicators

Thirty-three LEDs are arranged on the front panel of the FM 453. Table 1-3 describes these LEDs and what they mean.

Table 1-3 Status and Error Displays

LED	Significance
INTF (rot) – Internal errors	This LED indicates an error condition in the FM 453. (see Troubleshooting, Chapter 11)
EXTF (rot) – External errors	This LED indicates an error condition outside the FM 453. (see Troubleshooting, Chapter 11)
STAT (yellow) – Status	This LED indicates various statuses (flashing). (see Troubleshooting, Chapter 11)
I0...I3 (green) – Digital Inputs	These LEDs indicate which input is ON (channels 1 to 3).
Q0...Q3 (green) – Digital outputs	These LEDs indicate which output is ON (channels 1 to 3).
NL (green) –	These LEDs indicate which input is ON (zero position for channels 1 to 3).
READY2 (green) – Drive unit ready	These LEDs indicate that the drive units are ready (READY2) for operation (channels 1 to 3).

Type Plate of the FM 453

Figure 1-4 describes all the information contained in the type plate of the FM 453.

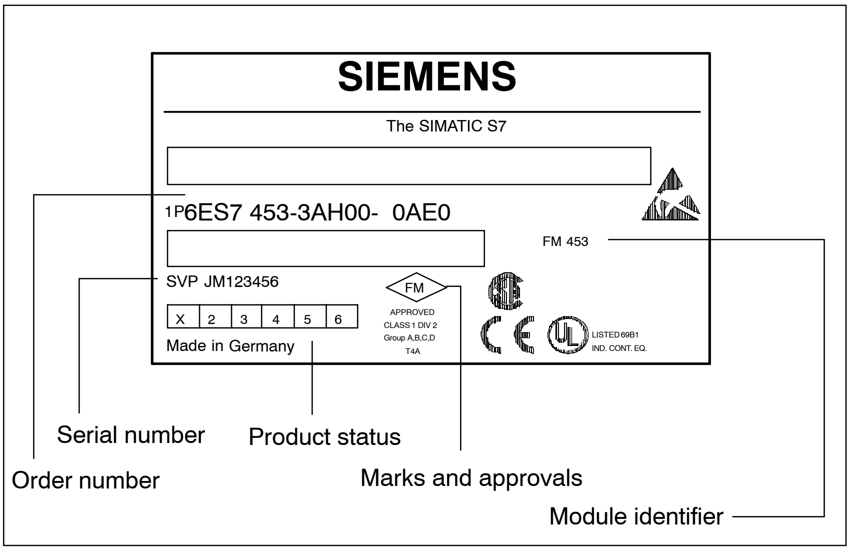


Fig. 1-4 Type Plate of the FM 453

1.3 Overview of Module Functions for Each Channel

Summary

The FM 453 module performs the following functions:

- Mode control
- Actual-value capture
- Servo position control
- Parameterizing the control mode
- Digital inputs and outputs
- Settings and functions that do not depend on operating mode
- Software limit switches
- Process interrupts
- Block sequence control
- Diagnostics and troubleshooting
- Data storage on the FM 453

Operating Mode Control

The user program passes the operating mode to the FM.

The FM 453 has the following modes available:

- Jogging
- Open-loop control
- Reference point approach
- Incremental mode, relative
- Manual data input (MDI)
- Automatic
- Automatic single block

Encoders

Incremental or absolute encoders (SSI) may be connected to the measuring system port.

Servo Position Control

Setpoint processing is performed in the FM 453 via the following functions:

- Interpolation
- Servo position control
- Stepper motor control
- Actuating signal driver
- Drive actuation

Parameterization of the Control Modes

In the parameterization, the following control modes can be set:

- Servomotor with servo position control
- Stepper motor with servo position control
- Stepper motor without servo position control

Digital Inputs/Outputs

Four digital inputs and four digital outputs for each channel can be used specifically to a given application.

You can connect:

- Reference-point switches
- Switches for external starting
- Touch probes
- Position reached, Stop ("PEH")
- Forward/backward rotation

The switching function is assigned to a given I/O number by way of the machine data.

Settings and Functions Not Dependent on Operating Mode

Special functions can be activated by specific settings in the user program, in addition to the mode (e.g. measurement on-the-fly, retrigger reference point, etc.).

Software Limit Switches

The operating range (specified by software limit switches) is automatically monitored after synchronization is recorded.

Process Interrupts

Process interrupts are triggered by such events as:

- Position reached
- Length measurement completed
- On-the-fly block change
- Measurement on-the-fly

Process interrupts are selected by way of machine data.

Block Sequence Control

Automatic processing of a traversing program, including subprograms created during the parameterization process. A number of traversing programs are available for execution on the module.

Diagnostics and Troubleshooting

Startup and ongoing operation of the module are monitored by fault and diagnostic interrupts. Faults or errors are reported to the system and displayed by the LEDs on the module.

Data Storage on the FM 453

Parameterization data (machine data, tool compensation data, traversing programs and increment sizes) is retained in storage on the FM 453.

2 Basic Principles of Positioning

What Is Positioning?

Positioning means moving a load to a defined position within a defined time, taking all influencing forces and torques into account.

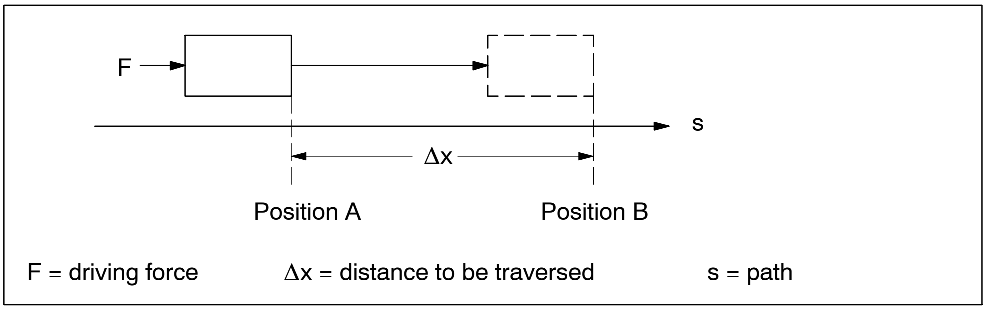


Fig. 2-1 Principle of a Positioning Action

Servo-controlled Positioning with Encoder

Servo-controlled positioning is:

- Control of the drive at the right speed while a movement is being performed.
- Specifying a target position and true-to-target axis approach into programmed target position
- Acquisition of the actual value at the connected encoder (incremental or absolute)
- Maintaining the axis in position in the face of interfering factors.
- For servo motors, the $\pm$10 V port is used
- For stepper motors, the pulse/direction outputs are used

Open-loop Controlled Positioning with Stepper Motor

Positioning with stepper motors is:

- Control of the drive at the right speed while a movement is being performed.
- Specifying a target position and true-to-target axis approach into programmed target position
- Generating the actual value via the pulse/direction signals

Arrangement of the Positioning Equipment

Figure 2-2 shows the structure of a position control circuit with the FM 453 for one channel.

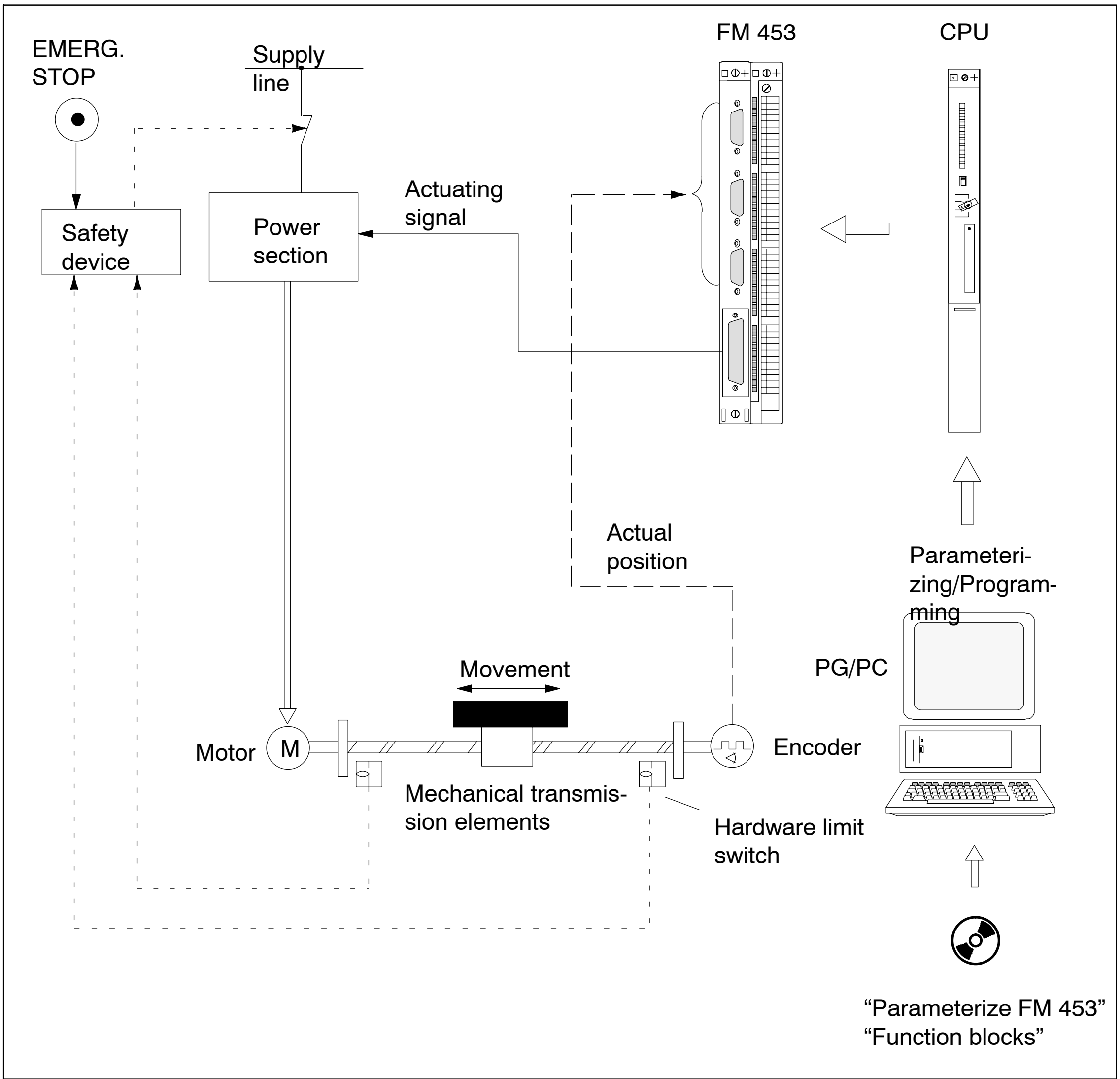


Fig. 2-2   Setup for Positioning (example)

FM 453

Positioning with the output of an analog actuating signal for the servo drive or pulses for the step drive.

Power Section

The power section processes the actuating signal and delivers the proper electric power to the motor.

The power section can be:

- A servo drive, e.g. SIMODRIVE 611-A
- A step drive, e.g. STEPDRIVE

Motor

The motor is actuated by the power section and drives the axis.

The motor can be:

- A servo motor, e.g. 1FT5
- A stepper motor, e.g. SIMOSTEP

Encoder

The encoder detects movement of the axis. It supplies pulses to the FM 453. The number of pulses is proportional to the distance traversed. Stepper motor operation is also possible without the encoder.

CPU

The CPU executes the user program.

Mechanical Transmission Elements

These include not only the axis, but also gear trains and clutch systems.

Peripherals

All other additional equipment is covered by the term peripherals.

Peripherals mainly include:

- Limit switches to limit the positioning range (safety devices).
- The programming device/PC is used for:
  - Assigning parameters using the software “Parameterize FM 453”
  - Programming the FM 453 using function blocks
  - Test/startup

Installing and Removing the FM 453 3

Chapter Overview

Overview

The FM 453 positioning module can be installed, in the same manner as a signal module, in a central controller or in an expansion unit (EUs 1 to 6).

Mechanical Set-Up

The options for the mechanical set-up and its configuration are described in the manual *S7-400/M7-400 Programmable Controller; Hardware and Installation*.

Important Safety Rules

There are important rules which you must follow when integrating an FM 453 in the S7-400 PLC in a plant or system.

These rules and specifications are described in the manual *S7-400/M7-400 Programmable Controller, Hardware and Installation*.

Module Replacement

A module can be replaced during operation of the programmable controller.

3.1 Installing the FM 453

Rules

No particular protective measures (EGB Guidelines) are necessary for the installation of the FM 453.

Note

Please refer to Appendix B in the manual *S7-400/M7-400 Programmable Controller, Hardware and Installation*.

Tools Required

A 4.5 mm (0.18 inch) screwdriver.

Procedure

To install the FM 453:

1. Hook the FM 453 onto the rail and swing it into position.
2. Screw the FM 453 down (torque approx. 0.8 to 1.1 Nm).
3. Attach the sub-D plugs to the encoder and drive unit.
4. Attach the front connector.
5. Fit the connector cover and lock it in place.
6. After the modules have been mounted, you can also assign each of them a slot number. Slot labels for this purpose are enclosed with the rack.

   The numbering scheme and how to plug in the slot labels are described in the manual *S7-400/M7-400 Programmable Controller, Hardware and Installation* .

Note

The slot determines the initial address of each module.

3.2 Removing the FM 453

Rules

No particular protective measures (EGB Guidelines) are necessary for the removal of the FM 453.

Note

Please refer to Appendix B in the manual *S7-400/M7-400 Programmable Controller, Hardware and Installation*.

Tools Required

A 4.5 mm (0.18 inch) screwdriver.

Procedure

To remove the FM 453:

1. Release the protective device on the front connector and unplug it.
2. Unlock the connector cover.
3. Detach the sub-D plugs from the encoder and drive unit.
4. Loosen the module fastening screws.
5. Swing the module out of the rack and unhook the module.

3.3 Module Replacement

Overview

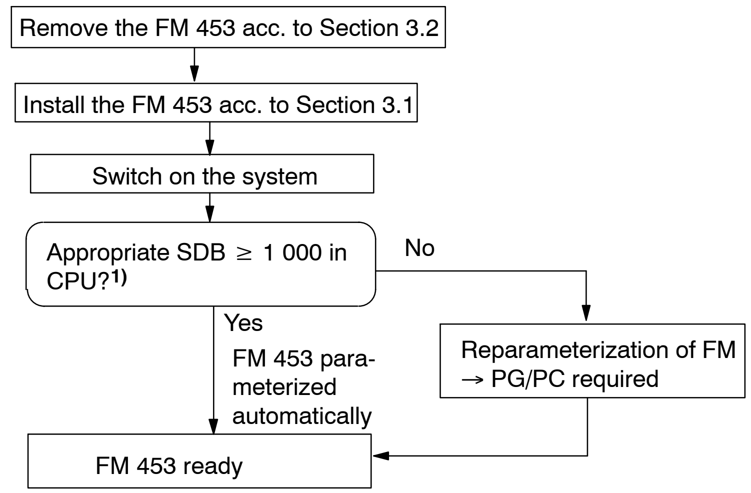
If a defective FM 453 has to be replaced, and no programming device/PC is available for parameterization, or the module is to be replaced while the system is switched on, please note the following start-up requirements (CPU, FM):

- An SDB ≥ 1 000 should be generated in order to complete the startup (for storing the parameter data); see Section 5.5.
- In the user program:
  - Integration of OB 83 “Remove/Insert interrupt”, see Chapter 6
  - Interrupt communication with the FM 453 before removing the old FM, and resume communication after installing the new FM.
  - If data/parameters are modified during operation and stored retentively on the FM, please follow the instructions in Section 9.3.1.

Replacing an FM 453

To replace a parameterized but defective FM 453:

1. Replacing the FM 453 with the system switched off



1) How to create an SDB ≥ 1 000 after startup, and how to load it in the CPU is described in Section 5.5.

Fig. 3-1 Replacing the FM 453 with the System Switched Off

2. Replacing the FM 453 with the system switched on

   CPU is at “STOP”: → see 1.

   CPU remains in “RUN”:

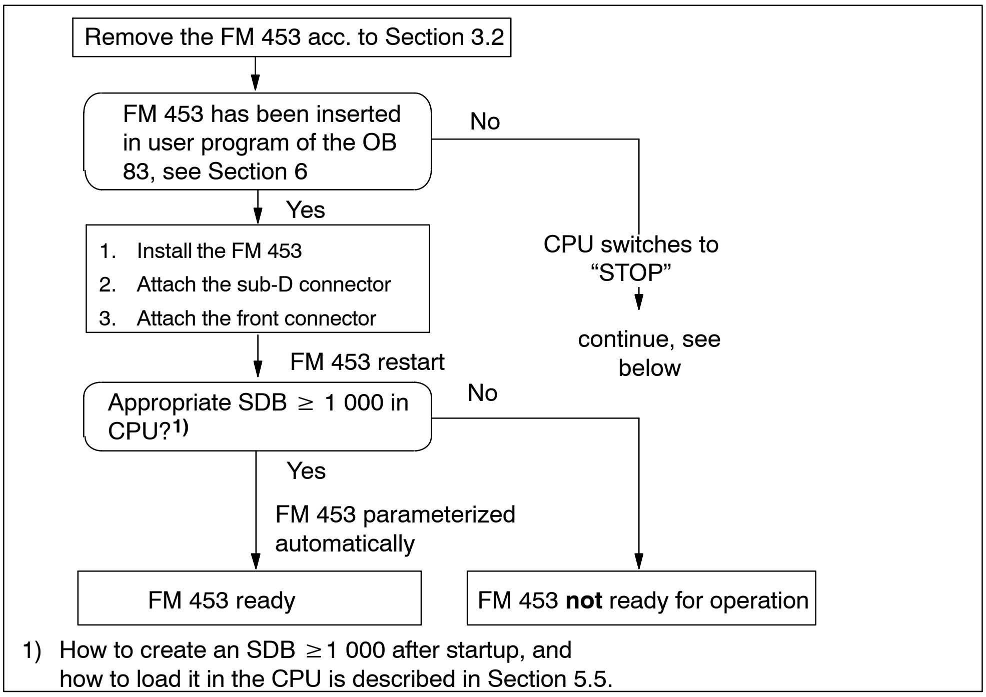


Fig. 3-2 Replacing the FM 453 with the System Switched On

Wiring the FM 453

4

Chapter Overview

Safety Rules

In order to ensure the safe operation of your plant, you should introduce the following additional measures, and adjust them appropriately to your system’s conditions:

- An EMERGENCY STOP concept meeting appropriate safety regulations (e.g. European standards EN 60204, EN 418 and associated standards).
- Additional measures for limiting the end position of axes (e.g. hardware limit switches).
- Equipment and measures for protecting the motors and power electronics in accordance with the installation guidelines for SIMODRIVE and FM STEPDRIVE/SIMOSTEP.

We also recommend you carry out a risk analysis in accordance with basic safety requirements / Appendix 1 of the EC machine directive, in order to identify sources of danger affecting the complete system.

Further References

Please refer also to the following chapters in the *S7-400/M7-400 Programmable Controller, Hardware and Installation manual*:

- Lightning protection and overvoltage protection: Appendix A.5
- Guidelines for handling of electrostatic sensitive devices (ESDs): Appendix B.
- Configuring the electrical installation: Chapter 4

For further information about EMC guidelines, we recommend the description in: *Equipment for Machine Tools, EMC guidelines for WS/WF equipment,* Order No.: 6ZB5 440-0QX01-0BA1.

Standards and Specifications

When wiring the FM 453 you must observe the relevant VDE guidelines.

4.1 Wiring Diagram for a FM 453

FM 453 with Servo Drive

Figure 4-1 shows how the individual components of the positioning controller with FM 453 and a servo drive are linked together.

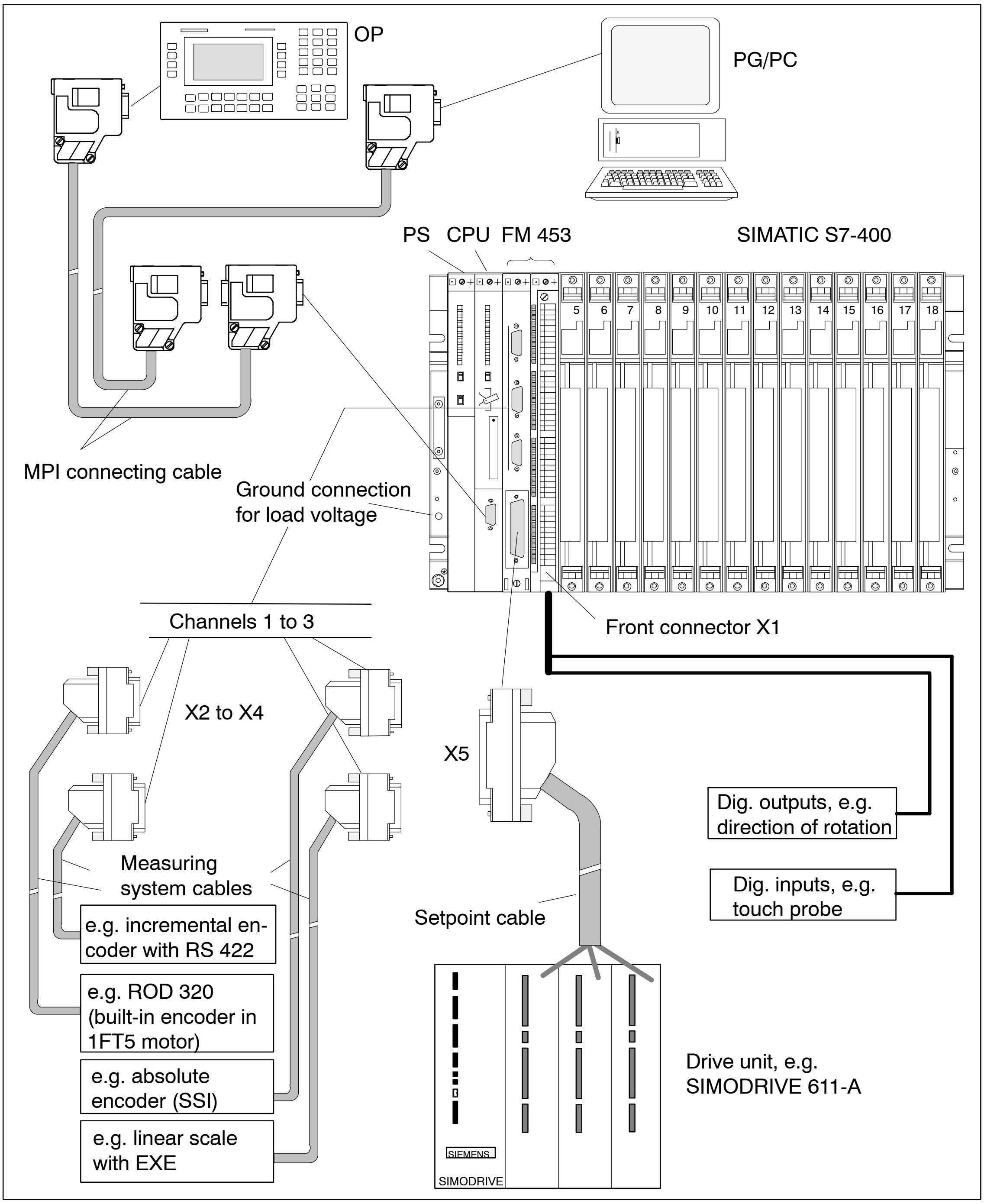


Fig. 4-1 Overview of Connecting Cables for a FM 453 with Servo Drive (example)

FM 453 with Step Drive

Figure 4-2 shows how the individual components of the positioning controller with FM 453 and a step drive are linked together.

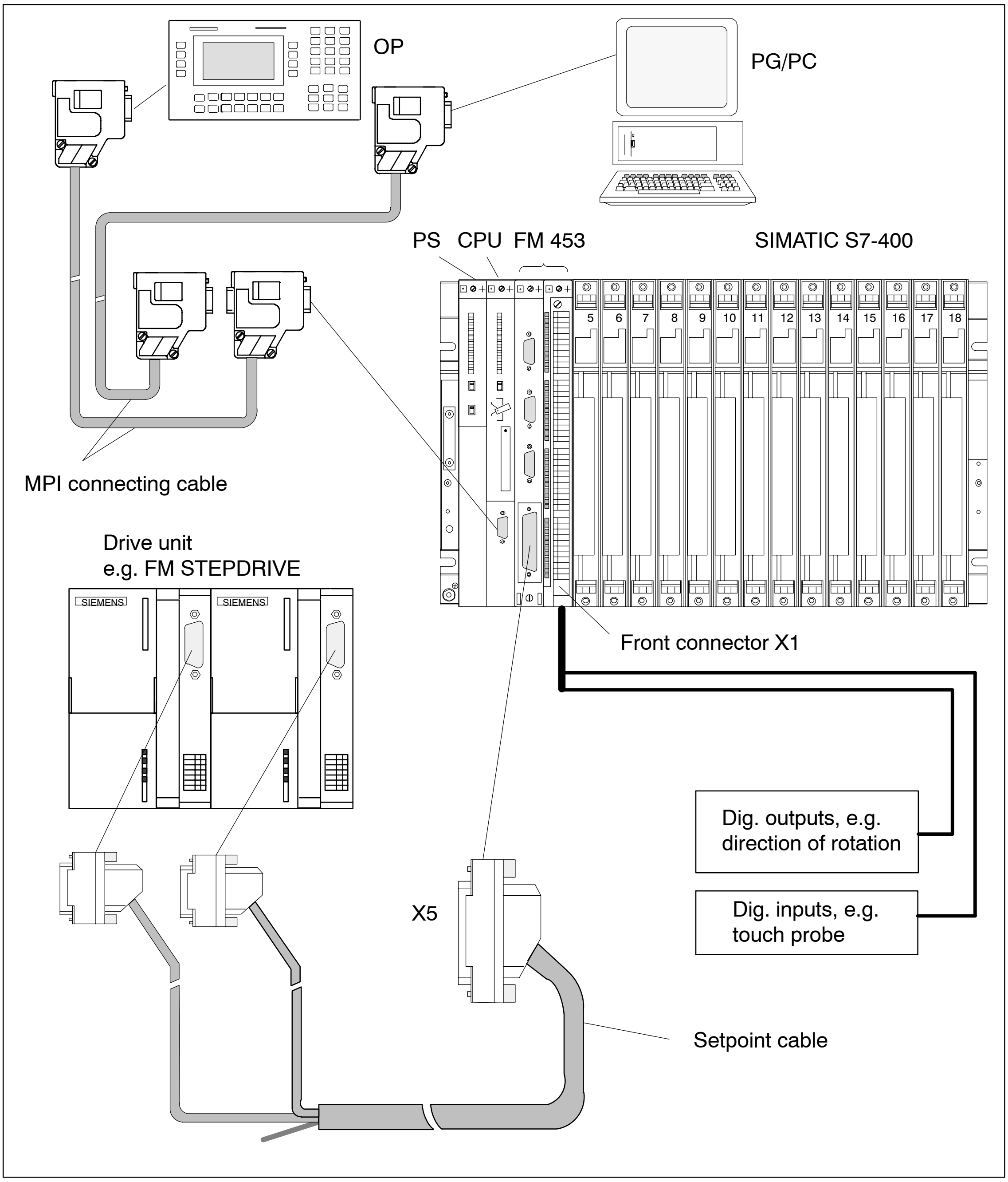


Fig. 4-2 Overview of Connecting Cables for an FM 453 with Step Drive (example)

Connecting Cables

Table 4-1 lists the connecting cables for a positioning controller with the FM 453.

Table 4-1 Connecting Cables for a Positioning Controller with FM 453

Type	Order No.	Description
MPI connecting cable	see *Catalog ST 70,* Order No. E86060-K4670-A101-A□	Connection between OP, programming device and S7-400 CPU
Setpoint cable	6FX2 002-3AB01-1□□0 see *Catalog NC Z* Order No.: E86060-K4490-A001-A□	Connection between FM 453 and SIMODRIVE 611-A servo drive ± 10 V ; three channels
Setpoint cable	6FX2 002-3AB04-1□□□	Connection between FM 453 and FM STEPDRIVE step drive; three channels
Setpoint cable	6FX2 002-3AB02-1□□□	Connection between FM 453, one step drive and three servo drives
Setpoint cable	6FX2 002-3AB03-1□□□	Connection between FM 453, two step drives and one servo drive
Measuring system cable	6FX2 002-2CD01-1□□0 see *Catalog NC Z* Order No.: E86060-K4490-A001-A□	Incremental encoder with RS 422 and FM 453 (EXE with linear scale)
Measuring system cable	6FX2 002-2CE01-1□□0 see *Catalog NC Z* Order No.: E86060-K4490-A001-A□	ROD 320 encoder with 1FT5 motor and FM 453
Measuring system cable	6FX2 002-2CC01-1□□0 see *Catalog NC Z* Order No.: E86060-K4490-A001-A□	Connection of absolute encoder (SSI) and FM 453

Front Connector

You need a 48-pin front connector for wiring the digital I/Os. It must be ordered separately.

The front connector is available in three different versions:

- with screw-type terminals Order No.: 6ES7 492-1AL00-0AA0
- with spring-loaded terminals Order No.: 6ES7 492-1BL00-0AA0
- with crimp terminals Order No.: 6ES7 492-1CL00-0AA0

see *Catalog ST 70,* Order No. E86060-K4670-A101-A□

4.2 Description of the Drive Interface

Connector for the Drive Unit

Power sections with analog interfaces (± 10 V) or stepper motor power sections which have at least one clock generator and direction input can be connected to the 50-pin male sub-D connector X5 of the FM 453. Mixed configurations for up to three drives are possible here.

Additionally, the FM 453 provides one enable signal per channel.

Connector Location

Figure 4-3 shows the installation position and identification of the plug on the module.

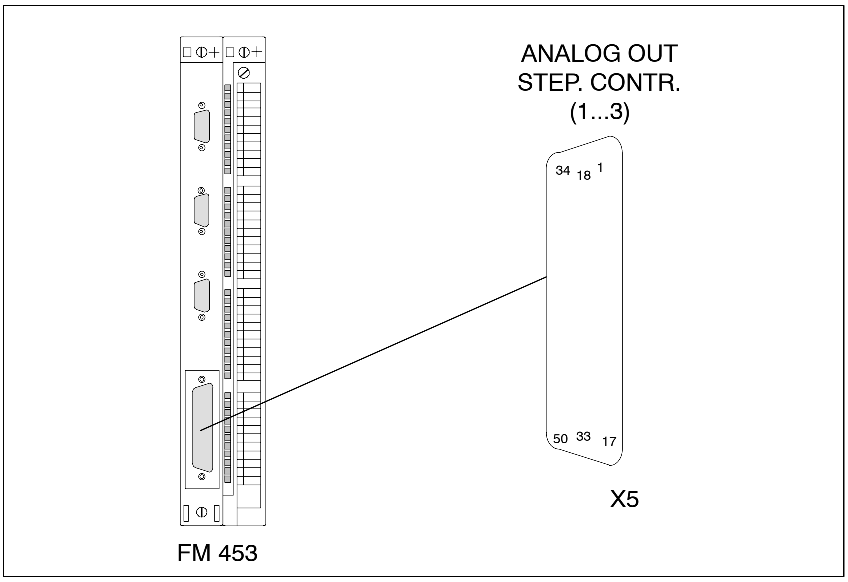


Fig. 4-3 Position of X5 Connector

Connector Pinout

Connector identifier: **X5** **ANALOG OUT / STEP. CONTR. / (1...3)**
Connector type: 50-pin sub-D plug connector

Table 4-2 Pinout of Connector X5

Pin	Name	Type	Pin	Name	Type	Pin	Name	Type
1	not assigned		18	ENABLE1	O	34	not assigned	
2	BS1	VO	19	ENABLE1_N	O	35	SW1	VO
3	SW2	VO	20	ENABLE2	O	36	BS2	VO
4	BS3	VO	21	ENABLE2_N	O	37	SW3	VO
5	PULSE1	O	22	GND		38	PULSE1_N	O
6	DIR1	O	23	GND		39	DIR1_N	O
7	PULSE2_N	O	24	GND		40	PULSE2	O
8	DIR2_N	O	25	GND		41	DIR2	O
9	PULSE3	O	26	ENABLE3	O	42	PULSE3_N	O
10	DIR3	O	27	ENABLE3_N	O	43	DIR3_N	O
11	PWM1/BOOST1	O	28	PWM2/BOOST2	O	44	PWM3/BOOST3	O
12	PWM1_N/ BOOST1_N	O	29	PWM2_N/ BOOST2_N	O	45	PWM3_N/ BOOST3_N	O
13	READY1_1_N	I	30	READY1_2_N	I	46	READY1_3_N	I
14	not assigned		31	not assigned		47	not assigned	
15	RF1_1	K	32	not assigned		48	RF1_2	K
16	RF2_1	K	33	not assigned		49	RF2_2	K
17	RF3_1	K				50	RF3_2	K

Signal Names

For step drives:

PULSE[1...3], PULSE[1...3]_N	Clock pulse, true and negated
DIR[1...3], DIR[1...3]_N	Direction signal, true and negated
ENABLE[1...3], ENABLE[1...3]_N	Enable signal, true and negated
PWM[1...3]/BOOST[1...3],	Current generation, true
PWM[1...3]_N/BOOST[1...3]_N	Current generation, negated
READY1[1...3]_N	Ready message 1
GND	Signal ground

For analog drives:

SW[1...3]	Setpoint
BS[1...3]	Reference potential for setpoint (analog ground)
RF[1.1...3.1], RF[1.2...3.2]	Contact for CL controller enable

Signal Type

O	Signal output
I	Signal input
VO	Voltage outlet
K	Switching contact

Note

The active level of each signal can be defined in MD37 (see Section 5.3.1,). Check the technical documentation for your drive device regarding assignment of signal levels to direction of rotation.

The following signal descriptions refer to:

- SIMODRIVE 611-A servo drive
- FM STEPDRIVE step drive

Servo Drives

Output signals:

One voltage signal and one enable signal are provided for each channel.

- **SETPOINT (SW)**

  An analog voltage signal in the range ± 10 V, for output of an rpm setpoint.

- **REFERENCE SIGNAL (BS)**

  A reference potential (analog ground) for the setpoint signal, internally connected with the logic ground.

- **SERVO ENABLE (RF)**

  A relay contact pair used to switch the axis-specific Enable signal for the power section, e.g. a SIMODRIVE drive unit. The FM 453 activates this signal when cyclic open-loop control mode is entered, that is, when runup and initialization were successfully completed and the user activated the single function “Servo Enable”. Prerequisite is, however, that MD37 is set for “Servo Enable active”.

Signal parameters of the outputs

The setpoint is output as an analog differential signal.

Table 4-3 Electrical Parameters of the Setpoint Signal

Parameters	Min	Max	Unit
Rated voltage range	–10	10	V
Output current	–3	3	mA

D/A converter resolution: 15 bits + sign

The axis enables are switched via relay outputs (“make” contacts).

Table 4-4 Electrical Parameters of the Relay Contacts

Parameters	Max	Unit
Switching voltage	50	V
Switching current	1	Q
Switching capacity	30	VA

Connecting cable

Permissible length: up to 35 m (115 ft)

Step Drives

Output signals:

One pulse, one directional and one enable signal are provided for each channel as true and negated signals. In addition, one additional signal per channel can be parameterized for current generation.

- **PULSE**

  The clock pulses control the motor. The motor executes one increment in response to each rising pulse edge.

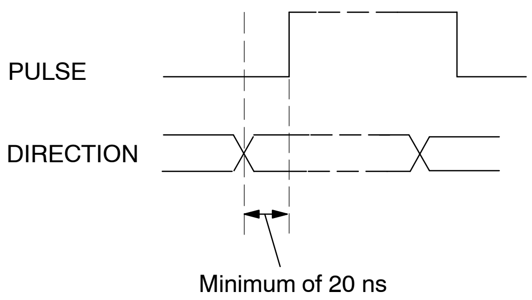
  This means that the number of pulses which are output determines the angle of rotation, i.e. the distance to be traversed.

  The pulse frequency determines the speed of rotation, i.e. the traversing speed.

- **DIRECTION**

  The signal levels which are output determine the direction of rotation of the motor.

  Signal ON: “Rotation to left”
  Signal OFF: “Rotation to right”



- **ENABLE**

  The FM 453 activates this signal anytime the cyclical control operating mode is detected.

  Signal ON: Power activation is enabled
  Signal OFF: Power activation is disabled, motor is current-free

- **PWM / BOOST**

  This signal is for purposes of altering the motor current.

  In the “PWM” function, a pulse width modulated signal is output which can be used to adjust the motor current between 0 and 100%.

  The “BOOST” function can be used to amplify the motor current:

  Signal ON: Motor current increases
  Signal OFF: Motor current normal

  Parameters are assigned to this signal in the machine data (see MD37, Section 5.3.1).

Signal parameters of the outputs

All output signals are output by way of differential-signal line drivers in compliance with Standard RS422. To ensure optimum noise immunity, the power section should feature differential signal receivers or optical coupler inputs to permit balanced signal transfer. Unbalanced transfer is also possible, however cable length in such cases is limited to a maximum of 10 m.

Note

In the case of asymmetrical transmission satisfactory functioning cannot be guaranteed because of the various non-standardized input circuits of the drive units. Especially the lead length and the limit frequency depend on the properties of the input circuit and the lead used. Furthermore, the reference potential GND must be floating in order to prevent electrical interference.

Table 4-5 Electrical Parameters of the Step Drive Signal Outputs

Parameters		Min	Max	Unit	when
Differential output voltage	V_{OD}	2		V	RL = 100 Ω
Output voltage “High”	V_{OH}	3.7		V	I_O = –30 mA
		4.5		V	I_O = –100 µA
Output voltage “Low”	V_{OL}		1.1	V	I_O = 30 mA
Load resistance	R_L	55		Ω	
Output current	I_O		±60	mA	
Pulse frequency	f_p		1	MHz	

Connecting cable

Permissible length (l):
for balanced transfer, 35 m
for unbalanced transfer, 10 m

Input signal

READY1_N

This input is non-isolated and works with a 5V level. A floating output (switching contact or optical coupler) may be connected. The FM 453 interprets this input as a Ready message from the power section.

An alternative connection option is available via the front connector X1 (READY2 see Section 4.6). For example, in incremental mode, channels 1 to 3 with cable 6FX2 002-3AB04-1□□□.

The use of READY1_N and READY2 is parameterized in accordance with the system configuration in the machine data (see MD37, Section 5.3.1).

Signal parameters of the input

Table 4-6 Electrical Parameters of the "READY1_N" Signal Input

Parameters	Value	Unit	Notes
1 Signal, voltage range V_H	3.5 ...5.5	V	or input open
0 signal, voltage range V_L	–1.5 ...-1	V	
0 signal, input current I_L	–1.5 ...-3	mA	

Signal Wiring (Output Signals)

Figure 4-4 shows various ways to wire the signals.

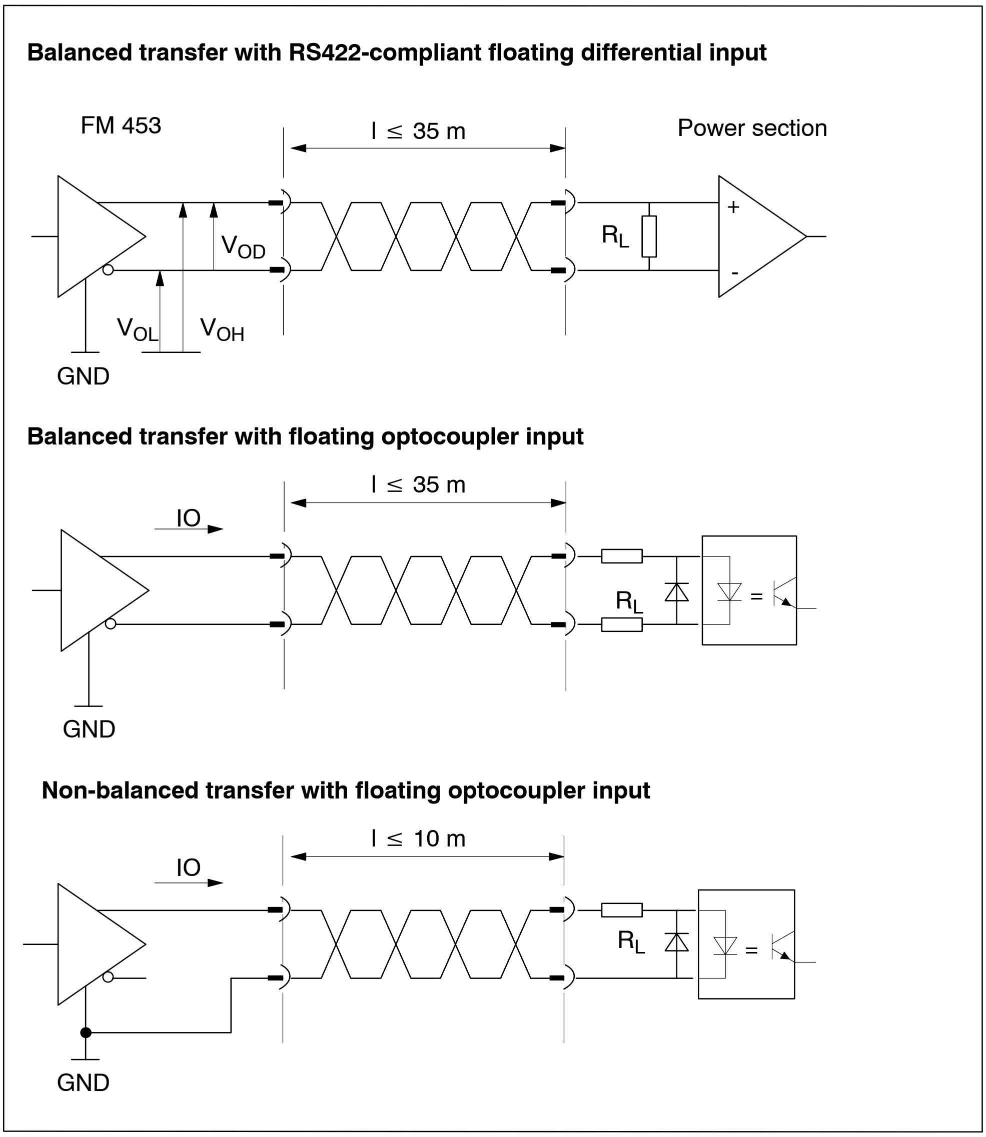
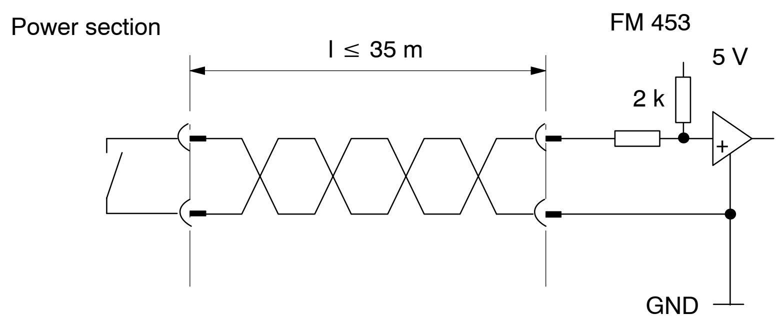


Fig. 4-4 Connection Options for Drive Port Output Signals

Signal Connection for the “READY1_N” Input

Figure 4-5 shows you different signal connection options for the “READY1_N” input.

Actuation of the “READY1_N” input by floating contact



Actuation of the “READY1_N” input by floating optocoupler

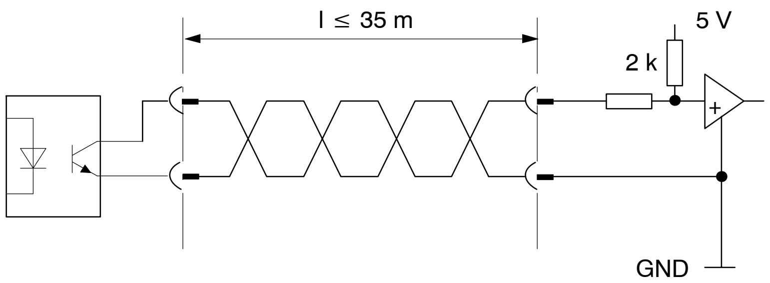


Fig. 4-5 Connection of the “READY1_N” Input

4.3 Connecting the Drive Unit

Danger

The only drives permitted are those with safe isolation.

To Connect the Connecting Cables

Please note:

Note

Use only shielded twisted pairs for lines. The shielding must be connected to the metallic or metallized connector jacket on the controller side. To protect the analog setpoint signal against low-frequency interference, we recommend that you not ground the shielding on the drive-unit side.

The cable set supplied as an accessory offers excellent immunity against interference.

Connecting Servo Drives

For servo drives, you use the ± 10 V interface.

Proceed as follows:

1. Wire the free cable end of the connecting cable to the terminals of the drive unit. (The terminal identifiers on the cable ends indicate the proper terminals for SIMODRIVE units.)
2. Open the cover and plug the female sub-D connector onto the module.
3. Lock the connector in place with the knurled screws. Close the connector cover.

Connecting cable

The connecting cable is a cable set for three channels with an analog interface. The terminals are identified for SIMODRIVE drive units.

Order No.: 6FX2 002-3AD01-1□□□

The connecting cable is available in a variety of lengths.

see *Catalog NC Z* , Order No.: E86060-K4490-A001-A□.

The following Figure shows you how to connect an FM 453 with a SIMODRIVE 611-A drive unit.

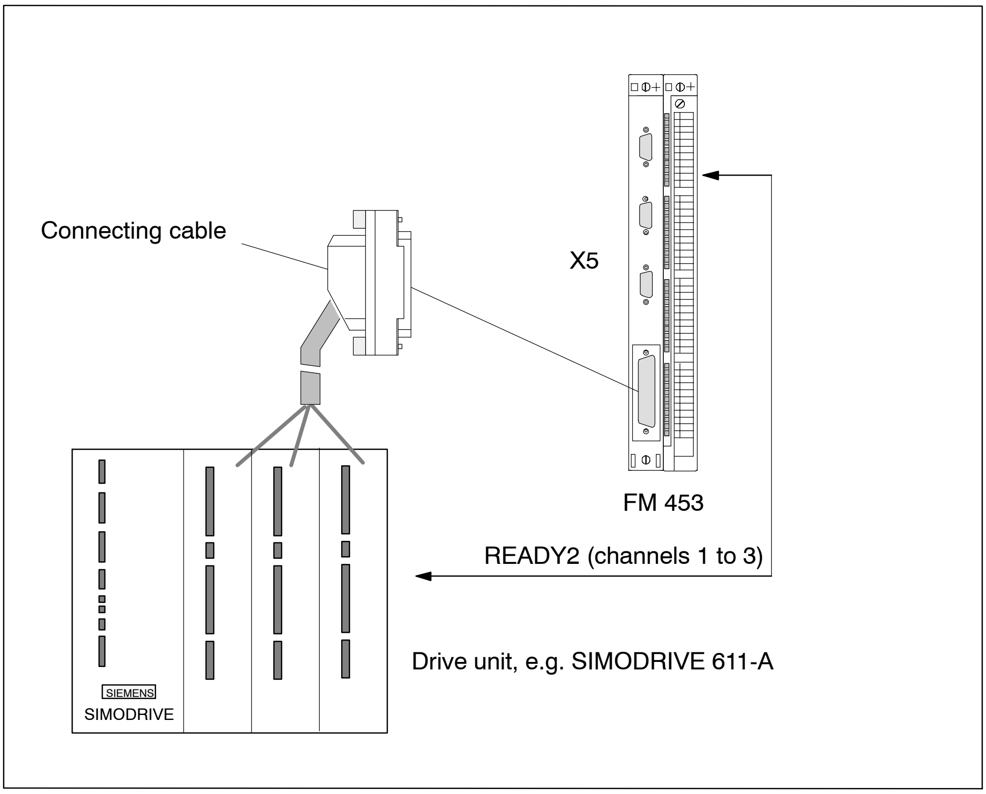


Fig. 4-6 Connecting a SIMODRIVE 611-A Drive Unit

Connecting Step Drives

Proceed as follows:

1. Open the cover of the FM 453 and plug the female sub-D connector onto the module.
2. Lock the connector in place with the knurled screws. Close the connector cover.
3. Open the front door of the FM STEPDRIVE and plug the male sub-D connector onto the step drive.
4. Lock the connector in place with the knurled screws. Close the front door.

Connecting cable

The connecting cable is a cable set for three channels with a step drive.

Order No.: 6FX2 002-3AB04-1□□□

The connecting cable is available in a variety of lengths.

For length code, see *Catalog NC Z*, Order No.: E86060-K4490-A001-A□

The following Figure shows you how to connect an FM 453 to FM STEPDRIVE drive units.

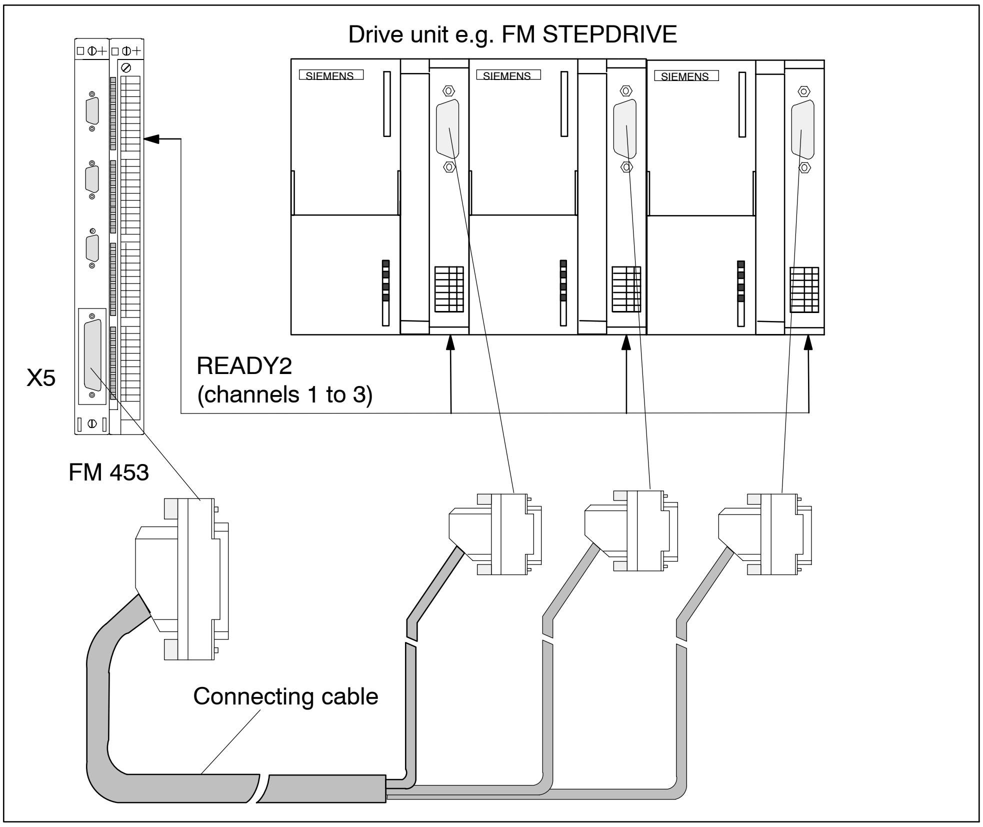


Fig. 4-7 Connecting to FM STEPDRIVE Drive Units

In this configuration with step mode channels 1 to 3, the external signal READY2 must be used for each channel.

Connecting Servo and Step Drives

In the case of mixed configurations, the drives are permanently assigned to the terminals of the separate channels.

You should always start with the step drives.

Example:

Connecting one step drive and two servo drives.

Step drive on channel 1
1. Servo drive on channel 2
2. Servo drive on channel 3.

Connecting two step drives and one servo drive.

1. Step drive on channel 1
2. Step drive on channel 2
Servo drive on channel 3

Connecting cable

The connecting cables are a cable set for three channels with:

- One step drive and two servo drives
  - Order No.: 6FX2 002-3AB02-1□□□
- Two step drives and one servo drive
  - Order No.: 6FX2 002-3AB03-1□□□

The connecting cable is available in a variety of lengths.

For length code, see *Catalog NC Z*, Order No.: E86060-K4490-A001-A□

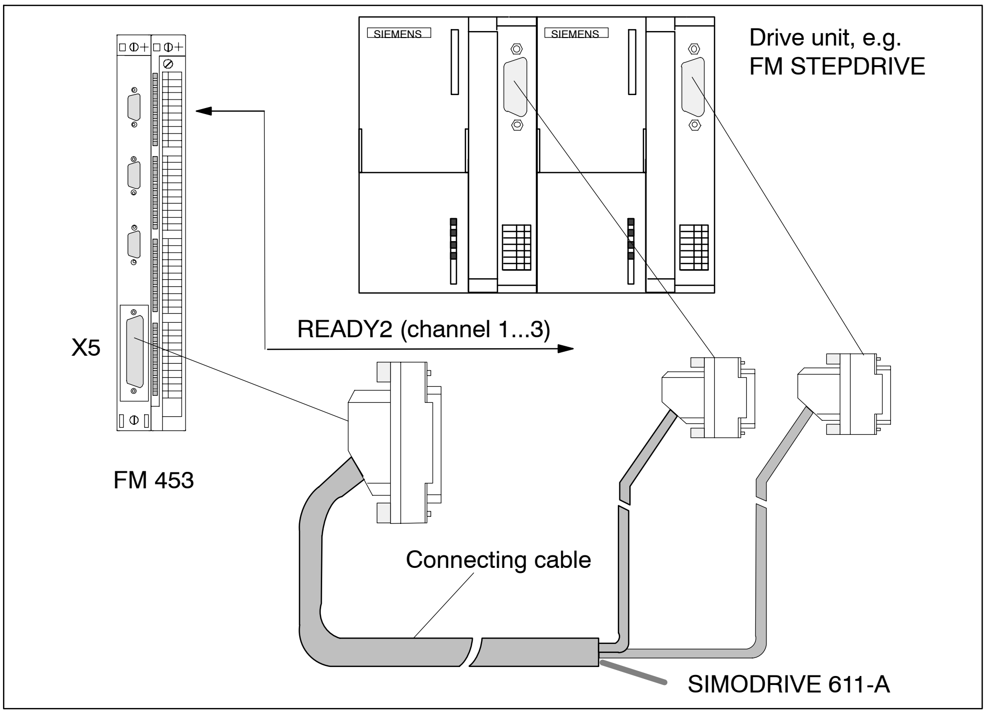


Fig. 4-8 Connecting to FM STEPDRIVE and SIMODRIVE Drive Units

In both configurations, the signal READY2 can be used alternately.

4.4 Description of the Measuring System Interface

Connectors for Encoders

For each channel, a 15-pin female sub D connector is provided for the connection of incremental encoders or absolute encoders (serial port).

Location of Connectors

Figure 4-9 shows where the connector is installed on the module, and how it is identified.

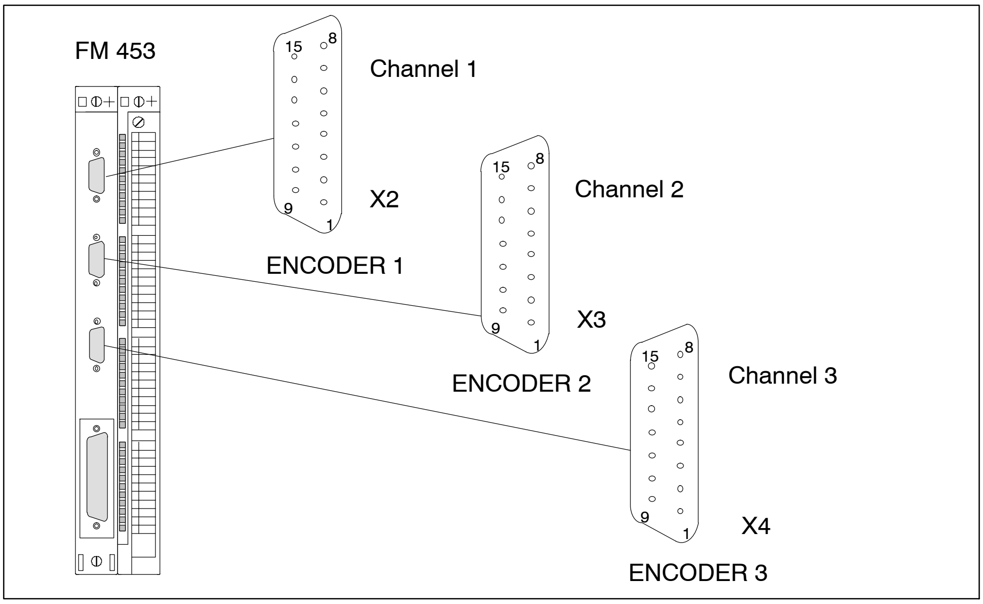


Fig. 4-9 Location of Connectors X2 to X4

Connector Pinout

Identifier: **X2, X3, X4** ENCODER 1...3
Type: 15-pin female sub-D plug connector

Table 4-7 Pinout of Connectors X2 to X4

Pin	Encoder		Type	Pin	Encoder		Type
	Incremental	Absolute			Incremental	Absolute	
1	not assigned			9	MEXT		VO
2		CLS	O	10	N		I
3		CLS_N	O	11	N_N		I
4	P5EXT		VO	12	B_N		I
5	P24EXT		VO	13	B		I
6	P5EXT		VO	14	A_N	DATA_N	I
7	MEXT		VO	15	A	DATA	I
8	not assigned						

Signal Names

A, A_N Track A true / negated (incremental encoder)
B, B_N Track B true / negated (incremental encoder)
N, N_N Zero mark true / negated (incremental encoder)
CLS, CLS_N SSI sliding pulse true / negated (absolute encoder)
DATA, DATA_N SSI data true / negated (absolute encoder)
P5EXT Power supply +5.2 V (pins 4 and 6 connected internally)
P24EXT Power supply +24 V
MEXT Power supply ground

Signal Type

VO Voltage outlet (power supply)
O Output (5 V signal)
I Input (5 V signal)

Connectable Encoder Types

Incremental or absolute (SSI) encoders may be connected directly (e.g. digital-rotary encoders); they are then selected via machine data.

Encoders with SINE/COSINE signals (e.g. length scales) may be connected by way of an external electronic pulse shaper (EXE) that converts the signals to 5 V levels.

Encoder Characteristics

Both encoders that can be connected directly and EXEs must meet the following requirements:

Incremental Encoders

Transfer procedure: Differential transfer with 5 V rectangular signals (such as RS422 standard)

Ausgangs-Signale: Track A as true and negated signal (U_{a1}, $\overline{U_{a1}}$)
Track B as true and negated signal (U_{a2}, $\overline{U_{a2}}$)
Zero signal N as true and negated signal (U_{a0}, $\overline{U_{a0}}$)
When connecting an incremental encoder, please note that at the instant of the zero pulse (true signal), the signals of tracks A and B must also be "true".
Where applicable, the negated signal must be wired and any directional accommodations (MD19) made.
"1" signal $\geq$ 2.4 V
"0" signal < 0.8 V

Maximum output frequency: 1 MHz

Phase shift, track A to B: 90° ±30°

Power consumption: Max. 300 mA

Absolute Encoders (SSI)

Transfer procedure: Synchronous-serial interface (SSI) with 5 V differential-signal transfer signals (such as RS422 standard)

Output signals: Data as true and negated signal

Input signals: Sliding pulse as true and negated signal

Resolution: Not more than 25 bits

Maximum transfer frequency: 1.25 Mbps

Power consumption: Max. 300 mA

Encoder Power Supply

The 5 V or 24 V power supply to the encoders is generated within the module from auxiliary voltage 1L+ (external supply, to 1 M) and is available on the female sub-D connector, and so you can power the encoders by way of the connecting cable, without additional wiring. The available voltage is electronically protected against shorting and thermal overload, and is monitored.

Requirement for auxiliary voltage supply:

The 24 V DC voltage must be generated as functional extra-low voltage with safe isolation (PELV).

Equipotential bonding is needed between ground reference potential 1M and the reference potential of the CPU (see Fig. 4-1 ”Ground connection for load voltage”).

Table 4-8 Electrical Parameters of Encoder Power Supply

Parameters	Min	Max	Unit
5 V power supply			
Voltage	5.1	5.3	V
Ripple		50	mV_{ss}
Current carrying capacity per channel		0.3	Q
24 V power supply			
Voltage	20.4	28.8	V
Ripple		3.6	V_{ss}
Current carrying capacity per channel		0.3	Q

Note

24 V encoders that are supplied via X2, X3 or X4 must not be inserted or removed when the FM 453 power supply is connected.

Using an External Power Supply for the Encoders

When the encoders are operated with an external power supply (that is, they do not utilize the FM’s voltage supply), the reference potential of the two voltage supplies must be connected.

Equipotential bonding between external voltage ground and reference potential of CPU (see Fig. 4-1 ”Ground connection for load voltage”).

The external supply voltage must be generated as functional extra-low voltage with safe isolation (PELV).

Connecting Cables to Encoder

The maximum cable length depends on the specifications of the encoder power supply, and on the transfer frequency. For trouble-free operation, you should not exceed the following values when using SIEMENS cable sets:

Table 4-9 Cable Length as a Function of Encoder Power Supply

Supply Voltage	Tolerance	Power Consumption	Max. Cable Length
5 V DC	4.75 V to 5.25 V	≤ 300 mA	25 m (82 ft)
5 V DC	4.75 V to 5.25 V	≤ 210 mA	35 m (115 ft)
24 V DC	20.4 V to 28.8 V	≤ 300 mA	100 m (328 ft)
24 V DC	11 V to 30 V	≤ 300 mA	300 m

Note

If you want to use incremental encoders with cable lengths longer than 25 or 35 m (82 or 115 ft), select a type that uses a 24 V power supply.

Table 4-10 Cable Length as a Function of Transfer Frequency

Encoder Type	Frequency	Max. Cable Length
Incremental encoder	1 MHz	10 m (32.8 ft)
	500 kHz	35 m (115 ft)
Absolute encoder (SSI)	1.25 Mbps	10 m (32.8 ft)
	156 kbps	250 m

For additional information on encoders, see Chapter 9.6.

4.5 Connecting the Encoders

To Connect the Connecting Cables

Please note:

Note

Use only shielded cables. The shielding must be connected to the metallic or metallized connector jacket.

The cable sets supplied as an accessory offer excellent immunity from interference, as well as cross-sections large enough for the power supply to the encoders.

The cable shielding must be connected to a grounded shielding bus over a large contact area in the proximity of the FM 453 and the sensors.

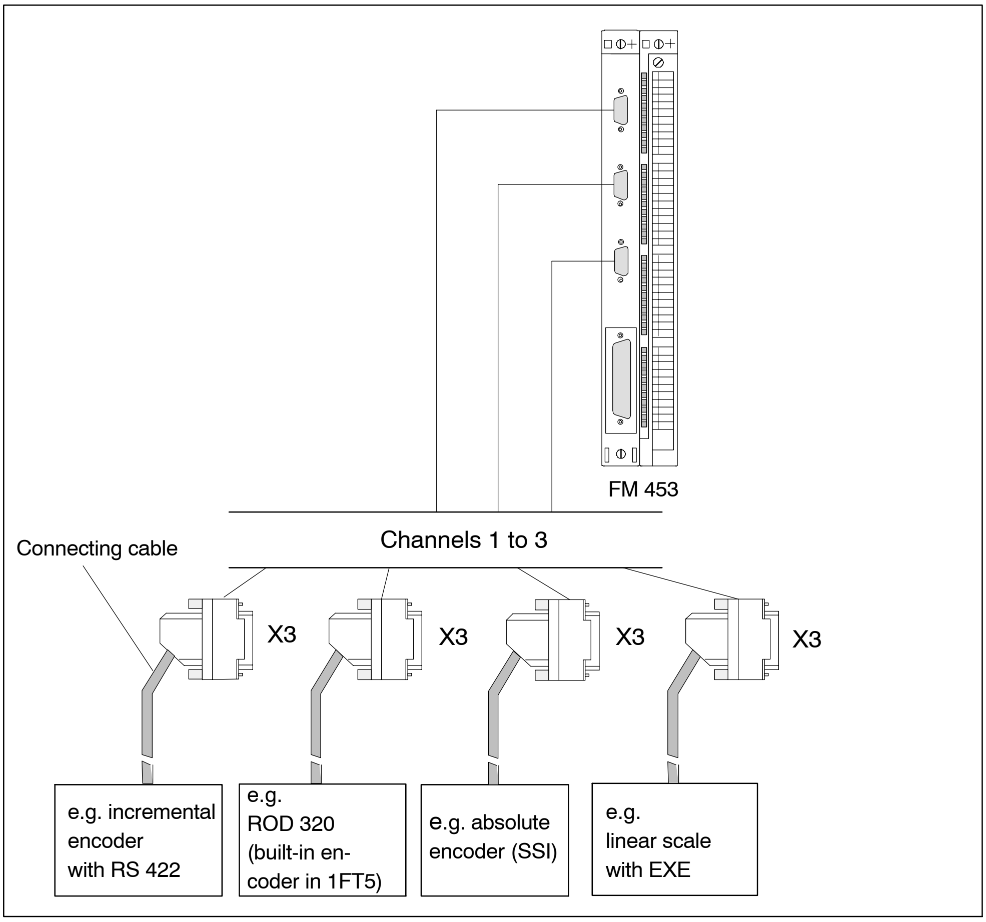


Fig. 4-10 Connecting Encoders

Procedure for Connecting Encoders

To connect the encoders:

1. Connect the connecting cables to the encoders.

   For absolute encoders (SSI) it may be necessary to cut and add connectors to the cable (end of the cable to the encoder) according to the manufacturer's instructions.

2. Open the cover and plug the male sub-D connector onto the module.
3. Lock the connector in place with the knurled screws. Close the connector cover.

Available Connecting Cables for Encoders

Cable set for incremental encoders with RS 422 or EXEs (for connection of linear scales)

Order No.: 6FX2 002-2CD01-1□□0

Cable set for built-in ROD 320 encoders with 17-pin round plugs.

Order No.: 6FX2 002-2CE01-1□□0

Cable set for absolute encoders (SSI) with a free cable end.

Order No.: 6FX2 002-2CC01-1□□0

Connecting cables are available in a variety of lengths.

see Catalog NC Z , Order No.: E86060-K4490-A001-A□.

4.6 Description of the I/O Port

Front Connector

Four digital input/outputs per channel, the zero position signal and the standby signal (READY2) may be connected to the 48-pin front connector X1 with its single-wire terminals.

LEDs

The current status of the I/O port is indicated by the LEDs next to the front connector:

- One LED each for INTF, EXTF and STAT
- 3 LEDs for zero position signal input, channels 1 to 3
- 3 LEDs for standby signal 2 input, channels 1 to 3
- 12 LEDs for digital inputs 1 to 3, channels 1 to 3
- 12 LEDs for digital outputs 1 to 3, channels 1 to 3

Location of Connector

Figure 4-11 shows the location of the front connector and the labels.

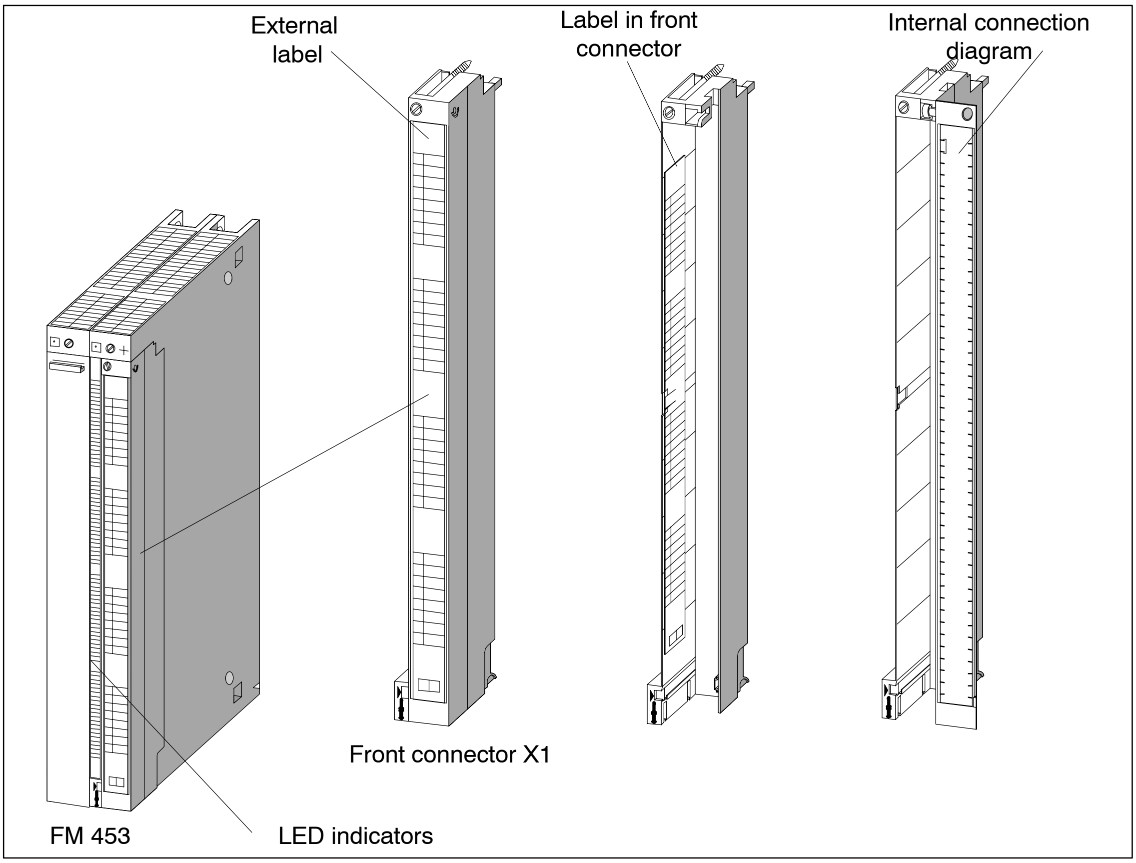


Fig. 4-11 Location of X1 Connector

Labels Figure 4-12 shows the labels of the FM 453.

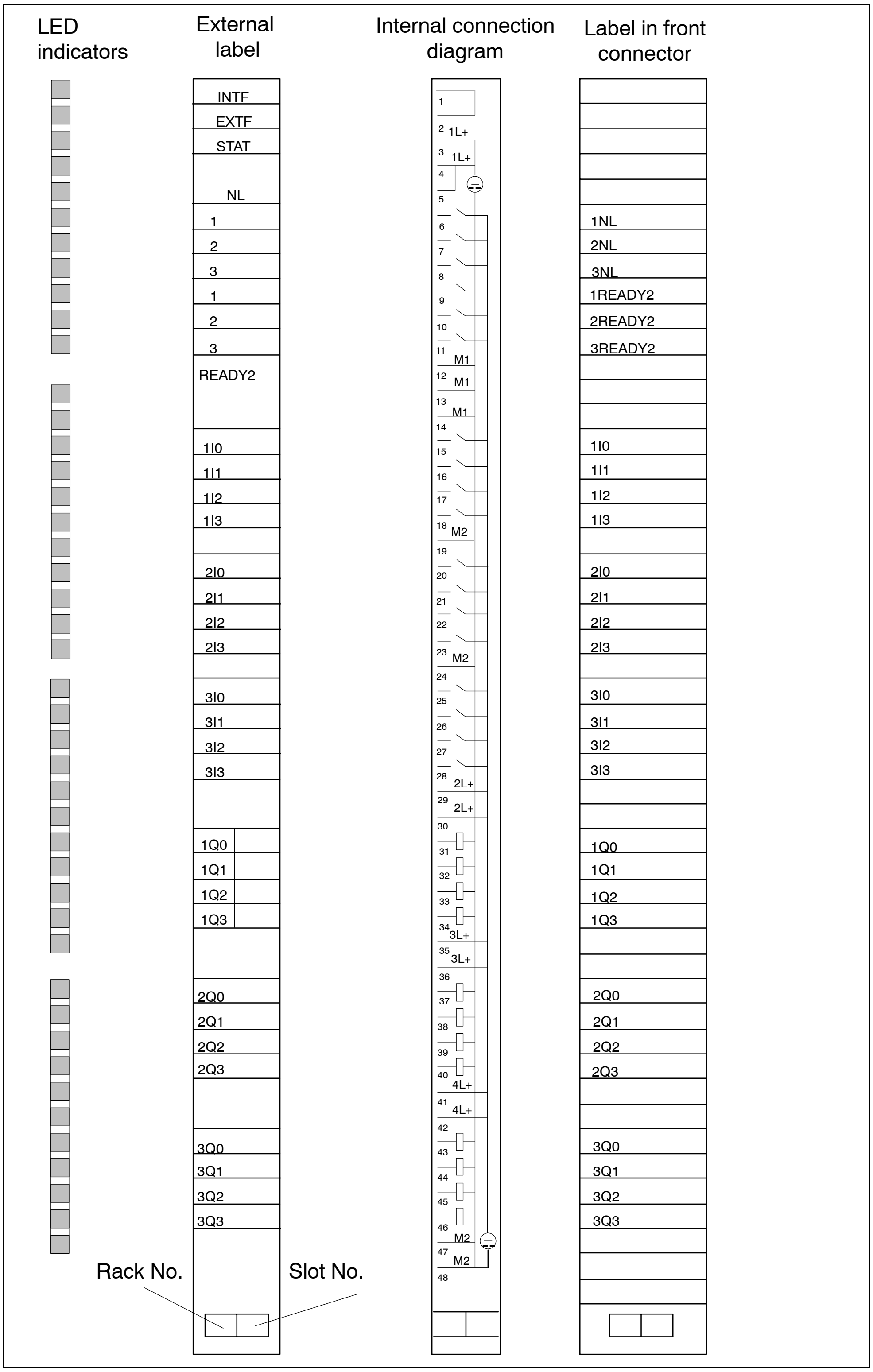


Fig. 4-12 Labels of the FM 453

Connector Pinout

Connector identifier: **X1**
Connector type: 48-pin S7 front connector with single-wire terminals

Table 4-11 Pinout of the Front Connector

Terminal	Name	Significance
1	M	Contains cable bridge for detection of the plugged in connector
2	FE_X1	
3	1L+	24 V DC auxiliary voltage for sensor supply1) Terminals 3, 4 and 5 are connected together on the module.
4	1L+	
5	1L+	
6	1NL	Input, zero position signal from channel 1
7	2NL	Input, zero position signal from channel 2
8	3NL	Input, zero position signal from channel 3
9	1READY2	Input, standby signal 2 from channel 1
10	2READY2	Input, standby signal 2 from channel 2
11	3READY2	Input, standby signal 2 from channel 3
12	M1	Reference potential for auxiliary voltage 1L+ Terminals 12, 13 and 14 are connected together on the module.
13	M1	
14	M1	
15	1I0	Digital input 0 from channel 1
16	1I1	Digital input 1 from channel 1
17	1I2	Digital input 2 from channel 1
18	1I3	Digital input 3 from channel 1
19	M2	Reference potential for auxiliary voltage 2L+ to 4L+3)
20	2I0	Digital input 0 from channel 2
21	2I1	Digital input 1 from channel 2
22	2I2	Digital input 2 from channel 2
23	2I3	Digital input 3 from channel 2
24	M2	Reference potential for auxiliary voltage 2L+ to 4L+3)
25	3I0	Digital input 0 from channel 3
26	3I1	Digital input 1 from channel 3
27	3I2	Digital input 2 from channel 3
28	3I3	Digital input 3 from channel 3

1) **In applications using encoders, 1L+ with reference 1M must always be connected to a 24 V auxiliary voltage and 1M must be connected to the CPU’s reference potential.** (see Fig. 4-1, “Ground connection for load voltage”)
2) If this channel is not utilized, the associated auxiliary voltage need not be connected.
3) Terminals 19, 24, 47 and 48 (reference potential 2M) are connected together on the module.

Table 4-11 Pinout of the Front Connector, continued

Terminal	Name	Significance
29	2L+	24 V DC auxiliary voltage for digital outputs, channel 1[2)] Terminals 29 and 30 are connected together on the module.
30	2L+	
31	1Q0	Digital output 0 from channel 1
32	1Q1	Digital output 1 from channel 1
33	1Q2	Digital output 2 from channel 1
34	1Q3	Digital output from channel 2
35	3L+	24 V DC auxiliary voltage for digital outputs, channel 2[2)] Terminals 35 and 36 are connected together on the module.
36	3L+	
37	2Q0	Digital output 0 from channel 2
38	2Q1	Digital output 1 from channel 2
39	2Q2	Digital output 2 from channel 2
40	2Q3	Digital output 3 from channel 2
41	4L+	24 V DC auxiliary voltage for digital outputs, channel 3[2)] Terminals 41 and 42 are connected together on the module.
42	4L+	
43	3Q0	Digital output 0 from channel 3
44	3Q1	Digital output 1 from channel 3
45	3Q2	Digital output 2 from channel 3
46	3Q3	Digital output 3 from channel 3
47	M2	Reference potential for auxiliary voltage 2L+ to 4L+[3)]
48	M2	

1) **In applications using encoders, 1L+ with reference 1M must always be connected to a 24 V auxiliary voltage and 1M must be connected to the CPU's reference potential.** (see Fig. 4-1, "Ground connection for load voltage")
2) If this channel is not utilized, the associated auxiliary voltage need not be connected.
3) Terminals 19, 24, 47 and 48 (reference potential 2M) are connected together on the module.

Digital inputs (I0 to I3)

The FM 453 provides four digital inputs per channel.

All inputs are optocoupler inputs with equal priority and the reference potential 2M. Switching functions are allocated to an input number by way of machine data; input polarity is selected in the same way (starting and shutdown slopes).

These fast inputs are PLC-compatible (24 V current-sourcing). Switches or contactless sensors (2-wire or 3-wire sensors) can be connected.

Possible uses include:

- As reference-point switches
- As switches for external Start, external block change
- As touch probes

See Section 5.3.1 for further applications.

NL Input

The zero position signal of the drive power section can be connected for each channel to a further input.

The zero position signal is specified in MD37 (see Section 5.3.1) and can be one of the following (see Section 9.7):

- Current-sourcing pattern zero signal for reference point approach
- Zero pulse, external, for reference point approach

READY2 Input

The standby signal 2 (controller ready) of the drive power section can be connected for each channel to a further input.

The message signal is specified in MD37 (see Section 5.3.1).

Note

The “READY2” input is configured as an isolated optical coupler input. See Section 4.7 for details about wiring.

Table 4-12 Electrical Parameters of NL and READY2 Digital Inputs

Supply voltage	24 V DC (permissible range: 20.4...28.8 V)
Electrical isolation	Yes
Input voltage	• 0 signal: -3 ... 5 V • 1 signal: 11 ... 30 V
Input current	• 0 signal: max. 3 mA • 1 signal: max. 7 mA
Input delay • over input voltage range • for 24 V input voltage	 • 0 → 1 signal: max. 15 μs • 1 → 0 signal: max. 45 μs • 0 → 1 signal: max. 8 μs • Internally approx. 20 μs for the Transfer Actual Value function
Polarity-reversal protection for input signals	Yes

Connection of the Input Signals

The procedure for connecting the input signals to the FM 453 is explained for the READY2 signal by way of example.

There are two methods for connecting the input signals:

- with power supplied from the auxiliary voltage L+
- with power supplied from the external signal source

Power from Auxiliary Voltage L+

Figure 4-13 shows how to connect the standby signal to connector X1 of the FM 453 (e.g. SIMODRIVE 611 drive on channel 1 of the FM).

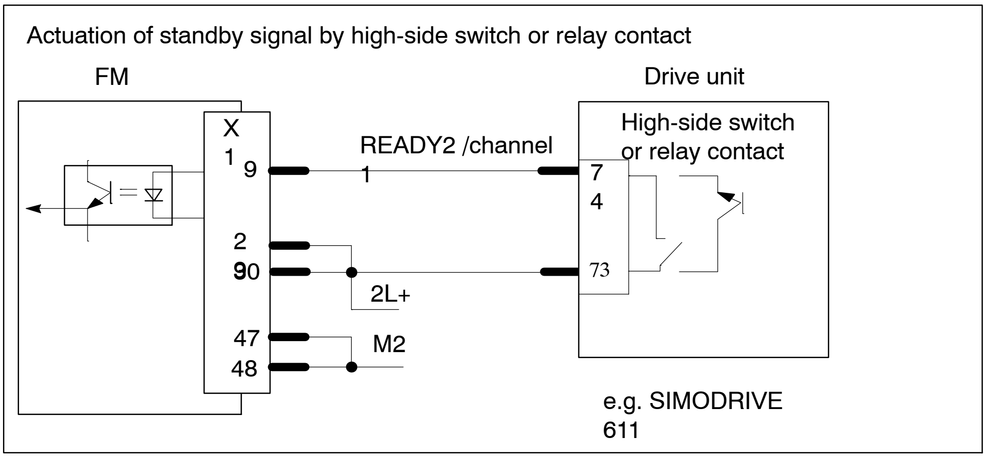


Fig. 4-13 Connection of Standby Signal, Power from Auxiliary Voltage L+

Power from the External Signal Source

Figure 4-14 shows how to power the standby signal from the drive unit.

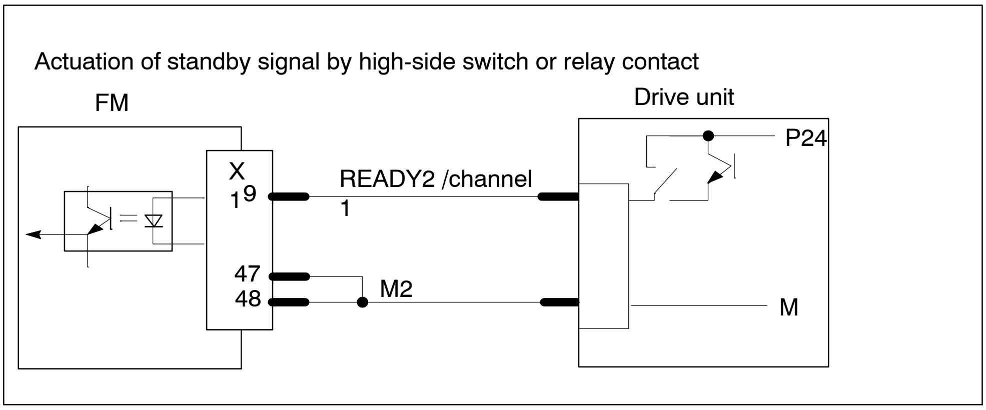


Fig. 4-14 Actuation of the Standby Signal, Power Supply from the Drive Unit

Digital Outputs (Q0 to Q3)

The FM 453 provides four digital outputs per channel.

All outputs have equal priority. Switching functions are allocated to an output number by way of machine data.

These four outputs are intended for wiring of application-specific signals.

Possible uses include:

- Position reached and stopped
- Switching function M command
- Forward/backward rotation

See Section 5.3.1 for further applications.

Table 4-13 Electrical Parameters of Digital Outputs

Supply voltage (auxiliary voltage 2L+ to 4L+)	24 V DC (allowable range: 20.4...28.8 V)
Electrical isolation	Yes
Output voltage	• 0 signal: Residual current max. 2 mA • 1 signal: (aux. v. 2L+ to 4L+ – 0.3 V)

Table 4-13 Electrical Parameters of Digital Outputs, continued, continued

Output current on signal "1" • at ambient temperature of 40°C – Rated value – Permissible value range – Lamp load • at ambient temperature of 60°C – Rated value – Permissible value range	 0.5 A 5 mA to 0.6 A (over auxiliary voltage range) max. 5 W 0.1 A 5 mA to 0.12 A (over auxiliary voltage)
Short-circuit/overload protection	Yes, for overtemperature, switches for each output separately
Switching rate	• Resistive load: max. 100 Hz • Inductive load: max. 0.25 Hz (with external quenching)
Polarity-reversal protection for auxiliary voltages	Yes
Total current of digital outputs	Simultaneity factor 100 % • up to 40°C: 6 A (for all channels) • 40°C to 60°C: 1.2 A (for all channels)

Auxiliary Voltage for Encoders 1L+ and Digital Outputs 2L+ to 4L+

A 24 V auxiliary voltage that has the parameters listed above must be connected for digital outputs and encoders with 5 V or 24 V supply voltages.

Danger

The 24 V auxiliary voltages 1L+ to 4L+ must be implemented as functional extra-low voltages with safe isolation to EN60204-1, Section 6.4, PELV (with grounding 1M, 2M).

Note

The interconnecting cable between power supply, auxiliary voltage connection 1L+...4L+ and appropriate reference potential 1M...2M may **not** exceed a maximum length of 10 m.

4.7 Wiring Up the Front Connector

Figure 4-15 shows how to lay the lines to the front connector.

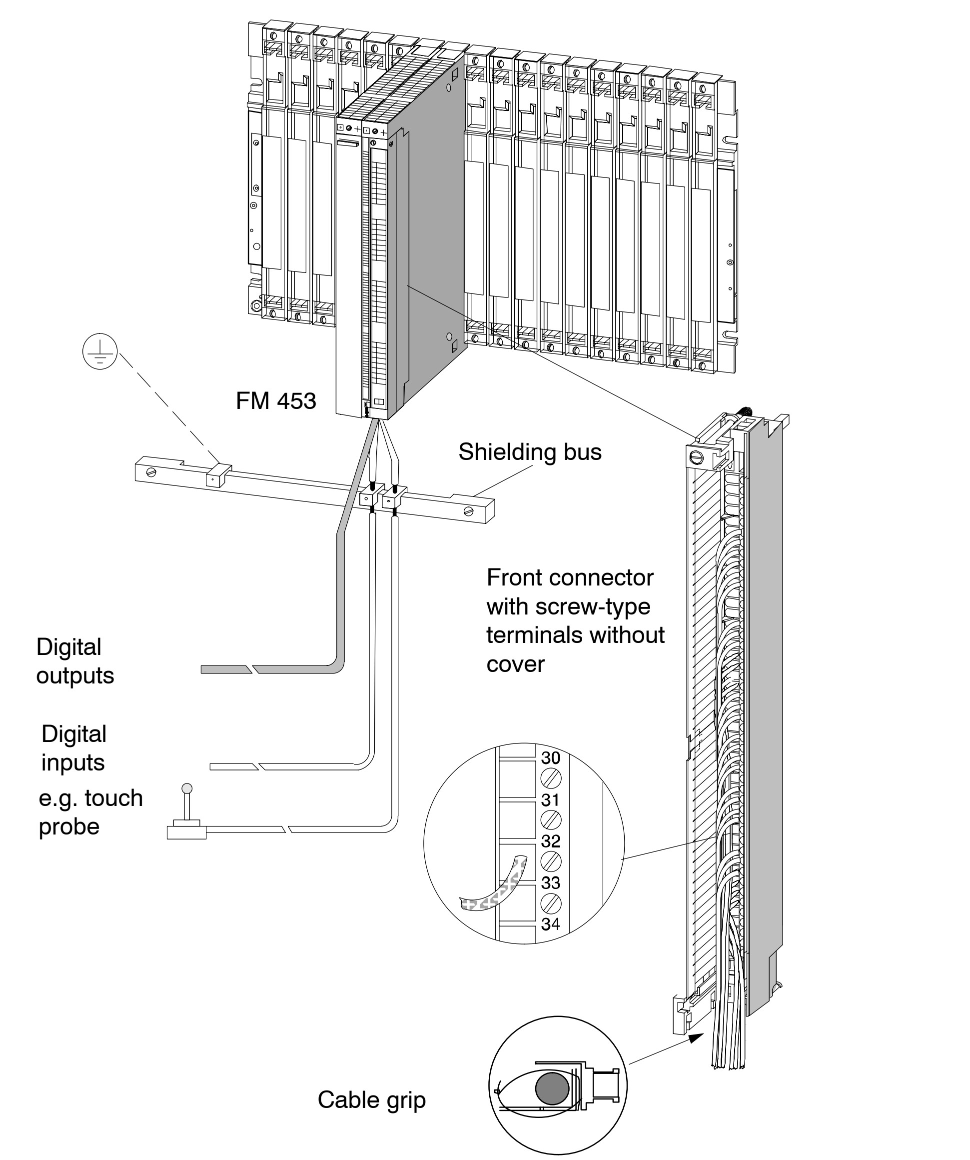


Fig. 4-15 Wiring of the Front Connector

Connecting Cables

Flexible conductor, cross-sectional area:

- 0.5 to 1.5 mm^2 for front connector with crimp terminals
- 0.25 to 2.5 mm^2 for front connector with screw-type terminals
- 0.08 to 2.5 mm^2 for front connector with spring-loaded terminals

Ferrules are not necessary.

You can use ferrules with or without insulated collars to DIN 46228 T.1 or T.4, Type A in the standard version for front connectors with screw-type or spring-loaded terminals.

You can connect two lines each measuring 1.0 mm^2. In this case, special ferrules must be used.

Please refer to the manual *S7-400/M7-400 Programmable Controller, Hardware and Installation*.

Note

To provide optimum immunity to interference, shielded cables should be used to connect the digital inputs, NL and READY2.

Tools Required

A 3.5 mm (0.13 inches) screwdriver or power screwdriver.

Procedure for Wiring the Front Connector

To wire the front connector (with screw-type terminals):

1. Remove the cover from the front connector.
2. Strip the insulation from the lines (8 to 10 mm).
3. Are you using ferrules?

   If so: Strip the insulation from the wires over 10mm. Press the ferrules onto the lines.
4. Apply the supplied cable grip to the connector.
5. Start wiring up from the bottom, otherwise from the top. Screw down unused terminals as well.

   The tightening torque should be 0.6-0.8 Nm.
6. Tighten the cable grip on the cable strand.
7. Close the front connector.
8. Label the connections on the supplied label.
9. Plug front connector onto the module.

For further details on wiring up a front connector, please refer to the manual *S7-400/M7-400, Programmable Controller, Hardware and Installation*.

Shielded Cables

When using shielded cables, the following additional steps are necessary:

1. The cable shielding must be connected to a grounded shielding bus over a large contact area in the proximity of the FM 453.

   Please refer to the manual *S7-400/M7-400 Programmable Controller, Hardware and Installation*.
2. Connect the shielded line to the module, but do not connect the shielding there.

Defining Parameters of the FM 453

5

Chapter Overview

Summary

This chapter gives you an overview of how to define the parameters of the FM 453 with the “Parameterize FM 453” tool.

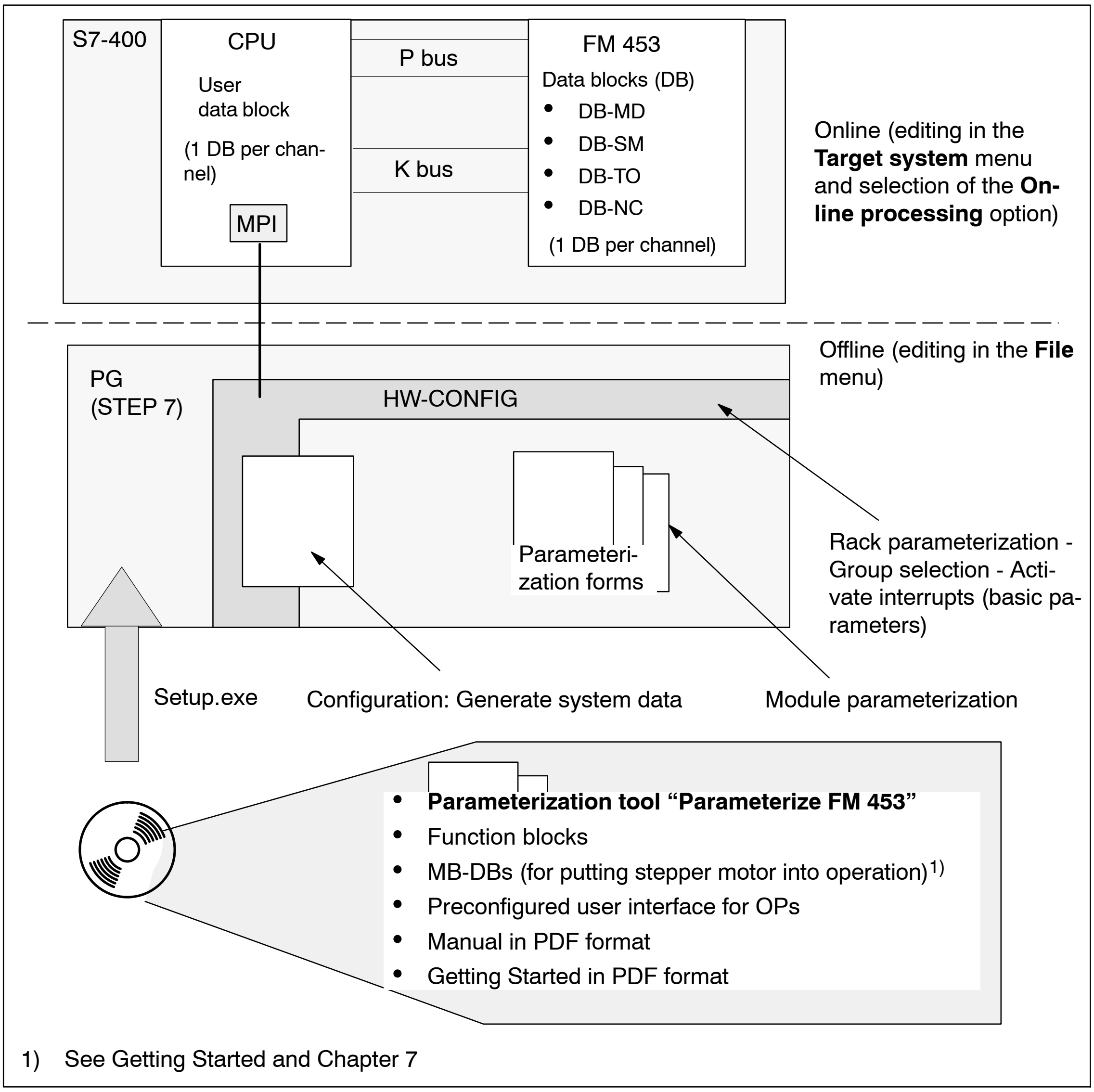


Fig. 5-1 Overview of Parameterization

5.1 Installation of “Parameterize FM 453”

Prerequisites

One of the following operating systems must be installed on the programming device (PG/PC):

- ”Windows Vista 32 Bit Ultimate”
- ”Windows Vista 32 Bit Business”
- “Windows 2000 SP4”
- “Windows 2003 Server“
- ”Windows XP-Professional”

You need the STEP 7 program (V5.3 + SP2 or higher by Windows Vista: V5.4 + SP3 or higher).

For online operation, the link between the PG and the S7-400 CPU must already be set up (see Figure 4-1).

Installation

The entire software (parameterization tool, function blocks and preconfigured user interface for OPs) is stored on CD ROM.

Install the software as follows:

1. Insert the CD ROM in the CD ROM drive of your PG/PC.
2. Run file **Setup.exe** on the CD ROM.
3. Follow the instructions displayed by the installation program step by step.

   Result: The software is installed in the following directories as standard:

   - “Parameterize FM 453” parameterization tool: **[STEP7 directory]\S7FUPOS**
   - Technology functions: **[STEP7 directory]\S7LIBS\FMSTSV_L**
   - User interface for OPs: **[STEP7 directory]\EXAMPLES\FM453\zEn17_02_FM453_OP_EX**
   - Sample applications: **[STEP7 directory]\EXAMPLES\zEn17_02** STEP7 project name: **zEn17_02_FM453_EX**
   - MD DBs (for putting stepper drive into operation): **[STEP7 directory]\EXAMPLES\FM453\MD**

5.2 Getting Started with "Parameterize FM 453"

Prerequisites

You have installed the software on your programming device/PC, as described in Section 5.1.

Configuration

Before you can configure your system, you must create a project in which to save the parameters. You will find further information on how to configure modules in your user manual *Standard Software for S7 and M7, STEP 7*. The description below outlines only the most important steps.

1. Start the *SIMATIC Manager* and open your project.
2. Insert a **SIMATIC 400 station** in the menu **Insert > Station**.
3. Select the **SIMATIC 400 station**. Call up the S7 hardware configuration from the menu **Edit > Open Object**.
4. Select a rack.
5. Select the FM 453 positioning module with the correct order number from the module catalog, and insert it in the hardware table as appropriate for your configuration.
6. Double-click a module to configure it.

   The **Properties** dialog box appears.

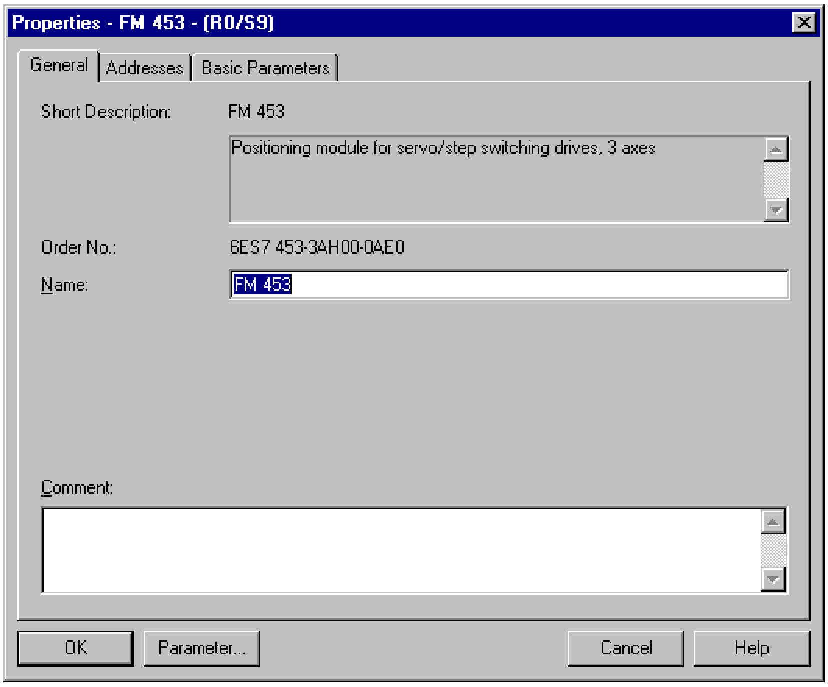


Fig. 5-2 Getting Started with "Parameterize FM 453"

7. By clicking on the tabs in this FM 453 window (General, Addresses and Basic Parameters), you can
   - Assign a name
   - Change the address of the FM as well as any input parameters for the POS_INIT block (see Section 6.3.1)
   - Configure the interrupts (diagnostic interrupt, hardware interrupt).

Note:

Further operation of the FM 453 is not possible with the CPU in the STOP state.

Click the **Parameters** button to call up the screen for setting the parameters.

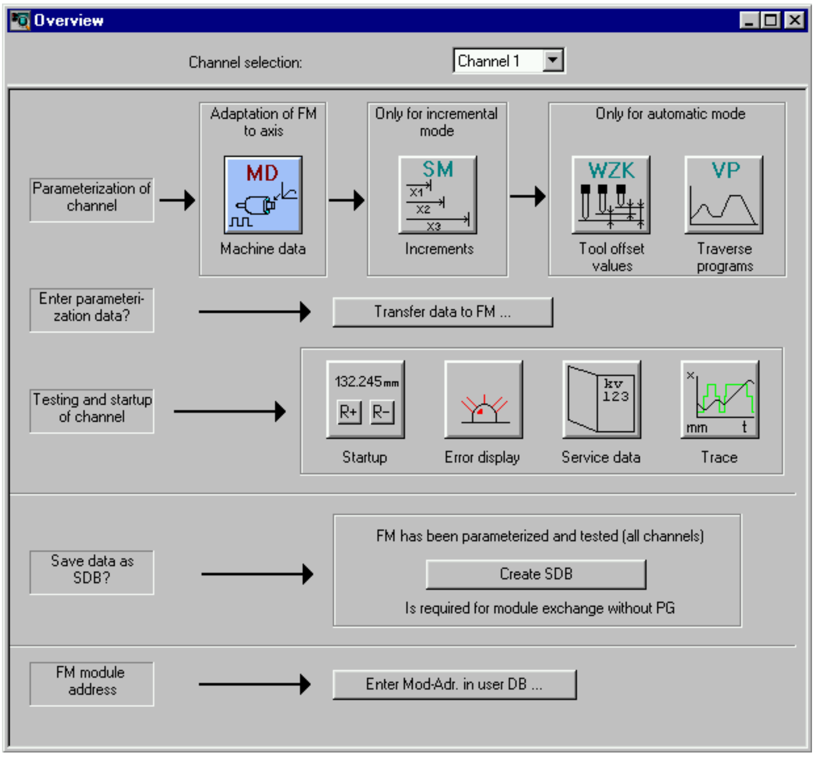


Fig. 5-3 Overview Display for Parameterization

You can return to this display at any point during parameterization by selecting the menu **View > Overview**.

The FM 453 module for universal positioning is parameterized in each channel by way of parameter DBs that reside in memory on the module. Here a key function is performed by the “Machine data” data block (DB-MD), since it is always needed, regardless of what technological function the module performs. All other parameter DBs are only needed as a function of the technology involved.

You can now set the parameters of your module. This chapter gives you an overview of the parameters that can be set.

You can use the mouse to change the size of the window for entering the parameter data and the size of the overview display.

Proceed as follows:

1. Position the mouse pointer on the top border of the window, so that it changes into an arrow.
2. Press the left mouse button, and drag the pointer downwards by moving the mouse.
3. Release the mouse button.
4. Position the mouse pointer on the bar with the name of the window.
5. Press the left mouse button, and drag the pointer upwards by moving the mouse. When you have moved the window to the correct position, release the mouse button.

When you have configured your project, you can call up the **Properties** screen in S7 Configuration by selecting the module and activating the menu command **Edit > Object Properties**.

Integrated Help

The parameterization user interface has an integrated help system to support you when you set the parameters of the positioning module. To call up the integrated help:

- Select the menu command **Help > Help Topics...**or
- press the **F1** key or
- select the symbol  and then move to the element or window you want information about and press the left mouse button.

5.3 Parameter Data

What Can I Parameterize?

You can parameterize the following data storage areas:

- Machine data (MD)
- Increment sizes (SM)
- Tool offset data (TO)
- Traversing programs (NC)
- User data (user data blocks)

This data is stored in data blocks (DBs) within the numerical range (not including user data):

from 1001 to 1239 for channel 1

from 1301 to 1539 for channel 2

from 1601 to 1839 for channel 3

The MD, SM, TO and NC data blocks are transferred to the FM 453 and reside in memory there.

Parameterization of SM, TO and NC may be omitted if the associated functions are not used.

The user data block must be stored in the CPU. Only then can it be filled with data online (see Section 6).

Parameterization data (except for user data) can also be created, edited and saved offline on the PG.

Data blocks (DB) of the FM 453

Table 5-1 gives you an overview of the data blocks in the FM 453 and their meaning.

Table 5-1 Data Blocks of the FM 453

Data Block	Significance
DB-MD	**Machine data** **DB No. = 1205 for channel 1** **DB No. = 1505 for channel 2** **DB No. = 1805 for channel 3** **User memory requirements (channel 1) = 324 bytes** Machine data serves to adapt the FM 453 to the user's own specific application. Parameterization with machine data is essential in order for the FM's functions to be activated for each channel. The parameterized DB-MD should be loaded to the FM. As it is written to the FM 453, the DB-MD is checked for the input limits of the individual values and their interdependencies. It is then stored only if all values are allowed. Otherwise data error messages are displayed by way of the MPI. A defective DB will not be retained when the power is turned off. The machine data can then be activated by way of "Activate machine data" or by switching the equipment on and off.
DB-SM	**Increments** **DB No. = 1230 for channel 1** **DB No. = 1530 for channel 2** **DB No. = 1830 for channel 3** **User memory requirements (channel 1) = 468 bytes** Increments serve in the "Relative incremental" operating mode as user-definable relative path distances for individual positioning. You can define from 1 to 100 increment sizes (see Section 5.3.2). Modifications can be made in all operating modes (even in "Incremental relative" mode) during movement. The modifications of the increments must always be complete before a new movement is started in "Incremental relative" mode. If this is not the case, the error message "incremental dimensions do not exist" is output Cl. 2/No. 13.
DB-TO	**Tool offset data** **DB No. = 1220 for channel 1** **DB No. = 1520 for channel 2** **DB No. = 1820 for channel 3** **User memory requirements (channel 1) = 308 bytes** The use of tool length compensation and wear values is described in Section 10.1. Up to 20 compensation or wear values are available. Tool offset data are required for the "Automatic and Automatic single block" modes. Modifications can be made in all operating modes and during movement. If modifications are made during starting or at block transitions when the tool compensation is active (internal access to offset values), the error message "tool offset value does not exist" is output Cl.3/No.35.

Table 5-1 Data Blocks of the FM 453, continued

Data Block	Significance
DB-NC	**Traversing programs** **Program No. + 1000 = DB No. = 1001...1199 for channel 1** **Program No. + 1300 = DB No. = 1301...1499 for channel 2** **Program No. + 1600 = DB No. = 1601...1799 for channel 2** **User memory requirements (channel 1) = 108 bytes + (20 x number of traversing blocks)** Traversing programs are required for the “Automatic and Automatic single block” modes. • Programs which are not selected can always be modified. • If modifications are made to a preselected program, including the subprogram, preselection of the program is canceled. You must then select the program again. A modification can be made to a program when BL = 0 (program call/end of program) and on Stop.
System data block SDB ≥ 1 000	**For module replacement without programming device** All the parameter data of the FM 453 (DB-MD, DB-SM, DB-WK, DB-NC) are stored in the SDB ≥ 1 000 for channels 1 to 3. This SDB is loaded into the CPU and is used as an additional means of data storage.
DB-SS	**Data block for status messages** **DB No. = 1000 forchannel 1** **DB No. = 1300 for channel 2** **DB No. = 1600 for channel 3** The DB-SS is an internal DB on the FM for testing, start-up and operator control and monitoring.
DB 1249	Internal DB on the FM, not relevant for user.

Data Block Structure

Table 5-2 gives a rough picture of data block structure.

Table 5-2 Data Block Structure

Addresses/ Offset	Contents	Comment
	DB header (36 bytes)	System information, not relevant for user
0 and above	User data area / structure header	Information for labeling of data block within the system
24 and above for MD, otherwise 32	User data	Parameterization data

Detailed data block structures and parameterization data for the individual types of data blocks can be found in the following sections.

5.3.1 Machine Data

DB Structure

Table 5-3 gives you an overview of the structure of the “machine data” data block (DB-MD).

DB No.: 1205 for channel 1

DB No.: 1505 for channel 2

DB No.: 1805 for channel 3

Table 5-3 DB Structure - Machine Data

Address	Variable Type	Value	Significance of the Variables	Comment
			DB header (36 bytes)	
0	WORD		Rack slot	Module address
2	WORD		DB No. (≥ 1000)	As in DB header
4	DWORD		Reserved	
8	WORD		Error No. (from FM)	With MMI services
10	WORD	1	Channel number	
12	2 STRING	MD	DB identifier/type	2 ASCII characters
16	DWORD	453	Module identifier	FM 453
20	4 CHAR	0	Version number/block number	(DB structure)
24 and above...			See machine data list MD5 - MD61	

Note: MD address in DB = (MD no. −5) * 4 + 24

Entering Values

In “Parameterize FM 453” select the menu **File > New > Machine Data** to call up the following display.

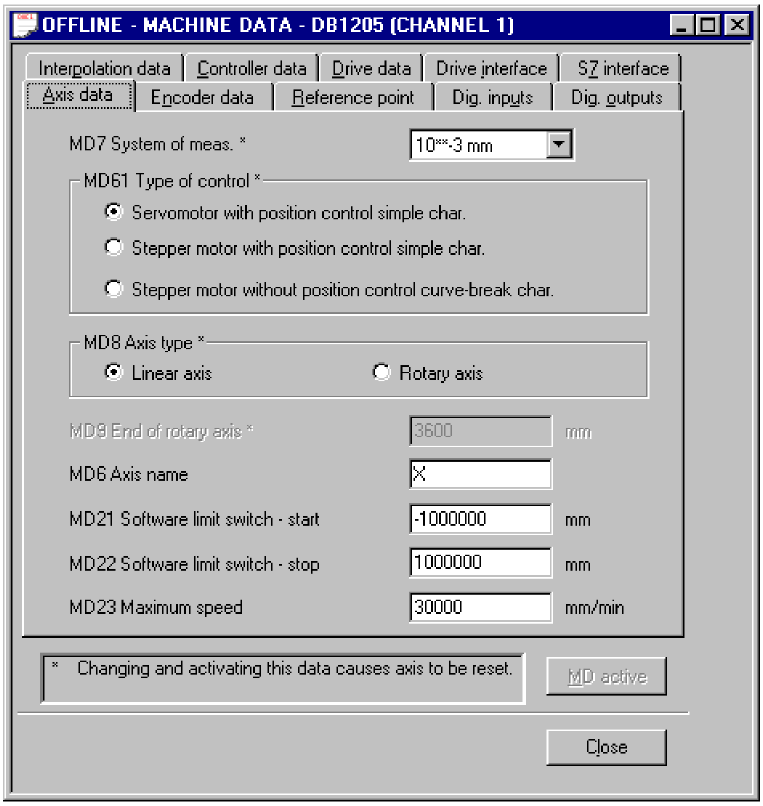


Fig. 5-4 Entering Values for Machine Data

Enter the machine data in the tab windows.

You can also enter your values in a table by selecting **View > Table form**.

When creating the MD DBs you must follow the instructions in Section 7 “Starting up the FM 453”.

Note

The measurement system (MD7) must match the measurement system specified in the other DBs.

The measurement system raster (MSR) is the smallest distance unit in the active system of measurement.

If at some point you have failed to take this precaution:

1. Delete all data blocks of the relevant channel (which do not match the measurement system) or clear the memory of the FM 453 completely.
2. Modify the other data blocks on the programming device.
3. Reload the data blocks to the FM 453.

Machine Data List

All machine data of the FM 453 are listed in Table 5-4.

Notes to the machine data list:

K stands for configuration data: see Section 9.3.3

E stands for user-definable machine data settings for readjustment (startup optimization) and technology; see Section 9.3.3

The units of measurement refer to the value representation in the MD DB.

Table 5-4 Machine Data List

No.	Designation	Default Values	Value/Meaning	Data Type/ Unit/Comments	See Sect.
1 - 4				not assigned	
5 E	Process interrupt generation	0	0 = Position reached 1 = Length measurement completed 3 = Change block on-the-fly 4 = Measurement on-the-fly	BITFIELD32	9.10
6 E	Axis name	X	max. 2 ASCII characters[1)]	4 bytes[3)]	
7 K	System of measurement	1	1 = 10^{-3} mm 2 = 10^{-4} inch 3 = 10^{-4} degrees 4 = 10^{-2} degrees	DWORD	9.4
8 K	Axis type	0	0 = linear axis 1 = rotary axis	DWORD	9.5
9 K	Rotary axis end[2)]	$36 \cdot 10^5$	0...1 000 000 000	DWORD (MSR)	
10 K	Encoder type	1	0 = not present 1 = incremental encoder 3 = absolute encoder (SSI, 13-bit) 4 = absolute encoder (SSI, 25-bit) 5 = absolute encoder (SSI, 21-bit) Fir tree format 6 = absolute encoder (SSI, 25-bit) Fir tree format 13 = absolute encoder (SSI, 13-bit) 14 = absolute encoder (SSI, 25-bit) 15 = absolute encoder (SSI, 21-bit) Fir tree format 16 = absolute encoder (SSI, 25-bit) Fir tree format	DWORD GRAY Code GRAY Code GRAY Code GRAY Code Binary Code Binary Code Binary Code Binary Code	9.6.1 9.6.2
11 K	Travel per motor revolution (division period)[2)]	10 000	1...1 000 000 000	DWORD (MSR) (integer component)	

MSR = Measuring system raster RPS = Reference point switch BMN = Current-sourcing zero
NIX = Zero pulse external PWM = Pulse width modulation

1) The variable axis name is implemented as axis letter (X, Y, Z, 0) with address extension (1 to 9).
Permissible characters: X, Y, Z, A, B, C, U, V, W, Q, E, 1 to 9 e. g.: “X”, “X1”
2) See Dependencies
3) The axis name is in bytes 3 and 4 (bytes 1 and 2 give the character length specification).

Table 5-4 Machine Data List, continued

No.	Designation	Default Values	Value/Meaning	Data Type/ Unit/Comments	See Sect.
12 K	Residual distance per encoder revolution2)	0	0...$2^{32}-1$	DWORD (2^{-32}MSR) (fractional component)	9.6.1 9.6.2
13 K	Increments per encoder revolution (division period)2)	2 500	2^1...2^{25} (for absolute encoder)	DWORD With increm. enc., evaluation takes place at 4 · MD.	9.6.1 9.6.2
14 K	Number of rotations - absolute encoder	0	0/1 = single-turn encoders 2^1...2^{12} for multi-turn encoders	DWORD Only powers of two are allowed.	
15 K	Baud rate - absolute encoder For baud rates which lie between these values, set the next lower baud rate	2	2 = 156 000 3 = 312 000 4 = 625 000 5 = 1 250 000 6 = 2 500 000 (no liability assumed)	DWORD	9.6.1 9.6.2
16 K	Reference-point coordinate	0	−1,000,000,000 ...+1,000,000,000	DINT (MSR)	9.2.3
17 K	Absolute-encoder readjustment	0	0...$2^{25}-1$	DWORD (Encoder grid) absolute encoder	9.6.4
18 K	Type of reference-point approach (reference-point approach direction)	0	0 = Direction +, zero ref. mark right 1 = Direction +, zero ref. mark left 2 = Direction −, zero ref. mark right 3 = Direction −, zero ref. mark left 4 = Direction+, RPS center 5 = Direction −, RPS center 8 = Direction +, RPS edge 9 = Direction −, RPS edge	DWORD Zero reference mark: See zero reference mark selection, Figure 5-5	9.2.3
19 K	Direction adjustment	0	0 = invert direction of measurement (not for sensor type = 0) 1 = invert direction of drive rotation	BITFIELD32	9.7
20 K	Hardware monitoring	0	0 = encoder cable break 1 = error, absolute encoder 2 = pulse monitoring (increm. enc.) 3 = voltage monitoring, encoder 8 = voltage monitoring ± 15 V 9 = voltage monitoring dig. outputs	BITFIELD32	9.6.1 9.6.2

MSR = Measuring system raster RPS = Reference point switch BMN = Current-sourcing zero
NIX = Zero pulse external PWM = Pulse width modulation

1) The variable axis name is implemented as axis letter (X, Y, Z, 0) with address extension (1 to 9). **Permissible characters: X, Y, Z, A, B, C, U, V, W, Q, E, 1 to 9 e. g.: “X”, “X1”**
2) See Dependencies
3) The axis name is in bytes 3 and 4 (bytes 1 and 2 give the character length specification).

Table 5-4 Machine Data List, continued

No.	Designation	Default Values	Value/Meaning	Data Type/ Unit/Comments	See Sect.
21 E	Software limit switch, beginning[2)]	-10^9	–1 000 000 000...1 000 000 000	DINT (MSR)	9.7 9.9
22 E	Software limit switch - end[2)]	10^9	–1 000 000 000...1 000 000 000		
23 E	Maximum speed	$30 \cdot 10^6$	10 ...500 000 000	DWORD (MSR/min)	9.7
24 E	Target range (position reached, stop)	1 000	0...1 000 000	DWORD (MSR)	
25 E	Monitoring time	0	0 = no monitoring 1 to 65535	DWORD (ms) rounded up to equate to the FM cycle	
26 E	Stationary range	10^4	1...1,000,000	DWORD (MSR)	
27 E	Reference-point shift	0	–1,000,000,000... +1,000,000,000	DINT (MSR)	9.2.3
28 E	Referencing velocity[2)]	$6 \cdot 10^6$	10...500 000 000	DWORD (MSR/min)	
29 E	Reducing velocity[2)]	$3 \cdot 10^6$	10...500 000 000		
30 E	Backlash compens.	0	0 to 1,000,000	DINT (MSR)	9.7
31 E	Directional reference of backlash	0	0 = as in search for reference (not for absolute encoders) 1 = positive 2 = negative	DWORD	

MSR = Measuring system raster RPS = Reference point switch BMN = Current-sourcing zero
NIX = Zero pulse external PWM = Pulse width modulation

1) The variable axis name is implemented as axis letter (X, Y, Z, 0) with address extension (1 to 9).
Permissible characters: X, Y, Z, A, B, C, U, V, W, Q, E, 1 to 9 e. g.: “X”, “X1”
2) See Dependencies
3) The axis name is in bytes 3 and 4 (bytes 1 and 2 give the character length specification).

Table 5-4 Machine Data List, continued

No.	Designation	Default Values	Value/Meaning	Data Type/ Unit/Comments	See Sect.
32 K	Type of output M-function	1	**during positioning:** 1 = time-controlled 2 = acknowledgment-controlled **before positioning:** 3 = time-controlled 4 = acknowledgment-controlled **after positioning:** 5 = time-controlled 6 = acknowledgment-controlled	DWORD serial output of up to 3 M functions in NC block	10.3 9.1
33 K	Output time M-function	10	1...100,000	DWORD (ms) rounded up to equate to the FM cycle	
34 K	Digital inputs[2]	0	0 = external start 1 = input for enable 2 = external block change 3 = set actual value on-the-fly 4 = measure 5 = RPS for search for reference 6 = reversing switch for search for reference	BITFIELD32 bit-coded function allocation: Bit No. I/O 0 Bit No. + 8 I/O 1 Bit No. + 16 I/O 2 Bit No. + 24 I/O 3 Front edge always activates the function	9.2.3 9.8
35 K	Digital outputs[2]	0	0 = Position reached, stop 1 = Axis movement forward 2 = Axis movement reverse 3 = Change M97 4 = Change M98 5 = Enable Start 7 = Direct output		9.8
36 K	Input adjustment (signal processing inverted)	0	8 = I0 inverted 9 = I1 inverted 10 = I2 inverted 11 = I3 inverted	BITFIELD32	9.8

MSR = Measuring system raster RPS = Reference point switch BMN = Current-sourcing zero
NIX = Zero pulse external PWM = Pulse width modulation

1) The variable axis name is implemented as axis letter (X, Y, Z, 0) with address extension (1 to 9).
Permissible characters: X, Y, Z, A, B, C, U, V, W, Q, E, 1 to 9 e. g.: "X", "X1"
2) See Dependencies
3) The axis name is in bytes 3 and 4 (bytes 1 and 2 give the character length specification).

Table 5-4 Machine Data List, continued

No.	Designation	Default Values	Value/Meaning	Data Type/ Unit/Comments	See Sect.
37 K	Control signals	1	0 = Controller enable active 2 = Controller ready active 3 = Controller ready inverted 4 = Controller ready via connector X5 (if Bits 24...27 active) 7 = Time override active 15 = Continue running after emergency stop (drive enable [AF]) 16 = autom. drift compens. active 17 = Boost active 18 = PWM active 19 = Boost/PWM inverted 24 = BMN active 25 = BMN inverted 26 = NIX active 27 = NIX inverted	BITFIELD32	9.7 9.1.1
38 E	Positioning loop amplification	1 000	1...10,000	DWORD ((MSR/min)/MSR)	9.7
39 E	Minimum following error, dynamic	0	0 = no monitoring 1...1 000 000	DWORD (MSR)	9.7
40 E	Acceleration	1 000	0 = without ramp 1...100,000	DWORD (10^3MSR/s^2)	9.7
41 E	Deceleration	1 000			
42 E	Jolt time	0	0...10,000	DWORD (ms)	9.7
43 E	Set voltage, max.	8 000	1,000...10,000	DWORD (mV)	9.7
44 E	Offset compensation	0	–5 000 ...+5 000	DINT (mV)	9.7
45 E	Actuating signal ramp	0	0...10 000 000 voltage ramp if MD61 = 0 frequency ramp if MD61 = 1, 7	DWORD [mV/s] [Hz/s]	9.7
46 E	Minimum idle time between two positioning cycles	2	1...10,000	DWORD [ms] rounded up to equate to FM cycle	9.7
47 E	Minimum traversing time at constant frequency	2			
48 E	Boost duration, absolute	100	1...1,000,000		9.7
49 E	Boost duration, rel.	100	1...100	DWORD [%]	9.7
50 E	Phase current travel	100			
51 E	Phase current idle[2)]	100			

MSR = Measuring system raster RPS = Reference point switch BMN = Current-sourcing zero
NIX = Zero pulse external PWM = Pulse width modulation

1) The variable axis name is implemented as axis letter (X, Y, Z, 0) with address extension (1 to 9).
Permissible characters: X, Y, Z, A, B, C, U, V, W, Q, E, 1 to 9 e. g.: "X", "X1"

2) See Dependencies

3) The axis name is in bytes 3 and 4 (bytes 1 and 2 give the character length specification).

Table 5-4 Machine Data List, continued

No.	Designation	Default Values	Value/Meaning	Data Type/ Unit/Comments	See Sect.
52 K	Increments per motor revolution[2)]	1 000	0 = not a stepper motor 4...10 000		9.7
53 K	Increment number per current-sourcing cycle	20	0...400	DWORD	9.7
54 E	Start/Stop frequ.	1 000	10...100 000	DWORD [Hz]	9.7
55 E	Frequency value for acceleration switchover[2)]	10 000	10...1 000 000 Minimum value: MD54 + 1 Maximum value: MD56 – 1		9.7
56 E	Maximum frequ.[2)]	50 000	500...1 000 000		9.7
57 E	Acceleration 1[2)]	100 000	10...10,000,000	DWORD [Hz/sec]	9.7
58 E	Acceleration 2[2)]	100 000	10...MD57, 0 as with MD57		9.7
59 E	Delay 1[2)]	100 000	10...10,000,000, 0 = as with MD57		9.7
60 E	Delay 2[2)]	100 000	10...MD59, 0 as with MD58		9.7
61 K	Control mode **Note:** MD can be activated only by power ON/OFF	0	0 = Servomotor with servo position control – simple characteristic 1 = Stepper motor with servo position control – simple characteristic 7 = Stepper motor without servo position control – stepped charact.	DWORD	9.7
65E	Speed for backlash compensation	0	0 1...100	DWORD [%]	9.7
66E	Mode for backlash compensation	0	0 = before positioning 1 = during positioning	DWORD	9.7

MSR = Measuring system raster RPS = Reference point switch BMN = Current-sourcing zero
NIX = Zero pulse external PWM = Pulse width modulation

1) The variable axis name is implemented as axis letter (X, Y, Z, 0) with address extension (1 to 9).
Permissible characters: X, Y, Z, A, B, C, U, V, W, Q, E, 1 to 9 e. g.: “X”, “X1”
2) See Dependencies
3) The axis name is in bytes 3 and 4 (bytes 1 and 2 give the character length specification).

Table 5-4 Machine Data List, continued

No.	Designation	Default Values	Value/Meaning	Data Type/ Unit/Comments	See Sect.
67E	Standstill speed	0	0 Automatic zero-speed monitoring 1...1 000 000 zero-speed monitoring detection if standstill speed falls below setpoint	– [MSR/min]	7.3.15
68E	TimeOut time for zero-speed monitoring	0	0 No TimeOut monitoring at zero–speed detection 1...100 000 Enforced zero-speed detection after the TimeOut time has elapsed	– [ms]	7.3.15
69 E	Response time for the standard diagnosis (10 V limiting)	0	0 Standard diagnosis without delay 1...10000 Response time for the standard diagnosis (effective at 3 ms interval, rounded up) > 10000 Parameterization tool error message: 0x055B MD69	[ms]	7.3.16
70 E	Function enable fürfor the response time in MD69	0	101 Function enable for the response time in MD69 Remaining values: No function enable for the response time in MD69	Code	

MSR = Measuring system raster RPS = Reference point switch BMN = Current-sourcing zero
NIX = Zero pulse external PWM = Pulse width modulation

1) The variable axis name is implemented as axis letter (X, Y, Z, 0) with address extension (1 to 9).
Permissible characters: X, Y, Z, A, B, C, U, V, W, Q, E, 1 to 9 e. g.: "X", "X1"
2) See Dependencies
3) The axis name is in bytes 3 and 4 (bytes 1 and 2 give the character length specification).

Dependencies

With certain combinations of machine data, restrictions in the value range arise for non-processing of the machine data.

These dependencies are verified on acceptance of the MD DB or individual machine data, and an error message is output in the event of a violation. Some checks are performed on the basis of internally calculated reference variables.

These reference variables and the dependency checks are described in the tables below.

Reference variables generated internally from MD:

Generation of travel per encoder revolution **UMWEG**

UMWEG = MD11 + MD12 $\cdot$ 2^{-32}

Generation of internal measured value factor

MD10	MD61	Measured Value Factor
0	0	MWFAKTOR = 1
	1, 7	MWFAKTOR = UMWEG / MD52
1	–	MWFAKTOR = UMWEG / (4 $\cdot$ MD13)
3, 4, 5, 6, 13, 14, 15, 16	–	MWFAKTOR = UMWEG / MD13

Generation of minimum acceleration for stepper motor **SMAMIN**

MD61	SMAMIN
0	as required, not used in checks
1, 7	SMAMIN = 1000 $\cdot$ MD52 / UMWEG

Activation of software limit switches **SEAKT**

MD21	MD22	SEAKT
$= -10^9$	$= +10^9$	0 (inactive)
$\neq -10^9$	$= +10^9$	1 (active)
$= -10^9$	$\neq +10^9$	
$\neq -10^9$	$\neq +10^9$	

Internal generation of absolute traversing range limits **VFBABS**

MWFAKTOR	VFBABS
< 1	$10^9 \cdot$ MWFAKTOR
≥ 1	10^9 /

Checks for servo motor and stepper motor:

MD9 check

<table>
<tr><th>MD8</th><th>MD10</th><th>MD61</th><th colspan="2">Permissible Rotary Axis End</th></tr>
<tr><td>0</td><td>–</td><td>–</td><td colspan="2">any, not used</td></tr>
<tr><td rowspan="6">1</td><td rowspan="2">0</td><td>0</td><td>–</td><td rowspan="6">(MD23/60 000) · Sampling time ≤ MD9 ≤ VFBABS</td></tr>
<tr><td>1, 7</td><td rowspan="3">Note additional interdependency with MD18!</td></tr>
<tr><td rowspan="2">1</td><td>1, 7</td></tr>
<tr><td>0</td></tr>
<tr><td>3, 13</td><td>–</td><td>UMWEG mod MD9 == 0</td></tr>
<tr><td>4, 5, 6, 14, 15, 16</td><td>–</td><td>(MD14 · UMWEG) mod MD9 == 0 1)</td></tr>
<tr><td colspan="3" rowspan="3">Additional interdependency with MD18</td><td>MD18</td><td>Permissible Rotary Axis End</td></tr>
<tr><td>≥ 4</td><td>–</td></tr>
<tr><td>< 4</td><td>MD9 mod UMWEG == 0</td></tr>
</table>

1) MD9 is the ratio of a power of 2^x or 2^{-x} to the absolute value range of the encoder (see Section 9.6.2)

Note: A sampling time of 3 ms is assumed

MD11, MD12, MD13 check → results in MWFAKTOR (see above)

Permissible measured value factor range: 2^{-14} < MWFAKTOR < 2^{14}

MD13 check

MD10	Increments per Encoder Revolution	
0, 1	–	
3, 4, 13, 14	2^x	x = 1, 2, 3, ...
5, 15	2^x	x = 1 ... 12
6, 16	2^x	x = 1 ... 13

MD14 check

MD10	No. of Revolutions	
0, 1, 3, 13	–	
4, 14	2^x	x = 1, 2, 3, ...
5, 15	2^x	x = 1 ... 9
6, 16	2^x	x = 1 ... 12

MD21, MD22 check (Part 1)

SEAKT	MD8	Permissible Software Limit Switches
0	–	MD21 = -10^9, MD22 = $+10^9$
1	0	MD21 ≥ –VFBABS MD22 ≤ VFBABS MD21 < MD22
	1	0 ≤ MD21 < MD9 0 ≤ MD22 < MD9 MD21 ≠ MD22

MD21, MD22 check (Part 2)

SEAKT	MD10	Permissible Software Limit Switches
0	–	MD21 = -10^9, MD22 = $+10^9$
1	0, 1	–
	3, 13	MD22–MD21 ≤ UMWEG
	4, 5, 6, 14, 15, 16	MD22–MD21 ≤ MD14 · UMWEG

MD28 check

Permissible Velocity	10 ≤ MD28 ≤ MD23

MD29 check

MD10	Permissible Velocity
3, 4, 5, 6, 13, 14, 15, 16	any, not used
0, 1	10 ≤ MD29 ≤ MD23

MD31 check

MD30	MD10	Permissible Directional Reference of Backlash
0		–
≠ 0	0, 1	
	3, 4, 5, 6, 13, 14, 15, 16	1, 2

MD34 check

Permissible: BYTE0(MD34) ≠ BYTE1(MD34) ≠ BYTE2(MD34) ≠ BYTE3(MD34)

MD35 check

Permissible: BYTE0(MD35)&0x7F ≠ BYTE1(MD35)&0x7F ≠ BYTE2(MD35)&0x7F ≠ BYTE3(MD35)&0x7F

Checks for stepper motor only (MD61.0 == 1):

MD52 check (checked via input limit)

Permissible increment number:4 ≤ MD52

Permissible increment evaluation factor:	2^{-14} < UMWEG/MD52 < 2^{14}

MD53 check

MD53	Permissible Increment Number Per Current-Sourcing Cycle
0	
≠ 0	MD53 ≥ 4

MD55 check

Permissible frequency:	MD54 ≤ MD55 ≤ MD56

MD56 check

Permissible frequency:	MD23/MWFAKTOR/60 ≤ MD56 ≤ $MD23_{max}$/MWFAKTOR/60

MD57 check

Permissible Acceleration:	MD57 ≥ SMAMIN

MD58 check

MD58	Permissible Acceleration
0	
≠ 0	SMAMIN ≤ MD58 ≤ MD57

MD59 check

MD59	Permissible Acceleration
0	
≠ 0	SMAMIN ≤ MD59

MD60 check

MD60	MD59	Permissible Acceleration
0		
≠ 0	0	SMAMIN ≤ MD60 ≤ MD57
	≠ 0	SMAMIN ≤ MD60 ≤ MD59

MD66 check

MD66	MD61	Permissible MD65
0	0, 1	0 to 100
	7	0 to (MD56 · MWFAKTOR · 60) · 10 / MD23
1	0	MD65 < (10 V – MD43 [V]) · 100 / 10 V
	1	MD65 < (MD56 – MD23FREQ) · 100 / MD23FREQ
	7	MD65 < (MD54 – MD23FREQ) · 100 / MD23FREQ (The first % increment that exceeds the absolute value of MD54 is permissible, but takes effect on a rounded-off version of MD54)

Zero Reference Mark

Figure 5-5 shows the relationship between the zero reference mark in your application and the relevant machine data.

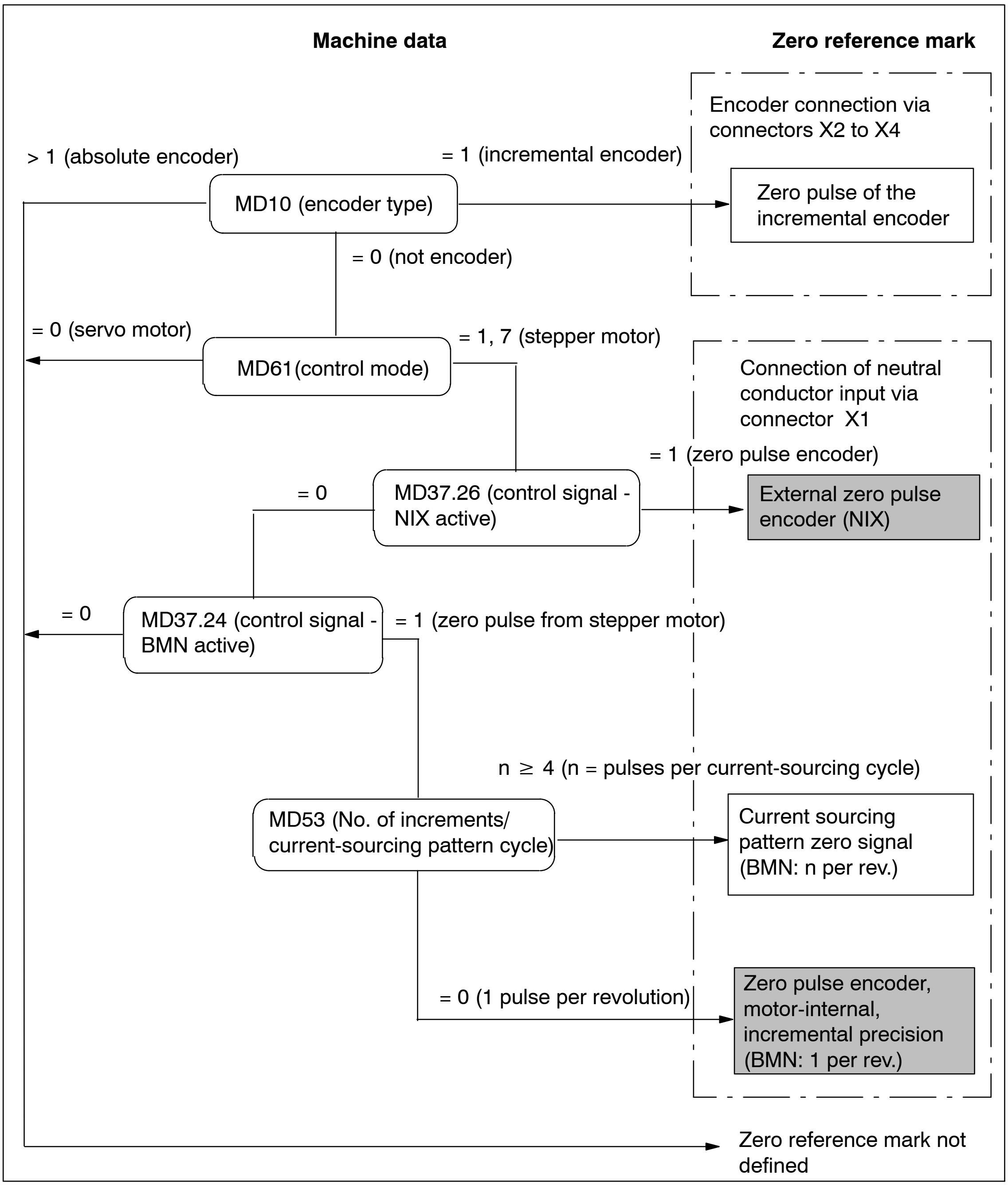


Fig. 5-5 Zero Reference Mark Selection

Note

In the case of the zero mark variants that are marked with a grey background, the “Rotation monitoring” function can be used.

5.3.2 Increments

DB Structure

Table 5-5 gives you a general view of the structure of the "Increments" data block (DB-SM).

DB No.: 1230 for channel 1
DB No.: 1530 for channel 2
DB No.: 1830 for channel 3

Table 5-5 DB Structure – Increments

Address	Variable Type	Value	Significance of the Variables	Comment
			DB header (36 Byte)	
0	WORD		Rack slot	Module address
2	WORD		DB No. (≥ 1000)	As in DB header
4	DWORD		Reserved	
8	WORD		Error No. (from FM)	With MMI services
10	WORD	1	Channel number	
12	2 STRING	SM	DB identifier/type	2 ASCII characters
16	DWORD	453	Module identifier	FM 453
20	4 CHAR	0	Version number/block number	(DB structure)
24	DWORD	1 – 3	Measurement-system grid per MD7	Unit of measurement
28	WORD	0/1	Parameter (DB) backup	Job via MMI
30	WORD		Reserved	
32	DWORD	0 – 10^9	Increment 1	
36	DWORD	0 – 10^9	Increment 2 to increment 100	see Section 9.2.4

Input of Values

Values are input in the increments menu of the "Parameterize FM 453" tool.

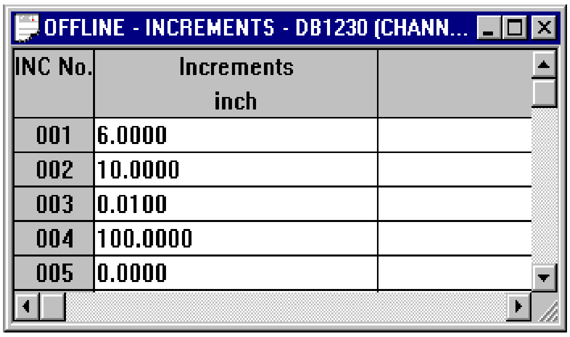


Fig. 5-6 Entering Values for Incremental Dimensions

5.3.3 Tool Offset Data

DB Structure

Table 5-6 gives you a general view of the structure of the “tool offset data” data block (DB-WK).

DB No.: 1220 for channel 1

DB No.: 1520 for channel 2

DB No.: 1820 for channel 3

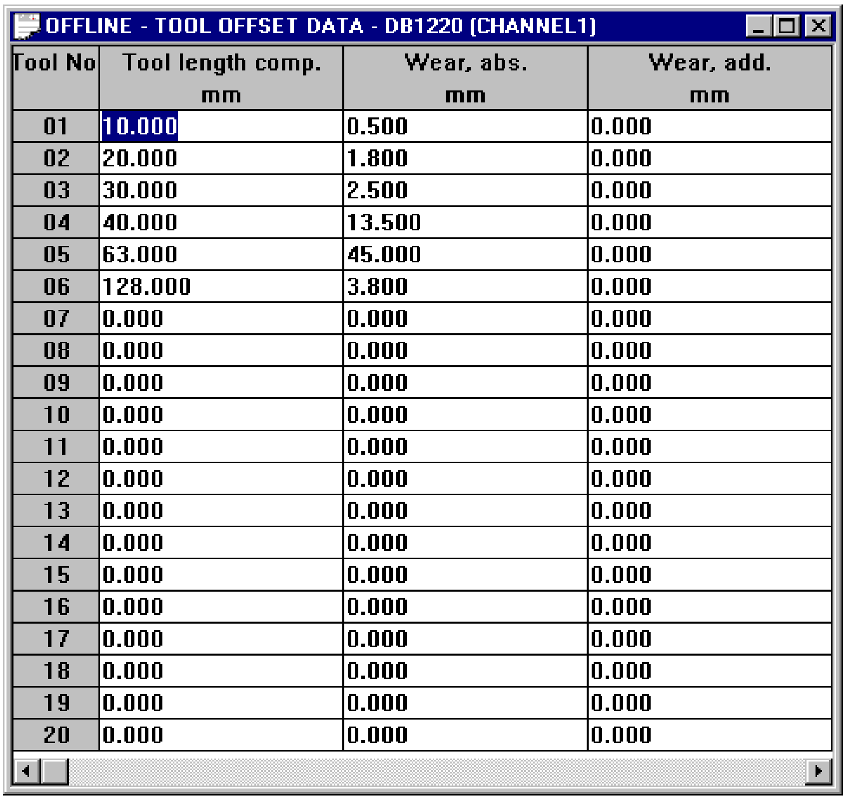
Table 5-6 DB Structure – Tool Offset Data

Address	Variable Type	Value	Significance of the Variables	Comment
			DB header (36 bytes)	
0	WORD		Rack slot	Module address
2	WORD		DB No. (≥ 1000)	As in DB header
4	DWORD		Reserved	
8	WORD		Error No. (from FM)	With MMI services
10	WORD	1	Channel number	
12	2 STRING	TO	DB identifier/type	2 ASCII characters
16	DWORD	453	Module identifier	FM 453
20	4 CHAR	0	Version number/block number	(DB structure)
24	DWORD	1 – 3	Measurement-system grid per MD7	Unit of measurement
28	WORD	0/1	Parameter (DB) backup	Job via MMI
30	WORD		Reserved	
32	DINT DINT DINT	-10^9 – 10^9 -10^9 – 10^9 -10^9 – 10^9	Tool length offset 1 Wear value 1 absolute Wear value 1 additive	Tool 1 see Section 10.1
44	DINT DINT DINT	$-10^9...10^9$ $-10^9...10^9$ $-10^9...10^9$	Tool length offset 2 Wear value 2 absolute Wear value 2 additive to Tool length offset 20 Wear value 20 absolute Wear value 20 additive	Tool 2 to Tool 20 see Section 10.1

Input of Values

Values are input in the tool offset data menu of the “Parameterize FM 453” parameterization tool.

If the additive wear value is changed online, the FM calculates the new wear parameter as an absolute value and the additive tool wear is reset to 0.



OFFLINE - TOOL OFFSET DATA - DB1220 (CHANNEL1)

Tool No	Tool length comp. mm	Wear, abs. mm	Wear, add. mm
01	10.000	0.500	0.000
02	20.000	1.800	0.000
03	30.000	2.500	0.000
04	40.000	13.500	0.000
05	63.000	45.000	0.000
06	128.000	3.800	0.000
07	0.000	0.000	0.000
08	0.000	0.000	0.000
09	0.000	0.000	0.000
10	0.000	0.000	0.000
11	0.000	0.000	0.000
12	0.000	0.000	0.000
13	0.000	0.000	0.000
14	0.000	0.000	0.000
15	0.000	0.000	0.000
16	0.000	0.000	0.000
17	0.000	0.000	0.000
18	0.000	0.000	0.000
19	0.000	0.000	0.000
20	0.000	0.000	0.000

Fig. 5-7 Entering Values for Tool Offset Data

5.3.4 Traversing Programs

DB Structure

Table 5-7 gives you a general view of the structure of the “traversing programs” data block (DB-NC).

DB No.: 1001...1199 for channel 1

DB No.: 1301...1499 for channel 2

DB No.: 1601...1799 for channel 3

Table 5-7 DB Structure – Traversing Programs

Address	Variable Type	Value	Significance of the Variables	Comment
			DB header (36 bytes)	
0	WORD		Rack slot	Module address
2	WORD		DB No. (≥ 1000)	As in DB header
4	DWORD		Reserved	
8	WORD		Error No. (from FM)	With MMI services
10	WORD	1	Channel number	
12	2 STRING	NC	DB identifier/type	2 ASCII characters
16	DWORD	453	Module identifier	FM 453
20	4 CHAR	0	Version number/block number	(DB structure)
24	DWORD	1 – 3	Measurement-system grid per MD7	Unit of measurement
28	WORD		Reserved	
30	WORD		Reserved	
32	18 STRING	ASCII char.	NC program name	max. 18 characters
52	STRUCT	NC block	NC block new (modification range)	
72	STRUCT	NC block	1st traversing block	
92	STRUCT	NC block	2nd to 100th traversing block	see Sections 9.3.12, 10.1

Input of Traversing Programs

An empty window is provided for the input of NC traversing programs . Here you can input your traversing program as follows:

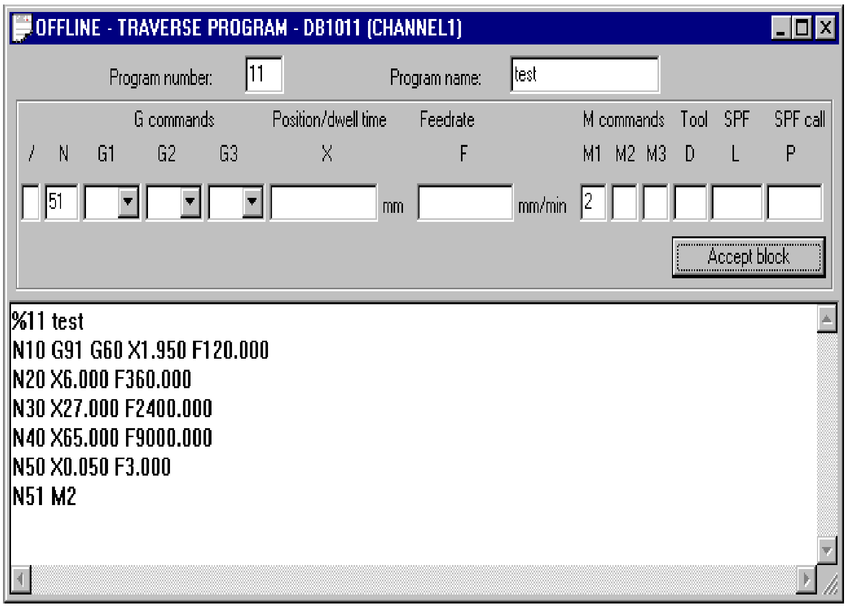


Fig. 5-8 Entry for Traversing Programs

1. % Program number Program name

   The “%” can be input only in the first line. This input is mandatory. The DB number is formed from the program number.

   The program name is optional and may have up to 18 characters.

2. N<block number> – G<command> (G1, G2, G3) – X<value> – F<value> – M<command> (M1, M2, M3) – D<No.> (tool offset number) – L<No.> – P<No.> – (for NC programming, see Chapter 10).

   – You must enter the block number (N) **first and in ascending order**. The rest of the inputs may be in any desired sequence.

   – Input separators as a blank.

You must enter characters in upper case letters.

You can also use the guided input area at the top of the screen. The program number and the program name are saved when you exit the input box. You can save the traversing blocks with the “Save Block” button.

5.4 Parameterization with “Parameterize FM 453”

Entering the Values

You have a variety of options for entering your parameterization data.

1. User data

   You can input values or select texts in a table. Select input fields with the cursor and enter the values. You can select the associated texts for the values with the space key.

2. Machine data

   The values are entered in dialog boxes and windows selected by option tabs.

   To display the machine data in a table, select the menu **View > Table form**. Here you can enter the values as described in the user data section.

3. Tool compensation data and increment sizes

   You can input the values in a table. Select input fields with the cursor and enter the values.

4. Traversing programs

   Traversing programs are input in text format.

A comment column is included in the tables for MD, SM, and TO values. This comment is not stored in the data block. It can be printed out or stored with the data in the file on export.

5.5 Storing the Parameter Data in SDB >= 1 000

Overview

The FM 453 stores its parameter data internally.

In order to ensure that the parameter data are available if there is a fault on the FM 453 and no programming device/PC is at hand, the data can be stored in a system data block in the CPU (SDB ≥ 1 000). The CPU transfers the data stored in SDB ≥ 1 000 to the FM 453 on each new start.
If the FM 453 has no machine data or the internal time stamp (time of creation) is invalid, the data are transferred from SDB ≥ 1 000 to the FM 453 and saved there.

The time stamp is renewed every time a DB (parameter initialization data) is opened and when a file is imported. If the contents of the DB are modified (for instance the machine data), a new time stamp is also generated when the DB is saved or loaded.

You must ensure that the parameter data in SDB ≥ 1 000 always match the parameter data on the FM 453 when start-up is complete.

Note

If parameter initialization data are modified again in the FM following creation of SDB ≥ 1000, they are overwritten when the CPU is restarted (see “Time stamp”, above).

SDB ≥ 1 000 should not be created until start-up is finished.

If you need to modify the data subsequently, you should generate SDB ≥ 1 000 again and load it into the CPU. You can delete the previous SDB before you load the new one, however the new SDB automatically overwrites the old one when it is generated. The old SDB and the new SDB do not have to be allocated the same number.

Creating the SDB

Prerequisite: Online connection with the FM 453

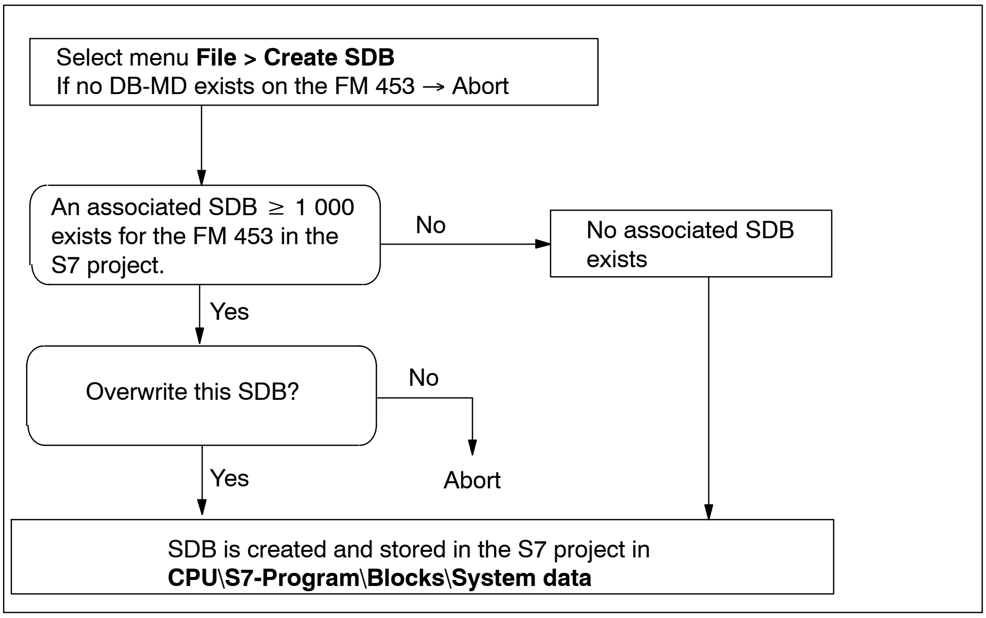


Fig. 5-9 Creating SDB ≥ 1 000

Display/Delete SDB in the S7 Project

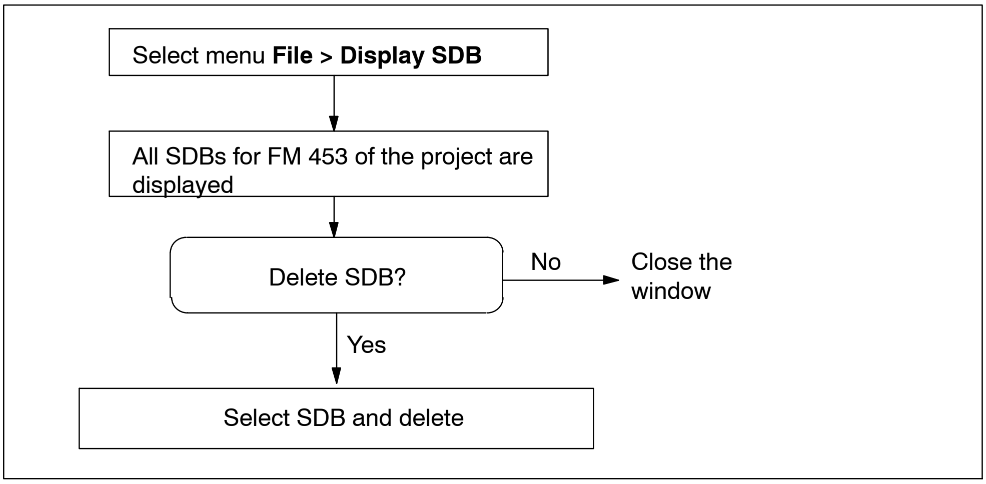


Fig. 5-10 Displaying/Deleting SDB ≥ 1 000

Loading the SDB in the CPU

When you have created the SDB, you must load the “system data” of the project into the CPU.

There are two ways of proceeding:

1. First method

   Select the online window in the *SIMATIC Manager* (the online and offline windows must be open)

   Copy the system data from the offline project in **CPU\S7-Program\Blocks\System data** into the online project (drag with the mouse or select Copy/Paste).

2. Second method

   Select the system data in the *SIMATIC Manager* in **CPU\S7-Program\Blocks\System data**.

   Activate the menu **Target system > Load** (or the right mouse button) to load the system data into the CPU

   or

   Use the menu **Target system > Load in EPROM memory card on CPU**

You can also program the memory card for the CPU on a programming device/PC.

If the configuration is loaded from HW-CONFIG, this SDB is **not** loaded into the CPU.

Deleting SDBs in the CPU

To delete the SDBs in the CPU:

1. Select “Parameterize FM 453”.
2. Select menu **File > Display SDB**. Delete the SDB(s).
3. Close “Parameterize FM 453” and in the *SIMATIC Manager* in Online Project select **CPU\S7-Program\System data**. Delete the system data.
4. Transfer the system data to the CPU again (see above)

Programming the Technological Functions 6

Chapter Overview

General remarks

The purpose of the function description of the blocks and of the interface is to illustrate communications between the CPU and the FM 453 in the SIMATIC S7 programmable controller. The programmable blocks and the AW-DB (which is the interface to the FM 453) make it possible for you to write your user program to suit your particular application.

Note

This description applies to only one channel/axis; the process must be repeated for each additional channel/axis.

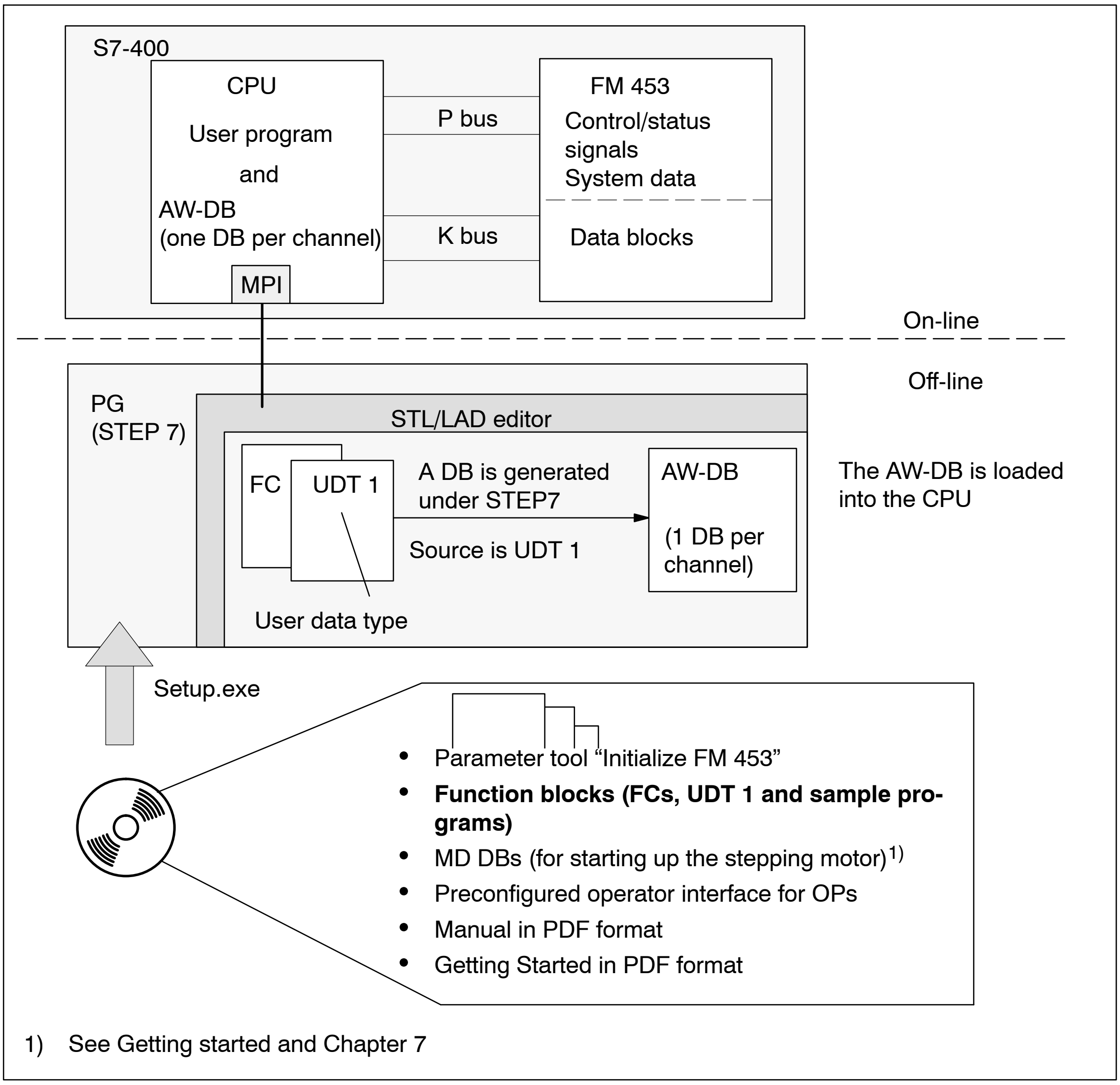


Fig. 6-1 Programming Overview

Prerequisites

The following prerequisites must be fulfilled for the development of your user program if you want to control the FM 453:

- You must have installed the software on the PG/PC as per Section 5.1.

  The block library containing the basic functions is normally stored in directory **[STEP7 directory]\S7LIBS\FMSTSV_L**.

- The link from PG/PC to the S7 CPU must be established Figures 4-1 to 4-2).
- You must have already created your project for the SIMATIC S7 (see "FM 453, First Steps").

6.1 Programming Fundamentals

Overview

In this chapter you will find information on the following:

- Section 6.1.1, Page 6-3: Interface, user data blocks (AW-DBs)
- Section 6.1.2, Page 6-5: : Standard function blocks, overview
- Section 6.1.3, Page 6-6: Communication between CPU and FM 453
- Section 6.4, Page 6-27: Interrupts
- Section 6.1.4, Page 6-7: Structure of a user program
- Section 6.1.5, Page 6-8: Insert-/remove-module interrupt
- Section 6.1.6, Page 6-8: Rack failure
- Section 6.1.7, Page 6-8: Connecting an OP
- Section 6.1.8, Page 6-9: Procedures for writing a user program (AWP)

6.1.1 Interface, User Data Blocks (AW-DBs)

The AW-DB (interface) is created off-line.

The user can access the signals and/or data on the interface using absolute or symbolic addresses (creation of the AW-DB with UDT structure).

The interface is allocated to the relevant channel via the input parameters of the DB_NO standard function blocks. The module address is part of the user DB. It is entered by the POS_INIT block or manually via ”Parameterize FC 453” using the ”Enter Mod-Adr in user DB” button in the main screen). The user DB must already exist.

Creating the AW-DB

Proceed as follows:

1. Open your project and select **SIMATIC xxx > CPUxxx > S7 Program > Blocks**.
2. The data block (for example DB 1) is generated under STEP 7 with the menu command **Insert > S7 Block > Data Block**.
3. The LAD/STL/FBD editor is started by double-clicking on this data block.
4. In the “New data block” dialog, select “Data block with assigned user-specific data type”.
5. UDT 1 is displayed.

   UDT 1 contains the structure of the AW-DB.
6. Select UDT 1 and confirm with **OK**.
7. You have now created the AW-DB.
8. Save this AW-DB with **File > Save**.
9. Close the editor.

Information about symbolic programming

Normally, the blocks are entered in the symbol table with the symbol name, address, and data type (the symbol table is supplied in the project and in the library). If you change the block number in your project with the SIMATIC Manager, the numbering in the symbol table must also be changed. Block allocation via the symbol table is always absolutely unique.

Before writing and compiling your user program, you must enter the blocks (AW-DBs, FCs) which you are using for your particular configuration in the symbol table. The symbolic structure of the interface is stored in the UDT block provided. The symbolic relationship is established via your STEP 7 project, the symbol table, and the UDT block.

Appendix C shows the UDT with symbols and absolute address.

Sample symbol table.

Symbol	Address	Data Type	Comments
DB_FM1	DB 1	UDT 1	AW-DB for FM 453, channel 1
POS_INIT	FC 0	FC 0	Initialization, channel 1
POS_CTRL	FC 1	FC 1	Data interchange, channel 1
DB_FM2	DB 2	UDT 1	AW-DB for FM 453, channel 2

6.1.2 Standard Function Blocks, Overview

The Table below provides an overview of the fucntion calls (FC), data blocks (DB) and organization blocks (OB) required for communication with and control of the FM 453.

Table 6-1 Standard Function Blocks for the FM 453 (overview)

Block	Block Name	Description/Function	Remarks
FC 0 Page 6-11	POS_INIT	Call in OB 100 and OB 83, start-up/initialization	Required for application, no. can be changed 1)
FC 1 Page 6-13	POS_CTRL	Call in OB 1, cyclic operation (synchronization with FM 453) Basic functions and operating modes, interface processing, read and write requests	
FC 2 Page 6-23	POS_DIAG	Call in OB 82, internal errors, external errors, and external channel errors on the FM	
FC 3 Page 6-26	POS_MSRM	ACall in OB 40 or OB 1, measured value readout	To be used only if function is required for the application, no. can be changed 1)
DB (UDT)	AW-DB	Interface to the FM	Required for application
OB 1	–	Cyclic level	Required for application
OB 82	–	Diagnostic interrupt level	
OB 100	–	Start-up level	
OB 83	–	Remove-/insert-module interrupt	Required for FM removal / insertion / rack failure
OB 86	–	Rack failure	
OB 122	–	I/O access error	

1) – Block number can be changed in the SIMATIC Manager
– Symbol table entries can be changed in conjunction with symbolic programming only

---

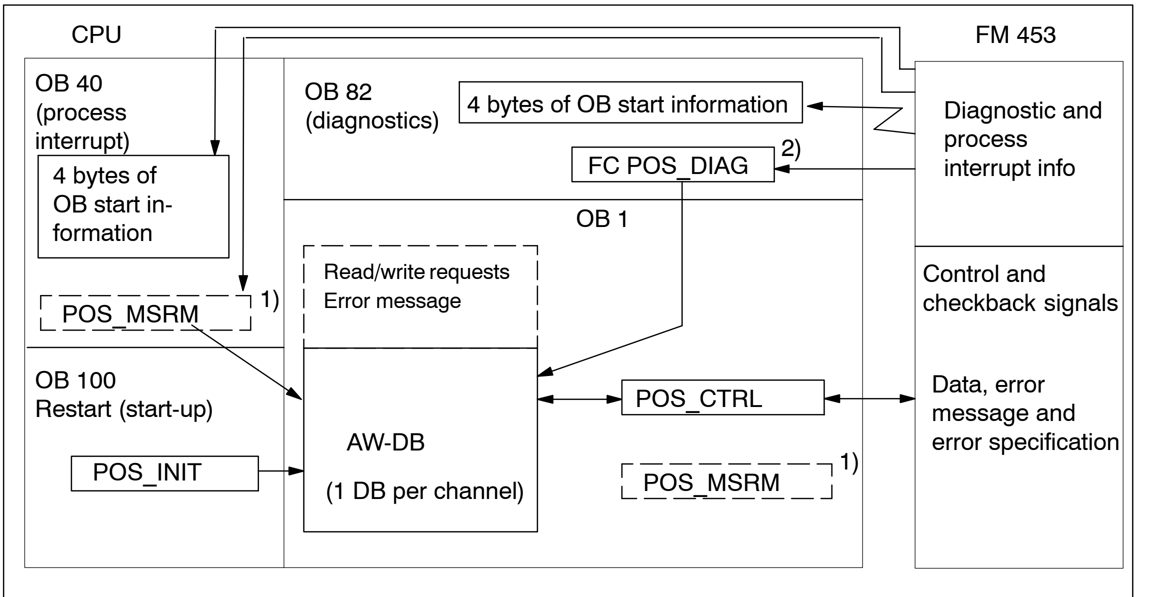
Note

The symbolic block identifier is used from here on.

6.1.3 Communication between the CPU and the FM 453

Linking the FM 453 into the user program

The Figure below shows you how the FM 453, the AW−DB and the technological functions communicate.



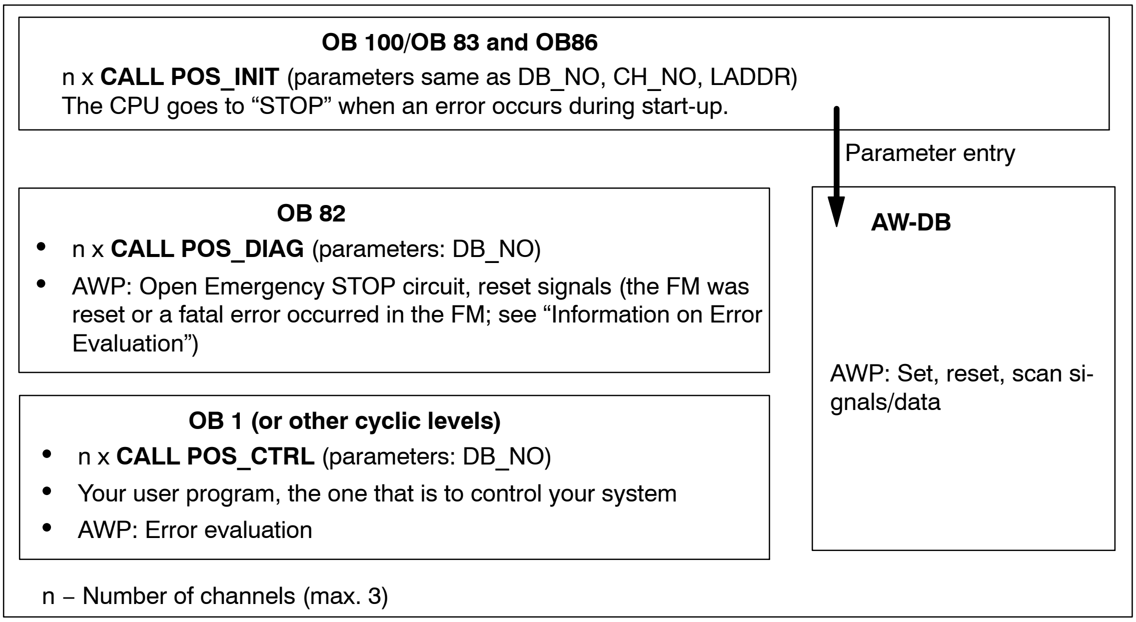
1) This block can only be called **either** in OB 40 **or** in OB 1, but not in both simultaneously.

2) This block needs to be called only once for one channel per module. It contains diagnostic information for all three channels (see Sections 6.5 and 11.2.2).

Fig. 6-2 Overview diagram for embedding the FM 453 in the user program

6.1.4 Structure of a User Program

The diagram below provides an overview of the structure of the user program (AWP).



Note

GET/PUT functions (SFC 72/73) from/to the FM are not guaranteed to work properly, that is to say, these functions are not supported, since they are not required. Parameter initialization data can be modified via the “Modify parameters/data” signal (AW-DB, DBX39.3).

Information on signal processing:

The FM 453’s cycle (= 3 ms) and the user cycle (OB 1) are asynchronous to one another. Depending on the instant of signal transfer to the FM 453, the time it takes to process signals may be = 1 to < 2 x the FM cycle. This must be taken into account particularly when user cycles are short. If necessary, the processing status of the FM 453 should be queried before activating a new action.

Information on testing the user program

When testing the user program with “Set breakpoint”, please note that it is not always possible to resume the program scan with the FM 453 after the breakpoint has been reached (for technical reasons).

For example, movements activated by the user program cannot be halted when the user program has reached the breakpoint.

The program can be resumed by executing a restart (CPU: STOP/RUN), by resetting the channel, or by changing the operating mode.

6.1.5 Remove-/Insert-Module Interrupt OB 83

Should it be necessary to continue system operation following failure of the FM 453, the user program must have an OB 83. OB 83 must be programmed so that communication with the FM 453 in OB 1 is suppressed when the FM 453 is removed (for example by setting a memory bit and evaluating it in OB 1). In order for the user program to be able to resynchronize itself with the FM 453, the POS_INIT block (the same sequence as with OB 100) must be loaded when the FM 453 is inserted. In addition, organization block OB 122 (I/O access error OB) must also be loaded into the CPU.

6.1.6 Rack Failure

If an expansion rack contains an FM 453 and if the system is to continue operating should the rack’s power fail, the program must contain an OB 86.

OB 86 is handled in the same way as OB 83 (see Section 6.1.5).

6.1.7 Connecting an OP

Part of the AW-DB, namely the “Data field for operator control/monitoring” (DBB496 to DBB515), is used to store signals/data for an OP as per the preconfigured operator interface. In order to initiate actions, the relevant signals/data have to be transferred to the interface (relevant area in the AW-DB) via the user program (see Section 6.6, Example 4).

6.1.8 Procedures for Writing the User Program (AWP)

The ”zEn17_02_FM453_EX” sample project, which is part of the configuring package, serves as model for writing a user program.

Suggested procedure:

1. Open your project in the SIMATIC Manager.
2. Select **SIMATIC xxx > CPUxxx > S7 Program**.
3. Open the ”zEn17_02_FM453_EX” project in the SIMATIC Manager with **File > Open... > Projects**.
4. Select the “EXAMPLES” directory.
5. Select the “Symbols” file and copy it to your project under **SIMATIC xxx > CPUxxx > S7 Program** (replacing the existing object).
6. Open the ”Sources” directory and copy from it all STL sources into your project’s ”Sources” directory.
7. Open the “Blocks” directory and copy all blocks to your project’s “Blocks” directory (including UDT blocks).
8. Select the “Sources” directory in your project. Start the “LAD/STL/FBD Editor” by double-clicking on the “OB_example” file.
9. **Modify the appropriate input parameters (see POS_INIT in Section 6.3.1 and POS_DIAG in Section 6.3.3) in the POS_INIT call in OB 100 and in the FC POS_DIAG call in OB 82**.
10. **You can insert the relevant functions from the sample project “zDt17_02_FM453_EX” (see Section 6.6) in the “EXAMPLE CALLS” network in OB 1. The functions can be activated by writing your user program to set/reset the signals in the DB 100 (AW-DB for the examples) supplied.**

    The input parameter must be modified accordingly for the POS_CTRL (using the input parameters or the appropriate instance DB).
11. The organization blocks (OB 1, OB 82, OB 100) are generated from the STL source with the menu commands **File > Save** and **File > Compile** werden aus der AWL-Quelle die Organisationsbausteine (OB 1, OB 82, OB 100) (warnings from the compilation run can be ignored).
12. Close the editor.
13. Set the CPU to “STOP” and switch the CPU on.
14. In the SIMATIC Manager, select **SIMATIC xxx > CPUxxx > S7 Program > Blocks**.
15. Load all the S7 blocks (including system data) into your CPU (with the CPU at STOP) with **PLC > Load**.

6.2 Putting the FM 453 into Operation with the Parameter Initialization Tool

To put the FM 453 into operation with the parameter initialization tool “Initialize FM 453”, the CPU must be at “STOP”. It can also be at “RUN”, for example if you want to automate part of your plant or connect the drives, in which case the control/checkback signals “Switch P bus interface to start-up” (AW-DB, DBX14.1) and “Switching of P bus interface concluded” (AW-DB, DBX22.1) must be observed. For a description of these signals, see Section 9.1).

Following feedback of the “Switching of P bus interface concluded” bit (AW-DB, DBX22.1), the interface in the FM is no longer updated. No diagnostic interrupts, measured values, and so on, can be read.

Also please observe Section 7.3 “Testing and Optimization”.

Note

Observe the relevant safety measures if you want to move the axis.

6.3 Description of the Standard Function Blocks

Overview

This chapter contains information on the following:

- POS_INIT (FC 0) – AW-DB Initialization, Section 6.3.1, Page 6-11
- POS_CTRL (FC 1) – Data Interchange, Section 6.3.2, Page 6-13
- POS_DIAG (FC 2) – Read Diagnostic Interrupt DataSection 6.3.3, Page 6-23
- POS_MSRM (FC 3) – Read Measured Values, Section 6.3.4, Page 6-26

6.3.1 The POS_INIT (FC 0) block – Initialization

Function

Use the POS_INIT block to initialize specific areas of your AW-DB.

Call options

The POS_INIT block must be called once per channel in start-up OB 100, in OB 83 for “Remove-/insert-module interrupt”, and in OB 86 for “Rack failure”.

Call in LAD Representation (ladder diagram)	Call in STL Representation (statement list)
POS_INIT EN — ENO DB_NO — RET_VAL CH_NO LADDR	CALL POS_INIT DB_NO := CH_NO := LADDR :=

Parameters

The Table below lists the parameters for this block.

Name	Data Type	Param. Type	Description
DB_NO	INT	I	Data block number
CH_NO	BYTE	I	Number of the channel: 0 – Only one channel on the module } Same meaning internally 1 – First channel on the module } Same meaning internally 2 – Second channel on the module 3 – Third channel on the module 4...255 – Illegal
LADDR	INT	I	• Logical base address of the module; use entry from “HW-CONFIG”, → “Properties”, → “Address” (see Section 5.2) • 0 – No entry of addresses in the user DB

Parameter types: I = input parameter

Function description

The block carries out the following actions:

1. Entry of addressing values in user data block AW-DB, if parameter LADDR ≠ 0
   - Module address
   - Channel number
   - Channel address and the offset address derived from it
2. Deletion of the following structures in user data block AW-DB:
   - Control signals
   - Checkback signals
   - Initiate, Ready and Error signals for the job requests
   - Single functions and single commands and their Ready and Error signals
3. If the input parameter LADDR = 0, no address is entered in the user DB. It is assumed that the addressing values (module address) have been entered manually via ”Parameterize FM 453” (button ”Enter Mod-Adr in user DB” in main display).

Error evaluation

An error is signalled by the binary result BR = 0 or by RET_VAL < 0.

Possible errors are:

- Unknown channel number CH_NO and DB no. = 0 as input parameters; the AW-DB is not initialized.
- If no AW-DB is found, the CPU goes to STOP; view the CPU’s diagnostic buffer.

The error is made available in output parameter RET_VAL.

RET_VAL	Error
–1	Unknown channel number
–2	DB number = 0

6.3.2 The POS_CTRL (FC 1) block – Data Interchange

Function

The POS_CTRL block is the basic block for controlling the FM 453.

With the POS_CTRL block, you can:

- Process Read and Write requests
- Execute mode control (control and checkback signals)

The POS_CTRL block carries out the following actions:

1. Synchronization with the module/channel (only then is the exchange of signals/data possible).
2. Reading of the checkback signals. The POS_CTRL block puts the values/signals that are read into user data block AW-DB.
3. Transfer of the control signals from user data block AW-DB to the FM 453.
4. Carrying out of Write requests from user data block AW-DB, which includes the transfer of associated data from AW-DB and setting of the job status for the Write. Before the function is activated, all data required for the execution of the intended functions must be entered in AW-DB.
5. Carrying out of Read requests from user data block AW-DB, which includes transfer of the associated data to AW-DB and setting of the Read job status.
6. Automatic transfer of all single functions from user data block AW-DB to the FM 453 when one or more than one setting has been changed and setting of the Write job status (Set or Reset).
7. Automatic transfer of all single commands from user data block AW-DB to the FM 453 and setting of the Write job status. The single commands are reset following the transfer.
8. Automatic reading of the error number when an operator input error, traversing error or data error has occurred. The error number is entered in user data block AW-DB (DBB90 to DBB97) and the Read job status set.

Call options

The POS_CTRL block must be called cyclically (once in the OB 1 cycle, for instance) for each channel. Before calling the function, enter all data/signals required to execute the intended functions in user data block AW-DB.

Call in LAD Representation (ladder diagram)	Call in STL Representation (statement list)

POS_CTRL
EN ENO
DB_NO RET_VAL
	`CALL POS_CTRL`
	`DB_NO :=`
	`RET_VAL :=`

Parameters

The Table below lists the parameters for this block.

Name	Data Type	Param. Type	Description
DB_NO	INT	I	Data block number
RET_VAL	INT	Q	Return value

Parameter types: E = input parameter, Q = output parameter

Return values

The function returns the following values:

RET_VAL	BR	Description
1	1	At least 1 job/transfer in progress
0	1	No job/transfer in progress, no error
< 0	0	Error: • Data error (AW-DB, DBX22.4) • Communication error (AW-DB, DBW66)

Function description

The function works together with an AW-DB user data block. The DB number is passed to the function in the DB_NO parameter when the FC is called.

- **Start-up**

  The POS_CTRL block acknowledges start-up of the module/channel. During this time, the “RET_VAL” parameter and the “Write/Read job in progress” signals (AW-DB, DBX68.0 and DBX68.2) are TRUE.

- **Control and checkback signals**

  When the POS_CTRL block is called, the checkback signals are immediately read (using direct access) from the FM 453. Since the control signals and job requests are not processed until after these signals are read, the checkback signals reflect the status of the module before the block was called. The control signals are also written to the FM 453 using direct access.

  Depending on the chosen mode, the control signals “Negative direction” and “Positive direction” (AW-DB, DBX15.0, 15.2 and 15.3) are reset once start-up has actually taken place (edge formation of the signals for the FM).

  For information on the generation of the checkback signals “Process” (AW-DB, DBX13.6) and “Position” (AW-DB, DBX13.7), see “Mode control”.

- **Job requests**

  Data interchange with the module that goes beyond control and checkback signals is handled using job requests. Simultaneously pending Write or Read requests, however, can only be executed in succession, whereby one Read and one Write request are processed in one call.

  To issue a request, set the relevant initiation signal in user data block AW-DB (DBB38 to DBB43). In the case of Write requests, you must also make the appropriate data available.

  The request is serviced when the POS_CTRL block is called. A Read request is serviced in one call. A Write request requires at least three calls (or OB cycles) due to the acknowledgements required from the module. The interval between calls should exceed the length of an FM cycle.

  When a request has been serviced, the Initiate signal is removed (does not apply to single functions).

  The next job request is not determined or executed until the next block call has been made.

  For each job request, there is a Ready signal (AW-DB, DBX44.0 to 53.7) and an Error signal (AW-DB, DBX54.0 to 63.7) in addition to the Initiate signal.

  You should reset the Ready and Error signals for a job request following evaluation or prior to issuing the request.

- **Order in which job requests are serviced/priority**

  You may submit several job requests simultaneously, even together with Write requests for single commands and single functions.

  As soon as a Write request is detected (also on a signal change in the case of single functions), it is serviced immediately upon completion of the transfer currently in progress, if any. Be sure that signals for single commands are not set cyclically, as this could prevent other job requests from being serviced (priority).

  Order/priority of Write requests:

  1. Write single commands
  2. Write single functions
  3. Write requests.
     The Write requests are serviced in the order of the Initiate signals, which is stipulated in user data block AW-DB (from DBX38.0 to 39.7).

  Order/priority of Read requests:

  1. Read error code, operator/traverse errors or data errors
  2. Read requests
     The Read requests are serviced in the order of the Initiate signals, which is stipulated in user data block AW-DB (from DBX42.0 to 43.6).

- **Job request status**

  You can read the status of the job request in return value RET_VAL and in the “Write/read job in progress” signals in user data block AW-DB (DBX68.0 and DBX68.2). You can evaluate the status of an individual job request by evaluating the Initiate, Ready and Error signals for that job request.

Table 6-2 Job Request Status

Job Request Status	RET_VAL (integer)	Jobs in Progress (DBX68.0 DBX68.2)	Initiate Signals (DBB34...43)	Ready Signals (DBB44...53)	Error Signals (DBB54...63)
1. Job in progress	1	1	1	–	–
2. Job terminated without error	0	–	–	1	–
3. Write job terminated with error	–1	–	–	1	1
4. Write job aborted or not executed	–1	–	–	–	1
5. Read job aborted	–2	–	–	–	1
6. Write and Read aborted or not executed (in the case of simultaneous job requests)	–3	–	–	–	1

– Irrelevant for error evaluation

Processing status

Signal	Bedeutung
Write not possible (AW-DB, DBX68.1)	= TRUE; Write request cannot be serviced in this cycle because: • The axis is not initialized • Test mode is enabled • No operating mode is active • The selected operating mode has not yet been set In these cases, you can leave the Write request pending or you can cancel it. The POS_CTRL block resets the signal when all of the above-listed conditions are fulfilled.
Read not possible (AW-DB, DBX68.3)	= TRUE; Read request cannot be serviced at this time because: • The axis is not initialized • No mode has been selected • Test mode is enabled In these cases, you can leave the Read request pending or you can cancel it. The POS_CTRL block resets the signal when all of the above-listed conditions are fulfilled.
Reset status/error (AW-DB, DBX69.1)	With this signal you can reset **all** Ready and Error signals prior to processing of the pending job requests. The signal itself is then reset by the FC.

Error evaluation

Communication errors or data interpretation errors on the FM are flagged in the Binary Result (BR = 0) and by RET_VAL < 0; see job request status.

Possible errors are:

- Data transfer error (communication is not completed) during a transfer with SFC 58/59 “WR_REC / RD_REC”. The error code is made available in user data block AW-DB, DBW66 (RET_VAL value of these internal SFCs) (4., 5., 6. Under job request status, Table 6-2, also see Error List, Section 6.7).
- Data transferred with Write are checked for data errors by the module and interpreted. If a data error occurs, the checkback signal “Data error” (AW-DB, DBX22.4) is set to TRUE in user data block AW-DB (message: “Write job terminated with error”). The error number, read out via an internal job request, is entered in user data block AW-DB, DBB94 and 95 (job status, point 3, Table 6-2).

  You will find more information on data errors in the parameter initialization tool under the menu command **Debug > Error Evaluation** and in Chapter 11.

Performance in the event of an error during the servicing of a **Write request** (does not apply to single functions and commands):

- The Initiate signal is removed for the errored request and the Error signal (AW-DB, DBX54.0 to 63.7) and Ready signal (AW-DB, DBX44.0 to 53.7) are set (job request status, point 3, Table 6-2).
- The Initiate signal is also removed for all pending Write requests and the Error signal set (job request status, point 4, Table 6-2).
- Any pending Read requests are serviced. The error code (AW-DB, DBW66) for each request is re-set if another error occurs.

Performance in the event of an error during the servicing of a **Read request**:

- The Initiate signal is removed for the errored Read and the Error signal set (job request status 5. Table 6-2).
- Any pending Read requests are serviced. The error code (AW-DB, DBW66) for each request is re-set if another error occurs.

Performance in the event of an error during servicing of **single functions and commands**:

- The Write request is not serviced in its entirety, and the Error signal is set (job request status 4. Table 6-2).
- The function set/reset which led to initiation of the Write request is not activated.

Servicing Write requests

Before Write requests can be serviced, the data area associated with the Write request must first be initialized with the relevant values and the appropriate operating mode.

A Write request is initiated by setting the relevant job request number.

The following abbreviations are used in the Table below to indicate the adjacent operating mode:

Operating mode: T – Jogging mode
STE – Control mode
REF – Approach to reference point
SM – Incremental mode (relative)
MDI – MDI (Manual Data Input)
A/AE – Automatic mode / Automatic single block

The following Write requests are available:

Operating Mode / System Data	Write request	Data	T	STE	REF	SM	MDI	A/AE	See Sect.
Speed levels 1, 2	DBX38.0	DBB160...167	□	○	○	□	○	○	9.2.1
Voltage-/frequency levels 1, 2	DBX38.1	DBB168...175	○	□	○	○	○	○	9.2.2
Setpoint for incremental dimension	DBX38.2	DBB156...159	○	○	○	□	○	○	9.2.4
MDI block	DBX38.3	DBB176...195	○	○	○	○	□	○	9.2.5
MDI block, on-the-fly	DBX38.4	DBB222...241	–	–	–	–	x	–	9.2.5
Reserved	DBX38.5								
Set reference point	DBX38.6	DBB152...155	x	x	x	x	x	–	9.3.9
Set actual value	DBX38.7	DBB144...147	x	x	–	x	x	x	9.3.5
Set on-the-fly actual value	DBX39.0	DBB148...151	x	x	–	x	x	–	9.3.6
Zero offset	DBX39.1	DBB140...143	x	x	–	x	x	x	9.3.4
Reserved	DBX39.2		x	x	x	x	x	x	
Modify parameters/data	DBX39.3	DBB196...219	x	x	x	x	x	x	9.3.1
Digital outputs	DBX39.4	DBB220...221	x	x	x	x	x	x	9.8.2
Program selection	DBX39.5	DBB242...245	–	–	–	–	–	□	9.2.6
Application request	DBX39.6	DBB246...249	x	x	x	x	x	x	9.3.7
Teach-in	DBX39.7	DBB250...251	x	–	–	x	x	–	9.3.8
Coupled-axis grouping	DBX40.0	DBB252...253	x	○	○	○	x	x	9.3.10

○ Data are accepted, then processed in the relevant operating mode.
x Data are accepted or processed.
– Data are rejected with error (see error handling, Table 11-8 column 4, No. 1).
□ Data required to move the axis.

Servicing Read requests

A Read request is initiated by setting the relevant job request number. The relevant operating mode must be activated.

The following Read requests are available:

System Data \ Operating Mode	Read request	Data	T	STE	REF	SM	MDI	A/AE	See Sect.
Basic operating data	DBX42.0	DBB310...333	x	x	x	x	x	x	9.3.12
Active NC block	DBX42.1	DBB342...361						x	9.3.13
Next NC block	DBX42.2	DBB362...381						x	
Actual value for block change	DBX42.3	DBB398...401						x	9.3.15
Service data	DBX42.4	DBB402...433	x	x	x	x	x	x	9.3.16
Operating error number	DBX42.5	DBB86...89	x	x	x	x	x	x	6.3.3
Suppl. operating data	DBX43.5	DBB434...442	x	x	x	x	x	x	9.3.17
Parameters/data	DBX43.3	DBB446...469	x	x	x	x	x	x	9.3.18
Digital inputs/outputs	DBX43.4	DBB220...221	x	x	x	x	x	x	9.8
Application data	DBX43.6	DBB382...397	x	x	x	x	x	x	9.3.14
Read measured values	DBX43.7	DBB486...497	x	x	x	x	x	x	9.3.11 6.3.4
Coupled-axis grouping status	DBX43.0	DBB470...471	x	x	x	x	x	x	9.3.19

x Data are accepted or processed.

Operating mode control

The operating modes are discussed in detail in Section 9.2, the control-/checkback signals and handling information in Section 9.1.

The user must write the control signals to the user data block (AW-DB). The POS_CTRL block transfers the control signals from user data block AW-DB to the FM 453 and the checkback signals from the FM 453 to user data block AW-DB. The FM must be initialized.

The Table below lists the control and checkback signals, with symbols in German and English.

Table 6-3 Control/checkback signals

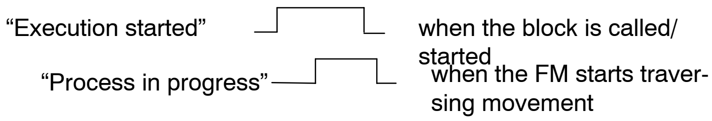
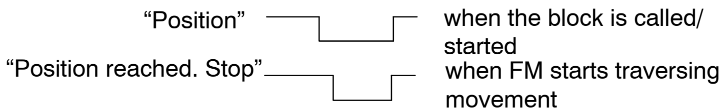
German	English	AW-DB	Description
Control signals			
TFB	TEST_EN	DBX14.1	Switch P bus interface to “Start-up”
BFQ/FSQ	OT_ERR_A	DBX14.3	Acknowledge operator errors and traversing errors
ST	START	DBX15.0	Start
STP	STOP	DBX15.1	Stop

Table 6-3 Control/checkback signals, continued

German	English	AW-DB	Description
R–	DIR_M	DBX15.2	Negative direction
R+	DIR_P	DBX15.3	Positive direction
QMF	ACK_MF	DBX15.4	Acknowledge M function
EFG	READ_EN	DBX15.5	Read Enable
SA	SKIP_BLK	DBX15.6	Skip block
AF	DRV_EN	DBX15.7	Drive enable
BA	MODE_IN	DBB16	**Operating mode** — **Code** Jog 01 Control 02 Approach to reference point 03 Incremental mode, relative 04 MDI 06 Automatic 08 Automatic single block 09
BP	MODE_TYPE	DBB17	**Operating mode parameters** — **Code** Speed levels 1 and 2 Voltage-/frequency levels 1 and 2 Incremental dimension selection 1...100, 254
OVERR	OVERRIDE	DBB18	Override
Checkback signals			
TFGS	TST_STAT	DBX22.1	Switching of P BUS interface completed
BF/FS	OT_ERR	DBX22.3	Operator-/traversing error
DF	DATA_ERR	DBX22.4	Data error
PARA	PARA	DBX22.7	Channel initialized
SFG	ST_ENBLD	DBX23.0	Start Enable
BL	WORKING	DBX23.1	Process in progress
WFG	WAIT_EI	DBX23.2	Wait for external Enable
T-L	DT_RUN	DBX23.5	Dwell time running
PBR	PR_BACK	DBX23.6	Reverse program scanning
BAR	MODE_OUT	DBB24	Active operating mode
SYN	SYNC	DBX25.0	Channel synchronized
ME	MSR_DONE	DBX25.1	End of measurement
FR–	GO_M	DBX25.2	Travel in negative direction
FR+	GO_P	DBX25.3	Travel in positive direction
SRFG	ST_SERVO	DBX25.4	Servo enable status
FIWS	FVAL_DONE	DBX25.5	Setting of on-the-fly actual value successfully completed
PEH	POS_RCD	DBX25.7	Position reached. Stop.
MNR	NUM_MF	DBB26	M function number
AMF	STR_MF	DBX27.4	M function modification

The status signals “Process in progress” and “Position reached. Stop” are not reported back to the user program until the FM has detected and processed the Start signal (≤ 2 FM cycles).

The calling of the POS_CTRL block and the relevant control/status signals forms the subsequent signals so that starting of the procedure can be detected earlier than would otherwise be the case.

Signal	Description
Execution started (AW-DB, DBX13.6)	= TRUE When a mode/movement is started with the relevant control signals or when the status for “Process in progress” (AW-DB, DBX23.1) = 1 
Position (AW-DB, DBX13.7)	= FALSE When status signal “Position reached. Stop.” (AW-DB, DBX25.7) = 0 is returned or when a mode is started with the relevant control signals. 

Single functions and single commands are also requred to control the FM 453.

All single commands and single functions that are active when the POS_CTRL block is called are transferred. The single commands are cancelled following transfer, even in the event of an error.

Operating Modes / System Data	Write Request	Function	T	STE	REF	SM	MDI	A/AE	See Sect.
Single functions	Internal	DBB34 and 35	□	x	□	□	□	□	9.3.2
Single commands	Internal	DBB36 and 37	x	x	x	x	x	x	9.3.3

x Data are accepted or processed.

□ Data required to move the axis.

The functions which can be activated in the FM using single settings or single commands are listed below.

Single Settings	Single Commands
Servo enable On-the-fly measuring Rotational speed monitoring (for stepper drive without sensor only) Parking axis Simulation Length measuring Retriggering of reference point Reset Enable input Follow-up mode (for drives with sensors only) Disable software limit position monitoring Automatic drift compensation (for servo drives only)	Activate machine data Delete residual distance Automatic block return Automatic block advance Restart Rescind set actual value

Error messages from the FM

When an operator error, traversing error or data error occurs, the error number is read automatically via a Read request. The error number is entered in the AW-DB user data block and the Read status set.

An operating error, reported via a diagnostic interrupt, can be read out with the Read request “Operating error no.” (AW-DB, DBX42.5).

Table 6-4 Error messages from the FM

Error	Message	Error No.	Error Acknowledgement
Data error	Status signal (AW-DB, DBX22.4)	Is read out via Read request (AW-DB, DBB94 and 95)	New Write request
Operator/traversing error	Status signal (AW-DB, DBX22.3)	Is read out via Read request (AW-DB, DBB 90 and 91)	Set/reset control signal “Acknowledge operator/traversing error” (AW-DB, DBX14.3)
Diagnostic interrupt	With OB 82 activated, data must be read out with POS_DIAG	In the case of operating errors read out with POS_DIAG, the error no. is read out via Read request DBX42.5 (AW-DB, DBB86 and 87)	Single command: Restart

For additional specific information, please refer to Chapter 11 “Error Handling”.

6.3.3 The FC POS_DIAG (FC 2) block - Read Diagnostic Interrupt Data

In the event of a fatal error, the FM 453 generates a diagnostic interrupt (OB 82 must be linked into the user program and interrupt parameter initialization activated on the FM 435) and makes the information available in the local data area. For information on diagnostic interrupts, see Section 6.4.

Additional information on external channel errors (operating errors) for FM 453 channels 1 to 3 is provided when you call the POS_DIAG block.

Call options

FC POS_DIAG can be called in interrupt OB 82 or in OB 1.

Call in LAD Representation (ladder diagram)	Call in STL Representation (statement list)

POS_DIAG
EN ENO
DB_NO RET_VAL
IN_DIAG
	`CALL POS_DIAG`
	`DB_NO :=`
	`RET_VAL :=`
	`IN_DIAG :=`

Parameters

The Table below lists the parameters for this block.

Name	Data type	Param. type	Description
DB_NO	INT	I	Data block number
RET_VAL	INT	Q	–1
IN_DIAG	BOOL	I/Q	Initiation signal for reading of the diagnostic data; is reset following execution of POS_DIAG.

Parameter types: I = input parameter, Q = output parameter,
I/Q = throughput parameter (initiation parameter)

Function description

The function works together with an AW-DB user data block. When the function is called, the AW-DB is forwarded with a DB_NO parameter.

Reading of the diagnostic data is started by setting the IN_DIAG parameter to TRUE. The block resets the parameter when the request has been serviced.

The IN_DIAG parameter remains set while the request is being serviced. Transfer of the data is terminated when the parameter is reset (IN_DIAG = FALSE).

Error evaluation

Errors are flagged in the Binary Result (BR = 0) and by RET_VAL < 0.

Possible errors are as follows:

Data transfer error during transfers with SFC 51 “RDSYSST”. The error is made available in the user DB AW-DB, DBW96 (see Error List, Section 6.7).

Diagnostic data

The prerequisite for the generation of a diagnostic interrupt is activation of the interrupt with the aid of the appropriate parameters (see Section 5.2).

If the user program does not contain an OB 82, the CPU goes to STOP.

The Table below contains the diagnostic information for the FM 453 (channels 1 to 3).

Please note that information regarding channel errors in the other FM channels is also read out.

Table 6-5 Diagnostic Information

Data Format	Message	AW-DB	Description
4 x 1 byte	When a diagnostic interrupt is generated, the relevant information is made available in the CPU (local data area, OB 82) and is entered in AW-DB by calling POS_DIAG.	DBX70.0	Module/group errors
		DBX70.1	Internal error/hardware error (group error DBB72, 73)
		DBX70.2	External error
		DBX70.3	External channel error (group error bytes 78, 80, 82)
		DBX70.5	Front connector missing
		DBX70.6	Module not initialized
		DBX71.0...3	Module type class for FM 453 = 08H
		DBX71.4	Channel information available
		DBX72.1	Communication error (K bus)
		DBX72.3	Response from watchdog timer
		DBX72.4	Internal supply voltage to the module failed (NMI)
		DBX73.2	FEPROM error
		DBX73.3	RAM error
		DBX73.6	Process interrupt lost

Table 6-5 Diagnostic Information, continued

Data Format	Message	AW-DB	Description
12 x 1 byte	When the POS_DIAG block is called, the information (incl. bytes 0 to 3) is read and entered in the AW-DB (DBB70).	DBB74	FM pos. ID (74H)
		DBB75	Length of the diagnostic information (16)
		DBB76	Number of channels (3)
		DBX77.0...2	Channel error vector (1 to 3)
		DBX78.0	Cable break (incremental position encoder) for channel 1
		DBX78.1	Error in absolute position encoder for channel 1
		DBX78.2	No increm. Error pulses or zero mark for channel 1
		DBX78.3	Voltage monitor f. sensor for channel 1
		DBX78.4	Voltage monitor ±15 V for channel 1
		DBX78.5	Voltage monitor f. digital outputs for channel 1
	When an operating error occurs, the error number can be read via Read request DBX42.5 (AW-DB, DBB86 to 89)	DBX78.7	**Operating error** (see Chapter 11, Error Handling) for channel 1
		DBB79	Unassigned
		DBB80	Same as DBB 76 but for channel 2
		DBB81	Unassigned
		DBB82	Same as DBB 78 but for channel 3
		DBB83...85	Unassigned

Tips for the user

Following a diagnostic interrupt, the diagnostic information and the associated module address (OB82_MDL_ADDR) is made available in the local data area of OB 82 for quick analysis.

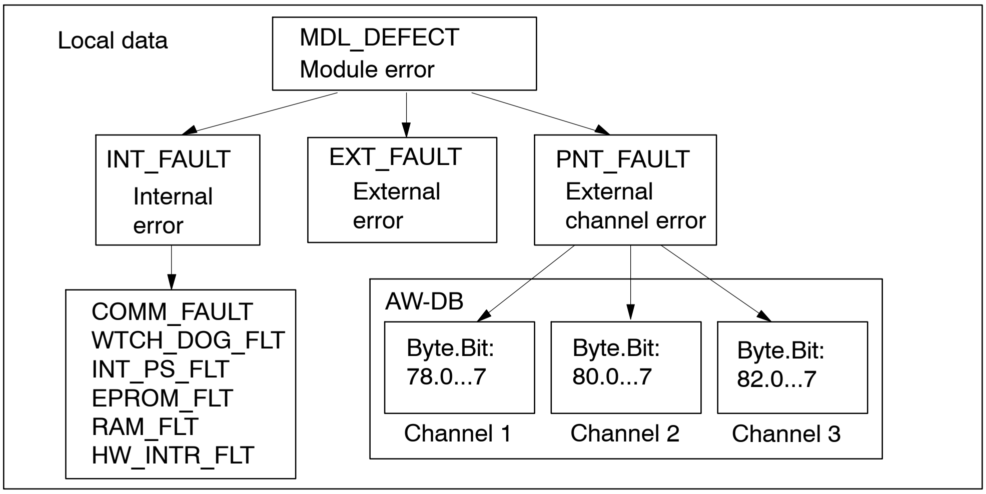


Fig. 6-3 Evaluating Diagnostic Information

6.3.4 The FC POS_MSRM (FC 3) block – Read Measured Values

Function

The POS_MSRM block reads the measured values in user data block AW-DB.

For information on process interrupts, please see Section 6.4.

For information on measured values see Section 9.3.11.

Note

The measured values can also be read by means of the POS_CTRL block (Read request). If more than one Read request is pending, this request will be processed in the relevant order.

The POS_MSRM block renders the measured values irrespective of other Read requests pending.

Call options

The POS_MSRM block can be called in OB 40 if process interrupts are enabled (see Section 5.2), or in OB 1, but it may not be called in both. The block must be called once per channel.

Call in LAD Representation (ladder diagram)	Call in STL Representation (statement list)
POS_MSRM EN ENO DB_NO RET_VAL IN_MSR	**CALL POS_MSRM** **DB_NO :=** **RET_VAL :=** **IN_MSR :=**

Parameters

The Table below lists the parameters for this block.

Name	Data type	Param. type	Description
DB_NO	INT	I	Data block number
RET_VAL	INT	Q	–1
IN_MSR	BOOL	I/Q	Start Read

Parameter types: I = input parameter, Q = output parameter,
I/Q = throughput parameter (initiation parameter)

Function description

The function works together with an AW-DB user data block. When the function is called, the DB number is forwarded in the DB_NO parameter.

Reading of the measured value is started by setting the IN_MSR parameter to TRUE. When the function has executed, the block resets the parameter.

The IN_MSR parameter remains set while the function is executing. Transfer of the data is terminated is complete when the parameter is reset (IN_MSR = FALSE).

Error evaluation

Errors are flagged in the Binary Result (BR = 0) and by RET_VAL < 0.

Possible errors are as follows:

Data transfer errors during transfers with SFC 59 “RD_REC”. The error is made available in the user data block AW-DB, DBW98 (see Error List, Section 6.7).

6.4 Interrupts

Interrupt processing

The FM 453 can generate process interrupts and diagnostic interrupts. You can process these interrupts only in an interrupt OB (OB 40 or OB 82). If an interrupt is generated without the associated OB having been loaded, the CPU goes to STOP (refer to the manual entitled *Programming with STEP 7*).

Interrupt servicing is enabled in the following stages:

1. General Interrupt Enable for the entire module:
   - Select the module in the hardware configuration.
   - Enable diagnostic and/or process interrupts with **Edit > Object Properties > Basic Parameters** (also see Figure 5.2).
   - Select the OB number for the process with **Edit > Object Properties > Addresses**.
   - Save and compile the hardware configuration.
   - Load the hardware configuration into the CPU.
2. Enable the events for the process interrupt in the machine data.

Evaluating a process interrupt

When the FM 453 generates a process interrupt, variable OB40_POINT_ADDR (or the corresponding variable in another process interrupt OB) contains the following information:

Table 6-6 Contents of Doubleword OB40_POINT_ADDR

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0								
1				On-the-fly measuring Channel 3	On-the-fly block change Channel 3		Length measurement terminated Channel 3	Position reached Chan-nel 3
2				On-the-fly measuring Channel 2	On-the-fly block change Channel 2		Length measurement terminated Channel 2	Position reached Chan-nel 2
3				On-the-fly measuring Channel 1	On-the-fly block change Channel 1		Length measurement terminated Channel 1	Position reached Chan-nel 1

The reason for the interrupt is made available in bytes 1, 2 and 3.

Lost process interrupts

If servicing of a process interrupt in the process interrupt OB has not yet been terminated, the module “makes a note” of all subsequent process interrupt events. If an event re-occurs before a process interrupt could be generated, the module generates the diagnostic interrupt “process interrupt lost”.

Evaluating a diagnostic interrupt

Following a diagnostic interrupt, the diagnostic information is made available in the local data area of OB 82 for quick analysis. Call the FC POS_DIAG function to ascertain the exact cause of error (see Section 6.3.3).

6.5 User Data Block (AW-DB)

Overview

The Table below describes the structure of the user data block.

This block must be created for each channel used.

Table 6-7 User Data Block (AW-DB)

AW-DB	**FM 453 and Channel Signals**							
Byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
General addresses								
DBW0	Module address (data type INT)							
DBW2	Channel number (data type INT)							
DBD4	Channel address							
DBW8	Internal (DS offset; data type INT)							
DBW10 to DBB12	Reserved							
DBB13	Position	Execution started						
Control signals								
DBB14					Acknow-ledge ope-rator/traver-sing error		Switch to P bus Start-up	
DBB15	Drive enable	Block skip	Read-in enable	Acknow-ledge M function	Positive di-rection	Negative direction	Stop	Start
DBB16	Operating mode							
DBB17	Operating mode parameters							
DBB18	Override							
DBB19 to DBB21	Reserved							
Checkback signals								
DBB22	Channel initialized			Data error	Operator/ traversing error		Switch to P bus com-pleted	
DBB23		Reverse prog. scan	Dwell in progress			Wait for external enable	Machining in progress	Start enable
DBB24	Active operating mode							

Table 6-7 User Data Block (AW-DB), continued

AW-DB	FM 453 and Channel Signals							
Byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
DBB25	Position reached. Stop.		On-the-fly setting of actual value completed	Servo enable status	Positive travel	Negative travel	End of measurement	Channel synchronized
DBB26	M function number							
DBB27				M function modification				
DBB28 to DBB33	Reserved							
Initiation signals								
Initiation signals for single settings (switches); transfer through Write request when change occurs								
DBB34	Simulation	Parking axis	Rotation monitoring				On-the-fly measuring	Controller enable
DBB35	Autom. drift compensation disabled	Software limit positions disabled	Follow-up mode	Enable input disabled	Retrigger ref. point	Length measurement		
Initiation signals for single commands; transfer through Write request when change occurs (signals are reset following transfer)								
DBB36	Reserved							
DBB37		Rescind setting of actual value	Restart		Automatic block return	Automatic block advance	Delete residual distance	Activate MD
Initiation signals for Write requests								
DBB38	Set actual value	Set reference point		On-the-fly MDI block	MDI block	Setpoint for incremental dimension	Voltage/ frequency levels 1, 2	Speed levels 1, 2
DBB39	Teach-in	Request application data	Program selection	Digital outputs	Modify parameters / data		Zero offset	On-the-fly setting of actual value
DBB40								Coupled–axis grouping
DBB41	Reserved							

Table 6-7 User Data Block (AW-DB), continued

AW-DB	FM 453 and Channel Signals							
Byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Initiation signals for Read requests								
DBB42			Operating error no.	Service data	Actual value block change	Next NC block	Active NC block	Basic operating data
DBB43	Read measured values	Application data	Additional operating data	Dig. inputs/ outputs	Parameter/ data			Coupled–axis grouping status
Ready signals								
Status/checkback signals from the POS_CTRL block								
DBB44	Simulation	Parking axis	Rotation monitoring				On-the-fly measuring	Controller enable
DBB45	Autom. drift compensation disabled	Software limit positions disabled	Follow-up mode	Enable input disabled	Retrig. ref. point	Length measurement		
DBB46	Reserved							
DBB47		Rescind setting of actual value	Restart		Autom. block return	Autom. block advance	Delete residual distance	Activate MD
DBB48	Set actual value	Set reference point		On-the-fly MDI block	MDI block	Setpoint for incremental dimension	Voltage/ frequency levels 1, 2	Speed levels 1, 2
DBB49	Teach-in	Request application data	Program selection	Digital outputs	Modify parameters/ data		Zero offset	On-the-fly setting of actual value
DBB50								Coupled–axis grouping
DBB51	Reserved							
DBB52	Data error read	Operator/ traversing error read	Operating error read	Service data	Actual value block change	Next NC block	Active NC block	Basic operating data
DBB53	Read measured values	Application data	Additional operating data	Dig. inputs/ outputs	Parameter/ data			Coupled–axis grouping status

Table 6-7 User Data Block (AW-DB), continued

AW-DB	FM 453 and Channel Signals							
Byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Error signals								
Error messages from the POS_CTRL block								
DBB54	Simulation	Parking axis	Rotation monitoring				On-the-fly measuring	Controller enable
DBB55	Autom. drift compensa-tion disa-bled	Software li-mit positions disabled	Follow-up mode	Enable input disabled	Retrig. ref. point	Length measure-ment		
DBB56	Reserved							
DBB57		Rescind setting of actual value	Restart		Autom. block return	Autom. block advance	Delete residual di-stance	Activate MD
DBB58	Set actual value	Set refe-rence point		On-the-fly MDI block	MDI block	Setpoint for incremental dimension	Voltage/ frequency levels 1, 2	Speed levels 1, 2
DBB59	Teach-in	Request application data	Program selection	Digital outputs	Modify pa-rameters/ data		Zero offset	On-the-fly setting of actual value
DBB60								Coupled–axis grouping
DBB61	Reserved							
DBB62	Data error read	Operator/ traversing error read	Operating error read	Service data	Actual va-lue block change	Next NC block	Active NC block	Basic operating data
DBB63	Read measured values	Application data	Additional operating data	Dig. inputs/ outputs	Parameter/ data			Coupled–axis grou-ping status
DBB64 to DBB65	Reserved							
Processing status of the POS_CTRL block								
DBW66	Error code (communications error) of the last job request/transfer (data type: INT)							
DBB68					Read re-quest not possible	Read job active	Write re-quest not possible	Write job active
DBB69							Reset status/error	

Table 6-7 User Data Block (AW-DB), continued

AW-DB	FM 453 and Channel Signals							
Byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Diagnostic data for the FM, read out with via the POS_DIAG block								
DBB70		Module not initialized	Front connector missing		Ext. chan. err. (DBB78, 80, 82)	External error	Int./HW err. (DBB 72, 73)	Module/ group fault
DBB71				Channel info available	Module type classes (08H)			
DBB72				Int. module supply volt. failed	Watchdog triggered		Comm. error (comm. bus)	
DBB73		Hardware int. lost			RAM error	FEPROM error		
DBB74	FM pos. ID (74H)							
DBB75	Length of diagnostic information (16)							
DBB76	Number of channels (3)							
DBB77						Channel error vector 3	2	1
DBB78	Channel 1							
	Operating error		Voltage mon. dig. output	Voltage mon. ± 15 V	Voltage mon. sensor	Error: no increm. or zero mark	Error: abs. pos. encoder	Error: inc. pos. encoder
DBB79	reserviert							
DBB80	Channel 2							
	Operating error		Voltage mon. dig. output	Voltage mon. ± 15 V	Voltage mon. sensor	Error: no increm. or zero mark	Error: abs. pos. encoder	Error: inc. pos. encoder
DBB81	Reserved							
DBB82	Channel 3							
	Operating error		Voltage mon. dig. output	Voltage mon. ± 15 V	Voltage mon. sensor	Error: no increm. or zero mark	Error: abs. pos. encoder	Error: inc. pos. encoder
DBB83 to DBB85	Reserved							

Table 6-7 User Data Block (AW-DB), continued

AW-DB				FM 453 and Channel Signals				
Byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Error code following flagging of an "Operating error" (is read if operating error is set following FC POS_DIAG)								
DBB86	Error number (DS 164) – Detail event class							
DBB87	Error number (DS 164) – Detail event number							
DBB88 to DBB89	Reserved							
Error code following flagging of "Operator-/traversing error"								
DBB90	Error number (DS 162) – Detail event class							
DBB91	Error number (DS 162) – Detail event number							
DBB92 to DBB93	Reserved							
Error code following flagging of "Data error"								
DBB94	Error number (DS163) – Detail event class							
DBB95	Error number (DS163) – Detail event number							
DBW96	Error code FC POS_DIAG (return code SFC 51) (Data type: INT)							
DBW98	Error code FC POS_MSRM (return code SFC 59) (Data type: INT)							
Data for the requests								
Zero offset								
DBD140	Data type: DINT							
Set actual value								
DBD144	Data type: DINT							
On-the-fly setting of actual value								
DBD148	Data type: DINT							
Set reference point								
DBD152	Data type: DINT							
Setpoint for incremental dimension								
DBD156								
Speed levels 1 and 2								
DBD160	Speed level 1							
DBD164	Speed level 2							
Voltage-/frequency levels 1 and 2								
DBD168	Voltage-/frequency level 1							
DBD172	Voltage-/frequency level 2							

Table 6-7 User Data Block (AW-DB), continued

AW-DB	FM 453 and Channel Signals							
Byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
MDI block								
DBB176 to DBB177	Reserved							
DBB178				Position/ dwell			G function group 2	G function group 1
DBB179					M function group 3	M function group 2	M function group 1	Speed
DBB180	G function no. of group 1							
DBB181	G function no. of group 2							
DBB182 bis DBB183	Reserved							
DBD184	Value for position/dwell (data type DINT)							
DBD188	Value for speed (data type DINT)							
DBB192	M function no. of group 1							
DBB193	M function no. of group 2							
DBB194	M function no. of group 3							
DBB195	Reserved							
Modify parameter/data or request reading of relevant data								
DBB196	DB type							
DBB197	Number							
DBB198	Quantity							
DBB199	Request							
DBB200 to DBB219	Data array, structure/data type of Write data as per bytes 1 to 4 of this structure (e.g. a program block or max. 5 MD items)							
Digital inputs/outputs								
DBB220					Digital input 3	Digital input 2	Digital input 1	Digital input 0
DBB221					Digital output 3	Digital output 2	Digital output 1	Digital output 0
On-the-fly MDI block								
DBB222 to DBB223	Reserved							
DBB224				Position/ dwell			G function group 2	G function group 1
DBB225					M function group 3	M function group 2	M function group 1	Speed
DBB226	G function no. of group 1							

Table 6-7 User Data Block (AW-DB), continued

AW-DB	FM 453 and Channel Signals							
Byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
DBB227	G function no. of group 2							
DBB228 to DBB229	Reserved							
DBD230	Value for position/dwell (data type DINT)							
DBD234	Value for speed (data type DINT)							
DBB238	M function no. of group 1							
DBB239	M function no. of group 2							
DBB240	M function no. of group 3							
DBB241	Reserved							
Program selection								
DBB242	Program number							
DBB243	Block number							
DBB244	Direction of processing							
DBB245	Reserved							
Request for application data								
DBB246	Application data 1							
DBB247	Application data 2							
DBB248	Application data 3							
DBB249	Application data 4							
Teach-in								
DBB250	Program number							
DBB251	Block number							
Coupled-axis grouping								
DBB252	Define coupled-axis grouping							
DBB253	Reserved for coupled-axis grouping							
DBB254 bis DBB309	Reserved							
Data read as per request								
Basic operating data								
DBD310	Actual position (data type DINT)							
DBD314	Actual speed							
DBD318	Residual distance (data type DINT)							
DBD322	Setpoint position (data type DINT)							
DBD326	Sum of active coordinate offset, tool offset, zero offset (data type DINT)							
DBD330	Rotational speed							

Table 6-7 User Data Block (AW-DB), continued

AW-DB	FM 453 and Channel Signals							
Byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
DBD334 to DBD338	Reserved							
Active NC block								
DBB342	Program number							
DBB343	Block number							
DBB344	Block skip	UP call	No. of UP calls	Position/ dwell		G function group 3	G function group 2	G function group 1
DBB345				Tool offset	M function group 3	M function group 2	M function group 1	Speed
DBB346	G function no. of group 1							
DBB347	G function no. of group 2							
DBB348	G function no. of group 3							
DBB349	Reserved							
DBD350	Value for position/dwell (data type DINT)							
DBD354	Value for speed (data type DINT)							
DBB358	M function no. of group 1							
DBB359	M function no. of group 2							
DBB360	M function no. of group 3							
DBB361	Tool offset no.							
Next NC block								
DBB362	Program number							
DBB363	Block number							
DBB364	Block skip	UP call	No. of UP calls	Position/ dwell		G function group 3	G function group 2	G function group 1
DBB365				Tool offset	M function group 3	M function group 2	M function group 1	Speed
DBB366	G function no. of group 1							
DBB367	G function no. of group 2							
DBB368	G function no. of group 3							
DBB369	Reserved							
DBD370	Value for position/dwell (data type DINT)							
DBD374	Value for speed (data type DINT)							
DBB378	M function no. of group 1							
DBB379	M function no. of group 2							
DBB380	M function no. of group 3							
DBB381	Tool offset no.							

Table 6-7 User Data Block (AW-DB), continued

AW-DB	FM 453 and Channel Signals							
Byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Application data								
DBD382	Application data 1 (data type: DINT)							
DBD386	Application data 2 (data type: DINT)							
DBD390	Application data 3 (data type: DINT)							
DBD394	Application data 4 (data type: DINT)							
Actual value block change								
DBD398	Data type DINT							
Service data								
DBD402	DAO output value or frequency output value (data type DINT)							
DBD406	Actual sensor value or pulse output counter (data type DINT)							
DBD410	Missing pulses (data type DINT)							
DBD414	K_v factor (data type DINT)							
DBD418	Following error or difference between setpoint and actual position (data type DINT)							
DBD422	Following error limit (data type DINT)							
DBD426	Setpoint overshoot value/switch adjustment (data type DINT)							
DBD430	Approach time/response time constant (data type DINT)							
Additional operating data								
DBB434	Override							
DBB435	NC traversing program no.							
DBB436	NC block no.							
DBB437	UP call counter							
DBB438	Active G90/91							
DBB439	Active G60/64							
DBB440	Active G43/44							
DBB441	Active D number							
DBB442					Accelera-tion/decele-ration limit	Limited to ± 10 V	Speed limit	
DBB443 to DBB445	Reserved							
Parameter/data								
DBB446	DB type (MD, incremental dimension or traversing program)							
DBB447	Number							
DBB448	Quantity							
DBB449	Request							
DBB450 to DBB469	Array, structure/data type according to data, to be read as per bytes 1 to 4 of this structure (e.g. a program record or max. 5 MD items)							

Table 6-7 User Data Block (AW-DB), continued

AW-DB	FM 453 and Channel Signals							
Byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Coupled-axis grouping status								
DBB470	Coupled-axis grouping status							
DBB471	Reserved for coupled-axis grouping							
DBB472 bis DBB485	Reserved							
Measured values								
Measured values as per POS_MSRM block call								
DBD486	Initial value or on-the-fly measured value (data type DINT)							
DBD490	Final value (data type DINT)							
DBD494	Measured length value							
Array for operator control/monitoring								
Operator control and monitoring								
DBB498	Volt./freq. levels transferred	Speed levels transferred	Increm. dim. transferred	Teach-in transferred	Prog. sel. transferred	MDI block transferred	Read MD	Write MD
DBB499	Operator/ traversing error	Data error	Diagnostic interrupt			Zero offset transferred	Set actual value transferred	MDI block transferred on-the-fly
DBW500	MD number							
DBD502	MD value (data type DINT)							
DBB506	Incremental dimension number							
DBB507	Reserved							
DBW508	Display number							
DBW510	Keyboard code							
DBW512	Reserved							
Operating mode selection								
DBB514		Jog mode	Auto mode	Auto/single block mode	MDI	Increm. mode (relative)	Approach to ref. point	Open-loop control mode
DBB515	Acknowledge diagn. interrupt	Acknowl. error						

Note

For a list of symbolic signal identifiers see the UDT 1 block in the “FMSTSV_L” library.

6.6 Sample Applications

Overview

This chapter provides information on the following:

- Basic example for setting the operating mode
- Example 1: Moving axes in "JOG mode" and " Approach to reference point mode"
- Example 2: Traversing an MD block
- Example 3: "Automatic" mode with program selection
- Example 4: Technology example for embedding OPs

General remarks

The sample project **"zEn17_02_FM453_EX"** ([STEP7 directory]\EXAMPLES\zEn17_02) is installed upon installation of the FM 453 configuring package.

The relevant technological functions (POS_CTRL, POS_DIAG, POS_INIT) are called in the OB 1, OB 82 and OB 100 blocks. DB 100 (DBEX) contains the relevant user signals/user data for all application examples.

Each example is programmed as a block (e.g., example 1 = FC 101, etc.). In The basic example (FC 100) is always necessary for the examples 1 to 3; it sets the relevant modes and copies the data between DB 1 and DB 100.

The examples 1 to 3 are interdependent. They are technologically simple examples which you can expand to suit your particular needs. To be able to use the functions provided by the examples 1 to 3, call the relevant examples in OB 1 analogous to example 1.

OB 1 contains an example after the call of POS_CTRL how the evaluation of the reported errors of the POS_CTRL could be programmed. You can expand this error evaluation accordingly if you want.

Example 4 requires the **OB_example4** source file specified in the source folder to be compiled. Since this is an application example for use of an OP, only example 4 should be called in OB 1, as not to overwrite data.

Note

In the examples, the axes do not traverse in simulation mode!

Because "DBEX" is a retentive DB, it is initialized in the start/restart routine (OB 100). If this is not required, simply delete the initialization section of OB 100 (network "DBEX Initialization").

Basic example for setting the operating mode

This example is always required for sample applications 1 to 3.

Open sample project “zEn17_02_FM453_EX” in the SIMATIC Manager with **File > Open... > Projects**. The block for this example is FC 100.

You will find the signals in “DBEX”.

This example must always be called. It sets the operating modes according to the user’s specifications, evaluates the mode status signals, and displays the current mode. The checkback signals required for the examples will be copied into “DBEX”.

In order to use the “Jog” or “Reference point approach” mode in Example 1, the user has to set the relevant mode code in byte MODE_IN of “DBEX” (01 for “Jog”, 03 for “Reference point approach). When “Jog” mode is selected, mode parameter 01 (MODE_TYPE) is additionally set for activating speed level 1 in “Jog” mode.

Mode	**Code**
Jog	01
Reference point approach	03
MDI	06
Auto	08

In Example 2, you must set “MDI” mode (mode coded in byte MODE_IN = 06).

In Example 3, you must set “Auto” mode (mode coded in byte MODE_IN = 08).

The active mode is displayed in byte MODE_OUT in the relevant code.

To restart the module (e.g. after diagnostic interrupt), bit RESET_AX must be set in “DBEX”. The example will then set bit RESET_AX in “AW-DB”. A restart will be initiated and bit RESET_AX reset in “DBEX”.

In order to work with the following examples, you must set the mode required for each.

Example 1

Open sample project “zEn17_02_FM453_EX” in the SIMATIC Manager with **File > Open... > Projects**. The block for this example if FC 101.

The signals are in “DBEX”. The signals relevant for Example 1 only are in structure “EX1”.

The Drive Enable and the Controller Enable for the axis are set in “DBEX” (OB 100: DRV_EN = TRUE, SERVO_EN = TRUE) and are transferred to the interface (AW-DB) in Example 1.

In order for the example to function, you must first set either “Jog” mode (mode code 01) or “Reference point approach” mode (mode code 03) in byte MODE_IN of the “DBEX”. The respective mode checkback signal is flagged in byte MODE_OUT.

The traversing movements are shown in bits “GO_M” = TRUE (traverse -axis 1) or “GO_P” = TRUE (traverse + axis 1).

“Jog” mode active:

Once a mode has become active, the Write request “VLEV_EN” (AW-DB, transfer speed level 1, 2) is executed once. If you want to transfer it again, you must either reset the “VLEV_D” bit (status/checkback signal from the request) or set the “JOBRESET” (reset status/error) in AW-DB.

If you set bit “DIR_M” (minus direction) or bit “DIR_P” (plus direction) to TRUE in “DBEX”, the axis is moved in either a negative or positive direction.

“Reference point approach” mode active:

When you set the “START” bit to TRUE, the axis is moved in a negative or positive direction (depending on the machine data initialization) until the reference point is located. If the reference point approach was successful, the axis is synchronized (SYNC=TRUE).

If an operator or traverse error occurred, this is flagged by bit “OT_ERR” = TRUE. An error can be acknowledged by setting bit “OT_ERR_A” to TRUE.

Note:

Variable table 1, which contains all the relevant signals for monitoring and controlling Example 1 (“control and monitor variable” tool), is located in the “Blocks” directory.

Example 2

Open sample project “zEn17_02_FM453_EX” in the SIMATIC Manager with **File > Open... > Projects**. The block for this example is FC 102.

The signals are in “DBEX”. The signals relevant for Example 2 only are in structure “EX2”.

The Drive Enable and the Controller Enable for the axis are set in “DBEX” (OB 100: DRV_EN = TRUE, SERVO_EN = TRUE), and are transferred to the interface (AW-DB) in Example 2.

In order for the example to function, you must set the “MDI” mode. Enter “MDI” mode (mode code 06) in the MODE_IN byte of “DBEX”. The relevant mode checkback signal is flagged in byte MODE_OUT.

Once the mode has been successfully set, a default MDI block is automatically transferred to the module (MDI network) when Write request “MDI_EN” has been set in “AW-DB” (transfer MDI block). This block can be changed in dependence on the system and the request. If it is to be retransferred, you either have to reset the “MDI_D” bit in “AW-DB” (status/checkback signal for request) or set bit “JOBRESET” (reset status/error).

Set the “START” bit in “DBEX” to TRUE in the “EX2” structure. The activated MDI block is started on the condition that the axis is synchronized and has a Start Enable. Then the “START” bit is reset. The MDI block cannot be restarted until the start enable is again available.

The block can be stopped by setting the “STOP” bit.
Only when the “STOP” bit has been reset to FALSE (and the “START” bit to TRUE) is a restart possible.

If an operator error or traversing error occurs, it is flagged by the “OT_ERR” bit (the bit is set to TRUE). The error can be acknowledged by setting the “OT_ERR_A” bit to TRUE.

Note:

Variable table 2, which contains all the relevant signals for monitoring and controlling Example 2 (“control and monitor variable” tool), is located in the “Blocks” directory.

Example 3

Open sample project “zEn17_02_FM453_EX” in the SIMATIC Manager with **File > Open... > Projects**. The block for this example is FC 103.

The signals are in “DBEX”. The signals relevant for Example 3 only are in structure “EX3”.

The program to be selected in the Example has the program number “10”. This program number is entered in Example 3.

The Read Enable, the Drive Enable, and the Controller Enable for the axis are set in “DBEX” (OB 100: READ_EN = TRUE, DRV_EN=TRUE, SERVO_EN=TRUE), and are transferred to the interface (AW-DB) in Example 3.

Prerequisite for successful program selection is the availability of that program in the FM.

In order for the example to function, you must set “Auto” mode. Set the “AUTO” mode (mode code 08) in byte MODE_IN of “DBEX”. The relevant mode checkback signal is flagged in byte MODE-OUT.

Following successful mode selection, the program with the number “10” is automatically selected by setting Write request “PROGS_EN” in “AW-DB”.

Set the “START” bit in “DBEX” to TRUE in structure “EX3”. The selected program is started, assuming that the axis is synchronized and has a Start Enable. Then the “START” bit will be reset.

The program can be stopped by setting the “STOP” bit. It can be restarted by resetting the “STOP” bit to FALSE (and the “START” bit to TRUE).

If an operator error or traversing error occurs, it is flagged in the “OT_ERR” bit (the bit is then TRUE). The error can be acknowledged by setting bit “OT_ERR_A” to TRUE.

Note:

Variable table 3, which contains all the relevant signals for monitoring and controlling Example 3 (“control and monitor variable” tool), is located in the “Blocks” directory.

Example 4

Open sample project “zEn17_02_FM453_EX” in the SIMATIC Manager with **File > Open... > Projects**. The block for this example is FC 104. Use OB 1, which is created after compiling the source file **OB_example4** in the source folder.

In this example, the HMI interface signals for the data range from DBB 498 through DBB 515 are transferred to the interface area for the control signals, e.g. the modes (see Section 8.2).

You can trigger write and read jobs by assigning the data fields to be transferred the appropriate parameters and data.

For example, if you select the machine data screen PIC_763, you can write an MD using the ”set” softkey (SK) and read an MD using the ”read” softkey (SK).

Once you have selected the mode screen PIC_75 on the operator panel and selected the appropriate mode SK, the selected mode will be accepted into the control signals of the interface, and the appropriate mode will be set.

If you select the diagnostic screen PIC_77, you can acknowledge an error by pressing the ”Quit” SK or acknowledge a diagnostic alarm by pressing the ”Res” SK.

In this way, all interface signals which can be activated by the OP are requested. You can assign default values to all data fields and transmit trigger pulses for the jobs to be executed.

Structure of “DBEX” (DB 100)

```
DATA_BLOCK "DBEX"

STRUCT                             // *** General signals ***
  ERR_CODE_INIT   : INT;           // Error code for POS_INIT
  ERR_CODE_CTRL   : INT;           // Error code for POS_CTRL
  ERR_CODE_DIAG   : INT;           // Error code for POS_DIAG
  OVERRIDE        : BYTE;          // Override
  MODE_IN         : BYTE;          // Mode setting (coded)
  MODE_OUT        : BYTE;          // Mode setting (coded)
  DRV_EN          : BOOL;          // Drive Enable
  SERVO_EN        : BOOL;          // Controller Enable
  OT_ERR_A        : BOOL;          // Acknowledgement for operator/traversing error
  RESET_AX        : BOOL;          // Restart
  DIAG_RD         : BOOL;          // Start of FC POS_DIAG
  PARA            : BOOL;          // Initialized
  SYNC            : BOOL;          // Synchronized
  START_EN        : BOOL;          // Start Enable
  POS_ROD         : BOOL;          // Position reached, Stop
  WORKING         : BOOL;          // Execution in progress
  GO_M            : BOOL;          // Traverse in negative direction
  GO_P            : BOOL;          // Traverse in positive direction
  OT_ERR          : BOOL;          // Operator-/traversing error
  DATA_ERR        : BOOL;          // Data error
  INIT_ERR        : BOOL;          // Error in POS_INIT
  DIAG_ERR        : BOOL;          // Error in POS_DIAG
  MINUS1          : BOOL;          // "MINUS1" error in POS_CTRL
  MINUS2          : BOOL;          // "MINUS2" error in POS_CTRL
  MINUS3          : BOOL;          // "MINUS3" error in POS_CTRL
  EX1: STRUCT                      // *** Signals for EXAMPLE 1 ***
    DIR_M         : BOOL;          // Negative direction
    DIR_P         : BOOL;          // Positive direction
    START         : BOOL;          // Start
    STOP          : BOOL;          // Stop
  END_STRUCT;
  EX2: STRUCT                      // *** Signals for EXAMPLE 2 ***
    START         : BOOL;          // Start
    STOP          : BOOL;          // Stop
  END_STRUCT;
  EX3: STRUCT                      // *** Signals for EXAMPLE 3 ***
    START         : BOOL;          // Start
    STOP          : BOOL;          // Stop
    READ_EN       : BOOL;          // Read Enable
  END_STRUCT;
END_STRUCT
BEGIN
END_DATA_BLOCK
```

6.7 Error List, System Messages (CPU)

The Table below lists some of the errors which occur during data transfer with the internal SFCs (RET_VAL in SFCs 51, 58 and 59; system messages) (see the Reference Manual entitled *System Software for S7-300/400; System and Standard Functions*).

Table 6-8 Error List

Error Code (AW-DB, DBW66)			Description
HEX	DEC	INT	
0	0	0	No errors
8081	32897	–32639	Length of “DR” field insufficient
8082	32898	–32638	SZL_ID invalid or not in CPU
8083	32899	–32637	Invalid INDEX
8084	32900	–32636	SZL can not be called via SFC
8085	32901	–32635	Information currently unavailable (caused by system)
80A0	32928	–32608	Negative acknowledgement when reading from module. Module removed during Read operation or module defective.
80A1	32929	–32607	Negative acknowledgement while writing to module. Module removed during Write operation or module defective.
80A2	32930	–32606	DP protocol error in layer 2 (data transfer over Profibus-DP interrupted, e.g. due to wirebreak, missing terminating resistor connector, parameter assignment error, etc.)
80A3	32931	–32605	DP protocol error in user interface/user (data transfer over Profibus-DP interrupted, e.g. due to wirebreak, missing terminating resistor connector, parameter assignment error, etc.)
80A4	32932	–32604	Communication problem on K (communication) bus
80B1	32945	–32591	Length specification invalid
80B2	32946	–32590	The configured slot is not occupied.
80B3	32947	–32589	Actual module type not the same as setpoint module type
80C0	32960	–32576	Module does not yet have the data to be read available
80C1	32961	–32575	Data from an identical Write job have not yet been processed on the module
80C2	32962	–32574	Module is currently servicing the maximum possible number of requests
80C3	32963	–32573	Needed resources (such as memory, etc.) are currently in use
80C4	32964	–32572	Communications error
80C5	32965	–32571	Distributed I/O not available
80C6	32966	–32570	Priority class abort (restart or background)
8522	34082	–31454	DB too short. The data cannot be read out of the DB (Write request)
8532	34098	–31438	DBs too long (Write request)
853A	34106	–31430	No DB (Write request)

Table 6-8 Error List, continued

Error Code (AW-DB, DBW66)			Description
HEX	DEC	INT	
8544	34116	–31420	Error on the n-th (n > 1) attempt to read a DB following the occurrence of an error (Write request)
8723	34595	–30941	DB too short. The data cannot be written to the DB (Read request).
8730	34608	–30928	DB write-protected in the CPU. Data cannot be written to the DB (Read request).
8732	34610	–30926	Number of the DB out of range (Read request)
873A	34618	–30918	No DB (Read request)
8745	34629	–30907	Error on the n-th attempt (n > 1) to write to a DB following the occurrence of an error (Read request)
Errors 80A2 to 80A4 and 80Cx are temporary, that is to say, they can be eliminated without your intervention after a certain period. Messages in the form 7xxx indicate the temporary communication status.			

6.8 Technical Specifications

Memory requirements

The Table below provides an overview of the memory requirements for the blocks and the user data block (AW-DB). All values are rounded.

Table 6-9 Memory Requirements for the FCs and User Data Block

No.	FC	Block in Bytes	MC7 Code in Bytes	Local Data in Bytes
0	POS_INIT	250	142	4
1	POS_CTRL	3 394	2 964	22
2	POS_DIAG	310	186	46
3	POS_MSRM	286	176	20
4	AW-DB	1 884	516	–

Execution times for the blocks using the following example

The times are rounded.

Configuration: CPU 413-2DP, FM 453 in Simulation mode

User cycle time: Approx. 7 ms

FM cycle: 3 ms

Table 6-10 Execution Times for the FCs

Block	Transfer	Cycle 1	Cycle 2	Cycle 3
POS_CTRL	Write control-/status signals without data	0.9 ms	–	–
	Write control-/status signals with data	1.0 ms	2.6 ms	1.0 ms
POS_CTRL	Read control-/status signals with data	2.5 ms	–	–
POS_DIAG	Read process and diagnostic data	2.2	–	–

Starting up the FM 453

7

Chapter Overview

Overview

This Chapter introduces you to the user interface for testing and start-up, and provides check lists for starting up the positioning module. The checklists will help you:

- Check all steps until the module is running.
- Prevent malfunctions of the module once it is in operation.

You are guided through start-up of the machine axes.

7.1 Installation and Wiring

Installation Information

You can find information about how to install your module:

- In Chapter 3 of this manual
- In the manual *S7-400/M7-400 Programmable Controller, Hardware and Installation*

Wiring Information

You can find information about how to wire your module:

- In Chapter 4 of this manual
- In the manual *S7-400/M7-400 Programmable Controller, Hardware and Installation*

Checklist

The checklist below will help you check important steps in the installation and parameterization of the FM 453 positioning module.

Table 7-1 Installation and Wiring Checklist

Step	Check	What to Do:	OK ✓
1	Slots	Plug the module into one of the suitable slots.	
2	Shielding	Check the shielding of the FM 453 positioning module: • To ensure proper shielding, the module must be screwed down firmly on the rack. • The shielding for shielded lines must be connected to the shielding terminal element. • The shielding for the setpoint cable should not be grounded on the drive-unit end.	
3	Hardware limit switches	Check the start/stop hardware limit switches. The hardware limit switch connections must be connected to the power section. The start/stop hardware limit switches should not be connected to the digital inputs.	
4	Parameterization	Make sure the FM 453 positioning module setup is consistent with the parameterization. Check in particular that: • The attached encoder matches the machine data. • The wiring of the digital I/O modules matches the machine data.	

7.2 Initial Values for Testing and Optimization

Parameterization Information

You can find information about parameterization:

- In Chapter 5 of this manual
- In the on-line help in “Parameterize FM 453”

Overview

The following opening display appears in the “Parameterize FM 453” tool:

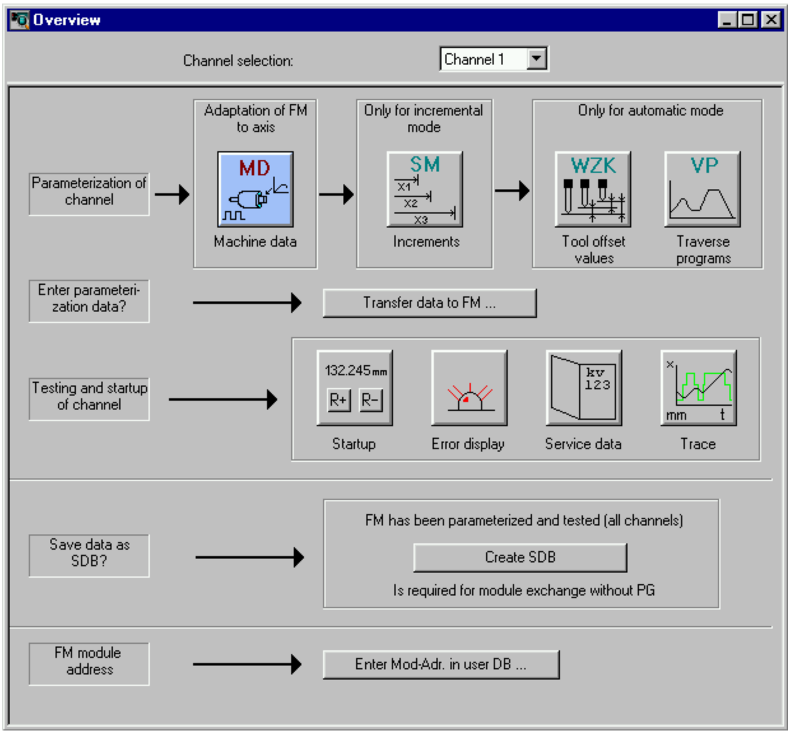


Fig. 7-1 Overview Display for Parameterization and Start-up

You can return to this display at any point during parameterization by selecting the menu **View > Overview**.

As it is written to the FM 453, the DB-MD is checked for the input limits of the individual values and their interdependencies. It is then stored only if all values are allowed. Otherwise data error messages are displayed by way of the MPI. A defective DB will not be retained when the power is turned off.

Checklist

Despite the “acceptance” testing just mentioned, the ultimate responsibility for the accuracy of all machine data lies with the module user. So it is highly advisable to perform startup using the following checklist.

Table 7-2 Parameterization Checklist

Step	Check	What to Do:	**OK** ✓
1	Machine data	**Set initial machine data contents** As shown in Table 5-4 machine data are subdivided into configuration data (**K**) and setting data (**E**). K data indicates how the FM 453 is connected to the machine axis or CPU user program, and must therefore already be fully set up before startup begins. When specifying the MD52 (number of increments per motor revolution) for step drives with adjustable increment number, select the one with which your maximum frequency (at maximum axis speed provided) reaches the next lowest value below the FM 453’s maximum frequency of 1 MHz. E data is intended for changes during startup, and serves to optimize FM 453 response for the technological process of positioning. The values in Table 7-3 are recommended, and sometimes necessary, as initial settings. **Initial machine data assignments for FM STEPDRIVE** To help you start up your machine axis with FM STEPDRIVE and the SIMOSTEP motors, you will find the MD DBs for open-loop control mode in the directory **[STEP7 directory]\EXAMPLES\FM453\MD** : • SIMOSTEP 2 si02_453.md • SIMOSTEP 4 si04_453.md • SIMOSTEP 6 si06_453.md • SIMOSTEP 10 si10_453.md • SIMOSTEP 15 si15_453.md These machine MD DBs achieve optimum operation assuming $I_{Load} = I_{Mot}$ $M_{Load} = 0.1 \cdot M_{Rated}$ $n_{max} = 2\,000\ min^{-1}$ You **must** optimize the machine data in accordance with the physical and technological conditions of your machine axis.	
2	Increments	Increments are only needed for the “Relative incremental” mode. For the next part of the startup procedure it is helpful to set up an “Increments” data block (DB-SM) with the following values: Value 1 1 MSR Value 2 10 MSR Value 3 100 MSR Value 4 1,000 MSR Value 5 10,000 MSR with rotary axes: Value 6 1 rotary-axis cycle (MSR) MSR = measurement-system grid	

Table 7-2 Parameterization Checklist, continued

Step	Check	What to Do:	OK ✓
3	Tool offset data	Tool offset data is needed only for the “Automatic” mode and is not necessary for the startup described here. Generally, it is not needed until you start up the user program on the S7-400 CPU.	
4	Traversing programs	Traversing programs are needed only for the “Automatic” mode and are not necessary for the startup described here. Generally, it is not needed until you start up the user program on the S7-400 CPU.	
5	Create SDB ≥ 1 000	When you have completed **all start-up actions** on the FM 453 and your plant, create, save and load SDB ≥ 1 000 into the CPU/onto the memory card of the CPU. All the parameter data (DBs) of the FM 453 (all 3 channels) are stored in SDB ≥ 1 000. This SDB allows you to replace the FM 453 module in the event of a fault, and to download the parameters without a programming device/PC.	

Note

The measurement system (MD7) must match the measurement system specified in the other DBs.

The measurement system raster (MSR) is the smallest distance unit in the active system of measurement.

If at some point you have failed to take this precaution:

1. Delete all data blocks of the relevant channel (which do not match the measurement system) or clear the memory of the FM 453 completely.
2. Modify the other data blocks on the programming device.
3. Reload the data blocks to the FM 453.

Initial Contents of MD

The table below shows you what initial contents are recommended or required for the E machine data at startup of the machine axis.

Enter the machine data in the tab windows in accordance with the control mode (MD61) as shown in the following table.

Table 7-3 Initial Contents of Machine Data

MD (E)	Value/Meaning	Explanation	MD61			OK ✓
			0	1	7	
5	0	Channel triggers no process interrupts	+	+	+	
21/22	$-10^9/+10^9$ [MSR]	Software limit switches inactive	+	+	+	
23[1)]	v_{max} = 10...5 · 10^8 (MSR/min)	Specified maximum speed	+[1)]	+	+	
24	1 000 [MSR]	Large PEH target range	+	+	+	
25	0	PEH time monitoring switched off	+	+/–	–	
26	1 000 000 [MSR]	Zero speed range monitoring set to maximum value	+	+/–	–	
27	0	Reference-point shift (incremental encoders only), readjustment value (see Section 7.3.7)	+	+	+	
28	$0.2 \cdot v_{max}$	20 % of maximum speed	+	+	+	
29	$0.1 \cdot v_{max}$	10 % of the maximum velocity (not for absolute encoders)	+	+	+	
30/31	0/0	Backlash compensation inactive	+	+	+	
38	1 000 [MSR/min/MSR]	Generally applicable position control loop gain	+	+	–	
39	0	Following-error monitoring inactive	+	+/–	–	
40/41	1 000/1 000[10^3MSR/s^2]	Mid-range acceleration values	+	+[2)]	–	
42	0	Jolt filter switched off	+	+	+	
43	U_{max} = 1,000...10,000 (mV)	Setpoint drive values for maximum velocity	+[1)]	–	–	
44	0	Offset value for drive setpoint	+	–	–	
45	0	Actuating signal ramp inactive	+	+	+	
46	100 [ms]	Minimum idle time between two positioning cycles	–	+	+	
47	100 [ms]	Minimum traversing time at constant frequency	–	+	+	
48	100	Boost duration absolute	–	+	+	
49	100	Boost duration relative	–	+	+	
50	100	Phase current travel	–	+	+	
51	100	Phase current idle	–	+	+	
54	f_{SS}	Start/Stop frequency	–	–	+[2)]	

1) This pair of values corresponds in the case of servomotors to the speed category of the drive. It serves as a basis for calculating the K_v factor in the servo, and must therefore be entered correctly.
Recommendation: So far as possible, U_{max} should be set in the range between 8 and 9 V.
2) Determined from the operating characteristic curve (see Section 7.3.2)
\+ Machine data is required.
– Machine data is not required.
+/– Machine data is required for axes with encoder / without encoder.

Table 7-3 Initial Contents of Machine Data, continued

MD (E)	Value/Meaning	Explanation	MD61			OK ✓
			0	1	7	
55	f_{eg}	Frequency value for acceleration switchover	–	–	+2)	
56	f_{max}	Max. frequency from drive configuration	–	+	+	
57 58 59 60		Acceleration values for power-up and braking	–	–	+2)	

1) This pair of values corresponds in the case of servomotors to the speed category of the drive. It serves as a basis for calculating the K_v factor in the servo, and must therefore be entered correctly.
Recommendation: So far as possible, U_{max} should be set in the range between 8 and 9 V.
2) Determined from the operating characteristic curve (see Section 7.3.2)
\+ Machine data is required.
– Machine data is not required.
+/– Machine data is required for axes with encoder / without encoder.

7.3 Testing and Optimization

Testing and optimization information

Once you have installed, wired and parameterized the unit, you can test and optimize your FM 453 positioning module. Testing and optimization can be performed with the aid of the testing and start-up interface with or without the user program.

You can also test individual modes and their traversing programs, and view and debug them during execution.

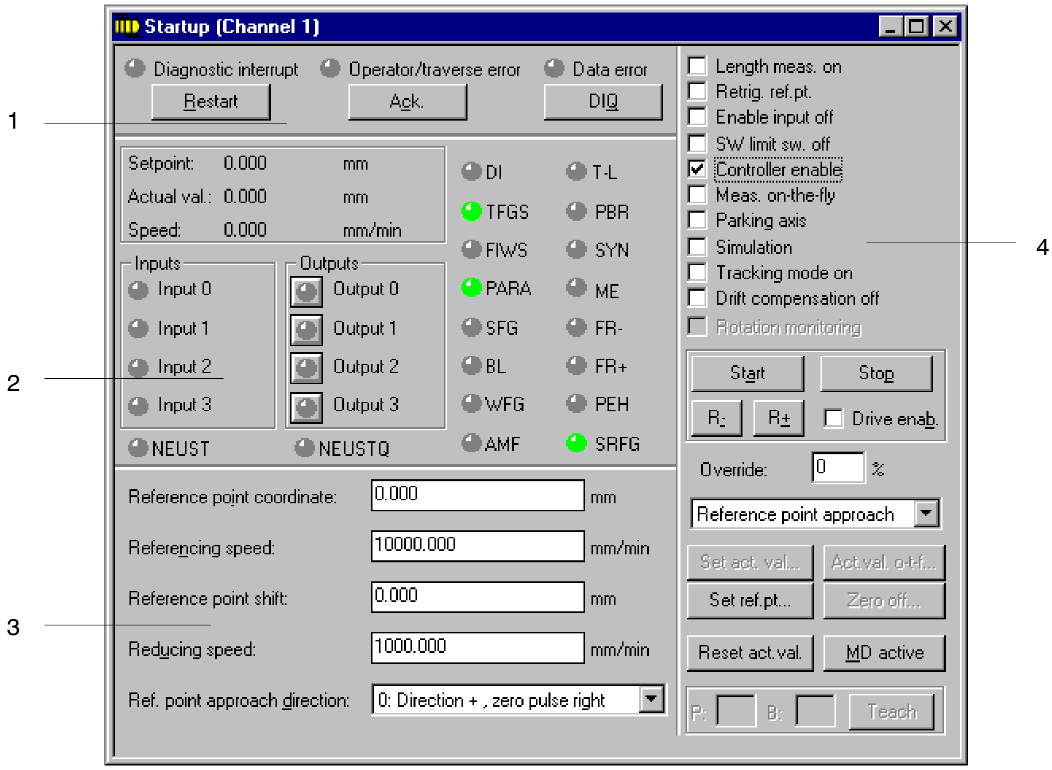
There are two ways of operating the FM:

- **CPU is in "STOP", test without user program**
- **CPU is in "RUN", test with user program**

  You can monitor the interface between the FM and the user program. You can also control the program from the start-up user interface when control signal [TFB] (TEST_EN) is enabled in the user program.

This interface is installed with "Parameterize FM 453". Once the FM 453 has been parameterized, you can call it up by selecting the menu **Test > Startup** or by selecting from the overview display.

When you call up this menu the following screen appears:



1 – Error field
2 – Status field (e.g. actual values, check-back signals)
3 – Field for mode-specific inputs
4 – Field for input of values/settings/commands and start/stop for movement

The abbreviations for the checkback signals are described in Table 9-2.

Bild 7-2 Startup Interface (e.g. for “Reference-point approach” mode)

Note

To start a movement, we recommend the following input sequence:

- Select a mode
- Turn simulation on (if you want an operating case)
- Servo enable
- Enable axis
- Override 1...100 %

You can operate the “R+” and “R–” buttons in the “jogging” mode as follows:

1. Select “R+” or “R-” with the mouse
2. Press the space bar

You can operate “Start” and “Stop” with the mouse, or with the space bar if you have already selected the button.

The digital outputs are not set in the “Stop” status of the CPU.

When you operate the following buttons, you will get dialog windows:

- Set actual value...
- Set actual value on-the-fly...
- Set reference point...
- Zero offset...

Warning

If you move the axis directly (without simulation), for safety’s sake make sure you can switch off the hardware if a hazard arises.

Note

If you use the start-up user interface to operate the FM 453 when the CPU is in “STOP”, and then switch the CPU to “RUN” and then immediately switch to the start-up interface in your user program by means of the [TFB] (TEST_EN) signals (e.g. if example application 3 is included in the user program), please note the following:

You must select the mode again from the start-up interface, or close the start-up interface and call it up again.

You can also call up the following screens:

The following display appears when you select **Test** > **Troubleshooting**:

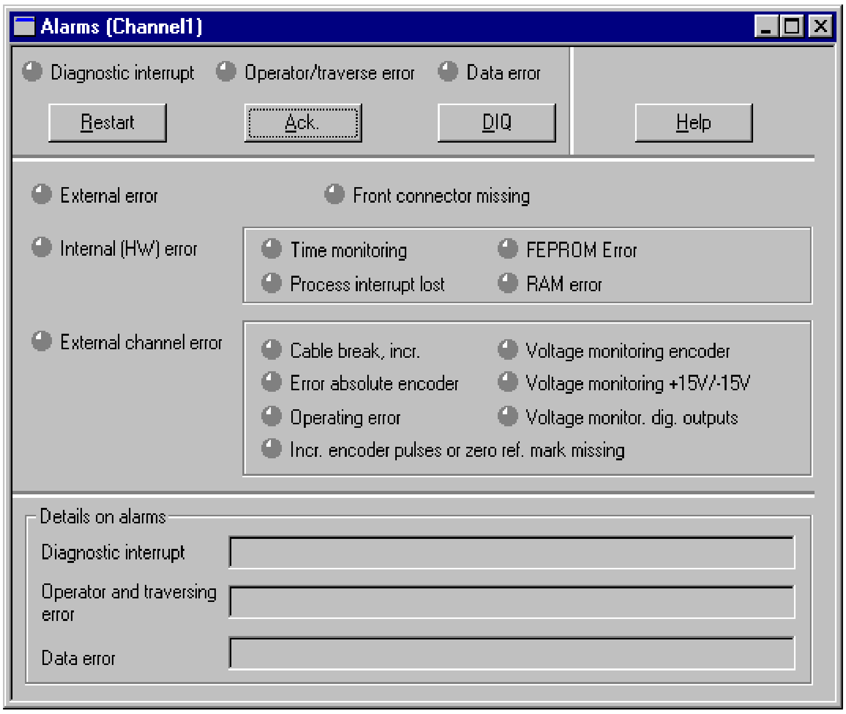


Fig. 7-3 Troubleshooting

The following display appears when you select **Test** > **Service data**:

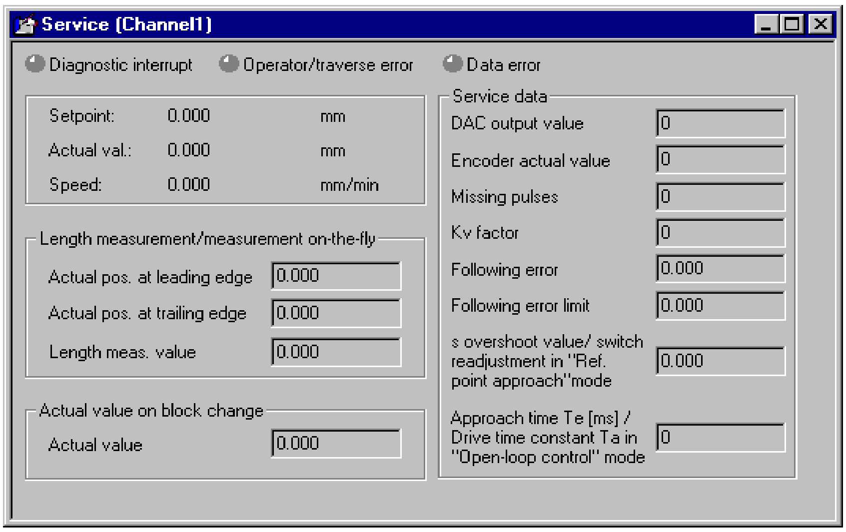


Fig. 7-4 Service Data

The following display appears when you select **Test** > **Trace**:

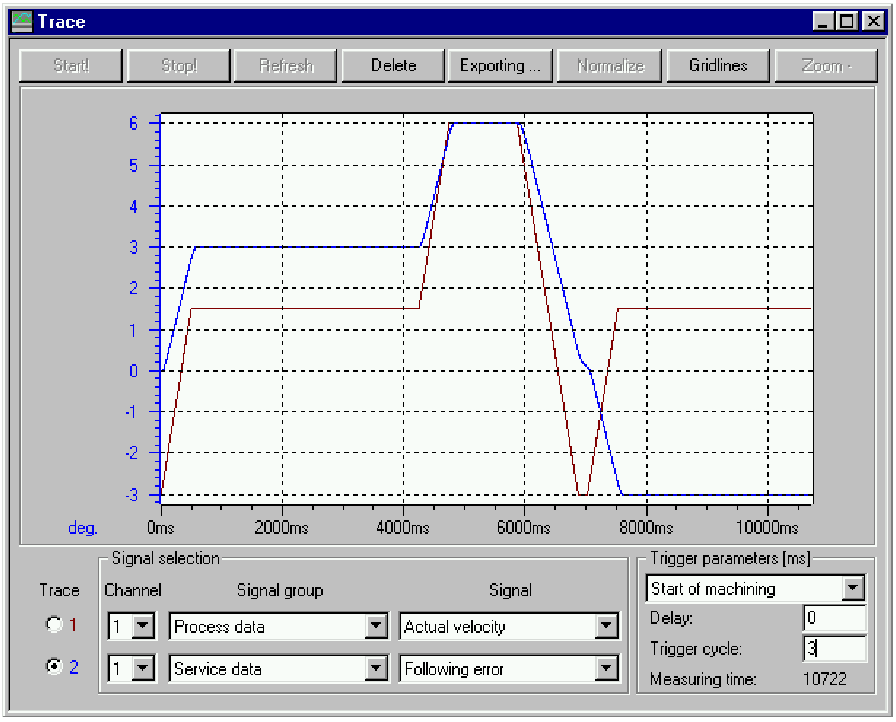


Fig. 7-5 Trace

Checklist

When starting up the machine axis, it is important to proceed step by step in a specified sequence. Depending on the parameterized control mode (MD16) and depending on your own application, certain steps have to be carried out as listed in the following table. It is important to note, in this context, the important role that the diagnostics functions (steps 10 to 12) play in safeguarding the functions of the FM 453 in interaction with your machine axis.

Table 7-4 Checklist - Startup of Machine Axis

Step	Check	What to do: See Section	MD61			**OK** ✓
			0	1	7	
1	Activation of machine data	7.3.1	+	+	+	
2	Evaluation of operating characteristic curves of the stepper motor	7.3.2	–	+	+	
3	Basic startup of stepper motor actuation	7.3.3	–	+	+	
4	Basic startup of servomotor actuation	7.3.4	+	–	–	
5	Monitoring of encoder actuation	7.3.5	+	+/–	–	
6	Startup of position controller	7.3.6	+	+	–	
7	Optimization of position controller	7.3.7	+	+	–	
8	Startup of stepper motor control	7.3.8	–	–	+	
9	Readjustment of reference-point coordinates	7.3.9	+	+	+	
10	Activation of position controller diagnostics	7.3.10	+	+/–	–	
11	Activation of stepper motor diagnostics	7.3.11	–	+	+	
12	Activation of software limit switches	7.3.12	+	+	+	
13	Activation of drift compensation	7.3.13	+	–	–	
14	Activation of backlash compensation	7.3.14	+	+	+	

\+ Startup step is necessary
– Startup step is not necessary
+/– Necessary for stepper motor with encoder / Not necessary for stepper motor without encoder

---

Note

In order for an axis to start, the start enable checkback signal must have been set.

If there is no start enable, this may be because:

- “Drive enable” is not set
- “Stop” is set
- “Operation in progress” is active

7.3.1 Activation of the Machine Data

Overview

The checkback signal PARA notifies you that a DB-MD has been retained. This machine data is automatically activated at power-up. The module's positioning functions are ready to operate.

If no DB-MD is present as yet on the FM 453 when the control is switched on, the module can only communicate by way of the MPI interface. The control signals are not processed by the FM 453. Once an error-free DB-MD has been transferred, the machine data is automatically activated, PARA is set and the control signals are processed.

If the FM 453 is working with activated machine data, you can transfer a new data block or individual parameters in modified form to the module and, if the entire DB-MD is error-free, put the new or modified data into effect by means of the ”Activate machine data” function provided that an operating mode is active (parameterizing tool ”Start-up display”).

The following approaches are possible:

- If only E data has been modified in the machine data record since the last activation, the equipment is activated with module status “Operation in progress” = 0, without interrupting the servo cycle. “SYN” is retained.
- If K data has also been modified in the machine data record since the last activation, activation takes place with module status “Operation in progress” = 0 by way of a cold restart of the servo, just as occurs for a power-up of the module. The instantaneous actual position is still displayed, but encoder pulses from incremental encoders might go unrecorded. “SYN” is reset.
- If the machine data record contains erroneous data at activation time, the function is rejected, with the “Machine data cannot be activated” error message (see Table 11-6, Class 2, No. 21).

7.3.2 Evaluating the Characteristics of the Stepper Motor

Overview

Basically, the stepper motor is a highly dynamic drive motor which is capable of following setpoint assignments more or less free of following error. It is also capable of handling the transition between idle time and movement (and back) by way of the start/stop frequency at a high rate of acceleration. This presupposes however, that the available motor torque at any given movement status, matches as a minimum, the torque necessary for executing the movement. In the following discussion, it is assumed that you are familiar with the necessary torque values for your particular application from the having conducted configuration of the drive. If necessary, refer to the formula or tabular material (e.g. Positec/Berger Lahr: [title translated: “Formulas + Computations for optimal stepper motor adjustment” [TN: available in English? If so, what is exact English title?] provided by the step drive manufacturers.

You can obtain optimal configuration of the speed profile for traversing movement when the speed-timing diagram, as shown in Figure 9-8, is well-defined.

You can determine the parameters for the speed profile, as shown in the following parameterization example, from the operating characteristic curves of the stepper motor you have in use. Always be sure to allow a torque reserve of approx. 20%.

Procedure

Determining the available or necessary torque:

$M_{Motor} = M_{Load} + M_{Accelerations}$

Determining the present moments of inertia:

$J_{Load} = J_{external\_rotational} + J_{external\_translational}$
$J_{total} = J_{Motor} + J_{Load}$

Assumed values from the parametering example:

M_{Motor} =	5 Nm	M_{Load} =	0.6 Nm (non-speed-dependent)
J_{Motor} =	$4\ kg \cdot cm^2$	J_{Load} =	$3\ kg \cdot cm^2$
f_{max} =	10 kHz	MD52 =	500 increments per revolution

Deceleration values are as acceleration values

Evaluation for open-loop controlled operation (MD61 = 7):

Proceed in accordance with the following instructions!

Evaluation for closed-loop controlled operation (MD61 = 1):

Proceed in accordance with the following instructions and

- In the evaluation algorithm (Figure 7-7), select the path “Parameterization of the velocity profile via simple ramp”
- Convert the accelerations computed for MD57 and MD59 as follows to MD40, MD41 and MD45:

Always	$MD40 = MD57 \cdot (MD11 + MD12 \cdot 2^{-32})/(1000 \cdot MD52)$
When MD59 = 0	MD41 = MD40
When MD59 ≠ 0	$MD41 = MD59 \cdot (MD11 + MD12 \cdot 2^{-32})/(1000 \cdot MD52)$
When MD40 ≤ MD41	MD45 = MD57
When MD40 > MD41	MD45 = MD59

Operating Characteristic Curve

Example of the operating characteristic curve of a stepper motor:

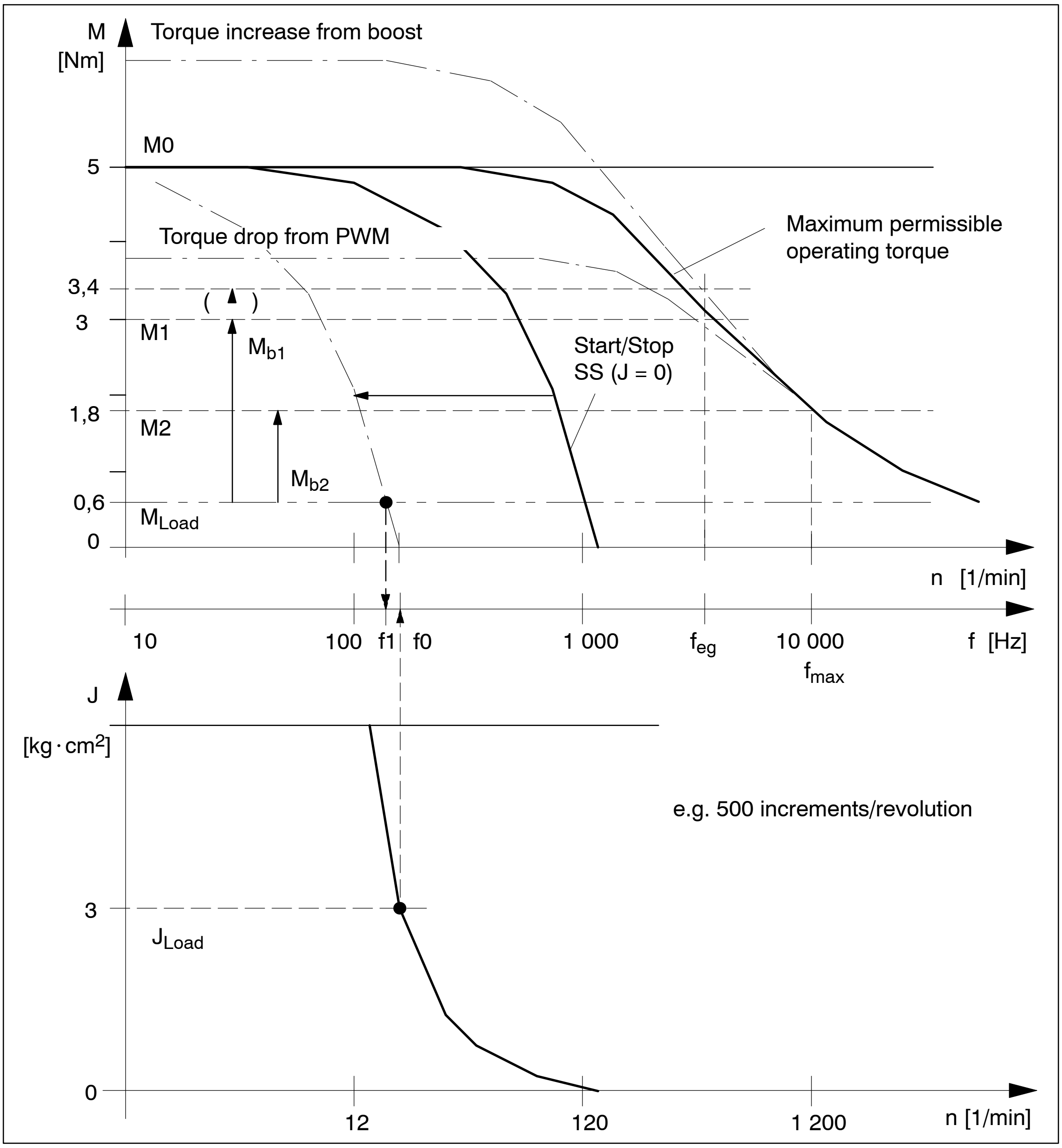


Fig. 7-6 Operating Characteristic Curve of the Stepper Motor

When you evaluate this example characteristic in accordance with the algorithm in Figure 7-7, you determine the following machine data:

MD54 = 100 Hz	Start/Stop frequency f_{ss}
MD55 = 3 000 Hz	Frequency value f_{eg}
MD57 = 218 000 Hz/s	Acceleration 1 ($f \leq f_{eg}$)
MD58 = 109 000 Hz/s	Acceleration 2 ($f > f_{eg}$)
MD59 = 0	Deceleration 1 = acceleration 1
MD60 = 0	Deceleration 1 = acceleration

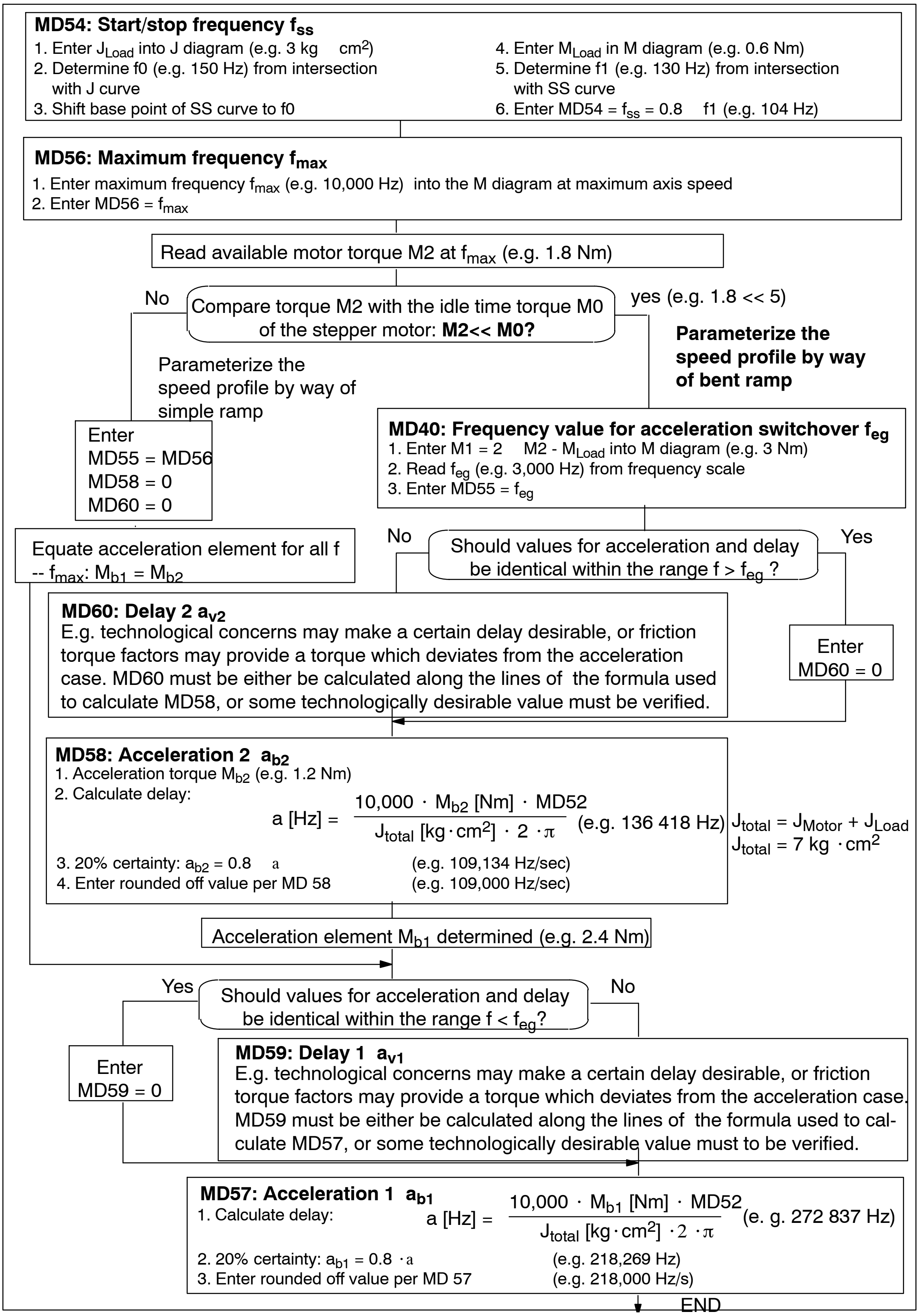


Fig. 7-7 Evaluation of Operating Characteristic Curves

Notes

Notes regarding special boundary conditions:

- It is evident from the above example that the acceleration torque within the lower speed range is approximately twice the value of the same value at maximum speed. This results in optimally-timed positioning cycles. Of course, the acceleration switchover is freely selectable in accordance within certain technological criteria. In this case the result is the value of the available motor torque M1 or M_{b1} according to the characteristic.
- In case your step drive features the "Current control through boost" function, you can count on the elevated curve for determining the acceleration torque. Any advantage from increased acceleration capability is realized from the torque curve only within the lower rpm range of the motor (e.g. M_{b1} = 3.4 Nm – 0.6 Nm = 2.8 Nm, M_{b2} unchanged).

  The following adjustments should be made:

  – electrical connection

  – MD37 (activation of the function)

  – MD48/49 (for monitoring of boost duration, see Section 7.3.9)
- In case your step drive features the "Current control through PWM" function, you can reduce the power loss converted in the motor, thereby reducing motor heating. This is possible because the acceleration torque is not needed. It is accomplished by reducing the motor current for idle and for constant travel phases proportional to the load torque. An advantage of reduced heating during constant travel becomes evident from the torque curve, particularly within the lower rpm range of the motor.

  The following adjustments should be made:

  – electrical connection

  – MD37 (activation of the function)

  – MD50 = (M_{Load} (f_{max}) : M_{Motor} (f_{max})) 100% (e.g. 60%)

  – MD51 = (M_{Load} (f = 0): M_{Motor} (f = 0)) 100% (e.g. 12%)

7.3.3 Basic Startup of Stepper Motor Actuation

Overview

The first step in the startup procedure for the drive is conducted to verify that the stepper motor will traverse as a matter of course in response to actuation by the FM 453 and therefore that the previously specified machine data are set correctly. This step is particularly important when the drive is implemented without an encoder, because undetectable positioning errors can result if increments are lost.

Use the following flow chart to verify the drive actuation and that the machine data determined so far are correct. A subsequent test should be conducted to verify that the stepper motor will traverse as a matter of course in response to actuation by the FM 453. A later test verifies that the positioning is correct (see Section 7.3.8).

Note

Always be sure to put MD modifications into effect with “Activate machine data.”

Caution

Before triggering any traversing movement, be sure to check that there is enough space for the axis to move in the desired direction.

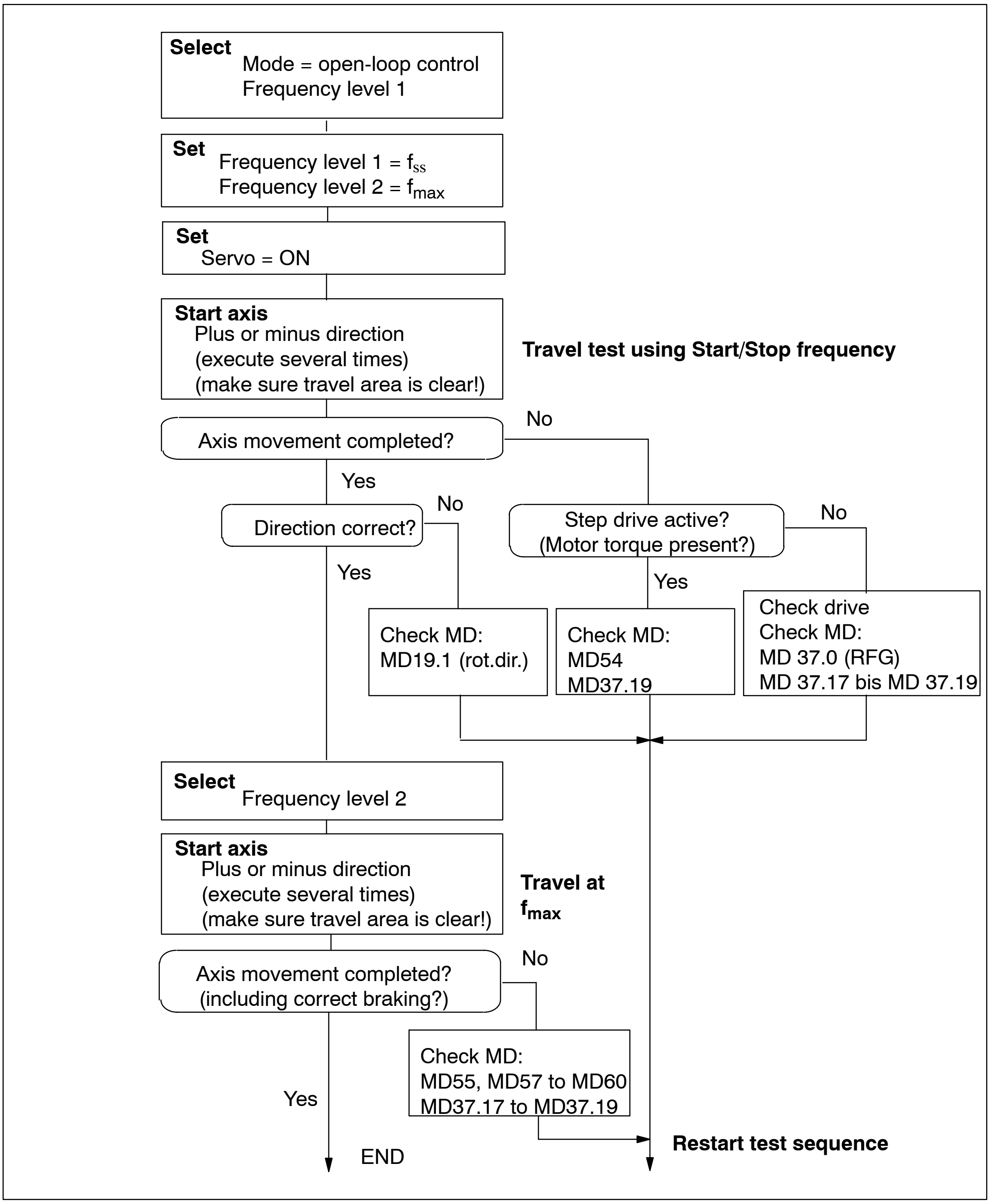


Fig. 7-8 Basic Startup of Stepper Motor Actuation

7.3.4 Basic Startup of Servomotor Actuation

Overview

With the following startup actions, you verify that the servo motor will traverse as a matter of course in response to actuation by the FM 453. You also determine the time constants of the servo drive that are required in later optimization steps for the servo position control.

Note

Always be sure to put MD modifications into effect with “Activate machine data.”

Caution

Before triggering any traversing movement, be sure to check that there is enough space for the axis to move in the desired direction.

Drive Actuation

You can use the following flow chart to check the actuation of the drive.

Note for the operator: Starting the axis

Start the axis with the “space bar” after preselecting the direction via R+ or R–.

The “Windows properties” allow for successive execution of the command (repeated starting/stopping of the axis) when the “space bar” is depressed in quick succession.

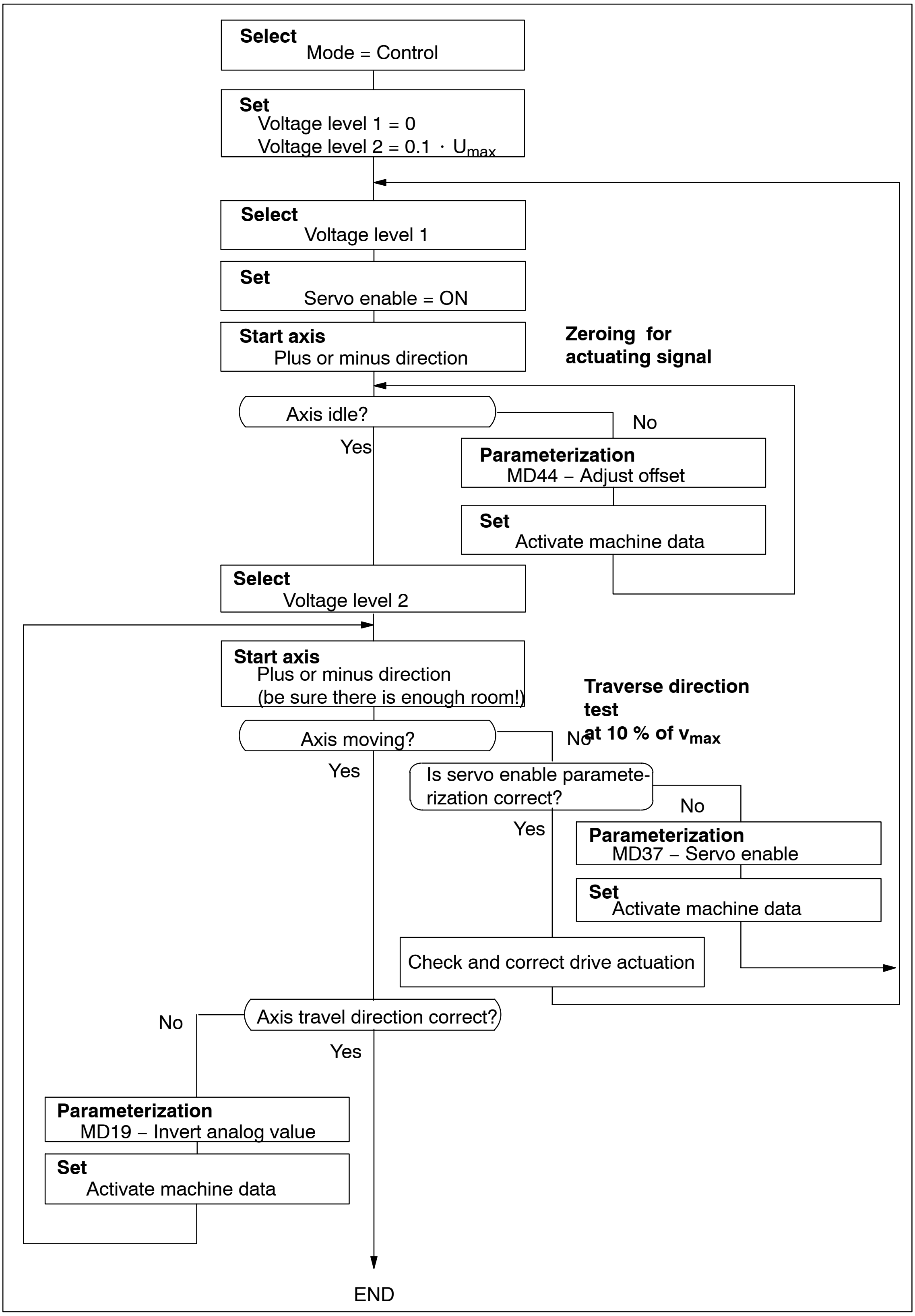


Fig. 7-9 Basic Startup of Servomotor Actuation

Drive Transition Time and Maximum Voltage Rise

For the following position-controller optimization, it is important to know the drive time constant (transition time). In open-loop control mode and on errors with the response "Everything Off" (see Section 11) the voltage value is fed to the drive by way of a ramp defined in MD45. A variety of drives, as well as certain mechanical or technological situations, may require a limitation on the voltage rise. If you do not have a specific value in hand and wish to find a suitable rise value by trial and error, please use the following procedure:

Note

A voltage rise setting will obviously make the axis stop more slowly if an "Everything Off" error response occurs.

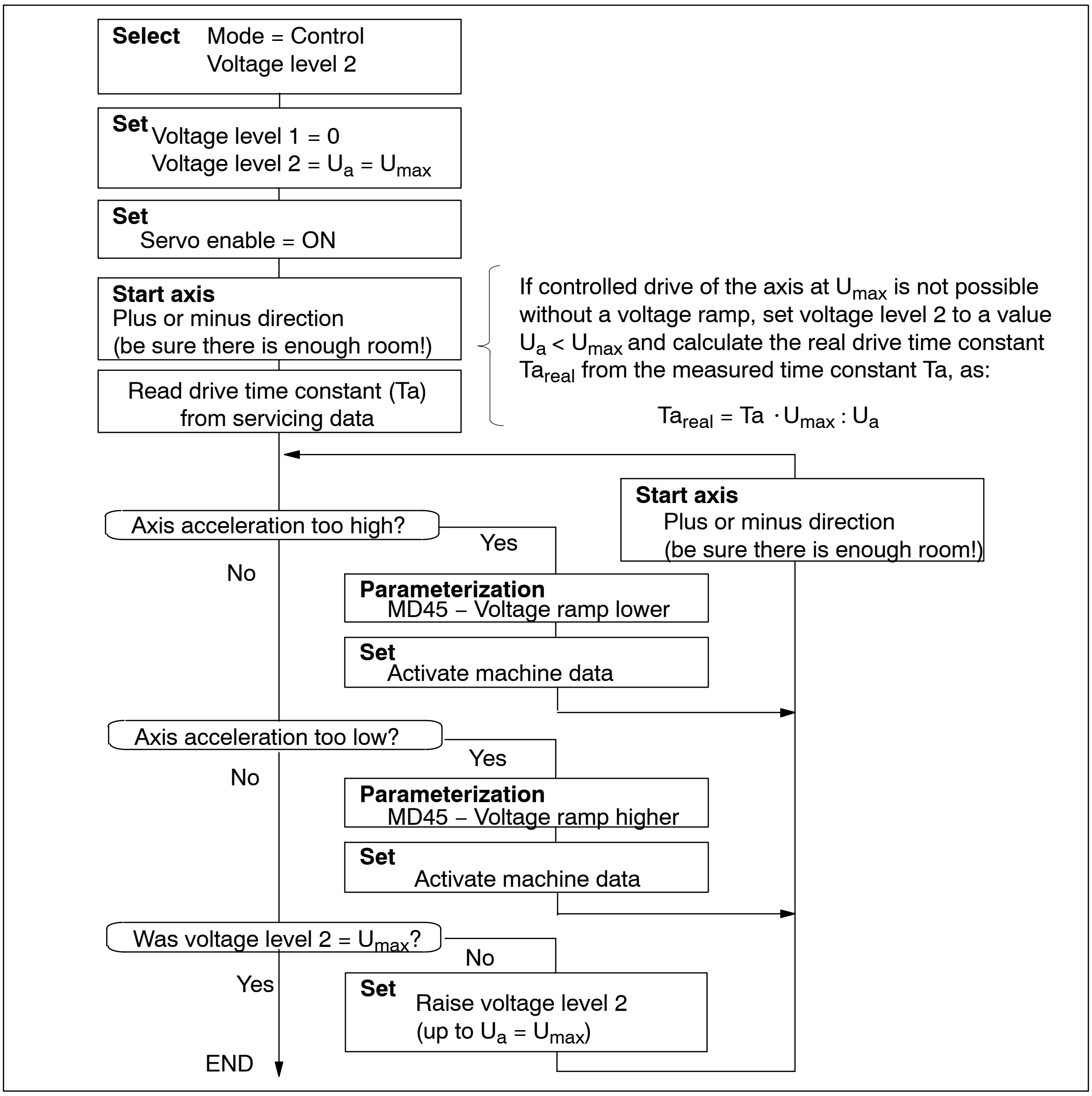


Fig. 7-10 Drive Transition Time and Maximum Voltage Rise

7.3.5 Checking the Encoder Actuation

Overview

You can use the following flowchart to check the encoder actuation.

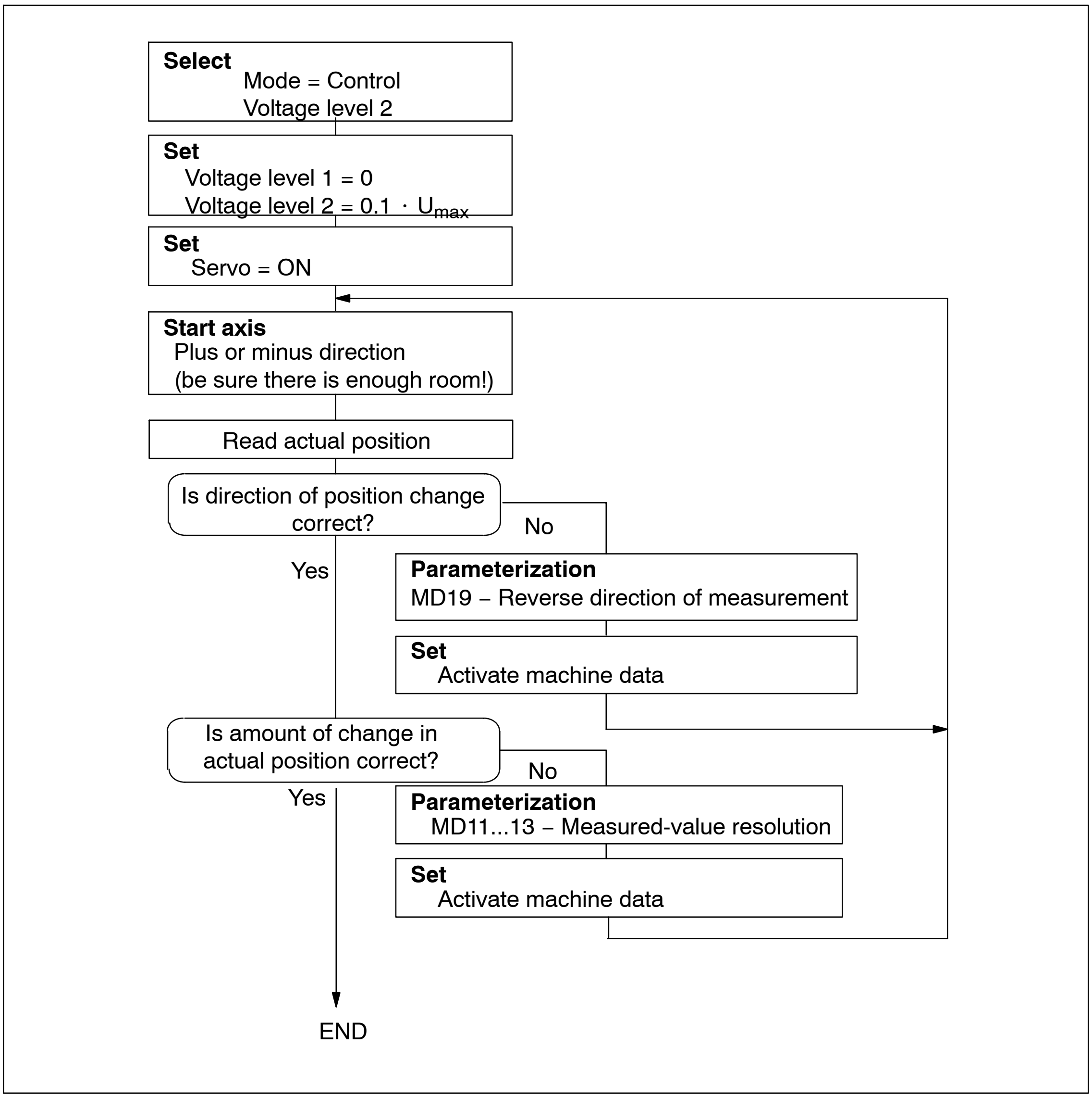


Fig. 7-11 Encoder Actuation

7.3.6 Startup of the Position Controller

Overview

By feeding back the measured displacement, a position controller closes the outermost loop of a controller cascade with the following structure:

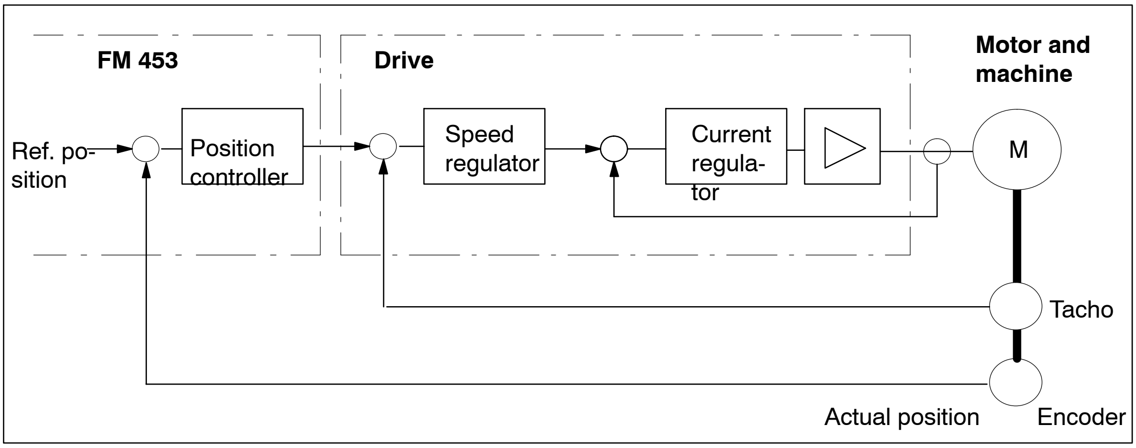


Fig. 7-12 Position Control Circuit with Servo Drive

With the following startup steps, you verify the basic functional capability of the position control. Optimization, in accordance with your technological criteria, is described in Section 7.3.7.

First check the basic functions

- Non-release control
- Speed assignment of servo drive
- Positioning

Special case:

In the control mode "Step drive in position control circuit" (MD61 = 1) without an encoder, the position control circuit is closed within the FM 453. The step drive itself is operated via open-loop control. The following tests are only partially relevant. Please refer to the associated notes.

Note

Always be sure to put MD modifications into effect with "Activate machine data."

Non-release Control

This test is only necessary when an encoder is used.

You can use the following flow chart to check the non-release control.

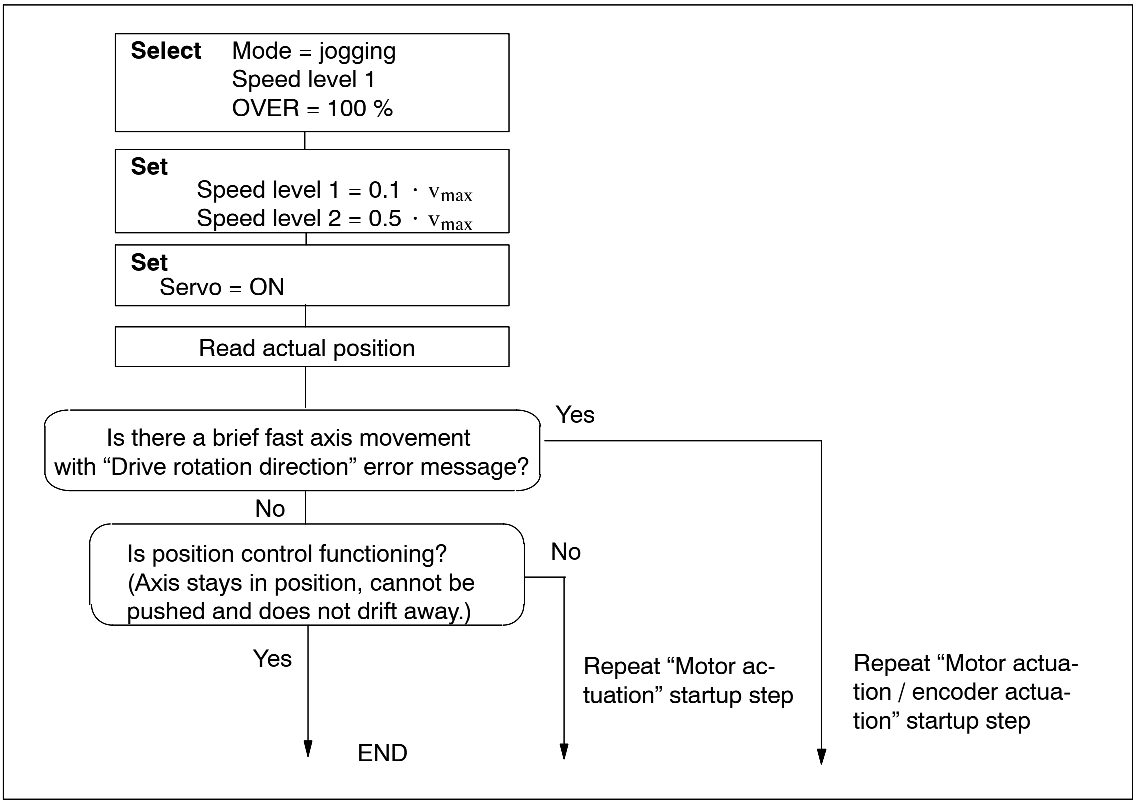


Fig. 7-13 Non-release Control

Speed Assignment of the Drive

This test is only necessary in the case of servo drives (MD61 = 0).

Use the following flow chart to check that the speed assignment of the drive corresponds to the parameterization in the machine data.

If you have carried out the “Check encoder actuation” startup step correctly, with each traverse, the actual traversing velocity of the machine axis will be shown on the “Velocity” display.

This test has to be conducted in order to ensure that the parameterized $K_V$factor is implemented with the correct value in the position control circuit. Fine calibration is then possible in the “Optimize position control” startup step with the aid of the K_V factor checkback signal in the service data.

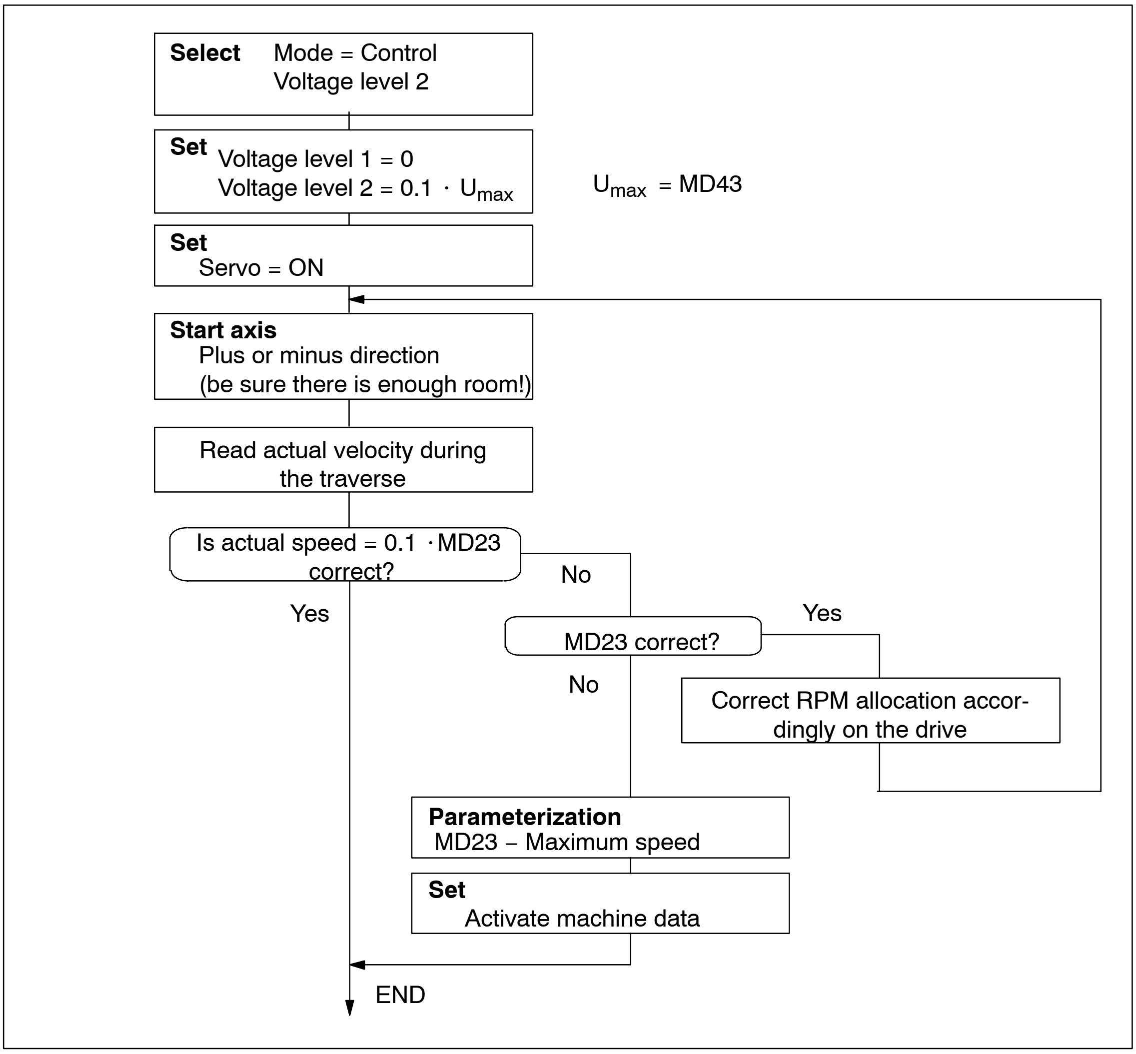


Fig. 7-14 Testing Speed Assignment

Positioning

Use the following flow chart to check axis travel to a target position.

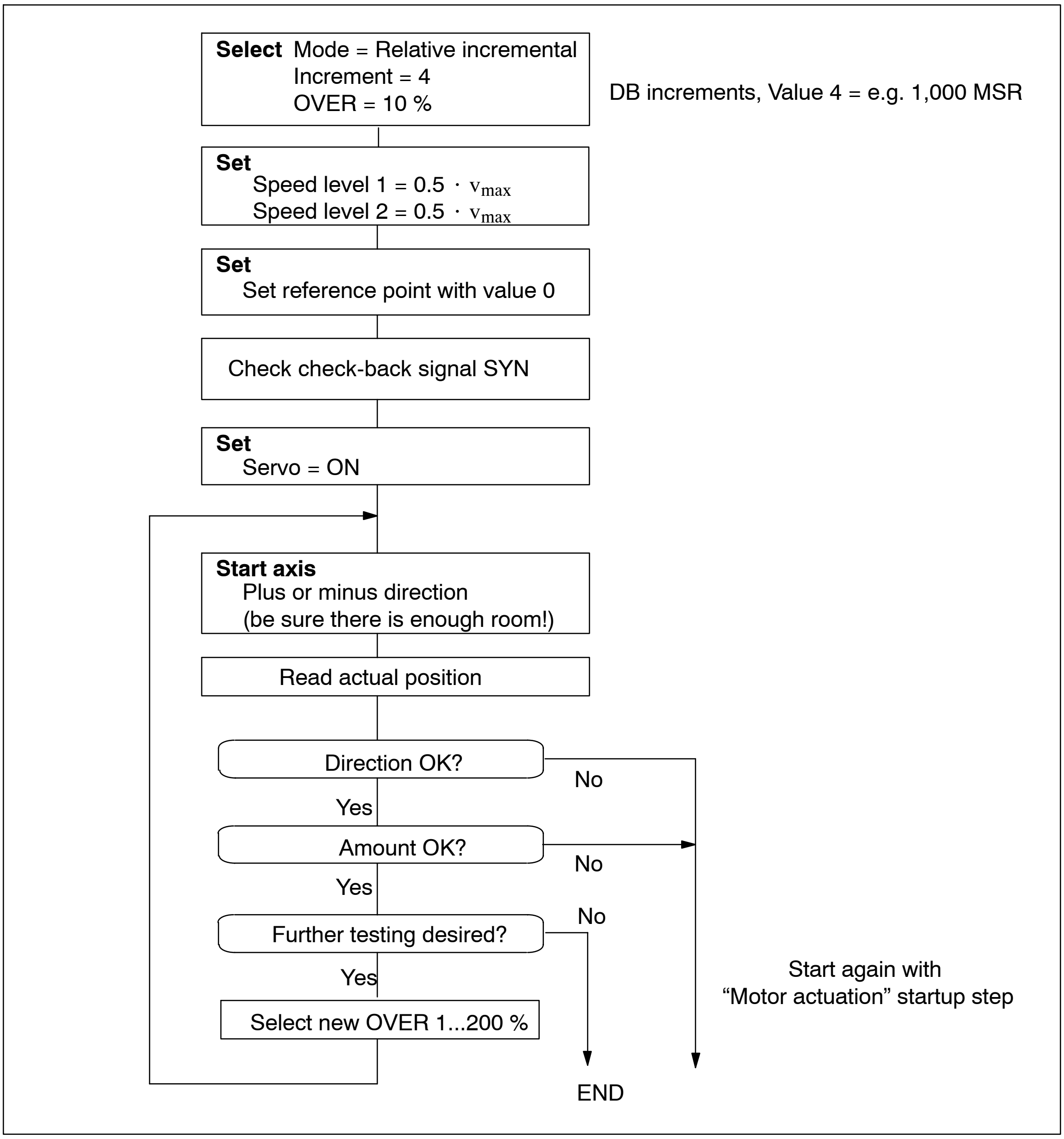


Fig. 7-15 Positioning

7.3.7 Optimizing the Position Controller

Overview

In principle, the dynamic response of an axis is essentially determined by the dynamic response of the stepper drive or variable-speed servo drive; there is not sufficient space to discuss this topic here. But this latter dynamic response, in turn, is influenced by the design characteristics of the machinery, such as friction, backlash, torsion and the like. By feeding back the measured displacement, a position controller closes the outer loop via the control loop section that contains the drive and, if applicable, the machine axis (see Figure 7-12).

Procedure

The following instructions are intended as an aid for practical situations.

Position controllers must meet a variety of requirements for various technological applications.

Assessment criteria for the quality of the positioning process can include:

- Good uniformity of traversing movement
- Little or no overshoot at the target point for positioning
- Short positioning time
- A continuous acceleration (soft travel).

In most applications, several of these criteria will be important, so that most of the time the dynamic response of the controller can be optimized only with a number of compromises.

Execute test movements as in Figure 7-16 during the optimization steps described below.

To Trigger Test Movements

You can trigger test movements as follows as you perform optimization:

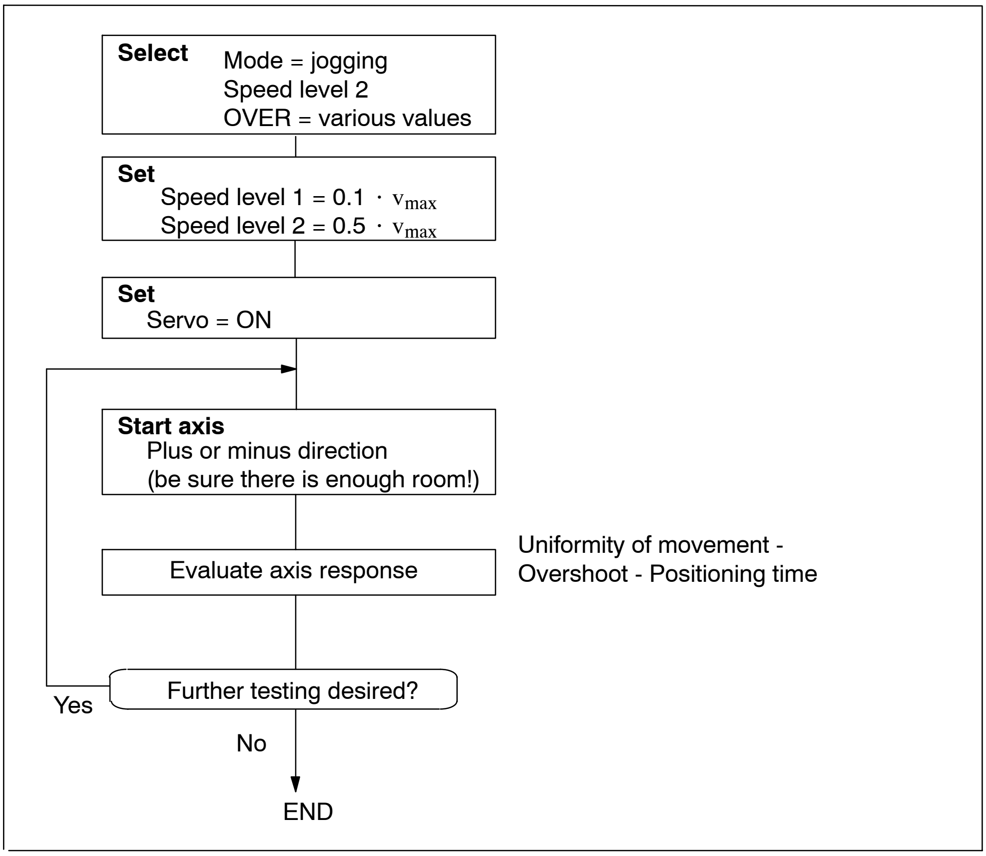


Fig. 7-16 Test Movements for Optimizing the Position Controller

Selecting Initial Values of Response-Defining MD

Servo drive

Set the following machine data in accordance with the drive time constant Ta (Ta_{real}) determined in Section 7.3.2 to the initial values for the optimization steps below, e.g. for an axis in MSR 10^{-3} mm:

- Acceleration, delay

  MD40 = MD41 [mm/s^2] = 30 · MD23 [mm/min] : Ta [ms]

- Jolt time

  MD42 (ms) = 0

- Positioning loop amplification

  MD38 (1/min) = 100,000 : Ta (ms)

The acceleration value that actually acts on the system is reduced by the time response of the position control circuit - i.e. as a function of the K_v value. The maximum acceleration (a) in this setting can be attuned to the drive time constant, and can be estimated as follows:

a_{max} [mm/s^2] = 16 · MD23 [mm/min] : Ta [ms]

Stepper drive

Set the following machine data to initial values for the following optimization steps:

- Acceleration, delay

  MD40 = MD41 = according to operating characteristic curve, see Section 7.3.2 "Procedure"

- Jolt time

  MD42 = 0

- Positioning loop amplification

  MD38 [1/min] = 1 000 = default value

- Minimum standstill time, minimum traversing time

  MD46 = MD47 = 100 ms

  These parameters are less important in servo-controlled operation, because a gentle movement reversal already exists due to the time response in the position control circuit. The values can usually be reduced by 1 ms in the direction of the minimum values. (For a description of these parameters, see Section 7.3.8, "Optimization of dynamic response")

Optimization of dynamic response

The qualitative effect of the parameters on the positioning procedure is illustrated by the following table:

Table 7-5 Effect of Machine Data that Defines Response in the Position Control Circuit

	MD38	MD40/41	MD42
Quiet running	small	–	–
Noise immunity	great	–	–
Soft movement reversal	small	great	great
Positioning without overshooting	small	great	great
Fast positioning	great	small	small

You can use the following startup actions to optimize position control to your requirements if necessary. Check all speed ranges, and if applicable give the greatest weight in evaluating the results to the speed that is the most significant for your technology.

These startup actions are only possible for servo drives (MD61 = 0) or step drives (MD61 = 1) when encoders are used.

Note

The values of MD40/MD41 can only be increased for step drives during optimization and then only to a limited extent when the frequency ramp (MD45) is parameterized with the correct values in accordance with the operating characteristic curve.

If the values are changed by an excessive amount, the error message “Following error too large” will be output. In this case, the values or the K_V factor (MD38) must be reduced to provide an adequate margin!

Optimization for uniformity of movement

You can make optimization of the position controller considerably easier by analyzing the actuating signal or drive speed (tachometer voltage) with a storage oscillograph. The resulting oscillograms for the transition functions U(t) and v(t), i.e. the oscillation pattern, can be interpreted more easily (see Figure 7-17).

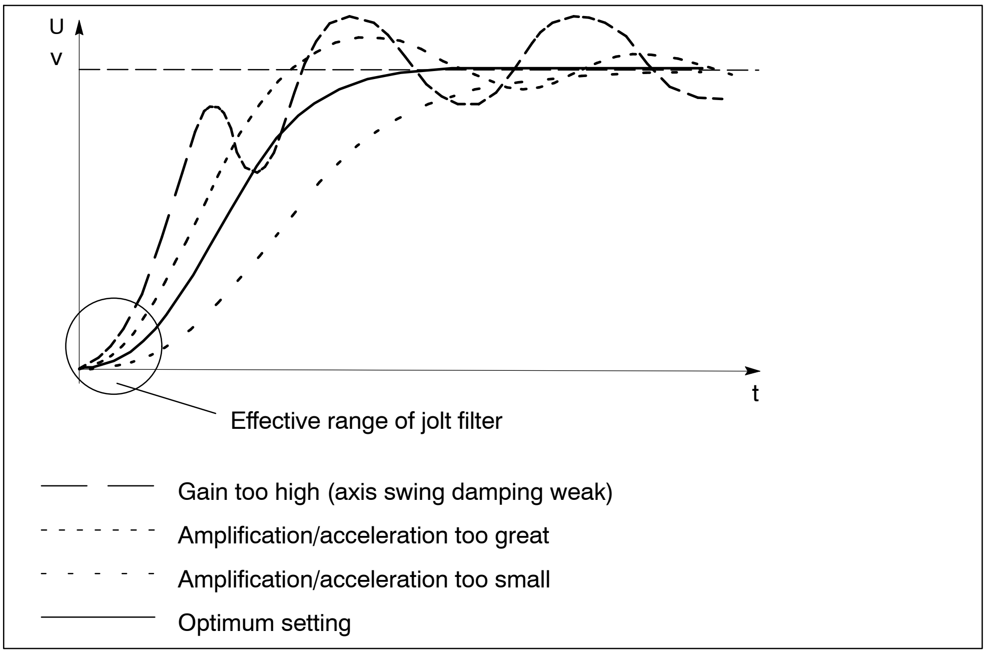


Fig. 7-17 Transition Function of the Position-Control Circuit

Optimization for overshoot

Evaluate the overshoot in the target position (s-overshoot in the servicing data).

For suitable machine data changes, see Table 7-5.

Optimization for positioning time

Evaluate the approach time to the target position (approach time Te in the servicing data).

For suitable machine data changes, see Table 7-5.

Optimization for especially soft travel (super-soft)

For particular applications, especially soft travel response of the axis is desirable. By choosing the following output values for the machine data affecting the dynamic response you can produce a very soft movement where the acceleration is controlled exclusively by the jolt filter. The effective maximum acceleration in movement-reversal processes responds proportionally to the difference in speed, and reaches its maximum in the transition from v = 0 to maximum speed (see Figure 7-18).

- Acceleration, delay

  MD40 = MD41 (mm/s^2) = 0
- Jolt time

  MD42 (ms) = 0.5 · Ta (ms)
- Positioning loop amplification

  MD38 (1/min) = 100,000 : Ta (ms)

The maximum value of the actual effective acceleration can be estimated as follows:

a_{max} [mm/s^2] = 16 · MD23 [mm/min] : Ta [ms]

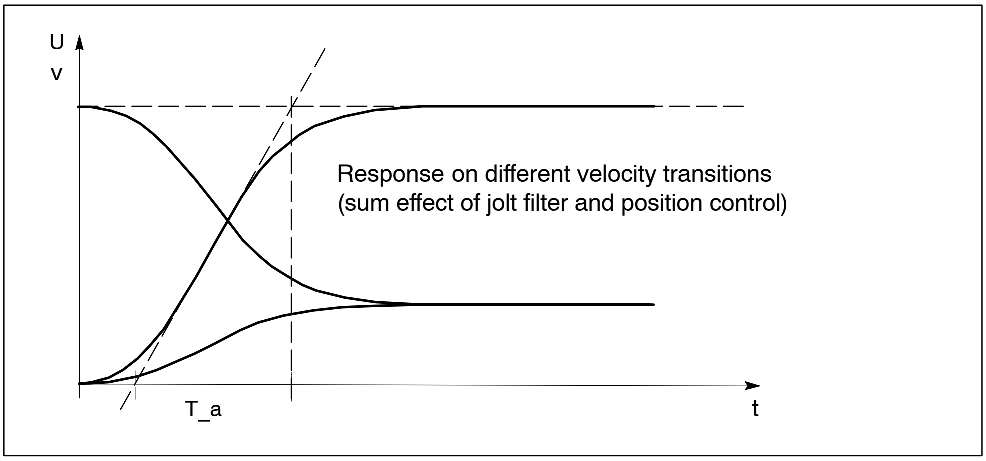


Fig. 7-18 Response on Different Velocity Transitions (Sum Effect of Jolt Filter and Position Control)

Compromise Optimization

When optimizing for several of the above criteria, you can determine the machine data from the results of the individual optimizations by a variety of methods:

- Guarantee of all partial results
  - Least determined value of MD38
  - Greatest value for each of MD40, MD41 and MD42
- Prioritization of one optimization criterion

  Set MD38 and MD40-MD42 to the values that match the highest-priority optimization criterion for your application, and again evaluate response as to the remaining criteria.
- Taking the mean of partial results

  Set MD38 and MD40-MD42 to the means of the individual partial results, and again evaluate response as to all criteria.

7.3.8 Startup of Stepper Motor Controller

Overview

The motor axis driven by the FM 453 is driven by pure, direct control. It features the following structure:

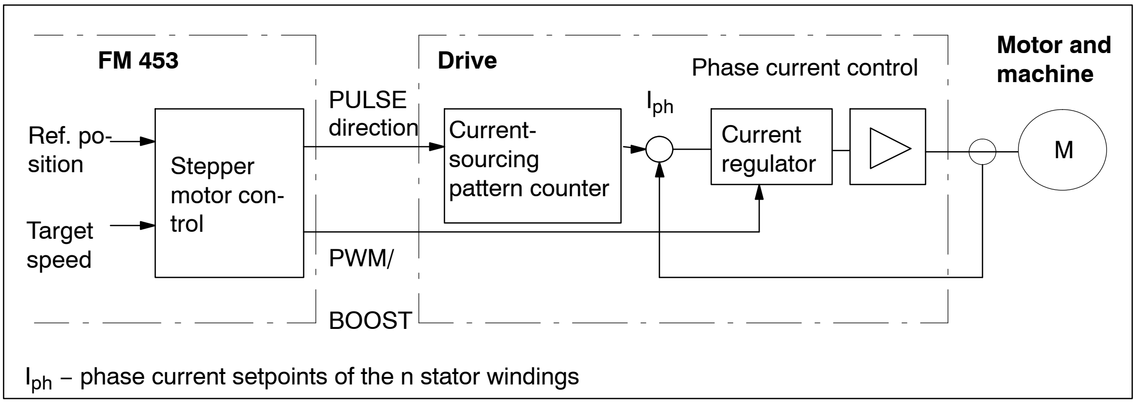


Fig. 7-19 Structure of the Stepper Motor Axis

The dynamic response of the axis is determined by the design characteristics of the machinery, such as friction, backlash, torsion, and the like. Being a control module, the FM 453 must be subordinated to these factors as they bear on parameterization. Following completion of basic startup as described in Section 7.3.3, optimization of parameterization should now be carried out geared to these factors as well as to the technology.

Different requirements are imposed on the axis dynamic response for different technological applications. Criteria for evaluating the quality of the positioning procedure may include the following:

Criteria for evaluating the quality of the positioning procedure may include the following:

- Constant acceleration curve (soft travel behavior)
- Good uniformity of the traversing movement
  (mechanical vibrations, stepper motor resonance!)
- Short positioning time

In most applications, several of these criteria will be important, so that most of the time parameter selection is possible only with some compromise involved.

Positioning

Use the following flow chart to check axis travel to a target position.

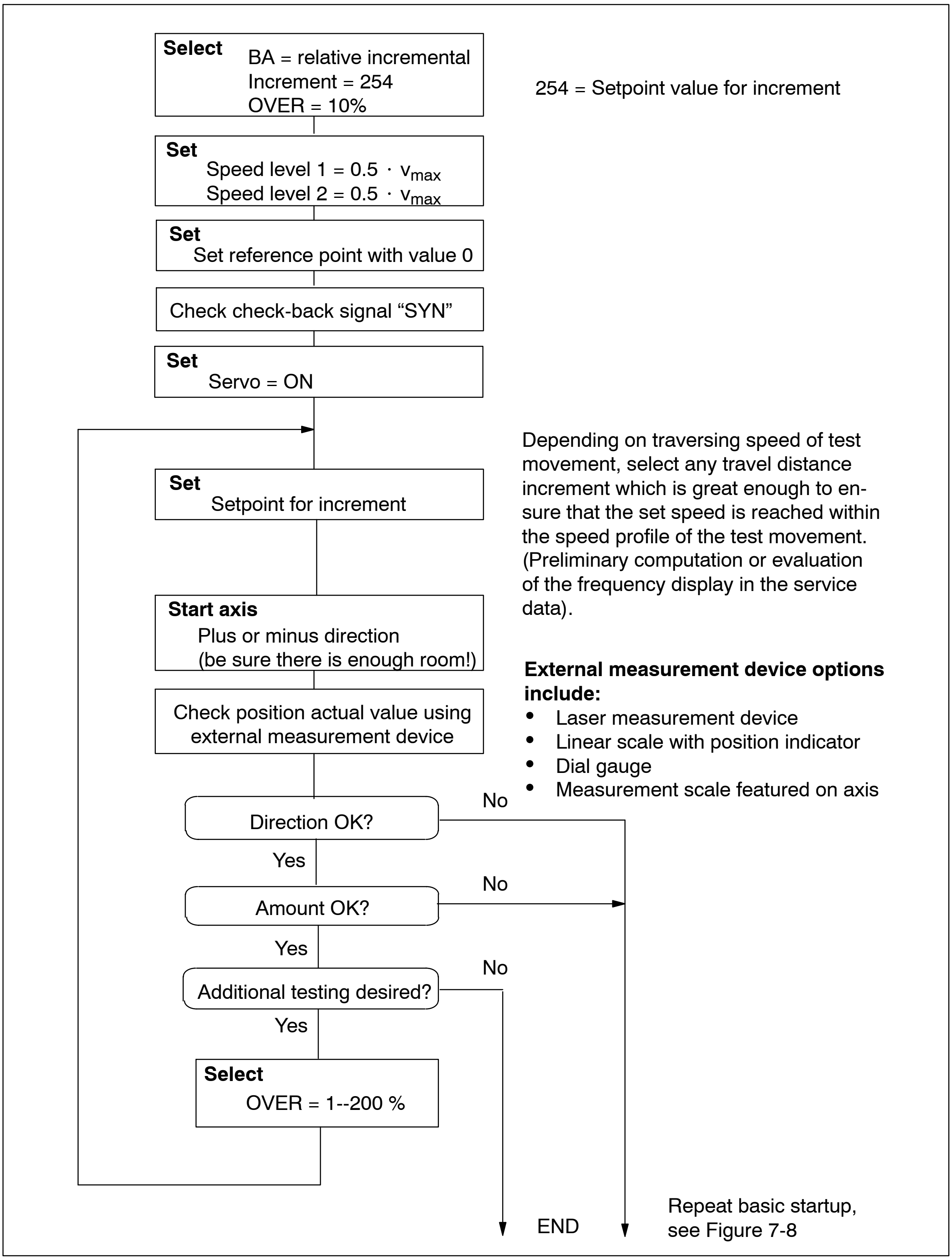


Fig. 7-20 Positioning Verification

Optimization of Dynamic Response

The following table shows you how to make parameter quality selection for any given axis dynamic response desired. The time values MD46 and MD47 are added to the previously documented machine data from basic startup. These times are essentially needed on a step drive-specific basis. They amount to a few ms. However, should the axis machinery have a tendency to vibrate, they can be used e.g. in the case of seamless transition between acceleration and delay (e.g. when traversing short distances), in order to prevent the resultant doubling of acceleration jump, or to permit the vibration which is induced at this discontinuous location, to die out by adding a constant travel time.

Table 7-6 Effect of Machine Data that Defines Response for the Open-loop Controlled Operation of the Step Drive

	MD54	MD55	MD57...60	MD46	MD47	MD42
Soft travel behavior	small	–	small	great	great	great
Suppression of resonance	great	–	great	great	great	great
Short positioning time	great	great	great	small	small	small

Triggering Test Movements

By implementing test movements in accordance with 7-21, optimize the stepper motor control to your requirements. Check all speed ranges, and if applicable give the greatest weight in evaluating the results to the speed that is the most significant for your technology.

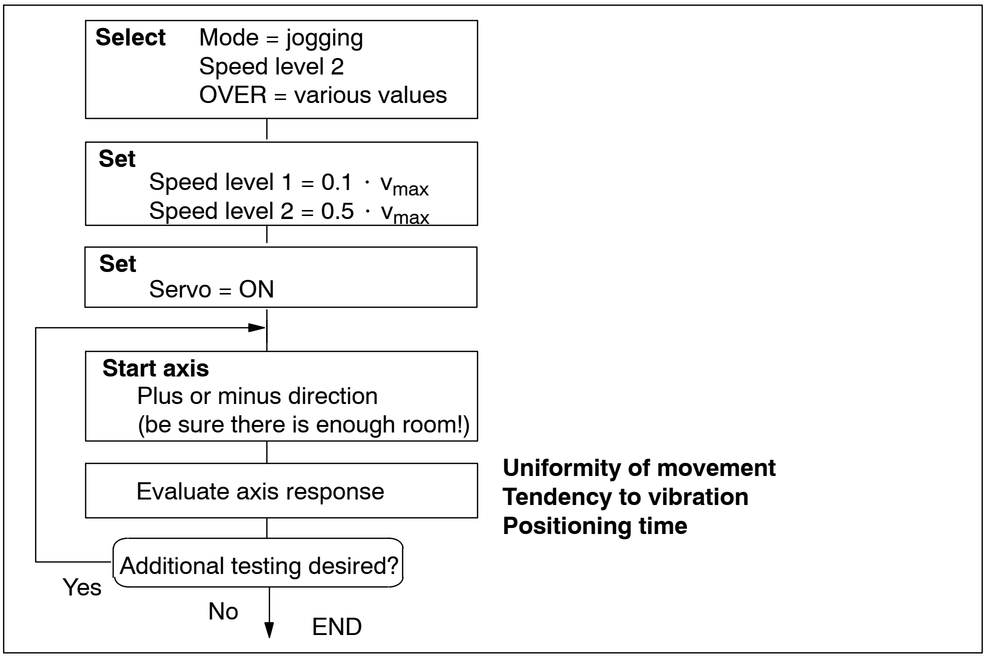


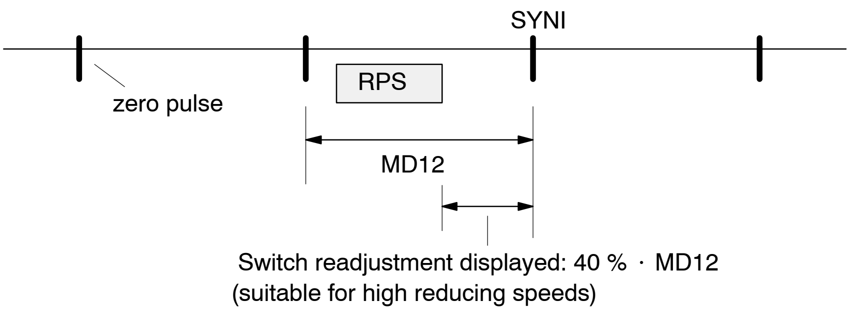
Fig. 7-21 Test Movements for Optimizing the Stepper Motor Control System

7.3.9 Realigning the Reference Point Coordinates

Axis with Incremental Encoder

To ensure distinct reproducibility of reference recordings, it is necessary for the synchronizing zero pulse (SYNI) to be a distinct distance away from the reference point switch (RPS) (see Section9.6.4 for details of generating the zero reference mark). At low reducing speeds (MD29), we recommend a distance of 10 % to 90 % and at high reducing speeds, a distance of 30 % to 70 % of the distance of one zero reference mark cycle (e.g. one revolution of the incremental encoder or the stepper motor). Check this value in the servicing data report after executing a reference point approach (switch alignment value) and if you find nonconformity to the required value range, make a corresponding adjustment in the relative position allocation between the encoder and the reference point switch.

Example: Positive search direction



Set the referencing velocity (MD28) to the highest value compatible with your requirements. It is important to be able to decelerate to the reducing velocity across the length of the reference-point switch. If this is not the case, an additional repositioning to the RPS occurs before the search phase of the synchronizing zero pulse begins. Compare the cycle of the executed traversing movements with Section 9.2.3 and optimize the referencing speed (MD28).

Then readjust the reference-point coordinates proper by entering the necessary reference-point shift in the machine data. After the machine data is activated, the new reference-point shift takes effect with the next search for reference.

Axis with Absolute Encoder (SSI)

In a suitable mode ("jogging", "incremental relative") move to a known point on the axis and execute the Set reference point function with the known position value. The set position and actual position will immediately be set to this value, and the allocation of an absolute value to the absolute encoder (SSI) will be entered in the machine data record (MD17). If you want to archive this value externally, apart from the module's own data memory, perform a readout of the machine data DB and save it to a floppy disk or to the hard disk of your PG.

7.3.10 Activating Position Controller Diagnostics

Overview

Once the position controller has been optimized, activate the position controller diagnostics. If position control is performing improperly or the axis is responding abnormally, this function will trigger error messages.

You can use the following flow chart to start the position controller diagnostics:

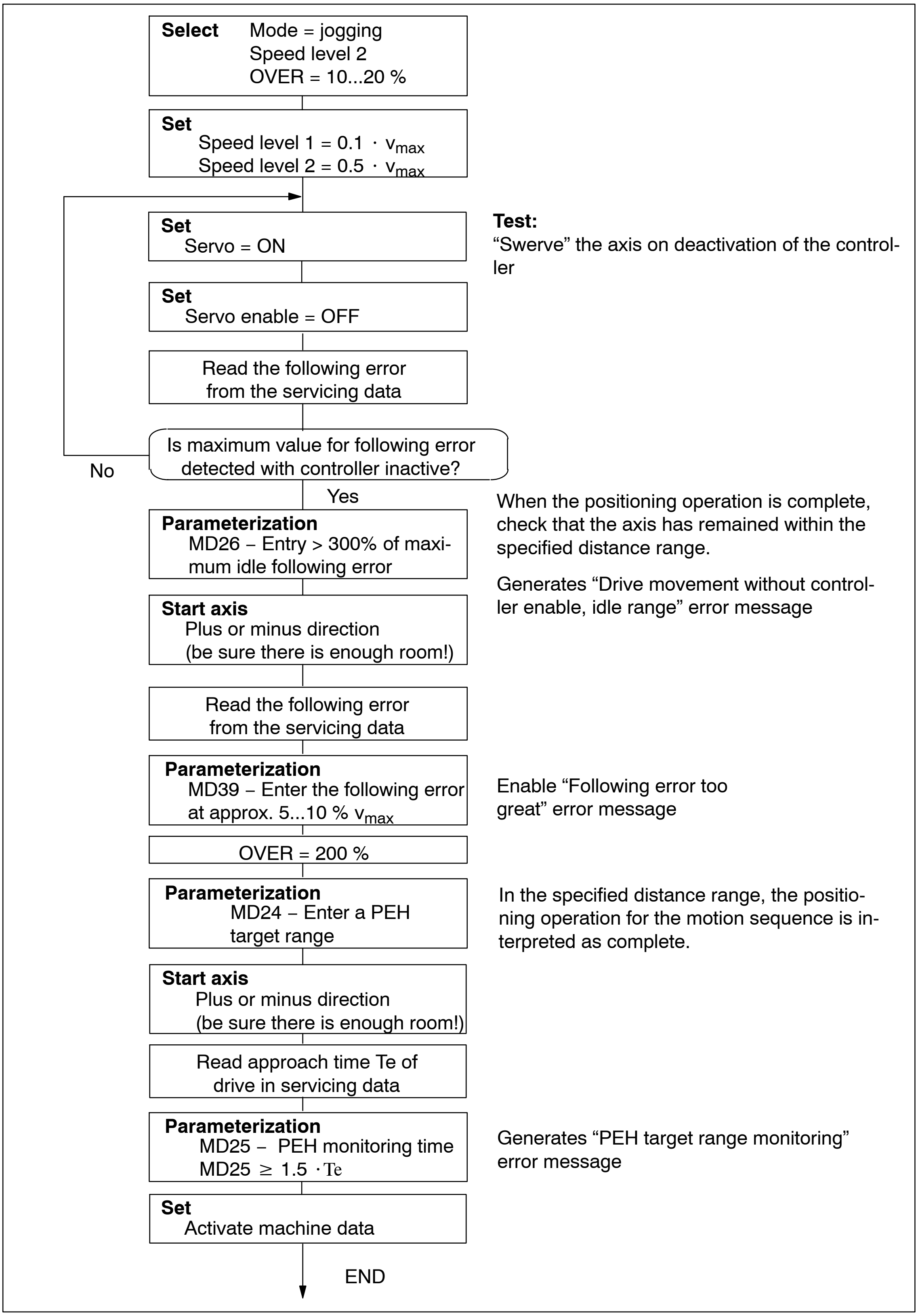


Fig. 7-22 Activation of Position Controller Diagnostics

7.3.11 Activating Stepper Motor Diagnostics

Overview

Once optimization of stepper motor control is completed, activate the stepper motor diagnostics as needed.

Boost

The boost signal is monitored in terms of its active time. This is in order to protect the drive motor against overheating.

Refer to the stepper motor drive documentation for information regarding maximum absolute and relative boost duration. Enter this information into machine data MD48 and MD49, provided for that purpose.

When boost function is parameterized, the FM 453 triggers the errors “Boost duration absolute” or “Boost duration relative” in the event that time for the active phase(s) of the Boost signal is exceeded.

Once parameterization is completed, check the diagnostics function for efficacy using a suitable test program with which particularly large proportions of acceleration and braking phases occur during execution.

Rotation Monitoring

This diagnostics function cannot be activated in the control mode MD61 = 1 with an encoder!

Activation is accomplished by way of the “Rotation monitoring” single-setting function (refer to Section 9.7.3 for functional description of rotation monitoring).

If the rotation monitoring function is programmed, the FM 453 will trigger the “Rotation monitoring” error in the event that the stepper motor is unable to follow the movement specified.

Check the efficacy of the diagnostics function. This is accomplished by electrically separating the cyclic zero pulse encoder or the power section of the stepper motor and executing a test movement in any operating mode.

7.3.12 Activation of Software Limit Switches

Overview

Move the axis carefully to the end positions defined for normal machining. Enter these position actual values into the machine data MD21/MD22 as software limit switches, and activate them.

Note

If you change the reference-point coordinate later or use Set reference point for the absolute encoder, you must redefine the positioning values of the software limit switches.

If you do not need the software limit switches, the input limits -10^9 and 10^9 MSR must be entered in MD21/MD22 (for default values, see Table 5-4).

7.3.13 Activation of Drift Compensation

Overview

If you want to use the drift compensation function in addition to the offset compensation already described in Section 7.3.2, activate it in the machine data (please see the function description in Section 9.7, position control).

7.3.14 Activation of Backlash Compensation

Overview

With indirect position measurement (for example, with an encoder on the motor) the free play of mechanical transmission elements during positioning may cause a position deviation of a machine part (such as a lathe saddle) that is to be positioned but does not lie in the measured-value feedback loop. As a rule, a piece of the distance will be "missing" after a reversal of direction. This backlash amount can be determined as a mean at various axis positions, and entered in the machine data MD30 and MD31.

You can use the following flow chart to determine backlash and activate backlash compensation.

Also please refer to the information on "backlash compensation" presented in Section 9.7!

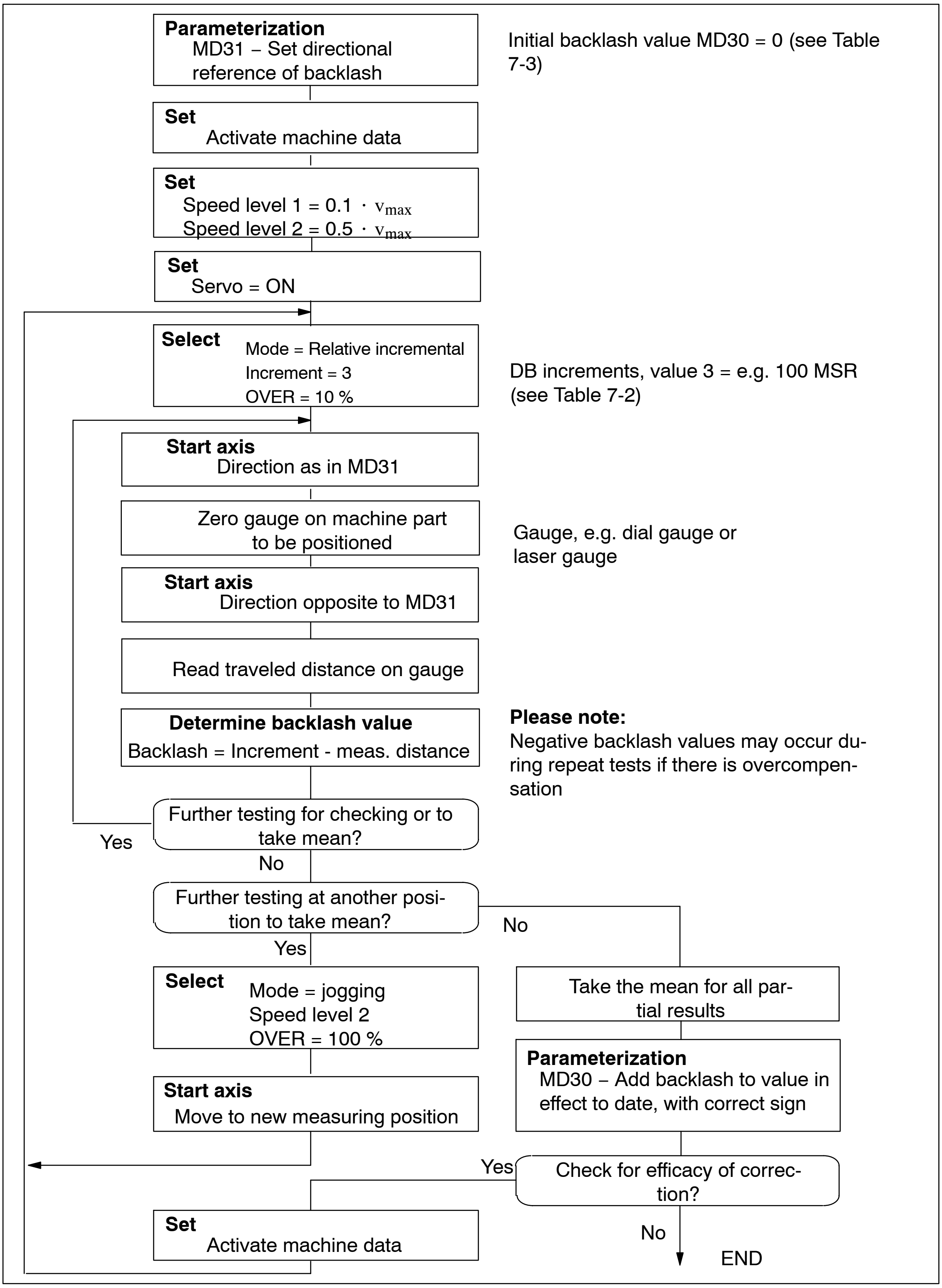


Fig. 7-23 Determination of Backlash and Activation of Backlash Compensation

7.3.15 Parameterizable zero-speed monitoring

Warning
The parameterizable zero-speed monitoring is only required in exceptions. The parameterization lies completely in the user's own responsibility and should be carried out with utmost care.

In the uncontrolled mode of the axis, a zero-speed monitoring of the axis motion is provided by the FM 453 via the velocity evaluation.

These are special cases in which the MD45 setpoint ramp is active:

- In the "Controlling" mode:

  Deceleration of an axis motion
- In all the other modes:
  - Cancellation of drive enable during an axis motion
  - Restart during an axis motion
  - In case of all errors with error reaction "All OFF"
  - In case of some errors with error reaction "Feed STOP" (see Section 11, Error handling)

The evaluation is provided using an automatic mechanism implemented in the software, which is intended to:

- quit the "Machining running" status
- quit the position control with servo enable activated

For extraordinary exceptional cases of technologically required sequence of motions or extraordinary dynamic behaviors of an axis, for which this automatic mechanism cannot determine an axis standstill reliably, new machine data will be introduced with which exact criteria can be parameterized to detect the end of the motion.

MD67	Zero speed (see Table 5-4)
MD68	TimeOut time for zero-speed monitoring (see Table 5-4)

Note

MD67 and MD68 are zero (0) by default. Thus, the automatic zero-speed monitoring is enabled – Principle of functioning as in earlier software versions.

MD67 and MD68 act independently of each other, i.e. can be parameterized in 4 possible combinations.

The TimeOut time is started after the setpoint 0 has been reached at the setpoint output of the FM 453, i.e. if MD45 is unequal to 0 after the setpoint ramp has been processed.

The parameterizable zero-speed monitoring is only active in the control modes "with position control" (the control mode is set in MD61).

7.3.16 Standard diagnosis for the position controller with parameterizable response time when overriding the actuating signal

Overview

The position controller of the FM 453 provides a standard diagnostic function which issues an error message when an output value of 10 V is reached as the maximum actuating signal for the drive.

Note

This diagnostic function cannot be deactivated.

It is deemed to be indispensable and serves for safety of the installation and protection of the operating personnel, in particular during commissioning of the machine.

Reaching of the 10 V output value can have the following causes and result in the following effects:

Table 7-7 Causes for reaching the 10 V output value

Effect	Cause	Response
U1 drive stopped:	Error ”Drive is not moving”	”Feedrate STOP”
U2 drive is moving in the opposite direction:	Diagnostic alarm ”Direction of rotation of the drive”	”All OFF”
U3 drive is moving in the setpoint direction:	No error message[1)]	None

1) Diagnosis possible by status evaluation of DS34[8].2)

The causes U1 and U2 which constitute the basis for the error messages above and result from a commissioned and optimized axis do not occur any longer in normal operation. Therefore, the appropriate error messages are already issued by the position controller when the 10 V output value occurs once.

In practice, there were several applications with inappropriately dimensioned axes. The encoder resolution in proportion to the parameterized maximum speed selected so was so bad that the distance corresponding to approximately one increment of the measuring system (”MR”) is covered when a setpoint of 10 V is output to the drive. In such an application, the axis status always represents itself as a standstill for the position controller, since also an axis being in position control can move by +/–1 increment (MR). The response criterion of the standard diagnostic function is:

- In case ”No drive motion” case: +/–2 MR/TZ
- In the ”Direction of rotation of the drive” case: v actual value sign opposite to the v setpoint

Calculating the required response time

The error message at the 10 V limit can be delayed by an appropriate time value by parameterizing a response time. If an axis motion by at least one increment (MR) in the programmed traversing direction is recognized, the response time is restarted. The error message is then issued according to the current axis status after expiry of the parameterized time.

It is recommended to proceed as follows:

- Calculate the maximum speed (MD23) into MR/TZ; (TZ = 3 ms):

  VMR = MD23 / TASTPROMIN / MWFAKTOR

  Calculate MWFAKTOR as per Section 5.3.1, Subsection ”Dependencies”.

  The number of sampling cycles per minute (TASTPROMIN) is 20,000.

- Calculate the theoretical minimum value for the required response time:

  TOV_min = 1 / VMR

- Define the practically required minimum value
  TOV = (2...3) · TOV_min. (This value, however, must be by a multiple higher in case of a bad starting behavior of the axis. When testing the axis, the value can be corrected starting from an initial value until a stable and safe positioning behavior is achieved.)

Enter the TOV value in MD69.

To avoid an undefined value in the existing MD69 automatically resulting in a new behavior when upgrading the firmware, the function must be re–enabled in MD70.

MD69	Standard diagnosis (see Table 5-4)
MD70	Function enable for the response time in MD69 (see Table 5-4)

Note

MD69 is zero (0) by default. Thus, the standard diagnosis is enabled without delay → principle of functioning as in earlier software versions.

The standard diagnosis cannot be deactivated, only its effect can be delayed.

MD69 is in effect immediately when activated and entered online (category E).

While the response time is running, the override status is signaled in DS34[8].2 (this also pertains to cause U3).

Warning

Inappropriate input values can result in hazards to the installation when the parameterized response time is activated for the standard diagnosis. Therefore, the use of MD69 shall be the user's solely responsibility. Siemens will not assume any liability in case of damage to the installation.

Parameterization examples

Example 1:

Machine data:

MD61 = 0

MD10 = 1 MD11 = 2,000,000 MSR MD12 = 0

MD13 = 1,000 MD23 = 1,000,000 MSR/min

Calculating MD69: MWFAKTOR = (MD11 + MD12 $\cdot$ 2^{-32}) / (4 $\cdot$ MD13)

MWFAKTOR = (2,000,000 + 0 $\cdot$ 2^{-32}) / (4 $\cdot$ 1,000) = 500

VMR = 1000000 / 20000 / 500 = 0.1

TOV_min = 1 / 0.1 = 10

MD69 = 20 ... 30

Example 2:

Machine data:

MD61 = 1

MD10 = 1 MD11 = 20000 MSR MD12 = 0

MD13 = 1024 MD23 = 30000000 MSR/min

Calculating MD69: MWFAKTOR = (MD11 + MD12 $\cdot$ 2^{-32}) / (4 $\cdot$ MD13)

MWFAKTOR = (20000 + 0 $\cdot$ 2^{-32}) / (4 $\cdot$ 1024) = 4,8828125

VMR = 30000000 / 20000 / 4,8828125 = 307,2

TOV_min = 1 / 307,2 = 0,00325...

MD69 = 0

This case where TOV_min < 1 is not an example for an inappropriate ratio of the encoder resolution to the parameterized maximum speed. Probably, the cause lies in an FM453 error message from the mechanics or in the axis optimization.

Human-Machine Interface 8

Chapter Overview

Summary

In this chapter you'll find an overview of the operator-control and monitoring capabilities offered by the FM 453.

For operator control and monitoring of the FM 453, a control panel can be connected to the CPU via the MPI interface (see Figure 1-1).

The FM can service no more than three nodes simultaneously.

The module uses the SIMATIC interface (backplane bus) to communicate with the control panel.

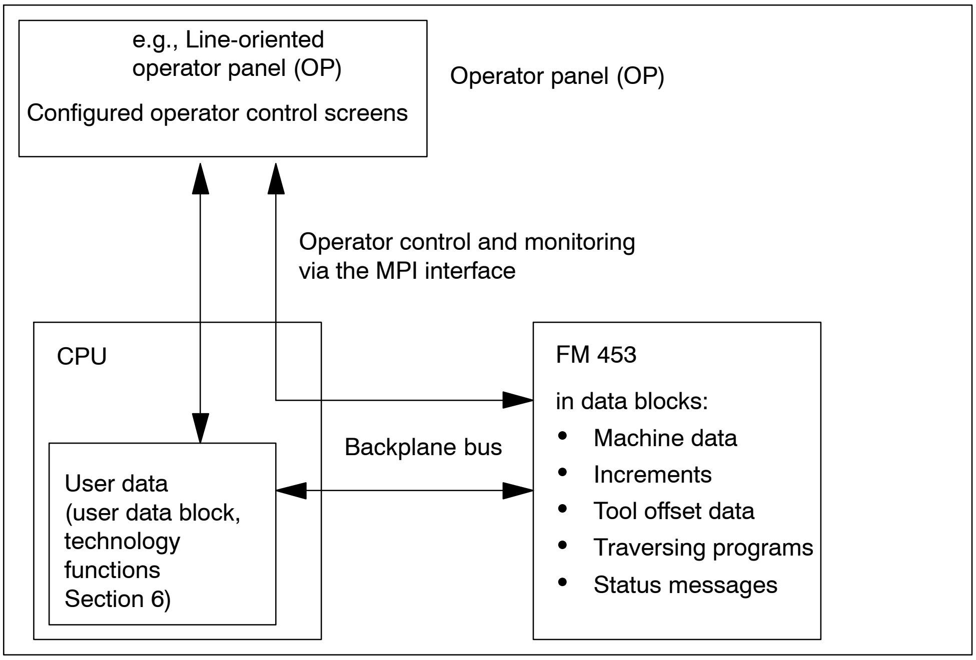


Fig. 8-1 Operator Control and Monitoring for the FM 453

Operator Control and Monitoring of FM Data/Signals on the CPU

The data and signals that can be controlled and monitored at the control panel are listed in the user data block. These data or signals must be processed by the user program.

What Can I Control on the FM 453?

Using the keyboard of the operator panel, you can change the data/signals in the data blocks:

- Machine data
  DB No. 1205 for channel 1
  DB No. 1505 for channel 2
  DB No. 1805 for channel 3
- Increments
  DB No. 1230 for channel 1
  DB No. 1530 for channel 2
  DB No. 1830 for channel 3
- Tool offset data
  DB No. 1220 for channel 1
  DB No. 1520 for channel 2
  DB No. 1820 for channel 3
- Traversing programs
  DB No. 1001...1199 for channel 1
  DB No. 1301...1499 for channel 2
  DB No. 1601...1799 for channel 3

What Can I Monitor on the FM 453?

The following data and signals can be displayed on the operator panel display:

- Machine data, see above
- Increments, see above
- Tool offset data, see above
- Traversing programs, see above
- Status messages
  DB No. 1000 for channel 1
  DB No. 1300 for channel 2
  DB No. 1600 for channel 3

  e.g.
  - Operating data, such as actual values
  - Active NC blocks
  - Linear measurements
  - Actual value block change
  - Check-back signals and error conditions
  - Servicing data

The configuring package includes pre-configured interfaces for the COROS OP 17, 27, 37 devices.

8.1 Standard HMI (Human-Machine Interface) for the OP 17, 27, 28

Overview

This Section describes the pre-configured interfaces which you will need to modify to suit your project (e.g. FM addresses, DB No.) for the COROS equipment (operator panel): OP 17, OP 27, OP 37.

The tool to be used for this is the “ProTool” configuring tool. You can use it to modify, add or delete graphics.

The user interface is addressed to:

- user DBs 1, 2 and 3 (channels 1, 2 and 3) in the CPU (controller: Steuerg_CPU; address = 2; slot = 3)
- the data blocks for status messages (DB-SS) 1000, 1300 and 1600 (channels 1, 2 and 3) in the FM 453 (controller: Steuerg_453; address 2; slot 8) or to the traversing program.

The OP 17, 27 and 37 devices are addressed via MPI address 9 in this sample configuration.

The pre-configured interfaces have been created by means of configuring tool ”SIMATIC ProTool/Pro CS B5.2.0, 18”.

The sample configurations are provided as a starting point for your project. Copy one of the following files as appropriate:

- **op17_453.pdb** for OP 17
- **op27_453.pdb** for OP 27
- **op37_453.pdb** for OP 37

You can edit the copy file to suit your application.

These files are stored in the following directory:

[STEP7 Directory]\EXAMPLES\FM453\zEn17_02_FM453_OP_EX

The text field “FM user name” represented in the images can be renamed to a text of your choice.

You can print out the entire configuration using “ProTool”. This provides you with detailed graphics descriptions.

DB-SS

The data block for status messages contains the control/checkback signals, as well as the system data of the FM 453. The data of the DB-SS can only be read.

Monitoring

The data for monitoring can be read and displayed directly in the BD-SS as well as in the corresponding parameterized DBs of the FM 453.

The advantage of reading directly from the FM is that the values/signals do not have to be read via the user program first.

Operator Control

For operator control, the data and signals (including memory bits and values) are written to the user DB of the user program.

User Program

The interface for the OPs is the user DB.

If control signals, single functions and single commands are set in the user DB by the OPs, they are transferred immediately to the FM by the POS_CTRL block.

The signals described under "Operator Control and Monitoring" (requests to transfer the data with Write as per Table 8-2) must be evaluated accordingly by the user program (taking into account any user-specific interlocks) before setting the Write or Read requests.

Information about sample projects

If all three channels are not used, the relevant softkey in the configuration example should be deleted.

The screens of the user interfaces (see Figs. 8-3, 8-5, 8-6 and description of individual displays) include display fields and input/output fields which contain the values of configured variables.

The screens of the user interface (see Figure , , and description of the individual screens) contain display fields and input/output fields. These fields contain values of configured variables.

- The display fields are addressed to the data blocks for status messages (“Steuerung_453”; DB1000 for channel 1, DB1300 for channel 2, DB 1600 for channel 3) are read directly from the FM 453 cyclically or on data blocks for traversing programs (e.g. channel 2 = DB 1301 to 1499).
- The input output fields are addressed to the user DBs (Steuerung_CPU; DB1 for channel 1; DB2 for channel 2; DB3 for channel 3).
  - Transmission of these values occurs from the OP 17, 27, 37 to the CPU into the user DB. These values (if needed) must be transmitted to the FM 453 by the user program.
  - If certain values or control signals can be written only under the right conditions (e.g. if axis is necessary on HOLD or selection of a certain operating mode), then the user program must ensure, by analyzing the response signals, that these conditions are met.

The pending errors are displayed in the “Error” line. More detailed error information is provided on the screens “Diagnostics, Troubleshooting” and “Interrupt messages.”

Description of the Individual Screens

The contents of the separate screens is shown in the configuration example.

The following screenshot shows, for example, the screen layout of PIC 7 ”Actual value display” of the OP 17 panel.

```
FM453          Name of FM              Act.val.display      Channel
.......        P.No: ....              S.No: ....           ...........

   Channel .                    ........... mm
                                      F: ..........
Residual travel: ............         OR: ... %
......         ............       ............
FM-WA          P select         P edit
```

Fig. 8-2 OP 17, Actual Value Display PIC 7

8.1.1 User Interface of the OP 17

The following illustration provides you with an overview of the configuration example for the OP 17 user interface (menu tree).

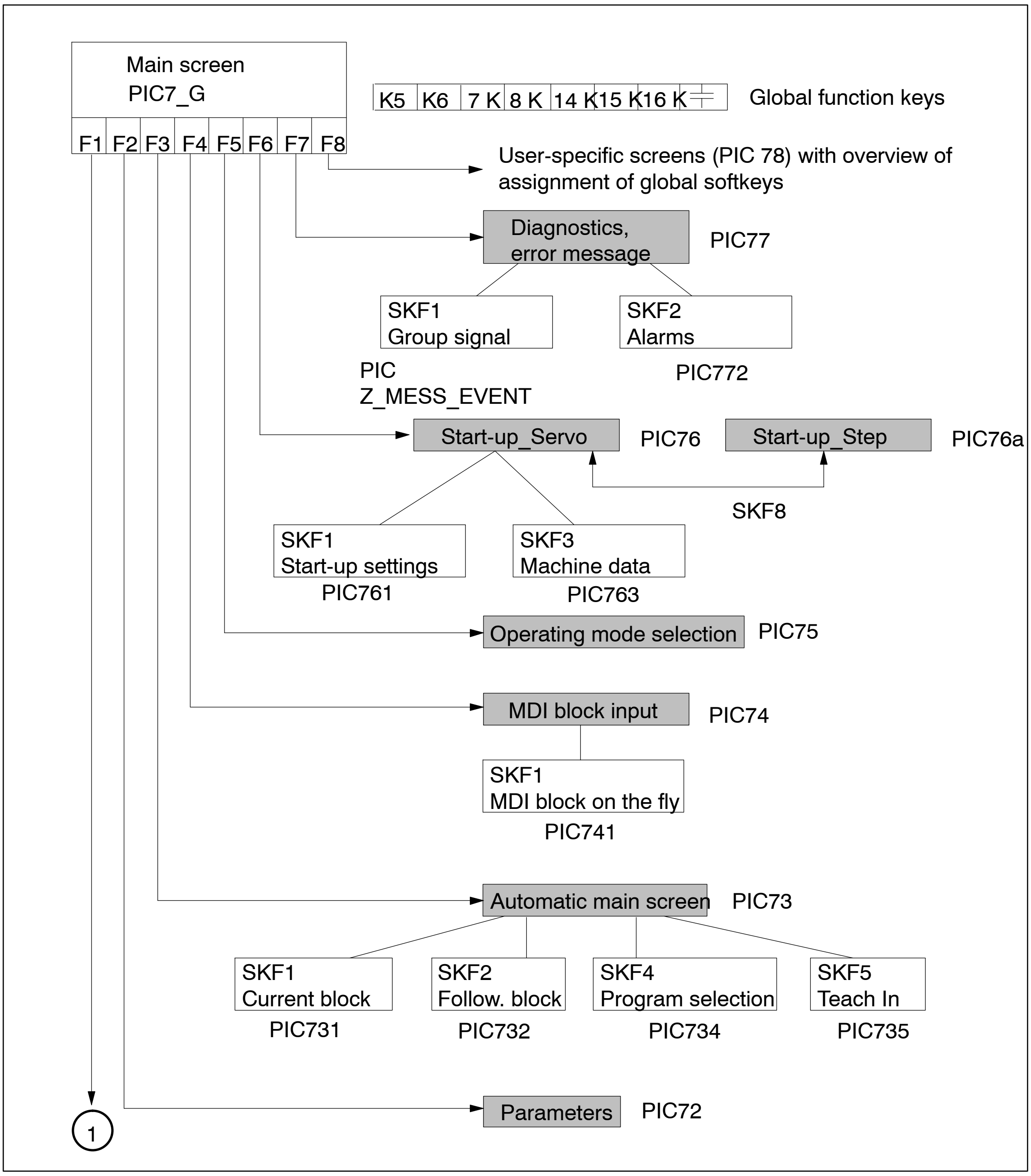


Fig. 8-3 Menu Tree of the OP 17 User Interface

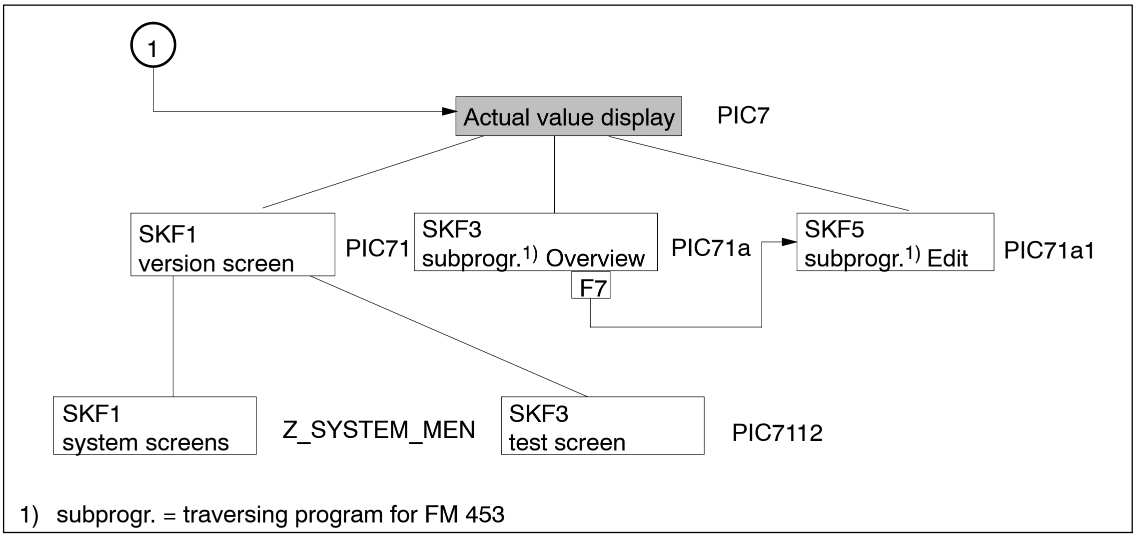


Fig. 8-4 Menu Tree of the OP 17 User Interface, continued

Figure 8-3/8-4 describes the functions of the global function keys for the user interface of the OP 17.

[ESC]	ESC key	You can use this key to call up the previous screen of the higher level (the table of contents in the main screen).
K5	Function key	You can use this key to jump from any point on the menu tree to the main screen (PIC7_G).
K6	Function key	You can use this key to jump from any point on the menu tree to the diagnostics error message screen (PIC77).
K7	Function key	You can use this key to jump from any point on the menu tree to the operating mode selection screen (PIC75).
K8	Function key	You can use this key to switch to the actual value display (PIC7).
K9	Function key	You can use this key to switch to channel 1.
K10	Function key	You can use this key to switch to channel 2.
K11	Function key	You can use this key to switch to channel 3.
K12	Function key	You can switch over to German by pressing this key.
K13	Function key	You can switch over to English by pressing this key.
K14	Function key	You can switch over to ”offline” mode by pressing this key.
K15	Function key	You can switch over to ”online” mode by pressing this key.
K16	Function key	You can switch over to ”Transfer” mode by pressing this key.
F1 ... **F8**		F1 to F8 (local soft keys)

8.1.2 User Interface of the OP 27

The following illustration provides you with an overview of the configuration example for the OP 27 user interface (menu tree).

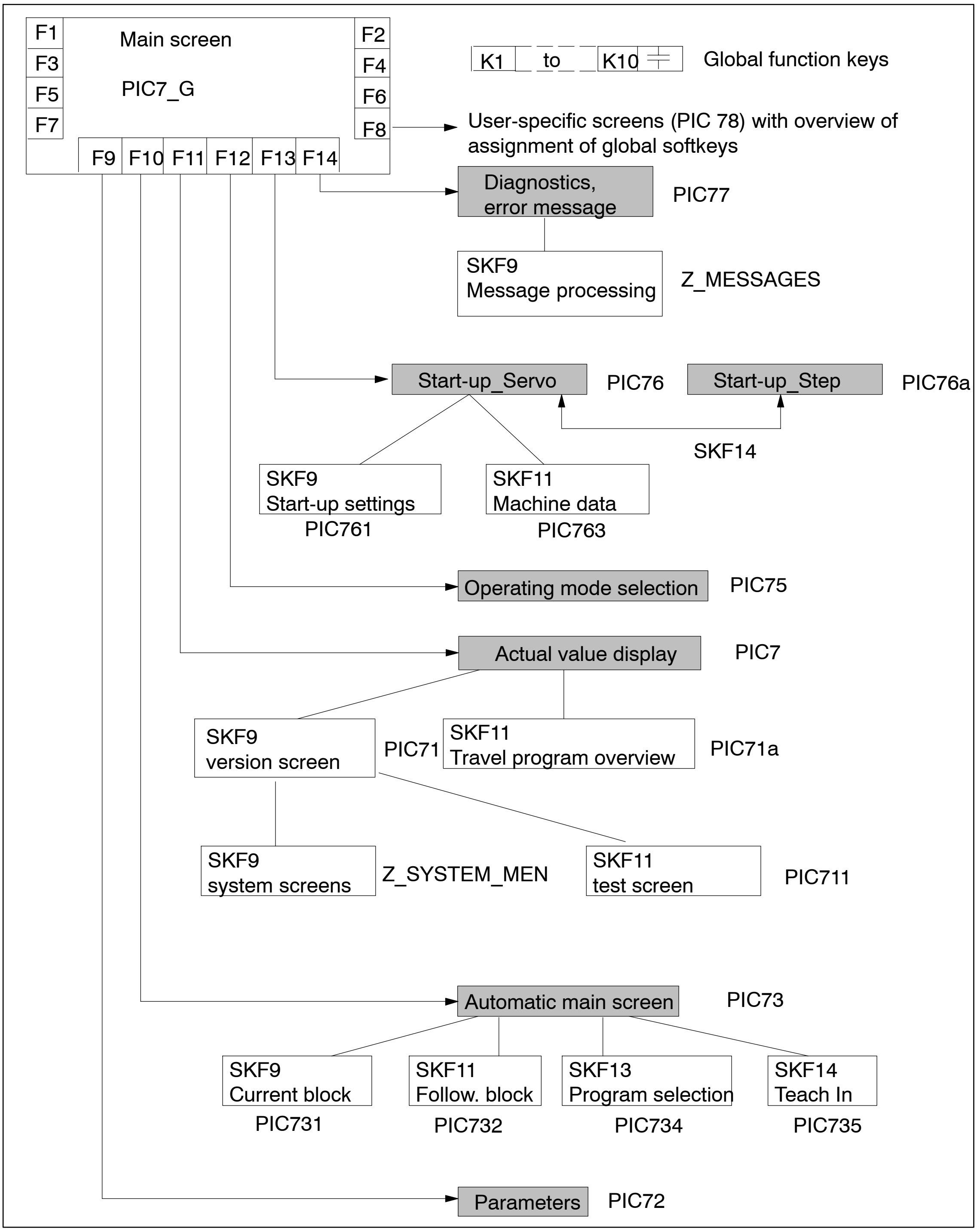


Fig. 8-5 Menu Tree of the OP 27 User Interface

Figure 8-5 describes the functions of the global function keys for the user interface of the OP 27.

ESC key		You can use this key to call up the previous screen of the higher level (the table of contents in the main screen).
K1	Function key	You can use this key to jump from any point on the menu tree to the main screen (PIC7_G).
K2	Function key	You can use this key to jump from any point on the menu tree to the diagnostics error message screen (PIC77).
K6	Function key	You can switch over to German by pressing this key.
K7	Function key	You can switch over to English by pressing this key.
K8	Function key	You can switch over to "offline" mode by pressing this key.
K9	Function key	You can switch over to "online" mode by pressing this key.
K10	Function key	You can switch over to "Transfer" mode by pressing this key.
F1 ... F14		F1 to F14 (local soft keys)
F1	Function key	You can use this key to switch to channel 1.
F2	Function key	You can use this key to switch to channel 2.
F3	Function key	You can use this key to switch to channel 3.

8.1.3 User Interface of the OP 37

The following illustration provides you with an overview of the configuration example for the OP 37 user interface (menu tree).

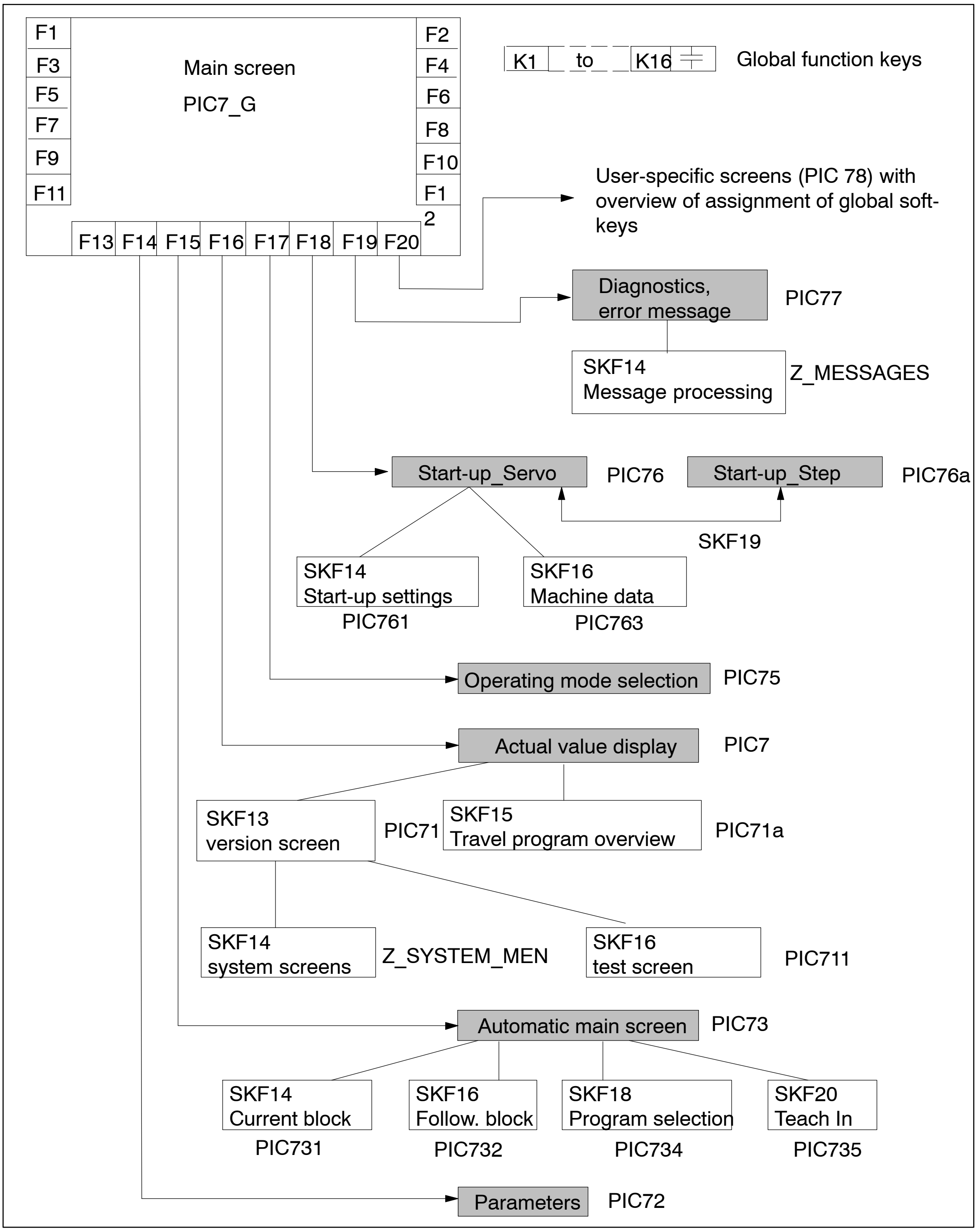


Fig. 8-6 Menu Tree of the OP 27 User Interface

Figure 8-6 describes the functions of the global function keys for the user interface of the OP 37.

⌧	ESC-Taste	You can use this key to call up the previous screen of the higher level (the table of contents in the main screen).
K5	Funktionstaste	ou can use this key to jump from any point on the menu tree to the main screen (PIC7_G).
K6	Funktionstaste	You can use this key to jump from any point on the menu tree to the diagnostics error message screen (PIC77).
K7	Funktionstaste	You can use this key to jump from any point on the menu tree to the operating mode selection screen (PIC75).
K8	Funktionstaste	You can use this key to switch to the actual value display (PIC7).
K12	Funktionstaste	You can switch over to German by pressing this key.
K13	Funktionstaste	You can switch over to English by pressing this key.
K14	Funktionstaste	You can switch over to ”offline” mode by pressing this key.
K15	Funktionstaste	You can switch over to ”online” mode by pressing this key.
K16	Funktionstaste	You can switch over to ”Transfer” mode by pressing this key.
F1 ... F20		F1 to F20 (local soft keys)
F1	Funktionstaste	You can use this key to switch to channel 1.
F2	Funktionstaste	You can use this key to switch to channel 2.
F3	Funktionstaste	You can use this key to switch to channel 3.

8.2 Analysis of the User DB by the User Program for Operator Control

Overview

The Table below tells you which Write requests must be submitted by the user program and which signals are written directly to the FM.

Table 8-1 Analysis of the User DB by the User Program

User DB, DBX...	Triggered by ...	User Program		See PIC...
		Function	User DB, DBX...	OP
499.5 499.6 499.7	FM 453	Diagnostic interrupt Data error Operator control/traversing error		7
499.1 = 1	SK “IWset”	Transfer data for “Set actual value” from the user DB to the FM	38.7	72
499.2 = 1	SK “NPVset”	Transfer data for “Set zero point offset” from the user DB to the FM	39.1	
37.6 = 1	SK “IWrü”	Transfer “Cancel setting of actual value” to the FM		
37.2 = 1	SK “SAvor”	Transfer “Block advance” to the FM		734
37.3 = 1	SK “SArü”	Transfer “Block return” to the FM		
498.3 = 1	SK “set”	Transfer data for “Program selection” from the user DB to the FM	39.5	
498.4 = 1	SK “set”	Transfer data for “Teach-in” from the user DB to the FM	39.7	735
498.2 = 1	SK “set”	Transfer data for “MDI block entry” from the user DB to the FM	38.3	74 6)
499.0 = 1	SK “set”	Transfer data for “MDI block on-the-fly” from the user DB to the FM	38.4	741 6)
34.0	TF “servo enable”	To change “Servo enable”, transfer yes/no to the FM		761
34.6	TF “park. axis”	To change “Parking axis”, transfer yes/no to the FM		

SK = Softkey, TF = Text field

1) The relevant code for the operating mode is to be entered in DBB16 of the user DB.
2) Code = 254 in DBB17 of the user DB
3) User DB, DBB196 = 1, DBB197 from DBW500+1, DBB198 = 1, DBB199 = 1
4) User DB, DBB196 = 1, DBB197 from DBW500+1, DBB198 = 1, DBB199 = 4, DBD200 of DBD502
5) User DB, DBBX499.5 must be acknowledged with DBX515.7; DBX399.6 and DBX399.7 must be acknowledged with DBX515.6
6) Applies only to OP 17

Table 8-1 Analysis of the User DB by the User Program, continued

User DB, DBX...	Triggered by ...	User Program		See PIC...
		Function	User DB, DBX...	OP
514.6 = 1 514.0 = 1 514.1 = 1 514.2 = 1 514.3 = 1 514.4 = 1 514.5 = 1	SK “Tipp” SK “Steu” SK “Refpk” SK “SMR” SK “MDI” SK “AutoE” SK “Autom”	Transfer data for “Jog” mode and “Jog” mode1) to the FM Transfer data for “Control” mode and “Control” mode1) to the FM Transfer “Reference point approach” mode1) to the FM Transfer data for “Incremental relative” mode and “Incremental relative” mode 1) to the FM Transfer “MDI” mode 1) to the FM Transfer “Automatic single block” mode 1) to the FM Transfer “Automatic” mode 1) to the FM	38.0 38.1 38.22)	75
35.6 37.5 = 1 37.1 = 1	TF “software limit switch off” TF “Restart axis” TF “Delete distance to go”	To change “Disable software limit switch”, transfer yes/no to the FM Transfer “Restart axis” to the FM Transfer “Delete distance to go” to the FM		761
498.1 = 1 37.0 = 1 498.0= 1	SK “read” SK “active” SK “set”	Read MD No. from the user DB, retrieve its value from the FM, and enter that value in the user DB Transfer “Activate MD” to the FM Transfer MD No. and its value from the user DB to the FM	3) 39.3 43.3 4) 39.3	763
515.7 = 1 515.6 = 1	SK “Res” SK “Ack”	Error acknowledgement “Res” in the FM 453 (diagnostic interrupt) Error acknowledgement “Quit” in the FM 453 (data error, operator control/traversing error)	5)	77

SK = Softkey, TF = Text field

1) The relevant code for the operating mode is to be entered in DBB16 of the user DB.
2) Code = 254 in DBB17 of the user DB
3) User DB, DBB196 = 1, DBB197 from DBW500+1, DBB198 = 1, DBB199 = 1
4) User DB, DBB196 = 1, DBB197 from DBW500+1, DBB198 = 1, DBB199 = 4, DBD200 of DBD502
5) User DB, DBBX499.5 must be acknowledged with DBX515.7; DBX399.6 and DBX399.7 must be acknowledged with DBX515.6
6) Applies only to OP 17

Variables in the User DB

The Table below contains the signals/data that must be entered in the user DB via the OP (FM interface).

For a detailed description of the structure of the user DB, see Section 6.5.

Table 8-2 Variables in the User DB

User DB	Variable Type	Significance	User DB
DBB17	BYTE	Velocity or voltage/frequency level 1, 2 [BP]	–
 DBX34.0 DBX34.6 DBX35.6	BOOL	Single functions Servo enable Parking axis Disable software limit monitoring	Internal Write request
 DBX37.0 DBX37.1 DBX37.2 DBX37.3 DBX37.5 DBX37.6	BOOL	Single commands Activate machine data Delete distance to go Automatic block advance Automatic block return Restart Undo set actual value	Internal Write request
DBD140	DINT	Zero offset	DBX39.1
DBD144	DINT	Set actual value	DBX38.7
DBD156	DWORD	Setpoint for incremental dimension	DBX38.2
DBD160	DWORD	Speed level 1	DBX38.0
DBD164	DWORD	Speed level 2	
DBD168	DWORD	Voltage/frequency level 1	DBX38.1
DBD172	DWORD	Voltage/frequency level 2	
DBB176 to DBB195	STRUCT	MDI block	DBX38.3
DBB222 to DBB241	STRUCT	MDI block on-the-fly	DBX38.4
DBB242	BYTE	Program selection – program number	DBX39.5
DBB243	BYTE	Program selection – block number	
DBB244	BYTE	Program selection – direction	
DBB250	BYTE	Teach-in – program number	DBX39.7
DBB251	BYTE	Teach-in – block number	
DBW500	WORD	MD No.	–
DBD502	DINT/ entspr. MD	MD value	–
DBB506	BYTE	SM No.	–

8.3 Data Block for Status Messages (DB-SS)

Overview

The following table contains the parameters/data which are readable during operation.

Table 8-3 Parameters/Data of the Interface Data Block (DB No. 1000 for Channel 1, 1300 for Channel 2, and 1600 for Channel 3)

Byte	Variable Type	Value	Significance of the Variables	Comment
0 – 35			DB header	
36 – 59			Internal header information	
Offset[1)]	**Variable Type**	**Value**	**Significance of the Variables**	**Comment**
24	8 x BOOL		Control signals	Byte 0
25	8 x BOOL		Control signals	Byte 1
26	2 x BYTE		Control signals	Byte 2, 3
28	2 x BYTE		Control signals	Byte 4, 5
30	2 BYTE		Free	
32	8 x BOOL		Response signals	Byte 0
33	8 x BOOL		Response signals	Byte 1
34	BYTE		Response signals	Byte 2
35	8 x BOOL		Response signals	Byte 3
36	BYTE		Response signals	Byte 4
37	8 x BOOL		Response signals	Byte 5
38	2 BYTE		Free	
40	32 x BYTE		Reserved	
72	DWORD		Velocity level 1	
76	DWORD		Velocity level 2	
80	DWORD		Voltage/frequency level 1	
84	DWORD		Voltage/frequency level 2	
88	DWORD		Setpoint for incremental value	
92	STRUCT	MDI block struct.	MDI block	
112	16 x BOOL		Single functions	
114	16 x BOOL		Single commands	
116	DINT		Zero offset	
120	DINT		Set actual value	
124	DINT		Set actual value on the fly	

1) A variable in the S7 protocol is addressed by the DB No. and, depending on data format, by the DBB, DBW and DBD No. (offset in DB), as well.

Table 8-3 Parameters/Data of the Interface Data Block (DB No. 1000 for Channel 1, 1300 for Channel 2, and 1600 for Channel 3), continued

Offset[1)]	Variable Type	Value	Significance of the Variables	Comment
128	16 x BOOL		Digital inputs/outputs	
130	STRUCT	MDI block struct.	MDI block on the fly	
150	BYTE		Program selection	Program number
151	BYTE		Program selection	Block number
152	2 x BYTE		Program selection	Direction, free
154	4 x BYTE		Request application data	Application data 1-4
158	BYTE		Teach In	Prog. no.
159	BYTE		Teach In	Block number
160	DINT		Reference coordinate	
164	2 x BYTE		Free	
166	2 x BYTE		Coupled-axis grouping	
168	3 x DINT		Free	
180	DINT		Actual position	Basic operating data
184	DINT		Actual velocity	Basic operating data
188	DINT		Residual travel	Basic operating data
192	DINT		Target position	Basic operating data
196	DINT		Total current coordinate shift	Basic operating data
200	DINT		Traversing speed, rotary axis	Basic operating data
202	DINT		Free	
208	DINT		Free	
212	STRUCT	NC block struct.	Active NC block	
232	STRUCT	NC block struct.	Next NC block	
252	DINT		Code application 1	Application data
256	DINT		Code application 2	Application data
260	DINT		Code application 3	Application data
264	DINT		Code application 4	Application data
268	DINT		Actual position on leading edge	Length meas. / in–process measur.
272	DINT		Actual position on trailing edge	Length measurement
276	DINT		Length measurement value	Length measurement
280	DINT		Actual value at ext. block change	
284	DINT		DAC output value (for servo drive) or frequency output value (for step drive)	Servicing data

1) A variable in the S7 protocol is addressed by the DB No. and, depending on data format, by the DBB, DBW and DBD No. (offset in DB), as well.

Table 8-3 Parameters/Data of the Interface Data Block (DB No. 1000 for Channel 1, 1300 for Channel 2, and 1600 for Channel 3), continued

Offset[1)]	Variable Type	Value	Significance of the Variables	Comment
288	DINT		Encoder actual value (for drive with encoder) or pulse output counter (for drive without encoder)	Servicing data
292	DINT		Missing pulse (for drives with incremental encoders)	Servicing data
296	DINT		K_v factor (position control loop gain) (for servo drive)	Servicing data
300	DINT		Following error (for servo drive) or difference between setpoint and actual positions (for step drive)	Servicing data
304	DINT		Following error limit (for drives with encoders)	Servicing data
308	DINT		s overshoot/switch readjustment in Reference Point Approach mode	Servicing data
312	DINT		Approach time Te /drive constant in in Control mode (for servo drive)	Servicing data
316	2 x BYTE		Coupled-axis grouping status	
318	30 x BYTE		Free	
348	BYTE		Override	Addit. operating data
349	BYTE		NC traversing program No.	
350	BYTE		NC block no.	Addit. operating data
351	BYTE		No. of callup subroutine loops	Addit. operating data
352	BYTE		G90/91 Active	Addit. operating data
353	BYTE		G60/64 Active	Addit. operating data
354	BYTE		G43/44 Active	Addit. operating data
355	BYTE		Active D No.	Addit. operating data
356 356.1 356.2 356.3	8 x BOOL		Status messages • Bit 1 Velocity limitation to limit value from MD • Limitation to ±10 V (for servo drive) • Limitation of min. acceleration or min. deceleration in effect	Additional operating data
357	8 x BOOL		Status messages	
358	2 x BYTE		Free	
360	4 x 8 x BOOL		Diagnostics, system-specific	
364	4 x BYTE		Diagnostics, channel-specific	Identifier
368	2 x 8 x BOOL		Diagnostics, channel-specific	Channel error

1) A variable in the S7 protocol is addressed by the DB No. and, depending on data format, by the DBB, DBW and DBD No. (offset in DB), as well.

Table 8-3 Parameters/Data of the Interface Data Block (DB No. 1000 for Channel 1, 1300 for Channel 2, and 1600 for Channel 3), continued

Offset[1)]	Variable Type	Value	Significance of the Variables	Comment
370	4 x 8 x BOOL		Diagnostics, channel-specific	
374	2 x BYTE		Free	
376	2 x BYTE		Operator control/guidance error	
378	BYTE		Free	
379	BYTE		Free	
380	2 x BYTE		Data error	
382	BYTE		Free	
383	BYTE		Free	
384	2 x BYTE		Operator control error	
386	BYTE		Free	
387	BYTE		Free	
338	32 x BOOL		Process interrupt	

1) A variable in the S7 protocol is addressed by the DB No. and, depending on data format, by the DBB, DBW and DBD No. (offset in DB), as well.

The control and checkback signals in Table 8-3 can be the following signals:

Byte \ Bit	7	6	5	4	3	2	1	0
Control signals:								
24					BFQ/FSQ		TFB	
25	AF	SA	EFG	QMF	R+	R−	STP	ST
26	Operating mode							
27	BP							
28	OVERR							
29								
Checkback signals:								
32	PARA			DF	BF/FS		TFGS	
33		PBR	T-L			WFG	BL	SFG
34	BAR							
35	PEH		FIWS	SRFG	FR+	FR−	ME	SYN
36	MNR							
37				AMF				

The following table describes the control and checkback signals in German and English.

Table 8-4 Control and Checkback Signals

German	English	Description
Control signals		
TFB	TEST_EN	Switch P bus interface to “Start-up”
BFQ/FSQ	OT_ERR_A	Acknowledge operator control and traversing errors
ST	START	Start
STP	STOP	Stop
R–	DIR_M	Negative direction
R+	DIR_P	Positive direction
QMF	ACK_MF	Acknowledgement for M function
EFG	READ_EN	Read Enable
SA	SKIP_BLK	Skip block
AF	DRV_EN	Drive Enable
BA	MODE_IN	**Mode** **Code** Jog 01 Control 02 Reference point approach 03 Incremental relative 04 MDI 06 Automatic 08 Automatic single block 09
BP	MODE_TYPE	**Operating parameters** **Code** Speed levels 1 and 2 Voltage/frequency levels 1 and 2 Incremental dimension selection 1...100, 254
OVERR	OVERRIDE	Override
Checkback signals		
TFGS	TST_STAT	Switching of P bus interface completed
BF/FS	OT_ERR	Operator control/traversing errors
DF	DATA_ERR	Data error
PARA	PARA	Channel initialized
SFG	ST_ENBLD	Start Enable
BL	WORKING	Execution in progress
WFG	WAIT_EI	Waiting for external Enable
T-L	DT_RUN	Dwell time running
PBR	PR_BACK	Reverse program scanning
BAR	MODE_OUT	Active mode
SYN	SYNC	Channel synchronized
ME	MSR_DONE	Measurement completed

Table 8-4 Control and Checkback Signals, continued

German	English	Description
FR–	GO_M	Negative travel
FR+	GO_P	Positive travel
SRFG	ST_SERVO	Servo enable status
FIWS	FVAL_DONE	On-the-fly setting of actual value completed
PEH	POS_RCD	Position reached. Stop.
MNR	NUM_MF	M function number
AMF	STR_MF	M function modification

Description of Functions 9

Chapter Overview

Summary

This chapter describes the functions of the FM 453.

By calling up the appropriate functions (FCs) you can activate these functions by way of the user program.

Note

The procedure is only described here for one channel. It must also be followed for each additional channel.

9.1 Control and Checkback Signals

Overview

The **POS_CTRL** block transfers the control signals from the user DB to the FM and transfers the checkback signals from the FM to the user DB.

Bit / Byte	7	6	5	4	3	2	1	0
Control signals:								
14					BFQ/ FSQ		TFB	
15	AF	SA	EFG	QMF	R+	R–	STP	ST
16	Operating mode							
17	BP							
18	OVERR							
19								
Checkback signals:								
22	PARA			DF	BF/FS		TFGS	
22		PBR	T-L			WFG	BL	SFG
24	BAR							
25	PEH		FIWS	SRFG	FR+	FR–	ME	SYN
26	MNR							
27				AMF				

9.1.1 Control Signals

Overview

The axis is operated and controlled by means of control signals.

Table 9-1 describes the control signals and their functions.

Table 9-1 Control Signals

Symbol		Name	Function
English	German		
TEST_EN	TFB	Sw./over P-bus interface	Interrupts communication with the user program, and switches over the P bus interface for operation with the start-up user interface.
OT_ERR_A	BFQ/FSQ	Acknow-ledge opera-tor/travel error	... resets an error message. Before acknowledging the error, correct its cause.
START	ST	Start	... starts movement in Automatic, MDI and Reference-point approach modes.
STOP	STP	Stop	... interrupts movement or processing of the program. ... cancels reference point approach.
DIR_M	R–	Direc-tion mi-nus	... moves axis in negative direction. • In Jogging and Control modes, moves axis in negative direction (level-dependent). • Starts movement in negative direction in Incremental relative and Reference-point approach modes. • Specifies direction of movement for rotary axes in MDI and Auto-matic modes.
DIR_P	R+	Direc-tion plus	... moves axis in positive direction. • In Jogging and Control modes, moves axis in positive direction (level-dependent). • Starts movement in positive direction in Incremental relative and Reference-point approach modes. • Specifies direction of movement for rotary axes in MDI and Auto-matic modes.
ACK_MF	QMF	Acknow-ledge M function	... only “acknowledge-driven” during M function output (see machine data list in Table 5-4, MD32). ... acknowledges receipt of M function. Program sequence can be con-tinued.
READ_EN	EFG	Read-in enable	... prevents read-in (processing) of the next block. ... has effect only in Automatic mode. The read-in enable is required in order to read in the next traversing block during program execution.
SKIP_BLK	SA	Skip block	... skips identified blocks in the program. ... has effect only in Automatic mode.

Table 9-1 Control Signals, continued

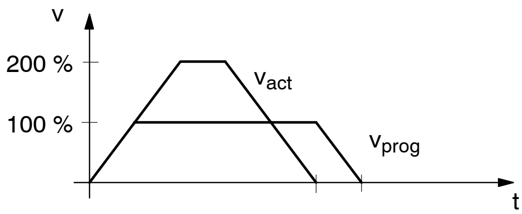
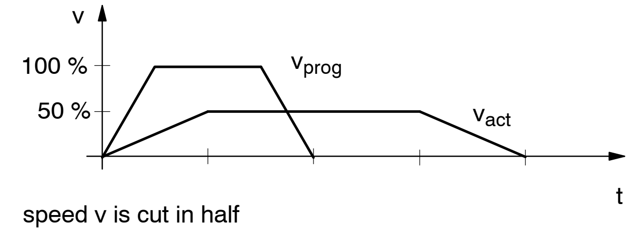
Symbol		Name	Function
English	**German**		
DRV_EN	AF	Drive enable	... enables movement. When the signal is reset, a **rapid deceleration** (as per MD45) of the movement takes place. On MD 37.15 = 0 program execution, or the movement, is canceled and the residual distance is deleted. On MD 37.15 = 1 machining resumes after emergency stop • Rapid deceleration of the movement. • With axis standstill FR+ or FR– = 0; BL = 1, – the drive remains activated and servo enable also remains active; the axis is held in position control. – the drive is deactivated; the user must activate “follow-up”. This deactivates zero speed control (the axis can be pushed away). • If an error occurs in this state (e.g. if the user starts a movement without a start enable, etc.), an error response is initiated, e.g. the residual distance is deleted, BL = 0, (a new path default must be defined).
MODE_IN	BA	Operating mode	Operating mode (see Section 9.2) — Code Jogging — 01 Open-loop control — 02 Reference point approach — 03 Incremental relative — 04 MDI — 06 Automatic — 08 Automatic single block — 09
MODE_TYPE	BP	Mode parameter	... selects speed levels in Jogging mode. ... selects voltage/frequency levels in Open-loop control mode. ... selects incr. in Incremental relative mode (value 1 ... 100 or 254).
OVERRIDE	OVERR	Override	... affects response of traversing movement. Range: 0-255% ... override has no effect in Control mode • Velocity override Range: 0-255% Speed adjusted by percentage **Example:** Override doubled from 100% to 200%  – speed v is doubled – acceleration and deceleration values are not affected $v_{act} = \frac{v_{prog} \cdot Override}{100}$ The positioning time is not cut in half.

Table 9-1 Control Signals, continued

Symbol		Name	Function
English	German		
OVERRIDE	OVERR	Override	• Time override If you parameterize the “time override” function in MD37, there are two ranges: – range 100-255%: speed override operates as described above – range 0-100%: time override operative Speed, acceleration and deceleration are changed in such a way that the time necessary for the traversing movement is directly correlated with the override value. **Example:** Cut override in half, from 100% to 50%  – speed v is cut in half – acceleration and deceleration are quartered $v_{act} = \frac{v_{prog} \cdot Override}{100}$ $a_{act} = \frac{a \cdot Override^2}{100^2}$ $t_{act} = \frac{t \cdot 100}{Override}$ Positioning time is doubled. Taking the override into account as a time override presupposes the following additional condition: If a traversing movement consists of multiple positioning blocks with block change on-the-fly (the axis does not stop between blocks), changing the override value affects only the speed. Acceleration and deceleration are additionally affected only after the axis comes to a stop (e.g. reversal of direction). **Note:** Time override has effect only in the MDI and Automatic modes.

Note

For further functions, **settings and commands** concerning open-loop control, see Section 9.3.2 and Section 9.3.3.

9.1.2 Checkback Signals

Overview

The checkback signals indicate the processing status of the axis and report it to the user program.

Table 9-2 describes the checkback signals and their functions.

Table 9-2 Checkback Signals

Symbol		Significance	Function
English	German		
TST_STAT	TFGS	Sw./over P bus interface complete	Communication with the user program is not possible, since the P bus interface has been switched over for operation with the start-up tool.
OT_ERR	BF/FS	Operator control and guidance errors	... signaled to the user if an operator-control error or travel error is pending (e.g. unallowed control signal has been set, (R+) and (R–) set simultaneously) An error message causes the movement to be canceled. see Chapter 11
DATA_ERR	DF	Data error	... is reported to the user when a data error occurs. see Chapter 11
PARA	PARA	Parameterize	... module parameterized. All machine data applicable for control of an axis are present on the module.
ST_ENBLD	SFG	Start enable	... signals that the FM 453 is ready for positioning and output. • "Start enable" is set: – if no static stop or error is pending and the drive enable is pending – if the mode setting and mode checkback match (after mode change) – if no axis functions (including M output, dwell time) are active, or after functions have been completed – for further processing of a function interrupted with unprogrammed stop – in Automatic mode, after program has been selected (one program active) and after M0, M2, M30, or at end of block with Automatic single-block • "Start enable" is deleted: – if a function has been started and is active, or – if a start condition is active (stat.) – if there is an error and an unprogrammed stop – in follow-up mode • Without Enable Start, none of the functions that can be operated with Travel Plus, Travel Minus and Start can be executed.

Table 9-2 Checkback Signals, continued

Symbol		Significance	Function
English	German		
WORKING	BL	Processing in progress	... indicates that a function has been started with Start or Travel Plus/Minus, and is active. • "Processing in progress" is set with: – "Jogging", "Control" mode during the movement up to standstill after cancelation of R+, R– – Reference-point approach mode, during approach until reference point is reached – "MDI", "Incremental relative mode", during the positioning process or while functions of the MDI block are being processed – Automatic mode, during processing of a traversing program until the end of the program. • "Processing in progress" is deleted: – by errors and restarts – by mode changes. – after axis standstill
WAIT_EI	WFG	Warten auf externe Freigabe	... takes effect only if a digital input has been parameterized by means of MD34 (see Section 9.8.1). Set: if the enable input has not yet been set or has been reset when a movement has been activated.
DT_RUN	T-L	Verweilzeit läuft	... only active in Automatic and MDI mode. As soon as a traversing block with a dwell time has been processed, (T-L) is output during the programmed time period.
PR_BACK	PBR	Programmbearbeitung rückwärts	... is set after a Start in Automatic mode if a program is being processed in reverse.
MODE_OUT	BAR	Active mode	The selected mode is not fed back until it is internally active. For a mode change, for example, a movement must be stopped before another mode can become active (does not apply to switching between Automatic and Automatic single-block modes).
SYNC	SYN	Synchronism	... module is synchronized (see Section 9.6.4) Required for axis motion in modes: • Incremental Relative • MDI • Automatic
MSR_DONE	ME	Measurem. End	... signals an executed measurement (see Section 9.3.11)

Table 9-2 Checkback Signals, continued

Symbol		Significance	Function
English	German		
GO_P GO_M	FR+ FR–	Travel plus Travel Minus	... means the axis is traveling in the direction of increasing actual values or in the direction of voltage output "+" in OL control mode. ... means the axis is traveling in the direction of decreasing actual values or in the direction of voltage output "–" in OL control mode. • As soon as an active travel movement is pending, the messages (FR+) or (FR–) are output depending on the traversing direction. They can only be pending as alternatives. • "Travel Plus" or "Travel Minus" is actuated at the start of the acceleration phase and remains active until the axis comes to a standstill or the POS_ROD target area has been reached.
ST_SERVO	SRFG	Servo enable status	• Feedback of servo enable status after single function has been activated • See also Section 9.3.2 "Servo enable" • See also Section 11.1, error reaction "Everything OFF"
FVAL_ DONE	FIWS	Set actual value on-the-fly complete	... set Actual value on-the-fly is executed. The signal is reset when "Set actual value on-the-fly" is activated (see Section 9.3.6).
NUM_MF	MNR	M function number	M command 0...99
STR_MF	AMF	Change M function	... is indicated simultaneously with the M function number. • If M functions are programmed in a traversing block, their output is signaled by setting "Change M function." • "Change M function" remains pending until: – the specified time has expired, for time-controlled M functions – the user has acknowledged, for acknowledgment-controlled M functions.

Table 9-2 Checkback Signals, continued

Symbol		Significance	Function
English	**German**		
POS_RCD	PEH	Position reached, Stop (“PEH”)	• When the preset target position is reached correctly, (PEH) is actuated, and remains in effect until the next axis movement. • “Target position reached correctly” means that during approach of the actual value to target position, a defined tolerance (PEH tolerance) must not be exceeded during a defined time (PEH time watchdog). If this is not the case, an error is signaled and positioning is interrupted. • (PEH) is actuated only in the following modes and cases: – Reference-point approach: If the reference point has been reached in full (including reference-point shift). – “MDI”, “Incremental relative”: If the preset position has been reached. – Automatic: If a traversing block has been positioned in full and the axis remains motionless until the next traversing movement. • It is not set if no synchronization is available yet.

9.1.3 General Handling Information

Overview

Before data/settings can be transferred to the FM 453, an operating mode must be active (e.g. “Jogging” mode = 1 and MODE = 1). That means that communication with the FM 453 has been initiated and the FM 453 has access to valid machine data.

Operating Modes (codes)	Relevant Control Signals	Relevant Checkback Signals	Required Data/ Settings
Jogging (01)	[R+], [R–], [STP], [AF], [OVERR], [BP] = 1 or 2	[BL], [SFG], [FR+], [FR–], [SYN], [WFG]	Speed levels 1, 2 (User DB, DBX38.0) Servo Enable (User DB, DBX34.0)
Open-loop control (02)	[R+], [R–], [STP], [AF], [BP] = 1 or 2	[BL], [SFG], [FR+], [FR–], [WFG]	Voltage/frequency levels 1, 2 (user DB, DBX38.1)
Reference point approach (03)	[R+], [R–], [ST], [STP], [AF], [OVERR]	[BL], [SFG], [FR+], [FR–], [WFG], [SYN], [PEH]	Servo Enable (user DB, DBX34.0)
Incremental relative (04)	[R+], [R–], [STP], [AF], [OVERR], [BP] = 1...100 for increment table or 254	[BL], [SFG], [FR+], [FR–], [WFG], [SYN], [PEH]	Speed levels 1, 2 (User DB, DBX38.0) Servo Enable (User DB, DBX34.0) Setpoint for incremental dimension (user DB, DBX34.2) (only if BP = 254; if BP is = 1 to 100, the relevant incremental dimensions must be parameterized)
MDI (06)	[ST], [STP], [AF], [QMF], [OVERR]	[BL], [SFG], [FR+], [FR–], [WFG], [SYN], [PEH], [AMF), [MNR], [T-L]	MDI block (user DB, DBX38.3) Servo Enable (user DB, DBX34.0)
Automatic (08) Automatic single block (09)	[ST], [S]), [EFG], [STP], [AF], [QMF], [OVERR]	[BL], [SFG], [FR+], [FR–], [WFG], [SYN], [PEH], [AMF], [T-L], [PBR], [MNR]	Program selection (user DB, DBX 39.5) (assuming that the relevant traversing program was parameterized), Servo Enable (user DB, DBX34.0)

Error condition:

- Reported via BF/FS – acknowledgement with BFQ/FSQ
- Reported via DF – acknowledgement with next correct data transfer
- Reported via diagnostic interrupt – acknowledgement with “Restart” (user DB, DBX37.5)

Hints to the User

Here are a few hints for starting a movement and about the response of the FM 453 to a change of the status of the S7-400 CPU:

It is assumed that the FM 453 has been parameterized correctly.

- First a mode must be set. The servo enable must subsequently be set in order to prevent the axis from “running away,”.
- Before starting a movement in any mode, the relevant data (e.g. speed levels) must be transferred and the override must be > 0.
- It is only possible to start the movement when the start enable is set and the enable input is set (if parameterized).

  Enable Start is set if:

  - No error occurred
  - Mode is active
  - No Stop is called
  - Drive enable is set
- A static Stop signal prevents all movements or block processing.
- Response of the FM 453 to transition of the S7-400 CPU from RUN to STOP state:
  - As described for Restart (see Section 9.3.3)
  - The digital outputs are switched off
  - Interface to the user program is switched off
- Response of the FM 453 to transition of the S7-400 CPU from STOP to RUN state:

  A cold restart of the module is executed.

Module Control

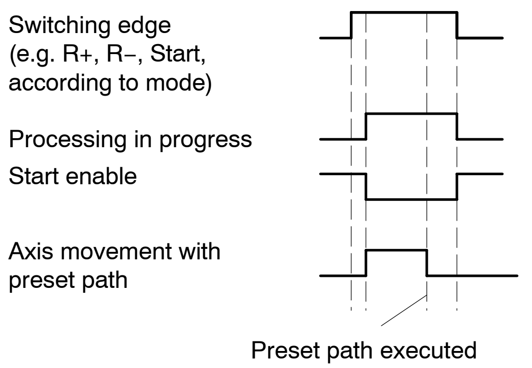
The following table lists the control signals used to start a movement.

Prerequisite: Drive enable [AF] = 1, Stop [STP] = 0,
Start enable [SFG] = 1

Mode	Parameters	Command / Signal State	Activation of Movement
Jogging (mode = 01)	Velocity level BP = 1 = level 1 BP = 2 = level 2	R+, R– / Level	R+ or R– with “Level” = 1 (R+ and R– simultaneously → error)
Control (mode = 02)	Voltage frequency level BP = 1 = level 1 BP = 2 = level 2	R+, R– / Level	R+ or R– with “Level” = 1 (R+ and R– simultaneously → error)
Reference point approach (mode = 03)	–	Start, R+, R– / Edge	Direction as in MD R+ or R– = 0/1 or Start = 0/1 (speed as in MD)
Incremental relative (mode = 04)	BP = 1...100 BP = 254	R+, R– / Edge	R+ = 0/1 or R = 0/1 (speed level 1)
MDI (mode = 06)	–	Start / Edge	Start = 0/1 (R+, R– relevant only for rotary axis with absolute measure specified for direction selection)
Automatic (mode = 08)	–	Start / Edge	Start = 0/1 (according to program presetting)
Automatic single block (mode = 09)	–	Start / Edge	Start = 0/1

Stat. Pending Start Condition

“Processing in progress” remains active after the end of machining and there is no start enable as long as the start condition is not reset.



The following table lists the control signals used to interrupt/terminate a movement.

Mode	Interrupt Movement	Continue Movement	Interrupt/ End Movement, Stop
Jogging (mode = 01)	Stop = 1 or Enable input[1)] = 0	Stop = 0 or Enable input[1)] = 1	R+ or R– with “Level” = 0 or mode change Drive enable = 0[2)]
Control (mode = 02)	Stop = 1 or Enable input[1)] = 0	Stop = 0 or Enable input[1)] = 1	R+ or R– with “Level” = 0 or mode change Drive enable = 0[2)]
Reference point approach (mode = 03)	–	–	Stop = 0/1 or ref. received or mode change or enable input[1)] = 0 Drive enable = 0[2)]
Incremental relative (mode = 04)	Stop = 1 or Enable input[1)] = 0	Stop = 0 or Enable input[1)] = 1, with R+ or R–	Position reached or mode change Drive enable = 0[2)]
MDI (mode = 06)	Stop = 1 or Enable input[1)] = 0	Stop = 0 or Enable input[1)] = 1, with Start = 0/1	Position reached or “block” processed or mode change Drive enable = 0[2]
Automatic (mode = 08)	Stop = 1 or Enable input[1)] = 0	Stop = 0 or Enable input[1)] = 1, with Start = 0/1	Program end or mode change New program selected after stop Drive enable = 0[2]
Automatic single block (mode = 09)	Stop = 1 or Enable input[1)] = 0	Stop = 0 or Enable input[1)] = 1, with Start = 0/1	Program end or mode change New program selected after stop Drive enable = 0[2]

1) **Prerequisite:** Digital input defined in MD34; see Section 9.8.1
2) if MD37.15 not defined, see Table 9-1 Control signal [AF]

9.2 Operating Modes

Overview

The following operating modes are implemented on the FM 453:

• Jogging (T)	Code 01
• Open-loop control (STE)	Code 02
• Reference point approach (REF)	Code 03
• Incremental relative (SMR)	Code 04
• MDI (Manual Data Input)	Code 06
• Automatic (A)	Code 08
• Automatic single block (AE)	Code 09

Selecting the Mode

The POS_CTRL block is called up in order to transfer the operating mode (code), which the user program entered in the user data block, to the FM 453.

The axis is controlled by enabling and disabling appropriate control signals.

Checkback Signal for Mode

When the specification is allowed, the FM 453 feeds back the specified mode to the user program. If this checkback mode matches the specified one, the mode is active.

Changing Modes

Changing modes triggers an internal stop.

If a mode change is attempted while a traversing movement is in progress, the modes are not switched until the axis comes to a stop. The mode checkback is performed after the movement in the old mode is completed.

9.2.1 Jogging

Overview

In Jogging mode, axis traversing movements are specified by way of the direction keys (R+ or R–) and by speed.

Velocity

Before the axis can be moved, speeds (velocities) 1 and 2 must first be transferred to the FM 453 (user DB, DBX38.0).

You can choose between two mutually independent velocities (level 1 and level 2) with the mode parameter (BP).

The velocity can also be controlled using the override, and can be changed during the movement.

Name	Lower Input Limit	Upper Input Limit	Unit
Speed	10	500 000 000	MSR/min

MSR stands for measurement system raster (see Section 5.3.1)

Handling by the User

The table below gives you an overview of how to handle this mode.

Triggering of Movement, Direction (R)	Level Selection	Speed
R+ or R– “level-controlled”	BP = 1	Value for speed level 1
	BP = 2	Value for speed level 2

Note

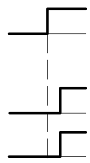
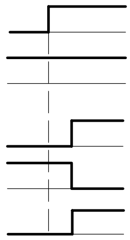
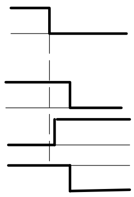
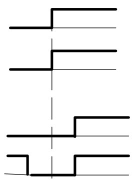
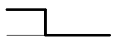
Please see also Section 9.1.3!

Control Actions

Prerequisites:

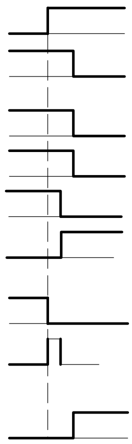
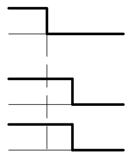
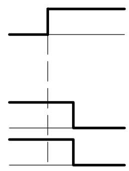
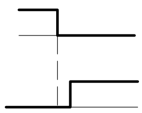
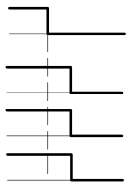
- The FM 453 has been initialized.
- The mode has been selected and acknowledged.
- Drive Enable [AF] is = 1 (control signal in user DB, DBX15.7)
- Stop [STP] is = 0 (control signal in user DB, DBX15.1)
- Servo Enable (RF) is = 1 (user DB, DBX34.0)
- Speed levels 1 and 2 have been transferred.

Table 9-3 Control Actions for “Jogging” Mode (examples)

Signal Name	Level	Explanation
Control action 1, enable “Jogging” mode		
Control signal: Mode [BA] **Checkback signals:** Active mode [BAR] Start enable [SFG]		The user initiates a [BA] command. The module returns [BAR] and [SFG].
Control action 2, move axis – positive direction		
Control signals: Direction plus [R+] Drive enable [AF] **Checkback signals:** Travel plus [FR+] Start enable [SFG] Processing in progress [BL]		When [SFG] and [AF] are active, [R+] is actuated. The axis cancels the [SFG] and outputs messages [BL] and [FR+]
Control action 3, deactivate axis – positive direction		
Control signal: Direction plus [R+] **Checkback signals:** Travel plus [FR+] Start enable [SFG] Processing in progress [BL]		[R+] is canceled When the axis has come to a standstill by way of the deceleration ramp[1)], the [BL] and [FR+] messages are canceled and [SFG] is activated. Before the axis comes to a standstill, it is possible to define a new direction “through start”.
Control action 4, move axis – negative direction		
Control signals: Direction minus [R–] Velocity level [BP] **Checkback signals:** Travel minus [FR–] Processing in progress [BL]		[R–] is actuated in combination with velocity level 2. The axis travels at velocity level 2, and returns [BL] and [FR–]. The [SFG] signal is canceled.
Control action 5, switch over set–up velocity		
Control signal: Velocity level [BP]		A switchover from [level 2 to level 1] causes a dynamic transition between velocity levels 1 and 2.

1) Does not apply to stepper drive

Table 9-3 Control Actions for “Jogging” Mode (examples), continued

Signal Name	Level	Explanation
Control action 6, ambiguous direction command (special situation)		
Control signals:		
Direction plus [R+]		[R+] is actuated while the axis is traversing with [R–].
Direction minus [R–]		
Checkback signals:		The ambiguous direction command causes the axis to stop and [BF/FS] to be output. [FR–] and [BL] are reset.
Travel minus [FR–]		
Processing in progr. [BL]		
Start enable [SFG]		
Operator control/travel error [BF/FS]		Only when [R+] is canceled and the error is acknowledged [BFQ/FSQ] is [SFG] actuated again and a new direction command can be initiated.
Control signals:		
Direction minus [R–]		
Error acknowledgement [BFQ/FSQ]		
Checkback signal:		
Start enable [SFG]		
Control action 7, cancel drive enable (special situation)		
Control signal:		
Drive enable [AF]		[AF] is deactivated during the traversing movement.
Checkback signals:		
Travel minus [FR–]		The axis is stopped immediately. [FR–] and [BL] are canceled.
Processing in progr. [BL]		
Control action 8, reset during axis motion (special situation)		
Single command “Restart”, DBX37.5)		Restart is defined during the traversing movement.
Checkback signals:		The axis is stopped immediately. [FR+] and [BL] are reset.
Travel plus [FR+]		
Processing in progr. [BL]		If incremental encoders are used, resynchronization is necessary. (SYN is cleared)
Control action 9, change direction		
Control signal:		
Direction plus [R+]		Only when [R+] is canceled is [SFG] reactivated.
Checkback signal:		
Start enable [SFG]		
Control action 10, change mode		
Control signal:		
Mode [BA]		A new [BA] 1 is preselected during the traversing movement.
Checkback signal:		The axis is stopped by way of the deceleration ramp1). [FR+] and [BL] are reset.
Active mode [BAR]		
Travel plus [FR+]		
Processing in progr. [BL]		

1) Does not apply to stepper drive.

9.2.2 Open-loop Control

Overview

In the “Control” mode, voltages of varying sizes or frequencies (if increments are used) with selectable magnitudes are specified and then used to perform a controlled movement. The direction of movement is determined by way of direction keys (R+ or R–).

The actual value of the axis is updated at the same time.

With the position control disabled (servo enable = 0), follow-up mode is active in the ”Control” mode.

Note

A control, which may have been activated by a controller enable, will be interrupted while the voltage/frequency is being output. After the Jogging signals R+ or R– have died off, control is referred to the new actual value, and reinstated after the axis comes to a stop, if the controller enable is still active when the axis stops.

Voltage/Frequency Values

The voltage/frequency is specified in the user DB, DBX38.1.

You can choose between two mutually independent voltage/frequency values (level 1 and level 2) with the mode parameter (BP).

Name	Lower Input Limit	Upper Input Limit	Unit
Voltage (levels 1/2)	0	10 000	mV
Frequency (levels 1/2):	0	1 000 000	Hz

The values for the voltage/frequency levels can be changed during movement.

Handling by the User

The table below gives you an overview of how to handle this mode.

Triggering of Movement, Direction (R)	Level selection	Speed
R+ or R– "level-controlled"	BP = 1	Value of voltage/frequency level 1
	BP = 2	Value of voltage/frequency level 2

Note

Beachten Sie auch Kapitel 9.1.3!

Control Actions

The control and checkback signals are handled in the same way as in "Jogging" mode.

9.2.3 Reference Point Approach

Overview

In Reference-point approach mode, the direction keys (R+ or R–) or Start are used to position the axis to a point (reference-point coordinate MD16) specified in the machine data.

The axis is thus synchronized (see Section 9.6.4).

The override is set to 100% for the reducing speed.

An active zero offset or Set actual value is reset.

Machine Data

The following table lists the machine data that is of significance for reference-point approach:

MD	Designation	Value/Meaning	Comments/ Unit
16	Reference-point coordinate	–1,000,000,000 – +1,000,000,000	(MSR)
18	Type of reference-point approach (reference-point approach direction)	0 = direction +, zero ref. mark right 1 = direction +, zero ref. mark left 2 = direction –, zero ref. mark right 3 = direction –, zero ref. mark left 4 = direction +, RPS center 5 = direction –, RPS center 8 = direction +, RPS edge 9 = direction –, RPS edge	Zero reference mark: See zero reference mark selection, Figure 5-5
27	Reference-point shift	–1,000,000,000 – +1,000,000,000	(MSR)
28	Referencing speed	10...500 000 000 see Section 5.3.1, Dependencies	(MSR/min)
29	Reducing speed	10...500 000 000 see Section 5.3.1, Dependencies	(MSR/min)
34	Dig. inputs	5 = reference point switch for reference point approach 6 = reversing switch for ref. point approach	Assigned depending on input

MSR stands for measurement system raster (see Section 5.3.1)

Handling by the User

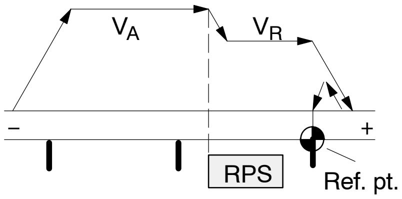
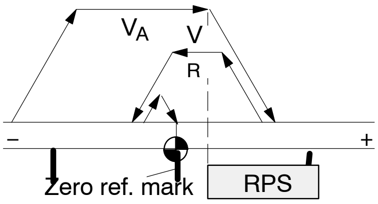
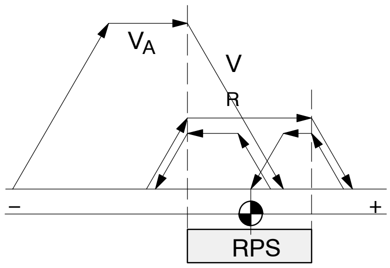
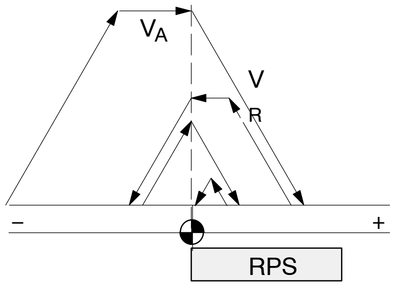
When an absolute encoder is used, only the reference point coordinate defined as a fixed point on the axis is approached in Reference-point approach mode.

When an incremental encoder is used, the user has two options for recording the reference point:

- with connected reference-point switch (RPS)
- without connected reference-point switch (RPS).

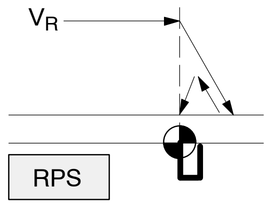
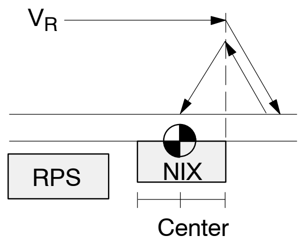
With Reference Point Switch (RPS)

It is necessary to connect the reference point switch (RPS) to a digital input and parameterize it in MD34.

Triggering of Movement, Direction for Synchronization (R)	Type of Reference-Point Approach	Sequence of Motions (Reference Point Offset = 0) V_A – referencing velocity V_R – reducing velocity
R+ ("edge-controlled") or Start	1st situation zero reference mark to right of RPS	
	2nd situation zero reference mark to left of RPS	
	3rd situation RPS centered (no zero pulse necessary)	
	4th situation RPS edge (no zero pulse necessary)	
R– ("edge-controlled") or Start	1st situation zero ref. mark to right of RPS	equals R+ 2nd situation mirrored
	2nd situation zero ref. mark to left of RPS	equals R+ 1st situation mirrored
	3rd situation RPS centered (no zero pulse necessary)	equals R+ 3rd situation mirrored
	4th situation RPS edge (no zero pulse necessary)	equals R+ 4th situation mirrored

When crossing the RPS, a signal length of $\Delta t \geq 2 \cdot$ FM cycle must be assured!

The following table shows you the exact location of the synchronization point on the current-sourcing pattern zero or zero pulse external.

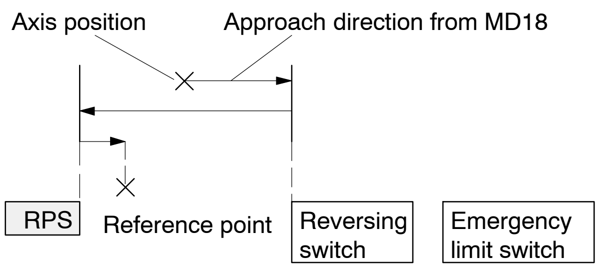
Synchronization Point Encoder Selection in MD37	Applicable for Type (0 – 3) of the Reference Point Approach per MD18
Current-sourcing pattern zero	
Zero pulse external (NIX)	

Using a Reversing Switch

If it is possible for the axis to be “behind” the reference point switch when you start reference point approach, a reversing switch can be installed at the end of the axis in the approach direction, in order to reverse the axis in the direction of the reference point switch.

On axis movements with referencing feed, a signal length of $\Delta t \geq 2 \cdot$ FM cycle must be assured for the reversing switch!

Example



The value for the reference-point shift (MD27) is traveled after the synchronization point is reached.

Without Reference-Point Switch (RPS)

The following table describes how a reference can be recorded without a reference-point switch.

Recording of synchronization	Sequence of movements
R+, R– or Start	1. Instantaneous position is defined as reference point (reference-point coordinate). 2. Value for reference-point shift is traveled.

Note

Please see also Section 9.1.3!

Control Actions

Prerequisites:

- The FM 453 has been initialized.
- The mode has been selected and acknowledged.
- Drive Enable [AF] is = 1 (control signal in the user DB, DBX15.7)
- Stop [STP] is = 0 (control signal in the user DB, DBX15.1)
- Servo Enable (RF) is = 1 (user DB, DBX34.0)

Table 9-4 Control Actions for “Reference point approach” Mode (examples)

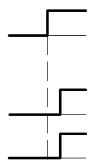
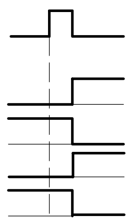
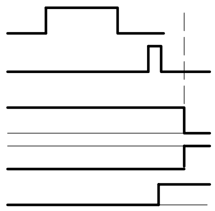
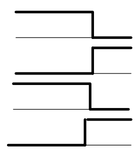
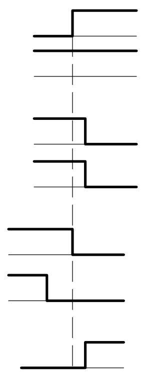
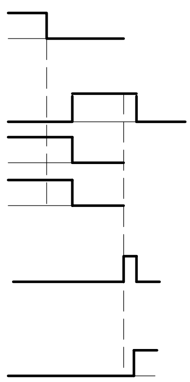
Signal Name	Level	Explanation
Control action 1, enable “Reference point approach” mode		
Control signal: Mode [BA] **Checkback signals:** Active mode [BAR] Start enable [SFG]		The user initiates a [BA] command. The module returns [BAR] and [SFG].
Control action 2, move axis – positive direction		
Control signal: Direction plus [R+] **Checkback signals:** Travel plus [FR+] Start enable [SFG] Processing in progress [BL] Synchronization [SYN]		When [SFG] is active, [R+] or [Start] are actuated, for example. The axis cancels [SFG], outputs the [BL] and [FR+] messages and travels here in the positive direction (defined in MD). An existing synchronization is reset.

Table 9-4 Control Actions for “Reference point approach” Mode (examples), continued

Signal Name	Level	Explanation
Control action 3, reference point switch (RPS) reached		
RPS Encoder zero marker **Checkback signals:** Travel plus [FR+] Travel minus [FR–] Synchronized [SYN]		When the RPS is reached, the velocity is reduced. The encoder is synchronized when the zero marker is detected. The axis is positioned by traversing through the reference point offset to the reference point (the direction is reversed if necessary).
Control action 4, approach reference point		
Checkback signals: Travel minus [FR–] Position reached, stop [PEH] Processing in progress [BL] Start enable [SFG]		When reference point is reached. [FR–] is removed. [PEH] is set. [BL] is also removed. [SFG] is set.
Control action 5, ambiguous direction command (special situation)		
Control signals: Direction plus [R+] Direction minus [R–] **Checkback signals:** Travel minus [FR–] Processing in progress [BL] **Control signals:** Direction plus [R+] Direction minus [R–] **Checkback signal:** Start enable [SFG]		[R+] is defined although [R–] is active. The ambiguous direction command causes the axis to stop. [FR–] and [BL] are canceled, and an error is output. The [SFG] does not reappear until [R+] and [R–] have been canceled].
Control action 6, cancel servo enable (special situation)		
Single function “Servo Enable” (DBX34.0) **Checkback signals:** Operator control/travel error [BF/FS] Travel minus [FR–] Processing in progress [BL] **Control signal:** Acknowledge operator control/travel error [BFQ/FSQ] **Checkback signals:** Start enable [SFG]		The “servo enable” is deactivated during the traversing movement. The axis is stopped immediately and outputs an error. [FR–] and [BL] are canceled. When the error is acknowledged, the error message is canceled and the start enable is activated.

9.2.4 Incremental Relative

Overview

In the Incremental Relative mode it is possible to execute single positionings over relative distances using user-definable increments.

The traversing movement is triggered with the direction keys (R+ and R–).

Defining the Position

The options available for defining the increment with the mode parameter are:

- Via the user program, by defining a position for incremental mode (user DB, DBX38.2)

  The setpoint for the incremental dimension must be entered in the AW-DB, DBD156, before the write order is initiated.

- Using the increment (SM) table; see Section 5.3.2

Speed level 1 (user DB, DBX38.0, see Section 9.2.1) is used as speed setpoint, and can be modified while the movement is in progress.

On-the-fly position changes (e.g. changing of the position setpoint during the course of a movement) is **not** possible.

Handling by the User

The table below gives you an overview of how to handle this mode.

Triggering of Movement, Direction (R)	Increment Selection	Position, Distance to Be Traveled
R+ or R–	BP = 254	in accordance with the setpoint for incremental dimension (user DB, DBX38.2)
	BP = 1...100	as in SM table (DB-SM)

Position setting

Name	Lower Input Limit	Upper Input Limit	Unit
Increment	0	1 000 000 000	MSR

MSR stands for measurement system raster (see Section 5.3.1)

Note the following when interrupting a movement with “Stop”:

- To continue movement in the same direction – the residual distance is processed with the appropriate direction key.
- To continue movement with “delete distance to go” (user DB, DBX37.1), the remaining distance to go is deleted and the incremental dimension is again traveled (provided the incremental dimension was not changed).
- To position in the opposite direction – the residual distance is deleted automatically.

Note

Please see also Section 9.1.3!

Control Actions

Prerequisites:

- The FM 453 has been initialized.
- The mode has been selected and acknowledged.
- The Drive enable [AF] is = 1 (control signal in the user DB, DBX15.7)
- Stop [STP] = 0 (control signal in the user DB, DBX15.1)
- The Servo Enable (RF) is = 1 (user DB, DBX34.0)
- Speed levels have been transferred
- The axis is synchronized

Table 9-5 Control Actions for “Incremental Relative” Mode (examples)

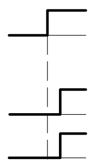
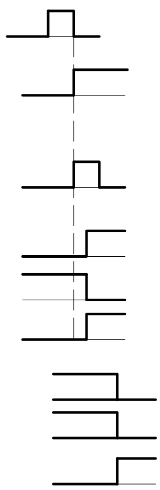
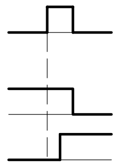
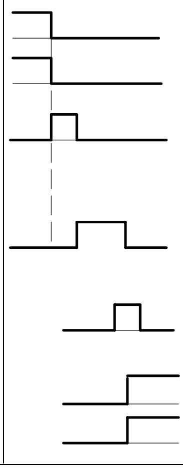
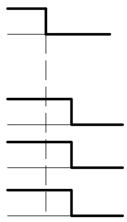
Signal Name	Level	Explanation
Control action 1, enable “Incremental relative” mode		
Control signal: Mode [BA] **Checkback signals:** Active mode [BAR] Start enable [SFG]		The user initiates a [BA] command. The module returns [BAR] and [SFG].
Control action 2, define position		
Transfer incremental dimension (DBX38.2) Select increment (254) **Control signal:** Direction plus [R+] **Checkback signals:** e.g. Travel plus [FR+] Start enable [SFG] Processing in progress [BL]		When the incremental dimension has been transferred and selected, [R+] can be specified. The axis cancels the [SFG] and outputs messages [BL] and [FR+]
e.g. Travel plus [FR+] Processing in progress [BL] Position reached, stop [PEH]		When the defined position has been reached, the axis enables [PEH] and checkback signals [FR+] and [BL] are reset. In the ”Incremental mode relative”, [SFG] is already set when the interpolator is ready (setpoint coincidence reached). [BL] continues to be present if a new Start ([R+] or [R–] has been provided before [PEH] is reached.

Table 9-5 Control Actions for “Incremental Relative” Mode (examples), continued

Signal Name	Level	Explanation
Control action 3, stop during positioning		
Control signal: Stop [STP] **Checkback signals:** Travel minus [FR–] Start enable [SFG]		If Stop is enabled during positioning, the axis stops. [FR–] is reset, and [SFG] is activated. [PEH] is not output, since positioning is not complete. Before the axis comes to a standstill, it is possible to define a new direction “through start”.
Control action 4, error during traversing movement		
Checkback signals: Travel plus [FR+] Processing in progr. [BL] **Control signal:** Acknowl. operator control/ travel error [BFQ/FSQ] **Checkback signals:** Start enable [SFG] **Control signal:** Direction plus [R+] **Checkback signals:** Travel plus [FR+] Processing in progr. [BL]		The axis moves. An error is output during the traversing movement. [FR+] and [BL] are canceled, and [BFQ/FSQ] is enabled. When the error has been acknowledged, the start enable is activated. The movement can be restarted with [R+]. [FR+] and [BL] are activated. [SFG] is canceled.
Control action 5, change mode		
Control signal: Mode [BA] **Checkback signals:** Active mode [BAR] Travel plus [FR+] Processing in progress [BL]		[BA] is deactivated during the traversing movement. The axis is stopped by way of the deceleration ramp[1]. [FR+] and [BL] are reset.

1) Does not apply to stepper drive.

9.2.5 MDI (Manual Data Input)

Overview

In the “MDI” mode, it is possible to execute single positionings via traversing blocks with relative or absolute path lengths. These traversing blocks are provided by the user program.

The MDI block and MD block on-the-fly have an identical block structure.

MDI Block

The structure of the MDI block is identical to that of the traversing blocks (see Chapter 10 resp. 9.3.13) except that it has neither a program number nor a block number.

The user program passes the “MDI block” (user DB, DBX38.3) to the FM 453, and the block can then be executed. The block can be executed repeatedly, since it is stored internally. The feedrate is override-dependent.

The MDI block remains in effect until it is overwritten with a new MDI block. A new block can be transmitted while another block is being processed.

Table 9-6 MDI Block (See Chapter 10 for Command Structure)

Name	Lower Input limit	Upper Input Limit	Unit
Position X / Dwell time t	–1,000,000,000 2	+ 1,000,000,000 100,000	MSR from MD7 ms
Speed F	10	500 000 000	MSR from MD7/min
G function group 1	G04 G90 G91	Dwell time Absolute measure Chain measure	–
G function group 2	G30 100% G31 10% to G39 90%	Override Acceleration/ Deceleration	–
M function group 1, 2, 3	M1...17, M19...96, M99: User functions M97, 98: Change signal is programmed as digital output M2, M30: Not allowed		–

MSR stands for measurement system raster (see Section 5.3.1)

For rotary axes with absolute programming, the commands [R+], [R–] are defined as direction commands. They must be available before positioning starts.

MDI Block On-the-Fly

The MDI block currently being processed is canceled when the user program outputs an “MDI block on-the-fly” (user DB, DBX38.4).

Transfer of “MDI block on-the-fly” interrupts the active “MDI block”. The new block is executed immediately without “Start”.

The MDI block on-the-fly is **not** saved in the FM 453.

With software version 2.1 of the FM 453 and higher, the error ”Data cannot be accepted at the time of transfer” (Class 4/No.1) is signaled when ”MDI block flying” is provided and [BL] has already been reset or [PEH] =1.

Block Structure

The following table shows the block structure of the MDI block.

X/t	Position/dwell time programmed (fills in value 1)
G1...G2	G function group 1...2
M1...M3	M function group 1...3
F	Speed programmed (fills in value 2)

Example 1)	Byte	Data format	Bit							
			7	6	5	4	3	2	1	0
0	0	Byte	0							
0	1	Byte	0							
Bit 0, 1, 4 set	2	8 bits	0	0	0	X/t	0	0	G2	G1
Bit 0 set	3	8 bits	0	0	0	0	M3	M2	M1	F
90	4	Byte	G function 1							
30	5	Byte	G function 2							
0	6	Byte	0							
0	7	Byte	0							
100,000	8	DINT	32-bit-value 1							
5,000	12	DINT	32-bit-value 2							
0	16	Byte	M function 1							
0	17	Byte	M function 2							
0	18	Byte	M function 3							
0	19	Byte	0							

1) Traversing block with absolute dimensions (G90), an end position of 100,000 DSG as per MD7, and a speed of 5,000 DSG/min.

Note:

When the assignment bit (byte 2 and byte 3) is not set, the associated values must be deleted.

Handling by the User

The table below gives you an overview of how to handle this mode.

Triggering of Movement	Type of Movement
Start	as defined by “MDI block” (user DB, DBX38.3)
“MDI block on-the-fly” transmitted to the FM 453	as defined by “MDI block on-the-fly” (user DB, DBX 38.4)

Note

Please see also Section 9.1.3!

Control Actions

Prerequisites:

- The FM 453 has been initialized.
- The mode has been selected and acknowledged.
- Drive Enable [AF] is = 1 (control signal in user DB, DBX15.7)
- Stop [STP] is = 0 (control signal in user DB, DBX15.1)
- Servo Enable (RF) is = 1 (user DB, DBX34.0)
- Axis is synchronized.

Table 9-7 Control Actions for “MDI” mode (examples)

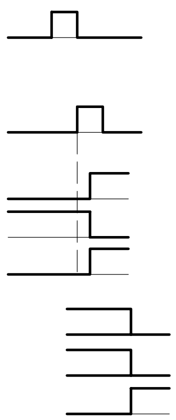
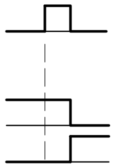
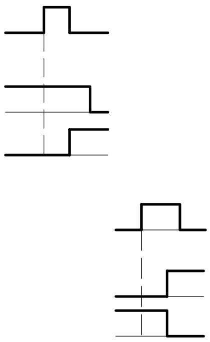
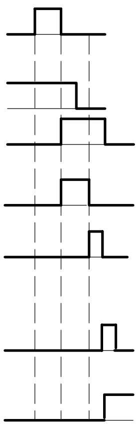
Signal Name	Level	Explanation
Control action 1, define position		
Transfer MDI block (DBX38.3)		When the MDI block has been transferred, [ST] can be initiated.
Control signal:		
Start [ST]		
Checkback signals:		
e.g. Travel plus [FR+]		The axis cancels the [SFG] and outputs messages [BL] and [FR+]
Start enable [SFG]		
Processing in progress [BL]		
e.g. Travel plus [FR+]		When the defined position has been reached, the axis enables [PEH]; [SFG] and checkback signals [FR+] and [BL] are reset.
Processing in progress [BL]		
Position reached, stop [PEH]		

Table 9-7 Control Actions for “MDI” mode (examples), continued

Signal Name	Level	Explanation
Control action 2, change position during positioning		
Transfer MDI block on-the-fly (DBX38.4) **Checkback signals:** Travel plus [FR+] Travel minus [FR–]		If a new “MDI block on-the-fly” is transferred during positioning, the current positioning operation is cance-led immediately, and the new positioning operation is started on-the-fly. In this case, for example, this causes the direction to be changed from [FR+] to [FR–].
Control action 3, stop during positioning with new start signal for resumed positioning		
Control signal: Stop [STP] **Checkback signals:** Travel minus [FR–] Start enable [SFG] **Control signal:** Start [ST] **Checkback signals:** Travel minus [FR–] Start enable [SFG]		If Stop is enabled during positioning, the axis stops. [FR–] is reset, and [SFG] is activated. [BL] remains active and [PEH] is not output, since positioning is not complete. If [ST] is initiated again, [FR–] and [SFG] are reset and positioning is completed. Before the axis comes to a standstill, it is possible to restart “through start”.
Control action 4, stop during positioning with new start signal and new MDI block		
Control signal: Stop [STP] **Checkback signals:** Travel plus [FR+] Start enable [SFG] Transfer MDI block (DBX38.3) Transfer “delete residual path” (DBX37.1) **Control signal:** Start [ST] **Checkback signals:** Travel minus [FR–]		If Stop is enabled during positioning, the axis stops. [FR+] is reset, and [SFG] is activated. When a new MDI block has been transferred, [ST] is enabled again. “Delete residual path” is also enabled. The axis deletes the residual path of the old positioning operation, and starts executing the new traversing block. [FR–] is enabled, and [SFG] is reset. **Note:** If no new “MDI block” is transferred, execution of the current “MDI block” is repeated from the start. Without “delete residual path”, the interrupted positio-ning operation would be continued (see control action 3)

9.2.6 Automatic

Overview

In the Automatic mode (following-block mode), the FM 453 processes traversing programs . autonomously. These programs are created with “Parameterize FM 453” (see Chapter 5, 5.3.4) and stored as a data block. The traversing programs contain information about movement sequences and outputs (see Chapter 10).

Program Selection

Programs are selected (user DB, DBX39.5) by way of the user program, by specifying a program number and an optional block number, as well as the direction of machining. A program can be selected only when other programs have been interrupted or terminated or at the start of a program.

A selected program remains active until it is inactivated by selecting program number = 0, or overwritten by selecting another program.

If modifications are made to a preselected program, including the subprogram, preselection of the program is canceled. You must then select the program again. A modification can be made to a program when BL = 0 (start of program/end of program) and on Stop.

Triggering of Movement	Select Program		Type of Movement (According to Programmed Blocks)
	Block No.	Processing Direction	
Start	0	forward	Start at beginning of program, process by ascending block number
	0	reverse	Start at end of program, process by descending block number
	e.g. 30	forward	Block search forward to block No. 30, by ascending block number
	e.g. 30	reverse	Block search in reverse to block No. 30, by descending block number
Start with automatic block search forward		forward	1. Automatic block search forward to interruption point 2. Positioning to interruption point (if a movement was performed in another mode) 3. Process the interrupted block and continue the program
Start with automatic block search in reverse		reverse	1. Automatic block search in reverse to interruption point 2. Positioning to interruption point (if a movement was performed in another mode) 3. Process the interrupted block and continue the program

User DB allocation

Data Format	Significance
Byte 0	Program number
Byte 1	Block number
Byte 2	Direction of machining: 0 = process forward 1 = process in reverse

Forward Processing

The program processes the block numbers in ascending order.

Processing begins at Start, with the first block (specified block number = 0).

If processing is to begin at some other point of the traversing program, specify the desired block number. Processing will take place by searching forward to this block, then processing forward until the program end command is recognized.

Backward Processing

The program processes the block numbers in descending order.

Processing begins at Start, with the last block (specified block number = 0).

If processing is to begin at some other point of the traversing program, specify the desired block number. Processing will take place by searching back to this block, then processing in reverse until the program beginning is recognized.

Note

If reverse processing is to execute the same sequence of movements as the forward movement, the effects of the corresponding commands must be taken into account in the programming. For example:

- M outputs should be written separately in a block; note M output (MD32) and G60/G64.
- Note change between G60/G64 and G90/G91.
- Note start and end of tool offsets.
- M18 is not executed.
- M02 and M30 at the end of the program are not processed.

Block Search Forward

The program is processed to the end point of the target block, including tool offset. M commands and dwell times are output and the traversing movements are suppressed.

When processing traversing programs with a forward block search, there are a number of special cases:

- The external forward block search (G50) is not executed.
- Continuous travel with functions to set (G88, 89) or delete (G87) an actual value on-the-fly is not executed.
- The blocks under G50, G87, G88, G89 (in the processing direction) should contain a path in absolute coordinates.

Block Search Backward

Similar to block search forward

Automatic Block Search Forward/Backward

Automatic block search forward/backward means that, after the interruption of an active automatic program (by an operating mode change), you can continue execution from this point of interruption in the appropriate direction of processing.

With forward block search, the interrupted program must previously have been going in the forward direction.

With block search in reverse, the interrupted program must previously have been going in the reverse direction.

The command for automatic forward or reverse block search is evaluated in the FM 453 at Start, and a forward or reverse block search to the interruption point is executed in the ”Jog” mode at the velocity of stage 1. Positioning to the interruption point takes place (if positioning has taken place previously in some other mode), and then the interrupted block is processed, including any required output.

Control Actions

Prerequisites:

- The FM 453 has been inititalized.
- The mode has been selected and acknowledged.
- Drive Enable [AF] is = 1 (control signal in user DB, DBX15.7)
- Stop [STP] is = 0 (control signal in user DB, DBX15.1)
- Servo Enable (RF) is = 1 (user DB, DBX34.0)
- Axis is synchronized

Table 9-8 Control Actions for “Automatic” Mode (examples)

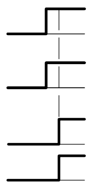
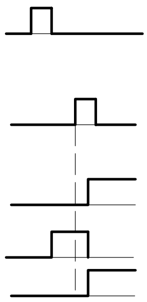
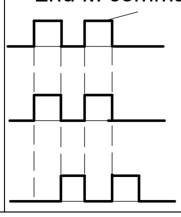
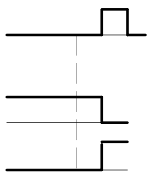
Signal Name	Level	Explanation
Control action 1, Automatic/Automatic single block mode		
Control signals: Mode [BA] Read-in enable [EFG] **Checkback signals:** Active mode [BAR] Start enable [SFG]		The user initiates [BA] and [EFG]. The module returns [BAR] and [SFG].
Control action 2, positioning by program selection		
Program selection (DBX39.5) **Control signal:** Start [ST] **Checkback signals:** Travel plus [FR+] or Travel minus [FR−] Start enable [SFG] Processing in progress [BL]		When [SFG] appears, the program can be activated by [ST] when [EFG] is active. Processing commences, e.g. with a positioning operation. [FR+] or [FR−] and [BL] are activated. [SFG] is reset.
Control action 3, M function output		
Checkback signals: Change M function [AMF] M function number [MNR] **Control signal:** Acknowledge M function [QMF]	2nd M command 	If M function output is acknowledgement-driven, for example, the user program can continue to process the [MNR] when [AMF] appears. M function output is complete. [QMF] acknowledges the M function, and [AMF] and [MNR] disappear.
Control action 4, M function output and positioning		
Control signal: Acknowledge M function [QMF] **Checkback signals:** Position reached, stop [PEH] Travel plus [FR+] or Travel minus [FR−]		Block with M output (same as control action 3) and position is started. The program is resumed on completion of the M function output. [FR+] and [FR−] are deactivated and [PEH] is reset.

Table 9-8 Control Actions for “Automatic” Mode (examples), continued

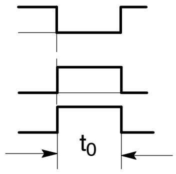
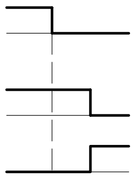
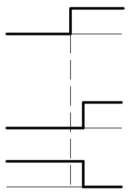
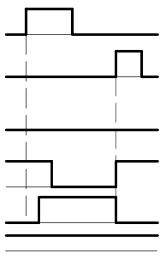
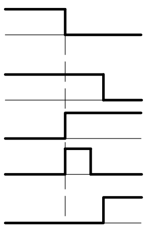
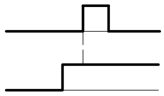
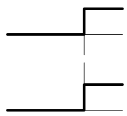
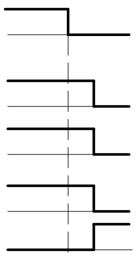
Signal Name	Level	Explanation
Control action 5, traversing block with dwell		
Checkback signals: Travel plus [FR+] or Travel minus [FR−] Dwell time running [T-L] Position reached, stop [PEH]		During processing of a traversing block with dwell, the dwell time t_0 [T-L] and [PEH] are output.
Control action 6, cancelation of the read-in enable during program execution (special situation)		
Control signal: Read-in enable [EFG] **Checkback signals:** Travel plus [FR+] or Travel minus [FR−] Position reached, stop [PEH]		If [EFG] is canceled during program execution, the current block is processed up to the end, and program execution is then suspended. [FR+] and [FR−] are reset. [PEH] is actuated.
Control action 7, resume program execution after read-in enable (special situation)		
Control signal: Read-in enable [EFG] **Checkback signals:** Travel plus [FR+] or Travel minus [FR−] Position reached, stop [PEH]		The program resumes on [EFG]. [FR+] and [FR−] are reset. [PEH] is reset.
Control action 8, stop during positioning with new start signal for resumed positioning (special situation)		
Control signals: Stop [STP] Start [ST] **Checkback signals:** Position reached, stop [PEH] Travel plus [FR+] Start enable [SFG] Processing in progr. [BL]		Interrupt with Stop [FR+] is cleared when the axis comes to a standstill, and [SFG] is enabled (if Stop is not active). [PEH] remains cleared, since the defined position has not yet been reached. Start clears [SFG] and enables [FR+] again. [BL] remains enabled. Before the axis comes to a standstill, it is possible to restart “through start”.
Control action 9, end of program reached		
Checkback signals: Travel plus [FR+] or Travel minus [FR−] Processing in progress [BL] Position reached, stop [PEH] M function number [MNR] Start enable [SFG]		The end of the program is indicated by the enabling of [PEH], output of M2, M30 and resetting of [BL].
Control action 10, delete start signal and residual path (special situation)		

Table 9-8 Control Actions for “Automatic” Mode (examples), continued

Signal Name	Level	Explanation
Control action 10, delete start signal and residual path (special situation)		
Control signal: Start [ST] Transfer “delete residual path” (DBX37.1)		If “delete residual path” is also preselected on [ST], the block interrupted by Stop is not executed up to the end, but the next block is started immediately.
Control action 11, positioning for rotary axis (special situation)		
Control signals: Direction plus [R+] or direction minus [R–] Start [ST]		If the axis is operated as a rotary axis, the FM always attempts to select the shortest path during positioning. This direction preference can be suppressed by specifying [R+] or [R–].
Control action 12, deactivate operating mode during program execution (special situation)		
Control signal: Mode [BA] **Checkback signals:** Old mode [BAR] Travel plus [FR+] or Travel minus [FR–] Processing in progress [BL] New mode [BAR]		If a new operating mode is selected during active program execution, the axis is stopped by way of the deceleration ramp[1]. [FR+] or [FR–] and [BL] are reset.

1) Does not apply to stepper drive.

9.2.7 Automatic Single Block

Overview

Functions, same as “Automatic” mode

Whereas in “Automatic” mode the FM 453 automatically starts processing the next block after completing a given block, in “Automatic single-block” mode the axis waits for a new Start signal after processing each block that contains a traversing path, dwell time or M command (except for blocks with G50, G88 or G89).

You can change between Automatic single-block and Automatic mode at any time, without stopping the movement or interrupting the output.

9.3 System Data

Overview

This chapter describes settings and functions that apply in various modes, and that are likewise necessary in order to control and operate the FM 453, and data of the FM available for checkback messages.

9.3.1 Modify Parameters/Data (Write request in user DB, DBX39.3)

Overview

You can use this function to modify parameters and data in the FM 453 data blocks or to define parameters and data which can then be read out with a Read request (user DB, DBX43.4) (see Section 9.3.18).

Structure of Write Request

The following table shows which parameters or data can be changed or read by setting the indicated codes.

Addr. in User DB	Data Format	Symbol	Description				
196	Byte	DB type	Type	1 = MD	2 = SM	3 = TO	4 = NC (travers. progr.)
197	Byte	data number	Info 1	MD No. (5...61)	SM No. (1...100)	TO No. (1...20)	Progr. No. (1...199)
198	Byte	number of data	Info 2	Number of MDs, consecutive (1...5)	Number of SMs, consecutive (1...5)	0 = TO compl. 1 = Tool length only 2 = Wear value abs. only 3 = Wear value add. only	Block No. (1...255)
199	Byte	job type	1 = Read job parameters 2 = Write parameters 4 = Write parameters and save retentively[1)]				
200... 219	depends on type	data array	• MD: Data format of machine data, see Table 5-4 or • SM: Data format of increments, see Table 5-5 (DWORD) or • WK: Data format of tool offset, see Table 5-6 (DINT) or • NC: Block format see Section 9.3.13 “Active NC Block”				

1) not with cyclic operation under 10 s

Example 1

The software limit switches (MD21, MD22) for the axis are to be set to the values 100 mm and 50,000 mm. These values are to remain in effect only until the unit is shut down.

DB type	= 1
data number	= 21
number of data	= 2
job type	= 2
data array	
Byte 200 to 203	= 100,000 (MD21, DINT data format)
Byte 204 to 207	= 50,000,000 (MD22, DINT data format)
Bytes from 208 on	= 0

For activation of the machine data, see Section 9.3.3

Notes

Please note the following when changing the parameter data:

- **Machine data**

  Machine data can always be modified. Once you have modified the machine data, the machine data have to be reactivated (for single command, see Section 9.3.3).

- **Increments**

  Modifications can be made in all operating modes (even in “Incremental relative” mode) during movement. The modifications of the increments must always be complete before a new movement is started in “Incremental relative” mode. If this is not the case, the error message “incremental dimensions do not exist” is output Cl. 2/No. 13.

- **Tool offset data**

  Modifications can be made in all operating modes and during movement. If modifications are made during starting or at block transitions when the tool compensation is active (internal access to offset values), the error message “tool offset value does not exist” is output Cl.3/No.35.

- **Traversing programs**

  – Programs which are not selected can always be modified.

  – If modifications are made to a preselected program, including the subprogram, preselection of the program is canceled. You must then select the program again. A modification can be made to a program when BL = 0 (start of program/end of program) and on Stop.

Delete block: Specify the program no. and the block no. in the “data field”. The other data/bits must not be assigned.

Insert block: The block number does not exist in the selected program. The contents should be entered in accordance with the “block format”.

Modify block: The block with the corresponding block number is overwritten with the contents in accordance with “block format”.

Example 2

Procedure for changing the actual value and the velocity in block 10 of traversing program 1.

1. Submit job request to read the block. Enter the following values in the user DB:

   DB type = 4
   Number = 1
   Number of data = 10
   Job type = 1
   Data array = 0

2. Set Write (user DB, DBX39.3).
3. Following termination of the Write request (one cycle later), read out the block by setting the Read request (user DB, DBX43.3).
4. Save the data read out from DBB 446 to 469 of the user DB in DBB196 to 219.
5. Enter the actual value in data array DBB208 to 211 in the user DB (data type DINT).
6. Enter the velocity in DBB212 to 215 of the user DB (data type DINT).
7. Enter a 4 in DBB199 (request) of the user DB (retentive storing of the block).
8. Set Write request (user DB, DBX39.3).

Retentive Storage of Parameter Data

Please note the following when using the function “Write parameters and with retentive storage” (byte 4, job type 4):

Retentive writing must only occur on demand (not cyclically)!

Modal data are stored on FEPROM (maintenance-free, no battery required). This memory has a physical limit for the possible number of delete/reprogram cycles: minimum 10^5, typically 10^6. The possible number of delete/reprogram cycles can be multiplied, from the user’s viewpoint, by providing a larger retentive memory capacity (much larger than the parameter data memory) and organizing the memory accordingly.

$$\text{Number of delete/reprogram cycles} = \frac{128\,000 \cdot 10^6 \text{ (typical)}}{\text{Block size (in bytes), in which parameter data are modified}}$$

Block sizes:

DB Machine data	324 bytes
DB Increments	468 bytes
DB Tool offset data	308 bytes
DB Traversing programs	108 + (20 x no. of traversing blocks) bytes

Example:

Assuming a service life of 10 years and 24-hour operation, a typical limit = 10^6.

Parameterization data	DB size	Number of possible delete/reprogram cycles	Number of possible delete/reprogram cycles per minute
MD	324 bytes	$412.9 \cdot 10^6$	78
Traversing programs (20 blocks)	508 bytes	$251 \cdot 10^6$	48

Note

SDB ≥ 1 000 (system data block, created for module replacement), contains parameter data which were valid at the time of start-up. If data/parameters are modified during operation and stored retentively on the FM 453, these data are not contained in SDB ≥ 1 000. These modifications are lost when the module is replaced, and should be traceable in the user program.

9.3.2 Single Functions (User DB, DBB34 and 35)

Overview

You can use this function to transfer single settings to the FM 453 and activate the corresponding functions. These settings are:

- Length measurement
- Measurement on-the-fly
- Retrigger reference point
- Switch off enable output
- Follow-up mode (only for drives with encoders)
- Switch off software end position monitoring
- Rotation monitoring (only for step drive without encoder)
- Switch off automatic drift compensation (only for servo drive)
- Enable CL controller
- Parking axis
- Simulation

Callup of Single Settings

The individual functions remain activated until they are reset.

Length Measurement, Inprocess Measurement

Since both functions use the same digital input on the FM 453, only one function can be executed at a time. In double activations, both functions are switched to inactive. An error message is issued.

For function description, see Section 9.3.11

Retrigger reference point

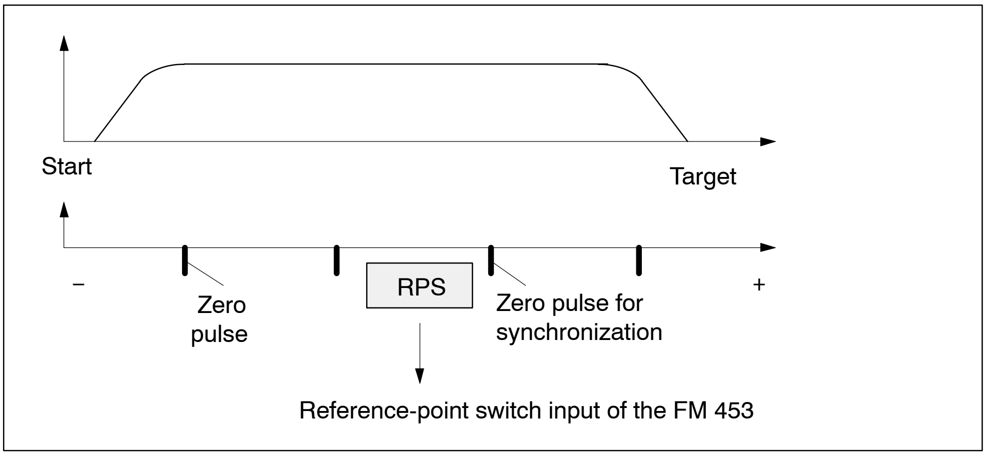
A precondition for retrigger reference point is that the axis has been synchronized by reference point approach.

With this setting, the axis is resynchronized upon overrunning the synchronization point when the direction of travel is the same as the direction of reference point approach. Regardless of the current speed, the reference point coordinates are allocated to the current actual position, taking into account any active shift.

When crossing the RPS, a signal length of $\Delta t \geq 2 \cdot$ FM cycle must be assured!

Any resulting change in the actual value causes no internal changes in the destination.

When a Set Actual Value On-the-Fly is pending, activation of Retrigger Reference Point is interlocked.



Hint to the user:

You can use Retrigger Reference Point, for example, to compensate for slippage of the trolley in a high-bay warehouse during operation, without having to resynchronize the axis with the Reference-Point Approach mode. When retriggering in reference point approach with a zero pulse, be careful that the total slippage between the reference point switch and the stepper motor does not increase to an extent that the synchronizing zero pulse migrates to an “adjacent” zero pulse!

Switch Off Enable Input

With the “switch off enable input” function, you can switch off evaluation of the enable input (see Section 9.8.1).

Follow-up mode

The “follow-up mode” function is used to cancel closed-loop control of the axis.

- For external movement of the axis, the actual value is tracked.
- This setting can be switched on or off only if “Processing in progress” = 0.

  (does not apply to MD37.15 ”Resume after Emergency Stop”)

Deactivate end Position Monitoring

You can use this function to deactivate monitoring of the software limit switches (see Section 9.9).

It can be switched on or off only if “Processing in progress” = 0.

Rotation Monitoring

Rotation monitoring is performed in all operating modes. It is automatically interrupted as the synchronization mark is passed in “Reference point approach” mode and in “Retrigger reference point” function.

The “rotation monitoring” function is described in Section 9.7.3.

Deactivate Automatic Drift Compensation

This function can be used to switch off the automatic drift compensation.

Automatic drift compensation means:

The drift is balanced to zero by an automatic matching of the analog actuating signal.

- The setting can be switched on or off if the axis is not in motion.
- Automatic drift compensation has no effect:
  - in Control mode
  - in the Follow-up Mode setting
  - if there is no servo enable
  - in the absence of a controller ready signal (if parameterized)
  - if the axis is in motion.

Servo Enable

You can use this function to:

- activate **position control** (the prerequisite for closed-loop-controlled operation of the FM 453)
- to switch the signal through to the drive as indicated in MD37
- to provide control of stops between movements in the Control mode.

Parking Axis

This function can be used to change over the measurement system while the complete system is running.

With this setting:

- Encoder synchronization (SYN = 0) is deleted
- Pending error messages are deleted and no new ones are initiated (including diagnostic interrupts) by the encoder when ”Parking Axis” is disabled.
- Digital outputs are inactive; analog voltage 0 V.

The setting can be switched on or off if “Processing in progress” = 0.

Simulation

You can use this function to:

- Test function sequences without the drive and measuring system.

  A drive, if any connected, must be switched off.
- Evaluate all digital inputs (**Caution**, if you are going to simulate sequences that use such signals, they should be connected to the inputs of the FM 453 - e.g. for Reference-Point Approach).
- The servo simulates a controlled system; “Controller Ready” is not necessary.
- The setting can be switched on or off if “Processing in progress” = 0.
- All internal function sequences behave as in normal operation.

When the function is deactivated, the axis is reset internally (see Restart, Section 9.3.3).

9.3.3 Single Commands (User DB, DBB36 and 37)

Overview

You can use this function to transfer single commands to the FM 453. These commands are:

- Activate machine data
- Delete residual distance
- Automatic block search in reverse
- Automatic block search forward
- Restart
- Istwert setzen rückgängig

Callup of Single Commands

The single commands are activated when the corresponding data record is transmitted to the FM 453.

The commands are deleted in the FM 453 after execution.

Activate Machine Data

Once you have downloaded the machine data (MD) or the MD block (from the programming device), the machine data have to be activated. At the first parameterization, the machine data is transferred automatically. In terms of effects, the FM 453 distinguishes between “K” and “E” machine data.

MD Category	Effect in FM 453 After Activation
“K”	“Reset” of the FM • As long as “Reset” is in progress, it is not possible to transfer other data • For internal response, see Restart
“E”	FM operating condition is maintained

For machine data, see Section 5.3.1.

This command is possible only when the axis is not in motion (“Processing in progress” = 0). An operating mode must be selected.

An MD block is likewise activated by switching on or off.

MD61 can be activated only by switching the FM 453 off and on.

Delete Residual Path

You can use this command to delete a residual distance that remains after a job has been canceled.

- Effective only in ”Incremental Relative”, ”MDI”, and ”Automatic” modes after a stop (SFG = 1 and BL = 1). If processing is not interrupted with a stop, the ”Delete Residual Distance” request is suspended in the FM 453.
- On starting after a Delete Residual Distance in MDI mode, the active MDI block is processed from the start.
- On starting after a Delete Residual Distance in Incremental Relative and Automatic modes, processing continues with the following block.

Automatic Block Search Forward

This command is described in Section 9.2.6.

Automatic Block Search Backward

This command is described in Section 9.2.6.

Restart

You can use this command to reset the axis.

- The setpoint output is interrupted.
- The instantaneous processing status is canceled, and synchronization in incremental encoders is deleted.
- Active compensation values are deleted.
- An acknowledge signal is issued for all errors.

Undo Set Actual Value

You can use this command to reset coordinates modified with the functions “Set actual value” and “Set actual value on-the-fly” to their original value (if the axis is not in motion).

9.3.4 Zero Offset (Write request in the User DB, DBX39.1)

Function of Zero offset

A selection, change or cancellation of a zero offset takes effect with the next positioning action. With a zero offset, the instantaneous shift of the coordinate system is canceled, provided that a zero offset was already active and the specified shift change ($ZONPV_{new}$ – ZO_{old}) was executed with the first positioning. All coordinates and software limit switches, the reference point and the actual value are updated accordingly.

The reference of the workpiece coordinate system is provided via the zero offset. The actual values read from the FM 453 refer to the machine coordinate system. The position specification in a traversing block is referred to the workpiece coordinate system.

Example of a zero offset:

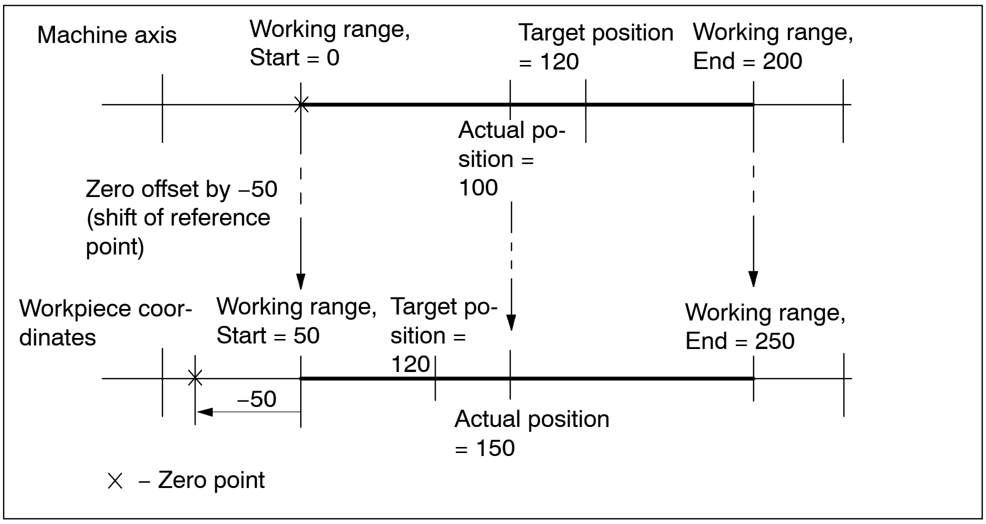


Fig. 9-1 Zero Offset

The zero offset can be deleted by:

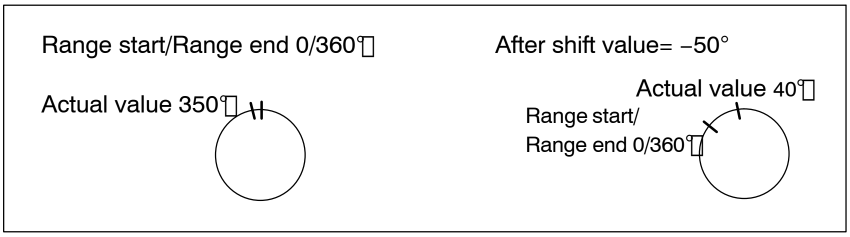
- Transmitting shift value = 0
- Starting Reference-Point Approach mode
- Set reference point
- Eliminating axis synchronization (e.g. by a restart).

Rotary Axis

The following restriction applies to a rotary axis:

Zero offset < Rotary-axis range. The actual value is normalized.

Example:



The Start and End of the Range Are Shifted –50°.

Exceptions:

In the “Incremental Relative”, “MDI” and “Automatic” modes, a zero offset is not possible until the block has been processed (position reached, programmed stop set), i.e., it is not possible when the axis is stationary after execution is interrupted with an abnormal stop.

9.3.5 Set Actual Value (Write request in the user DB, DBX38.7)

Overview

You can use this function to assign a new value to the current actual value.

Function of Set Actual Value

By transmitting the coordinates, the actual value is set to this value when the axis is not in motion (after selecting “Processing in progress” = 0). The coordinates of the software limit switches remain unchanged.

Example of setting actual value:

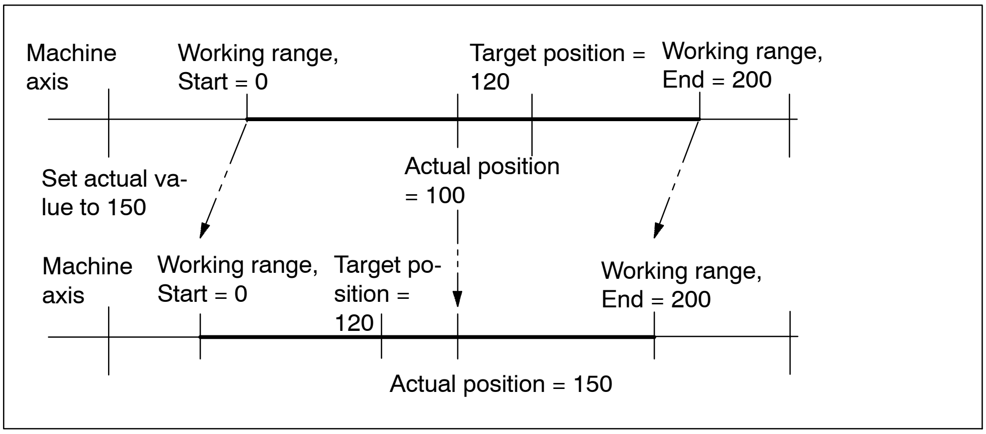


Fig. 9-2 Set Actual Value

The coordinates can be reset to their original value by:

- Including synchronization in Reference Point Approach mode
- Set reference point
- Undo set actual value
- Restart

9.3.6 Set Actual Value On the Fly (Write request in the user DB, DBX39.0)

Overview

You can use this function to assign a new value to the actual value by means of an external event.

Function of Set Actual Value On-the-fly

By transmitting the coordinates (new actual value), set actual value on-the-fly is activated.

However, the Set Actual Value function is not triggered via the appropriate digital input until “Processing in progress” = 1.

Set actual value on-the-fly can be activated again by transmitting Set actual value on-the-fly again.

The coordinates can be reset to their original value by:

- Including synchronization in Reference Point Approach mode
- Set reference point
- Undo set actual value
- Restart

Note:

For “set actual value on-the-fly” in “Automatic” mode, see Section 9.2.6

9.3.7 Request Application Data (Write request in the user DB, DBX39.6)

Overview

A selection of up to four display data items whose values can be read out with “read application data” (see Section 9.3.14).

Code table:

Code	Significance
0	No parameter request
1	Actual position
2	Actual velocity
3	Residual distance
4	Set position
5	Total current coordinate shift
6	Rotational speed
16	DAC output value (for servo drive) or frequency output value (for step drive)
17	Actual encoder value (for drive with encoder) or pulse output counter (0...2^{16}–1) [pulse] (for step drive without encoder)
18	Pulse errors (for drive with incremental encoder)
19	K_v factor (for servo drive)
20	Following error (for servo drive) or difference between setpoint and actual positions [MSR] (for step drive)
21	Following error limit (for drives with encoders)
22	s Overshoot/Switch readjustment in Reference Point Approach mode
23	Approach time Te [ms]/drive time constant Ta [ms] in “Open-loop control” mode (for servo drive)

The code should be entered in CODE_AP1...AP4.

These values are always updated in the FM cycle.

The selection is stored on the FM, i.e. you need to make the selection only once and read the corresponding values cyclically (user DB, DBX43.6).

9.3.8 Teach In (Write request in the user DB, DBX39.7)

Overview

In a program block selected with the program number and block number, the current actual position is entered as a position setpoint (**Caution:** This is an absolute position).

The Teach-in facility is possible only in the following modes:

- Jogging
- Incremental Relative
- MDI

and while the axis is not in motion.

The program and the appropriate program block must be present on the FM 453 (see Parameterization, Chapter 5).

9.3.9 Set Reference Point (Write request in the User DB, DBX38.6)

Overview

You can use this function to synchronize the axis without reference point approach.

Function

With Set Reference Point, a position value at the instantaneous position of the axis, indicated as a parameter, is accepted as an actual value.

For axes with an absolute encoder, the generated position reference is entered in MD17. At a known axis position, the known actual position of the system of measurement is transmitted to the FM 453 with Set Reference Point. This value is set as the actual value of the axis. At the same time, this position reference is saved, in that the assignment of the encoder actual value to the axis reference point is calculated from the assignment of the set actual position to the encoder actual value at this point of the axis; it is then entered in MD17.

”Set reference point” is not possible during machining ([BL] = 1) and will only come into effect after machining ([BL] = 0).

This function is not effective in “Automatic” mode (mode 08) or in “Automatic Single block” mode (mode 09).

9.3.10 Coupled-axis grouping (Write request in the User DB, DBX40.0)

Overview

This function can be used to traverse coupled axes simultaneously and synchronously.

The function ”Coupled axes” is available as from software version 2.1 of the FM 453.

Define coupled-axis grouping

User DB, DBB252: 0 = No coupling
3 = Axis 1 coupled with axis 2
5 = Axis 1 coupled with axis 3
7 = Axis 1 coupled with axes 2 and axes 3

Area of action

The area of action of the following master axis signals is transferred to the coupled axes as a function of operating mode in coupled-axis operation:

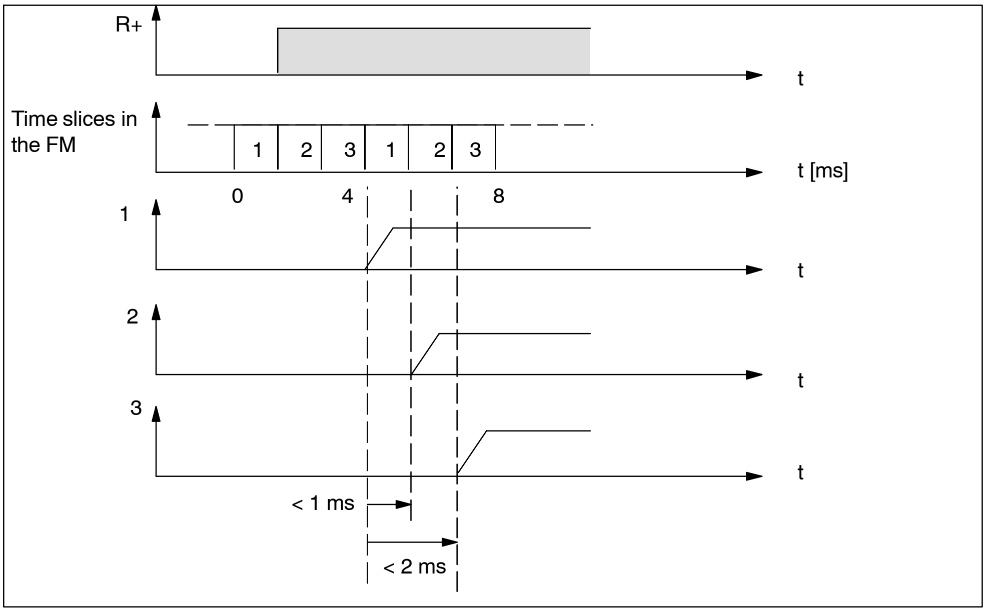
- Jog mode: R+; R–, override, velocity steps, enable input (dig. input)
- MDI/Automatic modes: R+; R–, start, override, external start and enabling input (dig. input)

This transfer of signals enables ”simultaneous starting” of the coupled axes (successively within one FM cycle, intervals of approximately 1 ms). They continue to operate independently of one another (no interpolation).

Only the specified signals are coupled. You must yourself ensure that all coupled axes are operable, i.e. same operating mode (Jog or MDI/Automatic), no error set, specified traversing paths and velocities, etc. The ”coupling” signals must be specified in axis 1 of a coupled-axis grouping. These signals are transferred instantaneously to the coupled axes by the FM 453. The set coupled-axis grouping remains valid, but not active, in operating modes ”Open-loop control”, ”Incremental mode relative” and ”Reference point approach”.

Example

Axes 1, 2 and 3 are coupled, [R+] is set in axis 1.



Since the signals for all axes are derived from axis 1, there is still a time delay between the axes, but this is not subject to spread (”delay distortion”). This means that the time delay between axes 1 / 2 is always < 1 ms and between axes 1 / 3 < 2 ms.

9.3.11 Measured Values

Prerequisites

The following prerequisites must be fulfilled in order to execute the function “measurement”:

1. Connect a bounce-free switching-signal encoder (touch probe) to a digital output of the FM 453.
2. Parameterize Measurement for this input in MD34.

Activating the Measurement Function

A “length measurement” or “in-process measurement” can be activated with “Single Functions” (user DB, DBB34 and 35).

Since both functions use the same digital input of the FM 453, only one function can be executed at a time. In double activations, both functions are switched to inactive. An error message is issued.

Reading Out the Measured Values

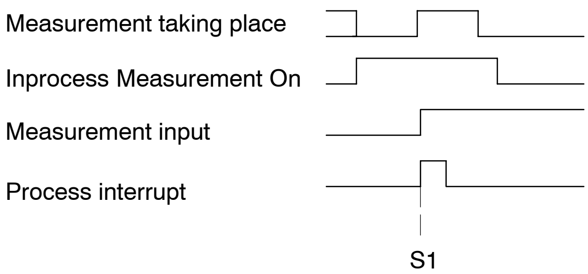
You can read out measured values from the FM 453 in the result returned by the “length measurement” and “in-process length measurement” functions by calling **FC POS_MSRM** and via Read request AW-DB, DBB43.7 (see Section 6.3.4).

Function Description

Measurement functions can be executed in all modes. An executed measurement is signaled by the checkback signal “ME” and optionally also by a process interrupt.

Inprocess measurement

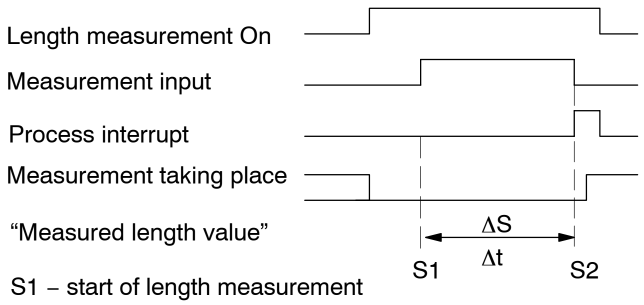
The present actual position is captured at each rising edge of the touch probe. At the same time, the axis movement is interrupted (servo-controlled braking).



S1 – execution of measurement

Length measurement

The present actual position is captured at both the rising and the subsequent falling edge of the touch probe. In addition, the actually traveled distance (absolute value) between the two edges of the probe is calculated.



S1 – start of length measurement
S2 – end of length measurement
ΔS – Measured length value
Δt – minimum signal length at the digital input: $\geq 2 \cdot$ FM cycle

The measured length is determined as follows under certain supplementary conditions:

- Retrigger the reference point:
  The measured length constitutes the difference of the edge positions.
- Set the actual value: The measured length constitutes the distance actually traversed.
- Zero offset:
  The “Zero offset” function does not change the actual position of the axis and is thus not relevant for evaluations regarding the “Length measurement” function.
- Rotary axis:
  The measured length is the path actually traversed over several rotations of the rotary axis.
- Direction reversal:
  The axis can change the traversing direction within the length to be measured as often as you want.
  - Case 1:
    The axis passes the falling edge in the traversing direction of the rising edge: The measured length is the difference of the edge positions.
  - Case 2:
    The axis passes the falling edge in the opposite direction to the rising edge: End of the length measurement with output of an error message.

Error Messages

The following table lists the errors that can occur in the execution of the Measurement function.

Error	Significance
Guidance errors	The “Digital input not parameterized” error is signaled when a measurement function is selected without a digital input having been parameterized (see Troubleshooting, Table 11-7, Class 3 No. 30).
Operator contr. errors	The “Measurement function undefined” error is signaled when both measuring functions are selected (see Troubleshooting, Table 11-6, Class 2 No. 16).
Measuring error	An erroneous length measurement is indicated by signaling back the length “–1.” Possible causes include: • Resynchron. in the Reference-Point Approach mode while a measurement is in progr. • Execution of the Set Reference Point function while a measurement is in progress • Direction of travel at the falling edge is opposite to the direction of travel of the previous rising edge

Measurement Checkback Signals

The checkback signal ME (see Section 9.1) signals the status of function execution, as follows:

“ME”	Measurement On-the-fly	Length Measurement
0	• the Length Measurement and Inprocess Measurement functions are inactive • with Start after a prior measurement	• the Length Measurement and Inprocess Measurement functions are inactive • with front edge of the touch probe signal after a prior measurement
1	With the front edge of the touch probe signal (= Inprocess Measurement is in progr.)	With the back edge of the touch probe signal (= Length Measurement is in progress)

Reading out the measurement values

You can read out measurement values from the FM 453 by calling the **POS_MSRM** block using read job AW-DB, DBB43.7 (see Section 6.3.4) after performing the ”Length measurement and in–process measurement“ functions.

The read–out measurement values are valid for the performed measuring process, starting from the “ME” checkback signal until the rising edge of the subsequent measurement job arrives.

No.	Value 0	Value "–1"	All Other Positive Values	All Other Negative Values
1	the Length Measurement and Inprocess Measurement functions are inactive	Actual position for rising touch-probe edge in Inprocess Measurem. and Length Measurem. functions		
2	• the Length Measurement and Inprocess Measurement functions are inactive • always with the Inprocess Measurement function	Actual position for falling touch-probe edge in Length Measurement function		
3	• the Length Measurement and Inprocess Measurement functions are inactive • always with the Inprocess Measurement function • measured length 0 is actually possible, because touch probe has been connected while axis is stationary	Erroneous length measurement	Measured length	Nonexistent

9.3.12 Basic Operating Data (Read request in the user DB, DBX42.0)

Overview

The following display data are basic operating data:

- Actual position (MSR)
- Actual speed (MSR/min)
- Residual distance (MSR)
- Set position (MSR)
- Total of active coordinate shifts for tool offset, zero offset (MSR)
- Rotational speed (rotary axis only) (rpm)

9.3.13 Active NC Block (Read request in the user DB, DBX42.1), Next NC Block (Read request in the user DB, DBX42.2)

Active NC Block

... are display data in “Automatic” mode

/	Skipped block
L	Subprogram callup (fills in UP number)
P	Number of runs for subprogram (fills in UP number of runs)
X/t	Position/dwell time programmed (fills in value 1)
G1-G3	G function group 1-3
D	Tool offset value number
M1-M3	M function group 1-3
F	Speed programmed (fills in value 2)

Byte	Data Format	Bit							
		7	6	5	4	3	2	1	0
0	Byte	NC program number							
1	Byte	NC block number							
2	8-bit	/	L	P	X/t	0	G3	G2	G1
3	8-bit	0	0	0	D	M3	M2	M1	F
4	Byte	G function 1							
5	Byte	G function 2							
6	Byte	G function 3							
7	Byte	0							
8	DINT	32-bit value 1 (UP number, bytes)							
12	DINT	32-bit value 2 (UP number of runs, bytes)							
16	Byte	M function 1							
17	Byte	M function 2							
18	Byte	M function 2							
19	Byte	D function							

Next NC Block

as described in “active NC block”

9.3.14 Application Data (Read request in the user DB, DBX43.6)

Overview

The values requested with ”request application data” (user DB, DBX42.3, see Section 9.3.7) are returned by the FM 453 when the user submits the Read request (user DB, DBX43.6).

These values are always updated in the FM cycle on the FM 453.

9.3.15 Actual Value Block Change (Read Request in the User DB, DBX42.3)

Overview

The “actual value block change” function is described in Section 10.1, G50, G88, G89.

9.3.16 Servicing Data (Read Request in the User DB, DBX42.4)

Overview

The following display data of the measuring circuit are servicing data:

- DAC output value [mV] (for servo drive) or
  frequency output value [Hz] (for step drive)
- Actual encoder value [MSR] (for drive with encoder) or
  pulse output counter (0...2^{16}–1) [pulse] (for drive without encoder)
- Pulse errors (for drive with incremental encoder)
- K_v factor (position control loop gain) (for servo drive)
- Following error [MSR] (for servo drive) or
  difference between setpoint and actual positions [MSR] (for step drive)
- Following error limit [MSR] (for drives with encoders)
- s Overshoot/Switch readjustment in Reference Point Approach mode [MSR]
- Approach time Te [ms]/drive time constant Ta [ms] in “Open-loop control” mode (for servo drive)

9.3.17 Additional Operating Data (Read request in the user DB, DBX43.5)

Overview

The following display data are additional operating data:

- Override (%)
- NC traversing program No.
- NC block No.
- UP callup counter
- G90/91 active, see Section 10.1
- G60/64 active, see Section 10.1
- G43/44 active, see Section 10.1
- D No. active, see Section 10.1
- Status messages 1 (data type: BOOL):
  - Speed limitation to limit value from MD23
  - Limitation to ± 10 V (for servo drive)
  - Limitation of minimum acceleration or minimum deceleration in effect
- Status messages 2 (data type: BOOL): not assigned

9.3.18 Parameters/Data (Read request in the user DB, DBX43.3)

Overview

This request is used to read the parameters and data modified by means of the ”change parameters/data” function (Write request in the user DB, DBX39.3, see Section 9.3.1).

9.3.19 Coupled-axis grouping status (Read request in the user DB, DBX43.0)

Overview

The momentary coupling status is read out.

User DB, DBB470: 0 = No coupling
3 = Axis 1 coupled with axis 2
5 = Axis 1 coupled with axis 3
7 = Axis 1 coupled with axes 2 and axes 3

9.4 System of Measurement

Overview

At the start of parameterization, you must fill in the basic machine data item **system of measurement** (MD7). This item governs the input of values.

Variants of the System of Measurement

You can set the system of measurement for the following three units:

- mm
- inches
- degrees

Input of Machine Data

All value inputs and all value ranges refer to the setting in the system of measurement.

Internal Processing of Values

In "Parameterize FM 453" and in the FM 453 itself, values are processed in the following base units:

- 0,001 mm
- 0.0001 inch
- 0.0001 degree

Examples

The sample values in the table below illustrate the relation between the system of measurement and internal values:

System of Measurement	Internal Values	Input at Interface	
mm	10^{-3} mm	10 995 · 10^{-3} mm	10.995 mm
inches	10^{-4} inch	10 995 · 10^{-4} in(ch)	1.0995 inch
degrees	10^{-4} degree 10^{-2} degree	3,600,000 · 10^{-4} degree 36,000 · 10^{-2} degree	360.0000 degree 360.00 degree

Note

The measurement system (MD7) must match the measurement system specified in the other DBs.

The measurement system raster (MSR) is the smallest distance unit in the active system of measurement.

If at some point you have failed to take this precaution:

1. Delete all data blocks of the relevant channel (which do not match the measurement system) or clear the memory of the FM 453 completely.
2. Modify the other data blocks on the programming device.
3. Reload the data blocks to the FM 453.

9.5 Axis Type

Overview

You can select the axis type with machine data item MD8. Choose either of the following types:

- Linear axis
- Rotary axis

Linear Axis

A linear axis moves between two range limits (traversing range min -10^9, max 10^9). The range limits may be bounded by software limit switches (MD21, MD22) to form the “working range.”

Linear axes have a limited traversing range. The limits are imposed by the:

- Resolution of the numerical scale
- The range covered by an absolute encoder.

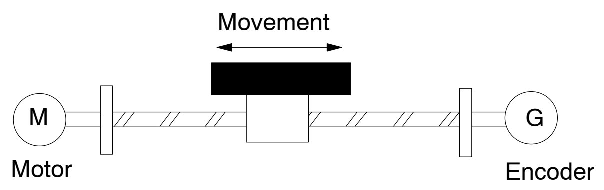


Fig. 9-3 Linear Axis

Rotary Axis

With rotary axes, the actual value is reset to “0” after one revolution. Rotary axes thus have an infinite traversing range.

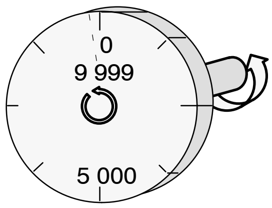


Fig. 9-4 Rotary Axis

Before you start a movement in “MDI” and “Automatic” modes, you can define a fixed direction of rotation with R+ or R−.

Rotary Axis End

Machine data item MD9 defines the value by which the FM 453 recognizes the end of the rotary axis.

This value is the theoretical maximum that the actual value can reach. At this value, display of the actual value switches back to 0.

The theoretical maximum, however, is never displayed, because it is physically located in the same position as the start of the rotary axis (i.e., 0).

Example:

The following example in Figure 9-4 illustrates the behavior of the axis.

Assume you specify a value of 10,000 for the end of the rotary axis.

The value 10,000 will never be displayed. The display always rolls over from 9,999 to 0.

If the direction of rotation is negative, the display rolls over from 0 to 9,999.

Encoders on Rotary Axes

Rotary axes are subject to certain restrictions in the choice of encoder/gearbox/motor, as shown in Figure 9-5. These restrictions arise from the need to reproduce the actual position accurately over several revolutions when referencing (with incremental encoders or on POWER OFF/ON with absolute encoders). See also “Dependencies”, Section 5.3.1).

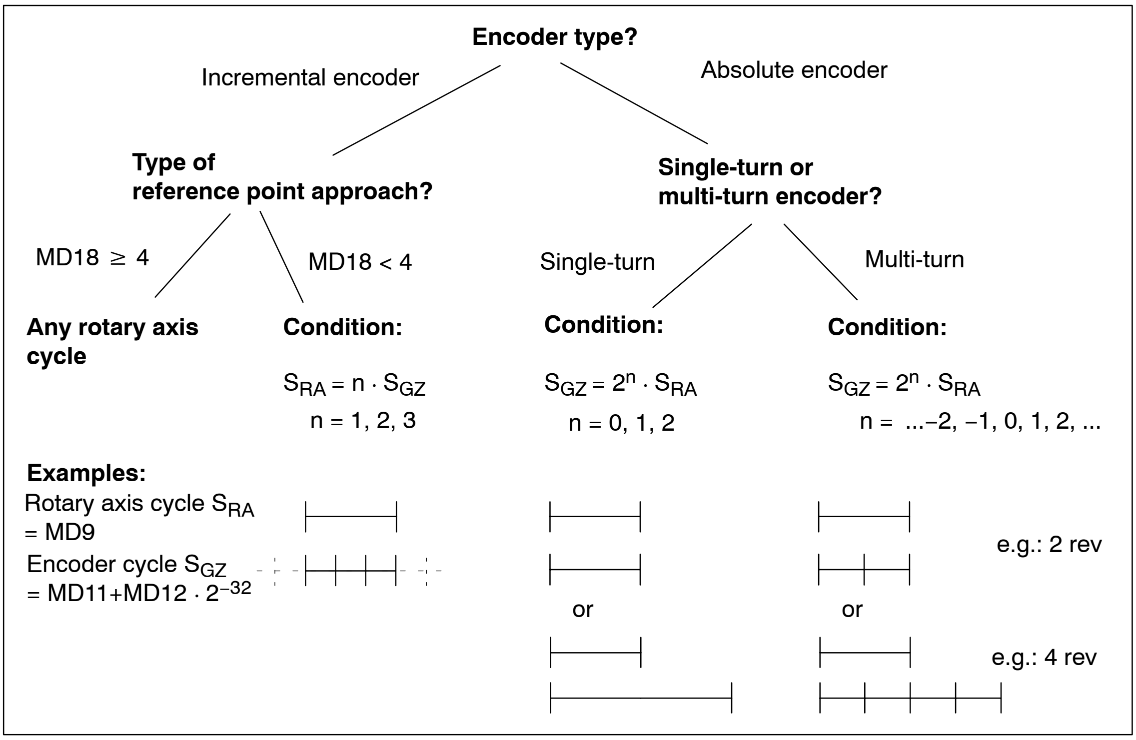


Fig. 9-5 Encoders on Rotary Axes

9.6 Encoders

Overview

One of the following encoders must be connected to the measuring-system interface of the FM 453 (see Fig. 1-1).

- Incremental encoder
- Absolute encoder (SSI)

Paths and positions are displayed in 10^{-3} mm, 10^{-4} inches or 10^{-4} degrees, as selected with machine data item MD7.

The path resolutionof the machine axis obtained by the encoder is calculated within the FM from machine data MD11 to MD13.

Encoder Selection

The prerequisite for achieving a given positioning accuracy is an n-fold improvement in path resolution by the encoder.

Recommended Values for n		
Minimum	**Optimum**	**Maximum**
2	4	10

For that reason, when configuring a given specific application, select an encoder that meets the desired positioning accuracy requirements.

The known design data for the machine axis and the desired measurement resolution A:

$$A = \frac{1}{n} \cdot \text{Positioning accuracy} \qquad \text{[mm], [inches], [degrees]}$$

yield a calculation of the necessary pulse number per encoder revolution according to the following relationship (taking a metric measuring system as an example):

Incremental Encoder	Absolute Encoder (SSI)	Stepper Motor without Encoder
$I_G = \frac{S\ [mm]}{4 \cdot i_{GS} \cdot A\ [mm]}$	$S_G = \frac{S\ [mm]}{i_{GS} \cdot A\ [mm]}$	$S_S = \frac{S\ [mm]}{i_{GS} \cdot A\ [mm]}$

The table below gives you an overview of the data used in this calculation and their meaning. You will find the machine data (MD) assignments under “Function parameters”.

Symbol	Significance
I_G	Increments per encoder rotation (incremental encoder)
S_G	Number of steps per encoder revolution (absolute encoder)
S_S	Number of increments per stepper motor revolution MD52
S	Distance per spindle or rotary table revolution [mm/rev], [inches/rev], [degrees/rev]
A	Required resolution [mm], [inches], [degrees]
4	Pulse multiplication (constant)
i_{GS}	Ratio between encoder and mechanism – Number of encoder revolutions $\left[\frac{\text{number of encoder revolutions}}{\text{spindle revolution}}\right]$ or $\left[\frac{\text{number of encoder revolutions}}{\text{rotary table revolution}}\right]$

If unusual numbers of pulses or steps result, the encoder with the next-higher number of pulses or steps should be selected.

Encoder and Stepper Motor

It is only permissible to mount rotary encoders onto stepper motors in the ratio 1:1. It is not appropriate to have an encoder resolution which is higher than the pulse resolution of the motor.

9.6.1 Incremental Encoders

Overview

Incremental encoders serve to detect position values, supplying pulses that the FM 453 adds up to form an absolute value. After the FM 453 is switched on, there is an offset, which cannot be determined in advance, between the internal position value and the mechanical position of the axis. In order to establish the position reference, the internal value must therefore be set to a predefined value at a specific axis position. This value is stored in the machine data (MD) as a reference point coordinate (see Section 9.2.3).

Incremental Encoders

The following variant applications are possible:

- **Rotary incremental encoder on linear axes**

  Encoders with one zero pulse per revolution may be used. The number of encoder pulses must be a multiple of ten or a power of two.

- **Rotary incremental encoder on rotary axes**

  Encoders with one zero pulse per revolution may be used. The number of encoder pulses must be a multiple of ten or a power of two. With indirect encoder mounting and reference point approach with a zero pulse (MD18 < 4), you must ensure that the revolution of the rotary axis is divisible without remainder by the cyclical zero pulse (see “Dependencies” Sections 5.3.1. and 9.5).

- **Linear scales on linear axes**

  Scales may be used with at least one reference zero pulse, or with a cyclic zero pulse.

  In comparison to rotary incremental encoders, instead of the encoder revolution a period of division is used as a basis here, corresponding for example to the segment between two zero-mark pulses.

Function Parameters

Table 9-9 shows you how to adapt the selected encoder to the FM 453.

Table 9-9 Function Parameters – Incremental Encoders

MD	Designation	Value/Meaning	Comments/Unit
10	Encoder type	**1 = Incremental encoder**	(Code number)
11	Displacement per encoder revolution (division period)	1...1 000 000 000 see Section 5.3.1, Dependencies	[MSR] (integer portion)
12	Residual distance per encoder revolution (division period)	0...$2^{32}-1$ see Section 5.3.1, Dependencies	[2^{-32}MSR] (fractional portion)
13	Increments per encc. revolution (division period)	$2^1...2^{25}$ see Section 5.3.1, Dependencies	Entry according to encoder rating plate
19.0	Direction adjustment	**1 = invert measured value direction**	
20 20.0 20.2 20.3	Hardware monitoring	 **1 = Cable break** **1 = Pulse monitoring** **1 = Voltage monitoring**	Entry for monitoring to be switched on

MSR stands for measurement system raster (see Section 5.3.1)

Sample Encoder Adjustment

Encoder: Number of increments per revolution (MD13) = 2,500

(The FM 453 works by the principle of quadruple evaluation. This yields an FM-internal number of increments per revolution = 10,000.)

Machine design:

- Motor with 50:30 gear ratio on spindle with 10 mm pitch = 10,000 MSR
- Encoder on motor.

From this one can calculate the following traversing distance per encoder revolution:

$$\text{Gear ratio:} \quad i = \frac{50 \text{ spindle revolutions}}{30 \text{ motor revolutions}} = 1.666666...$$

$$\text{Displacement per encoder revolution} = i \cdot 10{,}000 \text{ MSR} = 16{,}666.666... \text{ MSR}$$

The following values are entered:

MD	Value	Unit
11	16 666	[10^{-3} mm]
12	$0.666... \cdot 2^{32} = 2{,}863{,}311{,}530$	[$2^{-32} \cdot 10^{-3}$ mm]
13	2 500	[pulse/rev]

Monitoring/Error Diagnostics

If MD20 = 0 is input, all monitoring functions are active.

Individual monitoring functions can be inactivated by entering 0 in the designated bit of MD20.

You can deactivate the error messages using the single function “parking axis” (see Section 9.3.2).

Table 9-10 Error Diagnostics – Incremental Encoder

Diagnosis	Cause	Error Message
Cable break monitoring	Signals of one track pair (A, $\overline{A}$ / B, $\overline{B}$ / N, $\overline{N}$) do not behave as negations of one another.	The FM 453 responds with a diagnostic interrupt, external channel error (see Troubleshooting, Table 11-4)
Pulse monitoring	• In the case of decimal encoders (e.g. 1000 incr. per rotation), the pulse rate between two zero pulses is not divisible mod 10 • In the case of binary encoders (e.g. 1024 incr. per rotation), the pulse rate between two zero pulses is not divisible mod 16	• If the contents of the missing–pulse memory (sum of all mod values) exceed the value 7, the diagnostic interrupt ’external channel error’ (see Troubleshooting, Table 11-4) is generated. • The control signal ”Restart” clears the missing–pulse memory.
	In the Reference-Point Approach mode, no zero pulse is registered after leaving the reference-point switch within the path as defined in MD11, 12[1].	**Effect:** • Encoder cannot be synchronized. • On leaving the reference-point switch in Reference-Point Approach mode, the FM 453 will travel no more than the distance of one encoder revolution (MD11), and needs the deceleration distance from the reducing speed.
Voltage monitoring	Encoder power failure	Diagnostic interrupt, external channel error (see Troubleshooting, Table 11-4)

1) The monitoring can be disabled using MD20.

Warning

Hardware monitoring functions should be skipped only for test purposes, since positioning errors may destroy the machine.

Exception:

Pulse monitoring for encoders with non-cyclic zero pulse.

For connecting the encoders, see Section 4.5

9.6.2 Absolute Encoders (SSI)

Overview

Absolute encoders (SSI) have several significant advantages over incremental encoders:

- Longer cable lengths
- Reliable data capture by using a single-step GRAY code
- No encoder synchronization needed.

Absolute Encoders (SSI)

You can use 13/25-bit single-turn encodersl (left-justified) or 21/25-bit multi-turn encoders with the SSI protocol (left-justified or ”fir tree format”).

- **Absolute encoder (SSI) on linear axes**

  Make sure the value range of the encoder is at least equal to the traversing distance of the axis.

- **Absolute encoder on rotary axes**

  Make sure that the absolute value range captured by the encoder corresponds to a ratio of 2^x or 2^{-x} to one revolution of the rotary axis, and that it encompasses at least one rotary axis revolution (see “Dependencies” Section 5.3.1 and Figure 9-5).

Function Parameters

Table 9-11 shows you how to adapt the selected encoder to the FM 453.

Table 9-11 Function Parameters – Absolute Encoders (SSI)

MD	Designation	Value/Meaning	Comments/Unit
10	Encoder type	**3 = Absolute encoder (SSI 13 Bit)** **4 = Absolute encoder (SSI 25 Bit)** **5 = Absolute encoder (SSI 21 Bit) Fir tree format** **6 = Absolute encoder (SSI 25 Bit) Fir tree format** **13 = Absolute encoder (SSI 13 Bit)** **14 = Absolute encoder (SSI 25 Bit)** **15 = Absolute encoder (SSI 21 Bit) Fir tree format** **16 = Absolute encoder (SSI 25 Bit) Fir tree format**	GRAY Code GRAY Code GRAY Code GRAY Code Binary Code Binary Code Binary Code Binary Code
11	Displacement per encoder revolution (graduation)	1...1 000 000 000 see Section 5.3.1, Dependencies	[MSR] (integer portion)

Table 9-11 Function Parameters – Absolute Encoders (SSI), continued

MD	Designation	Value/Meaning	Comments/Unit
12	Distance–to–go per encoder revolution	0...2^{32}–1 see Section 5.3.1, Dependencies	[2^{-32} MSR] (fractional portion)
13	Increments per encoder rev. (graduation)	2^1...2^{25} see Section 5.3.1, Dependencies	Entry according to encoder rating plate
14	Number of revolutions of SSI encoder	0/1 = Single-turn encoder 2^1...2^{12} for multi-turn encoder see Section 5.3.1, Dependencies	Only powers of 2 allowed
15	SSI baud rate	2 = 156 000 Baud 3 = 312 000 Baud 4 = 625 000 Baud 5 = 1 250 000 Baud 6 = 2 500 000 Baud (no liability accepted)	(Code number) The baud rate depends on the cable length between FM 453 and encoder
19.0	Direction adjustment	**1 = Invert measured value direction**	–
20 20.1 20.3	Hardware monitoring	 **1 = Error in absolute encoder** **1 = Voltage monitoring**	Entry for monitoring to be switched on

MSR stands for measurement system raster (see Section 5.3.1)

Sample Encoder Adjustment

Encoder: Number of increments per revolution (MD13) = 4096 = 2^{12}

Number of revolutions (MD14) = 256 = 2^8

Machine axis design:

- Motor with 50:30 gear ratio on spindle with 10 mm pitch = 10,000 MSR
- Encoder on motor.

From this one can calculate the following traversing distance per encoder revolution:

$$\text{Gear ratio: } i = \frac{\text{50 spindle revolutions}}{\text{30 motor revolutions}} = 1.666666...$$

$$\text{Displacement per encoder revolution} = i \cdot 10{,}000 \text{ MSR} = 16{,}666.666... \text{ MSR}$$

The following values are entered:

MD	Value	Unit
11	16 666	[10^{-3} mm]
12	0.666... · 2^{32} = 2,863,311,530	[2^{-32} · 10–3 mm]
13	4096	[pulse/rev]
14	256	[rev]

Note

The encoder covers an absolute traversing distance of 256 · 16,666.666... MSR. In the 10^{-3} mm system of measurement this corresponds to a maximum axis traversing distance of 4,266.666... mm.

Monitoring/Error Diagnostics

If MD20 = 0 is input, all monitoring functions are active.

Individual monitoring functions can be inactivated by entering 0 in the designated bit of MD20.

You can deactivate the error messages using the single function “parking axis” (see Section 9.3.2).

Table 9-12 Error Diagnostics – Absolute Encoder

Diagnosis	Cause	Error Message
Voltage monitoring	Encoder power failure	Diagnostic interrupt, external channel error (see Troubleshooting, 11-4)
Error in absolute encoder	• Error in protocol for data transfer between absolute encoder and FM 453 • Cable break	Diagnostic interrupt, external channel error (see Troubleshooting, 11-4)

Warning

Hardware monitoring functions should be skipped only for test purposes, since positioning errors may destroy the machine.

When voltage monitoring is deactivated and the power supply to the encoders or the FM is switched off, an immediate failure in absolute value signaling can cause drive movements if:

- an operating mode other than open-loop control is active
- and follow-up mode is deactivated
- and the servo enable is activated or not parameterized.

Encoder Connection

See Section 4.5.

9.6.3 Stepper Motor Without Encoder

Overview

The FM 453 also operates with stepper motors without encoders.

The position resolution of the axis is determined by the traversing distance of one motor increment.

The control frequency pulses emitted by the FM 453 are added internally to form a position value.

Function Parameters

The following table shows you how to adapt a stepper motor to the FM 453.

MD	Designation	Value/Meaning	Comments/Unit
11	Travel per motor revolution (division period)	1...1,000,000,000 see Section 5.3.1, Dependencies	(MSR) (integer portion)
12	Residual distance per motor revolution (division period)	$0...2^{32}-1$ see Section 5.3.1, Dependencies	(2^{-32}MSR) (fractional portion)
52	Increments per motor revolution (division period)	4...10 000	Entry per stepper motor data plate

MSR stands for measurement system raster (see Section 5.3.1)

Example for Stepper Motor Adjustment

Stepper motor: Number of increments per revolution (MD52) = 10,000

Machine design:

Motor with 50:30 gear ratio on spindle with 10 mm pitch = 10,000 MSR

From this one can calculate the following traversing distance per motor revolution:

$$\text{Gear ratio:}\quad i = \frac{\text{50 spindle revolutions}}{\text{30 motor revolutions}} = 1.666666...$$

$$\text{Travel per motor revolution} = i \cdot 10{,}000\ \text{MSR} = 16{,}666.666...\ \text{MSR}$$

The following values are entered:

MD	Value	Unit
11	16 666	[10^{-3} mm]
12	$0.666... \cdot 2^{32}$ = 2,863,311,530	[$2^{-32} \cdot 10^{-3}$ mm]
52	10 000	–

9.6.4 Synchronization

Overview

When using incremental encoders, or stepper motors without encoders, at switch-on there is an offset, which cannot be determined in advance, between the internal position value in the FM and the mechanical position of the axis. To establish the position reference, the value internal to the FM must be synchronized with the real position value of the axis. Synchronization is performed by taking over a position value at a known point of the axis.

When using absolute encoders (SSI), at switch-on there is already a defined relationship between the position value internal to the FM and the mechanical position of the axis. This reference can be adjusted by setting an absolute encoder alignment value (see Section 9.3.9, Setting the reference point).

Absolute Encoder Alignment

is the compensation value for numerical alignment of the internal FM position value.

Zero Reference Mark

This signals the synchronization point of the axis, in some cases, with reference to the reference point switch (see Figure 5-5 “Zero reference mark selection”).

Reference Point Approach

is an operating mode used to position the axis at the reference point.

Reference Point

is a fixed point on the axis. It is:

- The target coordinate in the Reference-Point Approach mode
- Removed from the synchronization point by the amount of the reference-point shift, in axes with incremental encoders or stepper motors without encoders.

Reference Point Offset

Difference in distance between the synchronization point and the reference point.

The reference-point shift serves:

- for numerical measuring-system readjustment when an encoder is changed
- as a displacement reserve to brake the drive if the synchronization point is overshot.

Reference Point Switch (RPS)

The reference point switch selects the synchronizing zero marker on the traversing path of the axis.

- It is also the signal encoder for a speed reduction before the synchronization point is reached.
- It is connected to a digital input of the FM 453.

Synchronization Point

is a defined point on the traversing path of the axis. It is defined by the mechanical position of a reference-point switch or in association with a cyclic zero mark of an incremental encoder.

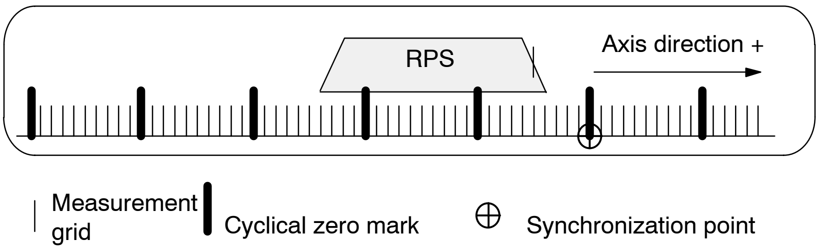
Synchronization

Creating the position reference between the internal FM position value and mechanical position of the axis.

Measured Value Synchronization With Incremental Encoders

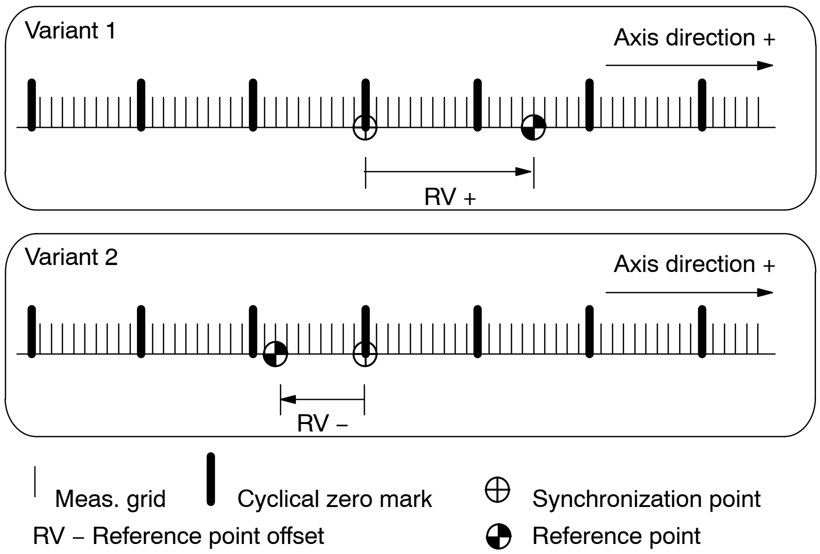
Irrespective of the approach direction, the synchronization point can be located on the side of the lower or the higher actual position values in relation to the reference point switch position. It is demarcated by the rising edge of a zero pulse or by the reference point switch. This selection is made by the MD18 (together with the approach direction).

Example



With reference to the synchronization point, the reference point can be located on the side of the lower or the higher position actual values. In the “reference point approach” operating mode the machine axis additionally traverses this distance, during its last phase of motion, once the synchronization point has been found. Consequently, the axis halts the motion, in each instance, exactly on the ref. point.

Example



9.7 Setpoint Processing

Overview

Setpoint processing in the FM 453 is performed via the interpolation, servo position control or stepper motor control, actuating signal driver and drive actuation. Either the servo position control or stepper motor control function is active depending on the control mode (MD61). Figure 9-6 gives an overview of the interaction of the functions. The separate functions are described in detail with reference to the relevant machine data in the following sections.

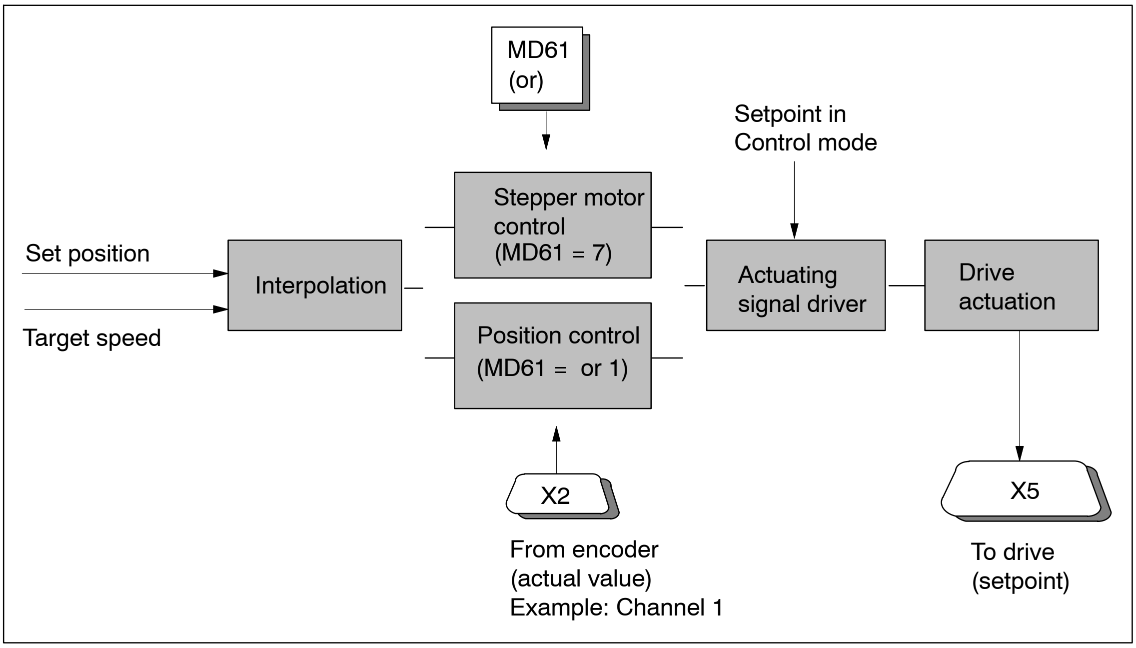


Fig. 9-6 Overview of the Functions Used in Setpoint Processing

9.7.1 Interpolation

Overview

In the interpolation function, a set position curve is generated as a function of time to present to the input of the position control loop or the stepper motor control. When the software limit switches are active, the traversing movement is limited in accordance with this range.

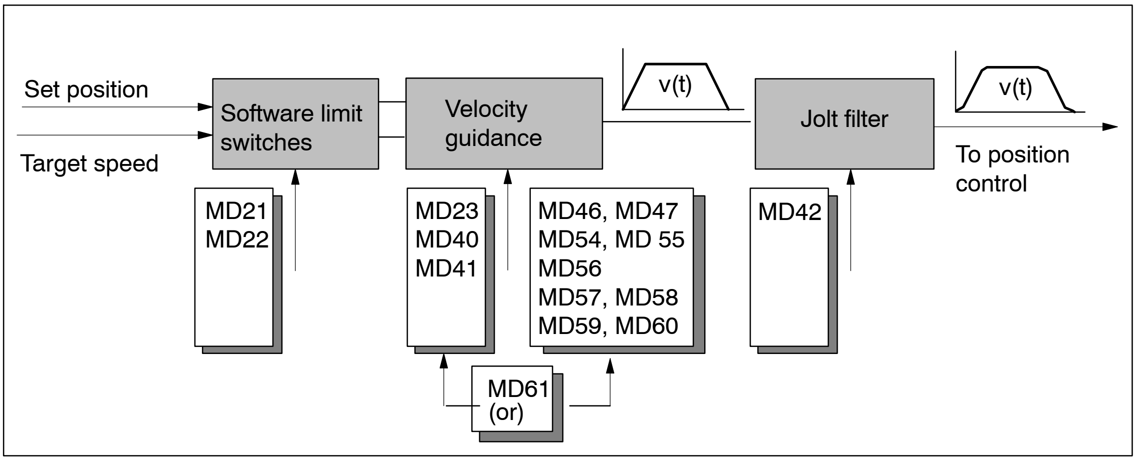


Fig. 9-7 Overview of Interpolation Function

The subfunctions of the interpolation function are described in detail here.

Software Limit Switches

Software limit switches MD21 and MD22 (see Section 9.9) are used to limit the working area.

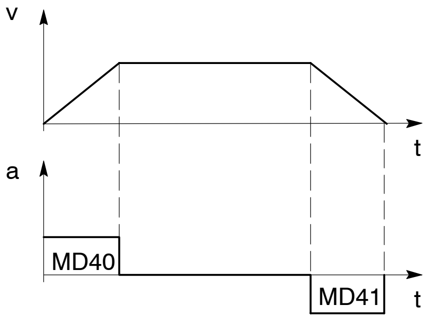
MD	Designation	Value/Meaning	Unit
21	Software limit switch, start	–1,000,000,000 – +1,000,000,000 see Section 5.3.1, Dependencies	[MSR]
22	Software limit switch, stop		

Velocity Guidance

The velocity guidance function is defined via the control mode (MD61). Two variants are available, the simple characteristic for servo-controlled operation or a stepped characteristic for open-loop controlled stepper motor operation.

Simple characteristic

The machine data for acceleration (MD40) and deceleration (MD41) can be used to adapt the transition response of the command variable defined by the interpolator to the transition response of the controlled system.



v – speed
a – acceleration
t – time

MD	Designation	Value/Meaning	Unit
40	Acceleration	0 = without ramp 1...100,000	$[10^3$ MSR/s$^2]$
41	Deceleration		
61	Control mode	0 = Servomotor with servo position control 1 = Stepper motor with servo position control 7 = Stepper motor without servo position control	

MSR stands for measurement system grid (see Section 5.3.1)

To set MD40/41, refer to Section 7.3.7

Stepped characteristic

The stepped characteristic is specially designed to comply with the demands of stepper motors on the frequency/time function which result from the fall off in torque with increasing stepper motor speed. A discontinuous traversing movement with a programmed speed is initiated or stopped below the Start/Stop frequency.

For higher traversing velocities, a ramp-shaped control cycle, which builds on the Start/Stop frequency, takes place within two velocity ranges with acceleration values of different parameterization capability.

When phases of constant travel are reached, or axis standstill, a minimum holding time is inserted for these states to esure that the motor or axis vibrations subside before a new acceleration phase is implemented.

The following illustrations provide you with examples of frequency profiles for selected traversing movements.

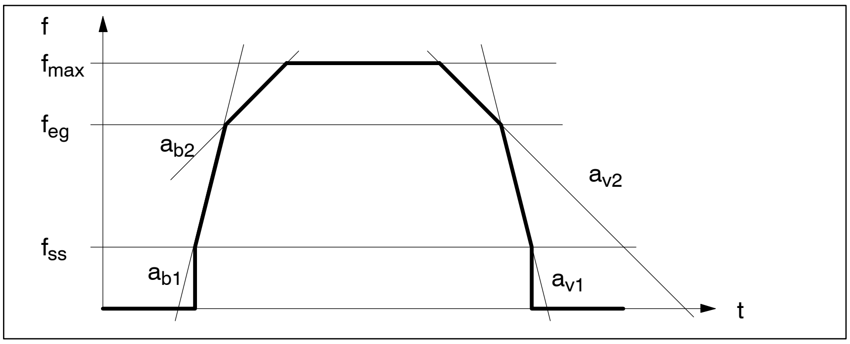


Fig. 9-8 Maximum Speed Frequency Profile

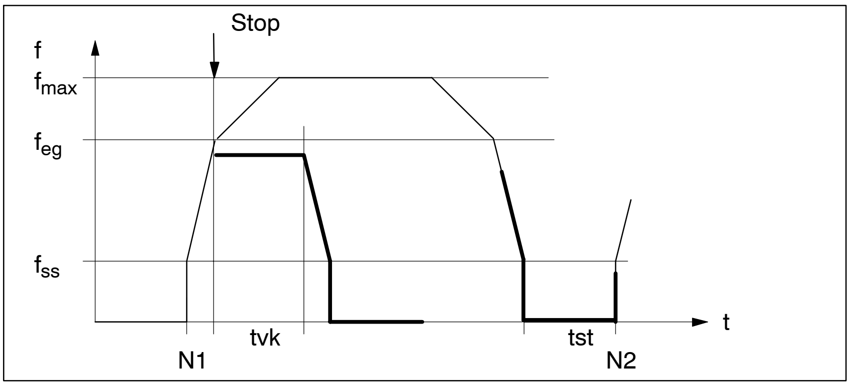


Fig. 9-9 Frequency Profile for Stop or G60

The following table shows you which parameters to use in matching frequency generation to the selected step drive.

MD	Designation	Value/Meaning	Unit
46	Minimum idle time between two positioning cycles (t_{st})	1 – 10,000	[ms]
47	Minimum traversing time at constant frequency (t_{vk})	1 – 10,000	[ms]
54	Start/Stop frequency (f_{ss})	10 – 100,000	[Hz]
55	Frequency value for acceleration switchover (f_{eg})	10...1,000,000[1)]	[Hz]
56	Maximum frequency (f_{max})	500...1,000,000[1)]	[Hz]
57	Acceleration 1 (a_{b1})	10...10,000,000[1)]	[Hz]
58	Acceleration 2 (a_{b2})	10...MD57; 0 = as with MD57[1)]	[Hz]
59	Delay 1 (a_{v1})	10 – 10,000,000, 0 = as with MD57[1)]	[Hz]
60	Delay 2 (a_{v2})	10...MD59; 0 = as with MD58	[Hz]

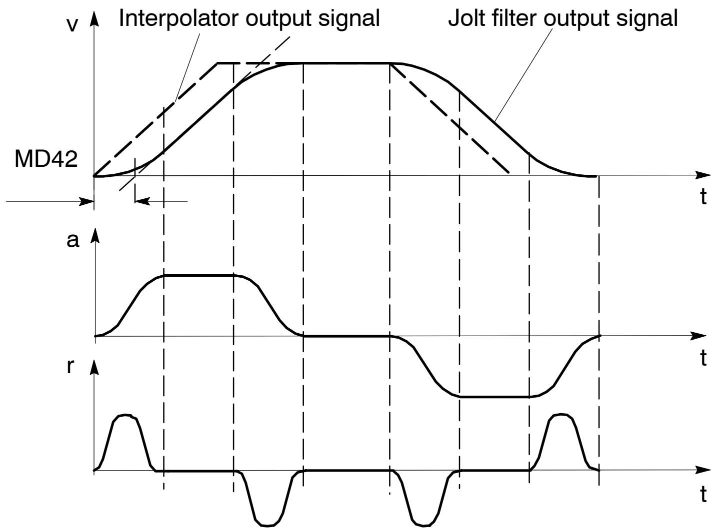
1) see Section 5.3.1, Dependencies

Jolt Filter

The jolt filter is effective in the case of a servo-controlled axis as well as for open-loop controlled operation of the step drive. In both cases, however, it is not effective in open-loop control mode due to the fact that in this operating mode, setpoint input takes place in the actuating signal driver.

Without jolt limitation, the acceleration and deceleration act as abrupt variables. Jolt limitation allows the break points of a ramp-like speed curve to be smoothed out for both acceleration and deceleration. This yields particularly “soft” (jolt-free) acceleration and braking for certain positioning tasks, such as conveying of fluids.

Jolt time can be set in MD42 as the parameter for jolt limitation.



v – speed
a – acceleration
r – jolt
t – time

MD	Designation	Value/Meaning	Unit
42	Jolt time	0...10,000	[ms]

9.7.2 Servo Position Control

Overview

In the servo position control function, the setpoint characteristic specified by the interpolation function is implemented in conjunction with the feed drive of the machine or installation in the form of a traverse movement of the axis . The following axis configurations are possible, depending on the parameterization:

MD61	MD10	Axis Configuration
0	0	Servo drive, speed positioned without encoder
	1	Servo drive in position controller with incremental encoder
	3, 4, 5, 6, 13, 14, 15, 16	Servo drive in position controller with absolute encoder
1	0	Step drive in position controller without encoder, with FM-internal pulse feedback
	1	Step drive in position controller with incremental encoder
	3, 4, 5, 6, 13, 14, 15, 16	Step drive in position controller with absolute encoder
7	–	Step drive in open-loop control mode

This function is subdivided into subfunctions as shown below, which are then described in detail:

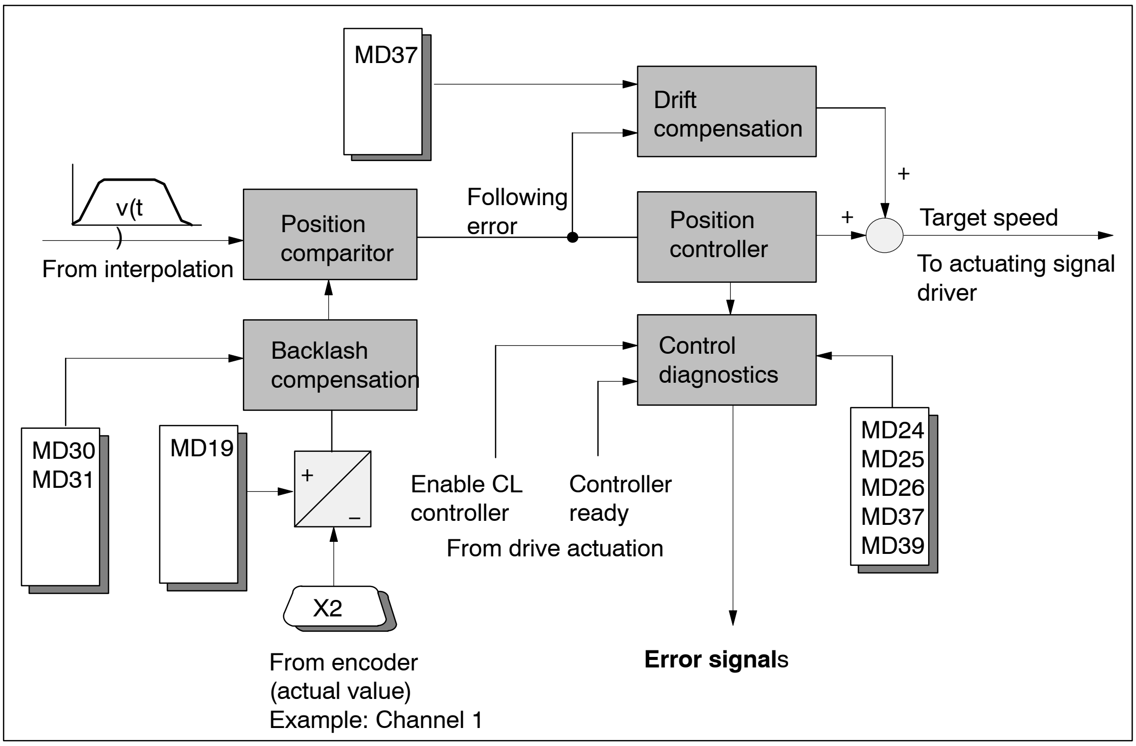


Fig. 9-10 Overview of Servo Position Control Function

Position Comparator

The following error is calculated by periodical comparison of the set position defined by the interpolator with the actual position of the axis detected by the encoder.

Following error = Set position − Actual position

Position Controller

The position controller generates an actuating signal that is required for calibrating to the following error zero value from the following error of the positioning loop that is generated by the position comparitor. The actuating signal represents a speed setpoint value that is transferred to the actuating signal driver. The position controller is a proportional-action controller that operates according to the following principle:

Internal velocity setpoint = Following error · Positioning loop amplification

Here, the positioning loop amplification determines the effect of a specific following error on the generation of the actuating signal for the drive to be actuated.

Positioning loop amplification

The positioning loop amplification (K_v factor) specifies at what speed of axis travel a given following error sets in. The mathematical (proportional) relationship is:

$$K_v = \frac{\text{Speed}}{\text{Following error}} = \frac{v\ [10^3\ \text{MSR/min}]}{\Delta s\ [\text{MSR}]}$$

Although the magnitude of the following error plays no dominant role for a single axis, the K_v factor still affects the following important characteristics of the axis:

- Positioning accuracy and stopping control
- Uniformity of movement
- Positioning time

The following relationship applies for these characteristics:

The better the axis design, the greater the achievable K_v factor, and the better the axis parameters from the technological viewpoint. The size of the K_v factor is especially affected by the time constants, backlash and spring components in the controlled system. In real applications the K_v factor moves within the following bandwidth:

- K_v = 0.2...0.5 poor-quality axis
- K_v = 0.5...1.5 good axis (normal case)
- K_v = 1.5...2.5 high-quality axis

The MD38 value is input with a resolution of 10^3, so that the following input value results:

$$MD38 = 10^3 \cdot K_v = 10^3 \cdot \frac{\text{Speed}}{\text{Following error}} = 10^3 \cdot \frac{v\ [10^3\ \text{MSR/min}]}{\Delta s\ [\text{MSR}]}$$

MD	Designation	Value/Meaning	Unit
38	Positioning loop amplification	1 – 10,000	[(MSR/min)/MSR]

Controller Diagnostics

Basic diagnostics

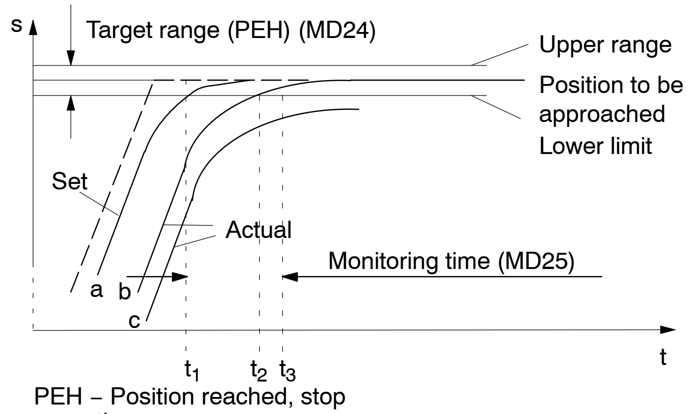
In servo-controlled mode, the manipulated variable is compared periodically with the possible maximum values (± 10 V or maximum frequency). A violation of the maximum limit is interpreted as follows:

No axis movement:	“No drive movement” error message (see Table 11-7, Class 3/No. 65)
Traverse in the opposite direction:	“Direction of drive rotation” error message (see Table 11-5, Class 1/No. 11)
Correct travel direction:	Overrange message in status message 1 (see Section 9.3.17, Additional operating data)

In all operating modes except Open-loop control mode, the “controller enable” signal is required for the duration of every traversing movement, irrespective of the parameter definitions. If the controller enable is not detected or is deactivated during the movement, the “servo enable missing” message is triggered (see Table 11-5, Class 3/No. 61).

In all operating modes except Open-loop control mode, the “servo ready” signal is required for the duration of every traversing movement when the parameter is active (MD37.2). If the servo ready signal is not detected or is deactivated during the movement, the “servo not ready” message is triggered (see Table 11-5, Class 3/No. 62).

Approach to the target position



PEH – Position reached, stop
s – path
t – time

On approach to a position, the monitoring time is activated:

Time	Position Monitoring
t_1 (a)	After the interpolator reaches the target position, the monitoring time (MD25) for reaching the target range is started in the CL controller, after the overtravel in the jolt filter dies down to the target range value (PEH on setpoint side).
t_2 (b)	Before the monitoring time expires, the actual position reaches the target range. Positioning is completed. A PEH is signaled, and exact matching is performed by the CL controller.
t_3 (c)	After the monitoring time expires, the actual position has not reached the target range (PEH). **Error message:** "PEH Target Range Monitoring" (see Troubleshooting, Table 11-5, Class 3/No. 64)

MD	Designation	Value/Meaning	Unit
24	Target range	0...1 000 000	[MSR]
25	Monitoring time	0 = no monitoring 1...65 534	[ms], rounded to 3−ms steps

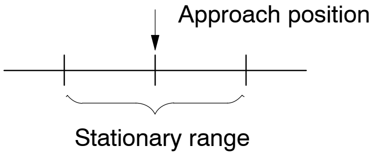
Following error monitoring

Axis standstill

A message is output on an axis standstill setpoint or deactivated servo enable if disturbances cause the axis to move out of position.

MD	Designation	Value/Meaning	Unit
26	Stationary range	0...1 000 000	[MSR]

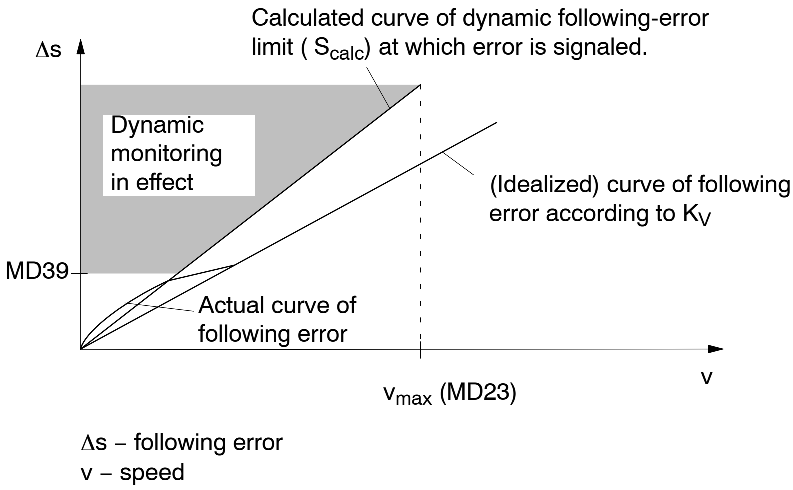
The standstill zone is located symmetrically around the target approach position.



When the tolerance window for idle is exceeded, the FM 453 signals a "Stationary Range" error (see Troubleshooting, Table 11-5,
Class 1/No. 12).

Axis moving

To monitor following error during movement, the FM 453 calculates the allowable following error for the instantaneous traveling speed from the parameterized positioning loop amplification (MD38). Above the parameterized "Minimum following error (dynamic)," a comparison is performed with the actual value for the following error.



MD	Designation	Value/Meaning	Unit
39	Minimum following error (dynamic)	0 = no monitoring 0...1,000,000	[MSR]

When the calculated dynamic following-error limit is exceeded
(1.5fold of the idealized following error), the FM 453 signals the error "Following error too large" (see Troubleshooting, Table 11-7, Class 3/No. 66).

Exception:

If an axis standstill occurs above the "minimum dynamic following error",the error message described under Basic diagnostics "no drive movement" is output (see Table 11-7, Class 3/No. 65).

Correction Functions

Drift compensation

Thermal conditions will shift the zero error in the control loop during operation. This effect is called drift. In a closed control loop with a proportional-action controller, this results in a temperature-dependent positioning error. You can activate automatic drift compensation with MD37, under which continuous balancing takes place in the positioning control loop.

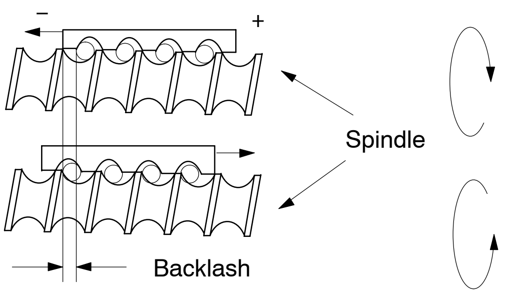
A basic compensation of the zero point error by means of the offet is required for the optimum effect of the drift compensation
(see MD44, offset compensation).

MD	Designation	Value/Meaning	Unit
37	Control signals	16 = automatic drift compensation active	–

Backlash compensation

Mechanical drive components as a rule have a certain amount of backlash (free play).

Mechanical reversing backlash can be compensated with MD30. In an indirect measuring system (with the encoder on the motor), the mechanical backlash is traveled at each change of direction before any axis movement occurs. The result is positioning errors.



When the position encoder is situated on the machine part to be positioned (e.g. on a saddle - direct arrangement), backlash adversely affects the achievable K_v factor. On the other hand, if the position encoder is attached to the drive motor (indirect arrangement), a high K_v factor can be achieved, but at the cost of position deviations that cannot be detected by the position controller. A backlash amount entered in MD30 is applied as a correction by the position controller as a function of the traveling direction at a given moment, thus achieving an approximate compensation for backlash in positioning.

MD31 is used to label the “backlash-free” or “accurate-measurand” traveling direction of the axis. If MD31 = 0, the “backlash-free” direction is the one that matches the direction of axis movement when synchronization is recorded. Depending on MD18, this will correspond to the following association:

MD18 = 0, 2, 4, 8: Plus direction is backlash-free
MD18 = 1, 3, 5, 9: Minus direction is backlash-free

MD	Designation	Value/Meaning	Unit
30	Backlash compen- sation	0 to 1 000 000	(MSR)
31	Directional reference of backlash	0 = as in reference point approach (only for incremental encoders)	–

The backlash is traversed at a speed of 1% of the maximum possible speed (MD23).

Other Function Options

The particulars of backlash compensation can be defined with MD65 and MD66.

MD	Function	Value/Description	Unit
65	Speed for backlash compensation	0 Backlash traversing speed 1 % of MD23 1...1 00 Backlash traversing speed in % of MD23	[%]
66	Mode for backlash compensation	0 = Backlash compensation prior to positioning 1 = Backlash compensation during positioning The backlash traversing speed is added to the programmed speed for the traversing job affected by override.	–

Note the following carefully:

- Backlash travel is not affected by override, and is uninterruptible.
- In the case of stepper motor control (MD61 = 7), MD65 is limited with regard to the start/stop frequency (MD54) if MD66 is = 1, and limited to 10% of the maximum frequency (0.1 * MD56) if MD66 is = 0.
- In the case of variants with position control (MD61 = 0 or MD61 = 1), MD65 is limited by the control margin (for servo motors see MD43). For stepper motors, the control margin is computed from the difference between the frequency required for maximum velocity (MD23) and the maximum frequency (MD56) of the stepper motor.
- If the interdependencies of the MDs are violated, an error is reported with ”range violation” as its cause.
- Backlash compensation goes into effect prior to reference point approach.
- A change in MD30 (backlash) takes effect only after a traversing movement in a backlash-free direction (MD31).

9.7.3 Stepper Motor Control System

Overview

In open-loop controlled operation of the stepper motor, the axis is driven via the frequency output of the pulse/direction interface with “counted” distance increments and without following error. This results in the maximum dynamics possible for the movement, because when the target position is reached via interpolation, setpoint value output to the step drive is also terminated.

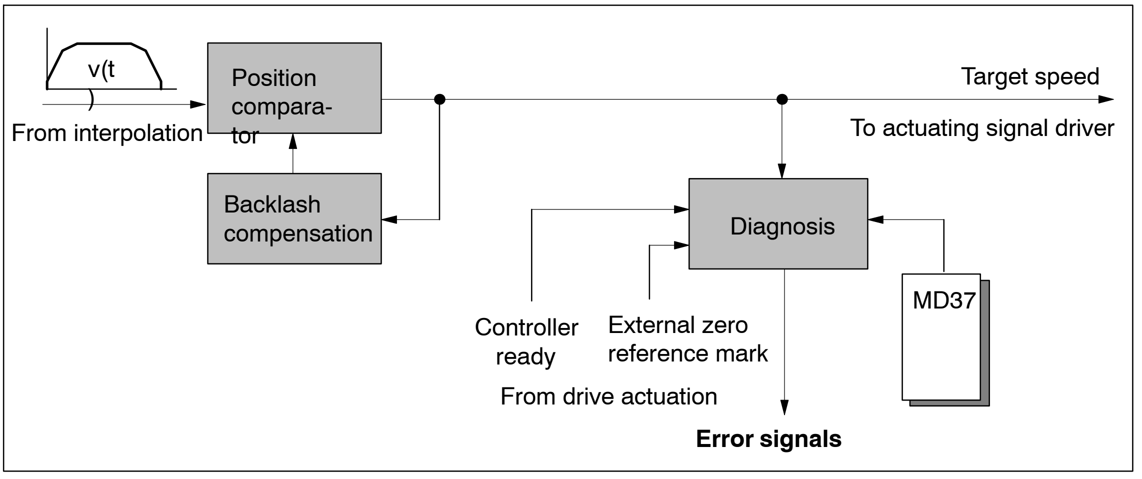


Fig. 9-11 Overview of Stepper Motor Control System

Diagnostics

Basic diagnostics

In all operating modes except Control mode, the “servo enable” signal is required for the duration of every traversing movement, irrespective of the parameter definitions. If the controller enable is not detected or is deactivated during the movement, the “servo enable missing” message is triggered (see Table 11-7, Class 3/No. 61).

In all operating modes except Open-loop control mode, the “controller ready” signal is required for the duration of every traversing movement when the parameter is active (MD37.2). If the servo ready is not detected or is deactivated during the movement, the “servo not ready” message is triggered (see Table 11-7, Class 3/No. 62).

Rotation monitoring

The following prerequisites must be met for the “Rotation monitoring” function:

1. External zero pulse (NIX) which is generated cyclically, precisely once per motor revolution

   Condition:

   At the maximum speed of the stepper motor, a signal length of $\Delta t \geq 2 \cdot$ FM cycle must be assured for the external zero pulse!

2. Connection to the “Controller message” (NL) input of the FM 453’s front panel connector.

3. Parameterization of the external zero pulse (MD37.26)

4. Use of the current-sourcing pattern zero signal is not allowed!

Activation of rotation monitoring:

For “rotation monitoring” single function, see Section 9.3.2

Error message:

- Error “Digital input not parameterized” (see Trouble-shooting, Table 11-7, Kl. 3/Nr. 30)

  Selecting function without parameterization for NIX

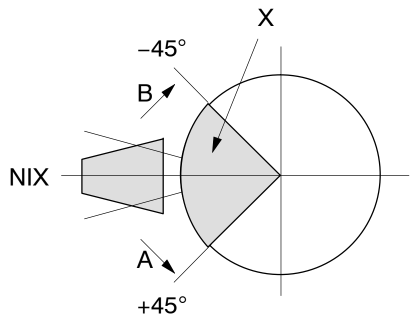
- “Rotation monitoring” error (see Troubleshooting, Table 11-7, Cl. 3/No. 66)
  - Motor turns too slowly (during acceleration/travel)
  - Motor turns too fast (during acceleration/travel)
  - External zero pulse failed
  - Incorrect number of increments per motor revolution parameterized (MD52)

Function description:

The external zero pulse is used as described below to monitor the motor rotation as specified in controlled operation (see Figure 9-12)

- The first NIX received synchronizes rotation monitoring.
- With every further NIX received, the system verifies whether the current pulse output of the stepper motor is within a window $n \cdot 360° \pm 45°$. The error “Rotation monitoring” is triggered by the occurrence of NIX edges which are outside the allowed window.
- With every FM cycle (3 ms) the system verifies whether the pulse output is outside a window $\pm$ (360° + 45°) since receipt of the last NIX. Positioning outside this allowable window also triggers the “Rotation monitoring” error.

- Stepper motor rotation without a specified setpoint value likewise triggers a “Rotation monitoring” error in response to the NIX edges caused by the unwanted rotation. This occurs whenever the preceding target position falls within the range outside the allowable window for the NIX edges. If an unwanted rotation occurs outside the allowable window, there is no way of identifying whether oscillation on a NIX edge position caused by malfunction generated the error, or whether complete motor revolutions are involved.
- Rotation monitoring is automatically discontinued whenever the synchronization mark is passed over in the “Reference point approach” operating mode, and the function “Retrigger reference point approach” is executed.



X – Permissible range for NIX
A – Following error trigger point on rotation + (after 1 rev. + 45°)
B – Following error trigger point on rotation – (after 1 rev. + 45°)
NIX – Zero pulse external
– (NIX center is synchronization point for rotation monitoring)

Fig. 9-12 Allowable Range Relative Position for the External Pulse

Correction Functions

Backlash compensation

(see “Backlash compensation” in Section 9.7.2)

9.7.4 Actuating Signal Driver

Overview

In the actuating signal driver, the internal setpoint velocity value from the position controller is converted for output to the DAC (Digital to Analog Converter) for the servo drive to be actuated or to the DFC (Digital to Frequency Converter) for the stepper motor to be actuated.

Analog Setpoint Output ±10 V interface

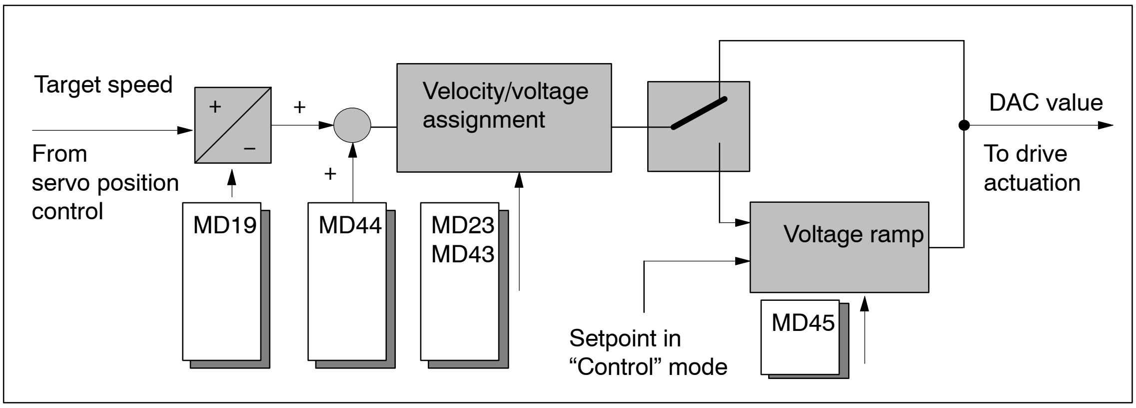


Fig. 9-13 Overview of Analog Setpoint Output

Direction alignment

MD19 allows you to align the direction by defining an assignment between the voltage sign of the manipulated signal and the axis movement.

MD	Designation	Value/Meaning	Unit
19.1	Direction adjustment	1 = Invert direction of drive rotation	–

Offset compensation

The analog modules in the positioning control loop (D/A converter of the FM453 and closed-loop controller module of the drive) cause a zero error because of operating-voltage and component tolerances. The result is that at an internal digital rotational-speed specification of zero in the FM 453, the drive motor will already be running undesirably. As a rule, drive controllers have adjustment capabilities for balancing. But by setting a voltage offset via MD44 the analog system can be balanced at startup from the FM side.

MD	Designation	Value/Meaning	Unit
44	Offset compensation	–5,000 – +5,000	(mV)

For calculation of the offset value, see Section 7.3.2, Drive interface.

Velocity/voltage assignment

The manipulated signal calculated by the position controller is available internally on the FM as a velocity setpoint (see position loop gain). To convert this value to the analog actuating signal, a conversion factor (DAC factor) within the FM is necessary. This factor is formed as the quotient of MD43 and MD23. MD23 contains the configured maximum speed of the machine axis, and MD43 contains the voltage setpoint of the actuating signal to be output by the FM 453 for this purpose; as a compromise between the highest possible resolution and adequate close-loop control reserve, this voltage should lie between 8 V and 9.5 V.

Warning

This assignment MUST be identical with the setting on the drive!

MD	Designation	Value/Meaning	Unit
23	Maximum speed	10 ... 500 000 000	(MSR/min)
43	Set voltage, max.	1,000...10,000	(mV)

Voltage ramp

A ramp-shaped voltage rise/drop can be defined in MD45 for the voltage output to the drive when the position controller is inactive. This serves to limit acceleration and thus power for the drive controller, and is preferable to setting options that may be available on the drive, since it has no adverse effects on active position control.

The voltage ramp is active in the following situations:

- Continuously in “Control” mode
- Deceleration on cancelation of the drive enable [AF] (see Section 9.1.1)
- Deceleration on transition of CPU from RUN to STOP
- Deceleration on error response “Everything Off” (see Sections 11.1, Tab. 11-4 and 11-5)
- Class 3 errors/Nos. 62, 65 and 66 (see Table 11-7)

MD	Designation	Value/Meaning	Unit
45	Voltage ramp	0...10,000,000	(mV/s)

Frequency Setpoint Output

(pulse/direction interface)

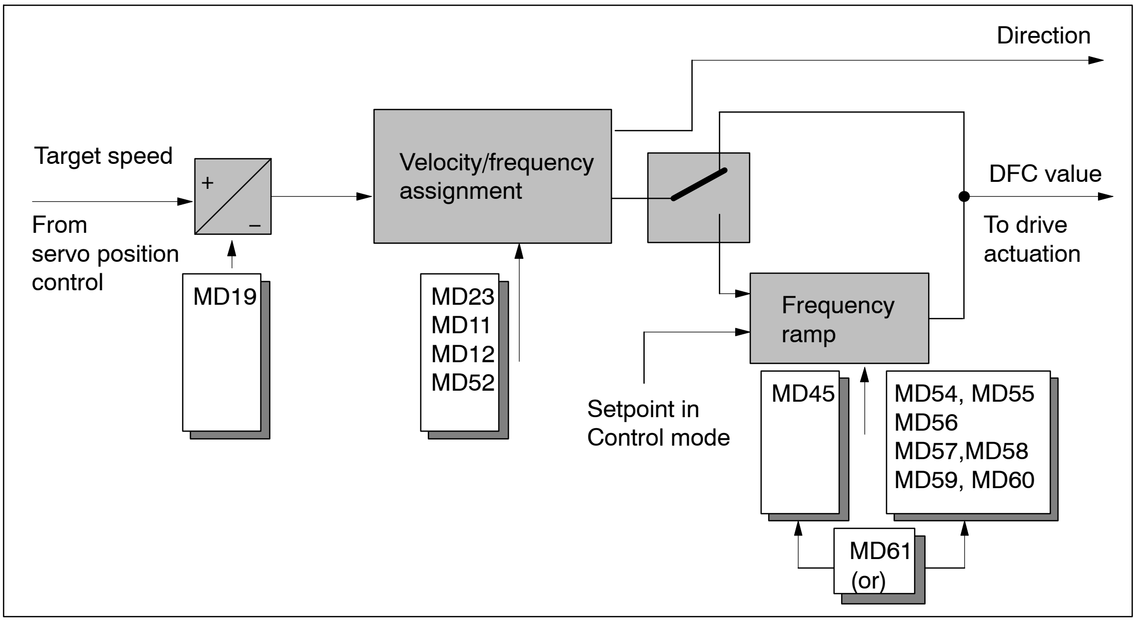


Fig. 9-14 Overview of Frequency Setpoint Output

The step drive is actuated via the digital interfaces "Pulse" and "Direction". The pulse frequency determines the motor speed. The pulse length is automatically set by the FM 453 to a symmetrical 1:1 sampling ratio with respect to the currently output frequency.

The direction information of the internal velocity setpoint value is converted into the "direction" signal for the step drive.

Direction alignment

MD19 allows you to align the direction by defining an assignment between the signal level of the "Direction" signal and the axis movement. Under default conditions, the following assignment applies:

"Direction" = 0 → Positive direction

"Direction" = 1 → Negative direction

MD	Designation	Value/Meaning	Unit
19.1	Direction adjustment	1 = Invert direction of drive rotation	–

Velocity/frequency assignment

An FM-internal conversion factor (DFC factor) is necessary for converting the internal setpoint velocity value to the setpoint required for programming the frequency output control for the purpose of generating the physical “Frequency” signal. This is determined by the pulse resolution of the step drive and is calculated from the parameterization of the distance assignment via the machine data MD11, MD12 and MD52. In the course of the dependency check on the machine data, it is checked that with this factor obtained from the maximum velocity MD23, a frequency is output with a magnitude less than or equal to the maximum frequency of the step drive that is parameterized in MD56 (see Section 5.3.1, “Dependencies” table). It is always possible, therefore, to implement a stepper motor whose nominal speed or nominal frequency exceeds the maximum value that is technologically required for your axis (MD23), but never one with values that are below this value.

MD	Designation	Value/Meaning	Unit
11	Displacement per encoder revolution (division period)	1...1,000,000,000[1)]	(MSR)
12	Residual distance per enc. revolution (division period)	0...$2^{32}-1$[1)]	[2^{-32}MSR]
23	Maximum speed	10...500 000 000	(MSR/min)
52	Increments per motor revolution (division period)	4...10,000[1)]	
56	Maximum frequency	500...1,000,000[1)]	[Hz]

1) see Section 5.3.1, Dependencies

Note

The relationship between MD56 and MD23 does **not** determine the speed assignment!

Frequency ramp

For outputting the frequency to the drive, MD45 can be used to parameterize a ramp-type frequency rise or fall which deviates from the values specified in the parameterization of the characteristic for velocity guidance.

The frequency ramp is active in the following situations:

- Continuously in Control mode
- Deceleration on cancelation of the drive enable [AF] (see Section 9.1.1)
- Deceleration on transition of CPU from RUN to STOP
- Deceleration on error response “Everything Off” (see Sections 11.1, Tab. 11-4 and 11-5)
- Class 3 errors/Nos. 62, 65 and 66 (see Table 11-7)

MD	Designation	Value/Meaning	Unit
45	Frequency ramp	0 = Frequency ramp acc. to characteristic (see Section 9.7.1, Velocity guidance) 1...10 000 000	[Hz/s]

9.7.5 Drive Actuation

Overview

In the interface between the FM 453 and the drive, apart from the actuating signal for the velocity setpoint for the traversing movement of the axis, other signals are exchanged.

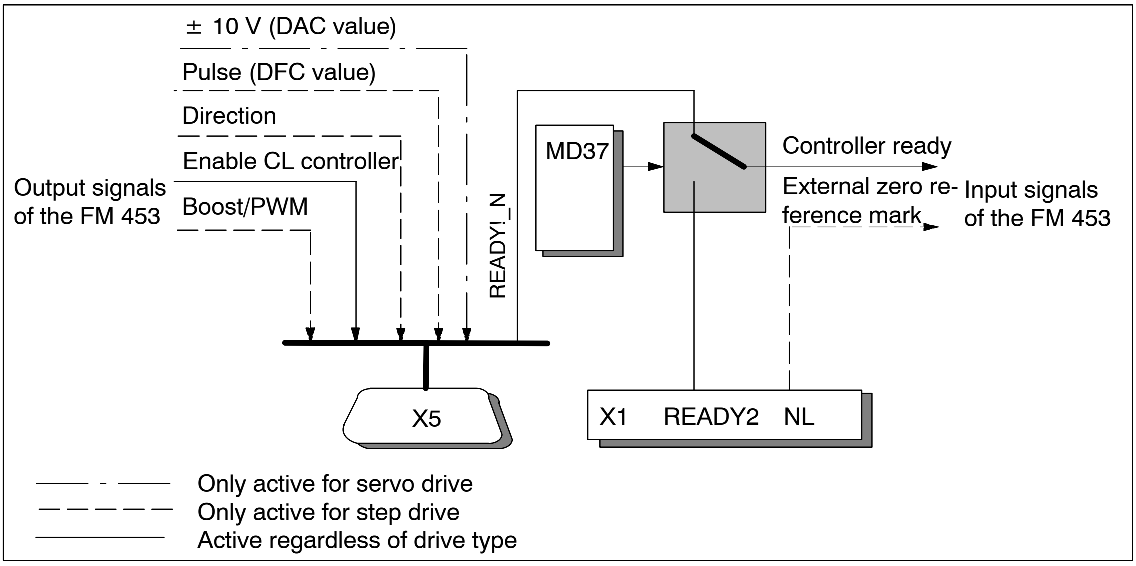


Fig. 9-15 Overview of Drive Actuation

Controller Enable, Controller Ready

These signals are used to activate the drive.

The “Controller ready” signal can be connected to the FM 453 either via the X5 connector at TTL level, or X1, with the 24 V level (see Section 4) and can be parameterized with respect to its active level.

“Control enable” is output as a closed contact when active (see Section 4.2).

MD	Designation	Value/Meaning	
37	Control signals		
37.0	Controller enable active	0: Signal not used 1: Signal used	Output signal
37.2	Controller ready active	0: Signal not connected 1: Signal is connected	Input signal
37.3	Controller ready inverted	0: Controller ready high active 1: Controller ready low active	
37.4	Controller ready input selection	0: at **Front panel connector X1 (READY2)** 1: at **D Sub connector X5 (Ready1_N)**	

In all operating modes except Control mode, the “servo enable” signal is required for the duration of every traversing movement, irrespective of the parameter definitions. If the controller enable is not detected or is deactivated during the movement, the “servo enable missing” message is triggered (see Table 11-7, Class 3/No. 61).

In all operating modes except Open-loop control mode, the “controller ready” signal is required for the duration of every traversing movement when the parameter is active (MD37.2). If the servo ready is not detected or is deactivated during the movement, the “servo not ready” message is triggered (see Table 11-7, Class 3/No. 62).

Optional Signals for Step Drive

Phase current control (“Boost” or “PWM”)

Via the interface signal “Boost” or “PWM” (Pulse Width Modulation), phase current control can be used to optimize the performance of the stepper motor. The FM 453 implements these two functions via an output. This is done by alternate machine data selection.

The active level of the signal can be parameterized.

Signal response:

Movement status	Output signal “Boost”	Output signal “PWM”
Idle	inactive	pulse duty factor per MD 51
Acceleration/delay	active	static active
Constant travel	inactive	pulse duty factor per MD 50

The following table shows you the available machine data for parameterizing the function.

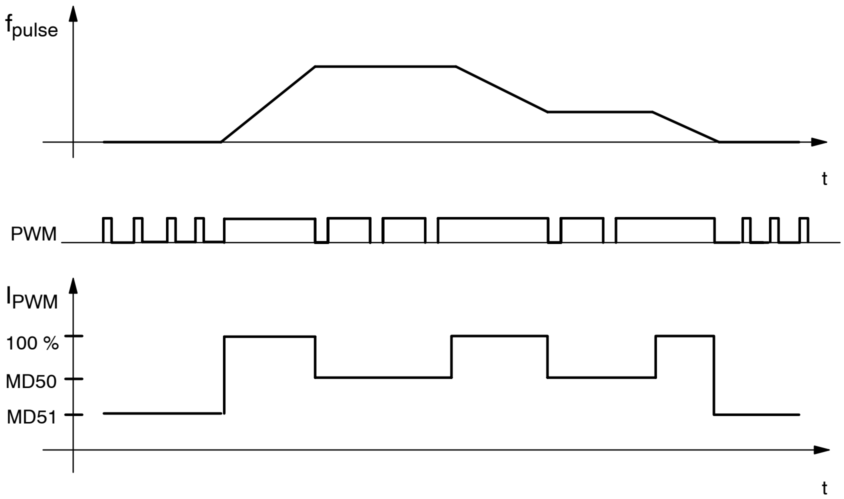
MD	Designation	Value/Meaning	
37	Control signals		
37.17	Boost active	0: Boost function not used 1: Boost function used	Output signal
37.18	PWM active	0: PWM function not used 1: PWM function used	
37.19	Boost/PWM inverted	0: Signal high active 1: Signal low active	
48	Boost duration absolute	1 ... 1,000,000 ms	
49	Boost duration relative	1 ... 100%	
50	Phase current travel	Pulse duty factor [%] see Section 5.3.1, Dependencies	
51	Phase current idle		

Function, PWM The signal is generated as a 20 kHz frequency.

Boost function: The signal is monitored with reference to the maximum absolute and relative active phase.

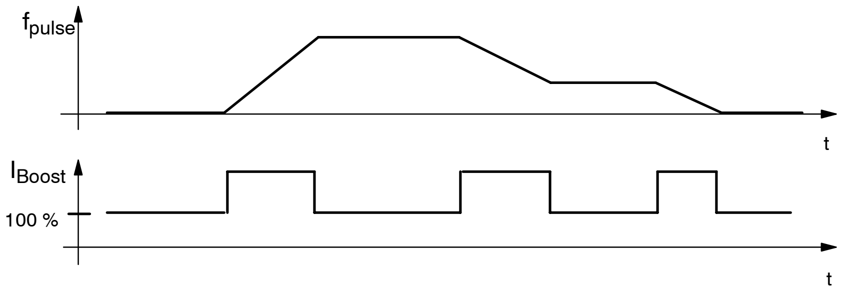
Effect: PWM

The motor phase current can be changed between 0 % and 100 %. Current modification is possible at zero speed and during continuous travel. On acceleration/deceleration, the current is always 100 % (max).



Effect: Boost

During acceleration/deceleration, the activated boost signal triggers a current increase on the drive unit. The amount of the increase is set on the drive unit. At zero speed and during continuous travel, the current is always 100 %.



Zero pulse generation

To support stepper motor axis synchronization, the FM 453 processes a cyclic input signal (which is dependent on the axis movement) as a zero marker (see Section 4.6). This signal can be either the “Current-sourcing pattern zero” signal from the step drive, or a “Zero pulse external” signal (e.g. initiator) generated once per stepper motor revolution. The signal is connected via the “NL” input. The active level of the signal can be parameterized.

The following cases must be distinguished:

Technical Implementation	Signal Shape	Parameter Definition
Signal encoder on the motor axis (e.g. initiator)	Active phase over several motor increments, one time per revolution	"Zero pulse external"
Cyclical signal generated by the step drive one time per motor revolution (e.g. zero trace of a motor-integrated incremental encoder)	Active phase over one motor increment, one time per revolution	"Current-sourcing pattern external" and MD53=0
Cyclical one-time signal in current-sourcing pattern from step drive	Active phase in current-sourcing pattern zero of the step drive, n-times per revolution (n = current-sourcing pattern number)	"Current-sourcing pattern external" and MD53= MD52/n

When the "Zero pulse external" signal is active, the rotation monitoring function can be implemented (see Section 9.7.3).

The following table shows you the available machine data for parameterizing the function.

MD	Designation	Value/Meaning	
37	Control signals		
37.24	Current-sourcing pattern zero active	0: Current-sourcing pattern zero not used 1: Current-sourcing pattern zero used	Input signal
37.25	Current-sourcing pattern zero inverted	0: Current-sourcing pattern zero high active 1: Current-sourcing pattern zero low active	
37.26	Zero pulse external active	0: Zero pulse external not used 1: Zero pulse external used	
37.27	Zero pulse external inverted	0: Zero pulse external high active 1: Zero pulse external low active	
53	Increment number per current-sourcing cycle	4...400[1)]	

1) Compare documentation from step drive manufacturer.

9.8 Digital Inputs/Outputs (Read request in the user DB, DBX43.4)

Overview

Four digital inputs and four digital outputs of the FM 453 can be used specifically to a given application.

The conventions and parameterization for this purpose are defined in the machine data MD34 to MD36.

The signals are processed in the FM cycle.

The signal status of the digital inputs and outputs can be recognized by readback (user DB, DBX43.4).

Function Parameters

Table 9-13 shows you the functions assigned to each digital I/O.

Table 9-13 Function Parameters for Digital I/Os

MD	Designation	Data Type, Bit Array/Meaning				
34	Digital inputs[1]	**I0**	**I1**	**I2**	**I3**	
		0	8	16	24 =	External start[2]
		1	9	17	25 =	Enable input
		2	10	18	26 =	External block change
		3	11	19	27 =	Set actual value on-the-fly
		4	12	20	28 =	Measurement (inprocess measurement, length measurement[2])
		5	13	21	29 =	Reference point switch for reference point approach[2]
		6	14	22	30 =	Reversing switch for reference point approach[2]
35	Digital outputs[1]	**Q0**	**Q1**	**Q2**	**Q3**	
		0	8	16	24 =	Position reached, stop
		1	9	17	25 =	Axis movement forwards
		2	10	18	26 =	Axis movement backwards
		3	11	19	27 =	Change M97
		4	12	20	28 =	Change M98
		5	13	21	29 =	Start enable
		7	15	23	31 =	Direct output

1) see Section 5.3.1, Dependencies
2) Signal length $\geq 2 \cdot$ FM cycle

Level adjustment

MD	Designation	Value/Meaning	Comments
36	Input adjustment	8 = I0 inverted 9 = I1 inverted 10 = I2 inverted 11 = I3 inverted	Front edge always activates the function

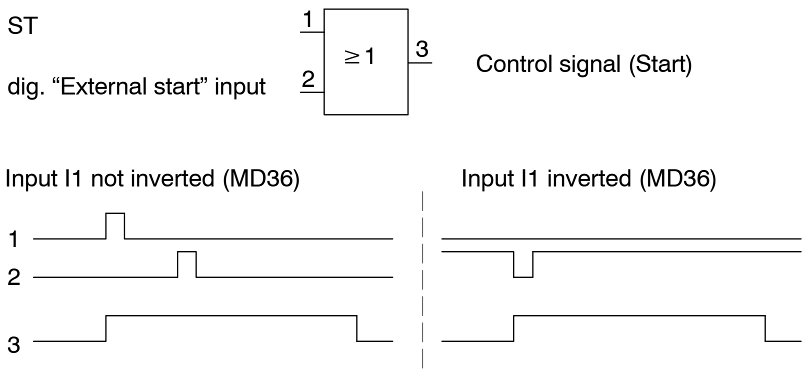
9.8.1 Function Description for Digital Inputs

External Start

The control signals of the axis include the start signal which triggers a positioning operation in “Reference point approach”, “MDI” and “Automatic” modes. A logical OR is established with the “External Start” digital input and the control signal (ST).

External start is connected to digital input I1.

Example



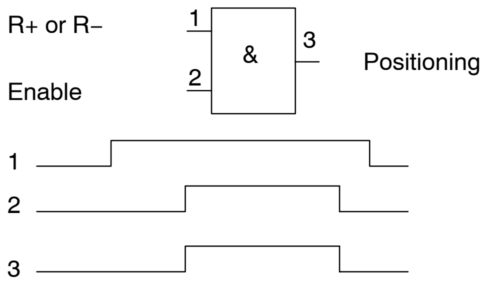
Minimum signal length at the digital input: $\geq 2 \cdot$ FM cycle

Enable Input

The enable input signal must be set, if defined in MD34, for a positioning operation/movement/output of the axis to take place. A reset stops the movement (external movement enable).

- In the “Jogging” and “Control” modes, the movement of the axis proceeds as long as the AND link continues between the control signal (R+/R–) and the enable input.

Example



- In the other modes, note the following:

  If the enable input is still not enabled after a start edge, the start edge is stored internally and “waiting for enable” is indicated by the checkback signals. When the input is set, movement begins and the stored Start edge is deleted (a Stop likewise deletes the stored Start edge).

External Block Change see Chapter 10

Set Actual Value On-the-fly see Chapter 10, 9.3.6

Measurement see Section 9.3.11

Reference Point Switch for Reference Point Approach see Section 9.2.3

Reversal Switch For Reference Point approach see Section 9.2.3

9.8.2 Function Description Digital Outputs (Write request in the user DB, DBX39.4)

Output of PEH, FR+, FR–, SFG

The following checkback signals: position reached, stop (PEH), axis movement forward (FR+), axis movement in reverse (FR–), and enable Start (SFG), are additionally output via digital outputs. The output assignment is parameterized by way of MD35.

Output of Change M97 or M98

The change M-function (AMF) checkback signal for the M functions M97 and M98 is output as a digital output. It allows these M functions (switching signals) to be applied without being delayed by the user cycle time.

Direct Output

Outputs Q0...Q3 (D_OUT1...D_OUT4), which are defined in MD35 as “direct output”, can be used directly by the user program (user DB, DBX39.4) and can also be controlled by the FM 453.

Since the same memory is used in the user DB for Write request (user DB, DBX39.4) and Read request (user DB, DBX43.4), the jobs cannot be used simultaneously in the cycle.

Note

The outputs are subject to deactivation on module errors of error classes with the response “Everything Off”.

9.9 Software Limit Switches

Overview

To limit the working range, entries in the machine data (MD21 and MD22) specify the start and stop limit switches. These limit switches are active at synchronization of the axis.

If the limit switches are not needed, values lying outside the possible working range should be entered in the machine data (MD21 and M22), or monitoring should be switched off via the user program.

Warning

The software limit switches do not replace the hardware limit switches for EMERGENCY STOP responses.

Effect of Software Limit Switches in Modes

Jogging mode

At the limit switch the traveling movement is stopped in the limit-switch position, and an error is signaled.

Control mode

If the actual value is beyond the end position, the traveling movement is stopped and an error is signaled. The limit-switch position is overshot by the amount of the necessary deceleration distance.

Reference-point approach mode

No effect.

“Incremental relative”, “MDI”, “Automatic” mode

Movement is stopped, or not even started, as soon as read-in of the set position reveals that the position lies outside the working range. An error is signaled.

The following special cases exist:

- Continuous travel (–) for set actual value on-the-fly (G88 see Chapter 10)
- Continuous travel (+) for set actual value on-the-fly (G89 see Chapter 10)

Effect of Software Limit Switches in Tracking Mode

If the actual value is beyond the end position, an error is signaled.

Response After Error

Leaving end position or traveling into working range after error

1. Acknowledge the error message!
2. Travel to the working range with the “Jogging”, “Control”, “Incremental Relative” or “MDI” mode.

Rotary Axis

The end position of MD_{start} may be greater than $MD_{stop.}$

When traveling into the working range (e.g. end position was previously switched off), the shortest path is always chosen.

If both default values are parameterized the software limit switches are inactive.

9.10 Process Interrupts

Overview

Process interrupts are interrupts that quickly signal states in the current process to the user program.

The appropriate setting in the machine data (MD5) specifies which signals are to be quickly communicated to the user program.

Process-Interrupt Generation

The process interrupt is generated by way of machine data item MD5:

MD	Designation	Significance
5	Process-interrupt generation (data type – bit field)	0 = Position reached 1 = Length measurement completed 3 = Change block on-the-fly 4 = Measurement on-the-fly

Hint to the User

You must program the interrupt processing routine in OB40.

The prerequisite is that process-interrupt signaling must have been activated as part of the environment definition (see Chapter 5).

Writing Traversing Programs

10

Chapter Overview

Overview

To execute the desired operations of the machine axis (sequence, position, etc.) in “Automatic” mode, the FM 453 needs certain information. This information is programmed with “Parameterize FM 453” (traversing program creation) in the form of a traversing program, based in principle on DIN 66025.

Traversing Programs

Each traversing program is stored under a program number.

A traversing program consists of not more than 100 traversing blocks.

The program number and traversing blocks are converted to an internal format (see Section 9.3.13), are stored in the appropriate data block, and are transferred to the module. Where they are administered.

The possible number of programs depends on the amount of memory available (max. 64 Kbytes) and on the length of the individual programs.

Program length in bytes: 108 + (20 x no. of traversing blocks)

Program Name

Any program can be assigned a name (optional).

The program name may have up to 18 characters, and is saved with the program.

Program Number

Programs may be numbered from 1 to 199.

Traversing Block

A traversing block contains all the data required to perform a machining step.

Program Structure

A program consists of several blocks. Each block number occurs only once, and numbers are arranged in ascending order.

A sample program structure follows:

/	N	G1	G2	G3	X/t	F	M1	M2	M3	D	L	P	
	5	90			500 000	100 000	10						Start of program = lowest block number
	6	91			–	–							
	7	–											
	:												
	:												
	45												
	46						2						End of program = M2 or M30

10.1 Traversing Blocks

Block Structure

The following Figure gives you an overview of the structure of traversing blocks.

/	N	G1	G2	G3	X/t	F	M1	M2	M3	D	L	P

/	–	Identifier for skipped block	
N	–	Block number	
G1	–	G function of first function group	see Table 10-1
G2	–	G function of second function group	see Table 10-1
G3	–	G function of third function group	see Table 10-1
X/t	–	Position/dwell time	
F	–	Speed	
M1	–	M function of first function group	see Table 10-2
M2	–	M function of second function group	see Table 10-2
M3	–	M function of third function group	see Table 10-2
D	–	Tool offset number	
L	–	Call a program as a subprogram	
P	–	Number of subprogram runs	

Skip Block /

Program blocks which are not to be executed every time the program runs can be identified as skippable blocks by an oblique "/ ". When the program is being processed, the "Skip block" control signal can be used to decide whether skippable blocks are to be skipped. The last block cannot be skippable.

Block Number N

The program is executed in ascending order of block numbers (1...255) or in descending order if executed in reverse.

G Function Group 1...3

In each traversing block only one G function may be entered from each G function group.

The following figure shows an example.

/	N	G1	G2	G3	X/t	F	M1	M2	M3	D
	10	90	34	43	100 000	400 00				10

G Functions

Table 10-1 lists the possible G functions and the individual G function groups.

Table 10-1 G Functions

G No.	G Function	G Function Group
04[1)]	Dwell time	1
87	Turn off measuring system shift for Set Actual Value On-the-Fly	1
88[1)]	Continuous travel for (–) for Set Actual Value On-the-Fly	1
89[1)]	Continuous travel for (+) for Set Actual Value On-the-Fly	1
90	Absolute dimensions	1
91	Incremental dimensions	1
30 31 32 . . . 39	100% override on acceleration/deceleration 10% override on acceleration/deceleration 20% override on acceleration/deceleration . . . 90% override on acceleration/deceleration	2
43	Tool offset (+)	3
44	Tool offset (–)	3
50[1)]	External block change	3
60	Block change – exact positioning	3
64	Set actual value on-the-fly, continuous-path mode	3

1) These G functions take effect only on a block-by-block basis. The other G functions remain active until canceled explicitly.

G30, G90 and G64 are the **initial settings** after the start of the program.

Dwell G04

A traversing block with dwell can only contain M functions and the time parameter apart from this G function.

The following applies for dwell time:

Name	Lower Input Limit	Upper Input Limit	Unit
Dwell time	3	100,000	ms

Odd input values are rounded upward in FM cycle steps (3 ms). Dwell times take effect only on a block-by-block basis.

Block Change G60, G64 (Approach Conditions)

With G60, the exact programmed position is approached and the feed movement is stopped (exact stop block change).

G64 causes the next block to be processed immediately as soon as the point of deceleration is reached (change block on-the-fly).

G60 and G64 are mutually exclusive and self-maintaining.

M commands have no effect on G64 operation.
(For a detailed description, see Section 10.3).

External Block Change (G50) with Delete Residual Path

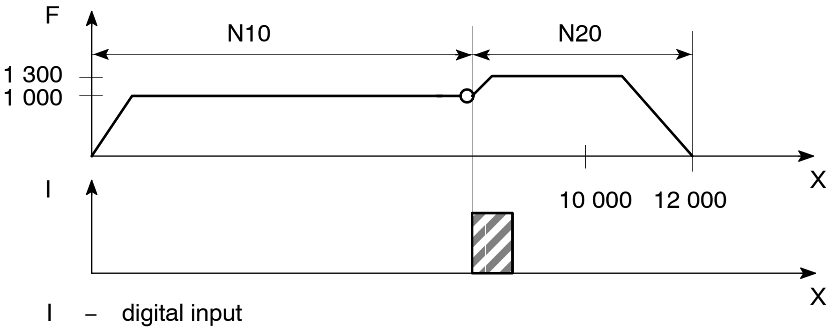
The “external block change” function causes a block change on-the-fly triggered by a digital input. The fast input must be parameterized with the “External block change” function by way of machine data item MD34.

The function takes effect only on a block-by-block basis (no effect on G60 and G64).

Example of External Block Change

The following figures show the program structure and program flow of an example of “External block change.”

/	N	G1	G2	G3	X/t	F	M1	M2	M3	D
	10			50	10 000	1 000				
	20				12 000	1 300				



I – digital input

Notes to the Example of External Block Change

The axis travels until a signal change from 0 to 1 takes place at the digital input. This triggers two reactions:

- A block change on-the-fly, and thus immediate processing of block N20.
- Storage of the actual position at the time of this signal change to “Actual value block change.” This position is also the starting position for any subsequent chain-measure programming.

Depending on the situation, N20 is processed as follows:

- If the block position in N20 is less than the actual position at the time when the digital input is received (reversal of direction), the equipment is stopped so that the position can then be approached in the opposite direction.
- If no position is programmed in block N20, movement is braked, the functions programmed in N20 are executed, and processing then moves on to the next block (except if the block contains M0, M2 or M30).
- If the programmed path in block N20 is less than the deceleration distance, the programmed position is overshot and then positioned by a reversal of direction.

If no signal change occurs at the digital input, the target position of N10 is approached, with the following additional response:

When the target position is reached, the error message “Digital input not actuated” is output (see Table 11-5, Class 2 No. 15).

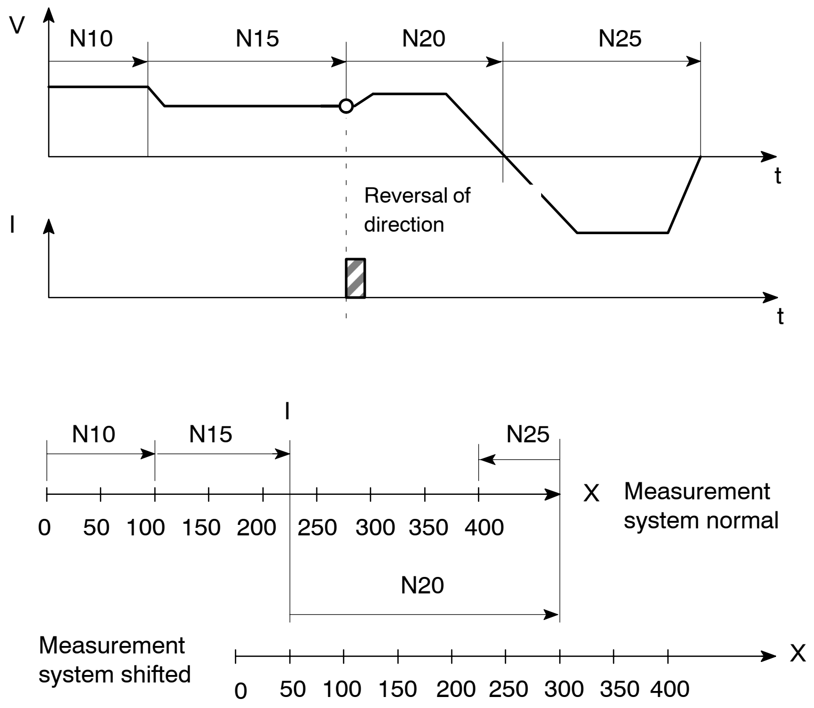
Set Actual Value On-the-fly G87, G88, G89

The “Set actual value on-the-fly” function is programmed and triggered by a digital input; the block change occurs on the fly and the actual value is set to a new dimension (programmed coordinate) at the same time. The digital input must be parameterized with the “Set actual value on-the-fly” function by way of machine data item MD34.

Example of Set Actual Value On-the-fly

The following figures show the program structure, program flow and actual-value curve for an example of “Set actual value on-the-fly.”

/	N	G1	G2	G3	X/t	F	M1	M2	M3	D
	10	90			100	400 000				
	15	89 (88)			50	200 000				
	20	90			300	400 000				
	25	87			400	400 000				



I – digital input

Notes to the Example of Set Actual Value On-the-fly

This changes blocks on-the-fly from N10 to N15, with G89 causing movement in a positive direction and G88 causing movement in a negative direction at the speed programmed in N15.

The axis now travels in the specified direction until a positive edge change occurs at the digital input. This triggers the following responses:

- Block change on-the-fly and immediate processing of block N20
- Set actual value on-the-fly to the block position from N15 (50 in the example), and resulting shift of the coordinate system
- Save current actual value.

The programmed position in block N20 refers to the shifted coordinate system.

At the block change from N20 to N25, G87 cancels the shift of the coordinate system and causes reference-measure programming to the block position of N25.

The saved actual value can be read out with “Actual value block change.”

The shift of the coordinate system is maintained until it is canceled by G87 or by a mode change. It is possible to use the existing shift of the coordinate system in different programs. The coordinate system can be shifted again without previously canceling an existing coordinate system shift.

G88, G89 can be programmed multiple times. The shift in each case refers to the original state. The software limit switches are always shifted concurrently.

If the signal change of the digital input does not occur, the axis runs until it reaches the limit switch.

Note

The G functions G87, G88 and G89 take effect only on a block-by-block basis and must be reselected if necessary.

Dimensions G90, G91

The traversing movement at a specific point can be described by

- Reference-measure input (absolute measure input) G90 or
- Incremental input (relative measure input) G91

You can switch back and forth at will between reference-measure and incremental input.

The status at startup is reference-measure programming G90.

G90 and G91 are modal.

Absolute Dimensioning G90

Absolute dimensioning is the method used to specify dimensions that generally refer to the coordinate system.

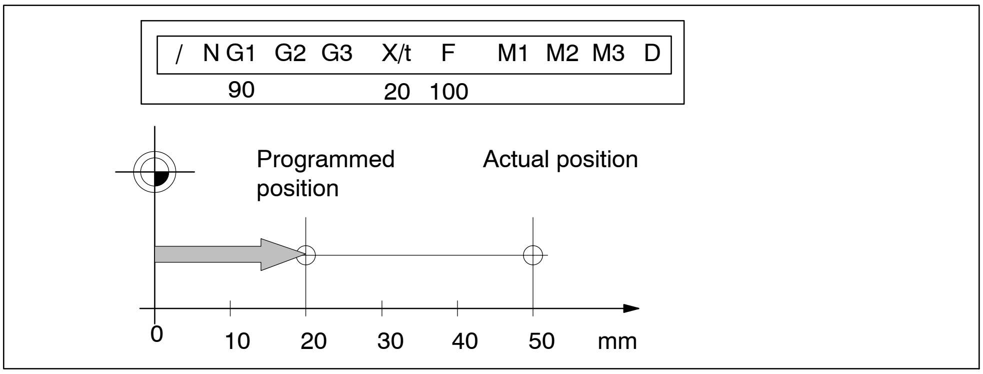


Fig. 10-1 Reference-Measure Input G90

Note

To ensure precise reproduction of the program, the first block should contain reference-measure programming.

Incremental Dimensioning G91

Incremental dimensioning is the method used to specify incremental dimensions that refer to the last actual position.

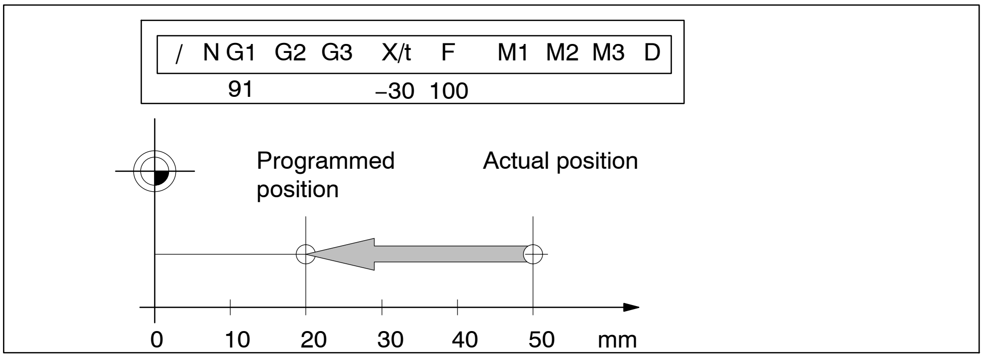


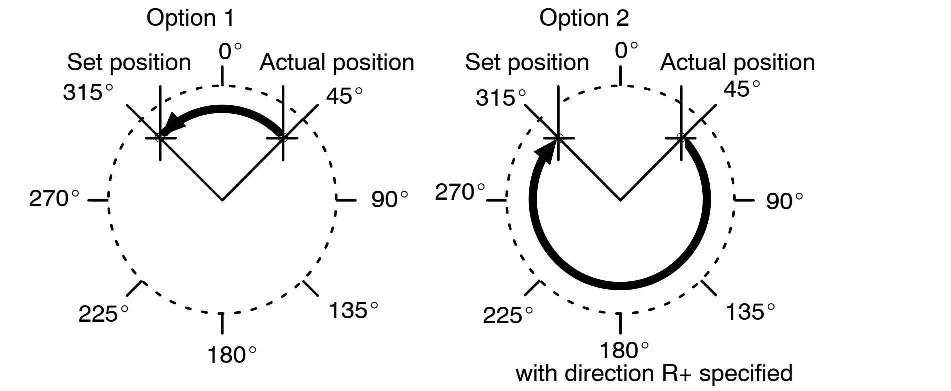
Fig. 10-2 Incremental Input G91

Axis as Rotary Axis

If the axis is operated as a rotary axis, the measuring system must be adjusted in such a way that the measurement scale refers to the full circle (e.g. 0_ and 360_).

- Reference-measure input G90

  In a full circle with 360°, reference-measure programming (G90) has the peculiarity that there are always two options for reaching the set position.



/	N	G1	G2	G3	X/t	F	M1	M2	M3	D
	10	90			315	100				

Fig. 10-3 Rotary Axis

Option 1:

With G90, the axis autonomously always takes the shortest path to reach the set position of 45°, going via 0° to 315°.

Option 2:

The control signals (R+) or (R–) force the respective direction of the axis – in this example 45° via 180° to 315°. (R+) or (R–) must already be pending when positioning is activated (START).

Note

The direction (R+) or (R–) must be specified sufficiently in advance. A traversing direction **cannot** be forced on a traversing block that is already active, or on the traversing blocks (up to 4) that have already been calculated in advance in G64 operation.

Operation with option 1 or option 2 is at the user's discretion.

- Incremental input G91

  With incremental programming G91, the direction of rotation of the rotary axis is defined by the sign of the position setpoint. Multiple rotations can be programmed by setting a value > 360° as the position setpoint.

Acceleration Override G30...G39

The acceleration override is used to control acceleration and deceleration during positioning movements. The acceleration and deceleration values are set by machine data. G30 through G39 in the traversing block can be used to achieve a percentage reduction in both values. These functions are modal.

G	Function
30	100% override for acceleration/deceleration
31	10% override for acceleration/deceleration
to	
39	90% override for acceleration/deceleration

Changing the acceleration override in the program prevents block change on-the-fly. Consequently G60 response is forced in the preceding block.

The acceleration override is turned off by:

- Mode changes
- Resetting the axis with a Restart (single command)
- Changing or ending the program.

Tool Compensation G43, G44

Tool compensation allows you to continue using an existing machining program, even when the tool dimensions have changed.

Tool offset is selected with G43 or G44, as applicable, and the tool offset number D1...D20. Tool offset is turned off with G43 or G44, as applicable, and the tool offset number D0.

A total of 20 tool offset storage areas and tool wear storage areas are available. The values are loaded to the module with the “Tool offset data” data block and are saved permanently. When selected, changed or turned off, the tool offset is not taken into account until the next positioning action.

A selected tool offset is maintained in effect until it is either turned off or replaced with a new one. Likewise a mode or program change, or the end of a program, will turn tool offset off.

Variants in Tool Offset

Tool offset is made up of two correction-value components:

- Tool length offset

  The tool length offset is the actual tool length from tool zero to the tool tip.

- Tool length wear value

  The tool length wear value allows the change in tool length due to wear to be compensated in two ways:

  Absolutely: by specifying a fixed wear value

  Additively: by adding an “offset value” to the current tool length wear value contents.

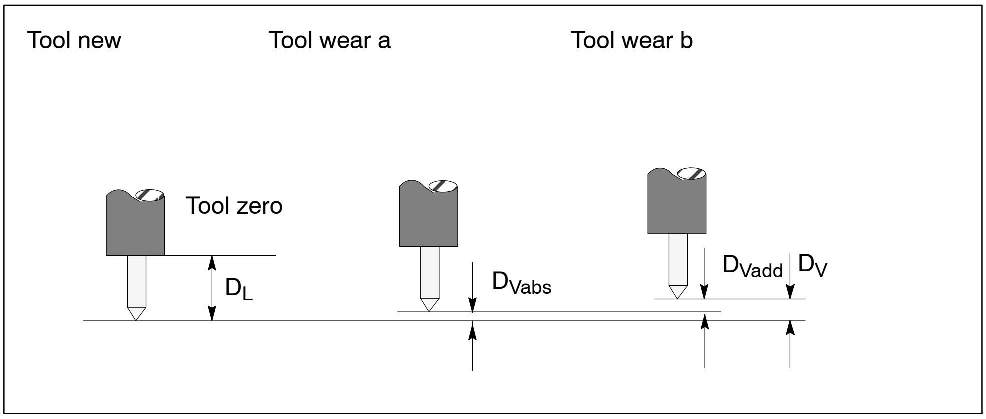


Fig. 10-4 Tool Offset

Notes to the figure:

The tool offset thus consists of the tool length offset and the tool length wear value:

$D = D_L - D_V$

$D_V = D_{Vabs} + D_{Vadd}$

D	–	Tool offset
D_L	–	Tool length offset (positive or negative)
DV	–	Tool length wear value (positive or negative)
D_{Vabs}	–	Wear, absolute (positive or negative)
D_{Vadd}	–	Wear, additive (positive or negative)

If the additive wear is modified on-line, the FM computes the new absolute wear and resets the additive wear to zero.

Direction of Tool Offset

The functions G44 (–) and G43 (+) correct the position value in such a way that the tool tip reaches the programmed set position.

- **Negative tool offset G44**

  As a rule, the tool points to the workpiece in a negative direction. With the infeed adjustment, the positioning value (traversing path) becomes smaller.

  Referred to the measuring system, the following position is thus approached:

  $X_{ms} = X_{set} + (D)$

  X_{ms} – Position of measuring system
  X_{set} – Programmed set position
  D – Tool offset

- **Positive tool offset G43**

  The positioning value (traversing path) becomes greater with the infeed adjustment. The position value is corrected by:

  $X_{ms} = X_{set} - (D)$

To program a tool offset in the traversing block, at least the tool length offset must be input. If no correction is to be applied even when the function has been selected, the tool length offset and tool length wear value must be preset to 0.

A tool length wear value can be deleted by an absolute input of 0.

Position X

Positions may be input with a negative or positive sign. The plus sign on positive values may be omitted.

Name	Lower Input Limit	Upper Input Limit	Unit
Position	– 1,000,000,000	+ 1,000,000,000	MSR from MD7

Speed F

The input speed is calculated against the override. If the speed value is numerically greater than the maximum allowed speed, it is limited to the magnitude of the machine data item. Speeds are self-maintaining and need to be re-input only when changed.

Name	Lower Input Limit	Upper Input Limit	Unit
Speed	10	500 000 000	MSR from MD7/min

M Functions

Up to three M functions can be programmed in one traversing block, with any assignment of M1, M2 and M3. The output sequence of the M functions is always M1→M2→M3 (for information about output see Section 9.1).

The following figure shows an example.

/	N	G1	G2	G3	X/t	F	M1	M2	M3	D
	10	90	34	43	100 000	400 00	10	11	12	1

Table 10-2 M Functions

M No.	M Function	M Function Group
0	Stop at end of block	1, 2, 3
2, 30	End of program	
1, 3...17	User functions	
18	Endless loop (skip back to start of program)	
19...29, 31...96	User functions	
97, 98	Change signal programmable as digital output	
99	User functions	

M0, M2, M18 and M30 are always output at the end of the traversing movement.

M0, M2, M18 and M30 are mutually exclusive within a single block.

Stop at end of Block M0

If M no. 0 is programmed in a traversing block, the program stops at the end of the traversing block and M0 is output. Only a new START edge causes the traversing program to be continued.

End of Program M2, M30

If M2 or M30 is programmed in a block, then after positioning is complete the M function is output with a subsequent programmed stop and a jump back to the start of the program. The Start edge can restart the program. M2 or M30 is always the last output in the block.

If the program is called up as a subprogram, the action skips to the main program. In this case M2 or M30 is not output.

Infinite Loop M18

M18 is always output as the last M function in the block.

Two cases are distinguished:

- M function M18 is output like any other M function. Only after the block has been processed all the way to the end (including M18) does the axis skip back to the start of the program.
- If M function M18 is programmed alone in the last block of a traversing program, the M function is not output, and the axis immediately skips back to the start of the program.

Change Signal Programmable as Digital Output M97, M98

If M97 or M98 is programmed in a block, the M function output proceeds via the digital outputs as defined in machine data item MD35, in the same way as the checkback signals.

Tool Offset Number D

Twenty tool offset numbers (D1...D20) are available. D0 in conjunction with G43 or G44 causes the tool offset to be switched off. The offset values must previously have been loaded to the module. Nonstandard offset values have a value 0.

Subprogram Call P, L

A block with a subprogram call (P is the “number of runs”, L is the “program number”) cannot contain any further information.

A maximum of 19 subroutines can be called up in one program. Nesting is not possible.

Name	Lower Input Limit	Upper Input Limit
P = Number of subprogram runs	1	250

10.2 Program Execution and Direction of Machining

Forward Processing

As a rule, programs are processed by ascending block number.

Reverse Processing

If programs are processed in reverse, the effects of commands must be taken into account in the programming:

- Commands are self-maintaining (G90, G91, G60, G64, G30...G39)
- Active tool offset (G43, G44, D0...D20)
- Change of coordinate systems via G87, G88, G89.

For these reasons, a distinction can be made between forward processing and reverse processing, in terms of both geometry and block transition response.

10.3 Block Transitions

Overview

This chapter describes the influence of certain commands on block transitions.

Exact Positioning - G60

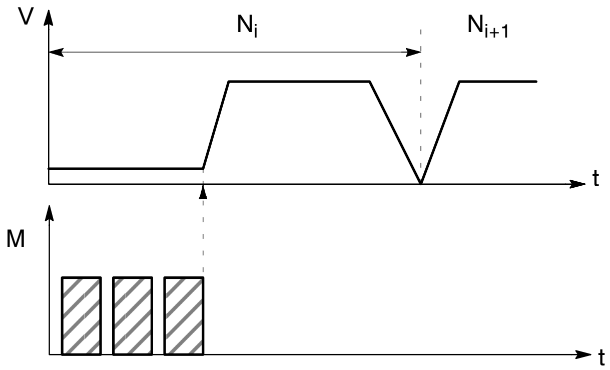
G60 mode is overlaid with G50 and G88 to G89 (force block change on-the-fly).

The program advances to the next block when the target range is reached.

The influence of M functions is as indicated in machine data item MD32.

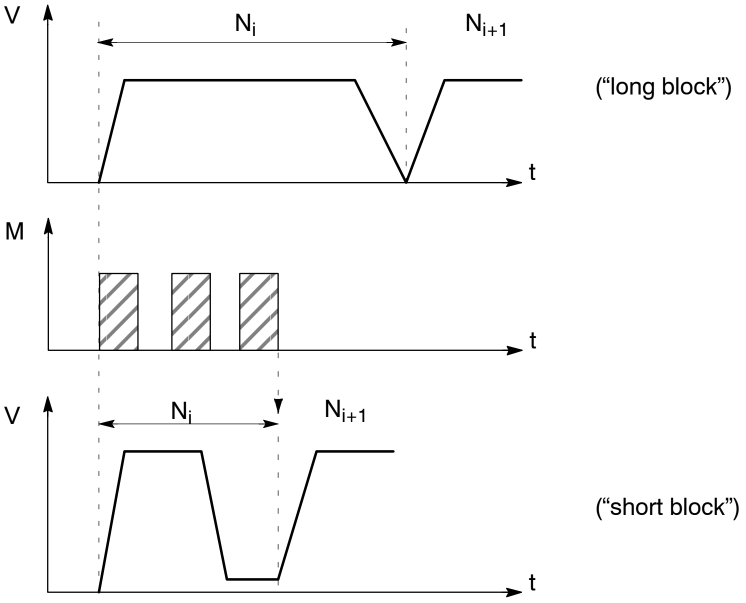
Output of M Function Before Positioning

Case 1



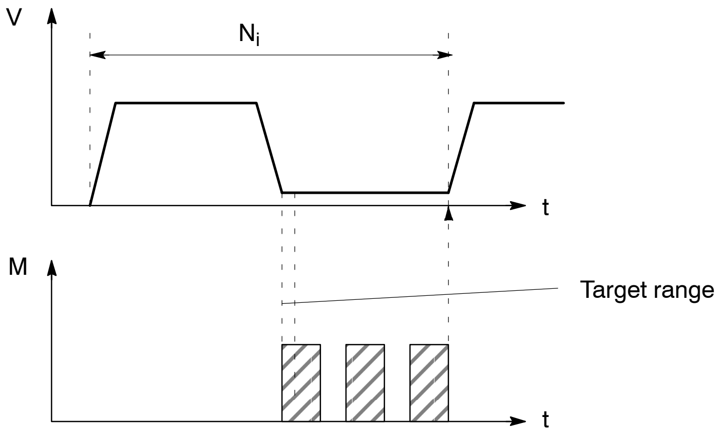
Output of M Function During Positioning

Case 2



Output of M Function After Positioning

Case 3



Change Block On-the-fly - G64 (Standard case)

Changing from one traversing block to the next proceeds without stopping the axis.

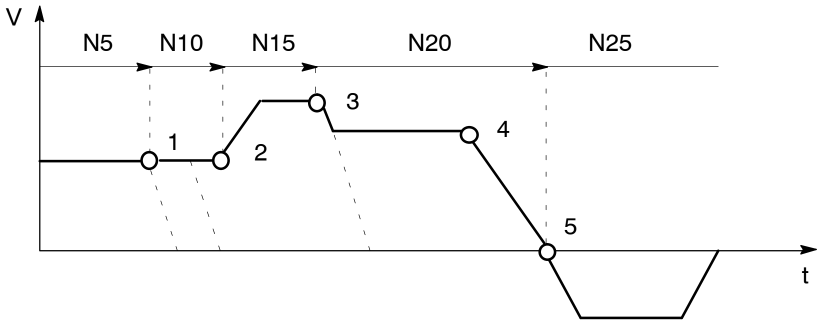
The acceleration and braking function is calculated for multiple blocks when the G64 function is programmed. The number of blocks processed in advance is three.

When the block changes, the feed rate is changed in such a way that a higher speed from a preceding block is never carried over into the next block, and a higher speed from a following block never goes into effect while a given block is still traversing its own path. This means that acceleration does not begin until the starting point of the block, and deceleration to a lower speed for a following block is initiated as with G60. When the speed of the following block is reached, the residual distance in the current block is processed at the feed rate of the following block.

Sample Programming (Standard case)

The following figure shows a sample program with the programming flow.

/	N	G1	G2	G3	X/t	F	M1	M2	M3	D
	5	90		64	10 000	100 00				
	10				20 000					
	15				30 000	200 00				
	20				40 000	150 00				
	25			64	30 000	100 00				



1 – Block N10 is started at the point of deceleration of N5.

2 – N15 is started at the point of deceleration of N10. Acceleration to the higher traversing speed begins when the set position of N10 is reached.

3 – N20 is started at a lower traversing speed at the braking point of N15.

4 – In a change of traversing direction, the axis brakes until it comes to a standstill and waits until the actual value of the encoder has reached the target range.

5 - When the target range is reached, the axis accelerates in the opposite direction up to the traversing speed of the new block.

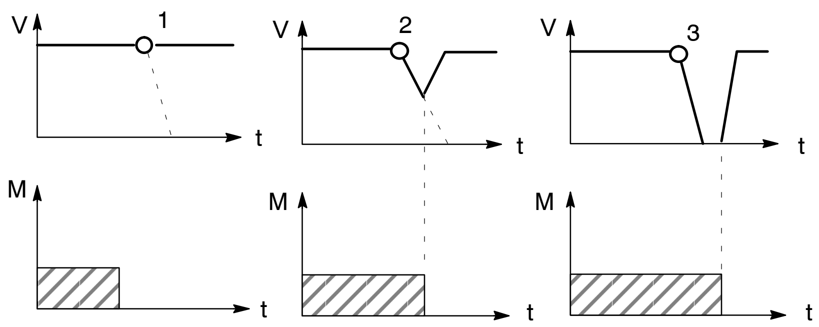
To be able to approach a position correctly, the axis must calculate the point of deceleration. The relevant parameters for this calculation are the residual traversing distance, the deceleration value and the current traversing speed.

The point of deceleration is also the earliest possible time for a block change.

Change Block On-the-fly - G64 (Deceleration)

There are a number of conditions that may delay or prevent a block change on-the-fly. Here a distinction is necessary between the case in which this type of block change is suppressed intentionally, and the case in which the selected function does not permit a block change on-the-fly.

- Block change on-the-fly is suppressed:
  - By removing the Enable read-in control signal - this stops program processing at the end of the current block. To continue the program, the enable must be re-input.
  - By output of the M function before or after positioning.
  - By M function M0 (stop at end of block). To continue the program, the START control signal must be reset.
  - By a block with a dwell time.
  - By processing a program in the Automatic/Single Block mode. Each block must be activated individually.
  - By a change in the acceleration override.
- Functions that themselves prevent block change on-the-fly:
  - M functions (during positioning).



1 – Since the M output is completed at the point of deceleration, a block change takes place on-the-fly.

2 – The M output is not yet complete at the point of deceleration. The axis begins to brake. At the end of the M output, the axis returns to speed (transition on-the-fly from deceleration ramp to acceleration ramp).

3 – Axis comes to a complete standstill and waits for the end ofM output.

Influence of M Function on Block Change On-the-fly

Machine data can specify the output time for M functions:

- M function is output before or after positioning with a block change

  M function output and positioning proceed in alternation.

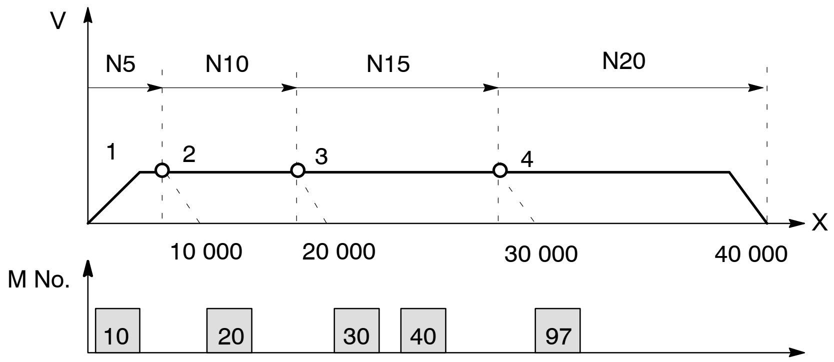
  - M function output before positioning causes exact-positioning response in the preceding block.
  - M function output after positioning causes exact-positioning response within the block.

- M function is output during positioning

  M function output and positioning proceed simultaneously.

  The following figure shows a sample program with M function output “during positioning”.

/	N	G1	G2	G3	X/t	F	M1	M2	M3	D
	5	90			10 000	100 00	10			
	10				20 000		20			
	15				30 000		30	40		
	20			60	40 000				97	



1 - Output of M10 is **not** position-dependent, since no relevant position for a position-dependent M function is present.

2 – At the block change from N5 to N10, output is prepared. Output of the M function does not proceed until the actual position has reached the programmed position of N5.

3 – If two M functions are programmed in a traversing block, the first M function is output depending on position, followed by the second M function.

4 – The change signal for M97 or M98 is output with the G64 block transition (digital output) if the actual position has reached the programmed position of the block. The actual position runs behind the set position (difference = overtravel).

Troubleshooting 11

Chapter Overview

Overview

The FM 453 provides diagnostics for the following:

- I/Os
- Module processes

This “Troubleshooting” chapter describes the different types of errors, their cause, effect and elimination.

Error Localization

The FM 453 distinguishes between

- Errors which trigger a diagnostic interrupt in the CPU, and
- Errors which the module reports by way of checkback messages.

In the event of diagnostic interrupt, STATUS LEDs light up in addition.

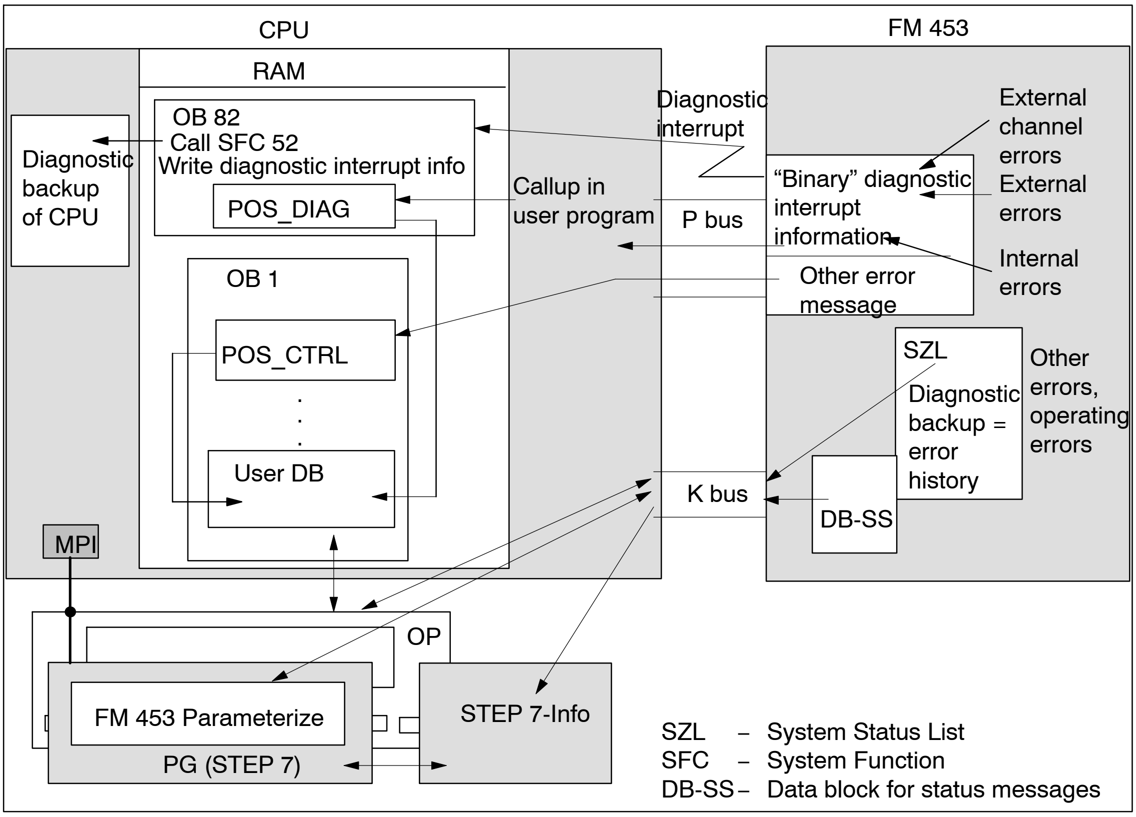


Fig. 11-1 Overview of Diagnostics/Errors

Programming Error Evaluation

The following manuals describe how to include diagnostics-capable modules in your user program, and how to evaluate the diagnostic messages:

- Programming manual *System Software for S7-300/400; Program Design* (OB Types, Diagnostic Interrupt OB 82)
- Reference manual *System Software for S7-300/400; System and Standard Functions*

A basic description of the diagnostic system of the S7-400 can be found in the *Standard Software for S7 and M7, STEP 7* user manual.

11.1 Error Classes and Module Responses

Overview

The FM 453 contains monitoring circuits which are active during startup or during continuous operation. Errors occurring during those times are reported to the system and to the user program.

The table below lists the error classes and their meaning.

Table 11-1 Error Classes, Overview

Message	Error Class	Response	Significance
Diagnostic interrupt	Internal errors	Everything OFF	...are hardware faults in the module which are discovered by diagnostics routines (e.g. memory errors). (See Section 6.3.3 for diagnostic interrupt data and error list, Table 11-4)
	External errors		... are errors which can occur due to faulty module connection (e.g. front panel connector missing). (See Section 6.3.3 for diagnostic interrupt data and error list, Table 11-4)
	External channel errors		...are measurement system errors or errors which can occur by connecting the digital outputs or during operation (operating errors) of the FM 453 (e.g. cable break, incremental value encoder). (See Section 6.3.3 for diagnostic interrupt data and error list, Table 11-4 and 11-5)
Checkback signals	Operator and travel errors	Feed STOP	... are errors (general operator control and guidance errors) which can occur during “operation” of the FM 453 (e.g. direction signals R+ and R– set at the same time, see Error List, Tables 11-6 and 11-7).
	Data errors	Warning!	... are errors (data, machine data and traversing program errors) which are detected on interpretation of invalid data (see Error List, Table 11-8).

Error Response

Each error message triggers an appropriate response.

Table 11-2 Overview of Internal Responses

Error Response	Significance
Everything OFF	• Movement stopped by actuating signal ramp (MD45) • Digital outputs disabled • Servo enable is de-activated • SYN is cleared after the error has been acknowledged with Restart • No new travel jobs possible
Feed STOP	• Stop movement by controlled deceleration • Travel job is canceled and terminated. • Measured data acquisition and position control are continued. • No new travel jobs possible
Warning	• Message only • Movement and control of axes not affected

11.2 Error Messages

Overview

The following approaches to error localization are available for the FM 453:

- Error display by LEDs
- Error messages to the system and to the user program

11.2.1 Fault Indication by LEDs

Status and error displays

The FM 453 features the following status and error displays:

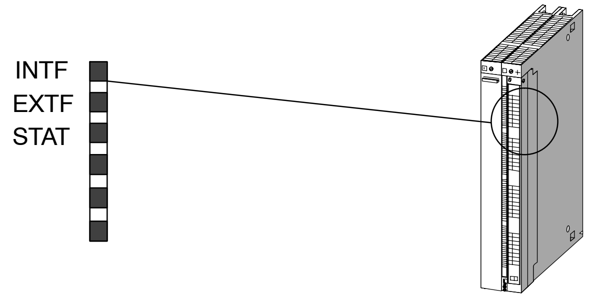


Fig. 11-2 Status and Error Displays of the FM 453

Significance of the status and error displays

The status and error displays are explained in the order in which they are arranged on the FM 453.

Table 11-3 Status and Error Displays

Display	Significance	Explanations
INTF (red) LED-ON	Group errors for internal errors	This LED indicates an error condition in the FM 453. Diagnostic interrupt (internal error). To eliminate the error, see Error List Table 11-4.
EXTF (red) LED-ON	Group errors for external errors	This LED indicates an external (channel) error. Diagnostic interrupt (external error or external channel error). To eliminate the error, see Error List, Table 11-4.
STAT (yellow) LED-ON LED-blinking	Diagnosis	This LED indicates various statuses (flashing). Diagnostic interrupt (external channel error). To eliminate the error, see Error List, Table 11-4. If this LED blinks when the “INFT” LED is simultaneously activated, this indicates a system error. If this occurs, then please consult the appropriate sales department. The exact circumstances which resulted in the error are of major importance in this case.

11.2.2 Diagnostic Interrupts

Overview

Internal errors, external errors and external channel errors are indicated to an interrupt-capable system by means of diagnostic interrupts (see diagnostic interrupt data in Tables 11-4, 11-5 and Section 6.3.3). This presupposes that the diagnostic interrupt message was activated at the time of configuration (see Chapter 5.2). If the system is not interrupt-capable, the diagnostic interrupt information must be read out cyclically using the POS_DIAG block.

Error Class	Coding	Message
Internal errors	Byte.bit no. 0.1 Group error byte 2, 3	“INF” LED
External errors	Byte.bit no. 0.2	“EXTF” and “STAT” LED
External channel errors	Byte.bit no. 0.2, 0.3 Group error byte 8	“EXTF” and “STAT” LED

A diagnostic interrupt is reported by the FM 453 as “incoming” or “outgoing”.

<table>
<tr><th colspan="6">Diagnostic Interrupt</th></tr>
<tr><td colspan="4">Message to the CPU (precondition: interrupt message activated (see Section 5.2))</td><td rowspan="3">Message in the “troubleshooting” display of “Parameterize FM 453”
Menu: Test > Troubleshooting</td><td rowspan="3">Entry in diagnostic buffer</td></tr>
<tr><td rowspan="2">No OB 82 exists → CPU switches to STOP</td><td colspan="2">OB 82</td><td>OB 1</td></tr>
<tr><td>Enters the diagnostic information in the diagnostic buffer of the CPU (4 bytes) and calls SFC 52</td><td>Enters the diagnostic information in the user DB starting at address 70 and calls POS_DIAG</td><td>Call of POS_DIAG</td></tr>
</table>

Interrupt Acknowledgement

If processing is to continue after a diagnostic interrupt, then Restart (user DB, DBX37.5) after the error has been remedied in the appropriate channel.

Internal errors cannot be acknowledged. External errors are self-acknowledging.

11.2.3 Errors Indicated by Way of Checkback Signals

Overview

Operator/travel errors [BF/FS] and data errors/machine data errors/traversing program errors [DF], are communicated to the user by way of checkback signals (call of the POS_CTRL block) and the operating error by way of a diagnostic interrupt (see Section 6.3.3). The error-specification is stored in the form of an error number (see Error List in Tables 11-6 to 11-8) in the corresponding data block (DS162/197/232 and DS163/198/233)

Error acknowledgement

Set/clear control signal [BFQ/FSQ]
or
on message [DF] → write a new write job.

Note

Invalid data are not accepted. The original data are retained.

Error Number Read-out

The errors are identified by the detail event class (DEKL) and by the detail event number (DENR).

Error Technology Class	DEKL	DENR	Message
Operating error	1	1...n	Diagnostic interrupt
Operator error	2	1...n	Checkback signals
Travel error	3	1...n	Checkback signals
Data error	4	1...n	Checkback signals or Data block
Machine data error	5	1...n	
Traversing program error	8	1...n	

11.2.4 Message in Data Block

Overview

Please note the following for direct access to DBs (e.g. using an OP).

If data errors/machine data errors/traversing program errors are detected when the parameters are written to the data block (e.g. in the parameterization tool), an error message is stored in the data block. The error-specification is stored in the form of an error number in the corresponding data block (see Error List in Table 11-8). The error message occurs each time the data block is written to until the cause has been eliminated.

We recommend scanning the error message after every write operation.

11.2.5 Viewing the Diagnostic Buffer (PG/PC)

Overview

The last five error messages are stored in the diagnostic buffer.

Proceed as follows:

1. Open your project in the **S7 SIMATIC Manager**.
2. Select the menu **View** > **Online.**
3. In the dialog box, select the FM 453 and the associated program.
4. You can view the diagnostic buffer in the menu **Target system** > **Module status.**

11.3 Error Lists

Note

In the following tables, please note:

The module response described under “Effect” refers to the error-specific module response. The error response described in Table 11-2 occurs in addition.

11.3.1 Diagnostic Interrupts

Overview

The diagnostic interrupts are listed according to error class in Tables 11-4, 11-5.

Table 11-4 Diagnostic Interrupt

Byte. Bit	Error Message, Error Analysis and Elimination		Message/ Display
0.1	**Internal errors**	**Error response: "Everything OFF", as in Table 11-2**	
2.1 (8031)	**Communication disturbance**		INTF (lit) EXTF STAT
	Cause	MPI/K-bus communication fault caused by unknown event	
	Effect		
	Elimination	• Check connection. • Check programming device/CPU. • Switch module on/off. • Replace module.	
2.3 (8033)	**Internal time monitoring circuit (Watchdog)**		
	Cause	• Pronounced noise conditions on the FM 453 • Error in the FM 453.	
	Effect	• Deactivation of entire FM 453. • LED indicators: INTF: ON STAT: Flashing cycle	
	Elimination	• Rectify noise conditions. • If this manual is observed, the errors should not occur. However, should this still be the case, please consult the responsible sales department. When doing so, it is vitally important to also report the exact circumstances leading to the error. • Replace the FM 453.	
2.4 (8034)	**Internal module power supply failure**		INTF EXTF STAT
	Cause	• Drastic voltage dip. • FM 453 power supply faulty.	
	Effect	Deactivation of entire FM 453.	
	Elimination	• Check FM 453 power connection. • If FM 453 power supply defective, replace FM 453.	

Note: (xxxx) value = Hexadecimal notation in diagnostic buffer.

Table 11-4 Diagnostic Interrupt, continued

Byte. Bit	Error Message, Error Analysis and Elimination		Message/ Display
0.1	**Internal errors**	**Error response: “Everything OFF”, as in Table 11-2**	
3.2 (8042)	**FEPROM error**		INTF ■ EXTF □ STAT □
	Cause	Memory for firmware code faulty.	
	Effect		
	Elimination	Replace the FM 453.	
3.3 (8043)	**RAM error**		
	Cause	Faulty flash-EPROM data memory.	
	Effect		
	Elimination	Replace the FM 453.	
3.6 (8046)	**Process interrupt lost**		
	Cause	• A process interrupt event was detected by the FM 453 and cannot be reported, because the same event has not yet been acknowledged by the user program/CPU. • Faults on backplane bus.	
	Effect		
	Elimination	• Incorporate OB40 into user program. • Check bus connection of the module. • Deactivate using MD5 process interrupt. • Switch module on/off.	
0.2	**External errors**	**Error response: “Everything OFF”, as in Table 11-2**	
0.5 (8005)	**Front connector missing**		INTF □ EXTF ■ STAT □
	Cause	Front connector X1 is not plugged into the FM 453.	
	Effect		
	Elimination	Plug in front connector X1.	
0.2, 0.3	**External channel errors**	**Error response: “Everything OFF”, as in Table 11-2**	
8.0 (8090) or 10.0 (80B0) or 12.0 (80D0)	**Cable break, incremental encoder**		INTF □ EXTF ■ STAT ■
	Cause	• Measurement system cable not plugged in or sheared off. • Encoder without internode signals. • Incorrect pin connection. • Cable too long.	
	Effect		
	Elimination	• Check encoder and measurement system cable. • Observe limit values. • Using the MD20, monitoring can be temporarily skipped, at the responsibility of the owner/operator.	

Note: (xxxx) value = Hexadecimal notation in diagnostic buffer.

Table 11-4   Diagnostic Interrupt, continued

Byte. Bit	Error Message, Error Analysis and Elimination		Message/ Display
0.2, 0.3	**External channel errors Error response: "Everything OFF", as in Table 11-2**		
8.1 (8091) or 10.1 (80B1) or 12.1 (80D1)	**Absolute encoder error**		INTF EXTF STAT
	Cause	Telegram traffic between FM 453 and the absolute encoder (SSI) is faulty or is disrupted: • Measurement system cable not plugged in or sheared off. • Unauthorized type of encoder (only allowable per MD10). • Encoder incorrectly set (programmable encoder). • Telegram length (MD13, MD14) incorrectly specified. • Encoder delivers erroneous values. • Noise interference on measurement system cable. • Baud rate set too high (MD15).	
	Effect		
	Elimination	• Check encoder and measurement system cable. • Check telegram traffic between encoder and FM 453. • Using the MD20, monitoring can be temporarily skipped, at the responsibility of the owner/operator.	
8.2 (8092) or 10.2 (80B2) or 12.2 (80D2)	**Erroneous pulses, incremental encoder or zero reference mark missing**		
	Cause	The pulses generated by the encoder are monitored for missing pulses (Section 9.6.1). This monitoring feature does not include a comparison with the parameter specifications in MD 13. • Encoder monitoring circuit has discovered erroneous pulses. • In "reference point operation" operating mode, no zero reference mark came within one encoder revolution after the reference point switch was passed. • Encoder faulty: does not deliver the specified number of pulses. • Interference on the measurement system cable.	
	Effect		
	Elimination	• Check encoder and measurement system cable. • Observe limit values. • Observe rules on shielding and grounding. • Using the MD20, monitoring can be temporarily skipped, at the responsibility of the owner/operator.	

Note: (xxxx) value = Hexadecimal notation in diagnostic buffer.

Table 11-4 Diagnostic Interrupt, continued

Byte. Bit	Error Message, Error Analysis and Elimination		Message/ Display
0.2, 0.3	**External channel errors**	**Error response: “Everything OFF”, as in Table 11-2**	
8.3 (8093) or 10.3 (80B3) or 12.3 (80D3)	**Voltage monitoring, encoder**		INTF EXTF STAT
	Cause	• Auxiliary 24 V DC voltage for encoder supply is not applied to front connector X1. • Short-circuit in encoder supply cable (5 V incrementally, 24 V SSI). • Failure of module internal encoder supply unit.	
	Effect		
	Elimination	• Check connections. • Replace the FM 453 if 24 V DC (1L+/1M) and encoder cable OK. • Using the MD20, monitoring can be temporarily skipped, at the responsibility of the owner/operator.	
8.4 (8094) or 10.4 (80B4) or 12.4 (80D4)	**Voltage monitoring ± 15 V**		
	Cause	Failure of module internal ± 15 V.	
	Effect		
	Elimination	• Replace the FM 453. • Using the MD20, monitoring can be temporarily skipped, at the responsibility of the owner/operator.	
8.5 (8095) or 10.5 (80B5) or 12.5 (80D5)	**Voltage monitoring of digital outputs**		
	Cause	Auxiliary 24 V DC voltage for digital outputs is not applied to front connector X1.	
	Effect		
	Elimination	• Check connections. • Replace the FM 453 if 24 V DC OK. • Using the MD20, monitoring can be temporarily skipped, at the responsibility of the owner/operator.	
8.7 (8097 or 10.7 (80B7) or 12.7 (80D7)	**For operating errors, see Table 11-5**		

Note: (xxxx) value = Hexadecimal notation in diagnostic buffer.

Table 11-5 Operating Errors

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Operator control errors		**Error response: "Everything OFF", as in Table 11-2**		
1 (01)	**1 (01)**	**Software limit switch beginning is passed**		Diagnostic interrupt
		Cause	Limit switch passed: in "Control" or "Correction" operating mode.	
		Effect	• The limit switch position is passed by the necessary stopping distance. • Set actual value is not executed.	
		Elimina-tion	• Following acknowledgment of the error, it is possible to traverse to the working range. • Alter value of software limit switch (MD21). • Switch off monitoring limit switch occasionally! (With the limit switches (MD21/22) disabled, the travel range limits are established by the maximum allowable values for the limit switches).	
1 (01)	**2 (02)**	**Software limit switch end is passed**		Diagnostic interrupt
		Cause	Limit switch passed in "Control" or "Correction" operating mode.	
		Effect	• The limit switch position is passed by the necessary stopping distance. • Set actual value is not executed.	
		Elimina-tion	• Following acknowledgment of the error, it is possible to traverse to the working range. • Alter value of software limit switch (MD22). • Switch off monitoring limit switch occasionally! (With the limit switches (MD21/22) disabled, the travel range limits are established by the maximum allowable values for the limit switches).	
1 (01)	**3 (03)**	**Beginning of traversing range passed**		Diagnostic interrupt
		Cause	When operating in "Control" operating mode with soft limits disabled, the traversing range beginning was passed.	
		Effect	The limit switch position is passed by the necessary stopping distance.	
		Elimina-tion	Following acknowledgment of the error, it is possible to traverse to the working range.	

Cl. = Detail event class, No. = Detail event number
Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-5 Operating Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Operator control errors		**Error response: “Everything OFF”, as in Table 11-2**		
1 (01)	**4 (04)**	**Traversing range end passed**		Diagnostic interrupt
		Cause	When operating in “Control” operating mode with soft limits disabled, the traversing range beginning was passed.	
		Effect	The limit switch position is passed by the necessary stopping distance.	
		Elimination	Following acknowledgment of the error, it is possible to traverse to the working range.	
1 (01)	**11 (0B)**	**Drive, direction of rotation**		Diagnostic interrupt
		Cause	Drive turns in wrong direction (reported only when setpoint voltage is ±10 V)	
		Effect		
		Elimination	• Check drive. • Check or correct MD19. • Following “Restart” continue working using the user program.	
1 (01)	**12 (0C)**	**Zero speed control range**		Diagnostic interrupt
		Cause	The zero speed control range was exited in the following instances: • Servo Enable deactivated • On an axis stillstand n the PEH target area • In ”Open−loop control” mode with no traversing command • Other causes: Same as ”Direction of rotation, drive”, Class 1/No. 11	
		Effect		
		Elimination	• Check electrical and mechanical drive disable (terminals, connecting cables, control element functions). • Match MD26.	
1 (01)	**90...99 (5A...63)**	**System errors**		Diagnostic interrupt “STAT” LED blinking.
		Cause	Internal errors in the module.	
		Effect	Undefined effects possible.	
		Elimination	If this manual is observed, the errors should not occur. However, should this still be the case, please consult the responsible sales department. When doing so, it is vitally important to also report the exact circumstances leading to the error.	

Cl. = Detail event class, No. = Detail event number
Note: Value (xx) = Hexadecimal notation of the error number.

11.3.2 Error Message

Overview

The errors are listed in Tables 11-6...11-8 according to error class.

Table 11-6 Operator Control Errors

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Operator control errors		**Error response : "Feed STOP" see Table 11-2**		
2 (02)	**1 (01)**	**Operating mode not allowed**		CBS
		Cause	The operating mode selected is not allowed.	
		Effect		
		Elimination	Select an allowed operating mode	
2 (02)	**4 (04)**	**Incorrect operating mode parameters**		CBS
		Cause	In the "Jogging" and "Control" operating modes, the selected velocity or control level is not 1 or 2. In incremental operation, the set value number is not allowed (1 - 100 and 254 permitted).	
		Effect		
		Elimination	Set operating mode parameters to an allowable value.	
2 (02)	**5 (05)**	**Start enable missing**		CBS
		Cause	A travel command was given in the absence of a start enable (start, external start, R+/R–).	
		Effect		
		Elimination	Restore travel command and wait for start enable.	
2 (02)	**9 (09)**	**Axis is not synchronized**		CBS
		Cause	Synchronization of the axes is necessary in the "Incremental, relative," "MDI" and "Automatic" operating modes.	
		Effect		
		Elimination	Execute reference point approach.	
2 (02)	**11 (0B)**	**Direction specification not allowed**		CBS
		Cause	In operating modes "Jog," "Control" or "Incremental, relative" the direction settings R+/R- are active at the same time. With "Reference point operation", the direction setting no longer agrees with the startup direction specified in the MD.	
		Effect		
		Elimination	Correct the direction parameters.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-6 Operator Control Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Operator control errors		**Error response : "Feed STOP" see Table 11-2**		
2 (02)	12 (0C)	**Axis movement not possible**		CBS
		Cause	Due to an unacknowledged error, no drive enable or stop, a traverse command was triggered.	
		Effect		
		Elimination	Restore traverse command and switch acknowledge error or Stop to inactive, or enable drive.	
2 (02)	13 (0D)	**Incremental value not in place**		CBS
		Cause	The setpoints defined by the operating mode parameters are missing or a change in incremental dimensions occurred when the operating mode started.	
		Effect		
		Elimination	Parameterize and read in setpoint parameters	
2 (02)	14 (0E)	**No program preselected**		CBS
		Cause	No program preselected at "Start."	
		Effect		
		Elimination	First preselect program then start.	
2 (02)	15 (0F)	**Digital input not activated**		CBS
		Cause	The programmed target was reached in a block with external block change (G50).	
		Effect		
		Elimination	Check programming (MD34) and connection of digital input.	
2 (02)	16 (10)	**Measurement function undefined**		CBS
		Cause	Length measurement and inprocess measurement selected simultaneously	
		Effect	No measurement function effective.	
		Elimination	Reselect one of the two measurement functions.	
2 (02)	21 (15)	**Activate machine data not allowed**		CBS
		Cause	• "Machining in progress" is still active (observe Section 7.3.1 carefully!) • change in MD61	
		Effect	Activate machine data not executed.	
		Elimination	Terminate processing, repeat activation.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-6 Operator Control Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Operator control errors		**Error response : “Feed STOP” see Table 11-2**		
2 (02)	**22 (16)**	**On-the-fly MDI block inoperative**		CBS
		Cause	MDI block inactive or already executed	
		Effect	On-the-fly MDI block is not being processed	
		Elimination	Delete error message and initiate execution as MDI block.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-7 Travel Errors

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Travel errors		**Error response : “Feed STOP” see Table 11-2**		
3 (03)	**1 (01)**	**Software limit switch, beginning**		CBS
		Cause	Limit switch approached in “Jog” operating mode, in “Automatic” operating mode if G88/89 without switching signal from the corresponding digital input. The axis is located to the left of the software limit switch because of actual value set.	
		Effect	• Axis movement is stopped at the limit switch position. • Set actual value is not executed.	
		Elimination	• Following acknowledgment of the error, it is possible to traverse to the working range. • Alter value of software limit switch (MD21) • Switch off monitoring limit switch occasionally! (With the limit switches (MD21/22) disabled, the travel range limits are established by the maximum allowable values for the limit switches).	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-7 Travel Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Travel errors		**Error response : "Feed STOP" see Table 11-2**		
3 (03)	**2 (02)**	**Software limit switch, end**		CBS
		Cause	Limit switch approached in "Jog" operating mode, in "Automatic" operating mode if G88/89 without switching signal from the corresponding digital input. The axis is located to the right of the software limit switch because of actual value set.	
		Effect	• Axis movement is stopped at the limit switch position. • Set actual value is not executed.	
		Elimination	• Following acknowledgment of the error, it is possible to traverse to the working range. • Alter value of software limit switch (MD22). • Switch off monitoring limit switch occasionally! (With the limit switches (MD21/22) disabled, the travel range limits are established by the maximum allowable values for the limit switches).	
3 (03)	**3 (03)**	**Traversing range beginning approached**		CBS
		Cause	• During traversing with soft limit switches disabled, the traversing range beginning was approached. • The axis is located to the left of the traversing range beginning because of actual value set. (Traversing range: $\pm 10^9$ or from range covered by absolute encoder.)	
		Effect	• Axis movement is stopped at the traversing range limit. • Set actual value is not executed.	
		Elimination	Travel in the opposite direction	
3 (03)	**4 (04)**	**Traversing range end approached**		CBS
		Cause	• During traversing with soft limit switches disabled, the traversing range end was approached. • The axis is located to the left/right of the traversing range end because of actual value set. (Traversing range: $\pm 10^9$ or from range covered by absolute encoder.)	
		Effect	• Axis movement is stopped at the traversing range limit. • Set actual value is not executed.	
		Elimination	Travel in the opposite direction.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-7 Travel Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Travel errors		**Error response : "Feed STOP" see Table 11-2**		
3 (03)	**5 (05)**	**Target position not within traversing range**		CBS
		Cause	• The position to be approached is outside the working range limited by the software limit switches. • The rotary axis programming is specified as a reference value which does not fall within the positive complete circle.	
		Effect		
		Elimination	• Correct the position to be approached. • Alter value of software limit switch (MD). • Switch off monitoring limit switch occasionally! (With the limit switches (MD21/22) disabled, the travel range limits are established by the maximum allowable values for the limit switches).	
3 (03)	**23 (17)**	**Target velocity zero**		CBS
		Cause	• Zero was entered as programmed velocity. • No feed was programmed for positioning.	
		Effect		
		Elimination	Input an allowable velocity value.	
3 (03)	**28 (1C)**	**M2/M30 missing**		CBS
		Cause	• In the last program, block, no M2, M30 or M18 is programmed. • The last program block is a skip block.	
		Effect		
		Elimination	Per causes.	
3 (03)	**30 (1E)**	**Digital input not parameterized**		CBS
		Cause	For traversing with set actual value on the fly (G88, G89), external block change (G50) or measurement, no digital input necessary for that purpose is parameterized.	
		Effect	The functions are not started.	
		Elimination	Parameterize the digital inputs by way of MD34.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-7 Travel Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Travel errors		**Error response : "Feed STOP" see Table 11-2**		
3 (03)	**35 (23)**	**Tool offset value not in place**		CBS
		Cause	No tool offset values are available on the FM 453 or tool offsets are accessed and modified when an override is active.	
		Effect		
		Elimination	Parameterize and read in tool offset values	
3 (03)	**36 (24)**	**Set actual value on the fly, incorrect value**		CBS
		Cause	Value is no longer within the range $\pm 10^9$	
		Effect		
		Elimination	Input a correct value	
3 (03)	**37 (25)**	**MDI block on the fly, incorrect syntax**		CBS
		Cause	Incorrect M or G commands or incorrect block structure.	
		Effect		
		Elimination	Input a correct MDI block.	
3 (03)	**38 (26)**	**MDI block on the fly, incorrect velocity**		CBS
		Cause	Velocity not within the range between > 0 and max. allowable traverse velocity (500 000 000 MSR/min).	
		Effect		
		Elimination	Input a correct MDI block.	
3 (03)	**39 (27)**	**MDI block on the fly, incorrect position or dwell time**		CBS
		Cause	Position or dwell time is outside allowable values. Position: $\pm 10^9$ MSR Dwell time: > 100000 ms	
		Effect		
		Elimination	Input a correct MDI block.	
3 (03)	**40 (28)**	**MDI block on the fly erroneous**		CBS
		Cause	Incorrect block syntax.	
		Effect		
		Elimination	Input a correct MDI block.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-7 Travel Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination				Message/ Display
Travel errors		**Error response : "Feed STOP" see Table 11-2**				
3 (03)	**61 (3D)**	**Servo enable missing**				CBS
		Cause	Traverse command of the axis without servo enable (except for "Control" operating mode).	OR	Removal of servo enable during "Processing in progress".	
		Effect	No axis movement.	OR	Axis is stopped via voltage ramp MD45 (the Servo Enable is maintained until axis comes to a standstill)	
		Elimination	Set servo enable by way of user program.			
3 (03)	**62 (3E)**	**Controller not ready for operation**				CBS
		Cause	Axis started without "Controller ready message".	OR	"Controller ready message" canceled whilst "processing in progress".	
		Effect	No axis movement.	OR	Axis is stopped via voltage ramp (MD45) with actual value transfer after axis comes to rest (internally like follow-up mode)	
		Elimination	• Check drive/connecting cables. • Analysis of the "Controller ready" message can be disabled by MD37.			
3 (03)	**64 (40)**	**PEH target area monitoring**				CBS
		Cause	Following conclusion of the setpoint value specification to the position controller, the target area is not reached within the specified time.			
		Effect				
		Elimination	• Check drive. • Match MD24, MD25.			
3 (03)	**65 (41)**	**No drive movement**				CBS
		Cause	• Axis standstill at maximum drive control signal (± 10 V). • On violation of the defined following error limit.			
		Effect	• Deceleration of the drive via voltage ramp (MD45) • Actual value transfer (internally like "follow-up mode")			
		Elimination	• Check drive/connecting cables. • Check controller enable signal between FM 453 and drive.			

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-7 Travel Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Travel errors		**Error response : "Feed STOP" see Table 11-2**		
3 (03)	**66 (42)**	**Following error too great** (for drives with encoder) **Rotation monitoring** (stepper drive)		CBS
		Cause	Excessive following error during axis movement. Loss of step see Section 9.7.3	
		Effect	Deceleration of the drive via voltage ramp (MD45)	
		Elimination	• Check drive • Check MD23, MD43 (for drive with encoder) • Check MD46 to MD60 (stepper drive)	
3 (03)	**67 (43)**	**Boost duration absolute exceeded**		CBS
		Cause	Acceleration phase too long.	
		Effect		
		Elimination	• Check MD48. • Change drive configuration. • Change technology (axis traversing cycle).	
3 (03)	**68 (44)**	**Boost duration relative exceeded**		CBS
		Cause	Acceleration phases too high in component compared with idle/constant travel	
		Effect		
		Elimination	• Check MD49. • Change drive configuration. • Change technology (axis traversing cycle).	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
General data errors		**Error response: "Warning" see Table 11-2**		
4 (04)	**1 (01)**	**Data at time of transmission unacceptable**		CBS or DB
		Cause	Data not transmitted in appropriate operating mode.	
		Effect	Data not accepted.	
		Elimination	Transmit data in appropriate operating mode.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
General data errors		**Error response: "Warning" see Table 11-2**		
4 (04)	**2 (02)**	**Velocity level 1 incorrect**		CBS or DB
		Cause	Velocity not within the range between > 0 and max. allowable traverse velocity (500 000 000 MSR/min).	
		Effect	Velocity does not become effective.	
		Elimination	Input an allowed velocity value.	
4 (04)	**3 (03)**	**Velocity level 2 incorrect**		CBS or DB
		Cause	Velocity not within the range between > 0 and max. allowable traverse velocity (500 000 000 MSR/min).	
		Effect	Velocity does not become effective.	
		Elimination	Input an allowed velocity value.	
4 (04)	**4 (04)**	**Voltage/frequency level 1 is incorrect**		CBS or DB
		Cause	Voltage/frequency specified does not fall within the range of ± 10 V.	
		Effect	Voltage/frequency level does not become effective.	
		Elimination	Input an allowed voltage/frequency value.	
4 (04)	**5 (05)**	**Voltage/frequency level 2 is incorrect**		CBS or DB
		Cause	Voltage/frequency specified does not fall within the range of ± 10 V.	
		Effect	Voltage/frequency level does not become effective.	
		Elimination	Input an allowed voltage/frequency value.	
4 (04)	**6 (06)**	**Preset incremental value too high**		CBS or DB
		Cause	Incremental value is greater than 10^9 MSR.	
		Effect	Original incremental value is retained.	
		Elimination	Input an allowable incremental value.	
4 (04)	**7 (07)**	**MDI block, incorrect syntax**		CBS or DB
		Cause	Incorrect M or G commands or incorrect block structure.	
		Effect	Original MDI block is retained.	
		Elimination	Input a correct MDI block.	
4 (04)	**8 (08)**	**MDI block, incorrect velocity**		CBS or DB
		Cause	Velocity not within the range between > 0 and max. allowable traverse velocity (500 000 000 MSR/min).	
		Effect	Original MDI block is retained.	
		Elimination	Input a correct MDI block.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
General data errors		**Error response: ”Warning” see Table 11-2**		
4 (04)	**9 (09)**	**MDI block, position or dwell time incorrect**		CBS or DB
		Cause	Position or dwell time falls outside the allowable values. Position: $\pm 10^9$ MSR. Dwell time: > 100000 ms.	
		Effect	Original MDI block is retained.	
		Elimination	Input a correct MDI block.	
4 (04)	**10 (0A)**	**Zero offset value, offset value incorrect**		CBS or DB
		Cause	Value falls outside the range $\pm 10^9$ MSR.	
		Effect	Does not become effective.	
		Elimination	Input a correct value.	
4 (04)	**11 (0B)**	**Set actual value, actual value incorrect**		CBS or DB
		Cause	Actual value falls outside the software limit switches or outside the range $\pm 10^9$ MSR.	
		Effect	Set actual value does not become effective.	
		Elimination	Input a correct value.	
4 (04)	**12 (0C)**	**Set reference point value, reference point incorrect**		CBS or DB
		Cause	Value falls outside the range $\pm 10^9$ MSR.	
		Effect	Set reference point does not become effective.	
		Elimination	Input a correct value.	
4 (04)	**13 (0D)**	**Digital output not possible**		CBS or DB
		Cause	Output not available for direct output of the user program.	
		Effect	Output is not executed.	
		Elimination	• Correct user program. • Correct parameterization of the output assignment within the MD35 to the desired assignment.	
4 (04)	**14 (0E)**	**Request application data incorrect**		CBS or DB
		Cause	Incorrect request code.	
		Effect	Old application data are retained.	
		Elimination	Request code 0-6, 16-23 and 25 possible.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
General data errors		**Error response: "Warning" see Table 11-2**		
4 (04)	**15 (0F)**	**Teach In, program number incorrect**		CBS or DB
		Cause	The program was not parameterized or read in.	
		Effect	Teach In is not executed.	
		Elimination	Parameterize and read in program or correct program no.	
4 (04)	**16 (10)**	**Teach In, block number incorrect**		CBS or DB
		Cause	The block number in the program selected is not in place.	
		Effect	Teach In is not executed.	
		Elimination	Specify correct block number.	
4 (04)	**17 (11)**	**Teach In, dwell time or subprogram-request in block**		CBS or DB
		Cause	The block number in the program selected is not in place or incorrect block number was selected.	
		Effect	Teach In is not executed.	
		Elimination	Specify correct block number.	
4 (04)	**18 (12)**	**Teach In, no axis stoppage**		CBS or DB
		Cause	Axis is still in motion.	
		Effect	Teach In is not executed.	
		Elimination	Stop axis and repeat task.	
4 (04)	**19 (13)**	**Coupled-axis grouping incorrectly defined**		CBS or DB
		Cause	Incorrect request code	
		Effect	Request is not being processed	
		Elimination	Input of a correct value	
4 (04)	**40 (28)**	**Transmit non-relevant data**		CBS or DB
		Cause	The data (data blocks) transmitted are unknown to the FM 453.	
		Effect	Data not accepted.	
		Elimination	Correct user program.	
4 (04)	**81 (51) 82 (52) 83 (53) 84 (54) 85 (55)**	**Programmable modules communication: unauthorized DB type Programmable modules communication: Info 1 incorrect Programmable modules communication: Info 2 incorrect Programmable modules communication: unauthorized task Programmable modules communication: data errors**		CBS or DB
		Cause	Incorrect data.	
		Effect	Task is not executed.	
		Elimination	Correct and retransmit.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
General data errors		**Error response: "Warning" see Table 11-2**		
4 (04)	**120 (78)**	**Measurement system grid deviates**		CBS or DB
		Cause	The measurement system in the DBs "NC, SM, TO" does not agree with MD7.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
4 (04)	**121 (79)**	**Incorrect DB type in the module**		CBS or DB
		Cause	An incorrect type of DB has been transmitted into the FM 453.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Delete DB, correct and retransmit.	
4 (04)	**122 (7A)**	**DB type or DB no. already exists**		CBS or DB
		Cause	DB type already exists.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Delete corresponding DB prior to transmission.	
4 (04)	**123 (7B)**	**NC program number already exists**		CBS or DB
		Cause	NC program number already exists.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Prior to transmission, delete corresponding DB with the program number.	
4 (04)	**124 (7C)**	**"Save" parameter incorrect**		CBS or DB
		Cause	Coding not 0 or 1.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Coding not 0 or 1.	
4 (04)	**125 (7D)**	**DB memory full**		CBS or DB
		Cause	The available memory is assigned.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Delete unnecessary programs (DBs) or compress memory by way of parametering interface.	
4 (04)	**126 (7E)**	**Allowable program length exceeded**		CBS or DB
		Cause	Number of blocks too high.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct program and retransmit.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
General data errors		**Error response: "Warning" see Table 11-2**		
4 (04)	**127 (7F)**	**Writing parameters/data is not possible**		CBS or DB
		Cause	Axis does not come to a stop.	
		Effect	Parameters/data do not become effective.	
		Elimination	Stop axis.	
4 (04)	**128 (80)**	**Incorrect module identification**		CBS or DB
		Cause	DBs which do not belong to the module were transmitted (no identification 453).	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Transmit the DBs belonging to the FM 453.	
4 (04)	**129 (81)**	**Incremental value, incorrect value**		CBS or DB
		Cause	Value range outside $\pm 10^9$.	
		Effect	Incremental value not effective.	
		Elimination	Transmit correct value.	
4 (04)	**130 (82)**	**Tool offset, incorrect value**		CBS or DB
		Cause	Value range outside $\pm 10^9$.	
		Effect	Tool offset not effective.	
		Elimination	Transmit correct value.	
4 (04)	**131 (83)**	**Not possible to insert block**		CBS or DB
		Cause	Memory full.	
		Effect	Function is not executed.	
		Elimination	Delete unnecessary DBs and repeat function.	
4 (04)	**132 (84)**	**Not possible to delete block**		CBS or DB
		Cause	Block does not exist, no "assignment bit (bytes 2 and 3) enabled in block (when data available).	
		Effect	Function is not executed.	
		Elimination	Check program and repeat function with correct block no.	
4(04)	**144 (90)**	**SDB cannot be loaded**		CBS or DB
		Cause	Module not at standstill.	
		Effect	SDB is rejected.	
		Elimination	Stop module and retry load operation.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
General data errors		**Error response: "Warning" see Table 11-2**		
4(04)	**145 (91)**	**SDB user data error**		CBS or DB
		Cause	SDB contains value error.	
		Effect	SDB is rejected.	
		Elimination	Generate SDB with parameter assignment tool and retry load operation.	
Machine data errors		**Error response: "Warning" see Table 11-2**		
5 (05)	**7 (07)**	**Measurement system**		CBS or DB
		Cause	The measurement system grid (MSR) entered does not agree with the MSR in the other DBs of the module.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	• Check MSR and correct as necessary. • When making correct input, delete the other DBs on the module before retransmitting.	
5 (05)	**8 (08)**	**Type of axis**		CBS or DB
		Cause	No linear or rotary axis parameterized.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**9 (09)**	**Rotary axis**		CBS or DB
		Cause	Impermissible value range or dependency violation (see Section 5.3.1)	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**10 (0A)**	**Encoder type**		CBS or DB
		Cause	Unacceptable type of encoder.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Machine data errors		**Error response: "Warning" see Table 11-2**		
5 (05)	**11 (0B)** **12 (0C)** **13 (0D)** **14 (0E)**	**Travel per encoder revolution** **Distance to go per encoder revolution** **Increments per encoder revolution** **Number of revolutions, absolute encoder**		CBS or DB
		Cause	• Impermissible value range or • dependency violation on no. 11, 12, 13 (see Section 5.3.1).	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**15 (0F)**	**Baud rate, absolute encoder**		CBS or DB
		Cause	Unacceptable baud rate.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**16 (10)** **17 (11)**	**Reference point coordinates, absolute encoder adjustment**		CBS or DB
		Cause	Unacceptable value range.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**18 (12)**	**Type of reference point travel**		CBS or DB
		Cause	Unacceptable type of reference point travel.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**19 (13)**	**Direction matching undefined**		CBS or DB
		Cause	Direction matching undefined.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**20 (14)**	**Disable hardware monitoring undefined**		CBS or DB
		Cause	Disable hardware monitoring undefined.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Machine data errors		**Error response: "Warning" see Table 11-2**		
5 (05)	**21 (15)** **22 (16)** **23 (17)** **24 (18)** **25 (19)** **26 (1A)** **27 (1B)** **28 (1C)** **29 (1D)** **30 (1E)**	**Software limit switch, begin** **Software limit switch, end** **Maximum velocity** **Target range (PEH)** **Monitoring time** **Stoppage area** **Reference point offset** **Referencing velocity** **Reducing velocity** **Backlash compensation**		CBS or DB
		Cause	• Impermissible value range or • dependency violation on no. 21, 22, 28, 29 (see Section 5.3.1).	CBS or DB
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**31 (1F)**	**Backlash vector reference**		CBS or DB
		Cause	Backlash vector reference undefined.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**32 (20)**	**Type of output, M-function**		CBS or DB
		Cause	Type of output, M-function not defined.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**33 (21)**	**Output time, M-function**		CBS or DB
		Cause	Unacceptable value range.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**34 (22)**	**Digital inputs**		CBS or DB
		Cause	Inputs undefined or defined more than once.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**35 (23)**	**Digital outputs**		CBS or DB
		Cause	Outputs undefined or defined more than once.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**36 (24)**	**Input adapter**		CBS or DB
		Cause	Input adapter undefined.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Machine data errors		**Error response: “Warning” see Table 11-2**		
5 (05)	**38 (26) 39 (27) 40 (28) 41 (29) 42 (2A) 43 (2B) 44 (2C) 45 (2D)**	**Positioning circuit amplification Minimum following error, dynamic Speed-up Slow-down Jerk time Set voltage, max. Offset compensation Voltage ramp**		CBS or DB
		Cause	Unacceptable value range.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**67(43) 68 (44)**	**Control signals Number of increments per current-sourcing cycle**		CBS or DB
		Cause	Unacceptable value range.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**69(45) 70 (46) 71 (47) 72 (48) 73 (49) 74 (4A) 75 (4B)**	**Start/Stop frequency Frequency value for acceleration switchover Maximum frequency Acceleration 1 Acceleration 2 Delay 1 Delay 2**		CBS or DB
		Cause	• Impermissible value range or • dependency violation on no. 70...75 (see Sect. 5.3.1).	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**76(4C) 77(4D) 78(4E) 79(4F) 80(50) 81(51)**	**Minimum stoppage time between two positioning operations Minimum traversing time at constant frequency Boost duration absolute Boost duration relative Phase current traversing Phase current zero speed**		CBS or DB
		Cause	Unacceptable value range.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Machine data errors		**Error response: "Warning" see Table 11-2**		
5 (05)	**87 (57)** **88 (58)** **89 (59)** **90 (5A)** **91 (5B)**	**Velocity for backlash compensation** **Backlash compensation mode** **Illegal standstill speed for controlling** **Illegal time-out time for enforced zero-speed detection** **Illegal response time for the standard diagnosis**		CBS or DB
		Cause	Impermissible value range or dependency violation (see Section 5.3.1).	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**96 (60)**	**Software limit unacceptable**		CBS or DB
		Cause	Impermissible value range or dependency violation (see Section 5.3.1) with linear axes. Software begin limit switch greater than software limit switch end with rotary axes. Software begin/end limit switches not within rotary axis cycle and not at maximum input value.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**97 (61)**	**Limitation, software limit with absolute encoder**		CBS or DB
		Cause	Impermissible value range or dependency violation (see Section 5.3.1). Travel distance between SW limit switch begin and end is greater than the absolute value range of the encoder.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**99 (63)**	**Impermissible actual value evaluation factor**		CBS or DB
		Cause	Impermissible relationship in the assignments for distance per encoder revolution (MD11, 12) and increments per encoder revolution (MD13) (see Section 5.3.1).	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Machine data errors		**Error response: "Warning" see Table 11-2**		
5 (05)	**101 (65)**	**Impermissible increment evaluation factor for stepper drive**		CBS or DB
		Cause	Impermissible relationship in the assignments for distance per encoder revolution (MD11, 12) and steps per motor revolution (MD52) (see Section 5.3.1).	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**102 (66)**	**Limitation, software limit for linear axis**		CBS or DB
		Cause	For encoder resolutions/step resolutions < 1 MSR, the permissible traversing range in the ratio of MSR to increments is limited (e.g. for 0.5 μm per enc. pulse to $0.5 \cdot 10^9$ MSR) (see Section 5.3.1).	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
Traversing program errors Error response: "Warning"				
8 (08)	**1 (01)**	**Program selection, subprogram number incorrect**		CBS or DB
		Cause	• The subroutine requested in the program is not in place on the FM 453. • The subprogram called in the program contains another subprogram call. Nesting is not possible.	
		Effect	Program selection is not executed.	
		Elimination	• Parameterize and read in progr., correct as necessary. • Select another program.	
8 (08)	**8 (08)**	**Program selection, program number not in place**		CBS or DB
		Cause	The program was not parameterized, is not in place on the FM 453.	
		Effect	Program selection is not executed.	
		Elimination	• Parameterize and read in prog., correct as necessary. • Select another program.	
8 (08)	**9 (09)**	**Program selection, block number missing**		CBS or DB
		Cause	The block number is missing in the program selected.	
		Effect	Program selection is not executed.	
		Elimination	• Correct program. • Select different block number.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Traversing program errors Error response: “Warning”				
8 (08)	**10 (0A)**	**Program, block number unacceptable**		CBS or DB
		Cause	Block number missing or outside of the number range.	
		Effect	Program is not stored.	
		Elimination	Correct program.	
8 (08)	**11 (0B)**	**Program selection, direction specification incorrect**		CBS or DB
		Cause	Direction specification incorrect.	
		Effect	Program selection is not executed.	
		Elimination	Correct program selection and repeat.	
8 (08)	**12 (0C)**	**Program selection unacceptable**		CBS or DB
		Cause	Another program was preselected during a movement.	
		Effect	Program selection is not executed.	
		Elimination	Use STOP to stop program in progress, or repeat program selection at end of program.	
8 (08)	**20 (14)**	**Error, program number**		CBS or DB
		Cause	Program numbers in the blocks incorrect.	
		Effect	Program is not stored.	
		Elimination	Correct program, per cause.	
8 (08)	**21 (15)**	**No block in program**		CBS or DB
		Cause	No block in program.	
		Effect	Program is not stored.	
		Elimination	Correct program, per cause.	
8 (08)	**22 (16)**	**Error, block number**		CBS or DB
		Cause	Block number value range incorrect.	
		Effect	Program is not stored.	
		Elimination	Correct program.	
8 (08)	**23 (17)**	**Block number sequence incorrect**		CBS or DB
		Cause	Block number not in ascending order.	
		Effect	Program is not stored.	
		Elimination	Correct program.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Traversing program errors Error response: “Warning”				
8 (08)	**24 (18)**	**G function 1 unacceptable**		CBS or DB
		Cause	• The no. programmed as G function 1 is not allowed. • In block, other data besides M-functions were programmed with dwell time (G04).	
		Effect	Program/block not stored.	
		Elimination	Correct program, per cause.	
8 (08)	**25 (19)**	**G function 2 unacceptable**		CBS or DB
		Cause	The number programmed as G function 2 is not allowed.	
		Effect	Program/block not stored.	
		Elimination	Correct program, per cause.	
8 (08)	**26 (1A)**	**G function 3 unacceptable**		CBS or DB
		Cause	• The no. programmed as G function 3 is not allowed. • External block change (G50) was programmed in a block together with continuous operation for setting actual value on the fly (G88/89). • A tool offset (G43, G44) was called up without D no. • In selecting a D number, the direction specification is missing for the tool offset (G43, G44).	
		Effect	Program/block not stored.	
		Elimination	Correct program, per cause.	
8 (08)	**27 (1B)**	**M function unacceptable**		CBS or DB
		Cause	• The number programmed as M function is not allowed. • At least two of the M functions M0, M2, M18, M30, which cancel each other out, are found in one block.	
		Effect	Program/block not stored.	
		Elimination	Correct program, per cause.	
8 (08)	**28 (1C)**	**Position/dwell time missing**		CBS or DB
		Cause	• No dwell time specified in block with G04. • Target position missing with ext. block change (G50). • No new act. value programmed for function continuous operation with setting actual value on the fly (G88/89).	
		Effect	Program/block not stored.	
		Elimination	Correct program, per cause.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Table 11-8 General Data Errors, Machine Data Errors, Traversing Program Errors, continued

Cl.	No.	Error Message, Error Analysis and Elimination		Message/ Display
Traversing program errors Error response: "Warning"				
8 (08)	**29 (1D)**	**Incorrect D-NO (>20)**		CBS or DB
		Cause	The number for tool offset is greater than 20.	
		Effect	Program/block not stored.	
		Elimination	Correct program, per cause.	
8 (08)	**30 (1E)**	**Error, subroutine**		CBS or DB
		Cause	Subroutine without number of runs.	
		Effect	Program is not stored.	
		Elimination	Correct program, per cause.	
8 (08)	**31 (1F)**	**Velocity missing**		CBS or DB
		Cause	No velocity was programmed.	
		Effect	Program/block not stored.	
		Elimination	Correct program, per cause.	
8 (08)	**32 (20)**	**Error, callup subroutine**		CBS or DB
		Cause	Block syntax for callup subroutine is incorrect.	
		Effect	Program is not stored.	
		Elimination	Correct program, per cause.	
8 (08)	**33 (21)**	**D function unacceptable**		CBS or DB
		Cause	Block syntax for invoking a D function is incorrect.	
		Effect	Program is not stored.	
		Elimination	Correct program, per cause.	
8 (08)	**34 (22)**	**Incorrect program length**		CBS or DB
		Cause	Maximum block number exceeded.	
		Effect	Program is not stored.	
		Elimination	Correct program, per cause.	

Cl. = Detail event class, No. = Detail event number, CBS = Checkback signals, DB = Data block

Note: Value (xx) = Hexadecimal notation of the error number.

Technical Specifications A

Overview

This chapter describes the technical data for the FM 453 positioning module.

- General technical data
- Dimensions and weight
- Load memory
- Encoder inputs
- Drive port
- Digital inputs
- Digital outputs

General Technical Data

General technical data include:

- Electromagnetic compatibility
- Shipping and storage conditions
- Ambient mechanical and climate conditions
- Data on insulation testing, protection class and degree of protection

This information contains standards and test values with which the S7-400 complies or according to whose criteria the S7-400 was tested.

The general technical data are described in the manual "Installing an S7-400."

UL/CSA Certifications

The following certifications are on record for the S7-400:

UL Recognition Mark
Underwriters Laboratories (UL) in compliance with
UL Standard 508, File E 85972

CSA Certification Mark
Canadian Standard Association (CSA) in compliance with
Standard C 22.2 No. 142

FM Approval

The FM approval is on record for the S7-400:
FM certification in accordance with Factory Mutual Approval Standard Class Number 3611, Class I, Division 2, Group A, B, C, D.

Warning

Potential for personal injury and property damage.

In areas where there is a risk of explosion, personal injury and property damage may occur if you disconnect plugs while the S7-400 is in operation.

In areas where there is a risk of explosion, always cut off power to the S7-400 before disconnecting plugs.

Warning

WARNING - NEVER DISCONNECT WHILE CIRCUIT IS LIVE
UNLESS LOCATION IS KNOWN TO BE NONHAZARDOUS

CE Marking

Our products are in compliance with the 89/336/EWG “Electromagnetic Compatibility” EU Guideline and the harmonized European standards (EN) which it embodies.

The EC Declarations of Conformity in accordance with Article 10 of the EU Guideline referenced above can also be found on the Internet at:

http://support.automation.siemens.com//WW/view/de/15257461

Application

SIMATIC products are designed for application in an industrial environment.

Application	Requirement Concerning	
	Noise Emission	**Noise Immunity**
Industry	EN 50081-2 : 1993	EN 61000-6-2 : 1999

Observe Installation Guidelines

SIMATIC products meet these requirements, provided you observe the installation guidelines set out in the manuals during installation and operation.

Connected loads

Power consumption from 5 V backplane bus	Max. 1.6 A (nominal current)
Power loss	8 W
Auxiliary voltage 1L+...4L+ • Dynamic range • Static range	24 V DC 18.5...30.2 V (incl. ripple) 20.4 – 28.8 V
Power consumption for 1L for nominal voltage (generation of encoder supply voltage from 1L+)	Max. 1.0 A for 24 V encoder Max. 0.4 A for 5 V encoder
Power consumption 2L+...4L+ for nominal voltage for digital input channels 1 to 3	Max. 2 A per channel

Dimensions and Weights

Technical data for dimensions and weights:

Dimensions W × H × D (mm)	50 × 290 × 210
Weight (g)	ca. 1620

Memory for Parameter Data

RAM memory 64 Kbytes in total for the parameter data of the three channels FEPROM for retentive storage of parameter data.

FM Cycle

3 ms

Drive Port

Servo drive

Setpoint signal	
Rated voltage range	–10...10 V
Output current	–3...3 mA
Relay contact, controller enable	
Switching voltage	Max. 50 V
Switching current	Max. 1 A
Switching capacity	Max. 30 VA
Cable length	Max. 35 m

D/A converter resolution see Section 4.2.

Stepper drive

Output signals, 5 V to RS422 standard		
Differential output voltage	V_{OD}	Min. 2 V (R_L = 100 Ω)
Output voltage "1"	V_{OH}	Type 3.7 V (I_O = –30 mA)
Output voltage "0"	V_{OL}	Type 1.1 V (I_O = 30 mA)
Load resistance	R_L	Min. 55 Ω
Output current	I_O	Max. ±60 mA
Pulse frequency	f_P	Max. 1 MHz
READY1 ready signal (drive ready)		
Input voltage "1"		Open or min. 3.5 V
Input voltage "0"		Max. 1 V (for 2 mA loads)
Cable length		35 m for symmetrical transmission 10 m for asymmetrical transmission

Encoder Inputs

Position detection	• Incremental • Absolute (SSI)
Signal voltages	Inputs: 5 V, RS422-compliant
Encoder supply voltage	• 5 V/300 mA • 24 V/300 mA
Input frequency and line length for incremental encoder	• Max. 1 MHz wih 10 m conductor length shielded • Max. 500 kHz with 35 m conductor length shielded
Data transmission rates and line length for absolute encoder (SSI)	• Max. 1.25 Mbit/s with 10 m conductor length shielded • Max. 156 kbit/s with 250 m conductor length shielded
Cable length for incremental encoder	
• 5 V encoder supply	• Max. 25 m for max. 300 mA (tolerance 4.75...5.25 V) • Max. 35 m for max. 210 mA (tolerance 4.75...5.25 V)
• 24 V encoder supply	• Max. 100 m for max. 300 mA (tolerance 20.4...28.8 V) • Max. 300 m for max. 300 mA (tolerance 11...30 V)
Cable length for absolute encoder (SSI)	See data transmission rates

Digital Inputs

Number of inputs	6 per channel
Supply voltage	24 V DC (allowable range: 20.4 – 28.8 V)
Electrical isolation	Yes
Input voltage	• 0 signal: –3 – 5 V • 1 signal: 11 – 30 V
Input current	• 0 signal: Not more than 3 mA • 1 signal: Not more than 7 mA
Input delay • over input voltage range • for 24 V input voltage	 • 0 → 1 signal: max. 15 μs • 1 → 0 signal: max. 45 μs • 0 → 1 signal: max. 8 μs
Polarity-reversal protection for input signals	Yes
Connection of a 2-conductor sensor	Possible

Digital Outputs

Number of outputs	4 per channel
Supply voltage	24 V DC (allowable range: 20.4 – 28.8 V)
Electrical isolation	Yes
Output voltage	• 0 signal: Residual current max. 2 mA • 1 signal: (aux. v. 2L+...4L+ – 0.3 V)
Output current on signal "1" • at ambient temperature of 40°C – Rated value – Permissible value range – Lamp load • at ambient temperature of 60°C – Rated value – Permissible value range	 0.5 A 5 mA to 0.6 A (over auxiliary voltage range) Max. 5 W 0.1 A 5 mA to 0.12 A (over auxiliary voltage)
Short-circuit/overload protection	Yes, for overtemperature, switches for each output separately
Switching rate	• Resistive load: max. 100 Hz • Inductive load: max. 0.25 Hz (with ext. quenching)
Polarity-reversal protection for auxiliary voltages	Yes
Total current of digital outputs	Simultaneity factor 100 % • Up to 40°C: 6 A (for all channels) • 40°C to 60°C: 1.2 A (for all channels)

Connecting Cables

B

Chapter Overview

Overview

This chapter provides an overview of the cable sets to the connectable encoders and drives.

The encoder types that can be connected and the corresponding cable sets are listed in the following table.

Table B-1 Connecting Cables for Encoders

Encoder	Connecting Cable
Incremental encoder with RS 422 Linear scale with EXE	6FX2 002-2CD01-1□□0
ROD 320 enc. (built-in enc. in 1FT5 motor)	6FX2 002-2CE01-1□□0
Absolute encoder (SSI)	6FX2 002-2CC01-1□□0

The drives that can be connected and the corresponding cable sets are listed in the following table.

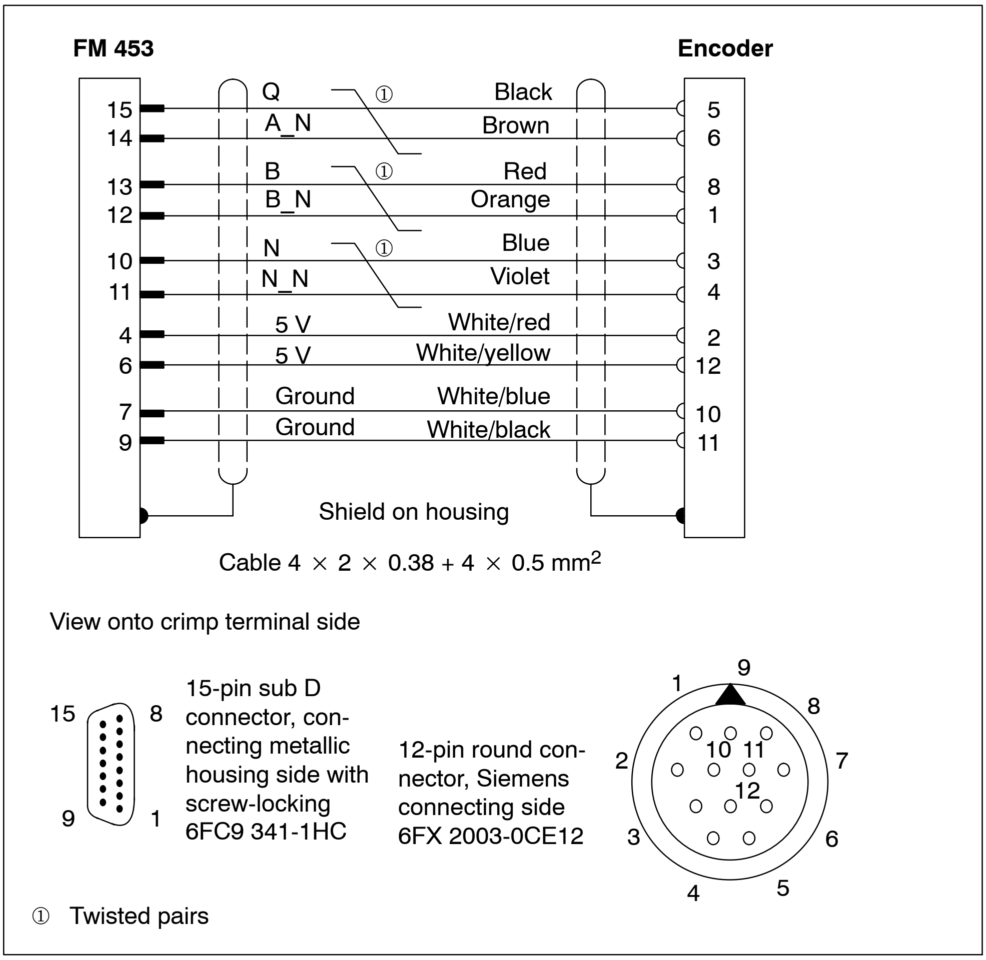
Table B-2 Connecting Cables for Drives

Drive Configuration	Connecting Cable
3 SIMODRIVE 611-A servo drives	6FX2 002-3AD01-1□□□
3 FM STEPDRIVE stepper drives	6FX2 002-3AB04-1□□□
1 FM STEPDRIVE stepper drive and 2 SIMODRIVE 611-A servo drives	6FX2 002-3AB02-1□□□
2 FM STEPDRIVE stepper drives and 1 SIMODRIVE 611-A servo drive	6FX2 002-3AB03-1□□□

B.1 Cable Set for Incremental Encoders with RS 422 or EXEs (for connection of linear scales)

Connections

The following figure shows the connecting cable between the FM 453 and the incremental encoder with RS 422 or FM 453 and EXE with a linear scale):



Order Notes

The cable cross-sections have already been specified in the diagram. The maximum length of the connecting cable is given in Chapter A, Technical Specifications.

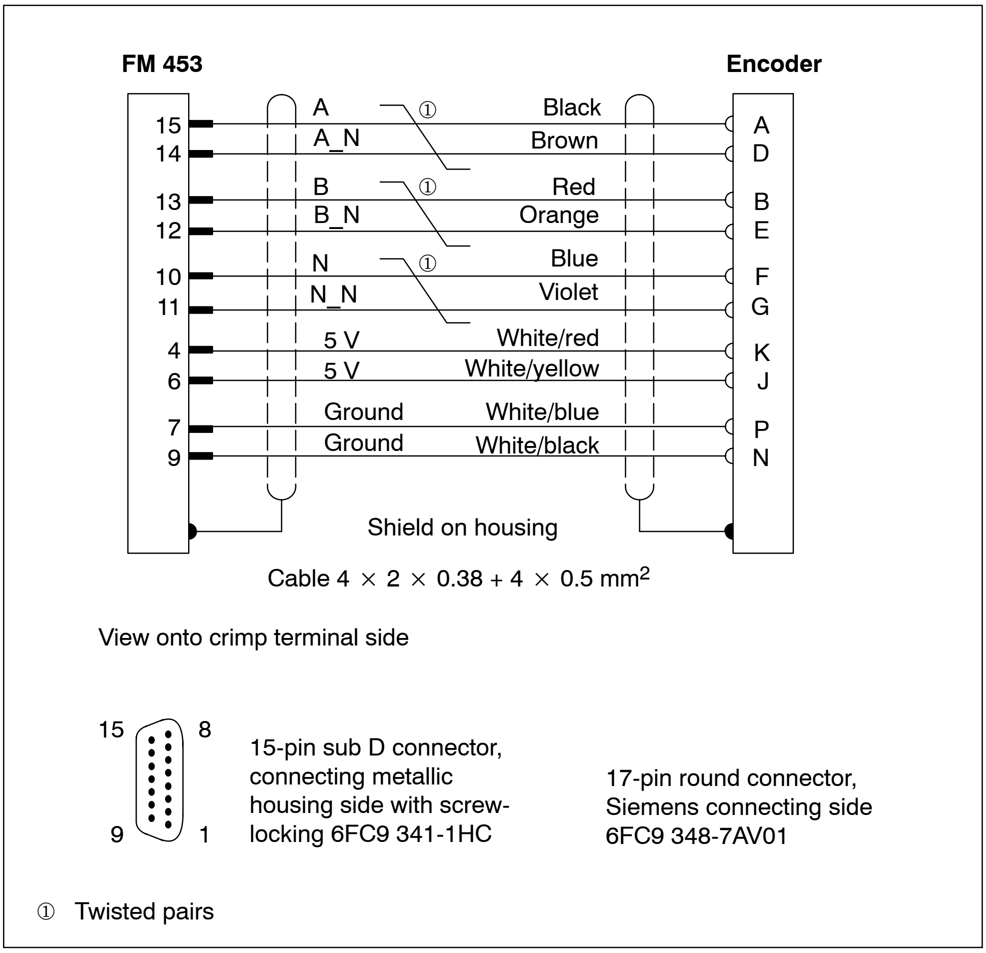
The corresponding order number is:

6FX2 002 2CD01-1□□0 (□□: For length code, see Catalog NC Z Order No. E86060-K4490-A001-A□).

B.2 Cable Set for Built-in ROD 320 Encoders with 17-pin Round Plugs

Connections

The following figure shows the connecting cable between the FM 453 and the ROD 320 encoder with the 1FT5 motor:



Order Notes

The cable cross-sections have already been specified in the diagram. The maximum length of the connecting cable is given in Chapter A, Technical Specifications.

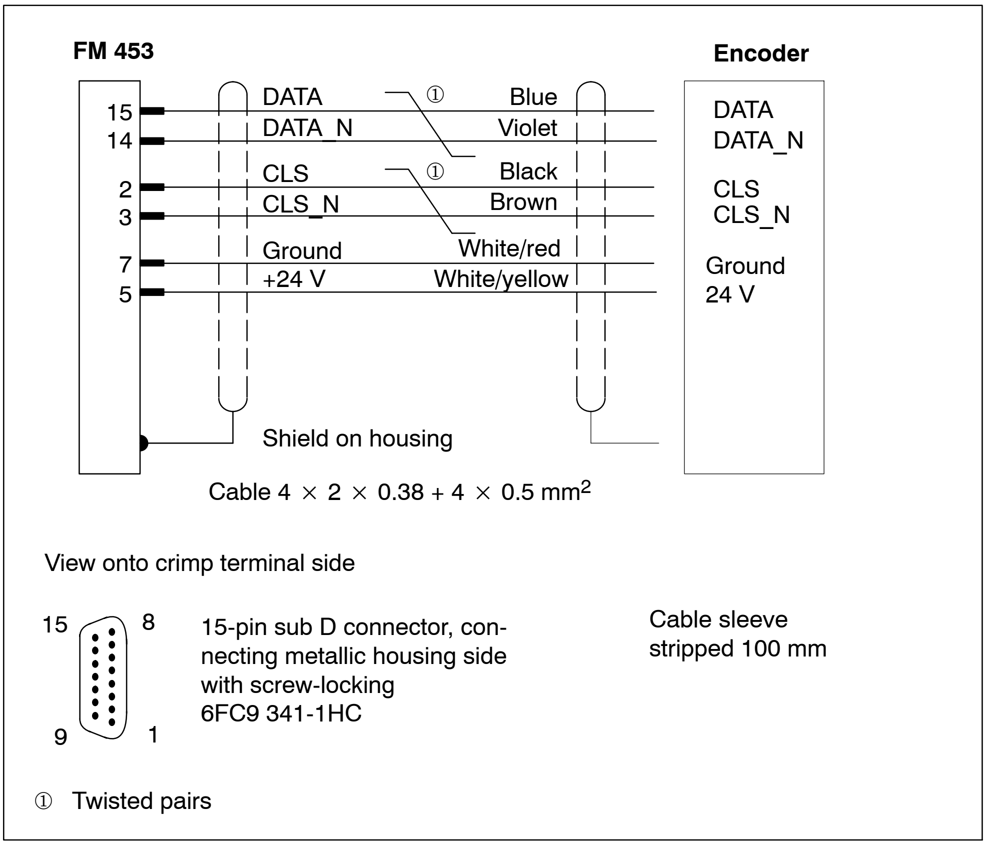
The corresponding order number is:

6FX2 002 2CE01-1□□0 (□□: For length code, see Catalog NC Z Order No. E86060-K4490-A001-A□).

B.3 Cable Set for Absolute Encoders (SSI) with a Free Cable End

Connections

The following figure shows the connecting cable between the FM 453 and the absolute encoder:



Order Notes

The cable cross-sections have already been specified in the diagram. The maximum length of the connecting cable is given in Chapter A, Technical Specifications.

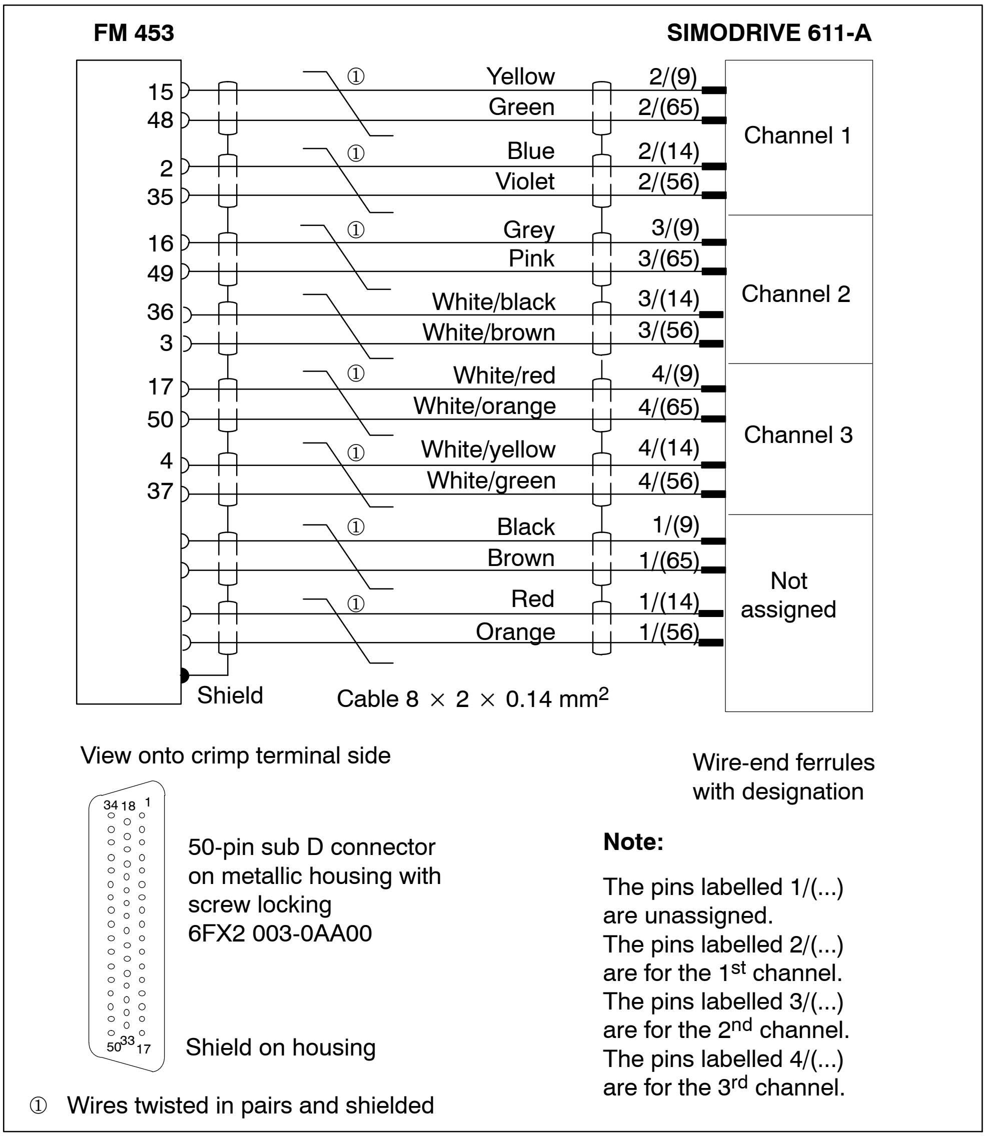
The corresponding order number is:

6FX2 002 2CC01-1□□0 (□□: For length code, see Catalog NC Z Order No. E86060-K4490-A001-A□).

B.4 Cable Set for SIMODRIVE 611-A Servo Drive (3 channels)

Connections

The following figure shows the connecting cable between the FM 453 and the SIMODRIVE 611-A servo drive (3 channels):



Order Notes

The cable cross-sections have already been specified in the diagram. The maximum length of the connecting cable is 35 m.

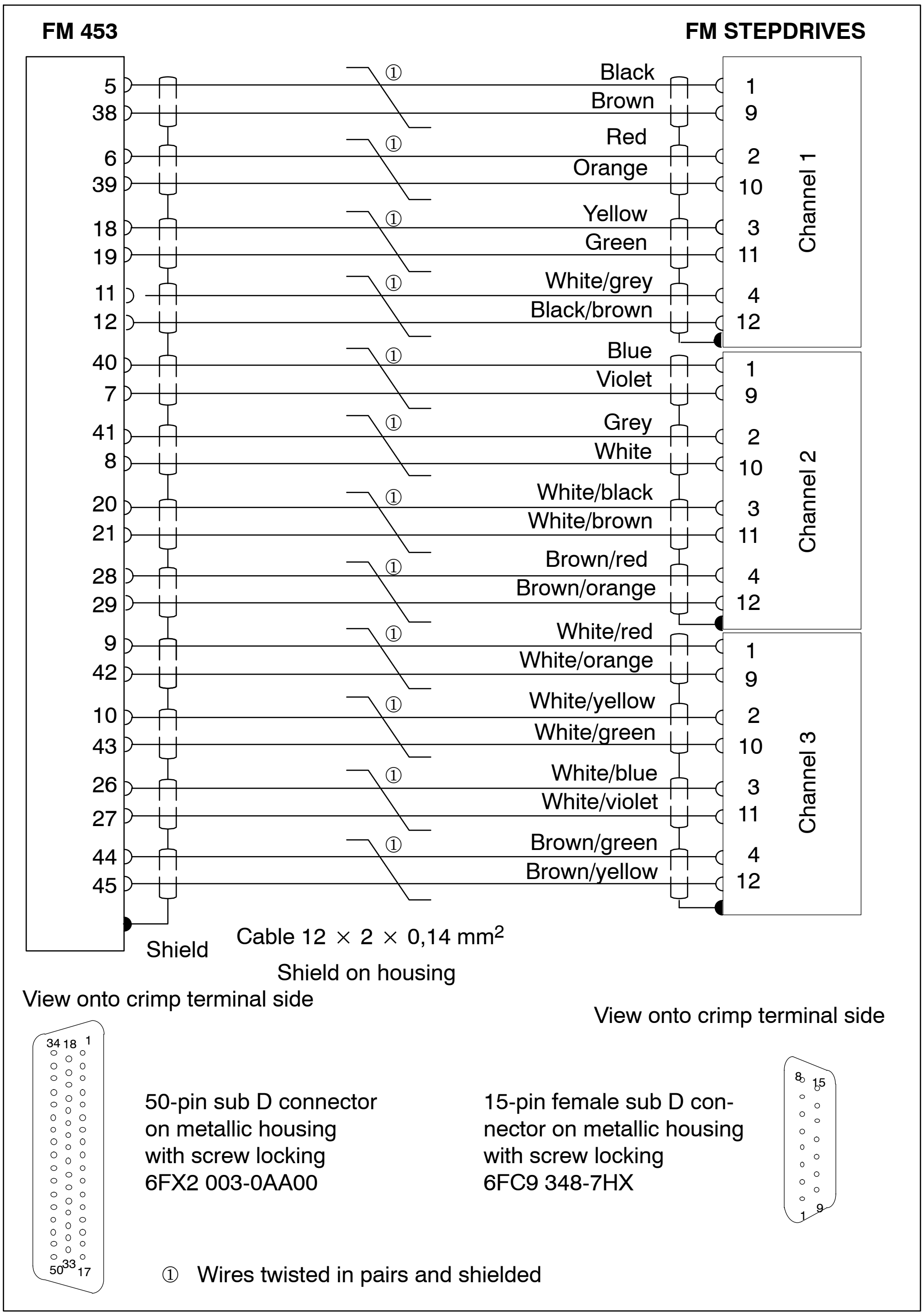
The corresponding order number is:

6FX2 002 3AD01-1□□□ (□□□ : For length code, see Catalog NC Z Order No. E86060-K4490-A001-A□).

B.5 Cable Set for FM STEPDRIVE Stepper Drive (3 channels)

Connections

The following figure shows the connecting cable between the FM 453 and three FM STEPDRIVE stepper drives:



Note

In this configuration with step mode for channels 1 to 3, the external READY2 signal must be used for each channel (see Figure 4-7).

Order Notes

The cable cross-sections have already been specified in the diagram. The maximum length of the connecting cable is:

- 35 m for symmetrical transmission
- 10 m for asymmetrical transmission

The corresponding order number is:

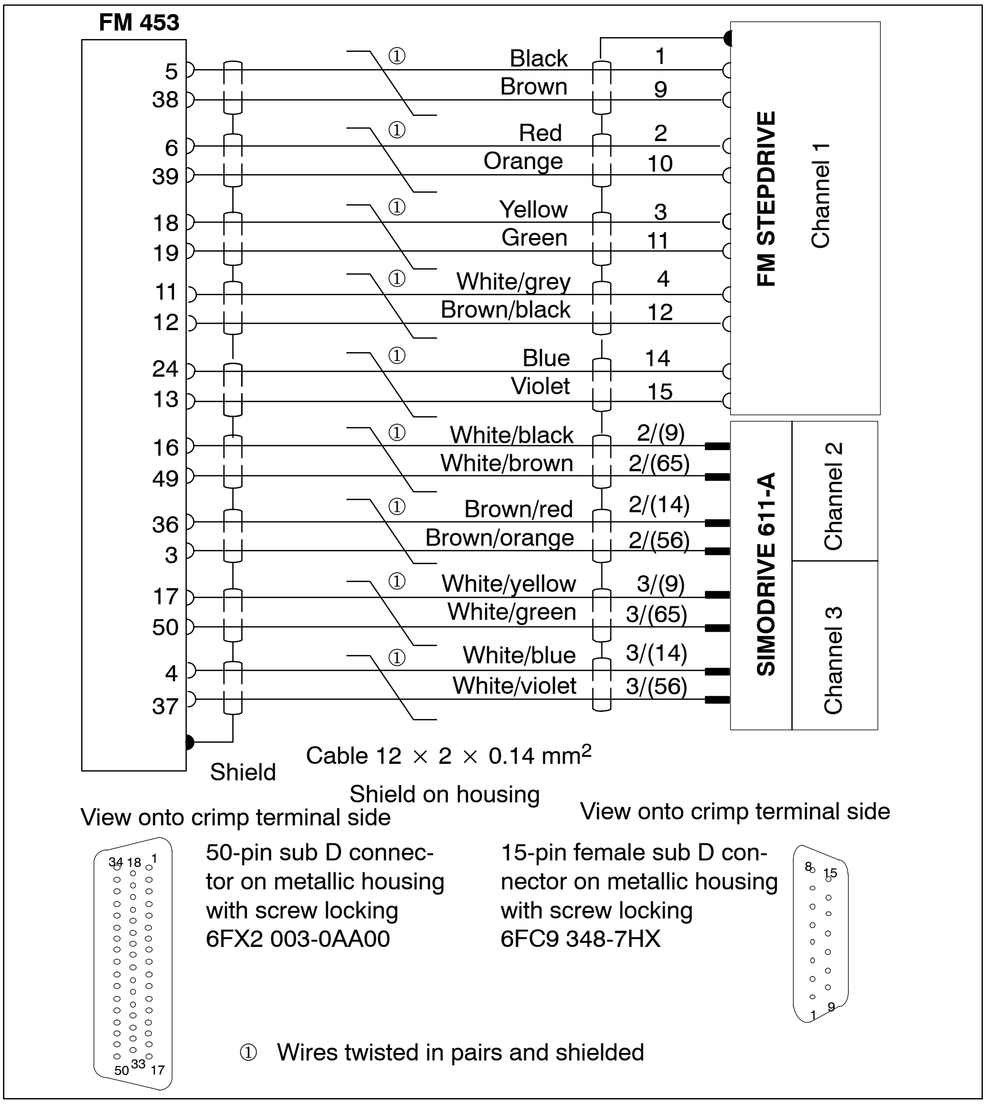
6FX2 002-3AB04-1□□□ (□□□: For length code, see Catalog NC Z Order No. E86060-K4490-A001-A□)[1].

1) Soon to be included in catalog

B.6 Cable Set for One FM STEPDRIVE Stepper Drive and Two SIMODRIVE 611-A Servo Drives (3 channels)

Connections

The following figure shows the connecting cable between the FM 453, one FM STEPDRIVE stepper drive and two SIMODRIVE 611-A servo drives:



Order Notes

The cable cross-sections have already been specified in the diagram. The maximum length of the connecting cable is 35 m.

The corresponding order number is:

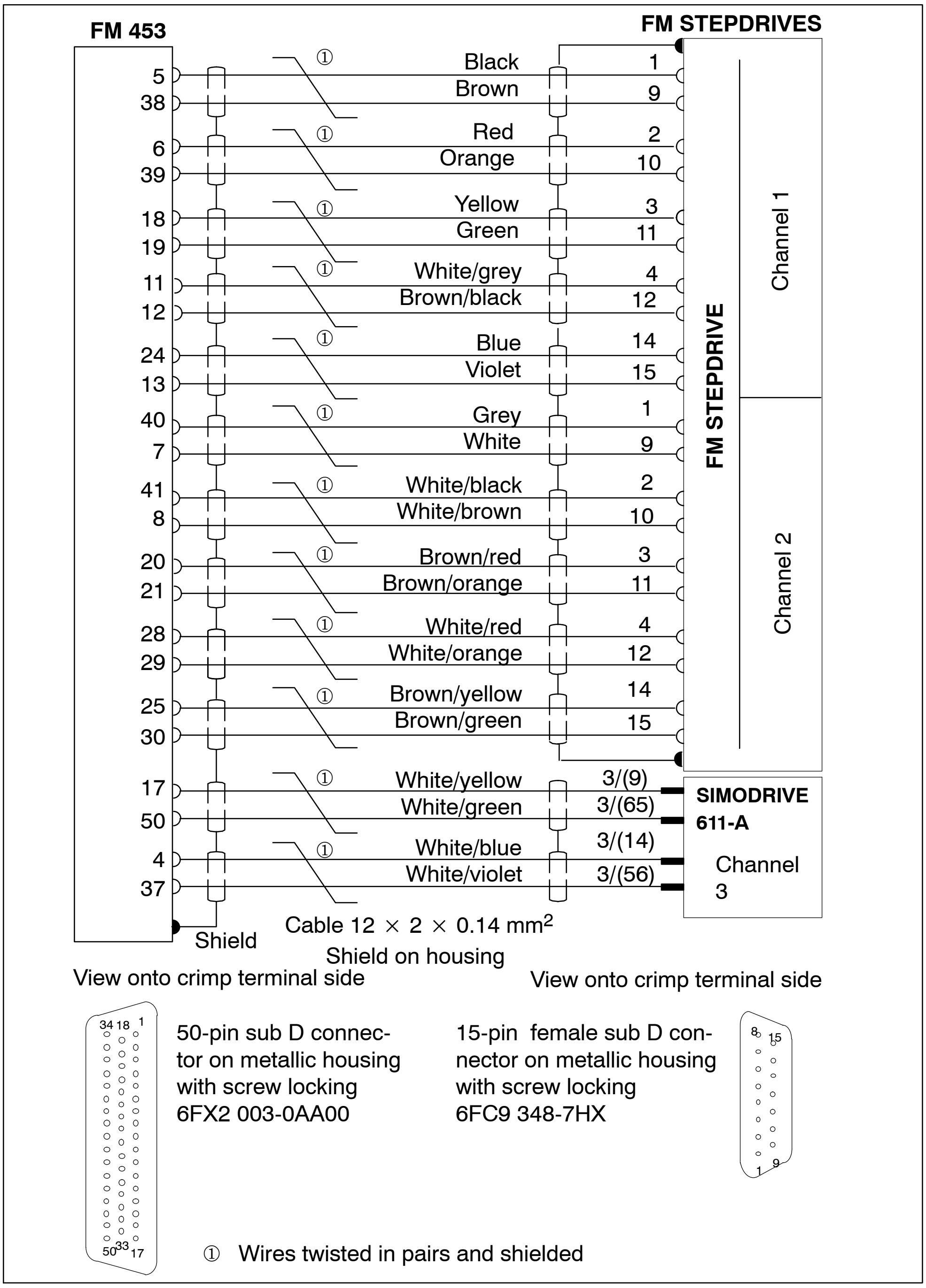
6FX2 002 3AB02-1□□□ (□□□: For length code, see Catalog NC Z Order No. E86060-K4490-A001-A□)[1].

1) Soon to be included in catalog

B.7 Cable Set for Two FM STEPDRIVE Stepper Drives and One SIMODRIVE 611-A Servo Drive (3 channels)

Connections

The following figure shows the connecting cable between the FM 453, two FM STEPDRIVE stepper drives and one SIMODRIVE 611-A servo drive:



Order Notes

The cable cross-sections have already been specified in the diagram. The maximum length of the connecting cable is 35 m.

The corresponding order number is:

6FX2 002 3AB03-1□□□ (□□□ : For length code, see Catalog NC Z Order No. E86060-K4490-A001-A□)[1].

1) Soon to be included in catalog

User Data Block (AW–DB)

C

Table C-1 User data block (AW–DB)

Absolute address	Variable	Data Type	Comment
General addresses			
0	MOD_ADR	INT	Module address
2	CH_NO	INT	Channel number
4	CH_ADR	DWORD	Channel address
8	DS_OFFS	INT	Offset for channel-specific data block number
10...13.5			Reserved
13.6	MODE_BUSY	BOOL	Execution started
13.7	POS_REACHED	BOOL	Position
Control signals			
14.0			Reserved
14.1	TEST_EN	BOOL	Switch to P bus Start-up
14.2			Reserved
14.3	OT_ERR_A	BOOL	Acknowledge operator/traversing error
14.4...14.7			Reserved
15.0	START	BOOL	Start
15.1	STOP	BOOL	Stop
15.2	DIR_M	BOOL	Negative direction
15.3	DIR_P	BOOL	Positive direction
15.4	ACK_MF	BOOL	Acknowledge M function
15.5	READ_EN	BOOL	Read-in enable
15.6	SKIP_BLK	BOOL	Block skip
15.7	DRV_EN	BOOL	Drive enable
16	MODE_IN	BYTE	Operating mode
17	MODE_ TYPE	BYTE	Operating mode parameters
18	OVERRIDE	BYTE	Override
19...21			Reserved
Checkback signals			
22.0			Reserved
22.1	TST_STAT	BOOL	Switch to P bus completed
22.2			Reserved
22.3	OT_ERR	BOOL	Operator/traversing error
22.4	DATA_ERR	BOOL	Data error
22.5...22.6			Reserved
22.7	PARA	BOOL	Channel parameterizell

Table C-1 User data block (AW−DB), Continued

Absolute address	Variable	Data Type	Comment
23.0	ST_ENBLD	BOOL	Start enable
23.1	WORKING	BOOL	Machining in progress
23.2	WAIT_EI	BOOL	Wait for external enable
23.3...23.4			Reserved
23.5	DT_RUN	BOOL	Dwell in progress
23.6	PR_BACK	BOOL	Reverse prog. scan
23.7			Reserved
24	MODE_OUT	BYTE	Active operating mode
25.0	SYNC	BOOL	Channel synchronized
25.1	MSR_DONE	BOOL	End of measurement
25.2	GO_M	BOOL	Negative travel
25.3	GO_P	BOOL	Positive travel
25.4	ST_SERVO	BOOL	Servo enable status
25.5	FVAL_DONE	BOOL	On-the-fly setting of actual value completed
25.6			Reserved
25.7	POS_RCD	BOOL	Position reached. Stop.
26	NUM_MF	BYTE	M function number
27.0...27.3			Reserved
27.4	STR_MF	BOOL	M function strobe signal
27.5...33			Reserved
Initiation signals for single settings			
34.0	SERVO_EN	BOOL	Controller enable
34.1	GAUG_FLY	BOOL	On-the-fly measuring
34.2...34.4			Reserved
34.5	TRAV_MON	BOOL	Rotation monitoring
34.6	PARK_AX	BOOL	Parking axis
34.7	SIM_ON	BOOL	Simulation on
35.0...35.1			Reserved
35.2	MSR_EN	BOOL	Length measurement
35.3	REF_TRIG	BOOL	Retrigger reference point
35.4	DI_OFF	BOOL	Enable input disabled
35.5	FOLLOWUP	BOOL	Follow-up mode
35.6	SSW_DIS	BOOL	Software limit positions disabled
35.7	DRIFT_OFF	BOOL	Autom. drift compensation disabled
Initiation signals for single commands			
36			Reserved
37.0	MD_EN	BOOL	Activate MD
37.1	DELDIST_EN	BOOL	Delete residual distance
37.2	SEARCH_F	BOOL	Automatic block advance
37.3	SEARCH_B	BOOL	Automatic block return

Table C-1 User data block (AW–DB), Continued

Absolute address	Variable	Data Type	Comment
37.4			Reserved
37.5	RESET_AX	BOOL	Restart
37.6	AVALREM_EN	BOOL	Rescind setting of actual value
37.7			Reserved
Initiation signals for Write requests			
38.0	VLEV_EN	BOOL	Speed levels 1, 2
38.1	CLEV_EN	BOOL	Voltage/frequency levels 1, 2
38.2	TRG254_EN	BOOL	Setpoint for incremental dimension
38.3	MDI_EN	BOOL	MDI block
38.4	MDIFLY_EN	BOOL	On-the-fly MDI block
38.5			Reserved
38.6	REFPT_EN	BOOL	Set reference point
38.7	AVAL_EN	BOOL	Set actual value
39.0	FVAL_EN	BOOL	On-the-fly setting of actual value
39.1	ZOFF_EN	BOOL	Zero offset
39.2			Reserved
39.3	PARCH_EN	BOOL	Modify parameters/data
39.4	DIGO_EN	BOOL	Digital outputs
39.5	PROGS_EN	BOOL	Program selection
39.6	REQAPP_EN	BOOL	Request application data
39.7	TEACHIN_EN	BOOL	Teach-in
40.0	AXCOU_EN	BOOL	Coupled-axis grouping
40.1...41			Reserved
Initiation signals for Read requests			
42.0	OPDAT_EN	BOOL	Basic operating data
42.1	ACT_BL_EN	BOOL	Active NC block
42.2	NXT_BL_EN	BOOL	Next NC block
42.3	BLEXT_EN	BOOL	Actual value block change
42.4	SERVDAT_EN	BOOL	Service data
42.5	OC_ERR_EN	BOOL	Operating error no.
42.6...42.7			Reserved
43.0	AXCOURD_EN	BOOL	Coupled-axis grouping status
43.1...43.2			Reserved
43.3	PARRD_EN	BOOL	Parameter/data
43.4	DIGIO_EN	BOOL	Dig. inputs/outputs
43.5	OPDAT1_EN	BOOL	Additional operating data

Table C-1 User data block (AW–DB), Continued

Absolute address	Variable	Data Type	Comment
43.6	APPDAT_EN	BOOL	Application data
43.7	MSRRD_EN	BOOL	Read measured values
Ready signals (for Initiation signals, single settings)			
44.0	SERVO_D	BOOL	Controller enable
44.1	GAUG_FLY_D	BOOL	On-the-fly measuring
44.2...44.4			Reserved
44.5	TRAV_MON_D	BOOL	Rotation monitoring
44.6	PARK_AX_D	BOOL	Parking axis
44.7	SIM_ON_D	BOOL	Simulation on
45.0...45.1			Reserved
45.2	MSR_D	BOOL	Length measurement
45.3	REF_TRIG_D	BOOL	Retrigger reference point
45.4	DI_OFF_D	BOOL	Enable input disabled
45.5	FOLLOWUP_D	BOOL	Follow-up mode
45.6	SSW_DIS_D	BOOL	Software limit positions disabled
45.7	DRIFT_OFF_D	BOOL	Autom. drift compensation disabled
Ready signals (for Initiation signals, single commands)			
46			Reserved
47.0	MD_D	BOOL	Activate MD
47.1	DELDIST_D	BOOL	Delete residual distance
47.2	SEARCH_F_D	BOOL	Automatic block advance
47.3	SEARCH_B_D	BOOL	Automatic block return
47.4			Reserved
47.5	RESET_AX_D	BOOL	Restart
47.6	AVALREM_D	BOOL	Rescind setting of actual value
47.7			Reserved
Ready signals (for Initiation signals for Write requests)			
48.0	VLEV_D	BOOL	Speed levels 1, 2
48.1	CLEV_D	BOOL	Voltage/frequency levels 1, 2
48.2	TRG254_D	BOOL	Setpoint for incremental dimension
48.3	MDI_D	BOOL	MDI block
48.4	MDIFLY_D	BOOL	On-the-fly MDI block
48.5			Reserved
48.6	REFPT_D	BOOL	Set reference point
48.7	AVAL_D	BOOL	Set actual value
49.0	FVAL_D	BOOL	On-the-fly setting of actual value

Table C-1 User data block (AW–DB), Continued

Absolute address	Variable	Data Type	Comment
49.1	ZOFF_D	BOOL	Zero offset
49.2			Reserved
49.3	PARCH_D	BOOL	Modify parameters/data
49.4	DIGO_D	BOOL	Digital outputs
49.5	PROGS_D	BOOL	Program selection
49.6	REQAPP_D	BOOL	Request application data
49.7	TEACHIN_D	BOOL	Teach-in
50.0	AXCOU_D	BOOL	Coupled-axis grouping
50.1...51			Reserved
Ready signals (for Initiation signals for Read requests)			
52.0	OPDAT_D	BOOL	Basic operating data
52.1	ACT_BL_D	BOOL	Active NC block
52.2	NXT_BL_D	BOOL	Next NC block
52.3	BLEXT_D	BOOL	Actual value block change
52.4	SERVDAT_D	BOOL	Service data
52.5	OC_ERR_D	BOOL	Operating error read
52.6	OT_ERR_D	BOOL	Operator/traversing error read
52.7	DA_ERR_D	BOOL	Data error read
53.0	AXCOURD_D	BOOL	Coupled-axis grouping status
53.1...53.2			Reserved
53.3	PARRD_D	BOOL	Parameter/data
53.4	DIGIO_D	BOOL	Dig. inputs/outputs
53.5	OPDAT1_D	BOOL	Additional operating data
53.6	APPDAT_D	BOOL	Application data
53.7	MSRRD_D	BOOL	Read measured values
Error signals (for Initiation signals, single settings)			
54.0	SERVO_ERR	BOOL	Controller enable
54.1	GAUG_FLY_ERR	BOOL	On-the-fly measuring
54.2...54.4			Reserved
54.5	TRAV_MON_ERR	BOOL	Rotation monitoring
54.6	PARK_AX_ERR	BOOL	Parking axis
54.7	SIM_ON_ERR	BOOL	Simulation on
55.0...55.1			Reserved
55.2	MSR_ERR	BOOL	Length measurement
55.3	REF_TRIG_ERR	BOOL	Retrigger reference point
55.4	DI_OFF_ERR	BOOL	Enable input disabled

Table C-1 User data block (AW−DB), Continued

Absolute address	Variable	Data Type	Comment
55.5	FOLLOWUP_ERR	BOOL	Follow-up mode
55.6	SSW_DIS_ERR	BOOL	Software limit positions disabled
55.7	DRIFT_OFF_ERR	BOOL	Autom. drift compensation disabled
Error signals (for Initiation signals, single commands)			
56			Reserved
57.0	MD_ERR	BOOL	Activate MD
57.1	DELDIST_ERR	BOOL	Delete residual distance
57.2	SEARCH_F_ERR	BOOL	Automatic block advance
57.3	SEARCH_B_ERR	BOOL	Automatic block return
57.4			Reserved
57.5	RESET_AX_ERR	BOOL	Restart
57.6	AVALREM_ERR	BOOL	Rescind setting of actual value
57.7			Reserved
Error signals (for Initiation signals for Write requests)			
58.0	VLEV_ERR	BOOL	Speed levels 1, 2
58.1	CLEV_ERR	BOOL	Voltage/frequency levels 1, 2
58.2	TRG254_ERR	BOOL	Setpoint for incremental dimension
58.3	MDI_ERR	BOOL	MDI block
58.4	MDIFLY_ERR	BOOL	On-the-fly MDI block
58.5			Reserved
58.6	REFPT_ERR	BOOL	Set reference point
58.7	AVAL_ERR	BOOL	Set actual value
59.0	FVAL_ERR	BOOL	On-the-fly setting of actual value
59.1	ZOFF_ERR	BOOL	Zero offset
59.2			Reserved
59.3	PARCH_ERR	BOOL	Modify parameters/data
59.4	DIGO_ERR	BOOL	Digital outputs
59.5	PROGS_ERR	BOOL	Program selection
59.6	REQAPP_ERR	BOOL	Request application data
59.7	TEACHIN_ERR	BOOL	Teach-in
60.0	AXCOU_ERR	BOOL	Coupled-axis grouping
60.1...61			Reserved
Error signals (for Initiation signals for Read requests)			
62.0	OPDAT_ERR	BOOL	Basic operating data
62.1	ACT_BL_ERR	BOOL	Active NC block
62.2	NXT_BL_ERR	BOOL	Next NC block
62.3	BLEXT_ERR	BOOL	Actual value block change

Table C-1 User data block (AW–DB), Continued

Absolute address	Variable	Data Type	Comment
62.4	SERVDAT_ERR	BOOL	Service data
62.5	OC_ERR_ERR	BOOL	Operating error read
62.6	OT_ERR_ERR	BOOL	Operator/traversing error read
62.7	DA_ERR_ERR	BOOL	Data error read
63.0	AXCOURD_ERR	BOOL	Coupled-axis grouping status
63.1...63.2			Reserved
63.3	PARRD_ERR	BOOL	Parameter/data
63.4	DIGIO_ERR	BOOL	Dig. inputs/outputs
63.5	OPDAT1_ERR	BOOL	Additional operating data
63.6	APPDAT_ERR	BOOL	Application data
63.7	MSRRD_ERR	BOOL	Read measured values
64...65			Reserved
Processing status of FC POS_CTRL			
66	JOB_ERR	INT	Error code SFC 58/59 (FC POS_CTRL)
68.0	JOBBUSY_WR	BOOL	Write job active
68.1	IMPO_WR	BOOL	Write request not possible
68.2	JOBBUSY_RD	BOOL	Read job active
68.3	IMPO_RD	BOOL	Read request not possible
68.4...69.0			Reserved
69.1	JOBRESET	BOOL	Reset status/error
69.2...69.7			Reserved
Diagnosealarmdaten (POS_DIAG)			
70.0	MDL_DEFECT	BOOL	Module/group errors (coming and going)
70.1	INT_FAULT	BOOL	Internal error/hardware error (group error DBB72, 73)
70.2	EXT_FAULT	BOOL	External error
70.3	PNT_INFO	BOOL	External channel error (group error bytes 78, 80, 82)
70.4			Reserved
70.5	FLD_CONNCTR	BOOL	Front connector missing
70.6	NO_CONFIG	BOOL	Module not initialized
70.7			Reserved
71	MDL_TYPE	BYTE	Module type class for FM 453 = 08H / Channel information available
72.0			Reserved
72.1	COMM_FAULT	BOOL	Communication error (K bus)
72.2			Reserved
72.3	WTCH_DOG_FLT	BOOL	Response from watchdog timer

Table C-1 User data block (AW−DB), Continued

Absolute address	Variable	Data Type	Comment
72.4	INT_PS_FLT	BOOL	Internal supply voltage to the module failed (NMI)
72.5...73.1			Reserved
73.2	EPROM_FLT	BOOL	FEPROM error
73.3	RAM_FLT	BOOL	RAM error
73.4...73.5			Reserved
73.6	HW_INTR_FLT	BOOL	Process interrupt lost
73.7			Reserved
74	POS_ID	BYTE	FM pos. ID (74H)
75	LEN_INFO	BYTE	Length of the diagnostic information (16)
76	CHEN_NO	BYTE	Number of channels (3)
77.0	CH_ERR_VE1	BOOL	Channel error vector 1
77.1	CH_ERR_VE2	BOOL	Channel error vector 2
77.2	CH_ERR_VE3	BOOL	Channel error vector 3
77.3...77.7			Reserved
78.0	CAB_BR1	BOOL	Cable break (incremental position encoder) for channel 1
78.1	ERR_ABE1	BOOL	Error in absolute position encoder for channel 1
78.2	ERR_PU1	BOOL	No increm. Error pulses or zero mark for channel 1
78.3	VO_ENC1	BOOL	Voltage monitor f. sensor for channel 1
78.4	VO_15_1	BOOL	Voltage monitor ± 15 V for channel 1
78.5	VO_DIO1	BOOL	Voltage monitor f. digital outputs for channel 1
78.6			Reserved
78.7	OC_ERR_EN1	BOOL	Operating error for channel 1
79			Reserved
80.0	CAB_BR2	BOOL	Cable break (incremental position encoder) for channel 2
80.1	ERR_ABE2	BOOL	Error in absolute position encoder for channel 2
80.2	ERR_PU2	BOOL	No increm. Error pulses or zero mark for channel 2
80.3	VO_ENC2	BOOL	Voltage monitor f. sensor for channel 2
80.4	VO_15_2	BOOL	Voltage monitor ± 15 V for channel 2
80.5	VO_DIO2	BOOL	Voltage monitor f. digital outputs for channel 2
80.6			Reserved
80.7	OC_ERR_EN2	BOOL	Operating error for channel 2
81			Reserved
82.0	CAB_BR3	BOOL	Cable break (incremental position encoder) for channel 3
82.1	ERR_ABE3	BOOL	Error in absolute position encoder for channel 3

Table C-1 User data block (AW−DB), Continued

Absolute address	Variable	Data Type	Comment
82.2	ERR_PU3	BOOL	No increm. Error pulses or zero mark for channel 3
82.3	VO_ENC3	BOOL	Voltage monitor f. sensor for channel 3
82.4	VO_15_3	BOOL	Voltage monitor ± 15 V for channel 3
82.5	VO_DIO3	BOOL	Voltage monitor f. digital outputs for channel 3
82.6			Reserved
82.7	OC_ERR_EN3	BOOL	Operating error for channel 3
83...85			Reserved
86	OC_ERR_NO	BYTE	Error number (DS 164) − Detail event class
87	OC_REE_CL	BYTE	Error number (DS 164) − Detail event number
88...89			Reserved
90	OT_ERR_NO	BYTE	Error number (DS 162) − Detail event class
91	OT_ERR_CL	BYTE	Error number (DS 162) − Detail event number
92...93			Reserved
94	DA_ERR_NO	BYTE	Error number (DS163) − Detail event class
95	DA_ERR_CL	BYTE	Error number (DS163) − Detail event number
96	DIAG_ERR	INT	Error code for POS_DIAG (return code SFC 51)
98	MSRM_ERR	INT	Error code for POS_MSRM (return code SFC 59)
100		ARRAY [100 ..139] BYTE	Internal, Reserved
Data for the requests			
140	ZOFF	DINT	Zero offset
144	AVAL	DINT	Set actual value
148	FVAL	DINT	On-the-fly setting of actual value
152	REFPT	DINT	Set reference point
156	TRG254	DWORD	Setpoint for incremental dimension
160	VLEVEL_1	DWORD	Speed level 1
164	VLEVEL_2	DWORD	Speed level 2
168	CLEVEL_1	DWORD	Voltage-/frequency level 1
172	CLEVEL_2	DWORD	Voltage-/frequency level 2
MDI block			
176	MDIB	STRUCT	MDI block
+ 0...+1			Reserved
+ 2.0	G_1_EN	BOOL	G function group 1
+ 2.1	G_2_EN	BOOL	G function group 2
+ 2.2...+ 2.3			Reserved
+ 2.4	X_T_EN	BOOL	Position/ dwell

Table C-1 User data block (AW−DB), Continued

Absolute address	Variable	Data Type	Comment
+ 2.5...+ 2.7			Reserved
+ 3.0	V_EN	BOOL	Speed
+ 3.1	M_1_EN	BOOL	M function group 1
+ 3.2	M_2_EN	BOOL	M function group 2
+ 3.3	M_3_EN	BOOL	M function group 3
+ 3.4...+ 3.7			Reserved
+ 4	G_1_VAL	BYTE	G function no. of group 1
+ 5	G_2_VAL	BYTE	G function no. of group 2
+ 6...+ 7			Reserved
+ 8	X_T_VAL	DINT	Value for position/dwell
+ 12	V_VAL	DINT	Value for speed
+ 16	M_1_VAL	BYTE	M function no. of group 1
+ 17	M_2_VAL	BYTE	M function no. of group 2
+ 18	M_3_VAL	BYTE	M function no. of group 3
+ 19			Reserved
		END_STRUCT	
Modify parameter/data			
196	PAR_CHAN	STRUCT	Modify parameter/data
+ 0	TYP	BYTE	DB type
+ 1	NUMB	BYTE	Number
+ 2	COUN	BYTE	Quantity
+ 3	JOB	BYTE	Request
+ 4	DATA	ARRAY [200 ..219] BYTE	Data array, structure/data type of Write data as per bytes 1 to 4 of this structure
		END_STRUCT	
Digital inputs/outputs (for read and write)			
220.0	D_IN0	BOOL	Digital input 0
220.1	D_IN1	BOOL	Digital input 1
220.2	D_IN2	BOOL	Digital input 2
220.3	D_IN3	BOOL	Digital input 3
220.4...7			Reserved
221.0	D_OUT0	BOOL	Digital output 0
221.1	D_OUT1	BOOL	Digital output 1
221.2	D_OUT2	BOOL	Digital output 2
221.3	D_OUT3	BOOL	Digital output 3

Table C-1 User data block (AW–DB), Continued

Absolute address	Variable	Data Type	Comment
221.4...7			Reserved
On-the-fly MDI block			
222	MDI_F	STRUCT	On-the-fly MDI block
+ 0...+ 1			Reserved
+ 2.0	G_1_EN	BOOL	G function group 1
+ 2.1	G_2_EN	BOOL	G function group 2
+ 2.2...+ 2.3			Reserved
+ 2.4	X_T_EN	BOOL	Position/dwell
+ 2.5...+ 2.7			Reserved
+ 3.0	V_EN	BOOL	Speed
+ 3.1	M_1_EN	BOOL	M function group 1
+ 3.2	M_2_EN	BOOL	M function group 2
+ 3.3	M_3_EN	BOOL	M function group 3
+ 3.4...+ 3.7			Reserved
+ 4	G_1_VAL	BYTE	G function no. of group 1
+ 5	G_2_VAL	BYTE	G function no. of group 2
+ 6...+ 7			Reserved
+ 8	X_T_VAL	DINT	Value for position/dwell
+ 12	V_VAL	DINT	Value for speed
+ 16	M_1_VAL	BYTE	M function no. of group 1
+ 17	M_2_VAL	BYTE	M function no. of group 2
+ 18	M_3_VAL	BYTE	M function no. of group 3
+ 19			Reserved
		END_STRUCT	
Program selection			
242	PROG_NO	BYTE	Program number
243	BLCK_NO	BYTE	Block number
244	PROG_DIR	BYTE	Direction of processing
245			Reserved
Request for application data			
246	CODE_AP1	BYTE	Application data 1
247	CODE_AP2	BYTE	Application data 2
248	CODE_AP3	BYTE	Application data 3
249	CODE_AP4	BYTE	Application data 4
Teach-in			
250	TEA_PROG_NO	BYTE	Program number

Table C-1 User data block (AW−DB), Continued

Absolute address	Variable	Data Type	Comment
251	TEA_BLCK_NO	BYTE	Block number
252	AXCOUDEF	BYTE	Define coupled-axis grouping
253		BYTE	Reserved for coupled-axis grouping
254	FELD2_INTERN	ARRAY [254...309] BYTE	Internal, Reserved
Basic operating data			
310	ACT_VAL	DINT	Actual position
314	SPEED	DWORD	Actual speed
318	REM_DIST	DINT	Residual distance
322	SET_POS	DINT	Setpoint position
326	SUM_OFST	DINT	Sum of active coordinate offset, tool offset, zero offset
330	TRAV_SPE	DWORD	Rotational speed
334...338			Reserved
Active NC block			
342	ACT_BL	STRUCT	Active NC block
+ 0	PROG_NO	BYTE	Program number
+ 1	BLCK_NO	BYTE	Block number
+ 2.0	G_1_EN	BOOL	G function group 1
+ 2.1	G_2_EN	BOOL	G function group 2
+ 2.2	G_3_EN	BOOL	G function group 3
+ 2.3			Reserved
+ 2.4	X_T_EN	BOOL	Position/dwell
+ 2.5	SR_L_EN	BOOL	No. of UP calls
+ 2.6	SR_N_EN	BOOL	UP call
+ 2.7	SKIP_EN	BOOL	Block skip
+ 3.0	V_EN	BOOL	Speed
+ 3.1	M_1_EN	BOOL	M function group 1
+ 3.2	M_2_EN	BOOL	M function group 2
+ 3.3	M_3_EN	BOOL	M function group 3
+ 3.4	TO_EN	BOOL	Tool offset
+ 3.5...+ 3.7			Reserved
+ 4	G_1_VAL	BYTE	G function no. of group 1
+ 5	G_2_VAL	BYTE	G function no. of group 2
+ 6	G_3_VAL	BYTE	G function no. of group 3
+ 7			Reserved

Table C-1 User data block (AW−DB), Continued

Absolute address	Variable	Data Type	Comment
+ 8	X_T_VAL	DINT	Value for position/dwell
+ 12	V_VAL	DINT	Value for speed
+ 16	M_1_VAL	BYTE	M function no. of group 1
+ 17	M_2_VAL	BYTE	M function no. of group 2
+ 18	M_3_VAL	BYTE	M function no. of group 3
+ 19	TO_VAL	BYTE	Tool offset no.
		END_STRUCT	
Next NC block			
362	NXT_BL	STRUCT	Next NC block
+ 0	PROG_NO	BYTE	Program number
+ 1	BLCK_NO	BYTE	Block number
+ 2.0	G_1_EN	BOOL	G function group 1
+ 2.1	G_2_EN	BOOL	G function group 2
+ 2.2	G_3_EN	BOOL	G function group 3
+ 2.3			Reserved
+ 2.4	X_T_EN	BOOL	Position/dwell
+ 2.5	SR_L_EN	BOOL	No. of UP calls
+ 2.6	SR_N_EN	BOOL	UP call
+ 2.7	SKIP_EN	BOOL	Block skip
+ 3.0	V_EN	BOOL	Speed
+ 3.1	M_1_EN	BOOL	M function group 1
+ 3.2	M_2_EN	BOOL	M function group 2
+ 3.3	M_3_EN	BOOL	M function group 3
+ 3.4	TO_EN	BOOL	Tool offset
+ 3.5...+ 3.7			Reserved
+ 4	G_1_VAL	BYTE	G function no. of group 1
+ 5	G_2_VAL	BYTE	G function no. of group 2
+ 6	G_3_VAL	BYTE	G function no. of group 3
+ 7			Reserved
+ 8	X_T_VAL	DINT	Value for position/dwel
+ 12	V_VAL	DINT	Value for speed
+ 16	M_1_VAL	BYTE	M function no. of group 1
+ 17	M_2_VAL	BYTE	M function no. of group 2
+ 18	M_3_VAL	BYTE	M function no. of group 3
+ 19	TO_VAL	BYTE	Tool offset no.
		END_STRUCT	

Table C-1 User data block (AW–DB), Continued

Absolute address	Variable	Data Type	Comment
Application data			
382	APP1	DINT	Application data 1
386	APP2	DINT	Application data 2
390	APP3	DINT	Application data 3
394	APP4	DINT	Application data 4
Actual value block change			
398	BLCK_EXT	DINT	Actual value block change
Service data			
402	OUT_VAL	DINT	DAO output value or frequency output value
406	ENC_VAL	DINT	Actual sensor value or pulse output counter
410	PULS_ERR	DINT	Missing pulses
414	KV_FA	DINT	K_v factor
418	FOLL_ERR	DINT	Following error or difference between setpoint and actual position
422	FERR_LIM	DINT	Following error limit
426	OSC_ERR	DINT	Setpoint overshoot value/switch adjustment
430	DR_TIME	DINT	Approach time/response time constant
Additional operating data			
434	OVERRIDE1	BYTE	Override
435	PROG_NO1	BYTE	NC traversing program no.
436	BLCK_NO1	BYTE	NC block no.
437	LOOP_NO1	BYTE	UP call counter
438	G90_91	BYTE	Active G90/91
439	G60_64	BYTE	Active G60/64
440	G43_44	BYTE	Active G43/44
441	TO_NO	BYTE	Active D number
442.0			Reserved
442.1	LIM_SP	BOOL	Speed limit
442.2	LIM_10	BOOL	Limited to ±10 V
442.3	LIM_SU	BOOL	Acceleration/deceleration limit
442.4... 445			Reserved
Parameter/data			
446	PAR_RD	STRUCT	Parameter/data
+ 0	TYP	BYTE	DB type
+ 1	NUMB	BYTE	Number
+ 2	COUN	BYTE	Quantity
+ 3	JOB	BYTE	Request

Table C-1 User data block (AW−DB), Continued

Absolute address	Variable	Data Type	Comment
+ 4	DATA1	ARRAY [450 ..469] BYTE	Array, structure/data type according to data, to be read as per bytes 1 to 4 of this structure
		END_STRUCT	
470	AXCOU_ST	BYTE	Coupled-axis grouping status
471		BYTE	Reserved for coupled-axis grouping
472		ARRAY [472...485] BYTE	Internal, Reserved
Measured values			
486	BEGIN_VAL	DINT	Initial value or on-the-fly measured value
490	END_VAL	DINT	Final value
494	LENGTH_VAL	DWORD	Measured length value
Operator control and monitoring			
498	USR	STRUCT	Operator control and monitoring
+ 0.0	BITC_0	BOOL	Write MD
+ 0.1	BITC_1	BOOL	Read MD
+ 0.2	BITC_2	BOOL	MDI block transferred
+ 0.3	BITC_3	BOOL	Prog. sel. transferred
+ 0.4	BITC_4	BOOL	Teach-in transferred
+ 0.5	BITC_5	BOOL	Incremental dimension transferred
+ 0.6	BITC_6	BOOL	Speed levels transferred
+ 0.7	BITC_7	BOOL	Voltage/frequency levels transferred
+ 1.0	BITC_8	BOOL	MDI block transferred on-the-fly
+ 1.1	BITC_9	BOOL	Set actual value transferred
+ 1.2	BITC_10	BOOL	Zero offset transferred
+ 1.3...+ 1.4			Reserved
+ 1.5	BITC_13	BOOL	Diagnostic interrupt
+ 1.6	BITC_14	BOOL	Data error
+ 1.7	BITC_15	BOOL	Operator/traversing error
+ 2	MD_NO	WORD	MD number
+ 4	MD_VALUE	DINT	MD value
+ 8	INC_NO	BYTE	Incremental dimension number
+ 9			Reserved
+ 10	PICT_NO	WORD	Display number
+ 12	KEY_CODE	WORD	Keyboard code
+ 14...+15			Reserved
+ 16.0	BITA_0	BOOL	Open-loop control mode

Table C-1 User data block (AW–DB), Continued

Absolute address	Variable	Data Type	Comment
+ 16.1	BITA_1	BOOL	Approach to reference point
+ 16.2	BITA_2	BOOL	Incremental mode (relative)
+ 16.3	BITA_3	BOOL	MDI
+ 16.4	BITA_4	BOOL	Auto/single block mode
+ 16.5	BITA_5	BOOL	Auto mode
+ 16.6	BITA_6	BOOL	Jog mode
+ 16.7... +17.5			Reserved
+ 17.6	BITA_14	BOOL	Acknowledge error
+ 17.7	BITA_15	BOOL	Acknowledge diagnostic interrupt
		END_STRUCT	

D List of Abbreviations

AS	Automation system
BA	Mode
BA “A/AE”	“Automatic/Automatic single block” mode
BA “REF”	“Reference point approach” mode
BA “SM”	“Incremental approach” mode
BA “STE”	“Open-loop control” mode
BA “T”	“Jogging” mode
BP	Mode parameter
BR	Binary result
CPU	Central Processing Unit of the SIMATIC S7
DAC	Digital-analog converter
DB	Data block
DBB	Data block byte
DB-MD	Data block for machine data
DB-NC	Data block for traversing programs
DB-SM	Data block for increments
DB-SS	Data block for status messages
DB-WK	Data block for tool offset data
DBX	Data block bit
DEKL	Detail event class
DENR	Detail event number
DFC	Digital-frequency converter
DP	Distributed I/O
EMC	Electromagnetic compatibility
EN	Enable (input parameter in LAD representation)
ENO	Enable output (output parameter in LAD representation)
EPROM	Erasable programmable read-only memory
ESD	Electrostatic sensitive device
EXE	External pulse shaper
FB	Function block
FC	Function

FEPROM	Flash EPROM: read/write memory
FM	Function module
HEX	Hexadecimal
HMI	Device for operating and monitoring of a process
I	Input parameter
IM	Interface module (SIMATIC S7)
I/Q	Throughput parameter (initialization parameter)
LAD	Ladder program
LED	Light emitting diode
MDI	Manual data input
MLFB	Machine-readable order designation
MPI	Multi point interface
MSR	Measurement system raster
OB	Organization block
OP	Operator panel
PEH	Position reached, stop
PG	Programming device
PLC	Programmable controller
PS	Power Supply (SIMATIC S7)
PWM	Pulse width modulation
Q	Output parameter
RFG	Controller enable
RPS	Reference point switch
S7-400	PLC of medium performance range
SDB	System data block
SFC	System function call (integrated functions)
SM	Signal module (SIMATIC S7, e.g. input/output module)
SSI	Synchronous Serial Interface
STEP 7	Programming device software for SIMATIC S7
STL	Statement list
SZL	System status list
TF	Technology function
UP	User program

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