SIEMENS

SIMATIC

FM 453 Servo Drive / Step Drive Positioning Module

Manual

This manual is a component part of the
FM 453 configuration package with the order number
6ES7 453-3AH00-7EG0

C79000-G7076-C453-01

Safety guidelines

This manual contains notices intended to ensure personal safety, as well as to protect the products and connected equipment against damage. These notices are highlighted by the symbols shown below and graded according to severity by the following texts:

Danger

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

Warning

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

Caution

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

Note

draws your attention to particularly important information on the product, handling the product, or to a particular part of the documentation.

Qualified Personnel

The device/system may only be set up and operated in conjunction with this manual.

Only **qualified personnel** should be allowed to install and work on this equipment. Qualified persons are defined as persons who are authorized to commission, to ground, and to tag circuits, equipment, and systems in accordance with established safety practices and standards.

Correct Usage

Note the following:

Warning

This device and its components may only be used for the applications described in the catalog or the technical description, and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens.

This product can only function correctly and safely if it is transported, stored, set up, and installed correctly, and operated and maintained as recommended.

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Siemens AG
Bereich Automatisierungstechnik
Industrial Automation Systems
Postfach 4848, D-90327 Nürnberg

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.

CE Marking

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

The EC Declarations of Conformity are held at the address below, where they can be obtained if and when required by the respective authorities in accordance with Article 10 of the EC Guideline referenced above:

SIEMENS Aktiengesellschaft
Bereich Automatisierungstechnik
AUT E 148
Postfach 1963
D–92209 Amberg
Federal Republic of Germany

Additional Assistance

If you should encounter any problems using this manual, or if you have any questions, please contact the office specified on the query form at the end of this manual.

Hotline

If you have an urgent problem, please contact:

Test Hotline, +49 911 / 895 – 7000

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Product Summary

1

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.

Chapter Overview

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.

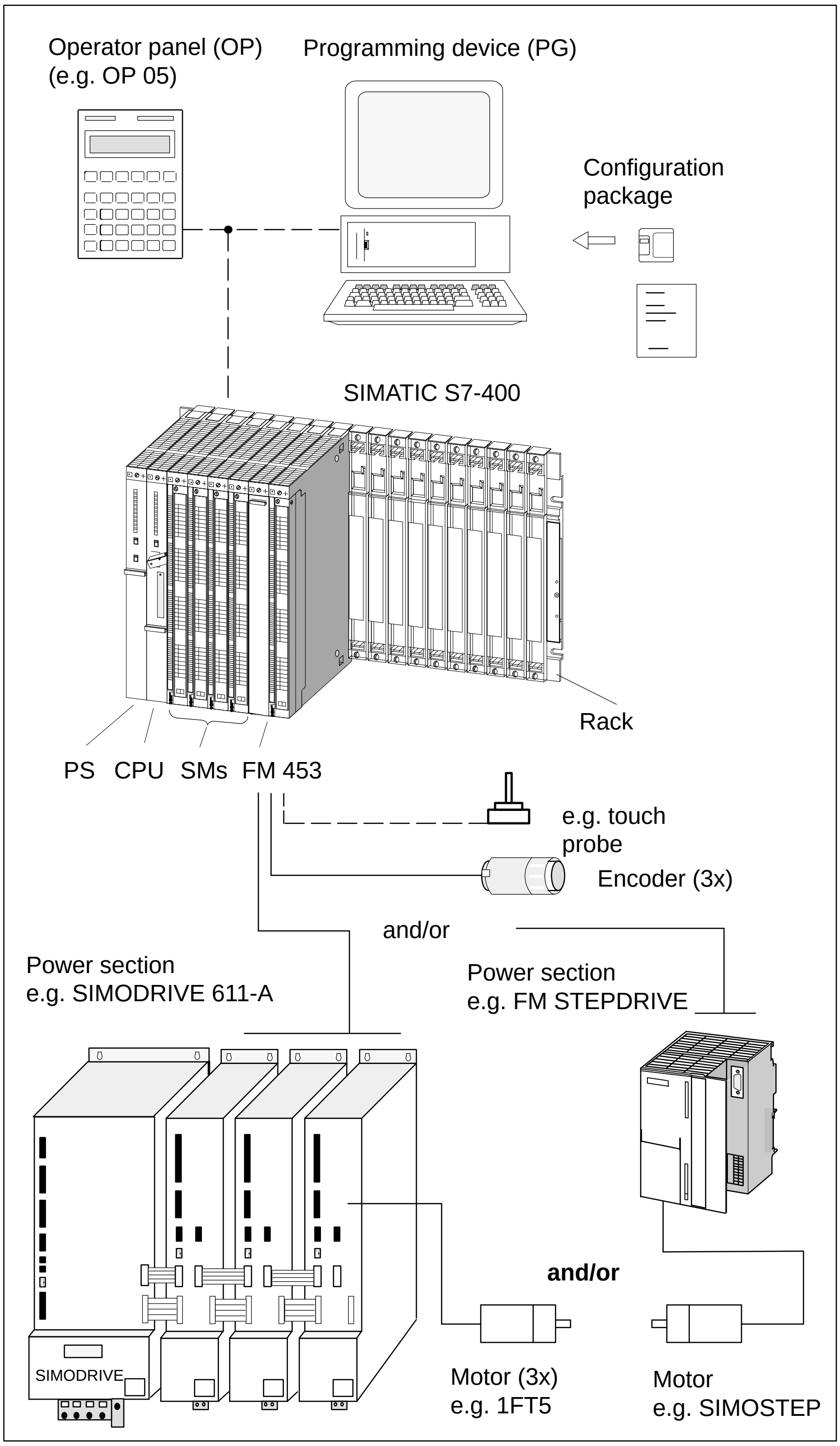


Fig. 1-1 System Overview (schematic)

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	... includes: • A manual • 3 1/2” diskette with: – Function-block package FCs. – The “Parameterize FM 453” parameterization tool. – Preconfigured interface for the COROS device OP 17.

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.

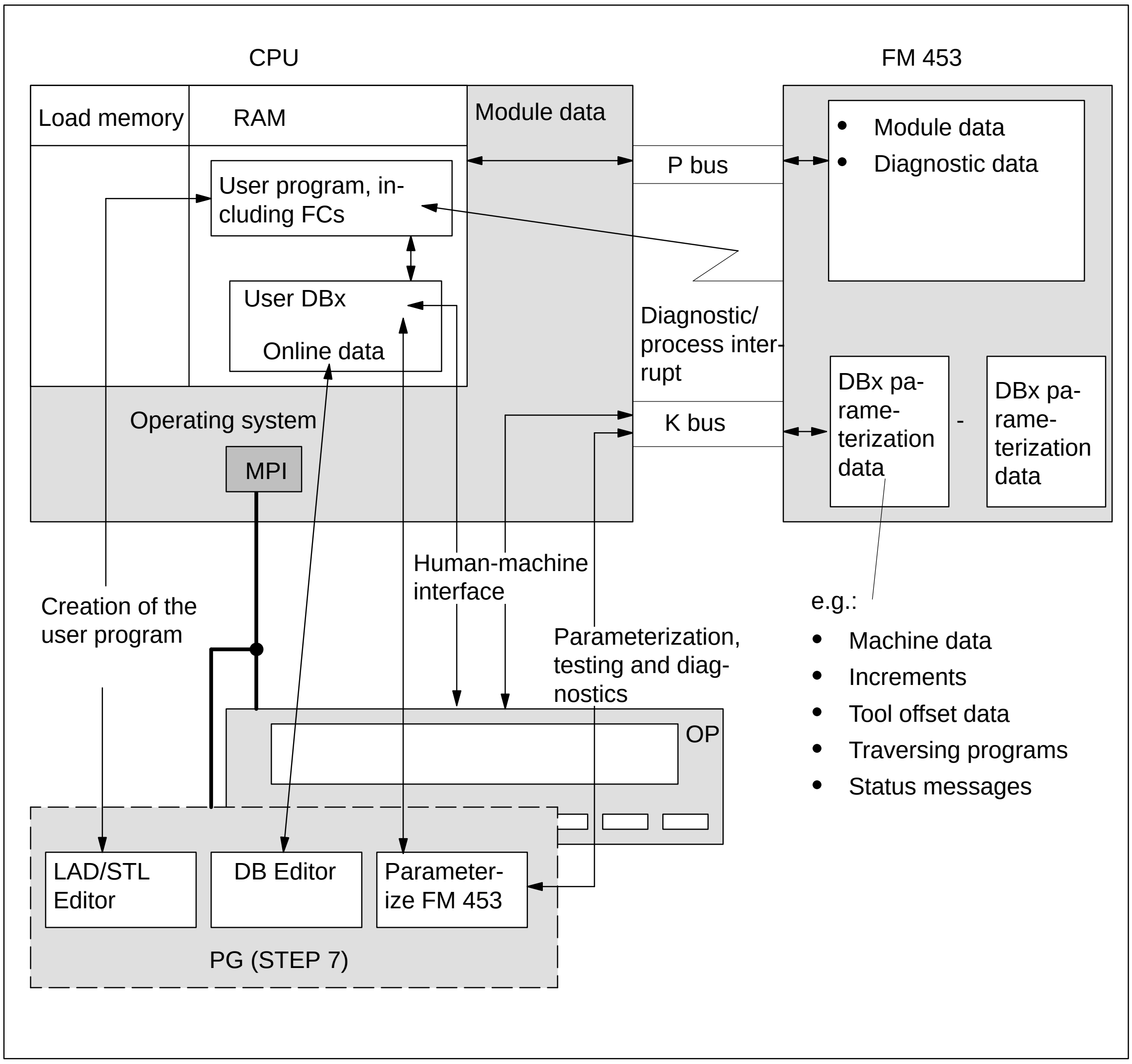


Fig. 1-2 Data Storage Concept

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).

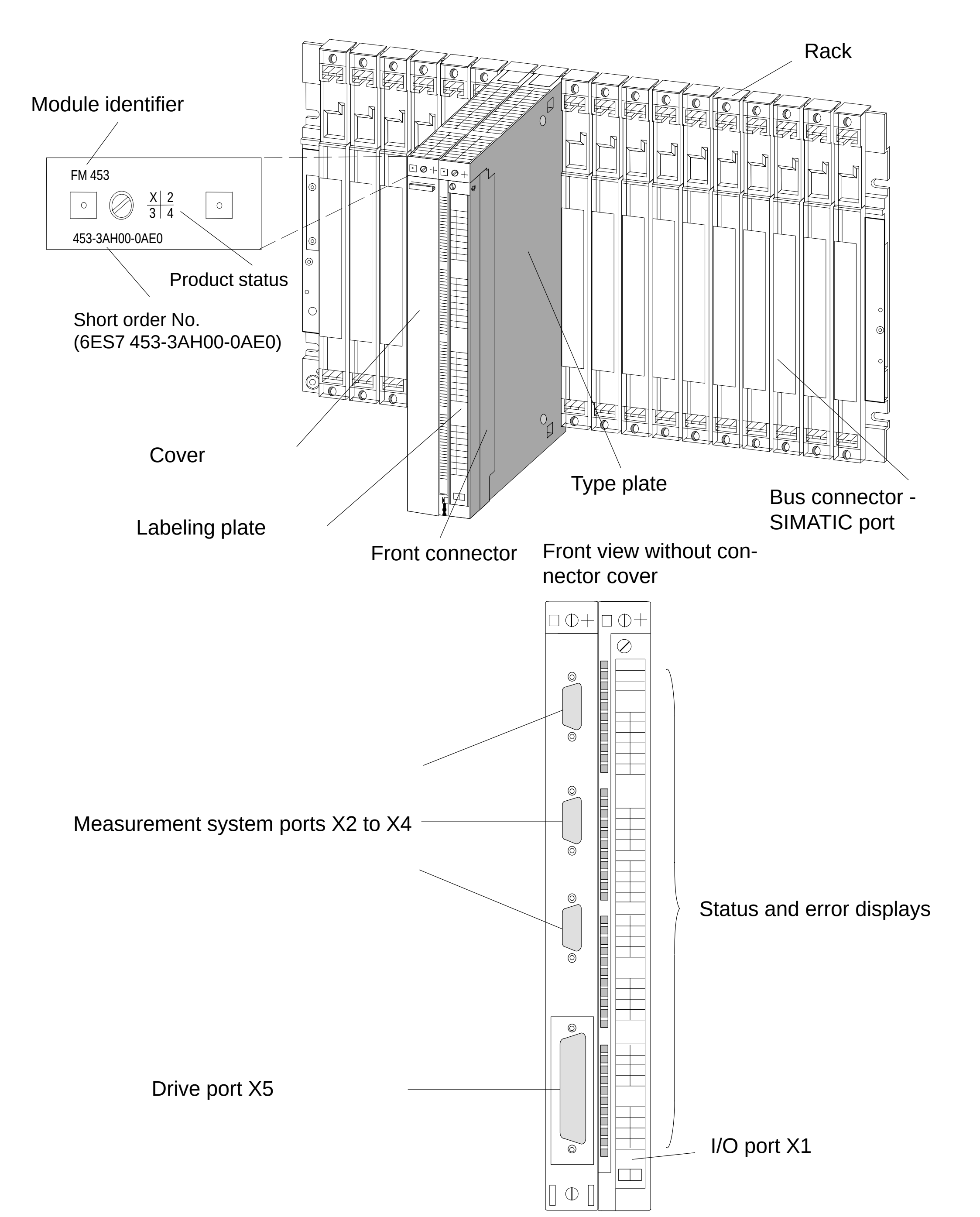


Fig. 1-3 View of the Ports and Front-Panel Elements

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.

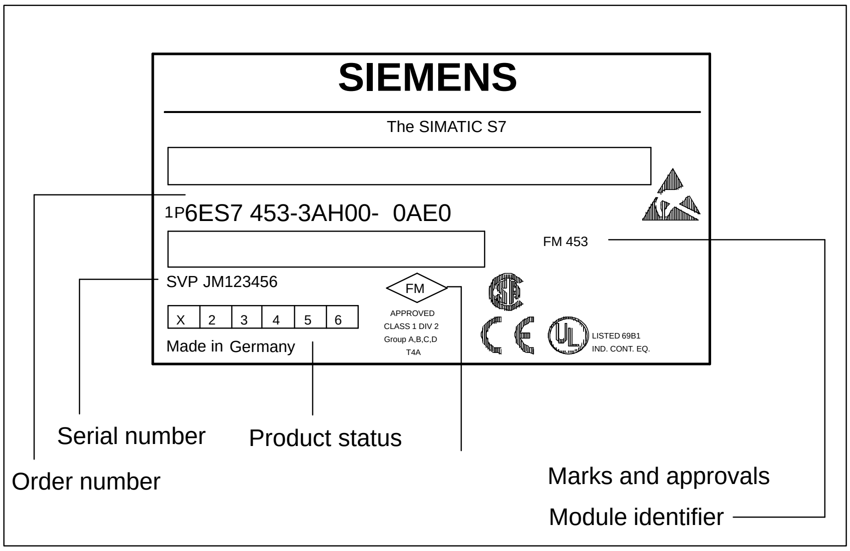


Fig. 1-4 Type Plate of the FM 453

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.

Basic Principles of Positioning

2

What Is Positioning?

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

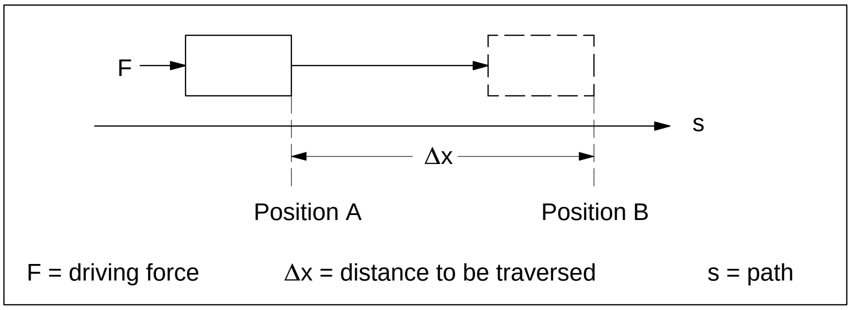


Fig. 2-1 Principle of a Positioning Action

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 ± 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.

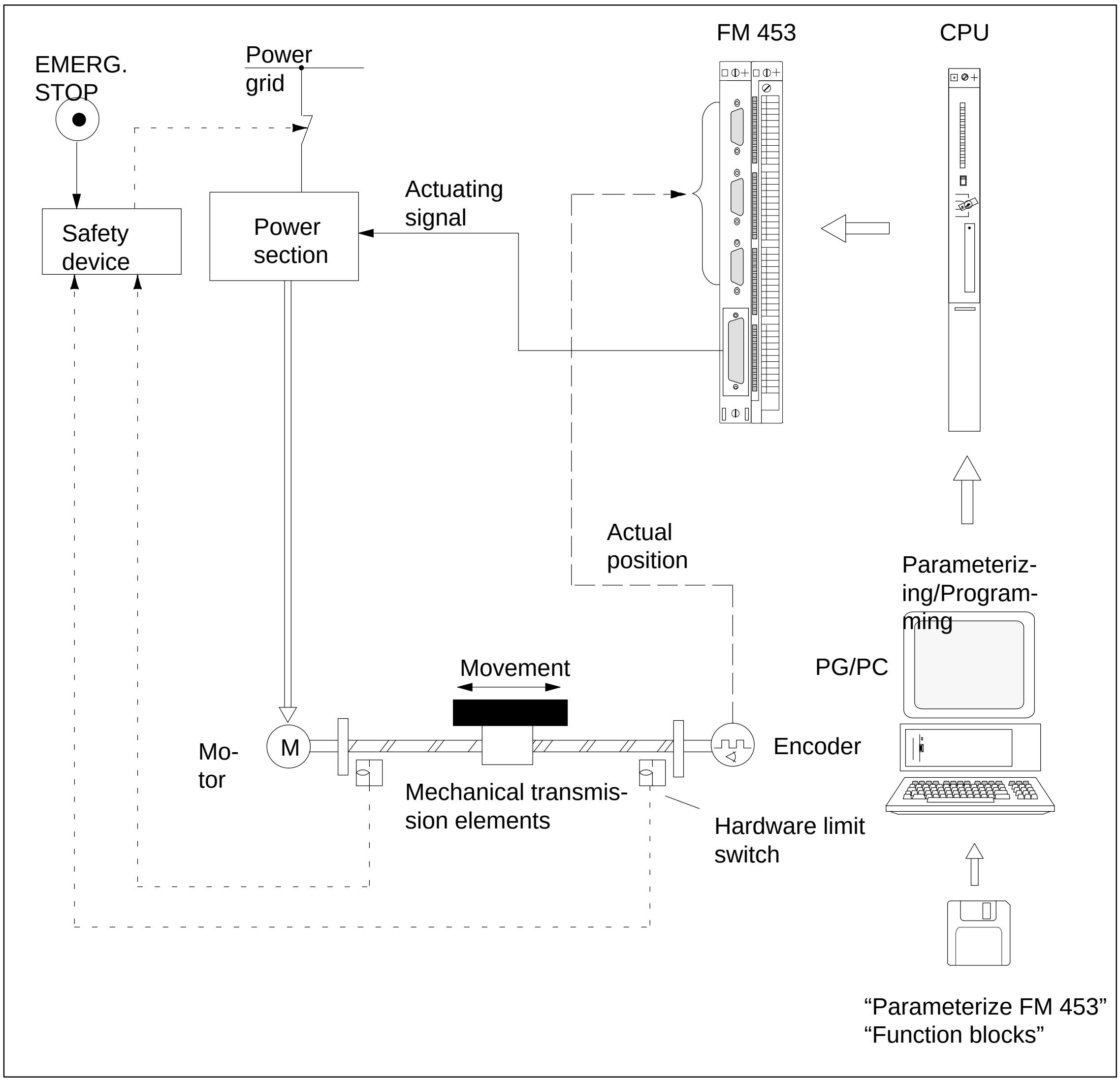


Fig. 2-2 Setup for Positioning (example)

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

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.

Chapter Overview

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 $\geq$ 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

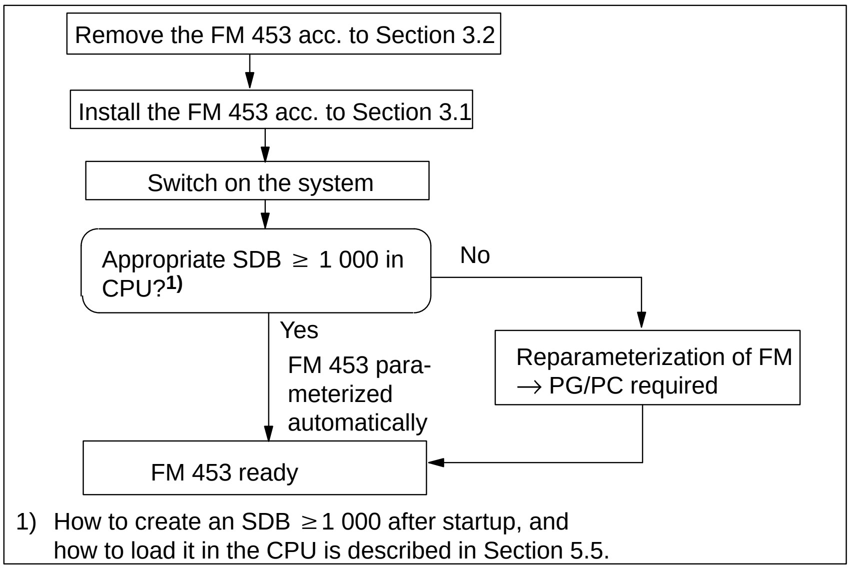


Fig. 3-1 Replacing the FM 453 with the System Switched Off

2. Replacing the FM 453 with the system switched on

   CPU is at “STOP”: → see 1.

   CPU remains in “RUN”:

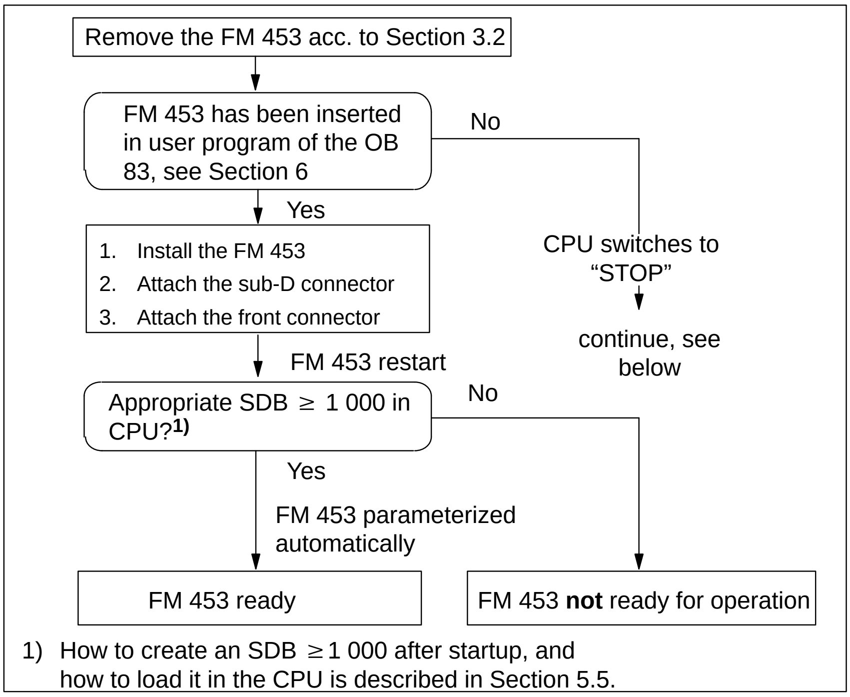


Fig. 3-2 Replacing the FM 453 with the System Switched On

Wiring the FM 453 4

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*:

- 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.

Chapter Overview

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.

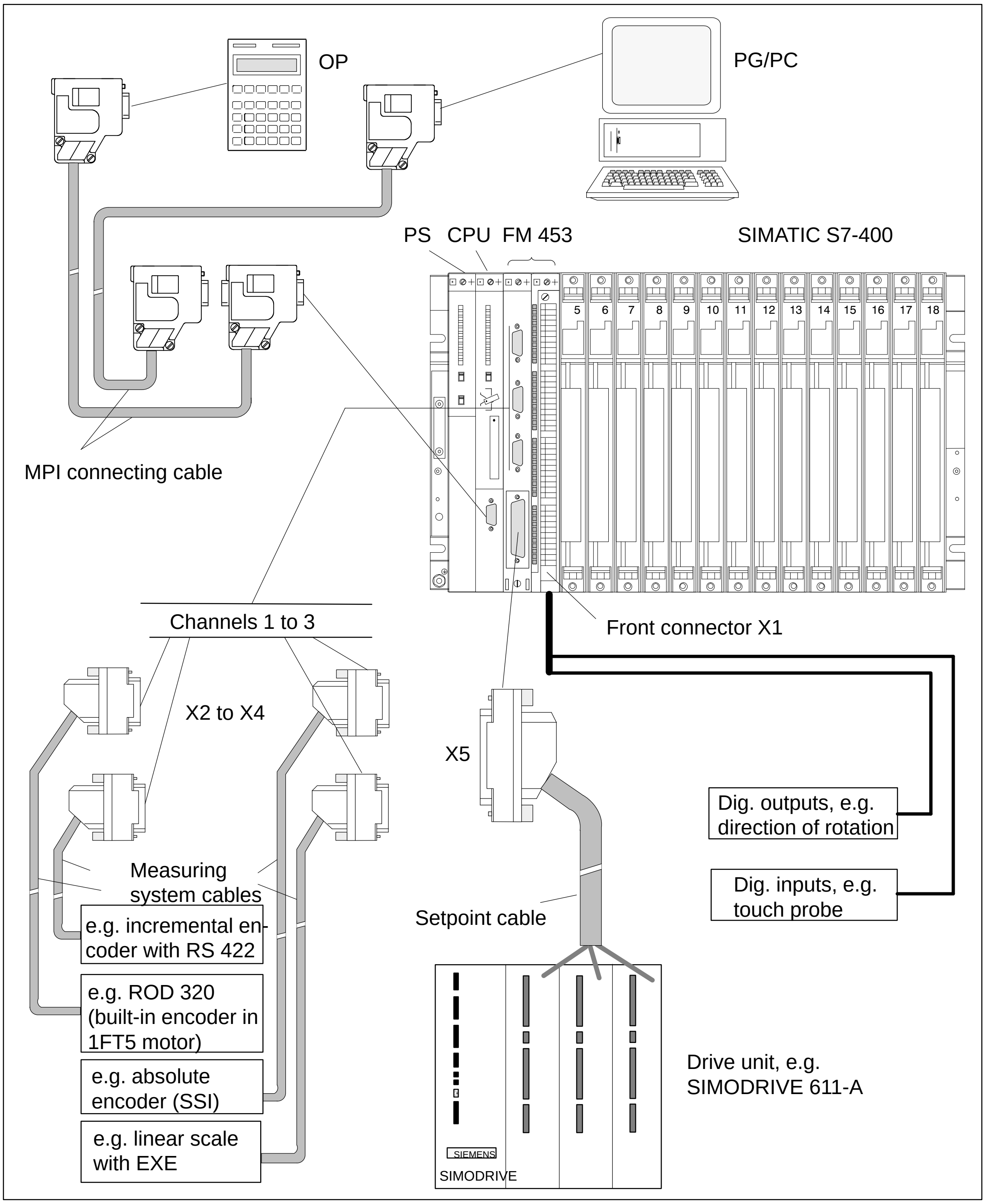


Fig. 4-1 Overview of Connecting Cables for a FM 453 with Servo Drive (example)

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.

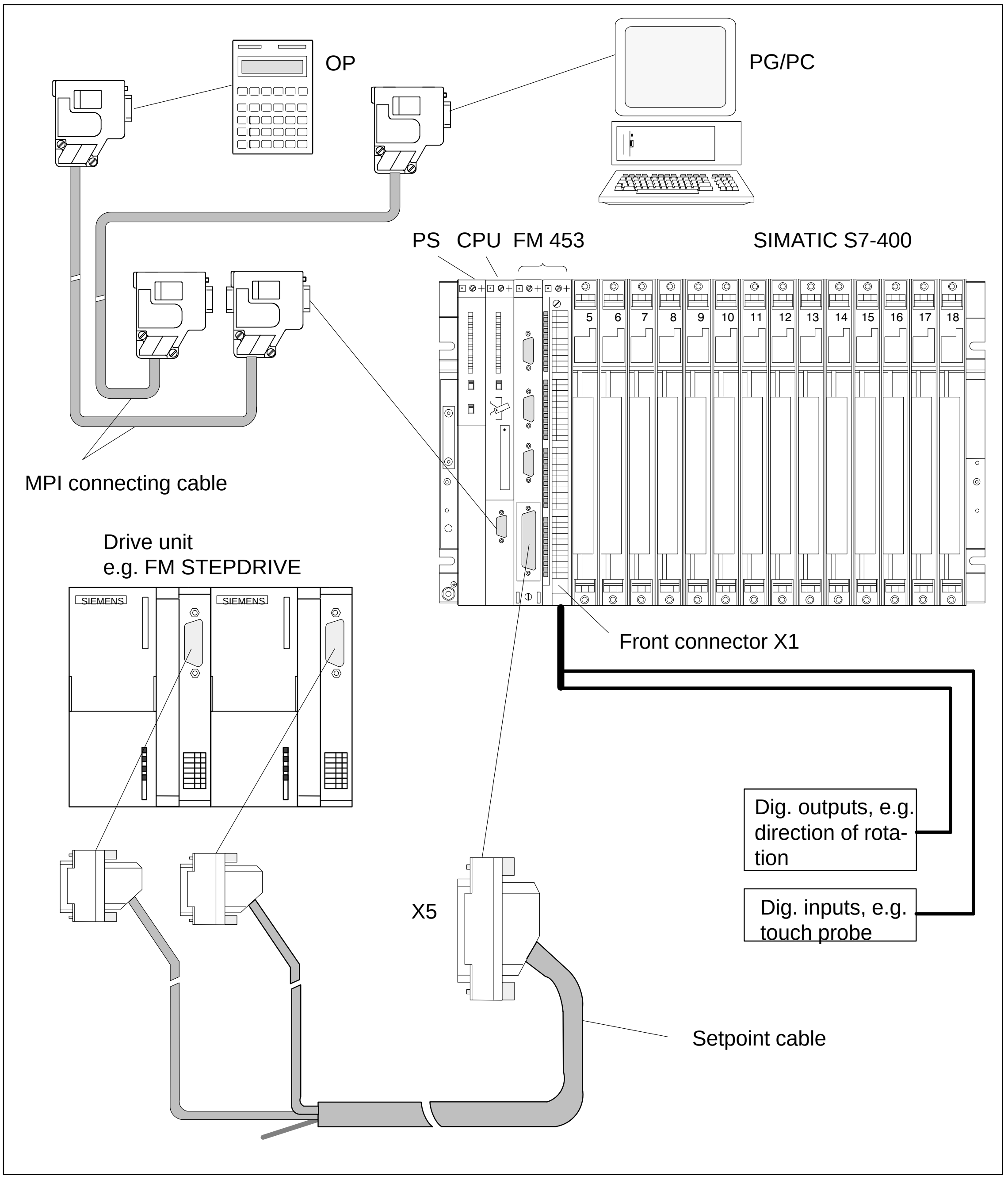


Fig. 4-2 Overview of Connecting Cables for an FM 453 with Step Drive (example)

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-A2	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-A4	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-A4	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-A4	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-A4	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-A2

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.

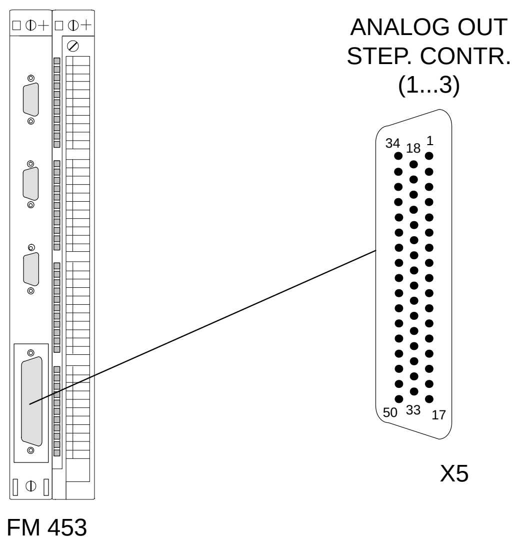


Fig. 4-3 Position of X5 Connector

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	M		38	PULSE1_N	O
6	DIR1	O	23	M		39	DIR1_N	O
7	PULSE2_N	O	24	M		40	PULSE2	O
8	DIR2_N	O	25	M		41	DIR2	O
9	PULSE3	O	26	ENABLE3	I	42	PULSE3_N	O
10	DIR3	O	27	ENABLE3_N	I	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
M — 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 of the power section. The signal is activated via the user program of the CPU.

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

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.

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.

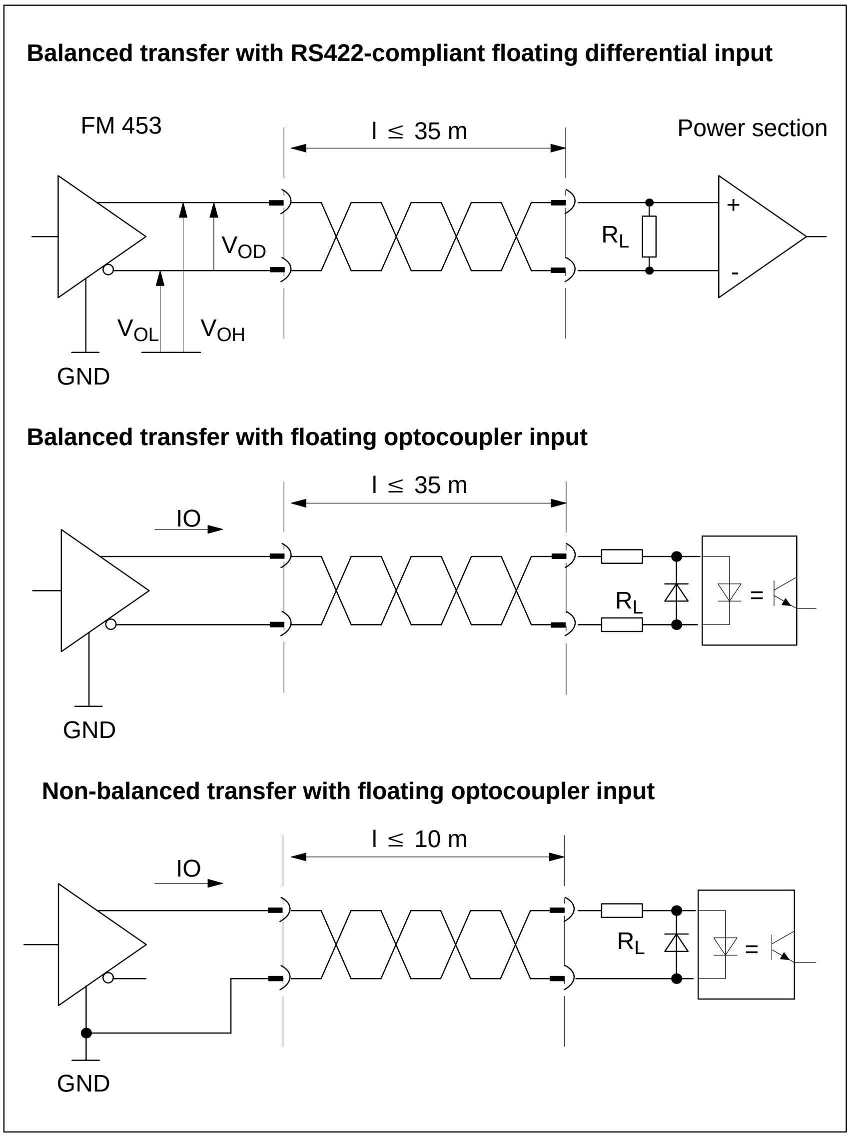


Fig. 4-4 Connection Options for Drive Port Output Signals

Signal Connection for the "READY1_N" Input

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

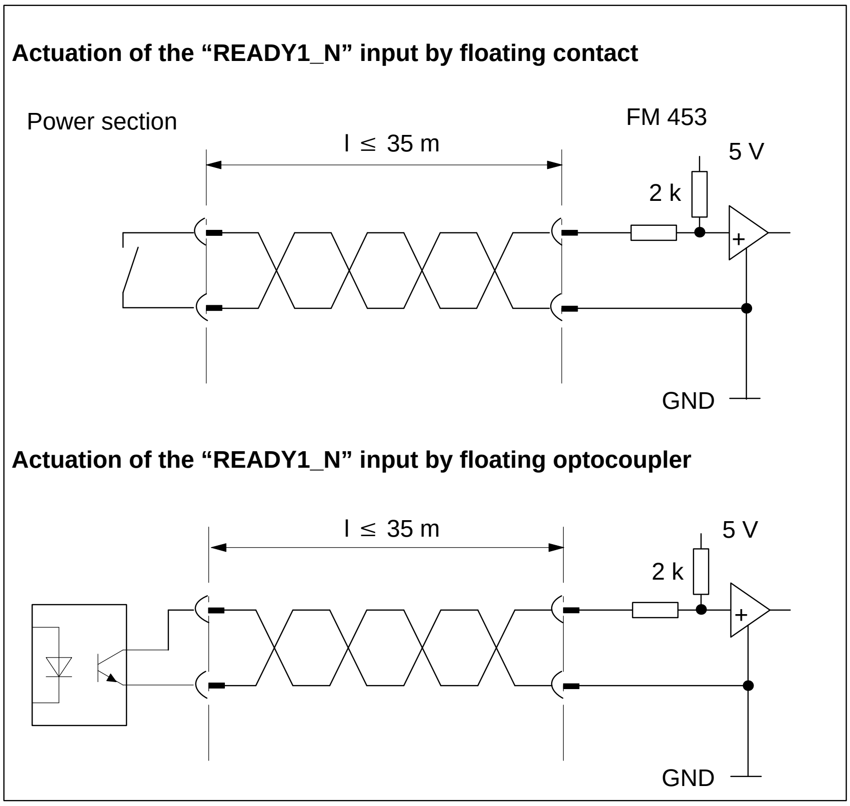


Fig. 4-5 Connection of the "READY1_N" Input

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-A4.

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

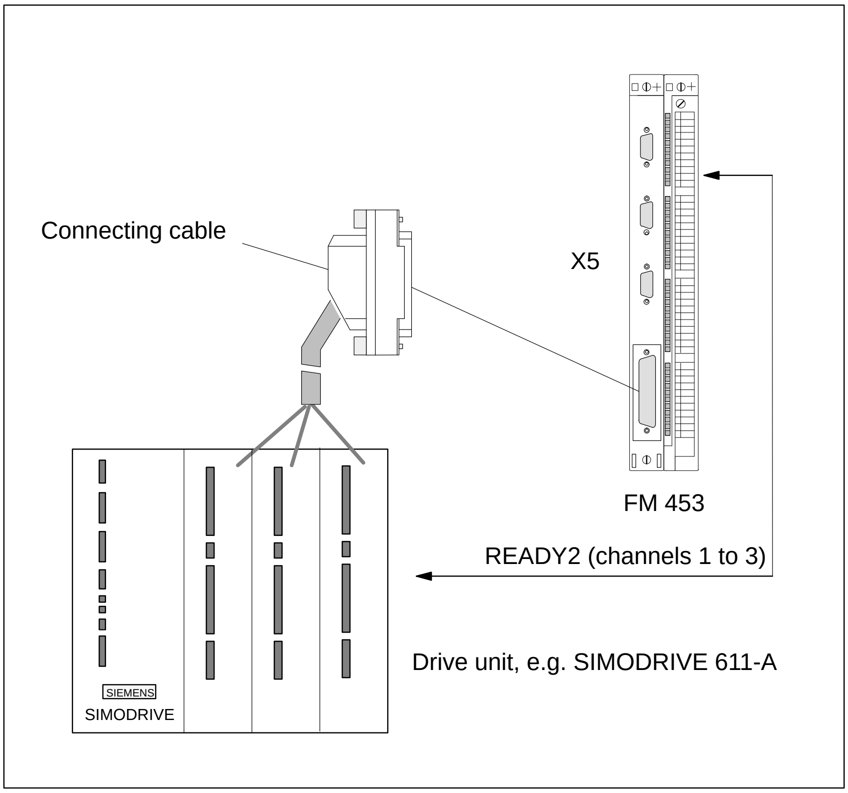


Fig. 4-6 Connecting a SIMODRIVE 611-A Drive Unit

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-A4

The following Figure shows you how to connect an FM 453 to FM STEP-DRIVE drive units.

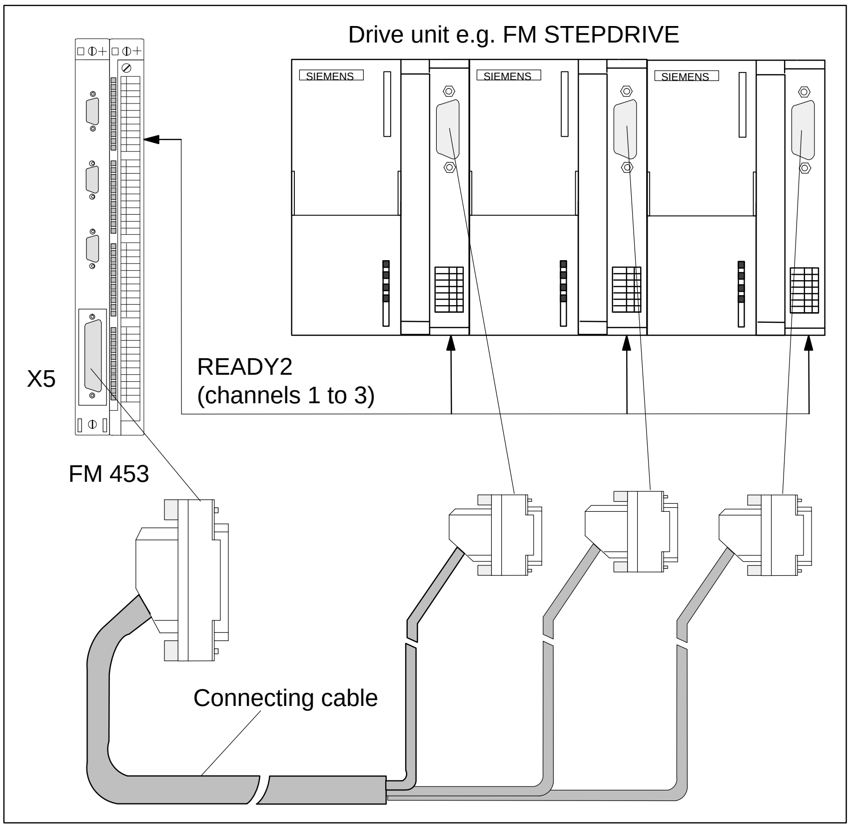


Fig. 4-7 Connecting to FM STEPDRIVE Drive Units

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-A4

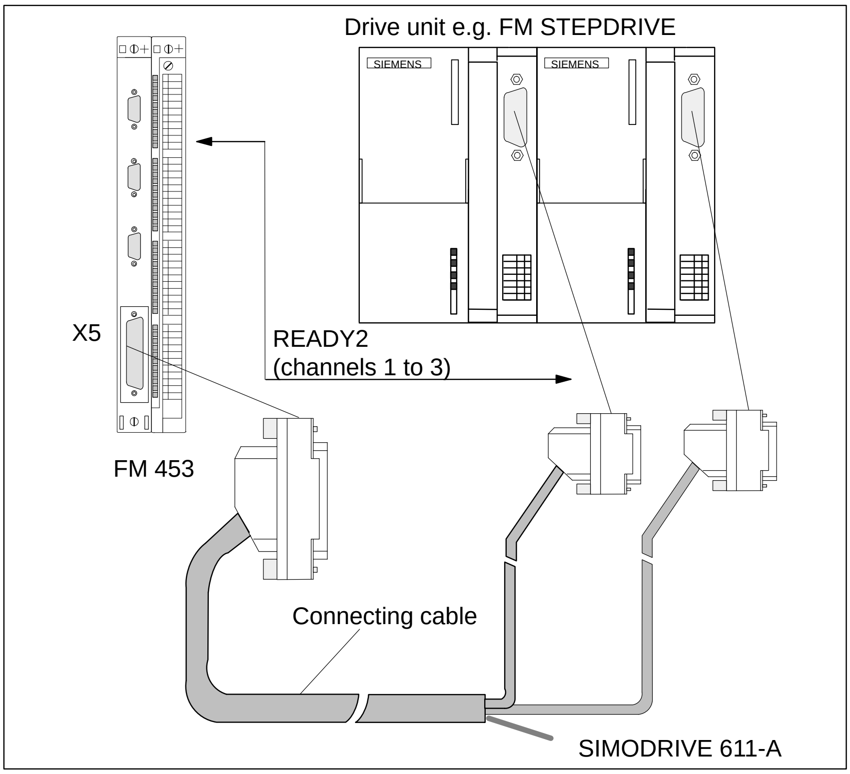


Fig. 4-8 Connecting to FM STEPDRIVE and SIMODRIVE Drive Units

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.

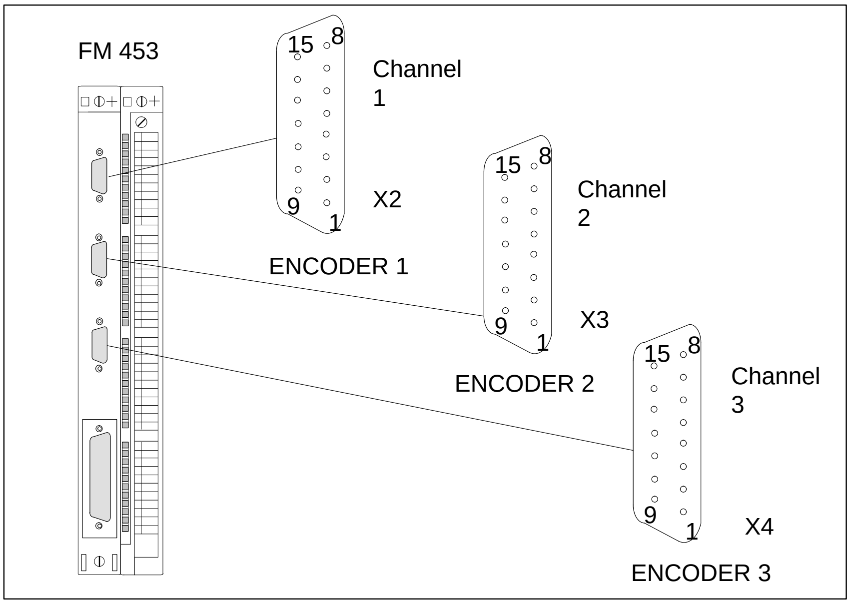


Fig. 4-9 Location of Connectors X2 to X4

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 (encoder)
P24EXT	Power supply +24 V (encoder)
MEXT	Power supply ground (encoder)

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)
Output signals:	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}, $\overline{U_{a0}}$)
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 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.

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

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

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.

When cables are routed unprotected, 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.

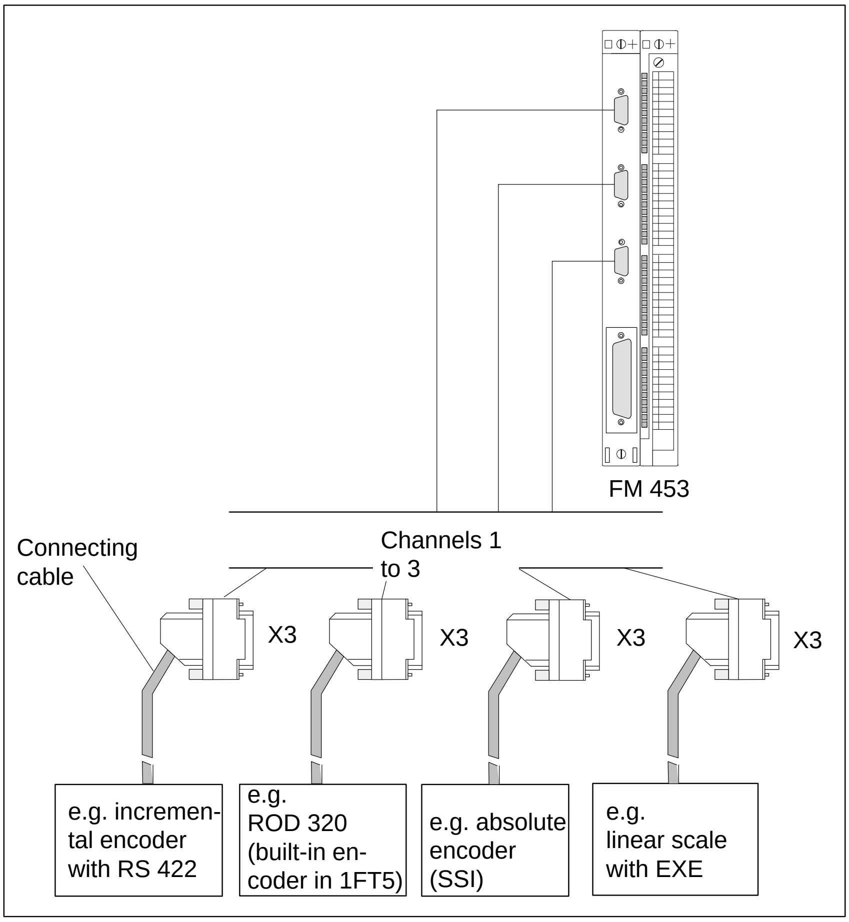


Fig. 4-10 Connecting Sensors

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-A4.

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.

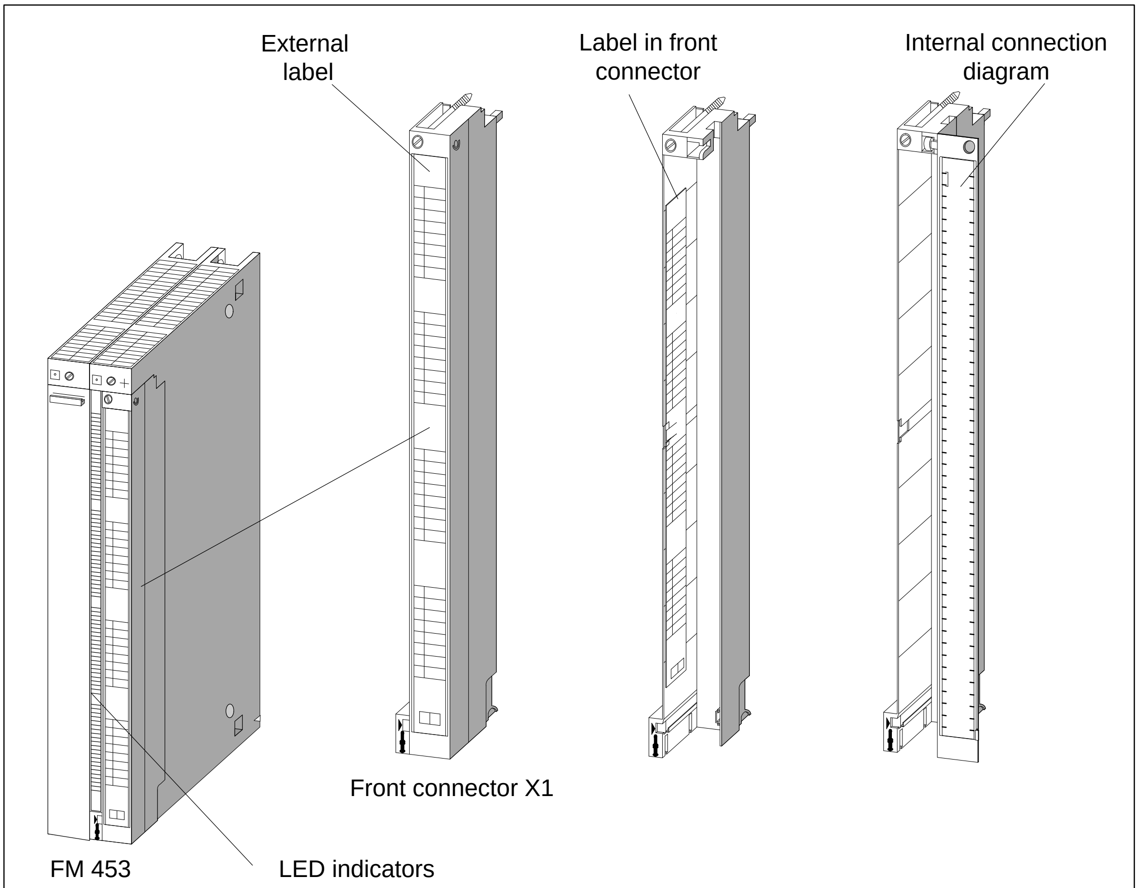


Fig. 4-11 Location of X1 Connector

Labels

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

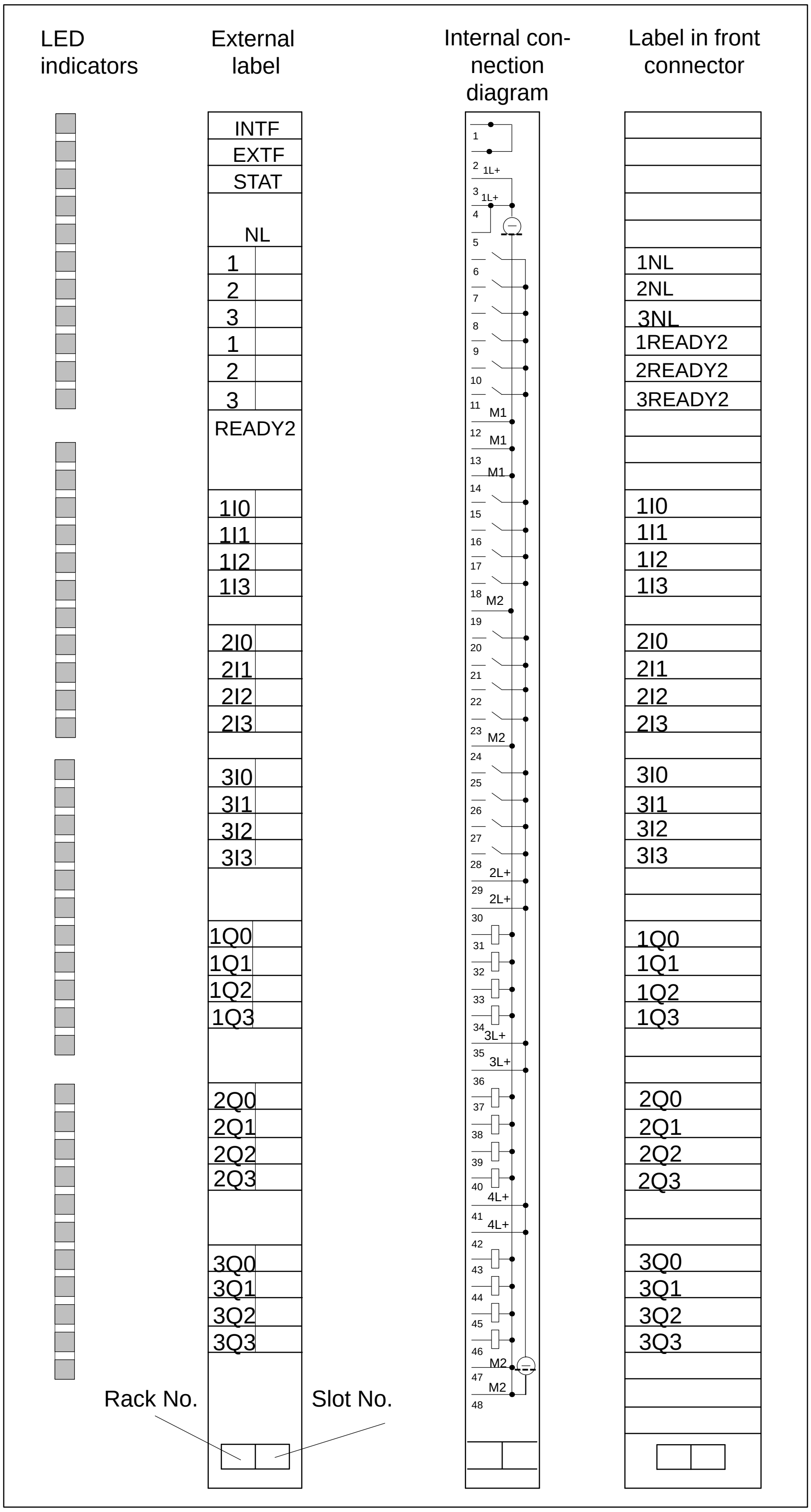


Fig. 4-12 Labels of the FM 453

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 supply[1] 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.**
2) If this channel is not utilized, the associated auxiliary voltage must 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 2 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.**
2) If this channel is not utilized, the associated auxiliary voltage must 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 (e.g. reference point switch signal) 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
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).

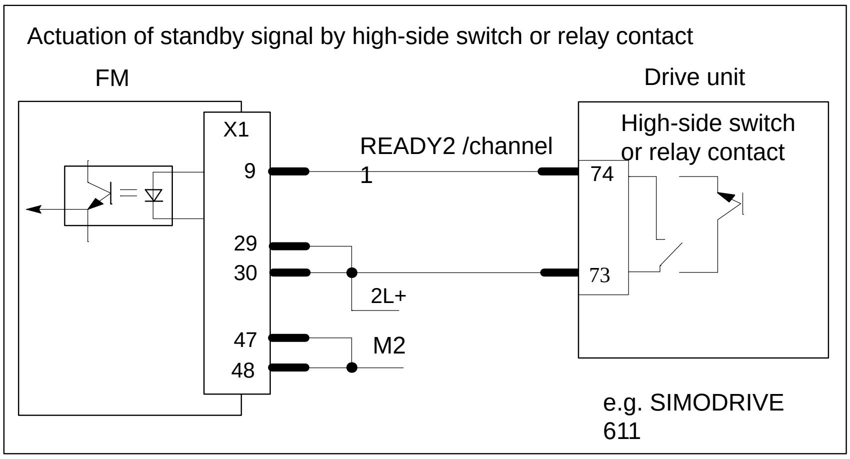


Fig. 4-13 Connection of Standby Signal, Power from Auxiliary Voltage L+

Power from the External Signal Source

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

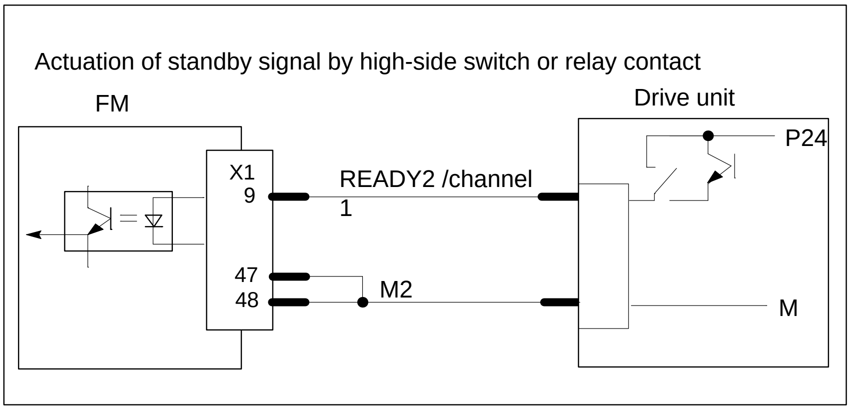


Fig. 4-14 Actuation of the Standby Signal, Power Supply from the Drive Unit

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)
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).

4.7 Wiring Up the Front Connector

Wiring the Front Connector

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

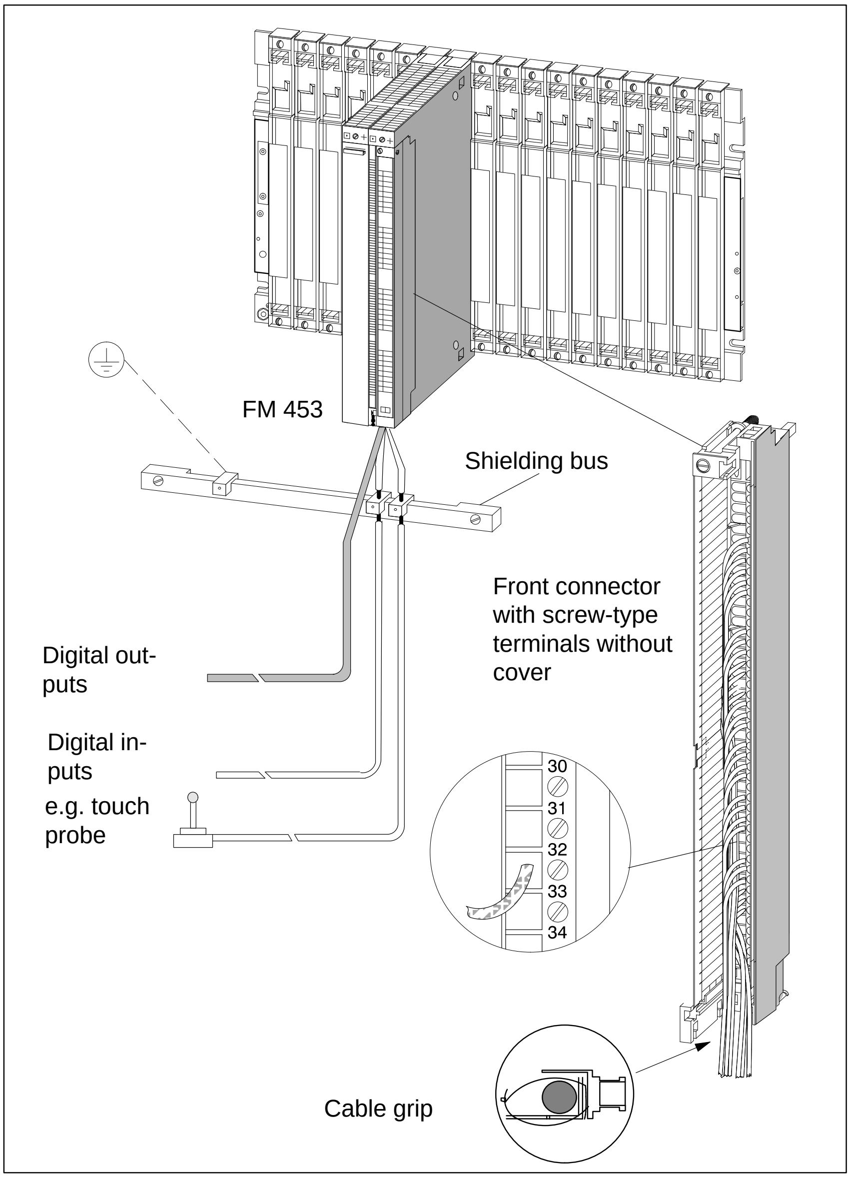


Fig. 4-15 Wiring of the Front Connector

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**

Summary

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

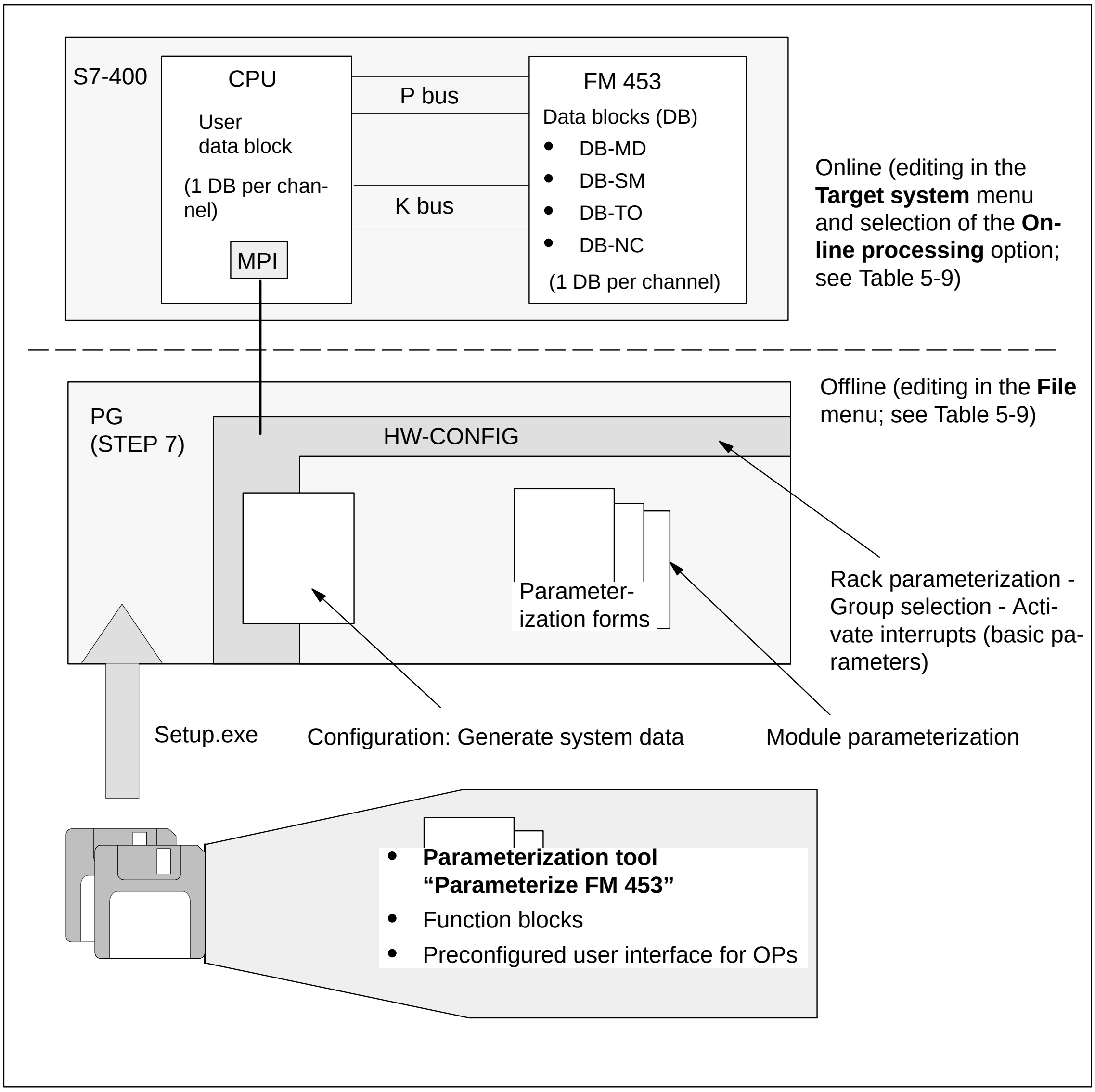


Fig. 5-1 Overview of Parameterization

Chapter Overview

5.1 Installation of “Parameterize FM 453”

Prerequisites

The Windows 95 operating system and appropriate STEP 7 program (V3.1 or higher) must already be installed on the programming device/PC.

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 two 3.5-inch diskettes and is installed complete.

Install the software as follows:

1. Insert diskette 1 in the floppy disk drive of your programming device/PC.
2. In Windows 95, start the interactive routine for installing the software by double-clicking the “Software” symbol in the Control Panel.
3. Select the floppy disk drive and the file **Setup.exe** in the dialog box, and start the installation program.
4. 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: **SIEMENS\STEP7\S7FUPOS**
   – Technology functions: **SIEMENS\STEP7\S7LIBS\FMST_SRV**
   – User interface for OPs: **SIEMENS\STEP7\EXAMPLES\S7OP_BSP**
   – Example applications: **SIEMENS\STEP7\EXAMPLE1\FMSTSVEX**

Note

If you chose a directory other than **SIEMENS/STEP7** when you installed **STEP 7**, this directory is entered instead.

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 and assign it.
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.

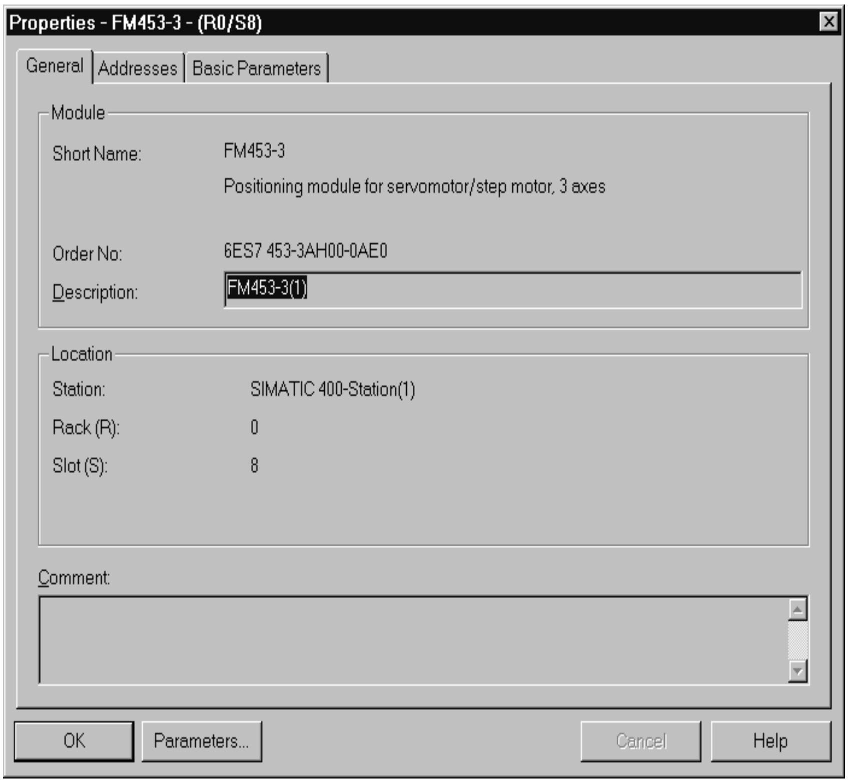


Fig. 5-2 Getting Started with “Parameterize FM 453”

7. By clicking the tabs in this window (General, Addresses and Basic Parameters), you can
   – Name the FM 353
   – Change the address of the FM 353
   – configure the interrupts.

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.

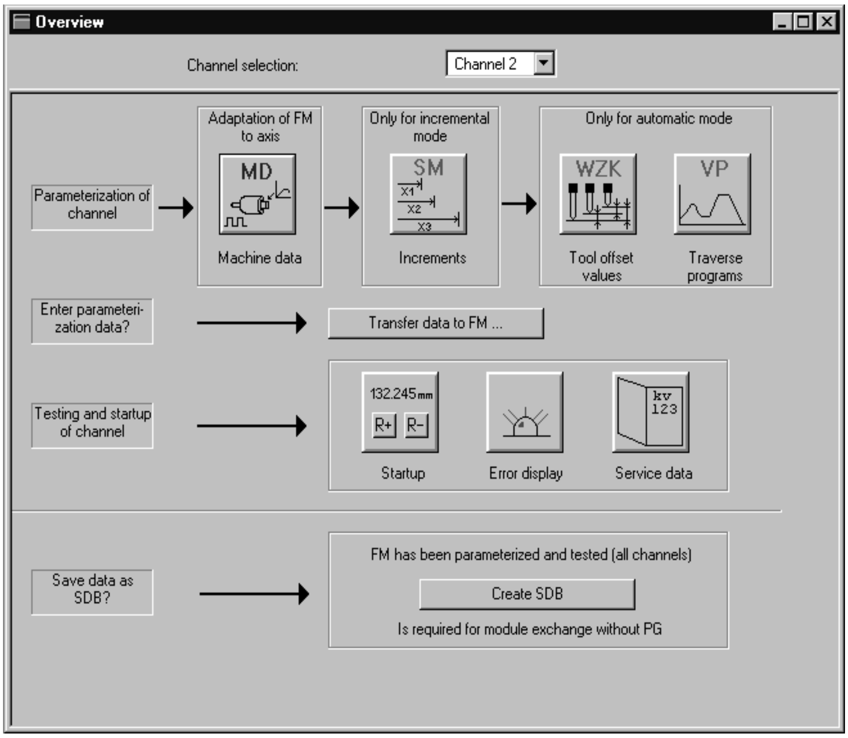


Fig. 5-3 Overview Display for Parameterization

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** **Block size (rounded in bytes) = 300** 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** **Block size (rounded in bytes) = 460** 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** **Block size (rounded in bytes) = 310** 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** **Block size (rounded in bytes) = 110 + (20 x no. 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)** **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.

User Data Block

Chapter 6 describes how to generate a user data block.

You can use "Parameterize FM 453" to fill the user DB with the data described in Table 5-2.

The menu **Target system** ▸ **Online editing** ▸ **User data** allows you to select and edit your user DB.

Table 5-2 User DB

Data Block	Significance
User DB	For the structure and data formats see Chapter 6 You can preload the following data to the DB provided the DB itself has been loaded to the CPU: • Module address[1)] • Channel address[1)] • Channel offset[1)] • Zero offset • Set actual value • Set actual value on-the-fly • Set reference point • Setpoint for increment • Speed level 1 • Speed level 2 • Voltage level 1 • Voltage level 2 • MDI block • MD block on-the-fly • Program selection, program number • Program selection, block number • Program selection, working direction • Code application data 1 • Code application data 2 • Code application data 3 • Code application data 4

1) You can only view these data. The data are edited by the FC INIT_DB (see Chapter 6).

Data Bloc Structure

Table 5-3 gives a rough picture of data block structure.

Table 5-3 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 5-4 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 5-4 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. ($\geq$ 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	

Entering Values

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

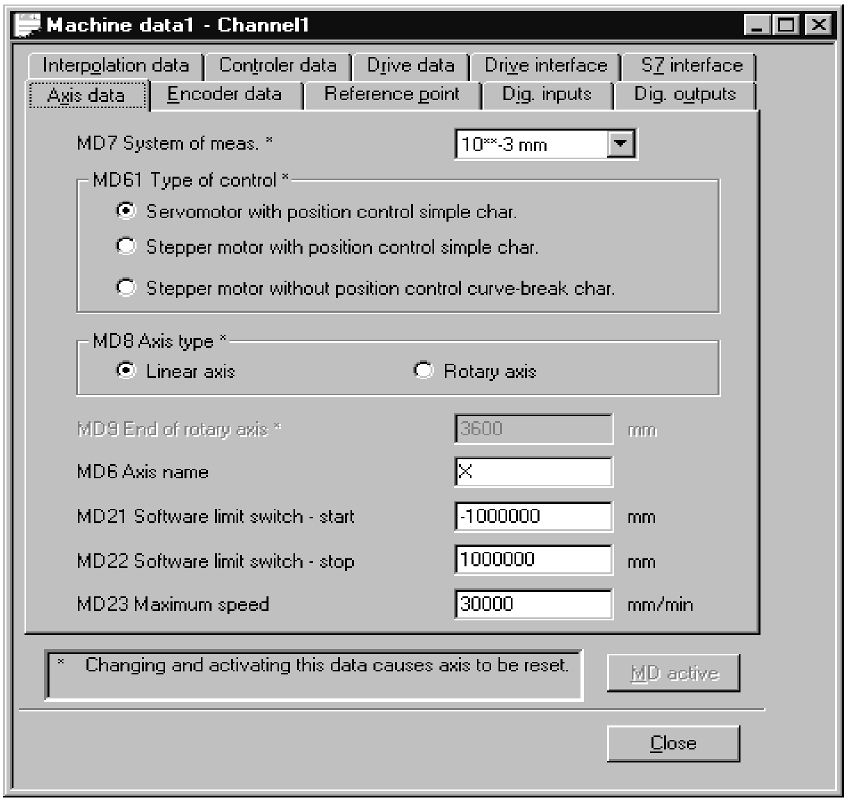


Fig. 5-4 Entering Values for Machine Data

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 5-5.

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 machine data DB.

Table 5-5 Machine Data List

No.	Designation	Default Values	Value/Meaning	Data Type/ Unit/Comments	See Section
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	
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) 13 = absolute encoder (SSI, 13-bit) 14 = absolute encoder (SSI, 25-bit)	DWORD GRAY Code GRAY 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)	
12 K	Residual distance per encoder revolution[2]	0	0 - 2^{32}-1	DWORD (2^{-32}MSR) (fractional component)	
13 K	Increments per encoder revolution (division period)[2]	2 500	2^1 - 2^{25}	DWORD With incremental encoders, evaluation takes place at $4 \cdot$ MD.	
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.	

Table 5-5 Machine Data List, continued

No.	Designation	Default Values	Value/Meaning	Data Type/ Unit/Comments	See Section
15 K	Baud rate - absolute encoder	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 (incremental encoder) 3 = voltage monitoring, encoder 8 = voltage monitoring ± 15 V 9 = voltage monitoring dig. outputs	BITFIELD32	9.6.1 9.6.2
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...100,000	DWORD (ms) rounded to 2-ms steps	
26 E	Stationary range	10^4	1 - 1,000,000	DWORD (MSR)	

Table 5-5 Machine Data List, continued

No.	Designation	Default Values	Value/Meaning	Data Type/ Unit/Comments	See Section
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 compensation	0	-1 000 000 - +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	
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 to 2-ms steps	
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

Table 5-5 Machine Data List, continued

No.	Designation	Default Values	Value/Meaning	Data Type/ Unit/Comments	See Section
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 compensation 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 to stages of module 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, relative	100	1 – 100	DWORD [%]	9.7
50 E	Phase current travel	100			
51 E	Phase current idle2)	100			
52 K	Increments per motor revolution2)	1 000	0 = not a stepper motor 4...10 000		9.7

Table 5-5 Machine Data List, continued

No.	Designation	Default Values	Value/Meaning	Data Type/ Unit/Comments	See Section
53 K	Increment number per current-sourcing cycle	20	0 – 400	DWORD	9.7
54 E	Start/Stop frequency	1 000	10 – 100 000	DWORD [Hz]	9.7
55 E	Frequency value for acceleration switch-over[2)]	10 000	10 – 1 000 000 Minimum value: MD54 + 1 Maximum value: MD56 – 1		9.7
56 E	Maximum frequency[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	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 characteristic	DWORD	9.7

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

MD10	MD61	Measured Value Factor
1	–	MWFAKTOR = UMWEG / (4 · MD13)
3, 4, 13, 14	–	MWFAKTOR = UMWEG / MD13

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

MD61	SMAMIN
0	as required, not used in checks
1, 7	SMAMIN = 1000 · 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
≥ 1	10^9 / MWFAKTOR

Checks for servo motor and stepper motor:

MD9 check

MD8	MD10	MD61	Permissible Rotary Axis End		
0	–	–	any, not used		
1	0	0	–		(MD23/60 000) · Sampling time ≤ MD9 ≤ VFBABS
		1, 7	MD18		
	1	1, 7	≥ 4	–	
		0	< 4	MD9 mod UMWEG == 0	
	3, 13	–	MD9 mod UMWEG == 0		
	4, 14	–	(MD14 · UMWEG) mod MD9 == 0		

Note: A sampling time of 2 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, ...

MD14 check

MD10	No. of Revolutions
0, 1, 3, 13	–
4, 14	2^x x = 1, 2, 3, ...

MD21, MD22 check

<table>
<tr><th>SEAKT</th><th>MD8</th><th colspan="3">Permissible Software Limit Switches</th></tr>
<tr><td>0</td><td>–</td><td colspan="3">MD21 = -10^9, MD22 = $+10^9$</td></tr>
<tr><td rowspan="4">1</td><td rowspan="3">0</td><td>MD21 ≥ –VFBABS</td><td>MD10</td><td></td></tr>
<tr><td>MD22 ≤ VFBABS</td><td>0, 1</td><td>–</td></tr>
<tr><td>MD21 < MD22</td><td>3, 13</td><td>MD22-MD21 ≤ UMWEG</td></tr>
<tr><td>1</td><td>0 ≤ MD21 < MD9
0 ≤ MD22 < MD9
MD21 ≠ MD22</td><td>4, 14</td><td>MD22-MD21 ≤ MD14 · UMWEG</td></tr>
</table>

MD28 check

Permissible Velocity	10 ≤ MD28 ≤ MD23

MD29 check

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

MD31 check

<table>
<tr><th>MD30</th><th>MD10</th><th>Permissible Directional Reference of Backlash</th></tr>
<tr><td>0</td><td></td><td rowspan="2">–</td></tr>
<tr><td rowspan="2">≠ 0</td><td>0, 1</td></tr>
<tr><td>3, 4, 13, 14</td><td>1, 2</td></tr>
</table>

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 pulse 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:	MD56 ≥ MD23/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

Zero Reference Mark

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

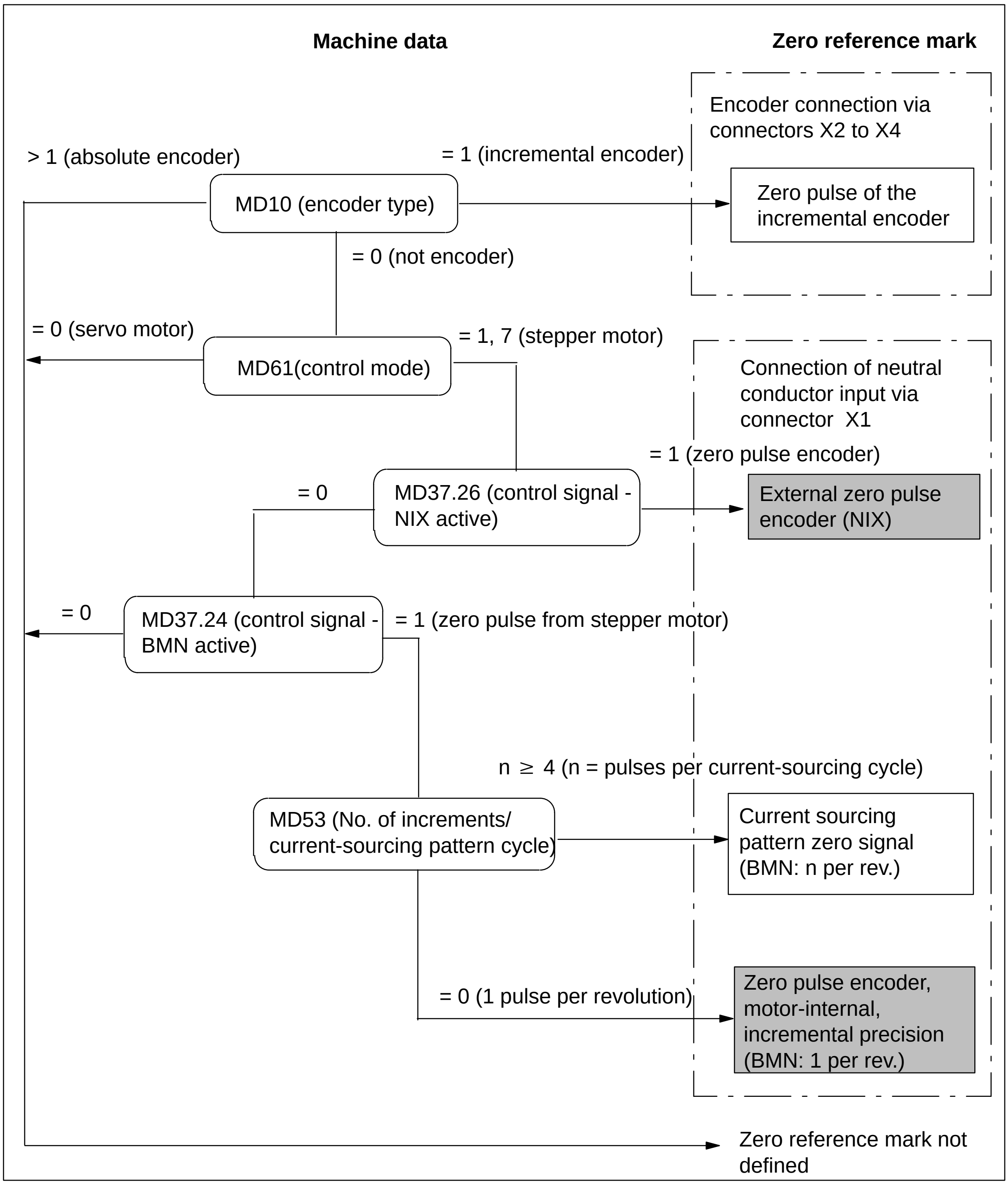


Fig. 5-5 Zero Reference Mark Selection

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 5-6 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 5-6 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. ($\geq$ 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” parameterization tool.

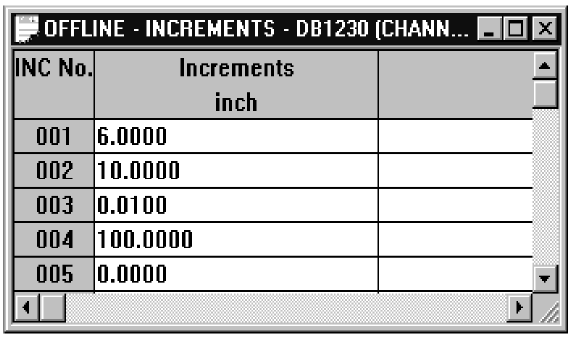


Fig. 5-6 Entering Values for Incremental Dimensions

5.3.3 Tool Offset Data

DB Structure

Table 5-7 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 5-7 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 DWORD	-10^9 – 10^9 -10^9 – 10^9 0 – 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 5-8 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 5-8 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 9.3.11, 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:

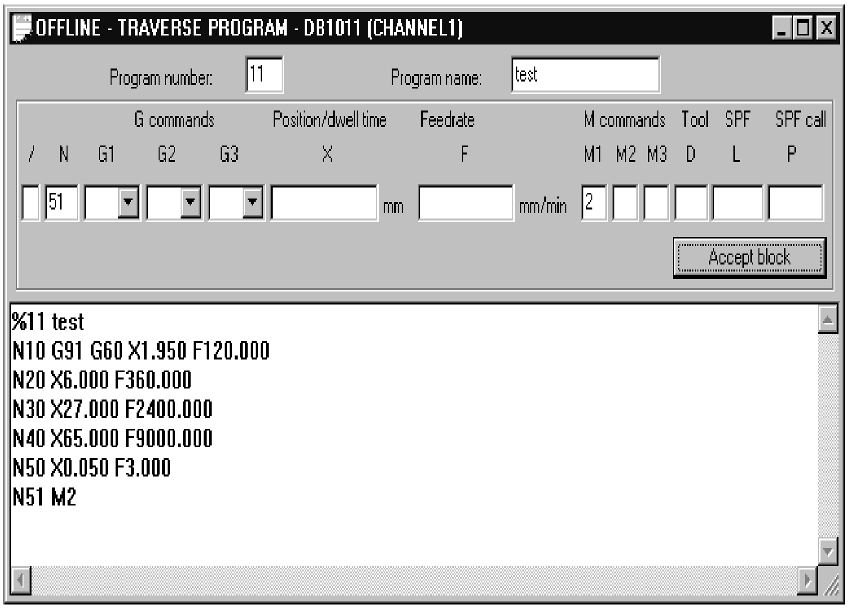


Fig. 5-8 Entry for Traversing Programs

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.

Menus of “Parameterize FM 453”

The following table shows you an overview of the menus of “Parameterize FM 453”.

Table 5-9 Menus of “Parameterize FM 453”

Menu Title or Entry (With Single Command)	Shortcut	Significance
File	–	Create, open, save, print and generate data blocks
New >	–	Creates a new data block
Machine data >	–	Creates a new DB-MD
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
Increment >	–	Creates a new DB-SM
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
Tool offset data >	–	Creates a new DB-TO
Channel 1	–	for channel 1

Table 5-9 Menus of “Parameterize FM 453”, continued

Menu Title or Entry (With Single Command)	Shortcut	Significance
Channel 2	–	for channel 2
Channel 3	–	for channel 3
Traversing program >	–	Creates a new DB-NC
Channel1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
Open >	–	Opens the data block stored on the programming device/PC
Machine data >	–	Opens the DB-MD stored on the programming device/PC
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
Increment >	–	Opens the DB-SM stored on the programming device/PC
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
Tool offset data >	–	Opens the DB-WK stored on the programming device/PC
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
Traversing program >	–	Opens one of the DB-NC stored on the programming device/PC
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
Import	Ctrl + O	Opens a data block which has been saved as a file
Close	Ctrl + F4	Closes the window of the current DB
Save	Ctrl + S	Saves the current data block on the programming device/PC
Export	–	Saves the current data block in a file
Check consistency	–	Checks the data in the current window for errors
Create SDB	–	Reads the FM data blocks which have been generated from this SDB (system data block), and stores them on the programming device/PC.
Display SDB...	–	Displays the SDBs which exist on the programming device/PC; they can then be deleted.
Print	Ctrl + P	Prints all or part of the current data block
Print preview	–	Displays the document in the print preview - no editing possible
Set page	–	Specifies page layout for printing
Set printer	–	Sets up the printer and sets print options

Table 5-9 Menus of “Parameterize FM 453”, continued

Menu Title or Entry (With Single Command)	Shortcut	Significance
1 <Name of DB last opened>	–	Opens the DB which was last opened
2 <Name of penultimate DB opened>	–	Opens the DB which was opened penultimately
3 <Name of third-last DB>	–	Opens the third-last DB
4 <Name of fourth-last DB>	–	Opens the fourth-last DB
Close	Alt + F4	Closes all parameterization windows and ends parameterization
Edit	–	Undo the last action, cut, copy, paste and delete selected objects, search and default value
Undo	Ctrl + Z	Undoes the last action
Cut	Ctrl + X	Deletes the selected data and saves it in a buffer (clipboard)
Copy	Ctrl + C	Copies the selected data to a buffer (clipboard)
Paste	Ctrl + V	Inserts the clipboard contents at the cursor position
Replace cells	–	Overwrites the field in a table with the clipboard contents
Copy channel	–	Allows data blocks for a channel to be copied to another channel
Search	Ctrl + F	Searches for text; the text may also be a number (e.g., MD No.)
Default values	–	Fills the current data block with default values
Destination system	–	Transfers data and data blocks
✓ Communications	–	Establishes or disconnects online connection with destination system
Load >	–	Loads data blocks or user data
in FM	Ctrl + L	Loads the current data block on the FM 453
in PG or FM...	–	Opens a transfer dialog
Online editing >	–	Edits the data blocks on the FM 453
Machine data >	–	Edits the machine data on the FM 453
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
Increment >	–	Edits the increments on the FM 453 online
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3

Table 5-9 Menus of “Parameterize FM 453”, continued

Menu Title or Entry (With Single Command)	Shortcut	Significance
Tool offset data >	–	Edits the tool offset data on the FM 453
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
Traversing program >	–	Edits the traversing programs on the FM 453
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
User data >	–	Edits the user data on the CPU
Channel 1...	–	for channel 1
Channel 2...	–	for channel 2
Channel 3...	–	for channel 3
Compress FM-RAM	–	Compresses the FM 453 working memory. This is possible only if the CPU is in STOP mode.
Clear flash memory	–	Clears the FLASH memory on the FM 453
Test	–	Startup and troubleshooting
√Startup >	–	Opens the startup window. Module control and observation
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
√Troubleshooting >	–	Opens the troubleshooting window. Displays faults in the module
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
√Service data >	–	Opens the window to look at servicing data
Channel 1	–	for channel 1
Channel 2	–	for channel 2
Channel 3	–	for channel 3
View	–	Select different views and presentations
Table form	–	Switches between dialog and table format (only with MD)
Contents of column 5 >	–	Defines what appears in the last column (MD only)
Default values	–	Displays default values (recommendations)
Limits	–	Displays upper and lower limits
√ Function bar	–	Switches the function bar on/off

Table 5-9 Menus of “Parameterize FM 453”, continued

Menu Title or Entry (With Single Command)	Shortcut	Significance
√ Status line	–	Switches the status line on/off
Overview	–	The overview display for parameterization appears
Extras	–	Settings in the data blocks
Set system of measurement >	–	Change the system of measurement in the current window
√ 10^{-3} mm	–	Input in mm
10^{-4} inch	–	Input in inches
10^{-4} degrees	–	Input in degrees
10^{-2} degrees	–	Input in degrees
Window	–	Arranges all parameterization windows. Changes to a specified window.
Arrange>	–	Arranges all windows
Overlapping	Shift + F5	Stacks all windows, one behind the other
Horizontal	–	Spaces all windows uniformly, top to bottom
Vertical	–	Spaces all windows uniformly, left to right
Arrange icons	–	Arranges parameterization window icons
Close all	–	Closes all open windows
√1 <opened window 1>	–	Changes to window <window name>
n <currently open window n>	–	Changes to window <window name>
Help	–	Search and display help functions
Help topics	F1	Offers a variety of ways to access help information
Using help	–	Displays information on how to use help
Info...	–	Displays information about the current version of the parameterization tool

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.

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

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

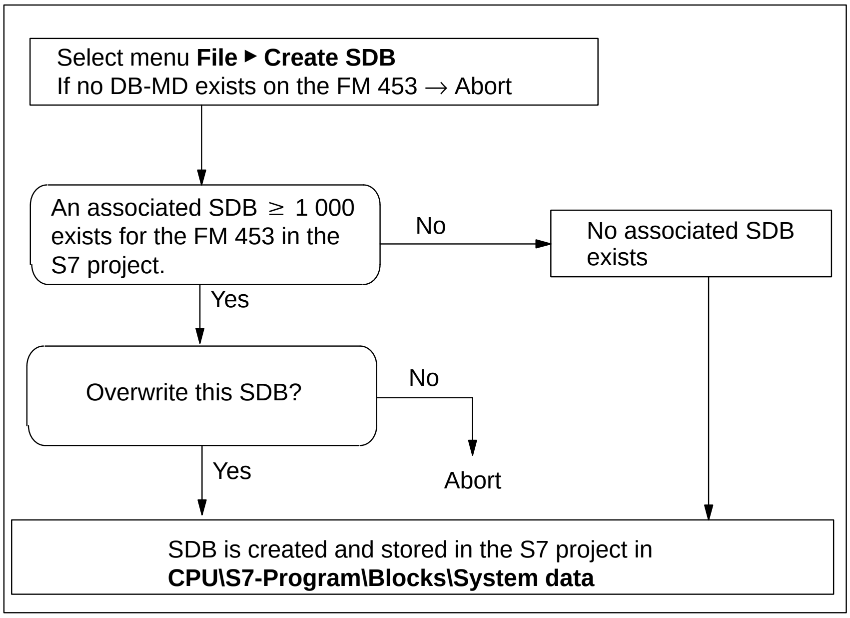


Fig. 5-9 Creating SDB ≥ 1 000

Display/Delete SDB in the S7 Project

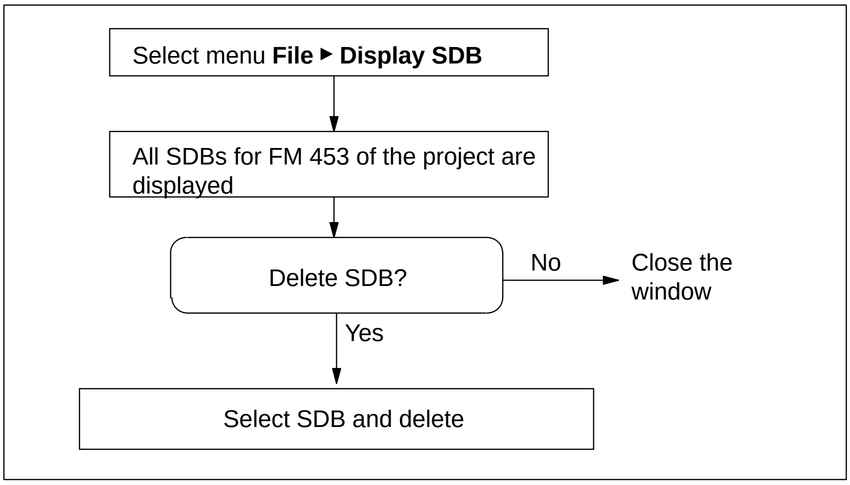


Fig. 5-10 Displaying/Deleting SDB $\geq$ 1 000

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 FM 453

6

Summary

The present programming instructions describe the functions (FCs) that allow you to establish communications between the CPU and the FM 453 function module in the SIMATIC S7-400.

Note

The procedure is only described here for one channel. It must also be followed for each additional channel.

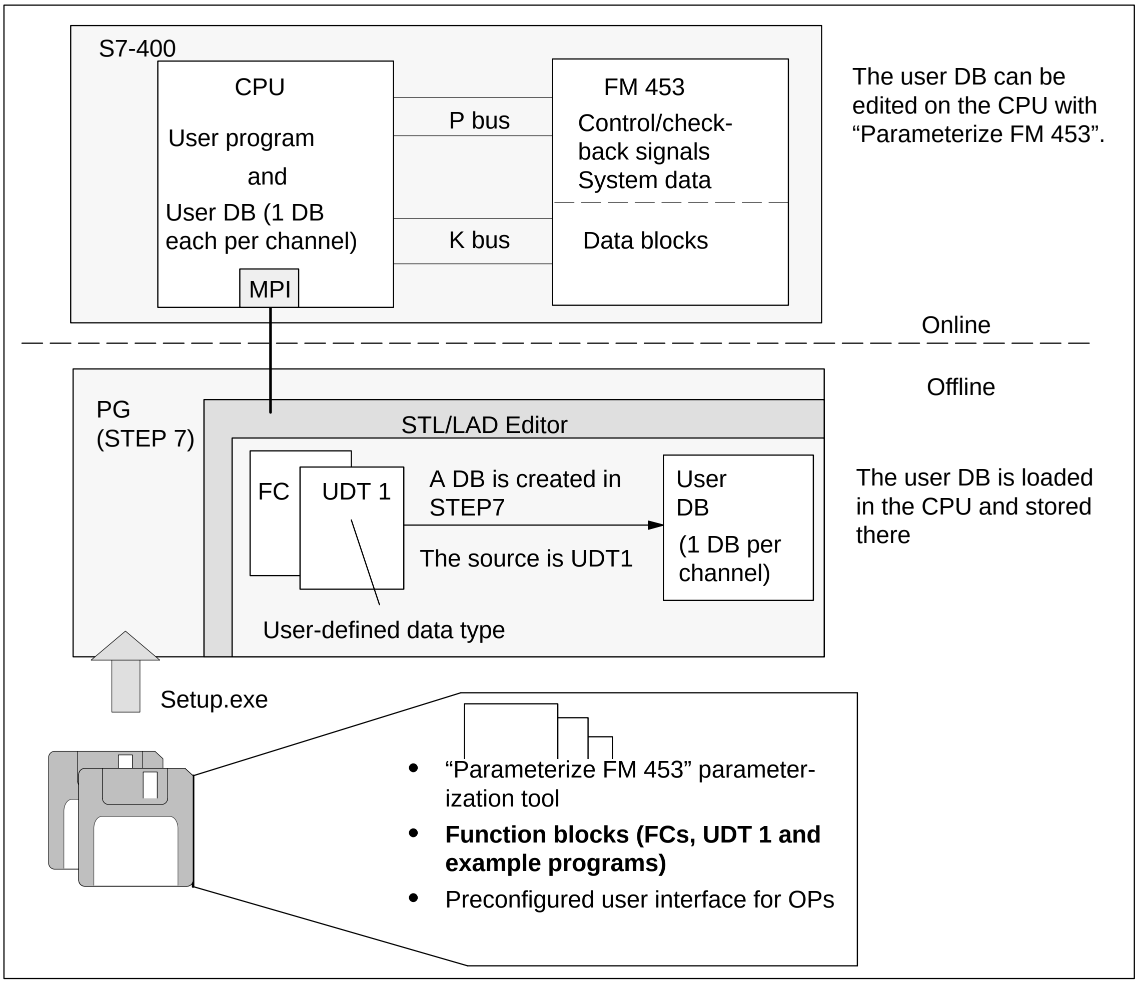


Fig. 6-1 Overview of Programming

Prerequisites

The following prerequisites must be fulfilled in order to control the FM 453 from your user program:

- You have installed the software on your programming device/PC, as described in Section 5.1.
- The link between the programming device/PC and the S7-400 CPU must already be set up (see Figure 4-1).

Creating the User DB

Proceed as follows:

1. Generate a data block in STEP 7 (DB 1).
2. Open DB 1 and select the property “mit zugeordneten anwenderspezifischen Datentyp”.

   Result: UDT 1 (user-defined data type) is offered
3. Click UDT 1

   Result: You have created the user DB (DB 1).
4. Load this user DB and save it in the CPU.
5. You can use “Parameterize FM 453” to fill the user DB in the CPU with data.

You must create a user DB for each channel.

Function Blocks

The following table gives you a general view of the function-block package (FCs) for the FM 453.

Table 6-1 Technology Functions for the FM 453

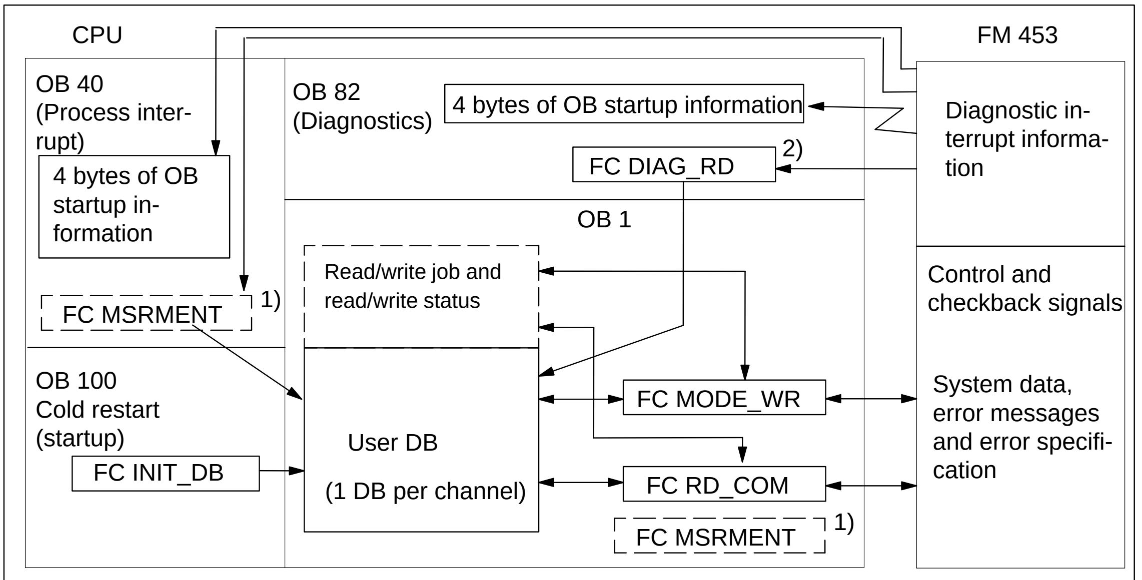
Function Block No.	Function Block Name	Significance
FC 1	INIT_DB	Initialize user DB
FC 2	MODE_WR	Control operating modes and process write jobs
FC 3	RD_COM	Process read jobs cyclically
FC 4	DIAG_RD	Read diagnostic interrupt data in OB 82
FC 5	MSRMENT	Read measured values
FC 6	DIAG_INF	Read diagnostic interrupt data in OB 1

Note

You can change the FC number for your project. The number is changed in the SIMATIC Manager by renaming the FC in your project with a free number. These changes should be entered in the symbol table at the same time.

Linking the FM 453 into the User program

The following figure shows you how the FM 453, the user data block (user DB) and technology functions communicate.



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

2) This FC only has to be called once in a channel. It contains diagnostics information for all three channels (see Sections 6.4 and 11.2.2).

Fig. 6-2 Overview of Linking the FM 453 into the User Program

Tips for the User

The user requires at least FC INIT_DB in order to initialize the user DB and FC MODE_WR for mode and write job processing.

FC RD_COM for reading data is only required if the FM data are to be processed in the user program (e.g. for display purposes).

Regardless of which or how many technology functions you use, you need a data block with a predefined structure (UDT 1) to contain all the necessary data or data storage areas. This data block is implemented as a user data block, and one way to set its default values is with the “Parameterize FM 453” parameterization tool.

Integration of OB 83 ”Remove/Insert interrupt”

In the event of an FM 453 becoming defective, to ensure that the equipment is able to continue operating, OB 83 has to be linked into the user program. In OB 83, when the FM 453 is removed, it must be ensured (for example, by setting a flag which is evaluated in OB 1), that the communication in OB 1 with the FM 453 is suppressed. To ensure that the user program can resynchronize itself with the FM 453, the FC INIT_DB must be linked in when the FM 453 is reinserted (same procedure as in OB 100). The organization block OB 122 (I/O access error OB) also has to be loaded into the CPU.

Chapter Overview

6.1 FC INIT_DB (FC 1) – Initialize user DB

Task

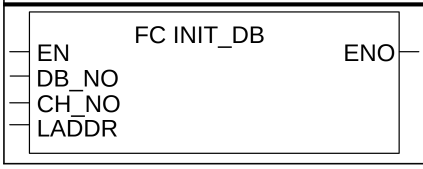
You can use FC INIT_DB to initialize specific areas of your user DB. For this purpose, you can call FC INIT_DB in OB 100 or OB 83 “Remove/Insert interrupt” once for each channel.

The FC performs the following actions:

1. Enters addressing values in the user DB
   - FM address
   - Channel address
   - Offset address
2. Deletes the following structures in the user DB
   - CONTROL_SIGNALS
   - CHECKBACK_SIGNALS
   - JOB_WR (write job)
   - JOB_RD (read job)

Call Options

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

	`CALL INIT_DB(`
	`DB_NO := ,`
	`CH_NO := ,`
	`LADDR := );`

Description of Parameters

The following table describes the parameters of this FC.

Name	Data Type	P Type	Meaning
DB_NO	WORD	I	Data block number
CH_NO	BYTE	I	Number of axis: 0 – Only one channel on the module 1 – First channel on the module 2 – Second channel on the module 3 – Third channel on the module 4...255 – Not valid
LADDR	INT	I	Logical base address of module, transfer entry from HW-KONFIG

Parameter types: I = input parameter

Principle of Operation

This function works together with a user DB. The structure of the user DB can be found in the library FMSTSVLI in data type UDT 1. You need one user DB for each channel which contains entries for addressing the FM 453 and the data for the individual functions of the FM 453. The DB number is passed when you call the FC with the DB_NO parameter.

Error Evaluation

Errors which occur are indicated in the binary result (BIE = 0).

Possible errors are:

Unknown channel number CH_NO; the user DB is not initialized.

Example Call

An example call is shown below for FC INIT_DB.

```
STL                                             Explanation
VAR_TEMP
      MODUL_ADR         : INT;                  // Module address
END_VAR

...

      L     512;                                // Enter module address
      T     MODUL_ADR;
                                                // Module address
      CALL  INIT_DB(                            // DB number
            DB_NO       := W#16#1,              // Only one channel on the module
            CH_NO       := B#16#1,              // Module address
            LADDR       := MODUL_ADR);
                                                // Binary result
      UN    BIE;                                // Error on initialization
      S     FEHLER_INITIALISIERUNG;
...
```

6.2 FC MODE_WR (FC 2) – Control Operating Modes and Process Write Jobs

Task

You can use FC MODE_WR to:

- Control modes
- Process write jobs

You must call FC MODE_WR once per channel in the OB 1 cycle.

The FC performs the following actions:

1. Reads the checkback signals. The values read by the FC are stored in the user DB in the structure CHECKBACK_SIGNALS.
2. Transfers the control signals from the user DB (structure CONTROL_SIGNALS). Depending on the mode selected (CHECKBACK_SIGNALS.MODE) control signals CONTROL_SIGNALS.START, CONTROL_SIGNALS.DIR_P and CONTROL_SIGNALS.DIR_M are cleared when a start is detected (edge generation of signals for FM).
3. Executes the write job from the user DB (JOB_WR), transfers the associated data from the user DB, and displays the write job status.
4. Generates the status bits JOB_WR.MODE_BUSY (operating mode busy, i.e. started) and JOB_WR.POS_REACHED (position reached).

Call Options

Call in LAD Notation (ladder diagram)	**Call in STL Notation (statement list)**

FC MODE_WR
EN ENO
DB_NO RET_VAL
	`CALL MODE_WR(`
	`DB_NO := ,`
	`RET_VAL := );`

Description of Parameters

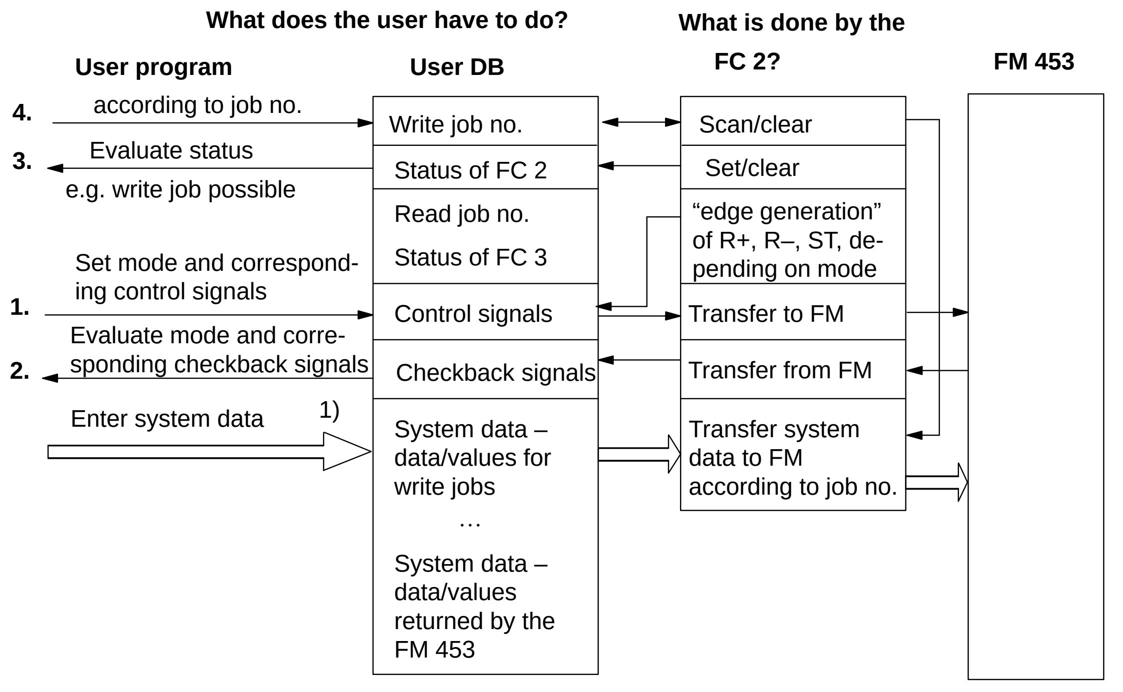
The following table describes the parameters of this FC.

Name	Data Type	P Type	Meaning
DB_NO	WORD	I	Data block number
RET_VAL	INT	Q	Return code of SFC 58 “WR_REC”

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

Principle of Operation

This function works together with a user DB. The structure of the user DB can be found in the library FMSTSVLI in data type UDT 1. You need one user DB for each channel which contains entries for addressing the FM 453 and the data for the individual functions of the FM 453. The DB number is passed when you call the FC with the DB_NO parameter.



1) Before the appropriate write job no. is set in the user DB, the system data to be written must be entered.

Error Evaluation

Errors which occur are indicated in the binary result (BIE = 0).

Possible errors are:

- Unknown write job (see JOB_WR.UNKNOWN)
- Data transfer error during communication with SFC 58 “WR_REC”. The error is returned in the output parameter RET_VAL (see reference manual *System Software for S7-300/400; System and Standard Functions*).
- The transferred data are verified and interpreted by the module. If a data error occurs, CHECKBACK_SIGNALS.DATA_ERR in the user DB structure is set to “1”. Further information on data errors can be found in the parameterization tool in the menu **Test ▸ Troubleshooting** and in Section 11.

Example Call

An example call is shown below for FC MODE_WR.

```
STL                                              Explanation

...

      O     DB_FM.JOB_WR.BUSY;                   // Write job busy
      O     DB_FM.JOB_WR.IMPOSS;                 // Write job processing impossible
      SPB   DAWR;                                // Jump to call

AT02: U     G_STUFE_SETZEN;
      SPEN  STRS;
      L     B#16#1;                              // Write job no. 1 for velocity level
      SPA   EINT;

STRS: L     B#16#0;                              // Only transfer control signals

EINT: T     DB_FM.JOB_WR.NO;                     // Write job no. in user DB

DAWR: CALL  MODE_WR(                             // FC Write data
            DB_NO     := W#16#1,
            RET_VAL   := FEHLERCODE_SCHREIBEN)

      UN    BIE;                                 // Binary result
      S     FEHLER_SCHREIBFKT;                   // Error on initialization
...
```

6.2.1 Process Write Jobs

Overview

Before a write job is processed, the data area belonging to the write job must be filled with the appropriate values. The last write job must have finished processing, i.e. JOB_WR.NO in the user DB (data byte DBB0) must have been cleared and status bit JOB_WR.DONE enabled.

You initiate a write job by entering the write job no. in JOB_WR.NO.

The following write jobs (JOB_WR.NO) are known:

Legend for the table below:

Operating mode:

T – Jogging
STE – Open-loop control
REF – Reference point approach
SM – Incremental relative
MDI – MDI (Manual Data Input)
A/AE – Automatic/Automatic single block

Operating Modes / System Data	Job no.	Addr. in user DB	T	STE	REF	SM	MDI	A/AE	See Section
Reference data is data/parameters for the corresponding mode.									
VLEVEL_1_2 – Velocity levels 1, 2	1	90.0	□	○	○	□	○	○	9.2.1
CLEVEL_1_2 – Voltage/Frequency levels 1, 2	2	98.0	○	□	○	○	○	○	9.2.2
TARGET_254 – Setpoint for increment	3	86.0	○	○	○	□	○	○	9.2.4
MDI_BLOCK	6	106.0	○	○	○	○	□	○	9.2.5
Reference data with execution activates settings/functions that apply in multiple modes.									
PAR_CHAN – change parameter/data	8	126.0	x	x	x	x	x	x	9.3.1
SINGLE_FUNCTIONS	10	40.0	□	x	□	□	□	□	9.3.2
SINGLE_COMMANDS	11	42.0	x	x	x	x	x	x	9.3.3
ZERO_OFFSET	12	44.0	x	x	–	x	x	x	9.3.4
SETTING_ACT_VALUE	13	48.0	x	x	–	x	x	x	9.3.5
FLYING_SETTING_ACT_VALUE	14	52.0	x	x	–	x	x	–	9.3.6
DIG_IO – digital outputs	15	150.0	x	x	x	x	x	x	9.8.2
MDI_FLY	16	152.0	–	–	–	–	x	–	9.2.5
PROG_SEL – program selection	17	172.0	–	–	–	–	–	□	9.2.6
REQ_APP – request application data	18	176.0	x	x	x	x	x	x	9.3.7
TEACH_IN	19	180.0	x	–	–	x	x	–	9.3.8
SETTING_REFERNCE_POINT	21	56.0	x	x	x	x	x	–	9.3.9
SRV_IN – reserved	22	182.0							

○ Data is accepted and only processed in the corresponding mode.

x Data is accepted or processed, as applicable.

– Data are rejected with error message (see Troubleshooting, Table 11-8 Class 4 No. 1).

□ Data required for movement of the axis; the servo enable is required for single settings. Data/single settings are transferred at least once per channel to the FM 453.

Write Job Status The status of a write job is indicated in the user DB (in data byte DBB1).

Table 6-2 Write Job Status

Bit in JOB_WR (DBX1.)	Significance
.BUSY, 0	= 1, write job busy This bit is set by FC MODE_WR as soon as it starts processing a write job (JOB_WR.NO > 0 and bit 2 JOB_WR.IMPOSS = 0). This bit is cleared by FC MODE_WR as soon as the write job has finished running (JOB_WR.NO = 0).
.DONE, 1	= 1, write Job finished This bit is set by FC MODE_WR as soon as it has finished a write job (also with error and unknown job). This bit is cleared by FC MODE_WR when a new write job begins. You can clear this bit manually.
.IMPOSS, 2	= 1, write job processing is not possible in this cycle: – because the axis is not parameterized – because test mode is active – because no mode is active – because the selected mode is not yet active In this case, you can leave the write job (JOB_WR) or delete it. FC MODE_WR clears the bit when all the above conditions have been met.
.UNKNOWN, 3	= 1, Write job unknown The write job (JOB_WR) which you specified is not within the known range. (see error evaluation). FC MODE_WR clears this bit as soon as JOB_WR contains a valid number. The unknown number is retained until then.
.MODE_BUSY, 6	= 1, when a mode/movement is started with the appropriate control signals or on a BL = 1 checkback (busy). MODE_BUSY when FC is called/started WORKING (BL) when movement is started by FM
.POS_REACHED, 7	0 = on the checkback POS_ROD = 0 (position reached, stop) or when a mode is started with the appropriate control signals. POS_REACHED when FC is called/started POS_POD [PEH] when movement is started by FM

6.2.2 Control Modes

Overview

Control/checkback signals are required in order to control the axis in the individual operating modes.

The operating modes are described in Section 9.2. The control/checkback signals and their handling are described in Section 9.1.

The user must enter the control signals in the user DB. FC MODE_WR transfers the control signals from the user DB to the FM 453 and transfers the checkback signals from the FM 453 to the user DB.

Byte \ Bit	7	6	5	4	3	2	1	0
Control signals:								
20					BFQ/FSQ		TFB	
21	AF	SA	EFG	QMF	R+	R–	STP	ST
22	operating mode							
23	BP							
24	OVERR							
25								
Response signals:								
28	PARA			DF	BF/FS		TFGS	
29		PBR	T-L			WFG	BL	SFG
30	BAR							
31	PEH		FIWS		FR+	FR–	ME	SYN
32	MNR							
33				AMF				

Single settings (in the user DB starting at address 40) and single commands (in user DB starting at address 42) are also required in order to control the FM 353. These are transferred by means of write jobs (system data).

Single Settings	Single Commands
Length measurement Inprocess measurement Retrigger reference point Deactivate enable input Deactivate software end position monitoring Follow-up mode (only for drives with encoders) Software end position monitoring Automatic drift compensation (only for servo drive) Rotation monitoring (only for step drive without encoder) **Servo enable** Parking axis Simulation	Activate machine data Delete distance to go Automatic block search backward Automatic block search forward Restart Undo set actual value

Troubleshooting

Checkback Signals [BF/FS] and [DF] (group error messages)
Error specification in user program (if necessary) Read out (on BF/FS) DS 162 (channel 1), DS 197 (channel 2), DS 232 (channel 3) or read out (on DF) DS 163 (channel 1), DS 198 (channel 2), DS 233 (channel 3) see example application 2

Error acknowledgment

Set/clear control signal [BFQ/FSQ]
or
on message [DF] → write a new write job

The following table describes the control and checkback signals in German and English.

Table 6-3 Control/Checkback Signals

German	English	Significance
Control Signals		
BP	MODE PA-RAMETER	Operating mode parameters Velocity levels 1 and 2 Voltage/frequency levels 1 and 2 Increment selection 1...100, 254
operating mode	MODE	Operating mode Jogging 01 Open-loop control 02 Reference point approach 03 Incremental relative 04 MDI 06 Automatic 08 Automatic single block 09
R+	DIR_P	Direction plus
R–	DIR_M	Direction minus
STP	STOP	Stop
ST	START	Start
OVERR	OVERRIDE	Override
AF	DRV_EN	Drive enable
SA	SKIP_BLK	Enable bit for block skip
EFG	READ_EN	Read enable
QMF	ACK_MF	Acknowledgment M function
BFQ/FSQ	OT_ERR_A	Acknowledgment operator control and guidance error
TFB	TEST_EN	Switch P BUS interface to “start-up”
Checkback signals		
MNR	NUM_MF	M function number
BL	WORKING	Program running
SFG	START_EN	Start enable

Table 6-3 Control/Checkback Signals, continued

German	English	Significance
BF/FS	OT_ERR	Operator control and guidance errors
BAR	MODE	Active operating mode
AMF	STR_MF	Modify M function
PBR	PR_BACK	Program scanning backward
T-L	DT_RUN	Dwell time running
PEH	POS_ROD	Position reached and stopped
FR+	GO_P	Go_plus
FR–	GO_M	Go_minus
ME	MSR_DONE	Measurement done
SYN	SYNC	Channel synchronized
DF	DATA_ERR	Data error
FIWS	FAVEL	Flying actual value done
TFGS	TST_STAT	Switchover, P-BUS port done
WFG	WAIT_EN	Wait for external enable
PARA	PARA	Channel parameterized

6.3 FC RD_COM (FC 3) – Process Read Jobs Cyclically

Task

You can use FC RD_COM to execute read jobs. You must call FC RD_COM once per channel in the OB 1 cycle.

The last read job must have finished processing, i.e. JOB_RD.NO in the user DB (data byte DBB2) must have been cleared and status bit JOB_RD.DONE enabled.

You initiate a new read job by entering the read job no. in JOB_RD.NO.

Do not include FC RD_COM in your user program if you do not process any read jobs.

The FC performs the following action:

Executes the read job (JOB_RD) from the user DB, transfers the associated data into the user DB, and displays the read job status.

Call Options

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

FC RD_COM
EN — ENO
DB_NO — RET_VAL
	`CALL RD_COM(`
	`DB_NO :=  ,`
	`RET_VAL := );`

Description of Parameters

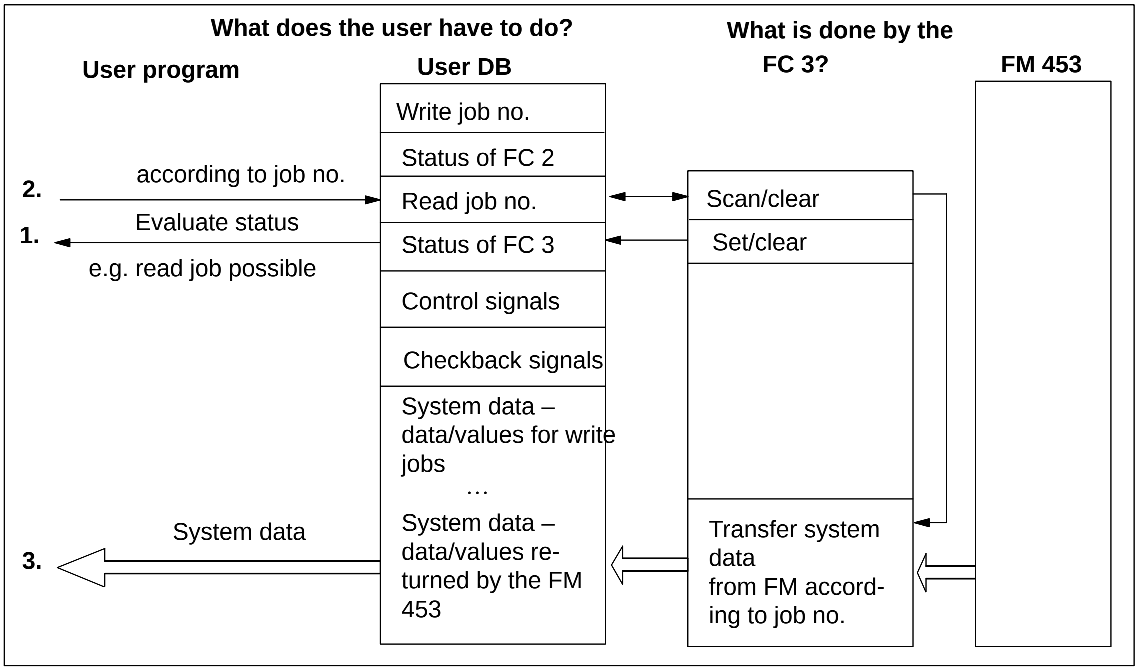
The following table describes the parameters of this FC.

Name	Data Type	P Type	Meaning
DB_NO	WORD	I	Data block number
RET_VAL	INT	Q	Return code of SFC 59 “RD_REC”

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

Principle of Operation

This function works together with a user DB. The structure of the user DB can be found in the library FMSTSVLI in data type UDT 1. You need one user DB for each channel which contains entries for addressing the FM 453 and the data for the individual functions of the FM 453. The DB number is passed when you call the FC with the DB_NO parameter.



The following read jobs (JOB_RD.NO) are known:

Legend for the table below:

Operating mode: T – Jogging
STE – Open-loop control
REF – Reference point approach
SM – Incremental relative
MDI – MDI (Manual Data Input)
A/AE – Automatic/Automatic single block

System Data / Operating Modes	Job no.	Addr. in user DB	T	STE	REF	SM	MDI	A/AE	See Section
Display data is data/parameters returned by the FM.									
DIG_IO – dig. inputs/outputs	101	150.0	x	x	x	x	x	x	9.8
OP_DAT – basic operating data	102	198.0	x	x	x	x	x	x	9.3.11
ACT_BLCK – active NC block	103	230.0						x	9.3.12
NXT_BLCK – next NC block	104	250.0						x	
APP_DAT – application data	105	270.0	x	x	x	x	x	x	9.3.13
BLCK_EXT – actual value block change	107	286.0						x	9.3.14
SERV_DAT – service data	108	290.0	x	x	x	x	x	x	9.3.15
SRV_OUT – reserved	109	322.0							

○ Data is accepted and only processed in the corresponding mode.
x Data is accepted or processed, as applicable.
– Data are rejected with error message (see Troubleshooting, Table 11-8 Class 4 No. 1).

Operating Modes / System Data	Job no.	Addr. in user DB	T	STE	REF	SM	MDI	A/AE	See Section
Display data is data/parameters returned by the FM.									
OP_DAT1 – additional operating data	110	354.0	x	x	x	x	x	x	9.3.16
PAR_READ – parameters/data	114	366.0	x	x	x	x	x	x	9.3.17

○ Data is accepted and only processed in the corresponding mode.

x Data is accepted or processed, as applicable.

– Data are rejected with error message (see Troubleshooting, Table 11-8 Class 4 No. 1).

Read Job Status

The status of a read job is indicated in the user DB (in data byte DBB3).

Bit in JOB_RD (DBX3.)	Significance
.BUSY, 0	= 1, Read job busy This bit is set by FC RD_COM as soon as it starts processing a read job (JOB_RD.NO > 0 and JOB_RD.IMPOSS = 0). This bit is cleared by FC RD_COM as soon as the read job has finished running (JOB_RD.NO = 0).
.DONE, 1	= 1, Read job finished This bit is set by FC RD_COM as soon as it has finished a read job (also with errors) This bit is cleared by FC RD_COM when a new read job begins. You can clear this bit manually.
.IMPOSS, 2	= 1, Read job not possible at the present time Read job processing is not possible: – because the axis is not parameterized – because no mode is preselected – because test mode is active In this case, you can leave the read job (JOB_RD.NO) or delete it. FC RD_COM clears the bit when all the above conditions have been met.
.UNKNOWN, 3	= 1, Read job unknown The read job (JOB_RD.NO) which you specified is not within the known range (see error evaluation). FC RD_COM clears this bit as soon as JOB_RD.NO contains a valid number. The unknown number is retained until then.

Error Evaluation

Errors which occur are indicated in the binary result (BIE = 0).

Possible errors are:

- Unknown read job (see JOB_RD.UNKNOWN)
- Data transfer error during communication with SFC 59 “RD_REC”. The error is returned in the output parameter RET_VAL (see reference manual *System Software for S7-300/400; System and Standard Functions*).

Example call

An example call is shown below for FC RD_COM.

```
STL                                               Explanation

...

      O     DB_FM.JOB_RD.BUSY;                    // Read job busy
      O     DB_FM.JOB_RD.IMPOSS;                  // Read job processing impossible
      SPB   DARD;                                 // Jump to call

      L     B#16#66;                              // Read job 102 for basic operating data
      T     DB_FM.JOB_RD.NO;                      // Store in job box

DARD: CALL  RD_COM(                               // Call read data FC
            DB_NO     := W#16#1,                  // DB number
            RET_VAL   := FEHLERCODE_LESEN)        // Return value

      UN    BIE;                                  // Binary result
      S     FEHLER_LESEFKT;                       // Error on initialization
...
```

6.4 Reading Diagnostic Information

Overview

FC DIAG_RD (FC 4) and FC DIAG_INF (FC 6) are used to read the diagnostic interrupt information for all three channels in the user DB.

FC 4 and FC 6 are intended as alternatives which you can use according to your needs.

6.4.1 FC DIAG_RD (FC 4) – Read Diagnostic Interrupt Data in OB 82

Task

You are only allowed to call FC DIAG_RD in interrupt OB 82.

Call Options

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

FC DIAG_RD
EN — ENO
DB_NO — RET_VAL
IN_DIAG
	`CALL DIAG_RD(`
	`DB_NO := ,`
	`RET_VAL := ,`
	`IN_DIAG := );`

Description of Parameters

The following table describes the parameters of the FC DIAG_RD.

Name	Data Type	P Type	Meaning
DB_NO	WORD	I	Data block number
RET_VAL	INT	Q	Return code of SFC 59 “RD_REC”
IN_DIAG	BOOL	I/O	Initiate reading of diagnostic data; is cleared after execution of FC 4.

Parameter types: I = input parameter, Q = output parameter,
I/O = in/out parameter (initiation parameter)

Principle of Operation

This function works together with a user DB. The DB number is passed when you call the function with the DB_NO parameter.

Reading of the diagnostic interrupt data DIAGNOSTIC_INT_INFO (in user DB starting at address 72) is started when you set the in/out parameter IN_DIAG to one. The parameter is reset by the FC after the job is executed.

The in/out parameter remains set while the job is running. Data transfer is complete when the in/out parameter is reset (IN_DIAG = FALSE).

Error Evaluation

Errors which occur are indicated in the binary result (BIE = 0).

Possible errors are:

Data transfer error during communication with SFC 59 “RD_REC”. The error is returned in the output parameter RET_VAL (see reference manual *System Software for S7-300/400; System and Standard Functions*).

<table>
<tr><td colspan="4">Diagnostic Interrupt
Message to the CPU (precondition: interrupt message activated (see Section 5.2))</td></tr>
<tr><td rowspan="3">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 72 and calls FC 4</td><td>Calls FC 6</td></tr>
<tr><td colspan="3">On operating error:
(addr. in user DB 80.7/82.7/84.7)
For further error specification by reading out DS 164 (channel 1), DS 199 (channel 2), DS 234 (channel 3) in OB 1
see example application 2</td></tr>
</table>

Diagnostic Data

The following table contains the diagnostic information for channels 1 to 3, DIAGNOSTIC_INT_INFO in the user DB starting at address 72.

Table 6-4 Diagnostic Information

Data Format	Byte.Bit No.	Significance
4-byte	0.0	Module/group disturbances (incoming and outgoing)
	0.1	Internal error/HW error (group error bytes 2, 3)
	0.2	External error
	0.3	External channel error (group error bytes 8, 10, 12)
	0.6	Module not parameterized
	1.0 – 3	Type class of module; for FM 453 = 08H
	1.4	Channel information present
	2.1	Communication disturbance (K bus)
	2.3	Time monitoring actuated/Watchdog
	2.4	Module internal power supply failed (NMI)
	3.2	FEPROM error
	3.3	RAM error
	3.6	Process interrupt lost

Table 6-4 Diagnostic Information, continued

Data Format	Byte.Bit No.	Significance
12-byte	4	FM Pos identifier (74H)
	5	Length of diagnostic information (16)
	6	No. of channels (3)
	7.0...2	Channel error vector (1...3)
	8.0	Cable break (incremental encoder) for channel 1
	8.1	Absolute encoder error for 1
	8.2	Error pulse incr. or zero ref. mark missing for channel 1
	8.3	Voltage monitoring encoder for channel 1
	8.4	Voltage monitoring ± 15 V for channel 1
	8.5	Voltage monitoring of digital outputs for channel 1
	8.7	Operating error (see Chapter 11, Troubleshooting) for channel 1
	9	Free
	10	Analog byte 8 for channel 2
	11	Free
	12	Analog byte 8 for channel 3
	13 – 15	Free

Hints to the User

In a diagnostic event, bytes 0 to 3 are automatically transmitted to the CPU, and the diagnostic organization block (OB82) is called up. The diagnostic OB should be included in the user program; otherwise the CPU will go to the Stop state. Byte 0 contains group error messages that are set simultaneously with the corresponding messages in bytes 2, 3 and 8.

The operating error (byte 8.7) is specified again. The error numbers are available for display purposes in the diagnostic buffer of the FM 453 and in the data block for status messages (DB-SS) (see Section). For special error evaluations in the user program, these error numbers are available in DS164.

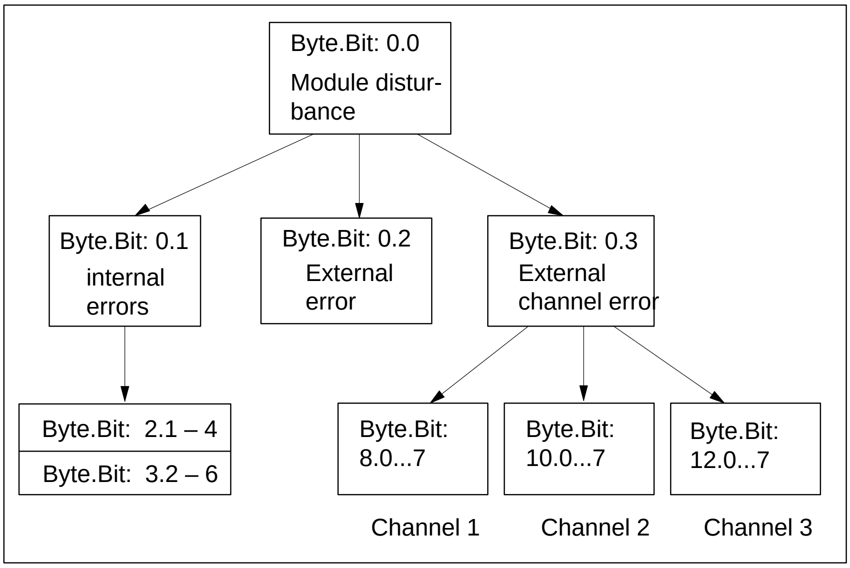


Fig. 6-3 Evaluation of Diagnostic Information

Example Call in OB 82

An example call is shown below for FC DIAG_RD.

```
STL                                           Explanation

...

      S     DIAG_READ;                        // Initiate read function

      CALL  DIAG_INF(                         // Call diagnostic information FC
            DB_NO     := W#16#1,              // DB number
            RET_VAL   := FEHLERCODE_LESEN,    // Return value
            IN_DIAG   := DIAG_READ);          // Initiate reading

      UN    BIE;                              // Binary result
      S     FEHLER_LESEFKT;                   // Error on initialization
...
```

6.4.2 FC DIAG_INF (FC 6) – Read Diagnostic Interrupt Data in OB 1

Task

You can call FC DIAG_INF in OB 1 (or at another cyclical program level).

For call options, parameters and evaluation, see Section 6.4.1.

Principle of Operation

This function works together with a user DB. The DB number is passed when you call the function with the DB_NO parameter.

Reading of the diagnostic interrupt data DIAGNOSTIC_INT_INFO (in user DB starting at address 72) is started when you set the in/out parameter IN_DIAG to one. The parameter is reset by the FC after the job is executed. The FC must be called up until it has reset the in/out parameter. When the FM 453 is used centrally, the Read job is processed within a single function-block callup. When the FM 453 is used in a distributed configuration, it may take several function-block callups to process the Read job.

The in/out parameter remains set while the job is running. Data transfer is complete when the in/out parameter is reset (IN_DIAG = FALSE).

Example Call in OB 1

An example call is shown below for FC DIAG_INF.

```
STL                                             Explanation

...

      U    DIAG_READ;                           // Call FC if initiation flag set
      SPB  DIRD;
      S    DIAG_READ;                           // Initiate read function

DIRD: CALL DIAG_INF(                            // Call diagnostic information FC
           DB_NO     := W#16#1,                 // DB number
           RET_VAL   := FEHLERCODE_LESEN,       // Return value
           IN_DIAG   := DIAG_READ);             // Initiate reading

      U    DIAG_READ;                           // Jump to end if read job not // yet fin-
      SPB  END;                                 ished

      UN   BIE;                                 // Binary result
      S    FEHLER_LESEFKT;                      // Error on read function

END:  NOP  0;

...
```

6.5 FC MSRMENT (FC 5) – Read Measured Values

Task

You use FC MSRMENT to read the measured values into the user DB (starting at address 60). You can call FC MSRMENT in OB 40, if the process interrupt was activated (see Section 5.2), or in OB 1. You are not allowed to call FC 5 simultaneously in both OBs.

Call Options

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

FC MSRMENT
EN ENO
DB_NO RET_VAL
IN_MSR
	`CALL MSRMENT(`
	`DB_NO := ,`
	`RET_VAL := ,`
	`IN_MSR := );`

Description of Parameters

The following table describes the parameters of FC 5.

Name	Data Type	P Type	Meaning
DB_NO	WORD	I	Data block number
RET_VAL	INT	Q	Return code of SFC 59 “RD_REC”
IN_MSR	BOOL	I/O	Start Read process

Parameter types: I = input parameter, Q = output parameter,
I/O = in/out parameter (initiation parameter)

Principle of Operation

This function works together with a user DB. The DB number is passed when you call the function with the DB_NO parameter.

Reading of the measured values MEASUREMENT_VALUES (in user DB starting at address 60) is started when you set the in/out parameter IN_MSR to one. The parameter is reset by the FC after the job is executed. The FC must be called up until it has reset the in/out parameter. When the FM 453 is used centrally, the Read job is processed within a single function-block callup. When the FM 453 is used in a distributed configuration, it may take several function block calls to process the read job (only applies when called in OB 1).

The in/out parameter remains set while the job is running. Data transfer is complete when the in/out parameter is reset (IN_MSR = FALSE).

Error Evaluation

Errors which occur are indicated in the binary result (BIE = 0).

Possible errors are:

Data transfer error during communication with SFC 59 “RD_REC”. The error is returned in the output parameter RET_VAL (see reference manual *System Software for S7-300/400; System and Standard Functions*).

Example Call in OB 1

An example call is shown below in OB 1.

```
STL                                             Explanation
      U     DB_FM.CHECKBACK_SIGNALS.MSR_DONE;   // “Measurement completed” checkback
      FP    FLANKENMERKER_MESSUNG_BEENDET;      signal
      S     “ANSTOSS_LESEFKT”;                  // Edge flag for “Measurement com-
                                                pleted”
      CALL  MSRMENT(                            // Set initiation parameters
            DB_NO     := W#16#1,
            RET_VAL   := FEHLERCODE_LESEN,      // CALLUP OF FC MSRMENT
            IN_MSR    := “ANSTOSS_LESEFKT”);

      U     “ANSTOSS_LESEFKT”;
      SPB   NWE;
                                                // Initiation bit is still set

      UN    BIE;
      S     FEHLER_LESEFKT;
                                                // Communication error
NWE:  NOP 0;                                    // Indicate error in Read function
```

Example Call in OB 40

An example call is shown below in OB 40.

```
STL                                             Explanation
...
      S     MW_LESEN;                           // Set job

      CALL  MSRMENT(                            // Call FC for reading measured values
            DB_NO        := W#16#1,             // DB number
            RET_VAL      := FEHLERCODE_LESEN,   // Return value
            IN_MSR       := MW_LESEN);          // Initiation parameter

      UN    BIE;
      S     FEHLER_LESEFKT;                     // Binary result
...                                             // Display error on read function
```

Note

The activation of “measurement” and the generation of the measured values is described in Section 9.3.10.

6.6 User Data Block

Overview

The following table provides you with a description of the user data block structure.

One of these user DBs must exist for each channel that is used.

Table 6-5 User DB for the FM 453

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
Job box for FC MODE_WR						
	0.0		JOB_WR	STRUCT		Write jobs
0.0	+0.0		NO	BYTE	B#16#0	Write job number
1.0	+1.0		BUSY	BOOL	FALSE	Write job busy
1.1	+1.1		DONE	BOOL	FALSE	Write job finished
1.2	+1.2		IMPOSS	BOOL	FALSE	Write job impossible
1.3	+1.3		UNKNOWN	BOOL	FALSE	Write job unknown
1.4	+1.4		BIT1_4	BOOL	FALSE	Reserved
1.5	+1.5		BIT1_5	BOOL	FALSE	Reserved
1.6	+1.6		MODE_BUSY	BOOL	FALSE	Start an operating mode
1.1	+1.7		POS_REACHED	BOOL	FALSE	Position reached
	=2.0			END_STRUCT		
Job box for FC RD_COM						
	2.0		JOB_RD	STRUCT		Read jobs
2.0	+2.0		NO	BYTE	B#16#0	Read job number
3.0	+3.0		BUSY	BOOL	FALSE	Read job busy
3.1	+3.1		DONE	BOOL	FALSE	Read job finished
3.2	+3.2		IMPOSS	BOOL	FALSE	Read job impossible
3.3	+3.3		UNKNOWN	BOOL	FALSE	Read job unknown
	=2.0			END_STRUCT		
is entered by FC INIT_DB						
4.0	+4.0		WORD4	WORD	W#16#0	Reserved
6.0	+6.0		WORD6	WORD	W#16#0	Reserved
8.0	+8.0		WORD8	WORD	W#16#0	Reserved
10.0	+10.0		WORD10	WORD	W#16#0	Reserved
12.0	+12.0	stat	MOD_ADR	WORD	W#16#0	Module address
14.0	+14.0	stat	CH_ADR	DWORD	DW#16#0	Channeladdress
18.0	+18.0	stat	DS_OFFS	BYTE	B#16#0	Offset for channel-specific data set number

Table 6-5 User DB for the FM 453, continued

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
19.0	+19.0	stat	RESERV_2	BYTE	B#16#0	Reserved
Control signals:		**FC MODE_WR**				
	20.0	stat	CONTROL_ SIGNALS	STRUCT		Control signals
20.0	+0.0		BIT0_0	BOOL	FALSE	Reserved
20.1	+0.1		TEST_EN	BOOL	FALSE	Switchover, P-bus interface
20.2	+0.2		BIT0_2	BOOL	FALSE	Reserved
20.3	+0.3		OT_ERR_A	BOOL	FALSE	Acknowledge operator-control/traversing error
20.4	+0.4		BIT0_4	BOOL	FALSE	Reserved
20.5	+0.5		BIT0_5	BOOL	FALSE	Reserved
20.6	+0.6		BIT0_6	BOOL	FALSE	Reserved
20.7	+0.7		BIT0_7	BOOL	FALSE	Reserved
21.0	+1.0		START	BOOL	FALSE	Start
21.1	+1.1		STOP	BOOL	FALSE	Stop
21.2	+1.2		DIR_M	BOOL	FALSE	Direction minus
21.3	+1.3		DIR_P	BOOL	FALSE	Direction plus
21.4	+1.4		ACK_MF	BOOL	FALSE	Acknowledge M function
21.5	+1.5		READ_EN	BOOL	FALSE	Enable read-in
21.6	+1.6		SKIP_BLK	BOOL	FALSE	Skip block
21.7	+1.7		DRV_EN	BOOL	FALSE	Drive enable
22.0	+2.0		MODE	BYTE	B#16#0	Operating mode
23.0	+3.0		MODE_ PARAMETER	BYTE	B#16#0	Mode parameter
24.0	+4.0		OVERRIDE	BYTE	B#16#0	Override
25.0	+5.0		BYTE5	BYTE	B#16#0	Reserved
26.0	+6.0		BYTE6	BYTE	B#16#0	Reserved
27.0	+7.0		BYTE7	BYTE	B#16#0	Reserved
	=8.0			END_STRUCT		
Response signals:		**FC MODE_WR**				
	28.0	stat	CHECKBACK_ SIGNALS	STRUCT		Checkback signals
28.0	+0.0		DAIN	BOOL	FALSE	Reserved
28.1	+0.1		TST_STAT	BOOL	FALSE	P bus interface switchover complete
28.2	+0.2		BIT0_2	BOOL	FALSE	Reserved

Table 6-5 User DB for the FM 453, continued

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
28.3	+0.3		OT_ERR	BOOL	FALSE	Operator control and guidance errors
28.4	+0.4		DATA_ERR	BOOL	FALSE	Data error
28.5	+0.5		FM_NSTQ	BOOL	FALSE	Reserved
28.6	+0.6		FM_NST	BOOL	FALSE	Reserved
28.7	+0.7		PARA	BOOL	FALSE	Parameterized
29.0	+1.0		START_EN	BOOL	FALSE	Enable start
29.1	+1.1		WORKING	BOOL	FALSE	Processing in progress
29.2	+1.2		WAIT_EN	BOOL	FALSE	Wait for external enable
29.3	+1.3		BIT1_3	BOOL	FALSE	Reserved
29.4	+1.4		BIT1_4	BOOL	FALSE	Reserved
29.5	+1.5		DT_RUN	BOOL	FALSE	Dwell time in progress
29.6	+1.6		PR_BACK	BOOL	FALSE	Program processing in reverse
29.7	+1.7		BIT1_7	BOOL	FALSE	Reserved
30.0	+2.0		MODE	BYTE	B#16#0	Active operating mode
31.0	+3.0		SYNC	BOOL	FALSE	Synchronized
31.1	+3.1		MSR_DONE	BOOL	FALSE	End measurement
31.2	+3.2		GO_M	BOOL	FALSE	Go_minus
31.3	+3.3		GO_P	BOOL	FALSE	Go_plus
31.4	+3.4		BIT3_4	BOOL	FALSE	Reserved
31.5	+3.5		FAVEL	BOOL	FALSE	Flying actual value done
31.6	+3.6		BIT3_6	BOOL	FALSE	Reserved
31.7	+3.7		POS_ROD	BOOL	FALSE	Position reached, Stop (“PEH”)
32.0	+4.0		NUM_MF	BYTE	B#16#0	M function no.
33.0	+5.0		BIT5_0	BOOL	FALSE	Reserved
33.1	+5.1		BIT5_1	BOOL	FALSE	Reserved
33.2	+5.2		BIT5_2	BOOL	FALSE	Reserved
33.3	+5.3		BIT5_3	BOOL	FALSE	Reserved
33.4	+5.4		STR_MF	BOOL	FALSE	Change M function
33.5	+5.5		BIT5_5	BOOL	FALSE	Reserved
33.6	+5.6		BIT5_6	BOOL	FALSE	Reserved
33.7	+5.7		BIT5_7	BOOL	FALSE	Reserved
34.0	+6.0		WORD6	WORD	W#16#0	Reserved

Table 6-5 User DB for the FM 453, continued

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
36.0	+8.0		DWORD8	DWORD	DW#16#0	Reserved
	=12.0			END_STRUCT		
Single functions:			**FC MODE_WR, job no. 10**			
	40.0	stat	SINGLE FUNCTIONS	STRUCT		Single settings
40.0	+0.0		SERVO_EN	BOOL	FALSE	Enable CL controller
40.1	+0.1		GAUG_FLY	BOOL	FALSE	Measurement on-the-fly
40.2	+0.2		BIT0_2	BOOL	FALSE	Reserved
40.3	+0.3		BIT0_3	BOOL	FALSE	Reserved
40.4	+0.4		BIT0_4	BOOL	FALSE	Reserved
40.5	+0.5		TRAV_MON	BOOL	FALSE	Rotation monitoring
40.6	+0.6		PARK_AX	BOOL	FALSE	Parking axis
40.7	+0.7		SIM_ON	BOOL	FALSE	Simulation on
41.0	+1.0		BIT1_0	BOOL	FALSE	Reserved
41.1	+1.1		BIT1_1	BOOL	FALSE	Reserved
41.2	+1.2		MSR_EN	BOOL	FALSE	Length measurement
41.3	+1.3		REFTRIG	BOOL	FALSE	Retrigger reference point
41.4	+1.4		DI_EN	BOOL	FALSE	Switch off enable output
41.5	+1.5		FOLLOWUP	BOOL	FALSE	Follow-up mode
41.6	+1.6		SSW_DIS	BOOL	FALSE	Switch off software end position monitoring
41.7	+1.7		DRIFTOFF	BOOL	FALSE	Switch off automatic drift compensation
	=2.0			END_STRUCT		
Single commands:			**FC MODE_WR, job no. 11**			
	42.0	stat	SINGLE_ COMMANDS	STRUCT		Single commands
42.0	+0.0		BIT0_0	BOOL	FALSE	Reserved
42.1	+0.1		BIT0_1	BOOL	FALSE	Reserved
42.2	+0.2		BIT0_2	BOOL	FALSE	Reserved
42.3	+0.3		BIT0_3	BOOL	FALSE	Reserved
42.4	+0.4		BIT0_4	BOOL	FALSE	Reserved
42.5	+0.5		BIT0_5	BOOL	FALSE	Reserved
42.6	+0.6		BIT0_6	BOOL	FALSE	Reserved
42.7	+0.7		BIT0_7	BOOL	FALSE	Reserved
43.0	+1.0		MDATA_EN	BOOL	FALSE	Activate MD

Table 6-5 User DB for the FM 453, continued

Abso-lute Ad-dress	Relative Address	Decla-ration	Variable	Data Type	Initial Value	Comments
43.1	+1.1		DEL_DIST	BOOL	FALSE	Delete residual distance
43.2	+1.2		SEARCH_F	BOOL	FALSE	Automatic block search for-ward
43.3	+1.3		SEARCH_B	BOOL	FALSE	Automatic block search in re-verse
43.4	+1.4		BIT1_4	BOOL	FALSE	Reserved
43.5	+1.5		RESET_AX	BOOL	FALSE	Restart
43.6	+1.6		AVAL_REM	BOOL	FALSE	Remove setting actual value
43.7	+1.7		BIT1_7	BOOL	FALSE	Reserved
	=2.0			END_STRUCT		
Zero offset:			**FC MODE_WR, job no. 12**			
44.0	44.0	stat	ZERO_OFFSET	DINT	L#0	Zero offset
Set actual value:			**FC MODE_WR, job no. 13**			
48.0	48.0	stat	SETTING_ ACT_VALUE	DINT	L#0	Set Actual value
Set actual value on the fly:			**FC MODE_WR, job no. 14**			
52.0	52.0	stat	FLYING_ SETTING_ ACT_VALUE	DINT	L#0	Set actual value on-the-fly
Set reference point:			**FC MODE_WR, job no. 21**			
56.0	56.0	stat	SETTING_ REFERENCE_ PIONT	DINT	L#0	Set reference point
Measured values:			**FC MSRMENT**			
	60.0	stat	MEASURE-MENT_VALUES	STRUCT		Measured values
60.0	+0.0		BEGIN_VALUE	DINT	L#0	Start value or measured value on the fly
64.0	+4.0		END_VALUE	DINT	L#0	End value
68.0	+8.0		LENGTH_ VALUE	DWORD	DW#16#0	Linear measurements
	=12.0			END_STRUCT		
Diagnostic interrupt data:			**FC DIAG_INF/FC DIAG_RD**			
	72.0	stat	DIAGNOSTIC_ INT_INFO	STRUCT		Diagnostic interrupt data
72.0	+0.0		BYTE0	BYTE	B#16#0	For system-specific diagnostic data, see Section 6.4
73.0	+1.0		BYTE1	BYTE	B#16#0	
74.0	+2.0		BYTE2	BYTE	B#16#0	
75.0	+3.0		BYTE3	BYTE	B#16#0	

Table 6-5 User DB for the FM 453, continued

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
76.0	+4.0		BYTE4	BYTE	B#16#0	Channel type
77.0	+5.0		BYTE5	BYTE	B#16#0	Info length per channel
78.0	+6.0		BYTE6	BYTE	B#16#0	No. of channels
79.0	+7.0		BYTE7	BYTE	B#16#0	Channel error vector
80.0	+8.0		BYTE8	BYTE	B#16#0	For individual errors, see Section 6.4
81.0	+9.0		BYTE9	BYTE	B#16#0	
82.0	+10.0		BYTE10	BYTE	B#16#0	Reserved
83.0	+11.0		BYTE11	BYTE	B#16#0	Reserved
84.0	+12.0		BYTE12	BYTE	B#16#0	Reserved
85.0	+13.0		BYTE13	BYTE	B#16#0	Reserved
	=14.0			END_STRUCT		
Setpoint for incremental value:			**FC MODE_WR, job no. 3**			
86.0	86.0	stat	TARGET_254	DWORD	DW#16#0	Setpoint for increment
Velocity levels 1 and 2:			**FC MODE_WR, job no. 1**			
	90.0	stat	VLEVEL_1_2	STRUCT		Velocity levels 1 and 2
90.0	+0.0		VLEVEL_1	DWORD	DW#16#0	Speed level 1
94.0	+4.0		VLEVEL_2	DWORD	DW#16#0	Speed level 2
	=8.0			END_STRUCT		
Voltage/Frequency level 1 and 2:			**FC MODE_WR, job no. 2**			
	98.0	stat	CLEVEL_1_2	STRUCT		Voltage/Frequency level 1 and 2:
98.0	+0.0		CLEVEL_1	DWORD	DW#16#0	Voltage/Frequency level 1 :
102.0	+4.0		CLEVEL_2	DWORD	DW#16#0	Voltage/Frequency level 2 :
	=8.0			END_STRUCT		
MDI block			**FC MODE_WR, job no. 6**			
	106.0	stat	MDI_BLOCK	STRUCT		MDI block
106.0	+0.0		BYTE0	BYTE	B#16#0	Reserved
107.0	+1.0		BYTE1	BYTE	B#16#0	Reserved
108.0	+2.0		G_1_EN	BOOL	FALSE	G function group 1
108.1	+2.1		G_2_EN	BOOL	FALSE	G function group 2
108.2	+2.2		BIT2_2	BOOL	FALSE	Reserved
108.3	+2.3		BIT2_3	BOOL	FALSE	Reserved
108.4	+2.4		X_T_EN	BOOL	FALSE	Position/dwell
108.5	+2.5		BIT2_5	BOOL	FALSE	Reserved
108.6	+2.6		BIT2_6	BOOL	FALSE	Reserved

Table 6-5 User DB for the FM 453, continued

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
108.7	+2.7		BIT2_7	BOOL	FALSE	Reserved
109.0	+3.0		V_EN	BOOL	FALSE	Speed
109.1	+3.1		M_1_EN	BOOL	FALSE	M function group 1
109.2	+3.2		M_2_EN	BOOL	FALSE	M function group 2
109.3	+3.3		M_3_EN	BOOL	FALSE	M function group 3
109.4	+3.4		BIT3_4	BOOL	FALSE	Reserved
109.5	+3.5		BIT3_5	BOOL	FALSE	Reserved
109.6	+3.6		BIT3_6	BOOL	FALSE	Reserved
109.7	+3.7		BIT3_7	BOOL	FALSE	Reserved
110.0	+4.0		G_1_VAL	BYTE	B#16#0	G function no. of group 1
111.0	+5.0		G_2_VAL	BYTE	B#16#0	G function no. of group 2
112.0	+6.0		BYTE6	BYTE	B#16#0	Reserved
113.0	+7.0		BYTE7	BYTE	B#16#0	Reserved
114.0	+8.0		X_T_VAL	DINT	L#0	Value – position/dwell
118.0	+12.0		V_VAL	DINT	L#0	Value of velocity
122.0	+16.0		M_1_VAL	BYTE	B#16#0	M function no. of group 1
123.0	+17.0		M_2_VAL	BYTE	B#16#0	M function no. of group 2
124.0	+18.0		M_3_VAL	BYTE	B#16#0	M function no. of group 3
125.0	+19.0		BYTE19	BYTE	B#16#0	Reserved
	=20.0			END_STRUCT		
Change parameters/data:			**FC MODE_WR, job no. 8**			
	126.0	stat	PAR_CHAN	STRUCT		Change parameters/data
126.0	+0.0		PAR_TYP	BYTE	B#16#0	DB type
127.0	+1.0		PAR_NUMB	BYTE	B#16#0	Number
128.0	+2.0		PAR_COUN	BYTE	B#16#0	Count
129.0	+3.0		PAR_JOB	BYTE	B#16#0	Job
130.0	+4.0		PAR_DATA	BYTE	B#16#0	Data array
131.0	+5.0		BYTE5		B#16#0	
132.0	+6.0		BYTE6		B#16#0	
133.0	+7.0		BYTE7		B#16#0	
134.0	+8.0		BYTE8		B#16#0	
135.0	+9.0		BYTE9		B#16#0	
136.0	+10.0		BYTE10		B#16#0	
137.0	+11.0		BYTE11		B#16#0	
138.0	+12.0		BYTE12		B#16#0	

Table 6-5 User DB for the FM 453, continued

Abso-lute Ad-dress	Relative Address	Decla-ration	Variable	Data Type	Initial Value	Comments
139.0	+13.0		BYTE13		B#16#0	
140.0	+14.0		BYTE14		B#16#0	
141.0	+15.0		BYTE15		B#16#0	
142.0	+16.0		BYTE16		B#16#0	
143.0	+17.0		BYTE17		B#16#0	
144.0	+18.0		BYTE18		B#16#0	
145.0	+19.0		BYTE19		B#16#0	
146.0	+20.0		BYTE20		B#16#0	
147.0	+21.0		BYTE21		B#16#0	
148.0	+22.0		BYTE22		B#16#0	
149.0	+23.0		BYTE23		B#16#0	
	=24.0			END_STRUCT		
Digital I/Os:			**FC MODE_WR, job no. 15/FC RD_COM, job no. 101**			
	150.0	stat	DIG_IO	STRUCT		Digital inputs and outputs
150.0	+0.0		D_IN0	BOOL	FALSE	Digital input 0
150.1	+0.1		D_IN1	BOOL	FALSE	Digital input 1
150.2	+0.2		D_IN2	BOOL	FALSE	Digital input 2
150.3	+0.3		D_IN3	BOOL	FALSE	Digital input 3
150.4	+0.4		BIT0_4	BOOL	FALSE	Reserved
150.5	+0.5		BIT0_5	BOOL	FALSE	Reserved
150.6	+0.6		BIT0_6	BOOL	FALSE	Reserved
150.7	+0.7		BIT0_7	BOOL	FALSE	Reserved
151.0	+1.0		D_OUT0	BOOL	FALSE	Digital output 0
151.1	+1.1		D_OUT1	BOOL	FALSE	Digital output 1
151.2	+1.2		D_OUT2	BOOL	FALSE	Digital output 2
151.3	+1.3		D_OUT3	BOOL	FALSE	Digital output 3
151.4	+1.4		BIT1_4	BOOL	FALSE	Reserved
151.5	+1.5		BIT1_5	BOOL	FALSE	Reserved
151.6	+1.6		BIT1_6	BOOL	FALSE	Reserved
151.7	+1.7		BIT1_7	BOOL	FALSE	Reserved
	=2.0			END_STRUCT		
MDI block on the fly:			**FC MODE_WR, job no. 16**			
	152.0	stat	MDI_FLY	STRUCT		MD block on-the-fly
152.0	+0.0		BYTE0	BYTE	B#16#0	Reserved
153.0	+1.0		BYTE1	BYTE	B#16#0	Reserved

Table 6-5 User DB for the FM 453, continued

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
154.0	+2.0		G_1_EN	BOOL	FALSE	G function group 1
154.1	+2.1		G_2_EN	BOOL	FALSE	G function group 2
154.2	+2.2		BIT2_2	BOOL	FALSE	Reserved
154.3	+2.3		BIT2_3	BOOL	FALSE	Reserved
154.4	+2.4		X_T_EN	BOOL	FALSE	Position/dwell
154.5	+2.5		BIT2_5	BOOL	FALSE	Reserved
154.6	+2.6		BIT2_6	BOOL	FALSE	Reserved
154.7	+2.7		BIT2_7	BOOL	FALSE	Reserved
155.0	+3.0		V_EN	BOOL	FALSE	Speed
155.1	+3.1		M_1_EN	BOOL	FALSE	M function group 1
155.2	+3.2		M_2_EN	BOOL	FALSE	M function group 2
155.3	+3.3		M_3_EN	BOOL	FALSE	M function group 3
155.4	+3.4		BIT3_4	BOOL	FALSE	Reserved
155.5	+3.5		BIT3_5	BOOL	FALSE	Reserved
155.6	+3.6		BIT3_6	BOOL	FALSE	Reserved
155.7	+3.7		BIT3_7	BOOL	FALSE	Reserved
156.0	+4.0		G_1_VAL	BYTE	B#16#0	G function no. 1
157.0	+5.0		G_2_VAL	BYTE	B#16#0	G function no. 2
158.0	+6.0		BYTE6	BYTE	B#16#0	Reserved
159.0	+7.0		BYTE7	BYTE	B#16#0	Reserved
160.0	+8.0		X_T_VAL	DINT	L#0	Value – position/dwell
164.0	+12.0		V_VAL	DINT	L#0	Value of velocity
168.0	+16.0		M_1_VAL	BYTE	B#16#0	M function no. of group 1
169.0	+17.0		M_2_VAL	BYTE	B#16#0	M function no. of group 2
170.0	+18.0		M_3_VAL	BYTE	B#16#0	M function no. of group 3
171.0	+19.0		BYTE19	BYTE	B#16#0	Reserved
	=20.0			END_STRUCT		
Program selection:			**FC MODE_WR, job no. 17**			
	172.0	stat	PROG_SEL	STRUCT		Select program
172.0	+0.0		PROG_NO	BYTE	B#16#0	Program number
173.0	+1.0		BLCK_NO	BYTE	B#16#0	Block number
174.0	+2.0		PROG_DIR	BYTE	B#16#0	Direction of machining
175.0	+3.0		BYTE3	BYTE	B#16#0	Reserved
	=4.0			END_STRUCT		

Table 6-5 User DB for the FM 453, continued

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
Request application data:			**FC MODE_WR, job no. 18**			
	176.0	stat	REQ_APP	STRUCT		Request application data
176.0	+0.0		CODE_AP1	BYTE	B#16#0	Application data 1
177.0	+1.0		CODE_AP2	BYTE	B#16#0	Application data 2
178.0	+2.0		CODE_AP3	BYTE	B#16#0	Application data 3
179.0	+3.0		CODE_AP4	BYTE	B#16#0	Application data 4
	=4.0			END_STRUCT		
Teach in:			**FC MODE_WR, job no. 19**			
	180.0	stat	TEACH_IN	STRUCT		Teach In
180.0	+0.0		PROG_NO	BYTE	B#16#0	Program number
181.0	+1.0		BLCK_NO	BYTE	B#16#0	Block number
	=2.0			END_STRUCT		
FC MODE_WR, job no. 22						
	182.0	stat	SRV_IN	STRUCT		Reserved
182.0	+0.0		SRV_IN1	DINT	L#0	
186.0	+4.0		SRV_IN2	DINT	L#0	
190.0	+8.0		SRV_IN3	DINT	L#0	
194.0	+12.0		SRV_IN4	DINT	L#0	
	=16.0			END_STRUCT		
Basic operating data:			**FC RD_COM, job no. 102**			
	198.0	stat	OP_DAT	STRUCT		Basic operating data
198.0	+0.0		ACT_VAL	DINT	L#0	Actual position
202.0	+4.0		SPEED	DWORD	DW#16#0	Actual speed
206.0	+8.0		REM_DIST	DINT	L#0	Residual distance
210.0	+12.0		SET_POS	DINT	L#0	Set position
214.0	+16.0		SUM_OFST	DINT	L#0	Total of active coordinate shifts for tool offset, zero offset.
218.0	+20.0		TRAV_SPE	DWORD	DW#16#0	Rotational speed
222.0	+24.0		DWORD24	DINT	L#0	Reserved
226.0	+28.0		DWORD28	DINT	L#0	Reserved
	=32.0			END_STRUCT		
Active NC block:			**FC RD_COM, job no. 103**			
	230.0	stat	ACT_BLCK	STRUCT		Active NC block
230.0	+0.0		PROG_NO	BYTE	B#16#0	Program number
231.0	+1.0		BLCK_NO	BYTE	B#16#0	Block number

Table 6-5 User DB for the FM 453, continued

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
232.0	+2.0		G_1_EN	BOOL	FALSE	G function group 1
232.1	+2.1		G_2_EN	BOOL	FALSE	G function group 2
232.2	+2.2		G_3_EN	BOOL	FALSE	G function group 3
232.3	+2.3		BIT2_3	BOOL	FALSE	Reserved
232.4	+2.4		X_T_EN	BOOL	FALSE	Position/dwell
232.5	+2.5		SR_L_EN	BOOL	FALSE	Subroutine call counter
232.6	+2.6		SR_N_EN	BOOL	FALSE	Subroutine call
232.7	+2.7		SKIP_EN	BOOL	FALSE	Skip block
233.0	+3.0		V_EN	BOOL	FALSE	Speed
233.1	+3.1		M_1_EN	BOOL	FALSE	M function group 1
233.2	+3.2		M_2_EN	BOOL	FALSE	M function group 2
233.3	+3.3		M_3_EN	BOOL	FALSE	M function group 3
233.4	+3.4		TO_EN	BOOL	FALSE	Tool offset
233.5	+3.5		BIT3_5	BOOL	FALSE	Reserved
233.6	+3.6		BIT3_6	BOOL	FALSE	Reserved
233.7	+3.7		BIT3_7	BOOL	FALSE	Reserved
234.0	+4.0		G_1_VAL	BYTE	B#16#0	G function no. of group 1
235.0	+5.0		G_2_VAL	BYTE	B#16#0	G function no. of group 2
236.0	+6.0		G_3_VAL	BYTE	B#16#0	G function no. of group 3
237.0	+7.0		BYTE7	BYTE	B#16#0	Reserved
238.0	+8.0		X_T_VAL	DINT	L#0	Value
242.0	+12.0		V_VAL	DINT	L#0	Value
246.0	+16.0		M_1_VAL	BYTE	B#16#0	M function no. of group 1
247.0	+17.0		M_2_VAL	BYTE	B#16#0	M function no. of group 2
248.0	+18.0		M_3_VAL	BYTE	B#16#0	M function no. of group 3
249.0	+19.0		TO_VAL	BYTE	B#16#0	Tool offset no.
	=20.0			END_STRUCT		
Next NC block:			**FC RD_COM, job no. 104**			
	250.0	stat	NXT_BLCK	STRUCT		Next NC block
250.0	+0.0		PROG_NO	BYTE	B#16#0	Program number
251.0	+1.0		BLCK_NO	BYTE	B#16#0	Block number
252.0	+2.0		G_1_EN	BOOL	FALSE	G function group 1
252.1	+2.1		G_2_EN	BOOL	FALSE	G function group 2
252.2	+2.2		G_3_EN	BOOL	FALSE	G function group 3
252.3	+2.3		BIT2_3	BOOL	FALSE	Reserved

Table 6-5 User DB for the FM 453, continued

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
252.4	+2.4		X_T_EN	BOOL	FALSE	Position/dwell
252.5	+2.5		SR_L_EN	BOOL	FALSE	Subroutine call counter
252.6	+2.6		SR_N_EN	BOOL	FALSE	Subroutine call
252.7	+2.7		SKIP_EN	BOOL	FALSE	Skip block
253.0	+3.0		V_EN	BOOL	FALSE	Speed
253.1	+3.1		M_1_EN	BOOL	FALSE	M function group 1
253.2	+3.2		M_2_EN	BOOL	FALSE	M function group 2
253.3	+3.3		M_3_EN	BOOL	FALSE	M function group 3
253.4	+3.4		TO_EN	BOOL	FALSE	Tool offset
253.5	+3.5		BIT3_5	BOOL	FALSE	Reserved
253.6	+3.6		BIT3_6	BOOL	FALSE	Reserved
253.7	+3.7		BIT3_7	BOOL	FALSE	Reserved
254.0	+4.0		G_1_VAL	BYTE	B#16#0	G function no. of group 1
255.0	+5.0		G_2_VAL	BYTE	B#16#0	G function no. of group 2
256.0	+6.0		G_3_VAL	BYTE	B#16#0	G function no. of group 3
257.0	+7.0		BYTE7	BYTE	B#16#0	Reserved
258.0	+8.0		X_T_VAL	DINT	L#0	Value
262.0	+12.0		V_VAL	DINT	L#0	Value
266.0	+16.0		M_1_VAL	BYTE	B#16#0	M function no. of group 1
267.0	+17.0		M_2_VAL	BYTE	B#16#0	M function no. of group 2
268.0	+18.0		M_3_VAL	BYTE	B#16#0	M function no. of group 3
269.0	+19.0		TO_VAL	BYTE	B#16#0	Tool offset no.
	=20.0			END_STRUCT		
Application data:			**FC RD_COM, job no. 105**			
	270.0	stat	APP_DAT	STRUCT		Application data
270.0	+0.0		APP1	DINT	L#0	Application data 1
274.0	+4.0		APP2	DINT	L#0	Application data 2
278.0	+8.0		APP3	DINT	L#0	Application data 3
282.0	+12.0		APP4	DINT	L#0	Application data 4
	=16.0			END_STRUCT		
Actual value on block change:			**FC RD_COM, job no. 107**			
286.0	286.0	stat	BLCK_EXT	DWORD	DW#16#0	Actual value block change
Servicing data:			**FC RD_COM, job no. 108**			
	290.0	stat	SERV_DAT	STRUCT		Servicing data

Table 6-5 User DB for the FM 453, continued

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
290.0	+0.0		OUT_VAL	DINT	L#0	DAC output value or frequency output value
294.0	+4.0		ENC_VAL	DINT	L#0	Actual encoder value or pulse output counter
298.0	+8.0		PULS_ERR	DINT	L#0	Pulse errors
302.0	+12.0		KV_FA	DINT	L#0	K_v factor
306.0	+16.0		FOLL_ERR	DINT	L#0	Following error or difference between setpoint and actual position
310.0	+20.0		FERR_LIM	DINT	L#0	Following error limit
314.0	+24.0		OSC_ERR	DINT	L#0	s overshoot value/switch adjustment
318.0	+28.0		DR_TIME	DINT	L#0	Positioning time/ response time constant
	=32.0			END_STRUCT		
FC RD_COM, job no. 109						
	322.0	stat	SRV_OUT	STRUCT		Reserved
322.0	+0.0		SRV_OUT1	DINT	L#0	
326.0	+4.0		SRV_OUT2	DINT	L#0	
330.0	+8.0		SRV_OUT3	DINT	L#0	
334.0	+12.0		SRV_OUT4	DINT	L#0	
338.0	+16.0		SRV_OUT5	DINT	L#0	
342.0	+20.0		SRV_OUT6	DINT	L#0	
346.0	+24.0		SRV_OUT7	DINT	L#0	
350.0	+28.0		SRV_OUT8	DINT	L#0	
	=32.0			END_STRUCT		
Additional operating data: FC RD_COM, job no. 110						
	354.0	stat	OP_DAT1	STRUCT		Additional operating data
354.0	+0.0		OVERRIDE	BYTE	B#16#0	Override
355.0	+1.0		PROG_NO	BYTE	B#16#0	NC traversing program No.
356.0	+2.0		BLCK_NO	BYTE	B#16#0	NC block No.
357.0	+3.0		LOOP_NO	BYTE	B#16#0	UP callup counter
358.0	+4.0		G90_91	BYTE	B#16#0	G90/91 active
359.0	+5.0		G60_64	BYTE	B#16#0	G60/64 active
360.0	+6.0		G43_44	BYTE	B#16#0	G43/44 active
361.0	+7.0		TO_NO	BYTE	B#16#0	Active D no.
362.0	+8.0		BIT8_0	BOOL	FALSE	Reserved

Table 6-5 User DB for the FM 453, continued

Abso-lute Ad-dress	Relative Address	Decla-ration	Variable	Data Type	Initial Value	Comments
362.1	+8.1		LIM_SP	BOOL	FALSE	Velocity limitation
362.2	+8.2		LIM_10	BOOL	FALSE	Limitation to ± 10 V
362.3	+8.3		LIM_SU	BOOL	FALSE	Limitation of the minimum acceleration or deceleration
362.4	+8.4		BIT8_4	BOOL	FALSE	Reserved
362.5	+8.5		BIT8_5	BOOL	FALSE	Reserved
362.6	+8.6		BIT8_6	BOOL	FALSE	Reserved
362.7	+8.7		BIT8_7	BOOL	FALSE	Reserved
363.0	+9.0		LIM_FR	BOOL	FALSE	Reserved
363.1	+9.1		LIM_FV	BOOL	FALSE	Reserved
363.2	+9.2		BIT9_2	BOOL	FALSE	Reserved
363.3	+9.3		LIM_FS	BOOL	FALSE	Reserved
363.4	+9.4		BIT9_4	BOOL	FALSE	Reserved
363.5	+9.5		BIT9_5	BOOL	FALSE	Reserved
363.6	+9.6		BIT9_6	BOOL	FALSE	Reserved
363.7	+9.7		BIT9_7	BOOL	FALSE	Reserved
364.0	+10.0		BYTE10	BYTE	B#16#0	Reserved
365.0	+11.0		BYTE11	BYTE	B#16#0	Reserved
	=12.0			END_STRUCT		
Parameters/data:			**FC RD_COM, job no. 114**			
	366.0	stat	PAR_READ	STRUCT		Parameters/data
366.0	+0.0		PAR_TYP	BYTE	B#16#0	DB type
367.0	+1.0		PAR_NO	BYTE	B#16#0	Number
368.0	+2.0		PAR_COUN	BYTE	B#16#0	Count
369.0	+3.0		BYTE3	BYTE	B#16#0	Reserved
370.0	+4.0		PAR_DATA	BYTE	B#16#0	Data array
371.0	+5.0		BYTE5	BYTE	B#16#0	
372.0	+6.0		BYTE6	BYTE	B#16#0	
373.0	+7.0		BYTE7	BYTE	B#16#0	
374.0	+8.0		BYTE8	BYTE	B#16#0	
375.0	+9.0		BYTE9	BYTE	B#16#0	
376.0	+10.0		BYTE10	BYTE	B#16#0	
377.0	+11.0		BYTE11	BYTE	B#16#0	
378.0	+12.0		BYTE12	BYTE	B#16#0	
379.0	+13.0		BYTE13	BYTE	B#16#0	

Table 6-5 User DB for the FM 453, continued

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
380.0	+14.0		BYTE14	BYTE	B#16#0	
381.0	+15.0		BYTE15	BYTE	B#16#0	
382.0	+16.0		BYTE16	BYTE	B#16#0	
383.0	+17.0		BYTE17	BYTE	B#16#0	
384.0	+18.0		BYTE18	BYTE	B#16#0	
385.0	+19.0		BYTE19	BYTE	B#16#0	
386.0	+20.0		BYTE22	BYTE	B#16#0	
387.0	+21.0		BYTE23	BYTE	B#16#0	
388.0	+22.0		BYTE24	BYTE	B#16#0	
389.0	+23.0		BYTE23	BYTE	B#16#0	
	=24.0			END_STRUCT		
Man-machine interface						
	390.0	stat	USR_CON	STRUCT		Man-machine interface
390.0	+0.0		BITC_0	BOOL	FALSE	Write MD
390.1	+0.1		BITC_1	BOOL	FALSE	Read MD
390.2	+0.2		BITC_2	BOOL	FALSE	Transfer MDI block
390.3	+0.3		BITC_3	BOOL	FALSE	Transfer program selection
390.4	+0.4		BITC_4	BOOL	FALSE	Transfer teach-in
390.5	+0.5		BITC_5	BOOL	FALSE	Transfer incremental value
390.6	+0.6		BITC_6	BOOL	FALSE	Transfer velocity levels
390.7	+0.7		BITC_7	BOOL	FALSE	Transfer voltage/frequency levels
391.0	+1.0		BITC_8	BOOL	FALSE	Transfer MDI block on the fly
391.1	+1.1		BITC_9	BOOL	FALSE	Transfer set actual value
391.2	+1.2		BITC_10	BOOL	FALSE	Transfer zero offset
391.3	+1.3		BITC_11	BOOL	FALSE	Reserved
391.4	+1.4		BITC_12	BOOL	FALSE	Reserved
391.5	+1.5		BITC_13	BOOL	FALSE	Diagnostic interrupt
391.6	+1.6		BITC_14	BOOL	FALSE	Data error
391.7	+1.7		BITC_15	BOOL	FALSE	Operator control and guidance errors
	=2.0			END_STRUCT		
392.0	392.0	stat	MD_NO	WORD	W#16#0	No.
394.0	394.0	stat	MD_VALUE	DINT	L#0	MD value
398.0	398.0	stat	INC_NO	BYTE	B#16#0	SM no.
399.0	399.0	stat	RESERV_3	BYTE	B#16#0	Reserved

Table 6-5 User DB for the FM 453, continued

Absolute Address	Relative Address	Declaration	Variable	Data Type	Initial Value	Comments
400.0	400.0	stat	PICT_NO	WORD	W#16#0	Display number
402.0	402.0	stat	KEY_CODE	WORD	W#16#0	Keycode
404.0	404.0	stat	RESERV_4	WORD	W#16#0	Reserved
	406.0	stat	OP_MODE	STRUCT		Mode selection
406.0	+0.0		BITA_0	BOOL	FALSE	OL Control
406.1	+0.1		BITA_1	BOOL	FALSE	Reference-point approach
406.2	+0.2		BITA_2	BOOL	FALSE	Incremental relative
406.3	+0.3		BITA_3	BOOL	FALSE	MDI
406.4	+0.4		BITA_4	BOOL	FALSE	Automatic/single-block
406.5	+0.5		BITA_5	BOOL	FALSE	Automatic
406.6	+0.6		BITA_6	BOOL	FALSE	Jogging
406.7	+0.7		BITA_7	BOOL	FALSE	Reserved
407.0	+1.0		BITA_8	BOOL	FALSE	Reserved
407.1	+1.1		BITA_9	BOOL	FALSE	Reserved
407.2	+1.2		BITA_10	BOOL	FALSE	Reserved
407.3	+1.3		BITA_11	BOOL	FALSE	Reserved
407.4	+1.4		BITA_12	BOOL	FALSE	Reserved
407.5	+1.5		BITA_13	BOOL	FALSE	Reserved
407.6	+1.6		BITA_14	BOOL	FALSE	Acknowledge error
407.7	+1.7		BITA_15	BOOL	FALSE	Acknowledge diagnostic interrupt
	=2.0			END_STRUCT		

6.7 Example Applications

Example 1

see STEP 7 example application FMSTSVEX\EXAMPLE1

The following blocks are required, in addition to the technology functions, in order to run this example application:

- DB 1 (user DB), FC 100 (example call)
- OB 1 (cycle) and OB 100 (cold restart)

The following operating modes are supported in example 1:

- Jogging
- Reference point approach
- MDI block

The associated data (velocity levels, MDI block, single functions) are transferred automatically to the FM after Power **On** or when the CPU switches from STOP to RUN. These values can be transferred again by setting the appropriate write memory (M17.4 to M17.6).

OB 100 contains certain default settings for velocity levels, MDI block, single functions (servo enable, simulation), operating mode (Jogging mode is active on start), mode parameters and override; however these can be changed according to the application.

Table 6-6 Memories: Example Application 1

Input Memories Used
M16.0 Start
M16.1 Stop
M16.2 Direction minus
M16.3 Direction plus
M16.4 Not used
M 16.5 Not used
M 16.6 Not used
M 16.7 Drive enable
M 17.0 Not used
M 17.1 Acknowledge operator control and guidance error
M 17.2 Mode selection
M 17.3 Not used
M17.4 Transfer velocity levels
M17.5 Transfer MDI block
M17.6 Transfer single functions
M 17.7 Not used
MB18 Operating mode (encoded)
MB19 Override

Example 2

see STEP 7 example application FMSTSVEX\EXAMPLE2

The following blocks are required, in addition to the technology functions, in order to run this example application:

- DB 1 (user DB), FC 100 (example call),
- OB 1 (cycle), OB 40 (process interrupt), OB 82 (diagnostic interrupt) and OB 100 (cold restart).

The following operating modes are supported in the example:

- Jogging
- Reference-Point Approach
- MDI block
- Automatic

The associated data (velocity levels, MDI block, single functions, single commands and program selection) are transferred automatically to the FM when the appropriate write memories are set. If no action is performed on the write job memories (M17.4 to M17.7), only control/checkback signals are transferred.

If the memory “DATEN LESEN“ (M17.3) is set, data are read (basic operating data).

You can acknowledge a diagnostic interrupt by setting the memory “RE-START” (M17.0).

An example for calling data set DS 162 (evaluation of operator control/guidance errors) is provided for special error evaluation at the end of FC 100. Data set 163 (evaluation of data errors) and data set 164 (evaluation of operating errors) are called similarly.

OB 100 contains certain default settings for velocity levels, MDI block, servo enable, simulation), operating mode (Jogging mode is active on start), mode parameters and override (100 %); however these can be changed according to the application.

Table 6-7 Memories: Example Application 2

Input Memories Used	Output Memories Used
M16.0 Start	M20.0 Free
M16.1 Stop	M20.1 Operator control and guidance errors
M16.2 Direction minus	M20.2 Data error
M16.3 Direction plus	M20.3 Channel parameterized
M16.4 Not used	M20.4 Start enable
M16.5 Read-in enable	M20.5 Processing in progress
M16.6 Skip block	M20.6 Not used
M16.7 Drive enable	M20.7 Dwell in progress
M17.0 Restart	M21.0 Program scanning backward
M17.1 Acknowledge operation/error	M21.1 Synchronized
M17.2 Operating mode selection active	M21.2 Free

Table 6-7 Memories: Example Application 2, continued

Input Memories Used	Output Memories Used
M17.3 Read data	M21.3 Travel minus
M17.4 Transfer velocity levels	M21.4 Travel plus
M17.5 Transfer MDI block	M21.5 Not used
M17.6 Transfer single functions	M21.6 Position reached, stop
M17.7 Transfer program selection	M21.7 Free
MB18 Operating mode (encoded)	MB22 Active mode
MB19 Override	MB23 Not used

Example call for DS 162 (channel 1)

The call for data sets 163 and 164 is programmed in the same way as the DS 162 call. The data sets are channel-specific, so when the data set is called, it must be ensured that the channel number is entered correctly. The data set number to be read on calling the SFC is calculated as the channel-specific data set offset plus the absolute data set number.

```
AWL                                                Explanation
VAR_TEMP
       R_DS162        : BOOL;                      // Auxiliary bit for data set
       REQ            : BOOL;                      // Parameter for SFC 59
       IOID           : BYTE;                      //
       LADDR          : WORD;                      //
       RECNUM         : BYTE;                      //
       DSNR           : BYTE;                      //
       BUSY           : BOOL;                      //
END_VAR

BEGIN

...

       UN    DB_FM.CHECKBACK_SIGNALS.OT_ERR;   // Only read DS162 if operating error
       SPB   NW5E;                             // otherwise jump to end of network

       U     R_DS162;                          // If read job already active,
       SPB   D162;                             // jump to call
INI1:  L     1;                                // Channel number
       DEC   1;
       L     35;                               // DS offset for DS 162, DS 163, DS 164
       *I;
       L     162                               // Absolute DS No.
       +I;                                     // DSNR:=(channel number – 1) * 35 +
                                                  162
       T     DSNR;                             // Enter DS number
       S     R_DS162;

D162:  CALL  SFC 59 (                          // Read operator control/guidance error
                                                  No. (DS162)
             REQ      := TRUE,                 // Request
             IOID     := B#16#54,              // IOID
             LADDR    := DB1.DBW12,            // Moduleaddress
             RECNUM   := DSNR,                 // Data set number
             RECORD   := P#M30.0 BYTE 4,       // Pointer (error No. in memory word
                                                  30)
             BUSY     := BUSY,                 // Busy
             RET_VAL  := FEHLERCODE_LESEN);    // Return value

       UN    BUSY;                             // If read job finished,
       R     R_DS162;                          // reset read job DS162
       UN    BIE;                              // Binary result
       S     FEHLER_LESEFKT;                   // Display read function error

–
```

Example 3

See STEP 7 example application FMSTSVEX\EXAMPLE3

The following blocks are required, in addition to the technology functions, in order to run this example application:

- DB 1 (user DB), FC 100 (example call),
- OB 1 (cycle), OB 100 (cold restart).

When you set memory M16.0 (P bus interface switchover), the job is transferred to the FM by means of control signals. If memory M20.0 is enabled, the job was executed successfully on the FM. You can now start up, test and optimize the FM with the “Parameterize FM 453” tool.

Table 6-8 Memory: Example Application 3

Input Memories Used	Output Memories Used
M16.0 Switch P bus interface to “start-up”	M20.0 Switchover to P bus interface done
M16.1 Not used	M20.1 Not used
M16.2 Not used	M20.2 Not used
M16.3 Not used	M20.3 Not used
M16.4 Not used	M20.4 Not used
M 16.5 Not used	M20.5 Not used
M 16.6 Not used	M20.6 Not used
M16.7 Not used	M20.7 Not used
MB17 Not used	MB21 Not used

6.8 Technical Specifications

Memory Allocation

The following table gives you an overview of the memory allocated to FCs.

Table 6-9 Memory Allocated to FCs

No.	FC	Block in Bytes	MC7 Code in Bytes	Local Data in Bytes
1	INIT_DB	224	120	4
2	MODE_WR	1226	970	26
3	RD_COM	774	584	24
4	DIAG_RD	302	180	34
5	MSRMENT	288	172	26
6	DIAG_INF	282	166	26

Processing Times

The following average processing times for FCs were measured with a CPU 413. The specified times are rounded:

Table 6-10 Processing Times of FCs

FC	Transfer	Cycle 1	Cycle 2	Cycle 3
INIT_DB	–	–	–	–
MODE_WR	Write control/checkback signals without data (job = 0)	0.8 ms	–	–
	Write control/checkback signals with data (job > 1)	0.9 ms	2.5 ms	0.9 ms
RD_COM	Read data	2.4 ms	–	–
DIAG_RD MSRMENT DIAG_INF	Read process and diagnostic interrupt data	2.2 ms	–	–

7 Starting up the FM 453

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.

Chapter Overview

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	Parameterize	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:

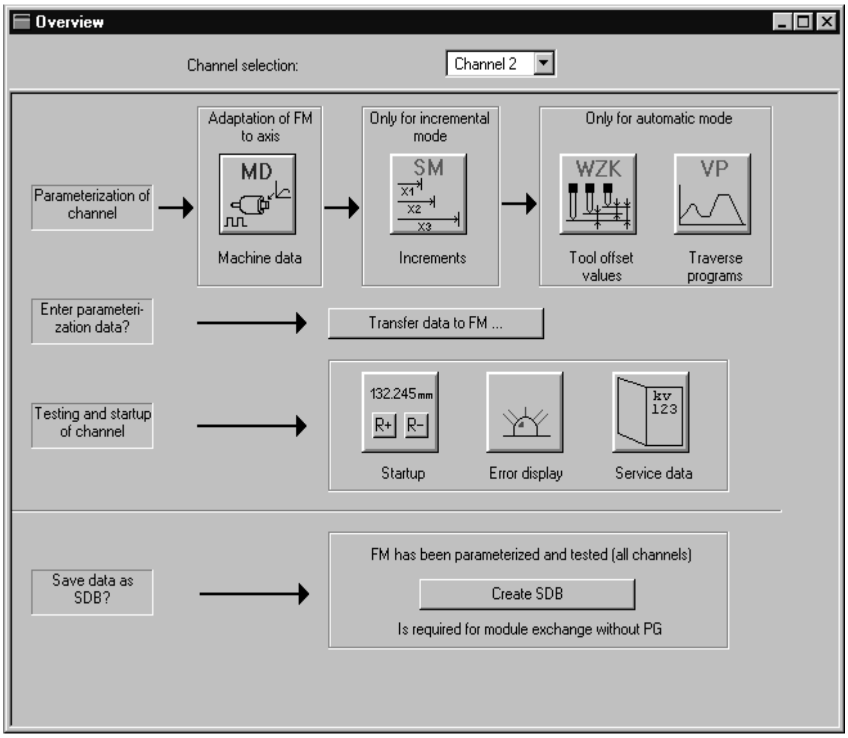


Fig. 7-1 Overview Display for Parameterization and Start-up

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 5-5 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 **SIEMENS\STEP7\EXAMPLES\FM_UPOS** : • 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	
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.	

Table 7-2 Parameterization Checklist, continued

Step	Check	What to Do:	OK ✓
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)]	$v_{max} = 10...5 \cdot 10^8$ (MSR/min)	Specified maximum speed	+[1)]	+	+	
24	1 000 [MSR]	Large PEH target range	+	+	+	
25	0	PEH time monitoring switched off	+	+/–	–	

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	
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)]	
55	f_{eg}	Frequency value for acceleration switchover	–	–	+[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	
56	f_{max}	Maximum 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.

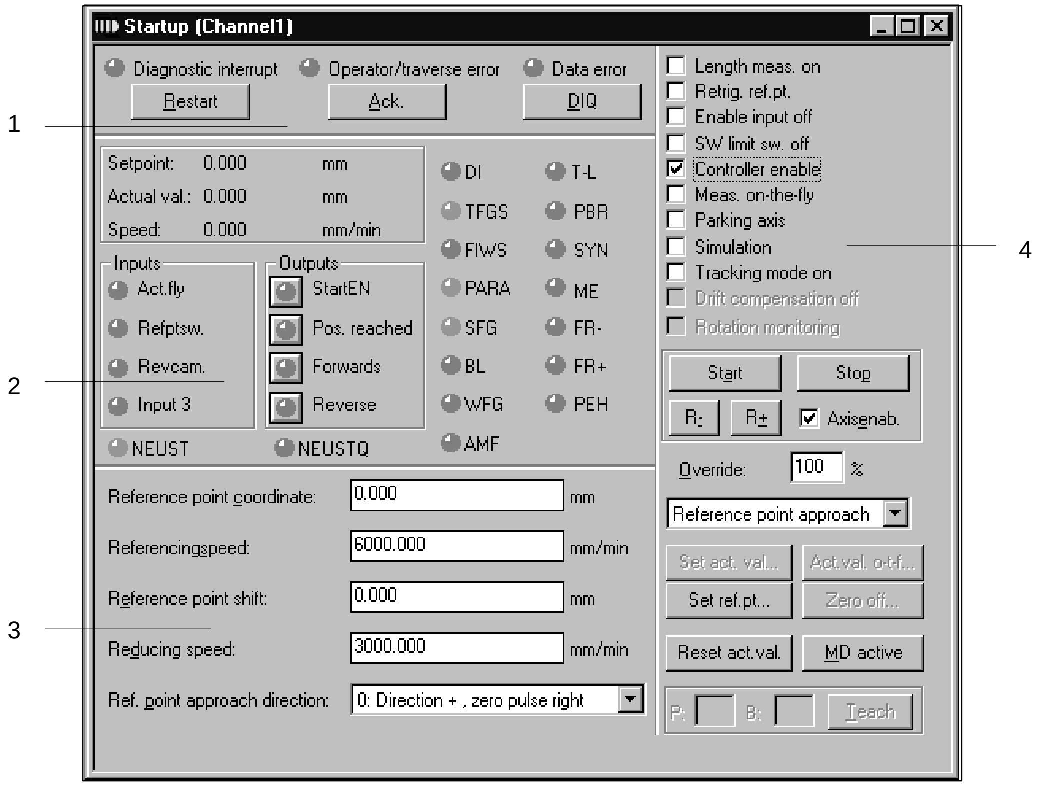
There are two ways of operating the FM:

- **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. Example application 3 (see Section 6.7) can be included in the user program for this purpose.

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 Section 6.2.2.

Fig. 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**:

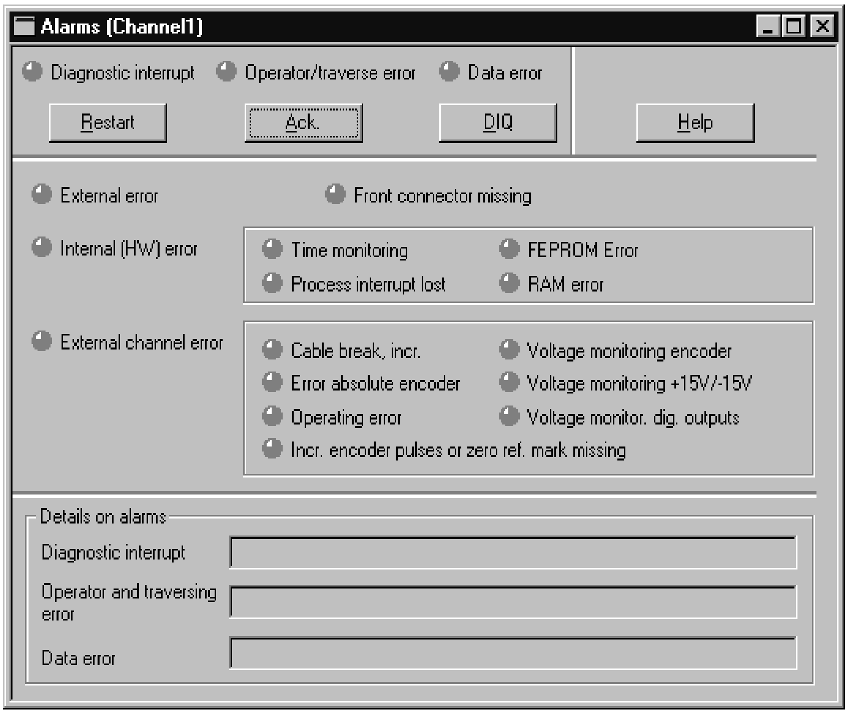


Fig. 7-3 Troubleshooting

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

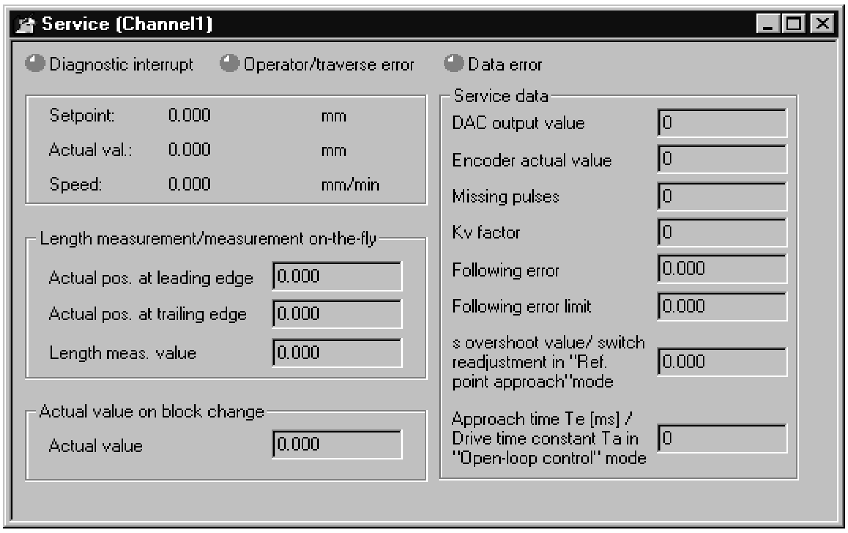


Fig. 7-4 Service Data

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:

- “Axis 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 this new data can then be put into effect by way of the "Activate machine data" function.

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 MD13 = 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 7-6), 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 · (MD11 + MD12 · 2^{-32})/(1000 · MD52)
When MD59 = 0	MD41 = MD40
When MD59 ≠ 0	MD41 = MD59 · (MD11 + MD12 · 2^{-32})/(1000 · MD52)
When MD40 ≤ MD41	MD45 = MD57
When MD40 > MD41	MD45 = MD59

Operating Characteristic Curve

Example of the operating characteristic curve of a stepper motor:

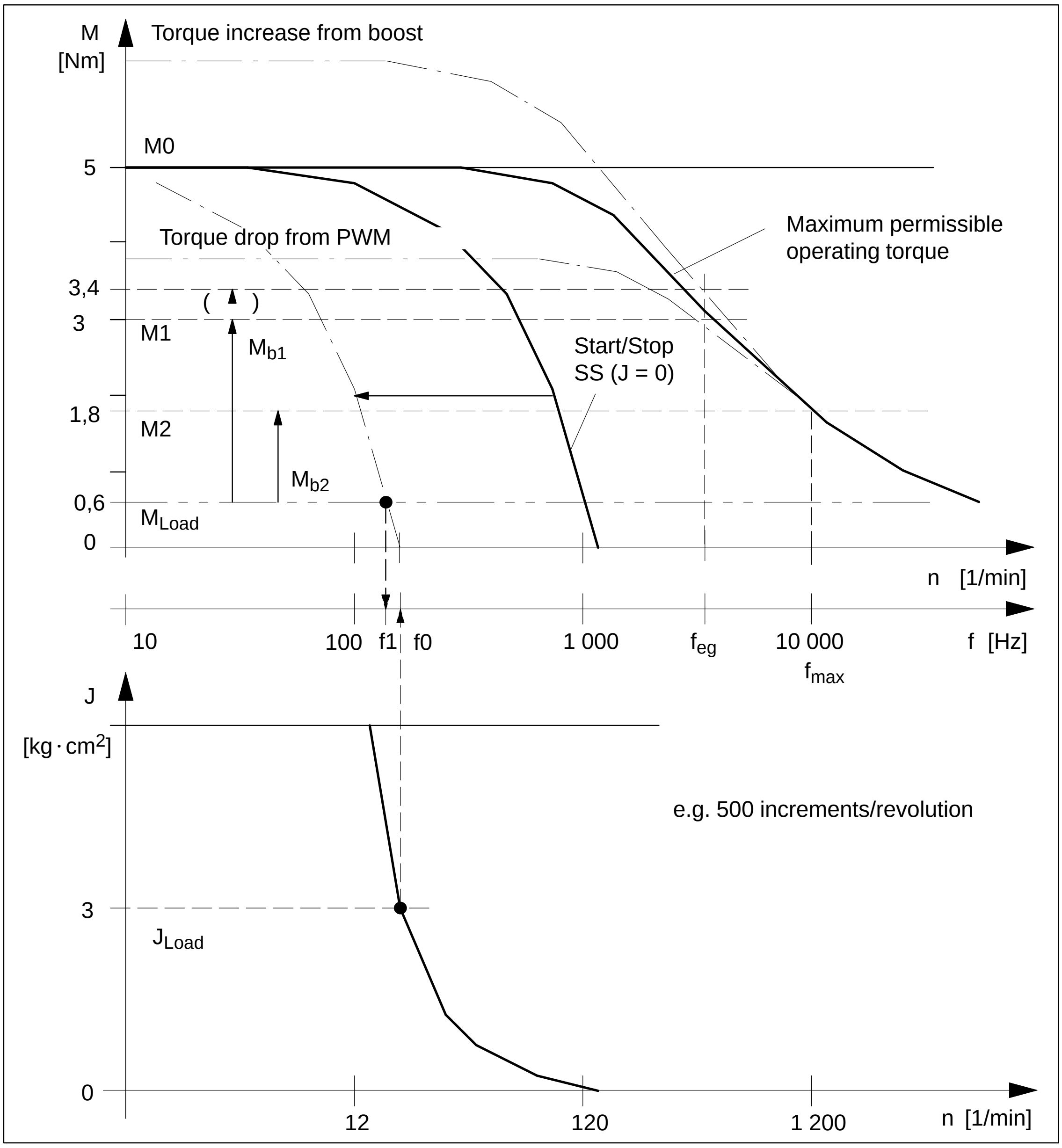


Fig. 7-5 Operating Characteristic Curve of the Stepper Motor

Determining the Machine Data

When you evaluate this example characteristic in accordance with the algorithm in Figure 7-6, 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

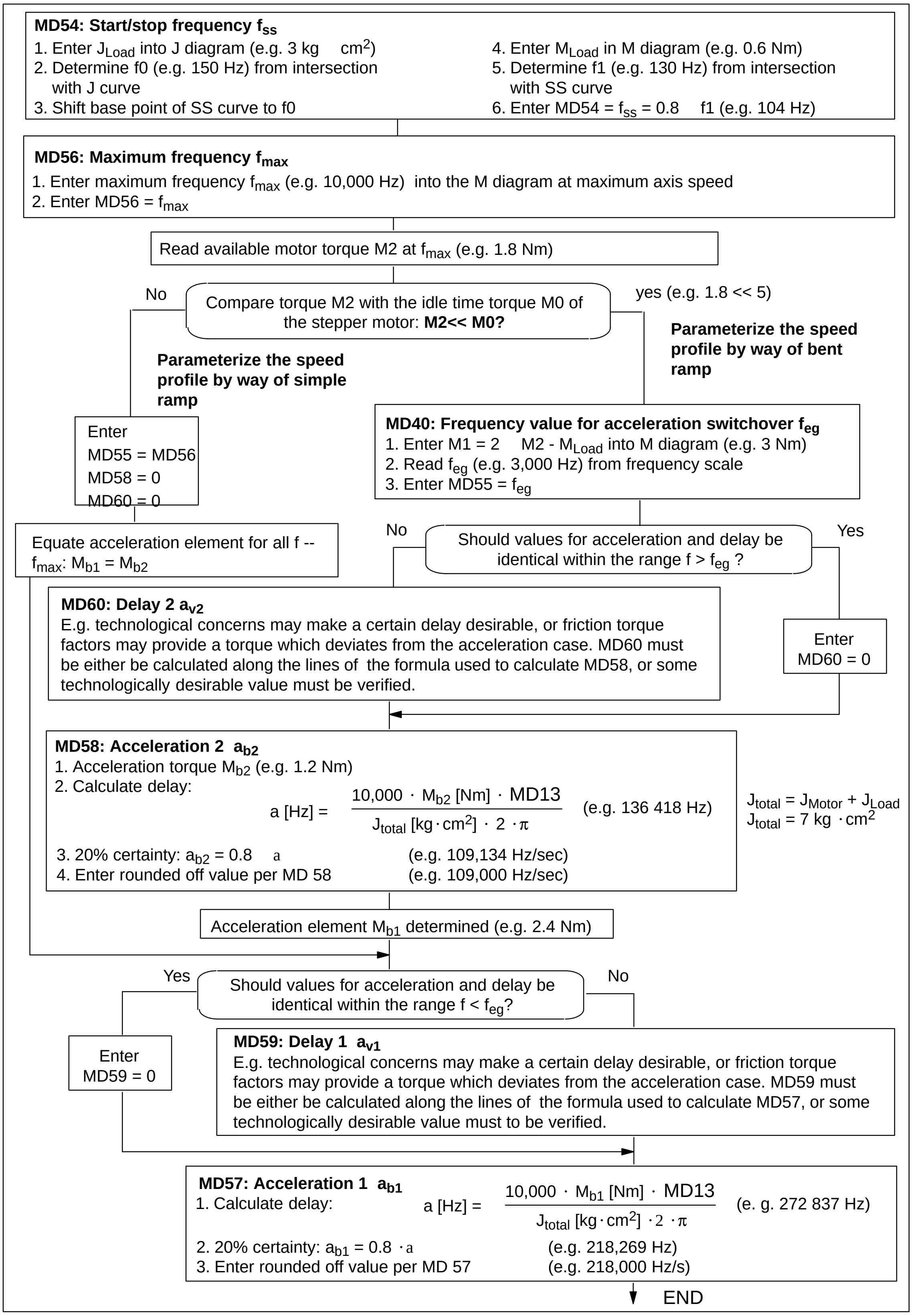


Fig. 7-6 Evaluation of Operating Characteristic Curves

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.

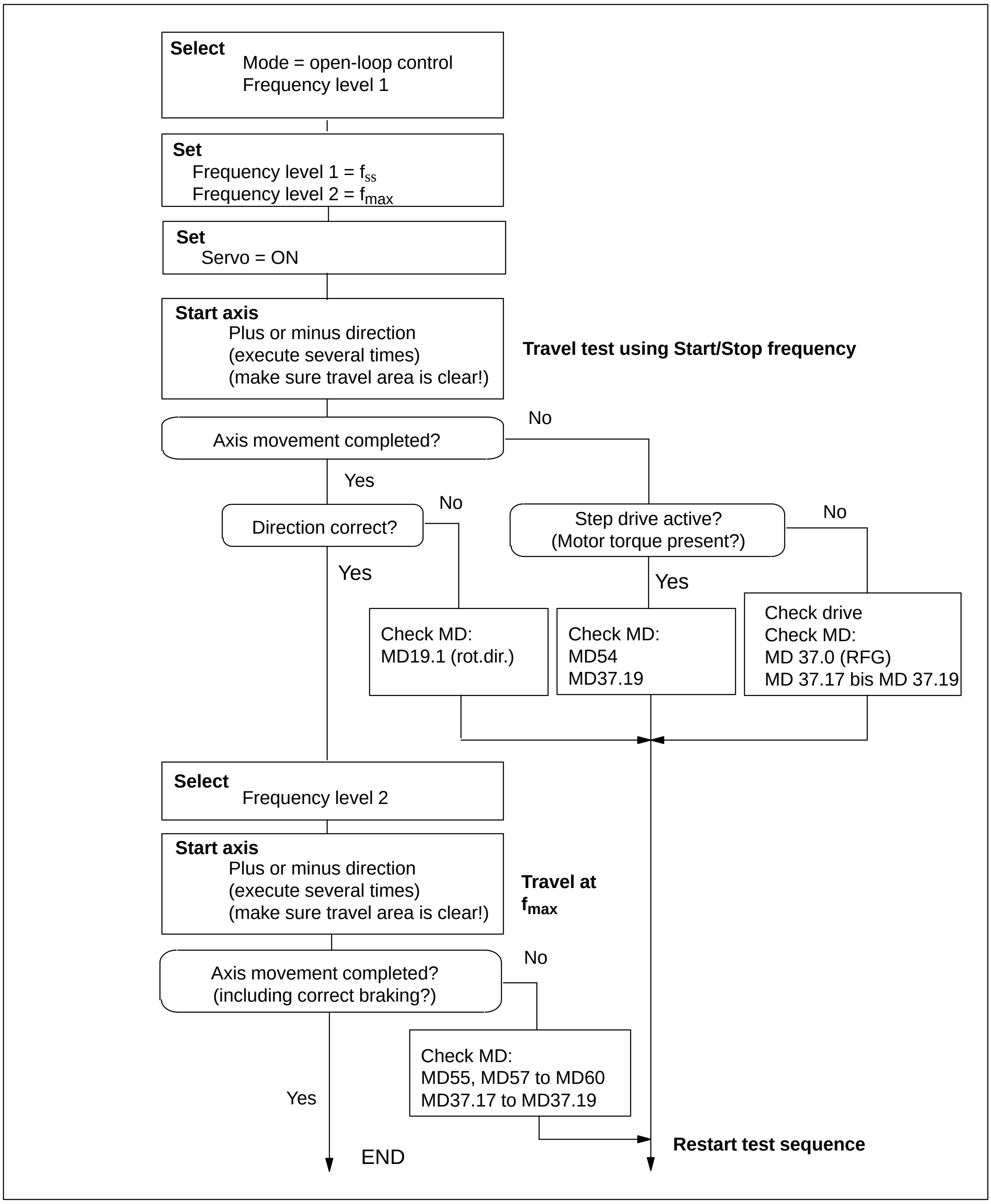


Fig. 7-7 Basic Startup of Stepper Motor Actuation

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.

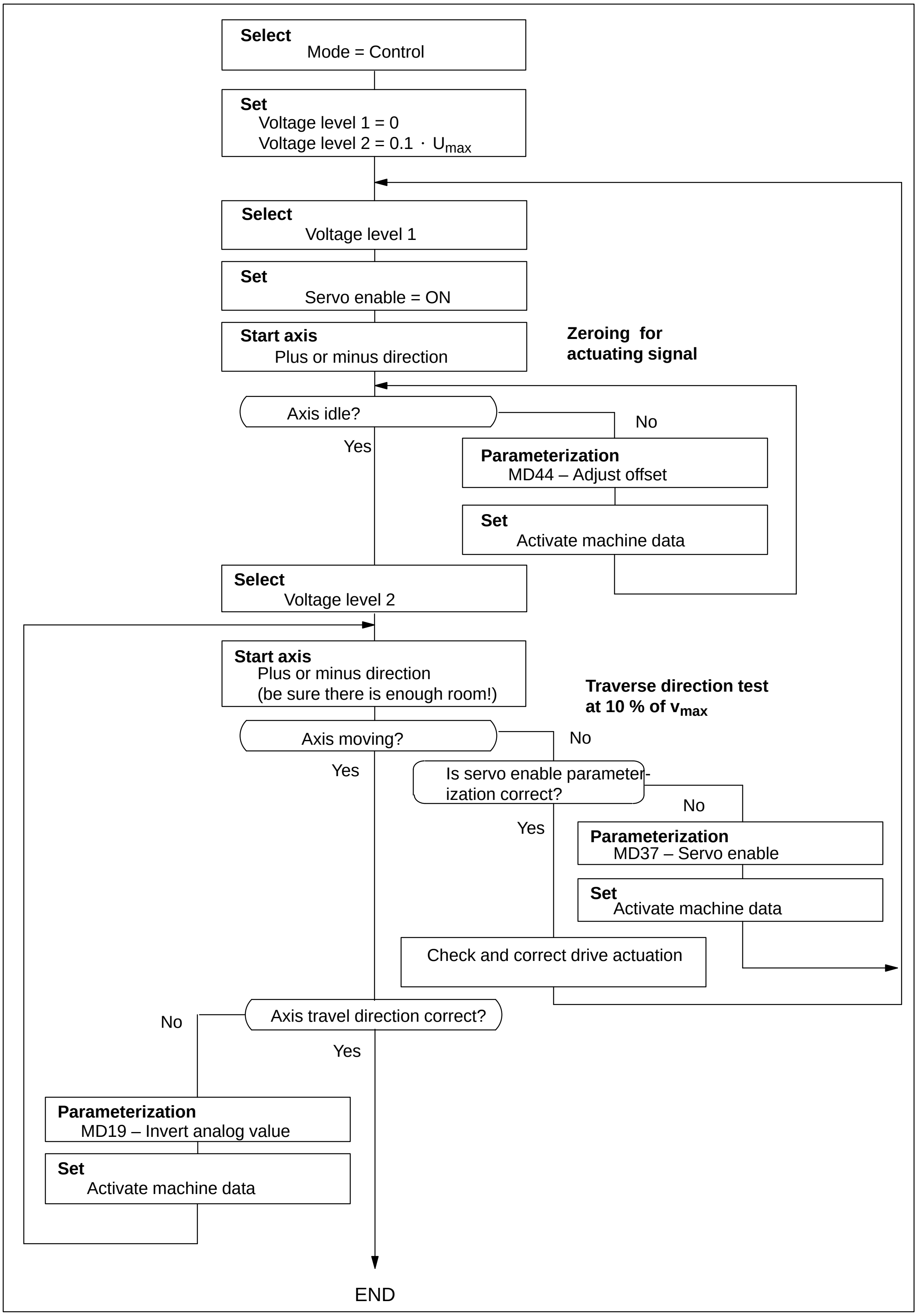


Fig. 7-8 Basic Startup of Servomotor Actuation

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.

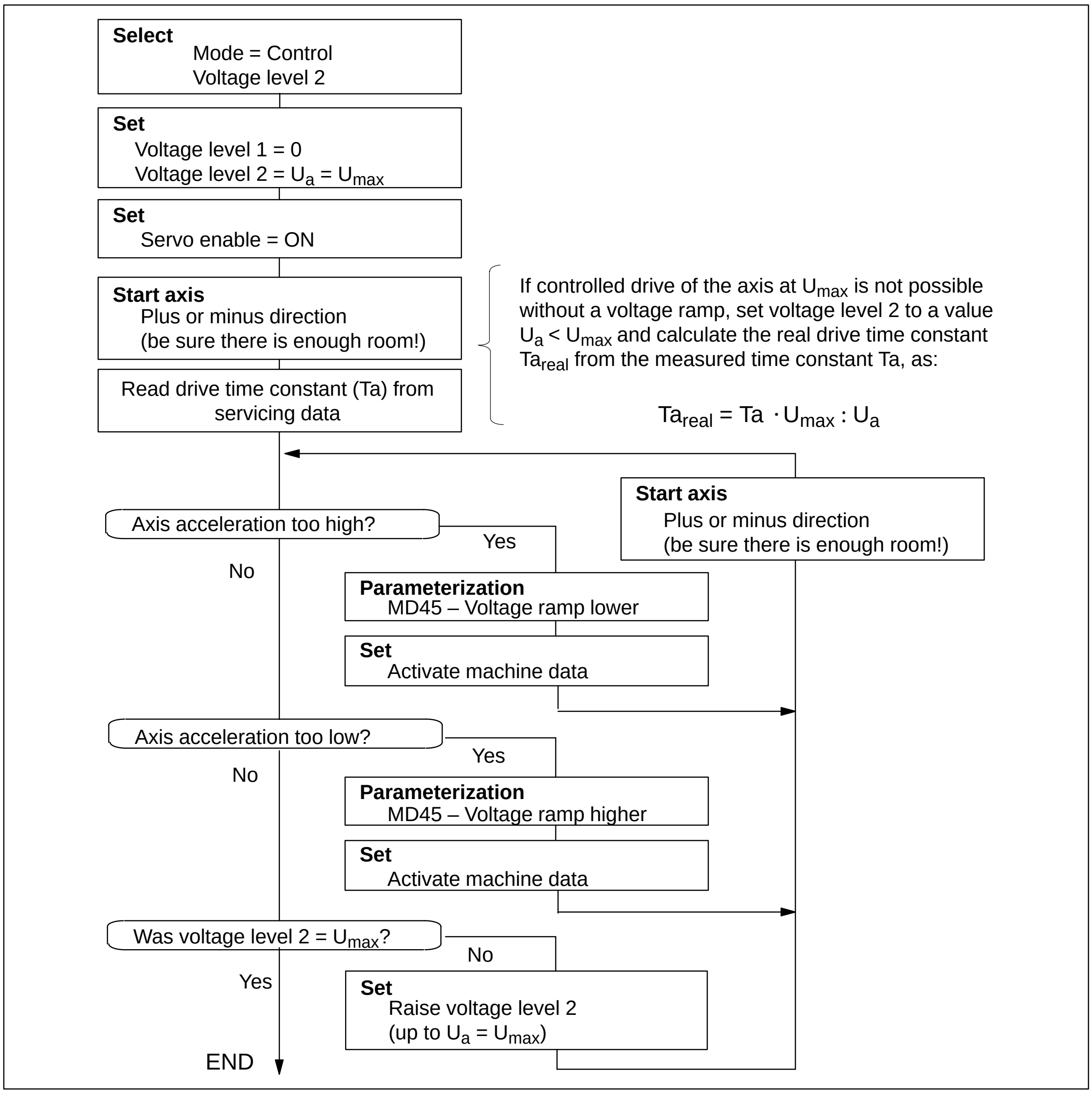


Fig. 7-9 Drive Transition Time and Maximum Voltage Rise

7.3.5 Checking the Encoder Actuation

Overview

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

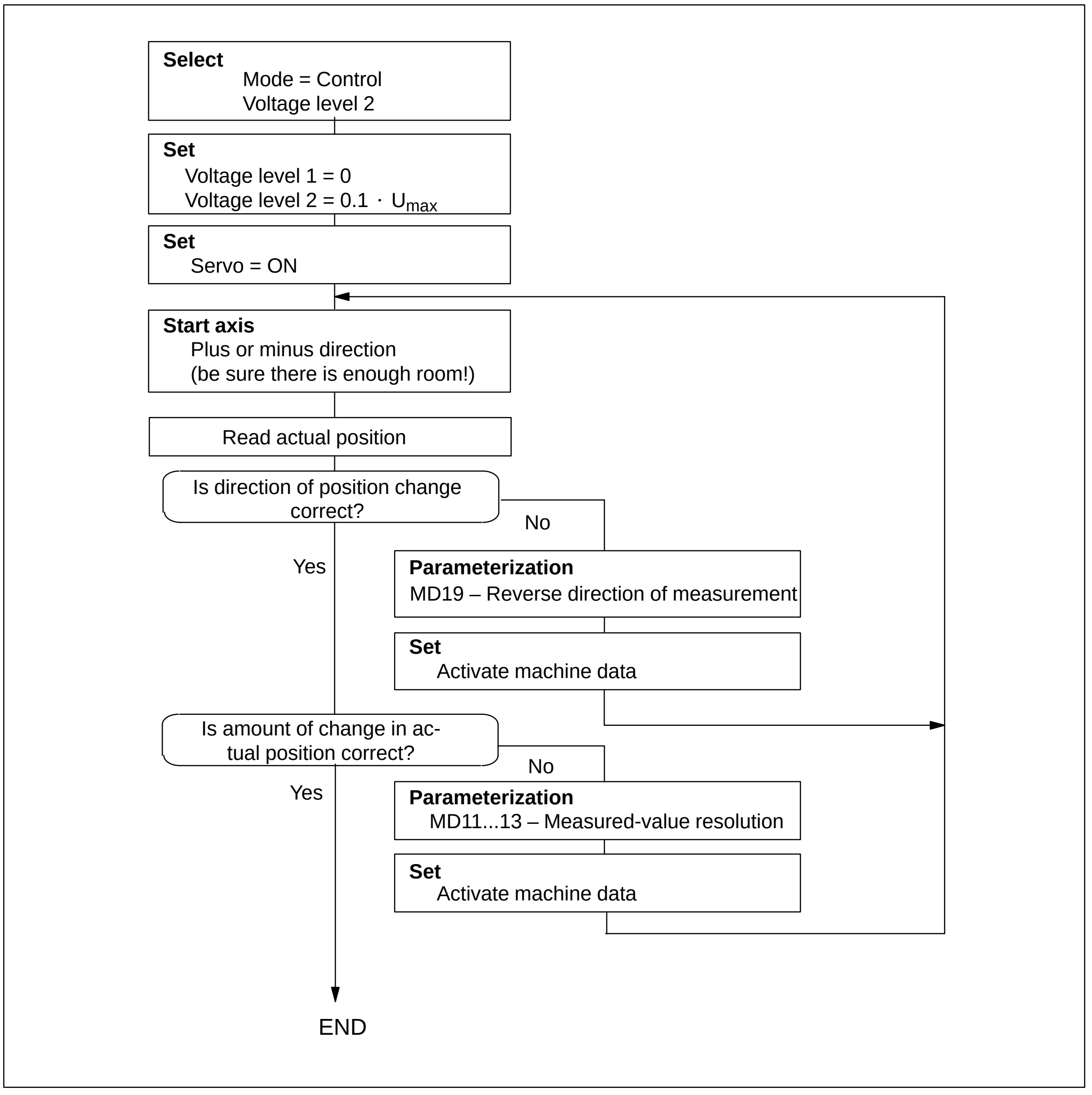


Fig. 7-10 Encoder Actuation

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:

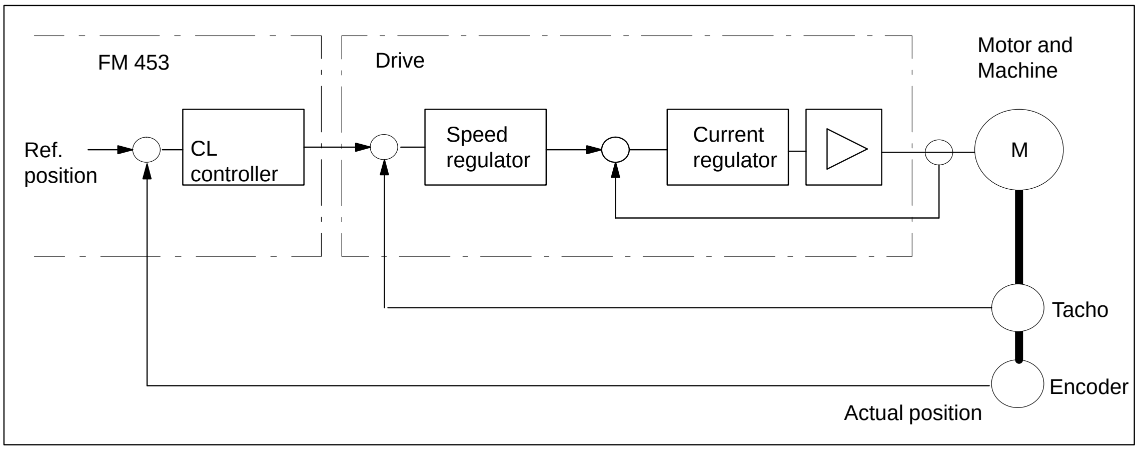


Fig. 7-11 Position Control Circuit with Servo Drive

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.

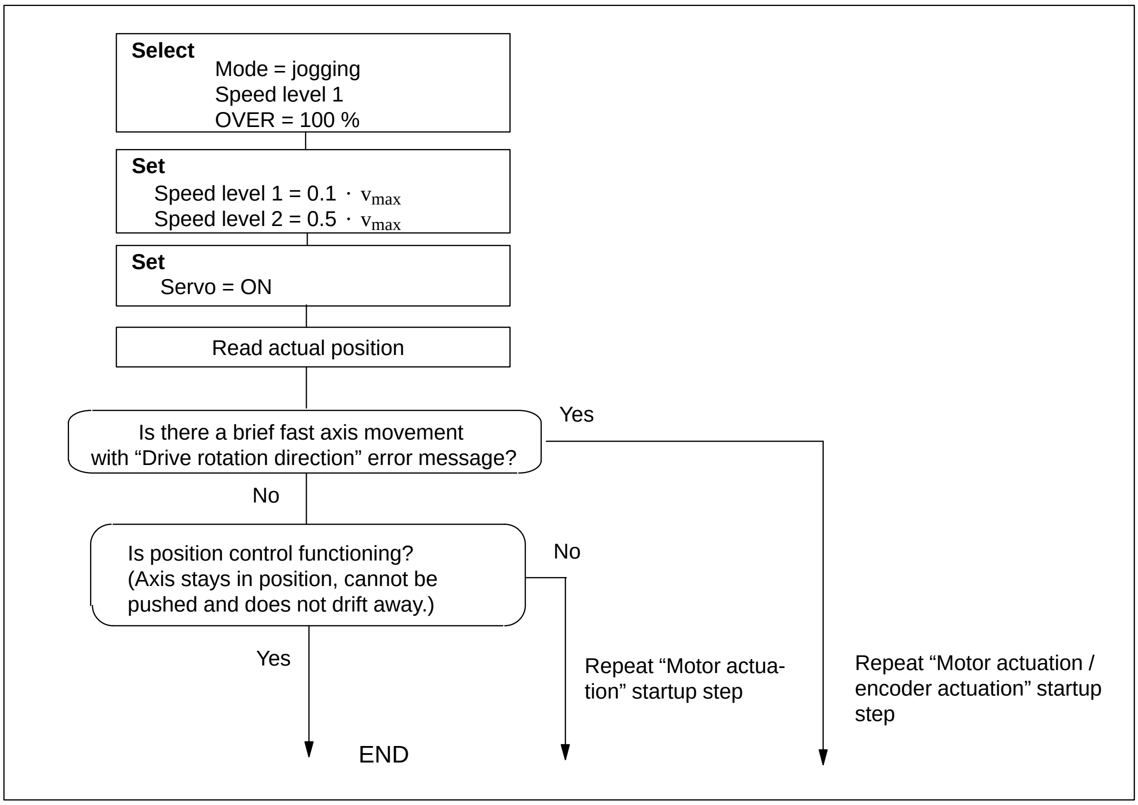


Fig. 7-12   Non-release Control

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.

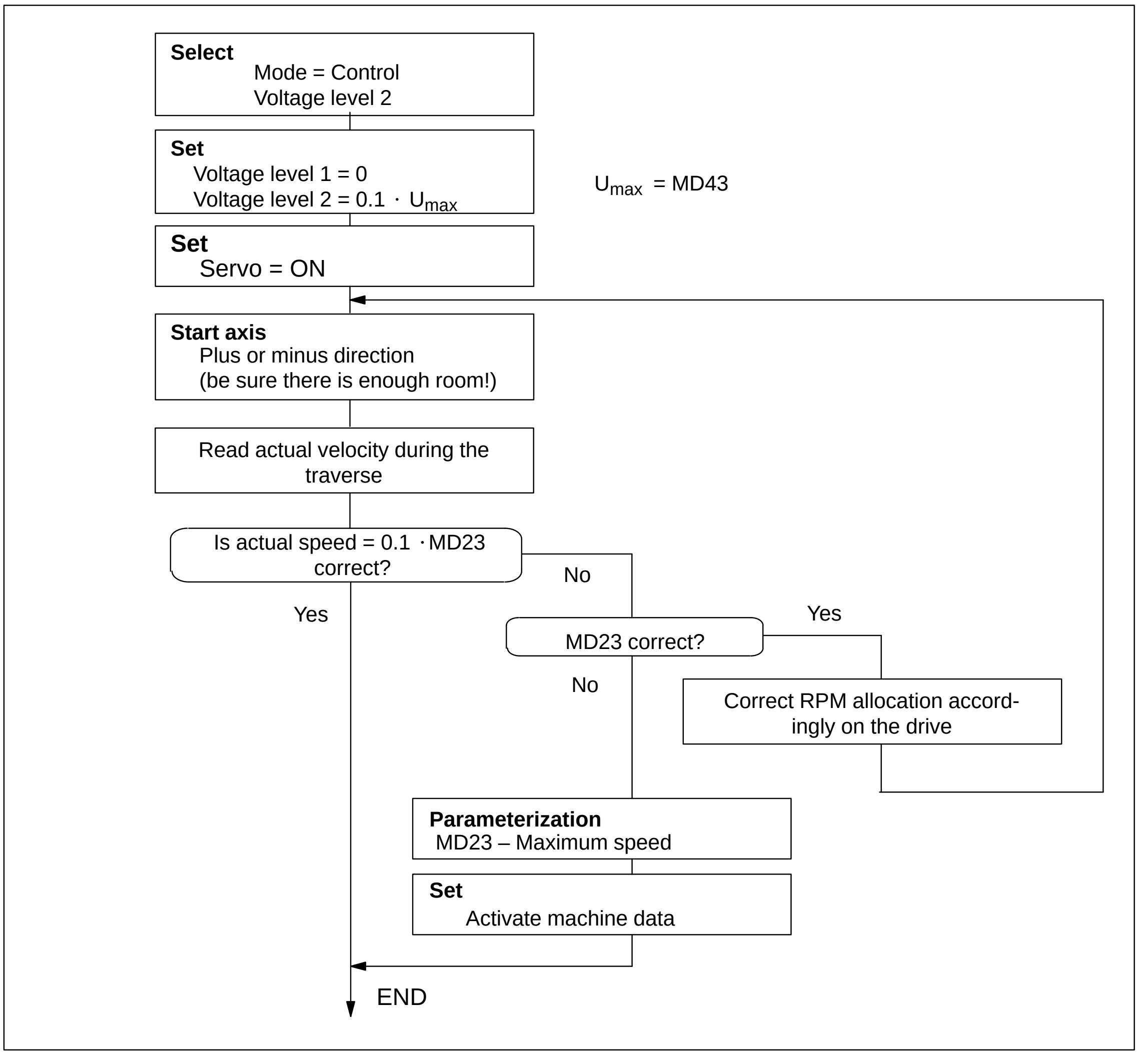


Fig. 7-13 Testing Speed Assignment

Positioning

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

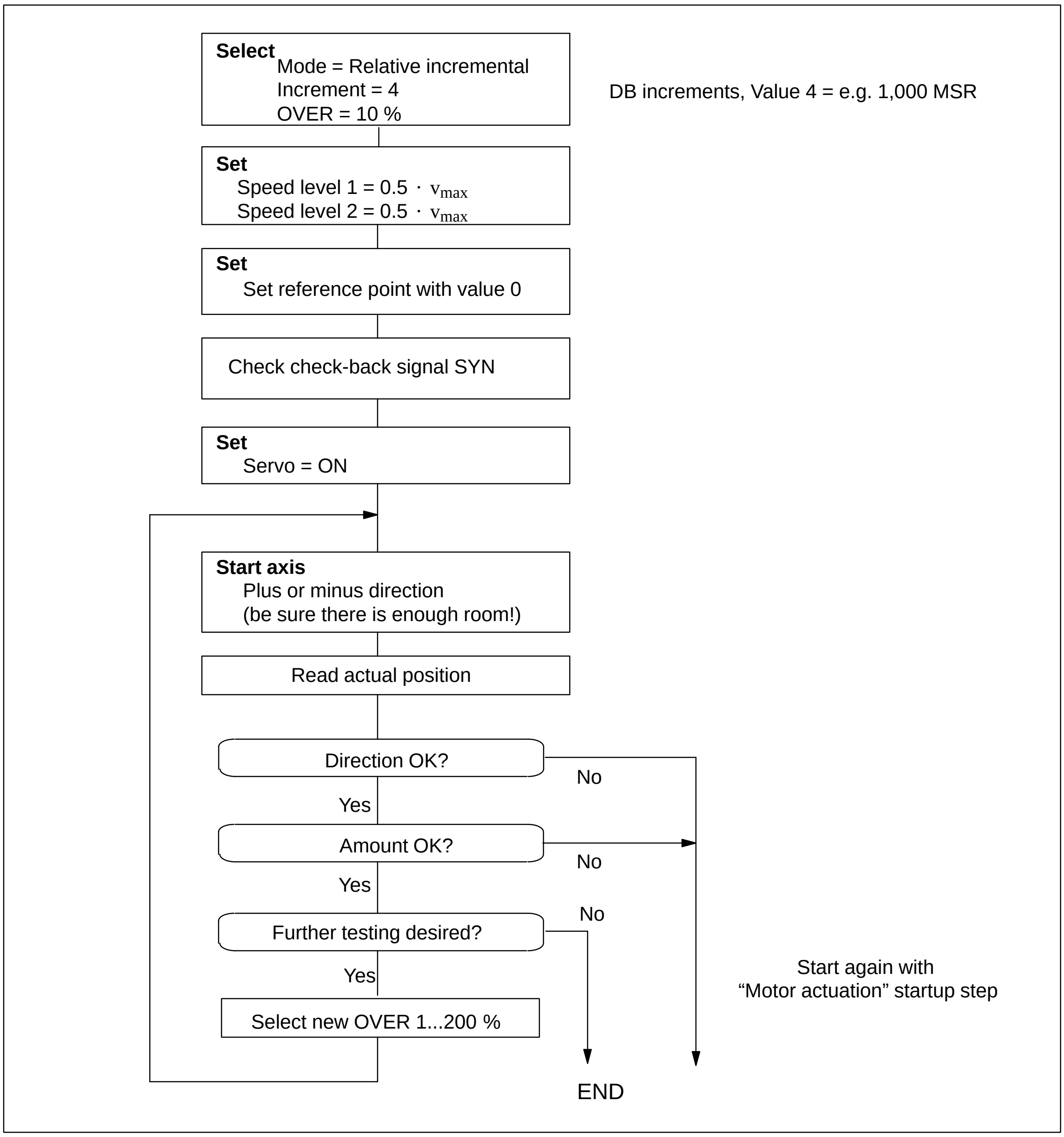


Fig. 7-14 Positioning

7.3.7 Optimizing the Position Control

Overview

In principle, the dynamic response of an axis is essentially determined by the dynamic response of the step 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 7-11).

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 7-15 during the optimization steps described below.

To Trigger Test Movements

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

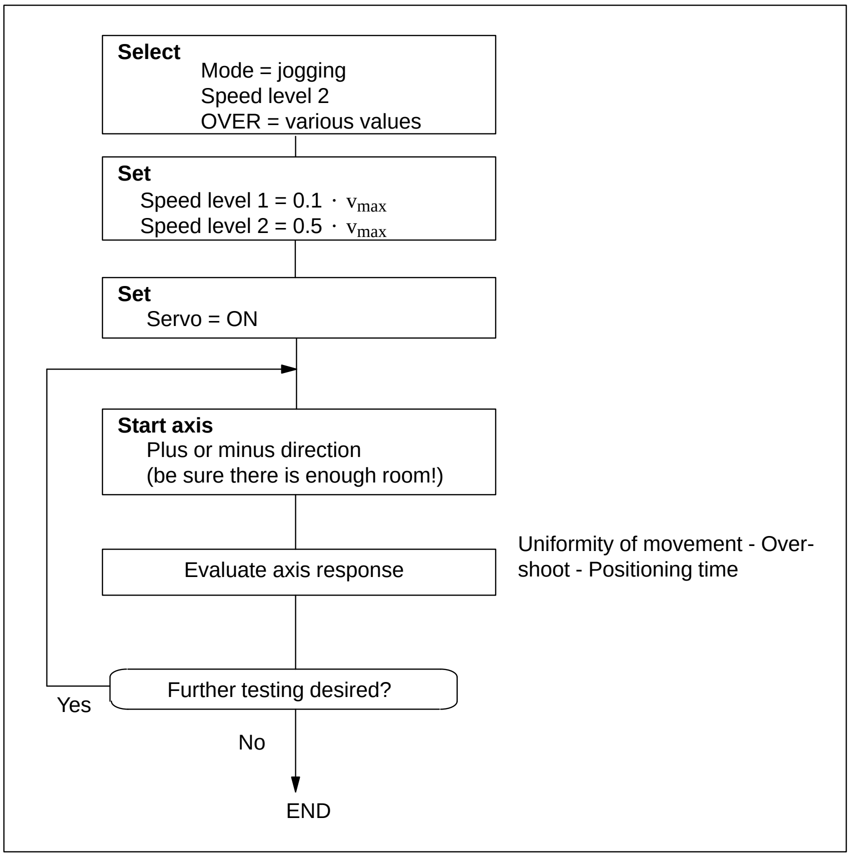


Fig. 7-15 Test Movements for Optimizing the Servo Control System

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]

Step 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 7-16).

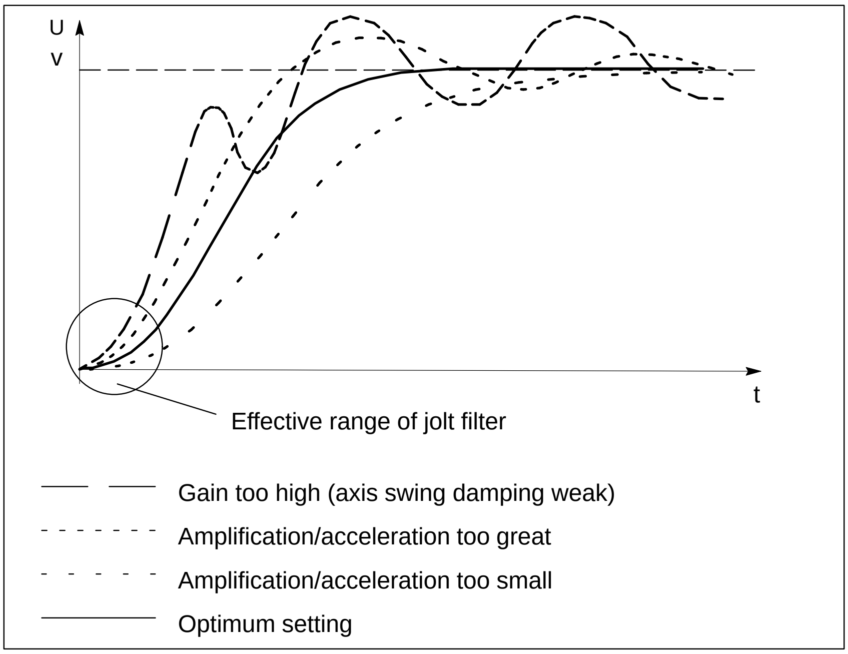


Fig. 7-16 Transition Function of the Position-Control Circuit

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 7-17).

- 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]

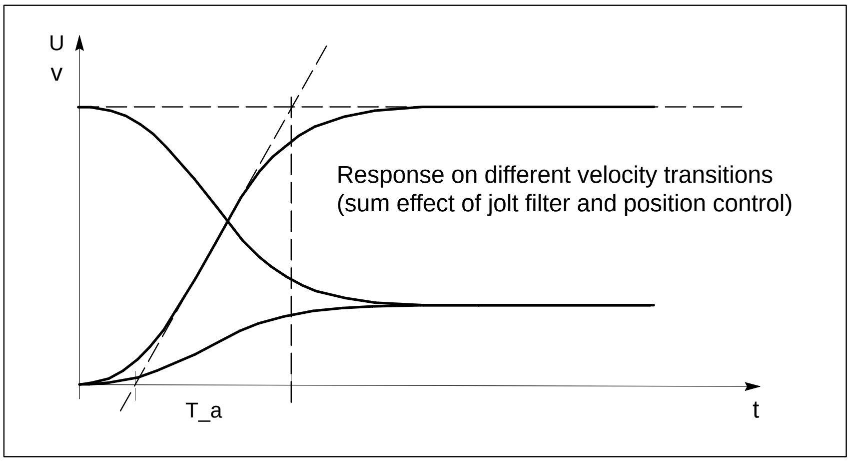


Fig. 7-17 Response on Different Velocity Transitions (Sum Effect of Jolt Filter and Position Control)

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 Control

Overview

The motor axis driven by the FM 453 is driven by pure, direct control. It features the following structure:

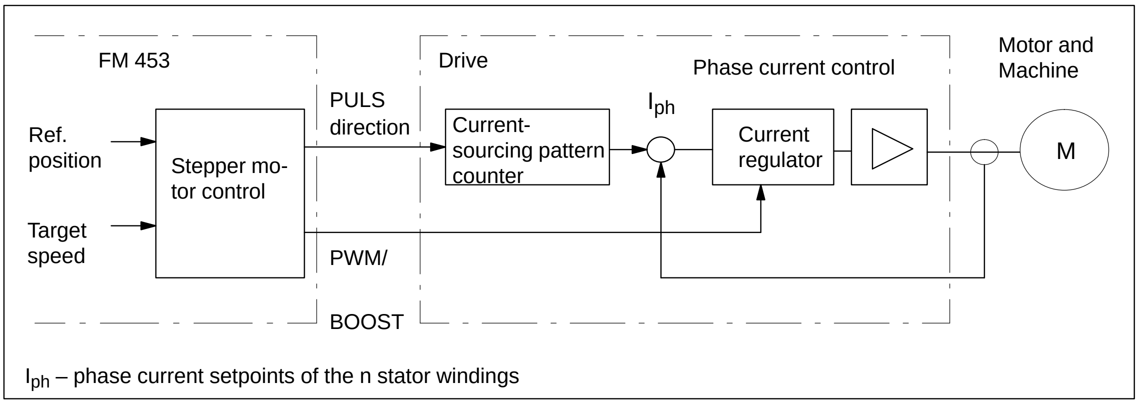


Fig. 7-18 Structure of the Stepper Motor Axis

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.

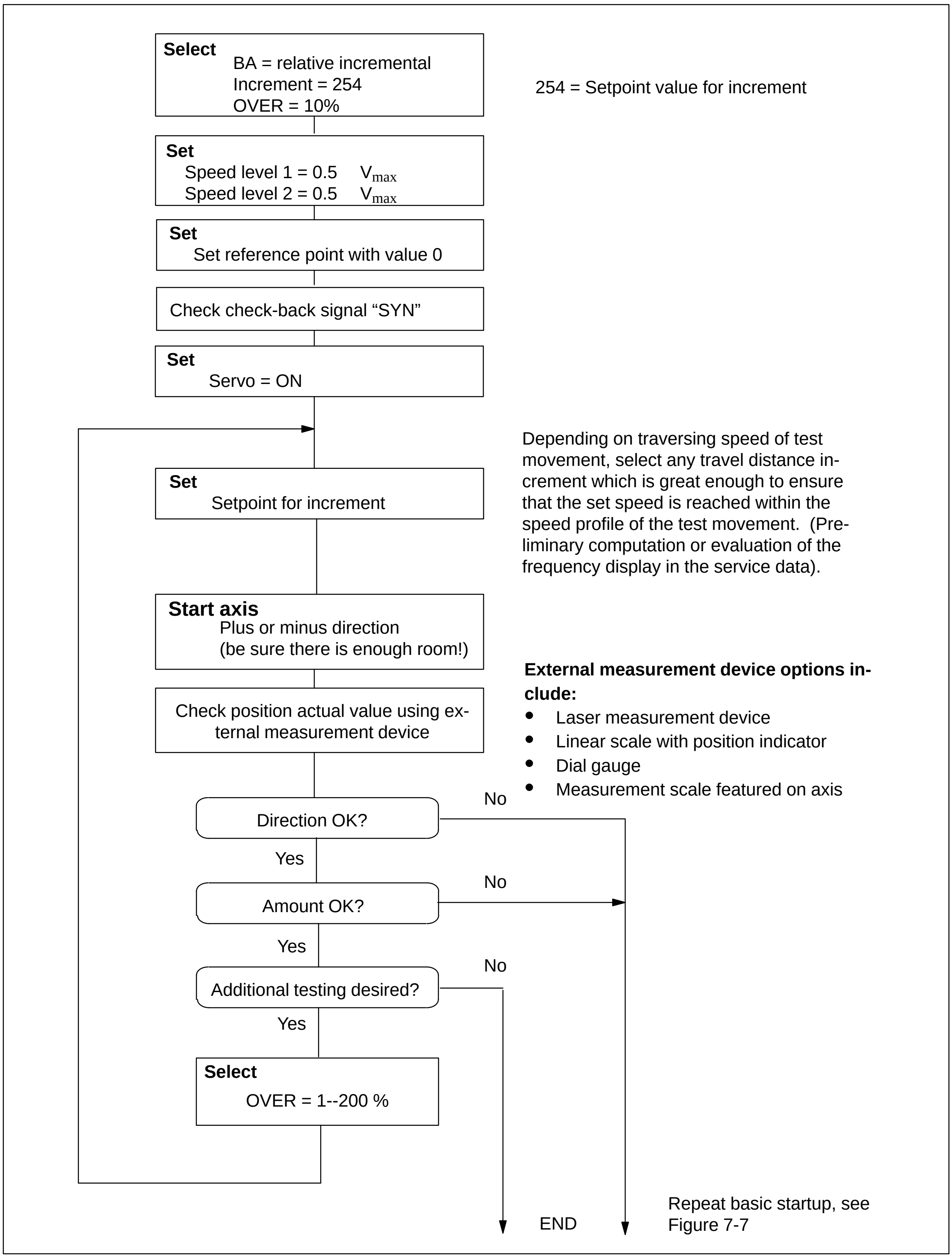


Fig. 7-19 Positioning Verification

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
Soft travel behavior	small	–	small	great	great
Suppression of resonance	great	–	great	great	great
Short positioning time	great	great	great	small	small

Triggering Test Movements

By implementing test movements in accordance with 7-20, 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.

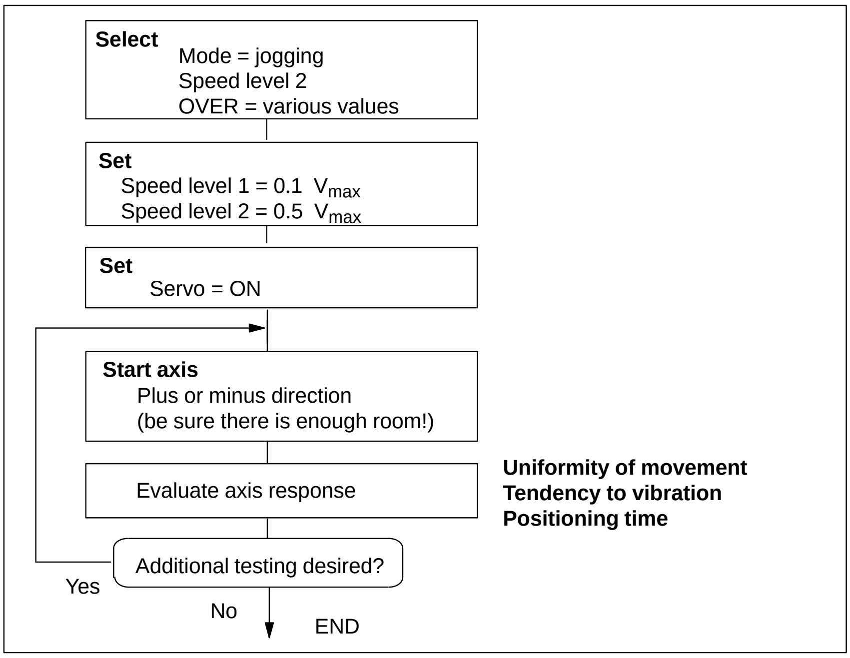


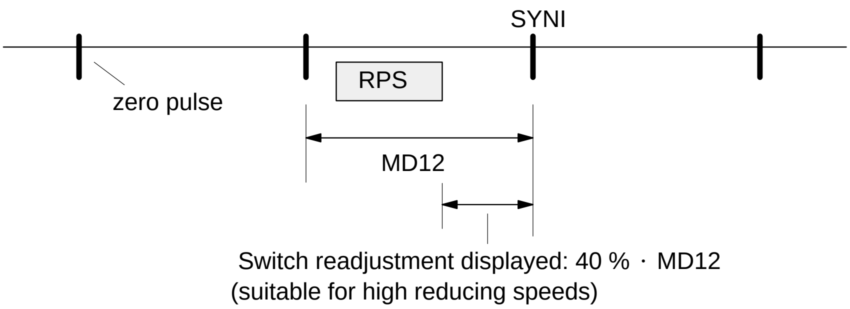
Fig. 7-20 Test Movements for Optimizing the Stepper Motor Control System

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:

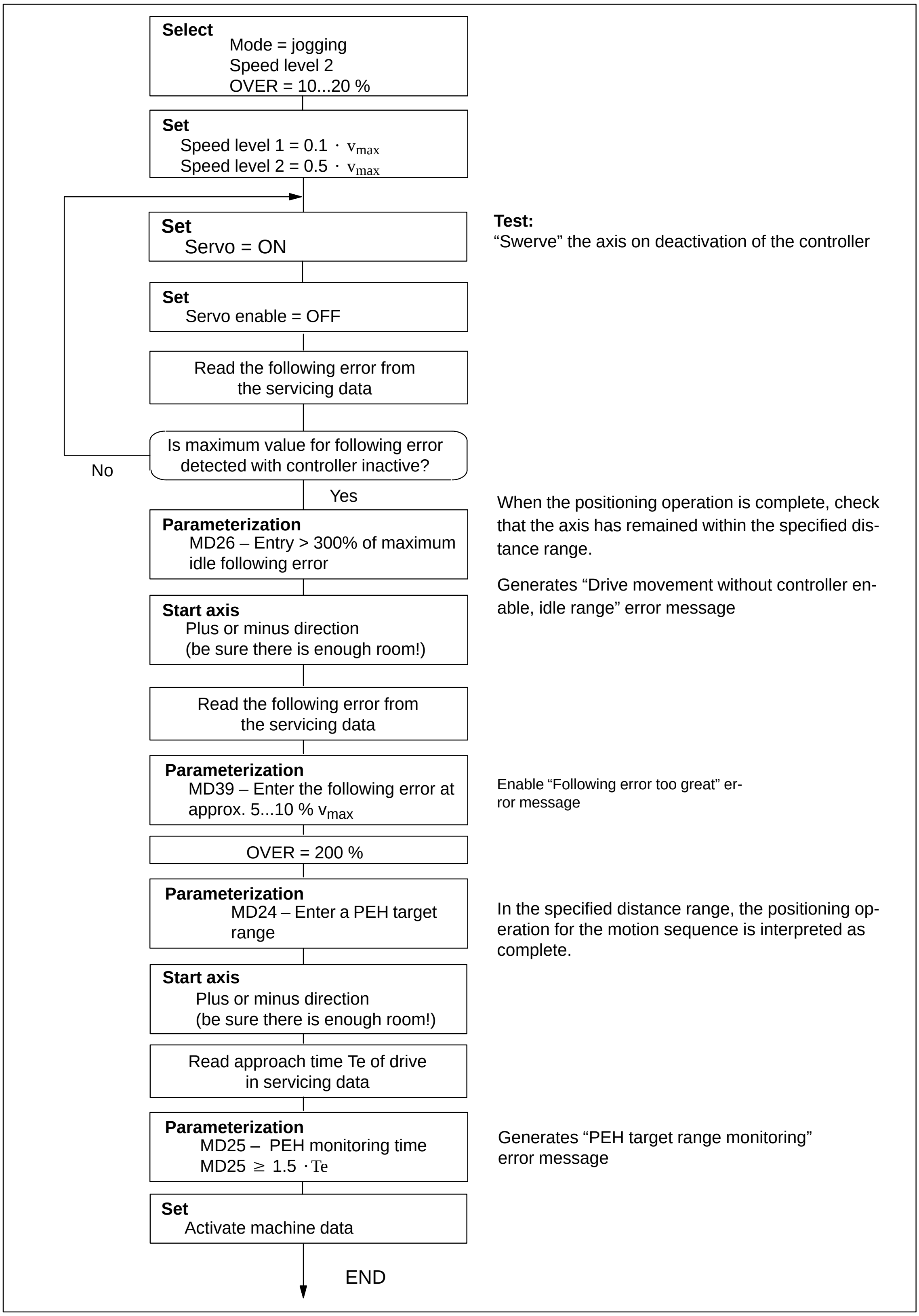


Fig. 7-21 Activation of Position Controller Diagnostics

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 5-5).

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.

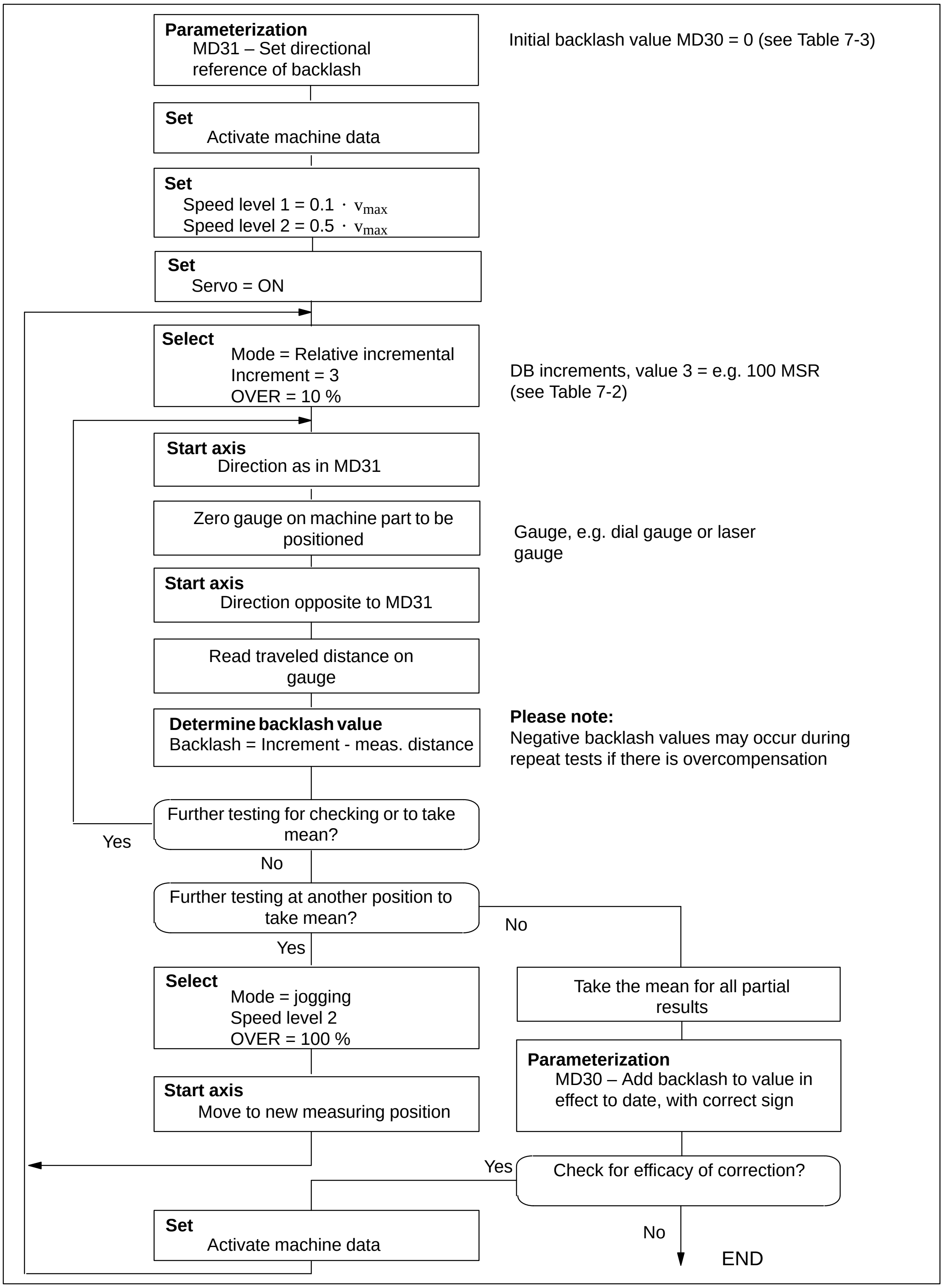


Fig. 7-22 Determination of backlash and activation of backlash compensation

Man-Machine Interface 8

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 module uses the SIMATIC interface (backplane bus) to communicate with the control panel.

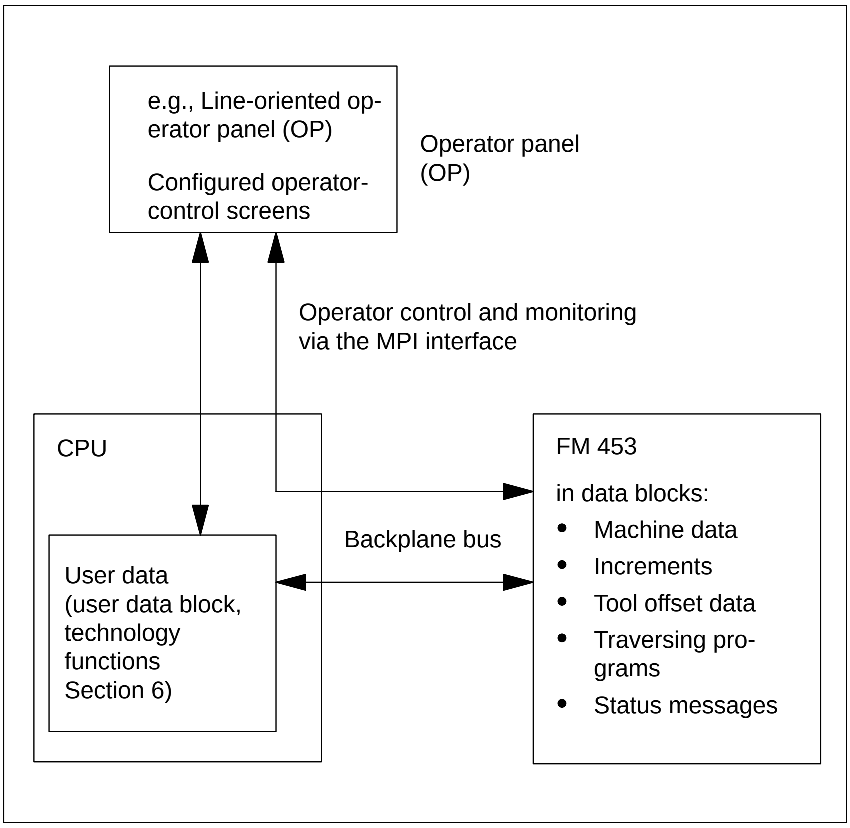


Fig. 8-1 Operator Control and Monitoring for the FM 453

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 configuration package includes a pre-configured interface for the COROS OP 17 device.

Chapter Overview

8.1 Standard HMI (Human-Machine Interface) for the OP 17

Overview

This Section describes a preconfigured user interface, which you will need to change according to your project (e. g. FM addresses, DB no.), for the COROS equipment (operator panel): OP 17

The tool to be used for this is the configuring tool “ProTool/Lite” or ProTool V3.0. You can use it to modify, add or delete screens.

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 has been addressed in this example configuration to the MPI address 9.

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/Lite” V3.0. This provides you with detailed screen descriptions.

You will find the preconfigured user interface in the following directory:

SIEMENS\STEP7\EXAMPLES\S7OP_BSP\01743_1a.pdb

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.

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

Your user program must analyze the signals (only those which are relevant to its applications). User-specific interlocks can be incorporated and the data/ signals are to be transmitted to the FM 453 by way of the FCs.

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).

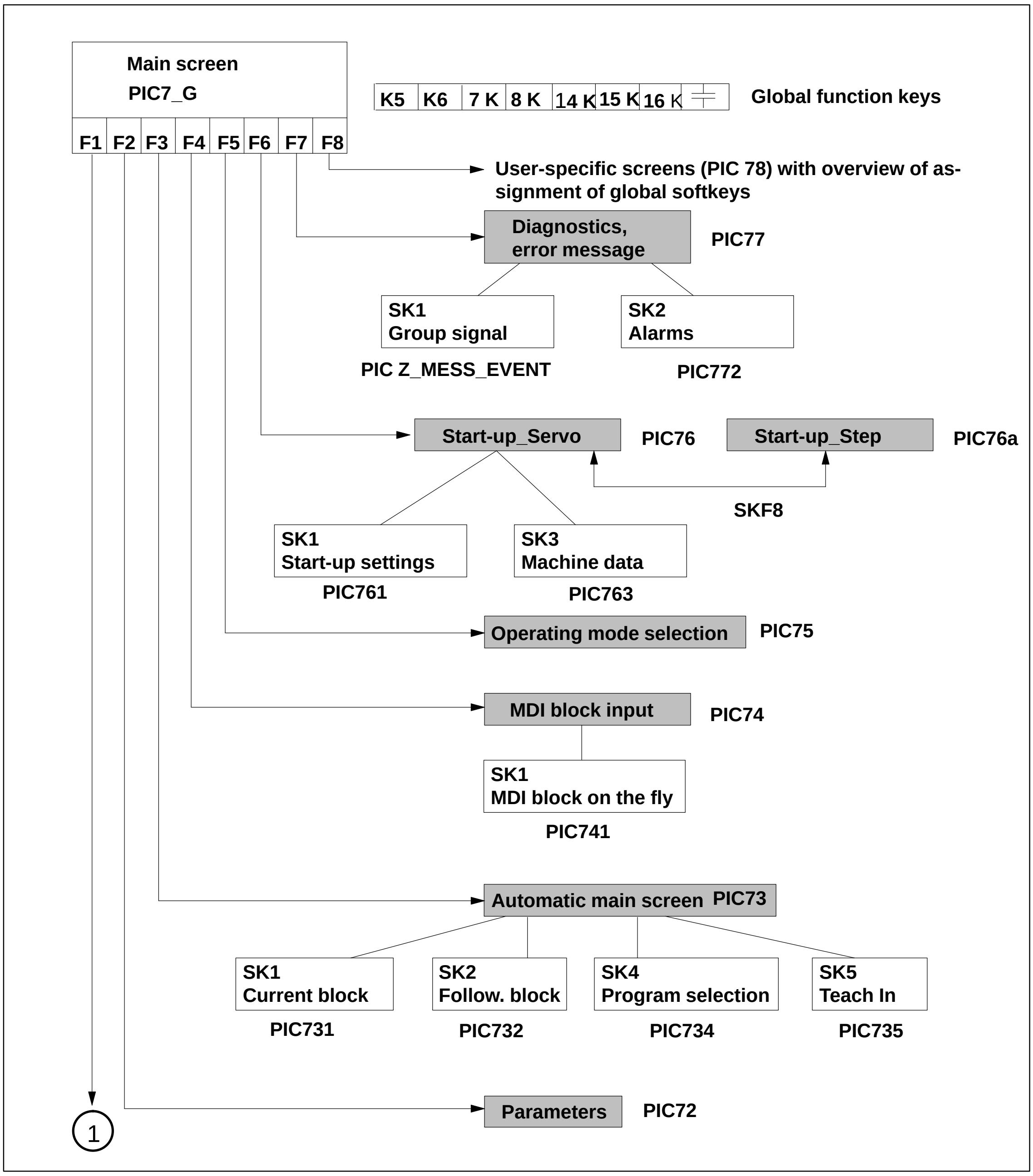


Fig. 8-2 Menu Tree of the OP 17 User Interface

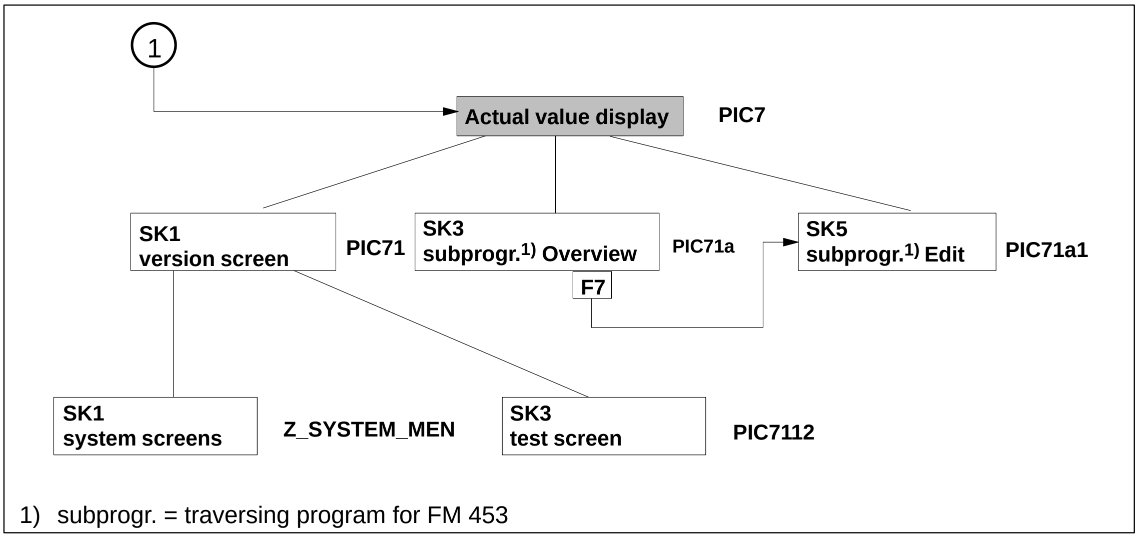


Fig. 8-3 Menu Tree of the OP 17 User Interface, continued

Figure 8-2 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).
7 K	**Function key**	You can use this key to jump from any point on the menu tree to the operating mode selection screen (PIC75).
8 K	**Function key**	You can use this key to switch to the actual value display (PIC7).
14 K	**Function key**	You can use this key to switch to channel 1.
15 K	**Function key**	You can use this key to switch to channel 2.
16 K	**Function key**	You can use this key to switch to channel 3.
F1 _ **F8**		F1 to F8 (local soft keys)

Note

If all three channels are not used, the relevant softkey (K14 to K16) in the configuration example should be deleted.

Note

The screens of the user interface (see Figure 8-2 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 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 illustration shows, for example, the screen layout of PIC 7 “Actual value display”.

```
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. 8-4 Actual Value Display PIC 7

The configuration example is intended as a starting point for your project. Copy the file 01743_1a.pdb. You can then adapt the copy as required for your application.

8.2 Analysis of the User DB by the User Program for Operator Control

Overview

The following table describes for you which functions must be executed by the user program. Execution of these functions is triggered by setting/deleting of certain memory bits of the operator panel or by certain events within the FM 453 (e.g. error messages).

Table 8-1 Analysis of the User DB by the User Program

OP 17	Triggered by –	User Program			See PIC...
Byte.Bit Event		**Set in User DB (Byte.Bit)**	**Function**	**Delete Byte.Bit**	**OP 17**
	FM 453	390.13 390.14 390.15	Diagnostic interrupt Data errors Operator control and guidance errors		7
390.9 = 1 390.10 = 1 42.14 = 1	SK “IWset” SK “NPVset” SK “IWrü”		Transfer data for “set actual value” from user DB to the FM Transfer data for “Zero point offset” from user DB to the FM Transfer “Remove setting actual value” flag to the FM	390.9 390.10 42.14	72
42.10 = 1 42.11 = 1 390.3 = 1	SK “SAvor” SK “SArü” SK “set”		Transfer “Automatic block search, forward” memory bit to the FM Transfer the “Automatic block search, backward” memory bit to the FM Transfer data for “Program selection” from user DB to the FM	42.10 42.11 390.3	734
390.4 = 1	SK “set”		Transfer data for “Teach In” from the user DB to the FM	390.4	735
390.2 = 1	SK “set”		Transfer data for “MDI block entry” from the user DB to the FM	390.2	74
390.8 = 1	SK “set”		Transfer data for “MDI block on the fly” from the user DB to the FM	390.8	741
40.0 40.6	TF “servo enable” TF “park. axis”		In case of modification, transfer “Controller enable” yes/no to the FM In case of modification, transfer “parking axis” yes/no to the FM		761

SK = Soft key, TF = Text field

Table 8-1 Analysis of the User DB by the User Program, continued

OP 17	Triggered by –	User Program			See PIC...
Byte.Bit Event		Set in User DB (Byte.Bit)	Function	Delete Byte.Bit	OP 17
406.6 = 1 406.0 = 1 406.1 = 1 406.2 = 1 406.3 = 1 406.4 = 1 406.5 = 1	SK “Tipp” SK “Steu” SK “Refpk” SK “SMR” SK “MDI” SK “AutoE” SK “Autom”		Transfer data for “Jog” operating mode and the “Jog” operating mode to the FM Transfer data for the “Control” operating mode and the “Control” operating mode to the FM Transfer the “Reference point approach” operating mode to the FM Transfer data for “Incremental relative” operating mode and the incremental relative mode to the FM Transfer “MDI” operating mode to the FM Transfer “Automatic single block” operating mode to the FM Transfer “Automatic” operating mode to the FM	406.6 406.0 406.1 406.2 406.3 406.4 406.5	75
40.14 42.13 = 1 42.9 = 1	TF “software limit switch off” TF “Restart axis” TF “Delete distance to go”		In case of modification, transfer “Software limit switch disable” yes/no to the FM Transfer “Restart axis” memory bit to the FM Transfer “Delete distance to go” memory bit to the FM	42.13 42.9	761
390.1 = 1 42.8 = 1 390.0 = 1	SK “read” SK “active” SK “set”		Read MD No. from the user DB, retrieve its value from the FM and enter into the user DB Transfer “activate MD” to the FM Transfer MD No. and its value from the user DB to the FM	390.1 42.8 390.0	763
406.15 = 1 406.14 = 1	SK “Res” SK “Ack”		Error acknowledgment “Res” in FM 453 (diagnostic interrupt) Error acknowledgment “Quit” in the FM 453 (data errors, operator control/guidance errors)	406.15 390.13 406.14 390.14 390.15	77

SK = Soft key, TF = Text field

Variables in the User DB

The following table contains the variables which are entered into the user DB.

See Section 6.6 for the structure of the user DB.

Table 8-2 Variables for user DB

Absolute address	Variable type	Significance	Job no.
23	BYTE	Velocity or voltage/frequency level 1, 2 [BP]	–
 40.0 40.6 41.6	16 BOOL	Single functions Controller enable Parking axis Deactivate software end position monitoring	10
 43.0 43.1 43.2 43.3 43.5 43.6	16 BOOL	Single commands Activate machine data Delete distance to go Automatic block search forward Automatic block search backward Restart Undo set actual value	11
44	DINT	Zero offset	12
48	DINT	Set Actual value	13
86	DWORD	Increment for incremental dimensions	3
90	DWORD	Speed level 1	1
94	DWORD	Speed level 2	
98	DWORD	Voltage/frequency level 1 :	2
102	DWORD	Voltage/frequency level 2 :	
106	STRUCT NC-Satz	MDI block	6
152	STRUCT NC-Satz	MD block on-the-fly	16
172	BYTE	Program selection – program number	17
173	BYTE	Program selection – block number	
174	BYTE	Program selection – direction	
180	BYTE	Teach In – program number	19
181	BYTE	Teach In – block number	

Table 8-2 Variables for user DB, continued

Absolute address	Variable type	Significance	Job no.
 390.0 390.1 390.2 390.3 390.4 390.5 390.6 390.7 391.0 391.1 391.2 391.5 391.6 391.7	16 BOOL	Function bits for the user program Write MD Read MD Transfer MDI block Transfer program selection Transfer Teach In Transfer increment Transfer velocity levels Transfer voltage/frequency levels Transfer MDI block on-the-fly Transfer set actual value Transfer zero offset Diagnostic interrupt Data error Operator control/guidance error	–
392	WORD	No.	–
394	DINT	MD value	–
398	BYTE	SM no.	–
  406.0 406.1 406.2 406.3 406.4 406.5 406.6 407.6 407.7	16 BOOL	Mode selection/change input to corresponding mode Open-loop control Reference point approach Incremental relative MDI Automatic single block Automatic Jogging Acknowledge error (“Quit” softkey) Acknowledge diagnostic interrupt (“Res” softkey)	–

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 DB-SS

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 structure	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	
128	16 x BOOL		Digital inputs/outputs	

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 DB-SS, continued

Offset[1)]	Variable Type	Value	Significance of the Variables	Comment
130	STRUCT	MDI block structure	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	4 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 structure	Active NC block	
232	STRUCT	NC block structure	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 measurement/in-process measurement
272	DINT		Actual position on trailing edge	Length measurement
276	DINT		Length measurement value	Length measurement
280	DINT		Actual value at external block change	
284	DINT		DAC output value (for servo drive) or frequency output value (for step drive)	Servicing data
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

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 DB-SS, continued

Offset[1)]	Variable Type	Value	Significance of the Variables	Comment
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	8 x DINT		Free	
348	BYTE		Override	Additional operating data
349	BYTE		NC traversing program No.	
350	BYTE		NC block no.	Additional operating data
351	BYTE		No. of callup subroutine loops	Additional operating data
352	BYTE		G90/91 Active	Additional operating data
353	BYTE		G60/64 Active	Additional operating data
354	BYTE		G43/44 Active	Additional operating data
355	BYTE		Active D No.	Additional 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 minimum acceleration or minimum 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
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	

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 DB-SS, continued

Offset[1)]	Variable Type	Value	Significance of the Variables	Comment
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:

Bit / Byte	7	6	5	4	3	2	1	0
Control signals:								
20					BFQ/FSQ		TFB	
21	AF	SA	EFG	QMF	R+	R–	STP	ST
22	operating mode							
23	BP							
24	OVERR							
25								
Response signals:								
28	PARA			DF	BF/FS		TFGS	
29		PBR	T-L			WFG	BL	SFG
30	BAR							
31	PEH		FIWS		FR+	FR–	ME	SYN
32	MNR							
33				AMF				

The following table describes the control and checkback signals in German and English.

Table 8-4 Control and Checkback Signals

German	English	Significance
Control signals		
BP	MODE PA- RAMETER	Operating mode parameters Velocity levels 1 and 2 Voltage/frequency levels 1 and 2 Increment selection 1...100, 254
Operating mode	MODE	Operating mode — Code Jogging — 01 Open-loop control — 02 Reference point approach — 03 Incremental relative — 04 MDI — 06 Automatic — 08 Automatic single block — 09
R+	DIR_P	Direction plus
R–	DIR_M	Direction minus
STP	STOP	Stop
ST	START	Start
OVERR	OVERRIDE	Override
AF	DRV_EN	Drive enable
SA	SKIP_BLK	Enable bit for block skip
EFG	READ_EN	Read enable
QMF	ACK_MF	Acknowledgment M function
BFQ/FSQ	OT_ERR_A	Acknowledgment operator control and guidance error
TFB	TEST_EN	Switchover, P-BUS port
Checkback signals		
MNR	NUM_MF	M function number
BL	WORKING	Program running
SFG	START_EN	Start enable
BF/FS	OT_ERR	Operator control and guidance errors
BAR	MODE	Active operating mode
AMF	STR_MF	Modify M function
PBR	PR_BACK	Program scanning backward
T-L	DT_RUN	Dwell time running
PEH	POS_ROD	Position reached and stopped
FR+	GO_P	Go_plus
FR–	GO_M	Go_minus
ME	MSR_DONE	Measurement done

Table 8-4 Control and Checkback Signals, continued

German	English	Significance
SYN	SYNC	Synchronized
DF	DATA_ERR	Data error
FIWS	FAVEL	Flying actual value done
TFGS	TST_STAT	Switchover, P-BUS port done
WFG	WAIT_EN	Wait for external enable
PARA	PARA	Parameterized

9 Description of Functions

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.

Chapter Overview

9.1 Control and Checkback signals

Overview

FC MODE_WR transfers the control signals from the user DB to the FM and transfers the checkback signals from the FM to the user DB.

Byte \ Bit	7	6	5	4	3	2	1	0
Control signals:								
20					BFQ/FSQ		TFB	
21	AF	SA	EFG	QMF	R+	R–	STP	ST
22	operating mode							
23	BP							
24	OVERR							
25								
Response signals:								
28	PARA			DF	BF/FS		TFGS	
29		PBR	T-L			WFG	BL	SFG
30	BAR							
31	PEH		FIWS		FR+	FR–	ME	SYN
32	MNR							
33				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	Acknowledge operato/tarvel 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–	Direction minus	... 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 Automatic modes.
DIR_P	R+	Direction 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 Automatic modes.
ACK_MF	QMF	Acknowledge M function	... only “acknowledge-driven” during M function output (see machine data list in Table 5-5, MD32). ... acknowledges receipt of M function. Program sequence can be continued.
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

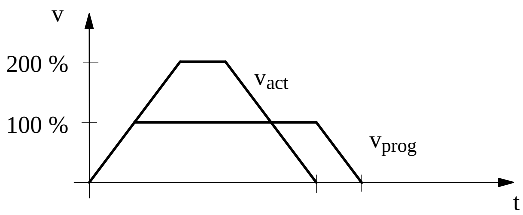
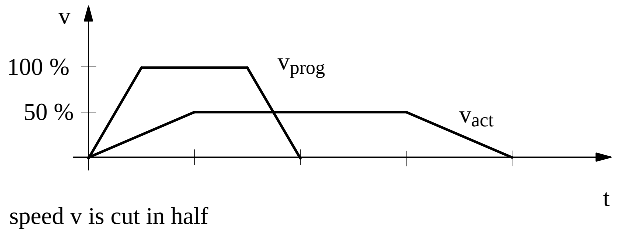
Symbol		Name	Function
English	**German**		
DRV_EN	AF	Drive enable	... enables movement. When the signal is reset, a **rapid deceleration** of the movement takes place. On MD 37.15 = 0 program execution, or the movement, is canceled and the residual distance is deleted. On MD 37.15 = 1 machining resumes after emergency stop • Rapid deceleration of the movement. • On axis standstill FR+ or FR– = 0; BL = 1 – if the drive remains activated and the servo enable active, the axis is held in position control mode. – if 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	operating mode	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 PARAMETER	BP	Mode parameter	... selects speed levels in Jogging mode. ... selects voltage/frequency levels in open-loop control mode. ... selects increment 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.
START_EN	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_EN	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	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 9.3.10)
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.

Table 9-2 Checkback Signals, continued

Symbol		Significance	Function
English	German		
FAVEL	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.
POS_ROD	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 Job No.
Jogging (01)	[R+], [R–], [STP], [AF], [OVERR], [BP] = 1 or 2	[BL], [SFG], [FR+], [FR–], [SYN], [WFG]	1, 10 (servo enable)
Open-loop control (02)	[R+], [R–], [STP], [AF], [OVERR], [BP] = 1 or 2	[BL], [SFG], [FR+], [FR–], [WFG]	2
Reference point approach (03)	[R+], [R–], [ST], [STP], [AF], [OVERR]	[BL], [SFG], [FR+], [FR–], [WFG], [SYN], [PEH]	10 (servo enable)
Incremental relative (04)	[R+], [R–], [STP], [AF], [OVERR], [BP] = 1...100 for increment table or 254	[BL], [SFG], [FR+], [FR–], [WFG], [SYN], [PEH]	1, 10 (servo enable), 3 (only if BP = 254, if BP = 1...100 the appropriate increments must be parameterized)
MDI (06)	[ST], [STP], [AF], [QMF], [OVERR]	[BL], [SFG], [FR+], [FR–], [WFG], [SYN], [PEH], [AMF), [MNR], [T-L]	6, 10 (servo enable)
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]	17 (assuming the corresponding traversing program was parameterized), 10 (servo enable)

Error condition:

- Message via BF/FS – acknowledgement with BFQ/FSQ
- Message via DF – acknowledgement on next correct data transfer
- Message via diagnostic interrupt – acknowledgement on “Restart” (job no. 11)

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 a mode, first transfer the appropriate reference data (e.g., speed levels with write job 1); 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

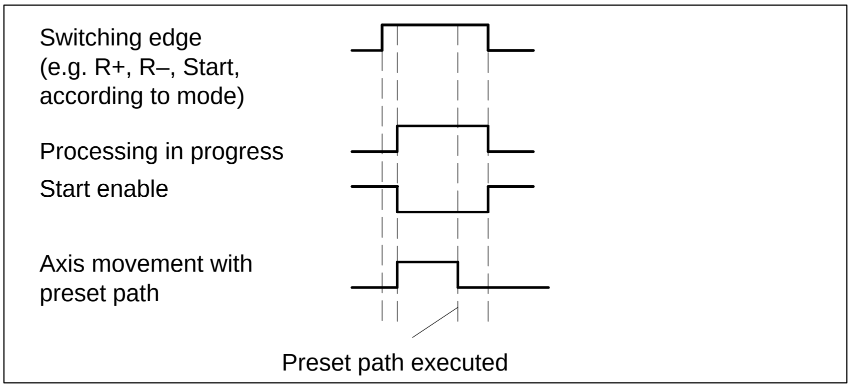
The following table lists the control signals used to start a movement.

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

FC MODE_WR 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 check-back is performed after the movement in the old mode is completed.

This does not apply to changes between Automatic and Automatic Single-Block mode.

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, the velocities 1 and 2 must first be transferred to the FM 453 with **job number 1**.

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

Preconditions:

- The FM 453 has been parameterized.
- The mode has been selected and confirmed
- Drive enable [AF] = 1 (control signal, FC MODE_WR)
- Stop [STP] = 0 (control signal, FC MODE_WR)
- Servo enable (RF) = 1 (FC MODE_WR, job no. 10)
- Velocity levels 1 and 2 have been transferred with FC MODE_WR, job no. 1)

Table 9-3   Control Actions for “Jogging” Mode (examples)

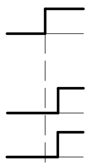
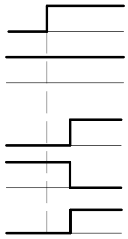
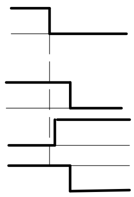
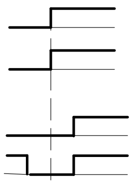
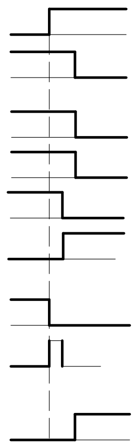
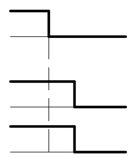
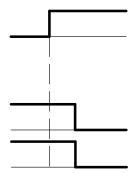
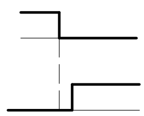
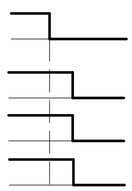
Signal Name	Level	Explanation
Control action 1, enable “Jogging” mode		
Control signal: Mode [BA] **Checkback signals:** Active mode [BAR] Start enable [SFG]		The user initiates a [BA] command. The module returns [BAR] and [SFG].
Control action 2, move axis – positive direction		
Control signals: Direction 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, 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.

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+] Direction minus [R–] **Checkback signals:** Travel minus [FR–] Processing in progress [BL] Start enable [SFG] Operator control/travel error [BF/FS] **Control signals:** Direction minus [R–] Error acknowledgement [BFQ/FSQ] **Checkback signal:** Start enable [SFG]		[R+] is actuated while the axis is traversing with [R–]. The ambiguous direction command causes the axis to stop and [BF/FS] to be output. [FR–] and [BL] are reset. 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 action 7, cancel drive enable (special situation)		
Control signal: Drive enable [AF] **Checkback signals:** Travel minus [FR–] Processing in progress [BL]		[AF] is deactivated during the traversing movement. The axis is stopped abruptly. [FR–] and [BL] are canceled.
Control action 8, reset during axis motion (special situation)		
Single command “Restart ”, job no. 11 **Checkback signals:** Travel plus [FR+] Processing in progress [BL]		Restart is defined during the traversing movement. The axis is stopped abruptly. [FR+] and [BL] are reset. If incremental encoders are used, resynchronization is necessary. (SYN is cleared)
Control action 9, change direction		
Control signal: Direction plus [R+] **Checkback signal:** Start enable [SFG]		Only when [R+] is canceled is [SFG] reactivated.
Control action 10, change mode		
Control signal: Mode [BA] **Checkback signal:** Active mode [BAR] Travel plus [FR+] Processing in progress [BL]		A new [BA] 1 is preselected during the traversing movement. The axis is stopped by way of the deceleration ramp. [FR+] and [BL] are reset.

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.

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 defined with **job No. 2**.

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 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

Please see also Section 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 overrideis 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 reference point approach	Assigned depending on input

MSR stands for measurement system raster (see Section 5.3.1)

Handling by the User

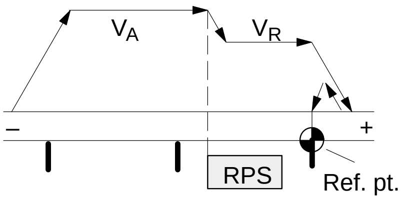
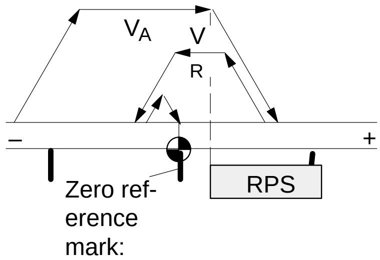
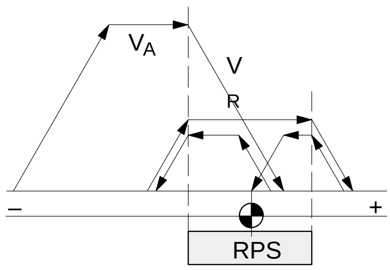
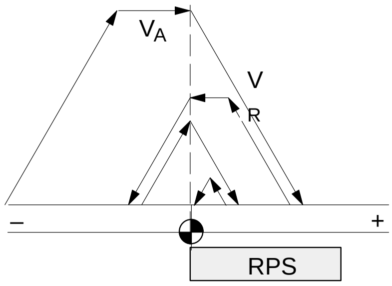
When an absolute encoder is used, only the reference point coordinate defined as a fixed point on the axis is approached in Reference-point approach mode.

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).

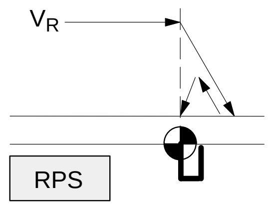
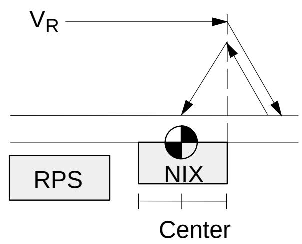
With Reference Point Switch (RPS)

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 reference mark to right of RPS	equals R+ 2nd situation mirrored
	2nd situation zero reference 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.

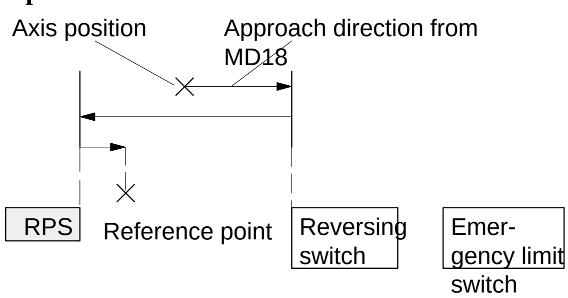
Synchronization Point Encoder Selection in MD37	Applicable for Type (0 – 3) of the Reference Point Approach per MD18
Current-sourcing pattern zero	
Zero pulse external (NIX)	

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

Preconditions:

- The FM 453 has been parameterized.
- The mode has been selected and confirmed
- Drive enable [AF] = 1 (control signal, FC MODE_WR)
- Stop [STP] = 0 (control signal, FC MODE_WR)
- Servo enable (RF) = 1 (FC MODE_WR, job no. 10)

Table 9-4 Control Actions for “Reference point approach” Mode (examples)

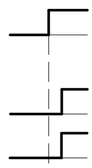
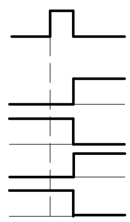
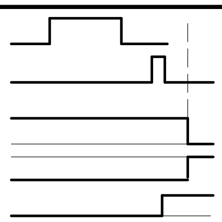
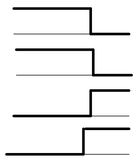
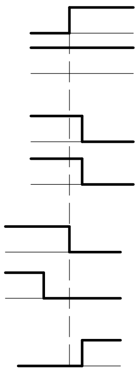
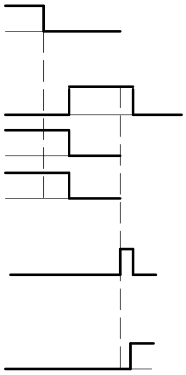
Signal Name	Level	Explanation
Control action 1, enable “Reference point approach” mode		
Control signal: Mode [BA] **Checkback signals:** Active mode [BAR] Start enable [SFG]		The user initiates a [BA] command. The module returns [BAR] and [SFG].
Control action 2, move axis – positive direction		
Control 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.
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).

Table 9-4 Control Actions for “Reference point approach” Mode (examples), continued

Signal Name	Level	Explanation
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 canceled. [PEH] is enabled. [BL] is also canceled. [SFG] is enabled.
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” (job no. 10) **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 abruptly 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 the position for the increment **job no. 3**
- Using the increment table; see Section 5.3.2

Velocity level 1 **job no. 1** (see Section) is used as the velocity setpoint and can be modified during the movement.

It is **not** possible to change position on-the-fly (e.g. changing the position setpoint during a movement).

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 setpoint for increment (job no. 3)
	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 residual distance” (job no. 11) the residual distance is deleted and the increment is traversed agai (provided the increment 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

Preconditions:

- The FM 453 has been parameterized.
- The mode has been selected and confirmed
- Drive enable [AF] = 1 (control signal, FC MODE_WR)
- Stop [STP] = 0 (control signal, FC MODE_WR)
- Servo enable (RF) = 1 (FC MODE_WR, job no. 10)
- Velocity levels have been transferred (FC MODE_WR, job no. 1)
- Axis is synchronized

Table 9-5 Control Actions for “Incremental Relative” Mode (examples)

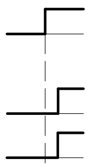
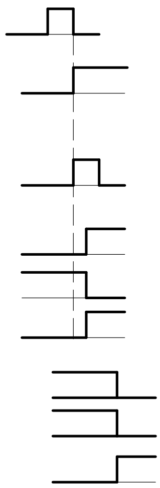
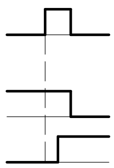
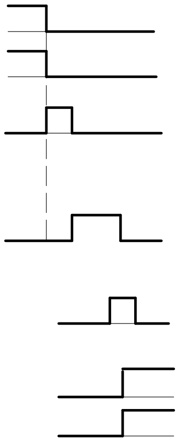
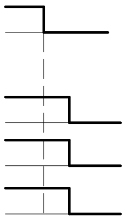
Signal Name	Level	Explanation
Control action 1, enable “Incremental relative” mode		
Control signal: Mode [BA] **Checkback signals:** Active mode [BAR] Start enable [SFG]		The user initiates a [BA] command. The module returns [BAR] and [SFG].
Control action 2, define position		
Transfer increment (job no. 3) Select increment (254) **Control signal:** Direction plus [R+] **Checkback signals:** e.g. Travel plus [FR+] Start enable [SFG] Processing in progress [BL] e.g. Travel plus [FR+] Processing in progress [BL] Position reached, stop [PEH]		When the increment has been transferred and selected, [R+] can be initiated. The axis cancels the [SFG] and outputs messages [BL] and [FR+] When the defined position has been reached, the axis enables [PEH]; [SFG] and checkback signals [FR+] and [BL] are reset.
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”.

Table 9-5 Control Actions for “Incremental Relative” Mode (examples), continued

Signal Name	Level	Explanation
Control action 4, error during traversing movement		
Checkback signals:		The axis moves.
Travel plus [FR+]		An error is output during the traversing movement. [FR+] and [BL] are canceled, and [BFQ/FSQ] is enabled.
Processing in progress [BL]		
Control signal:		
Acknowledge operator control/travel error [BFQ/FSQ]		
Checkback signals:		When the error has been acknowledged, the start enable is activated. The movement can be restarted with [R+].
Start enable [SFG]		
Control signal:		
Direction plus [R+]		
Checkback signals:		[FR+] and [BL] are activated.
Travel plus [FR+]		[SFG] is canceled.
Processing in progress [BL]		
Control action 5, change mode		
Control signal:		
Mode [BA]		[BA] is deactivated during the traversing movement.
Checkback signals:		
Active mode [BAR]		The axis is stopped by way of the deceleration ramp. [FR+] and [BL] are reset.
Travel plus [FR+]		
Processing in progress [BL]		

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 the traversing program block (see Chapter 10, however it does not have a program number or block number).

The user program passes the “MDI block” (**job no. 6**) 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

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 Dwell time G90 Absolute measure G91 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” (**job no. 16**).

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.

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)

Byte	Data Format	Bit							
		7	6	5	4	3	2	1	0
0	Byte	0							
1	Byte	0							
2	8 bits	0	0	0	X/t	0	0	G2	G1
3	8 bits	0	0	0	0	M3	M2	M1	F
4	Byte	G function 1							
5	Byte	G function 2							
6	Byte	0							
7	Byte	0							
8	DINT	32-bit value 1							
12	DINT	32-bit value 2							
16	Byte	M function 1							
17	Byte	M function 2							
18	Byte	M function 3							
19	Byte	0							

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” (job no. 6)
“MDI block on-the-fly” transmitted to the FM 453	as defined by “MDI block on-the-fly” (job no. 16)

Note

Please see also Section 9.1.3!

Control Actions

Preconditions:

- The FM 453 has been parameterized.
- The mode has been selected and confirmed
- Drive enable [AF] = 1 (control signal, FC MODE_WR)
- Stop [STP] = 0 (control signal, FC MODE_WR)
- Servo enable (RF) = 1 (FC MODE_WR, job no. 10)
- Axis is synchronized

Table 9-7 Control Actions for “MDI” mode (examples)

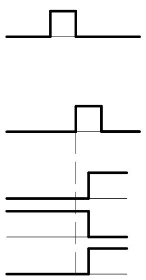
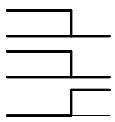
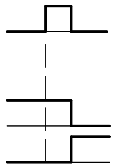
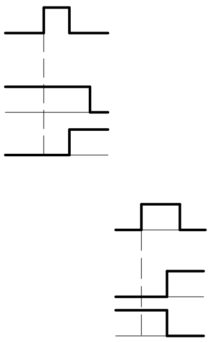
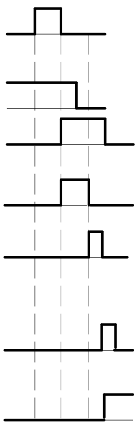
Signal Name	Level	Explanation
Control action 1, define position		
Transfer MDI block (job no. 6) **Control signal:** Start [ST] **Checkback signals:** e.g. Travel plus [FR+] Start enable [SFG] Processing in progress [BL]		When the MDI block has been transferred, [ST] can be initiated. The axis cancels 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]; [SFG] and checkback signals [FR+] and [BL] are reset.

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 (job no. 16) **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 canceled 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 (job no. 6) Transfer “delete residual path” (job no. 11) **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 positioning 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 (**job no. 17**) 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 search to the interruption point is executed. 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

Preconditions:

- The FM 453 has been parameterized.
- The mode has been selected and confirmed
- Drive enable [AF] = 1 (control signal, FC MODE_WR)
- Stop [STP] = 0 (control signal, FC MODE_WR)
- Servo enable (RF) = 1 (FC MODE_WR, job no. 10)
- Axis is synchronized

Table 9-8 Control Actions for “Automatic” Mode (examples)

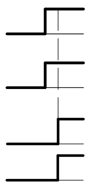
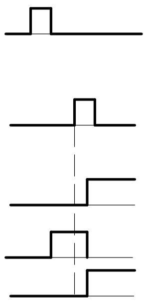
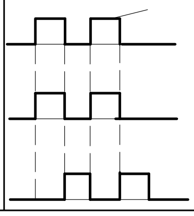
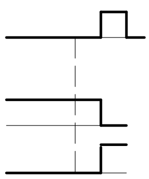
Signal Name	Level	Explanation
Control action 1, Automatic/Automatic single block mode		
Control signals: Mode [BA] Read-in enable [EFG] **Checkback signals:** Active mode [BAR] Start enable [SFG]		The user initiates [BA] and [EFG]. The module returns [BAR] and [SFG].
Control action 2, positioning by program selection		
Program selection (job no. 17) **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

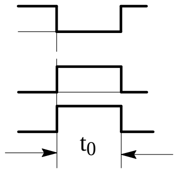
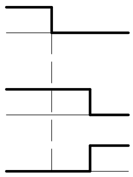
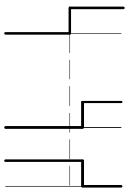
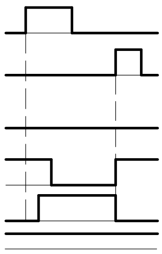
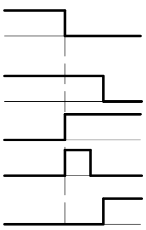
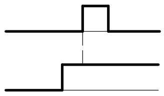
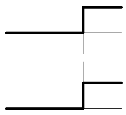
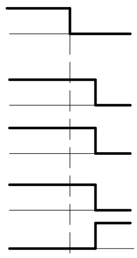
Signal Name	Level	Explanation
Control action 5, traversing block with dwell		
Checkback signals: Travel plus [FR+] or Travel minus [FR–] Dwell time running [T-L] Position reached, stop [PEH]		During processing of a traversing block with dwell, the dwell time t_0 [T-L] and [PEH] are output.
Control action 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 progress [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].

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” (job no. 11)		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. [FR+] or [FR–] and [BL] are reset.

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 multiple modes, and that are likewise necessary in order to control and operate the FM 453, and data of the FM available for checkback messages.

These settings/functions, which you can activate by calling FC 2 or FC 3 (see Section 6) with the appropriate job no., are listed in the table below.

Before you call FC 2 with the job no., the corresponding values must be entered in the user DB.

Chapter Overview

9.3.1 Change Parameters/Data (Job No. 8)

Overview

You can use this function to change parameters and data in the data function blocks of the FM 453, or to issue an order to read parameters or data from data function blocks. The parameters/data can then be read out with function call FC RD_COM job no. 114 (see Section 9.3.17).

Structure of Data Record

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				
126	Byte	DB type	type	1 = MD	2 = SM	3 = TO	4 = NC (traversing program)
127	Byte	data number	Info 1	MD No. (5...61)	SM No. (1...100)	TO No. (1...20)	Progr. No. (1...199)
128	Byte	number of data	Info 2	Number of MDs, consecutive (1...5)	Number of SMs, consecutive (1...5)	0 = Tool offset complete 1 = Tool length only 2 = Wear value abs. only 3 = Wear value add. only	Block No. (1...255)[1)]
129	Byte	job type	1 = Read job parameters 2 = Write parameters 4 = Write parameters and save				
130...149	depends on type	data array	Parameters/data (see data blocks, Section 5.3)				

1) For block format see Section 9.3.12 “Active NC block”

Example

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 5...8 = 100,000 (MD21)
 Byte 9...12 = 50,000,000 (MD22)
 Byte 13...24 = 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 overwriten with the contents in accordance with “block format”.

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 — approx. 310 bytes
DB Increments — approx. 460 bytes
DB Tool offset data — approx. 310 bytes
DB Traversing programs — 110 + (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	310 bytes	$412.9 \cdot 10^6$	78
Traversing programs (20 blocks)	510 bytes	$251 \cdot 10^6$	48

Note

SDB $\geq$ 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 $\geq$ 1 000. These modifications are lost when the module is replaced, and should be traceable in the user program.

9.3.2 Single Functions (Job No. 10)

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 9.3.10

Retrigger reference point

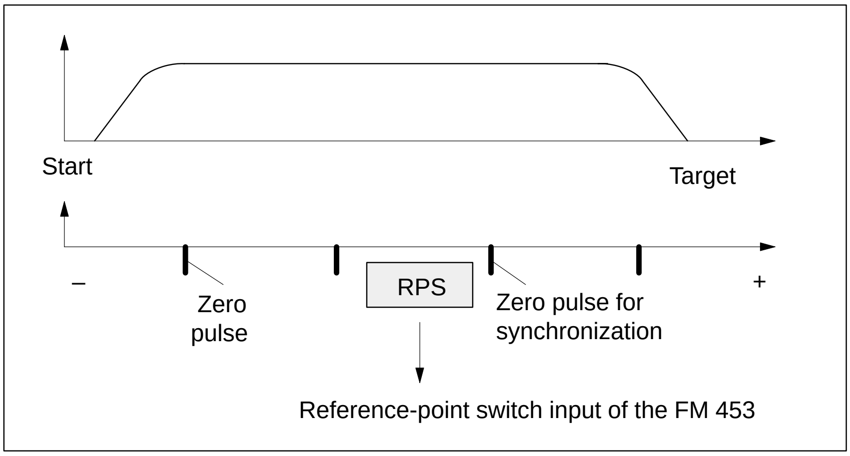
A precondition for retrigger reference point is that the axis has been synchronized by reference point approach.

With this setting, the axis is synchronized at each positive edge of the zero mark, after leaving the reference-point switch (RPS) in the direction of the zero mark (direction as in Reference-Point Approach). Regardless of the instantaneous speed, at this moment the reference-point coordinate is associated with the current actual position, taking any active shift into account.

When crossing the RPS, a signal length of $\Delta t \geq 2 \cdot$ FM cycle must be assured!

The resulting change in the actual value causes no internal changes in the target.

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.

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 triggered (including diagnostic interrupts)
- 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.
- 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 (Job No. 11)

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 MD block is likewise activated by switching on or off.

Delete Residual Path

You can use this command to delete a residual distance that remains after a job has been canceled.

- It is effective only in the “Incremental Relative”, “MDI”, and “Automatic” modes after a stop. If processing is not interrupted with a stop, the Delete Residual Distance requirement 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 (Job No. 12)

Overview

You can use this function to shift the current zero point.

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 a coordinate system is canceled, provided that a zero offset was already active and the specified shift was executed (relatively). All coordinates and software limit switches, the reference point and the actual value are updated accordingly.

Example of a zero offset:

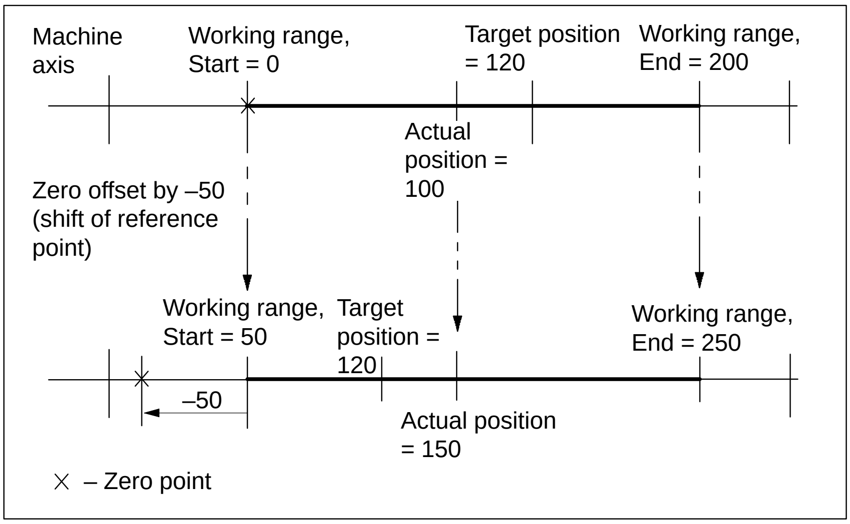


Fig. 9-1 Zero Offset

The zero offset can be deleted by:

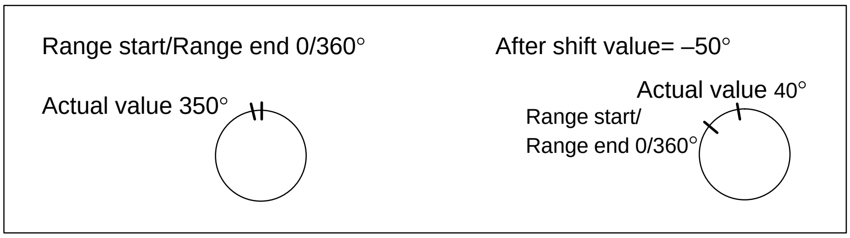
- Transmitting shift value = 0
- Starting Reference-Point Approach mode
- Set reference point
- Eliminating axis synchronization (e.g. by a restart).

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 (Job No. 13)

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:

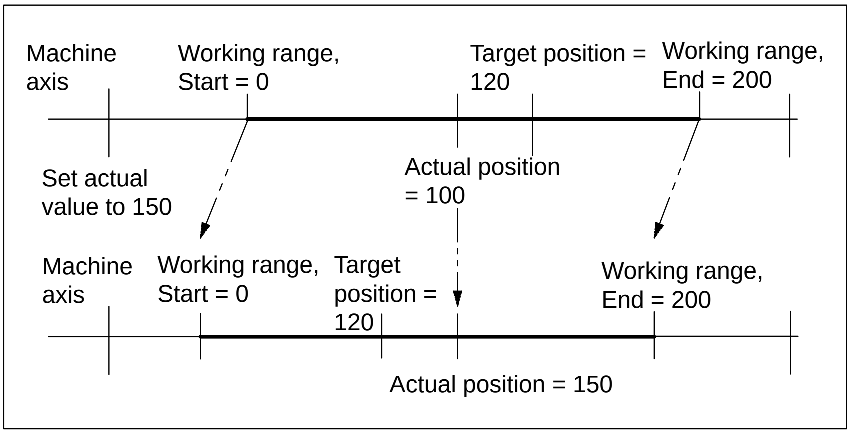


Fig. 9-2 Set Actual Value

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 (Job No. 14)

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 (Job No. 18)

Overview

A selection of up to four display data items whose values can be read out with “read application data” (see Section 9.3.13).

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 module cycle.

The selection is stored on the FM, i.e. you only need to make the selection once and read the correponding values cyclically (job no. 105).

9.3.8 Teach In (Job No. 19)

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, when “Processing in progress” = 0.

The program and the appropriate program block must be present on the FM 453 (see Parameterization, Chapter 5).

9.3.9 Set Reference Point (Job No. 21)

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.

9.3.10 Measured Values

Activating the Measurement Function

A "length measurement" or "inprocess measurement" can be activated by calling **FC 2** and **job no. 10** "single functions".

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 results from the execution of the "length measurement" and "inprocess measurement" functions, by calling **FC 5**.

Prerequisites

The following prerequisites must be fulfilled in order to execute the function "measurement":

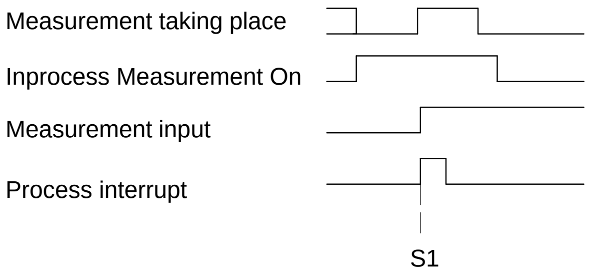
1. Connect a bounce-free switching-signal encoder (touch probe) to a digital output of the FM 453.
2. Parameterize Measurement for this input in MD34.

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

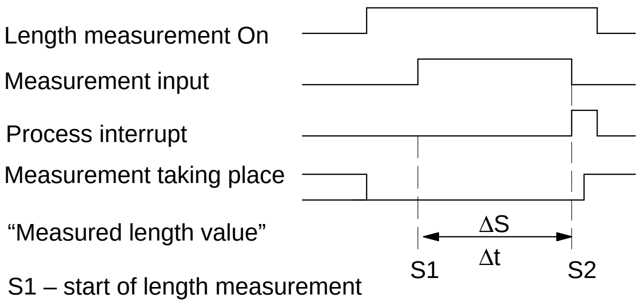
The present actual position is captured at each rising edge of the touch probe. At the same time, the axis movement is interrupted (servo-controlled braking).



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 (amount) 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 following response takes place with functions that change the current actual value:

- Resynchronization in Reference-Point Approach mode:measured length contains measurement-error message
- Set Reference Point:measured length contains measurement-error message
- Retrigger Reference Point:measured length is difference between edge positions
- Set Actual Value:measured length is actual traversed distance

Note

The zero offset function does not change the actual position of the axis, and is thus not relevant for the above observations regarding the Length Measurement function.

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 control 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: • Resynchronization in the Reference-Point Approach mode while a measurement is in progress • 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 progress)	With the back edge of the touch probe signal (= Length Measurement is in progress)

In association with the ME checkback signal, the read-out measured values are valid for the executed measurement process.

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 Measurement and Length Measurement 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

9.3.11 Basic Operating Data (Job No. 102)

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)

9.3.12 Active NC Block (Job No. 103), Next NC Block (Job No. 104)

Active NC Block

... are display data in “Automatic” mode

/	Skipped block
L	Subprogram callup (fills in UP number)
P	Number of callups for subprogram (fills in UP callup number)
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 callup number, 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”

9.3.13 Application Data (Job No. 105)

Overview

The values passed with “request application data” **job no. 18** (see Section 9.3.7) are returned from the FM 453.

These values are always updated in the module cycle on the FM 453.

9.3.14 Actual Value Block Change (Job No. 107)

Overview

The “actual value block change” function is described in Section 10.1, G50, G88, G89.

9.3.15 Servicing Data (Job No. 108)

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)

9.3.16 Additional Operating Data (Job No. 110)

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

9.3.17 Parameters/Data (Job No. 114)

Overview

The parameters and data requested for reading with the “modify parameters/data” function **job no. 8** (see Section 9.3.1) can be read.

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	$10\,995 \cdot 10^{-3}$ mm	10.995 mm
inches	10^{-4} inch	$10\,995 \cdot 10^{-4}$ in(ch)	1.0995 inch
degrees	10^{-4} degree 10^{-2} degree	$3{,}600{,}000 \cdot 10^{-4}$ degree $36{,}000 \cdot 10^{-2}$ 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.

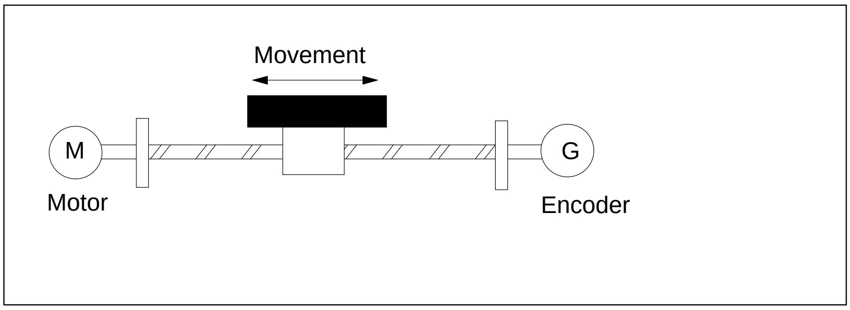


Fig. 9-3 Linear Axis

Rotary Axis

With rotary axes, the actual value is reset to “0” after one revolution. Rotary axes thus have an infinite traversing range.

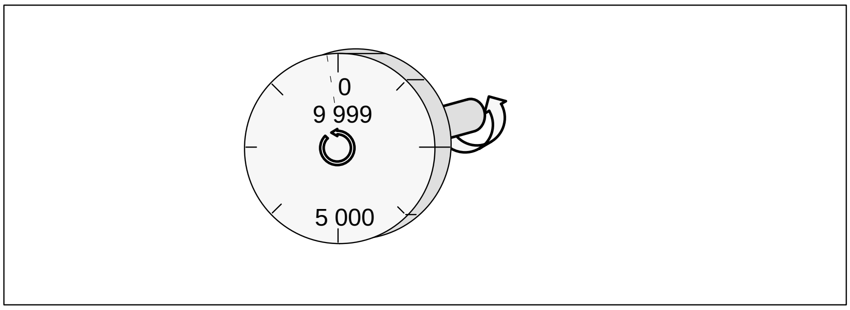


Fig. 9-4 Rotary Axis

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).

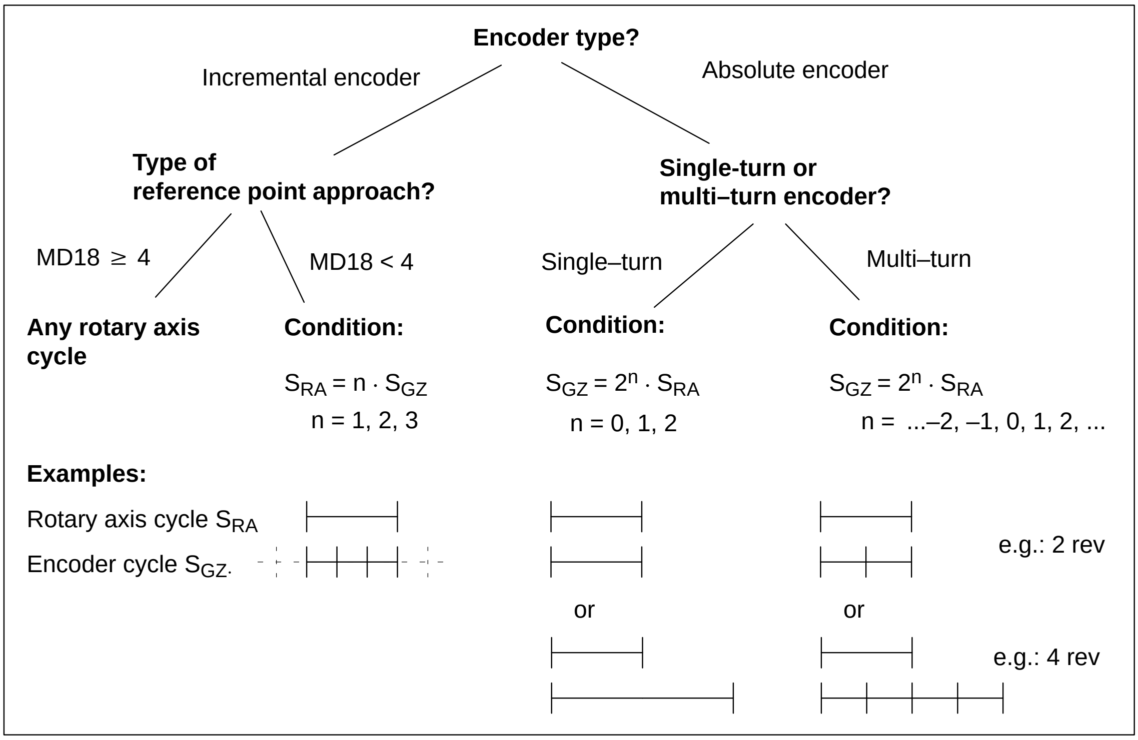


Fig. 9-5 Encoders on rotary axes

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 encoder 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:

$$\text{Gear ratio:} \quad i = \frac{\text{50 spindle revolutions}}{\text{30 motor revolutions}} = 1.666666...$$

$$\text{Displacement per encoder revolution} = i \cdot 10{,}000 \text{ MSR} = 16{,}666.666... \text{ MSR}$$

The following values are entered:

MD	Value	Unit
11	16 666	($10^{–3}$ mm)
12	$0.666... \cdot 2^{32}$ = 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	• Signal track missing • Actual no. of pulses/rev $\neq$ MD13 • No signal change to a track pair	• If the contents of the missing-pulse memory exceed a value of 7, a diagnostic interrupt, external channel error is output (see Troubleshooting, Table 11-4). • The missing-pulse memory is cleared with the control signal “Restart” . **Note:** For encoders with non-cyclic zero pulse $\rightarrow$ switch pulse monitoring in MD20 OFF.
	In Reference-Point Approach mode, no zero pulse is recorded after leaving the reference-point switch within the path as defined in MD11, 12.	**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)

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.

Encoder Connection

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-bit single-turn encoders, or 25-bit multi-turn encoders with the SSI protocol.

- **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)** **13 = Absolute encoder (SSI 13 Bit)** **14 = Absolute encoder (SSI 25 Bit)**	GRAY Code GRAY Code Binary Code Binary Code
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	$0...2^{32}-1$ see Section 5.3.1, Dependencies	(2^{-32} MSR) (fractional portion)
13	Increments per encoder revolution (division period)	$2^1...2^{25}$ see Section 5.3.1, Dependencies	Entry according to encoder rating plate

Table 9-11 Function Parameters – Absolute Encoders (SSI), continued

MD	Designation	Value/Meaning	Comments/Unit
14	Number of revolutions of SSI encoder	0/1 = Single-turn encoder $2^1 \ldots 2^{12}$ for multi-turn encoder	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:

$$\text{Gear ratio:} \quad i = \frac{50 \text{ spindle revolutions}}{30 \text{ motor revolutions}} = 1.666666...$$

$$\text{Displacement per encoder revolution} = i \cdot 10{,}000 \text{ MSR} = 16{,}666.666... \text{ MSR}$$

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	4096	(puls/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)
13	2 500	(pulse/rev)

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.

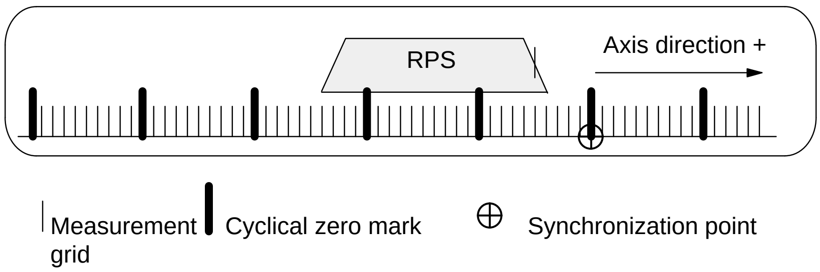
Synchronization

Creating the position reference between the internal FM position value and mechanical position of the axis.

Measured Value Synchronization With Incremental Encoders

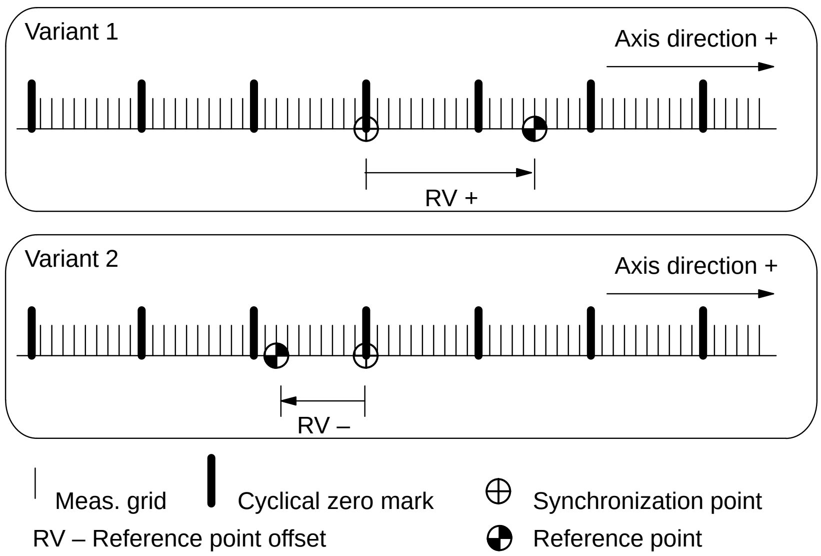
Irrespective of the approach direction, the synchronization point can be located on the side of the lower or the higher actual position values in relation to the reference point switch position. It is demarcated by the rising edge of a zero pulse or by the reference point switch. This selection is made 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 reference 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.

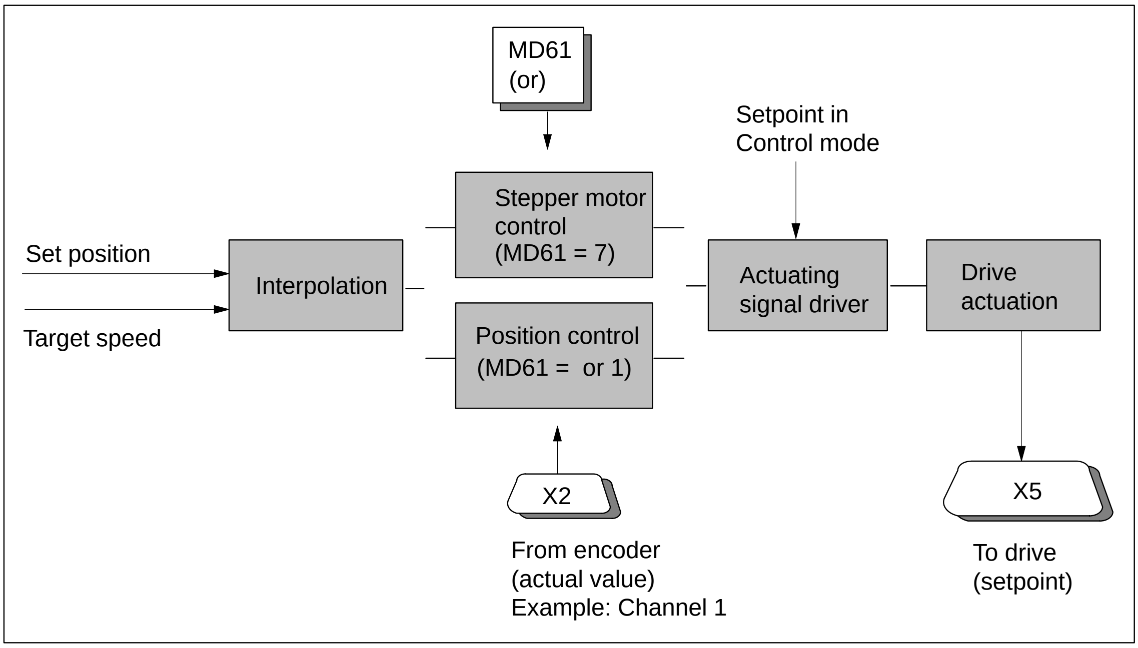


Fig. 9-6 Overview of the Functions Used in Setpoint Processing

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.

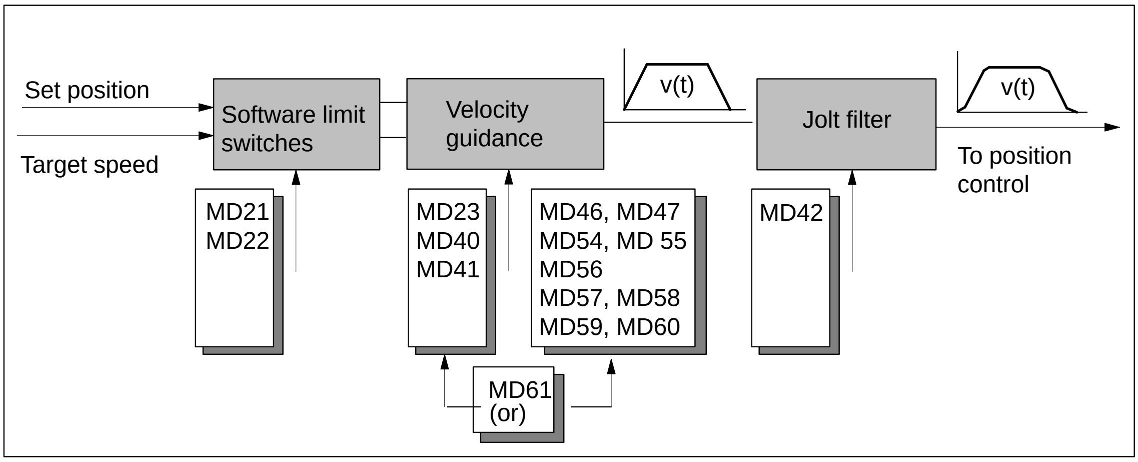


Fig. 9-7 Overview of Interpolation Function

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.

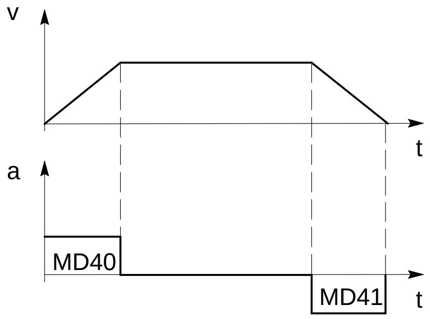
MD	Designation	Value/Meaning	Unit
21	Software limit switch, start	–1,000,000,000 – +1,000,000,000 see Section 5.3.1, Dependencies	[MSR]
22	Software limit switch, stop		

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)

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.

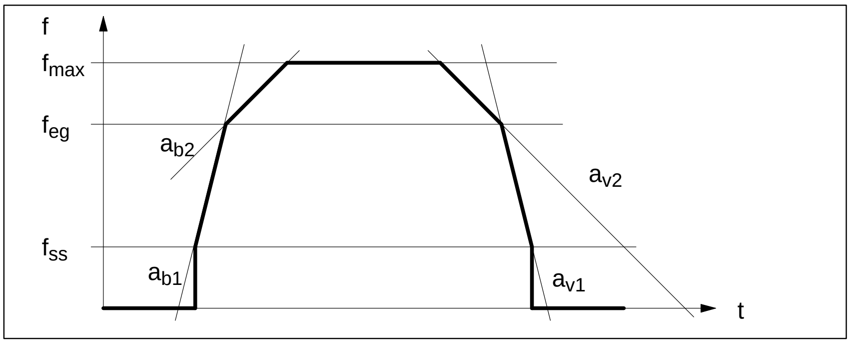


Fig. 9-8 Maximum Speed Frequency Profile

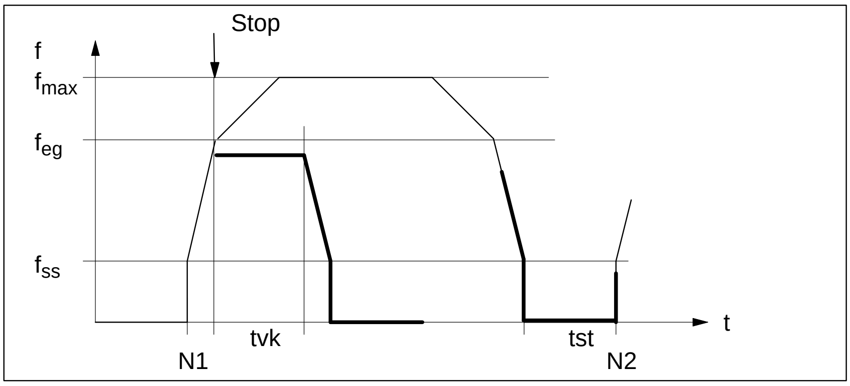


Fig. 9-9 Frequency Profile for Stop or G60

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]

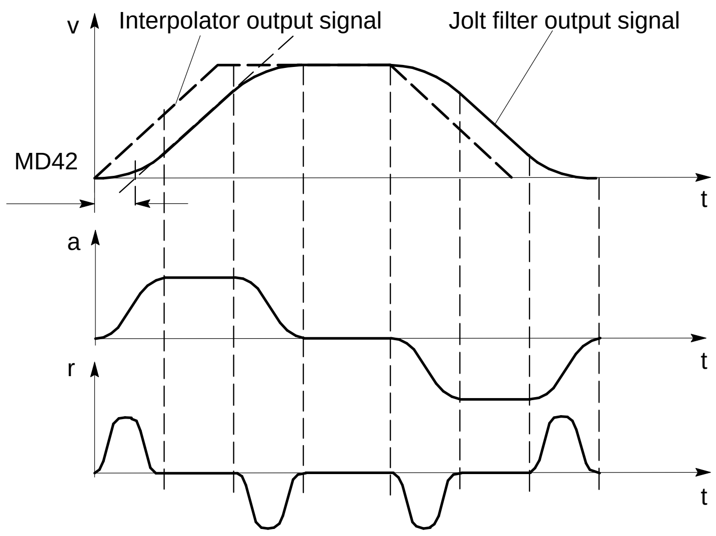
1) see Section 5.3.1, Dependencies

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, 13, 14	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, 13, 14	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:

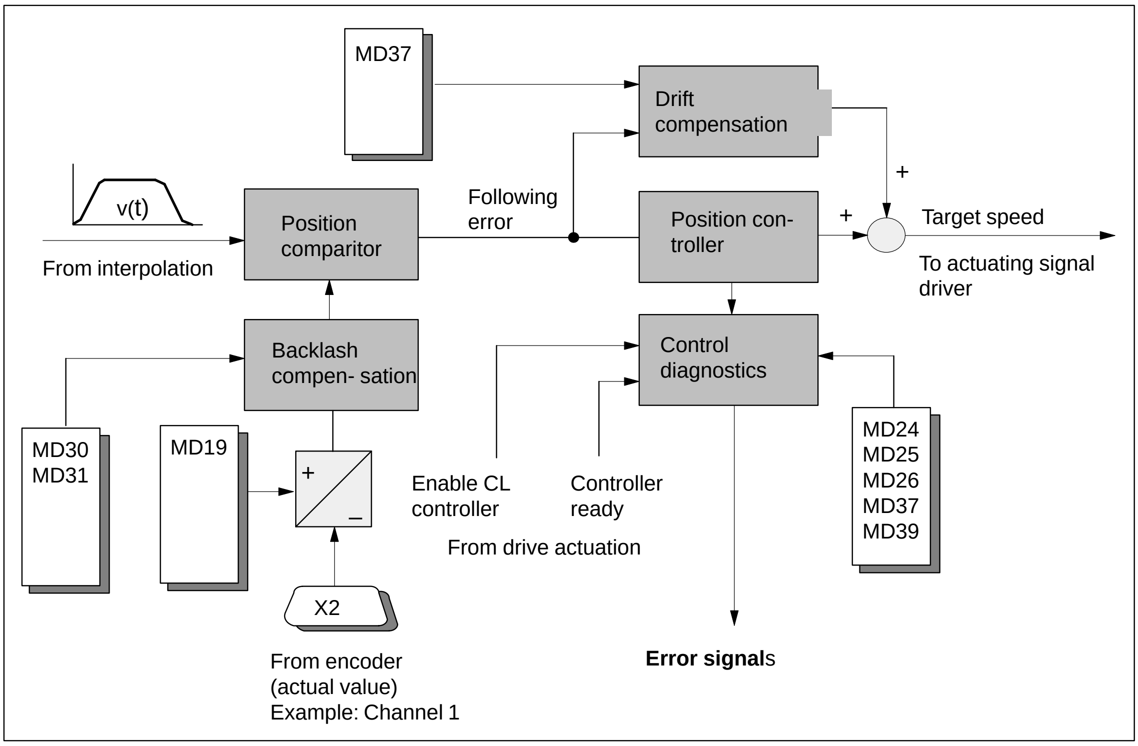


Fig. 9-10 Overview of Servo Position Control Function

Position Comparitor

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

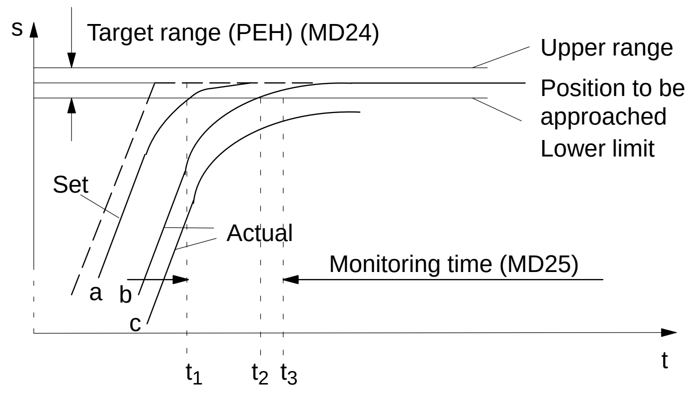
In servo-controlled mode, the manipulated variable is compared periodically with the possible maximum values (± 10 V or maximum frequency). A violation of the maximum limit is interpreted as follows:

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 9.3.16, 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



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...100,000	[ms], rounded to 2–ms steps

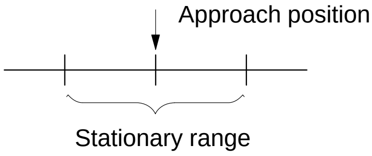
Following error monitoring

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]

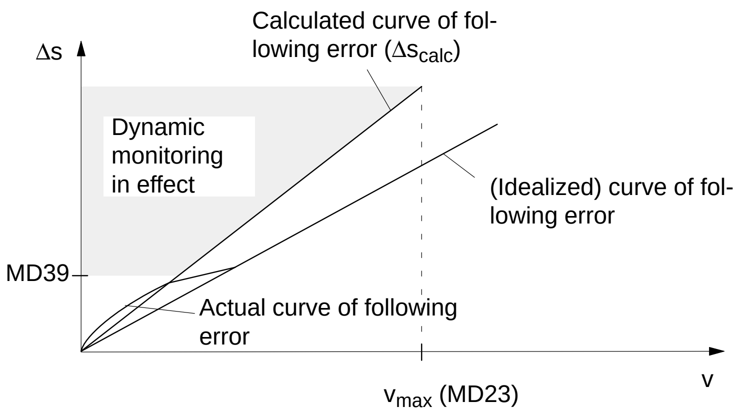
The standstill zone is located symmetrically around the target approach position.



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.



Δs – following error
v – speed

MD	Designation	Value/Meaning	Unit
39	Minimum following error (dynamic)	0 = no monitoring 0...1,000,000	[MSR]

When the calculated following-error limit is exceeded, the FM 453 signals a “Following error too great” error (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.

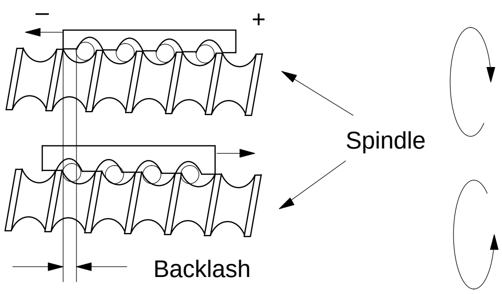
A basic compensation of the zero point error by means of the offet is required for the optimum effect of the drift compensation
(see MD44, offset compensation).

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	–1 000 000 – +1 000 000	(MSR)
31	Directional reference of backlash	0 = as in reference point approach (only for incremental encoders)	–

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.

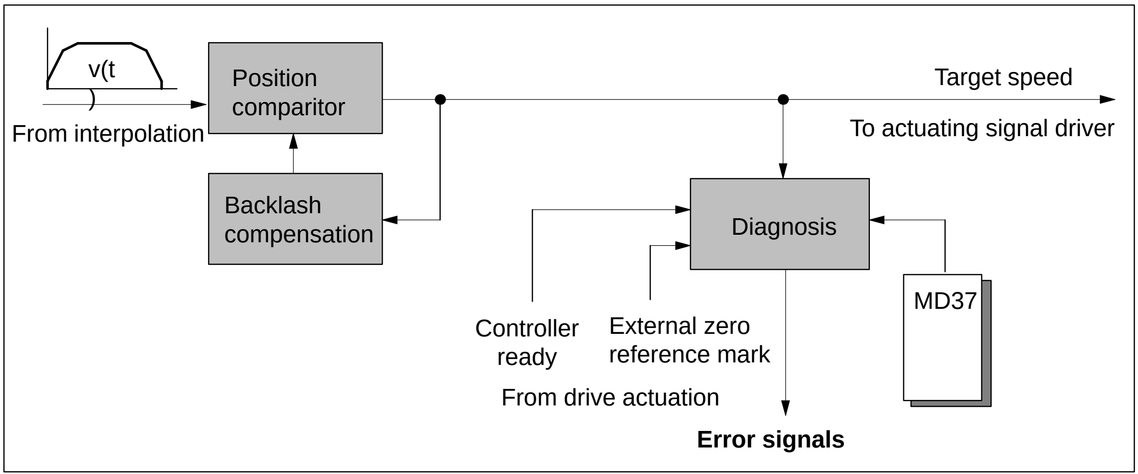


Fig. 9-11 Overview of stepper motor control system

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 type of reference point approach in modes 0 ... 3 (MD18)
4. Parameterization of the external zero pulse (MD37.26)
5. 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)

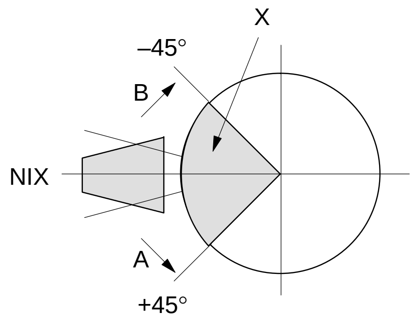
  Selecting function without parameterization for NIX
- “Rotation monitoring” error (see Troubleshooting, Table 11-7, Cl. 3/No. 66)
  – Motor turns too slowly (during acceleration/travel)
  – Motor turns too fast (during acceleration/travel)
  – External zero pulse failed
  – Incorrect number of increments 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 (2 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

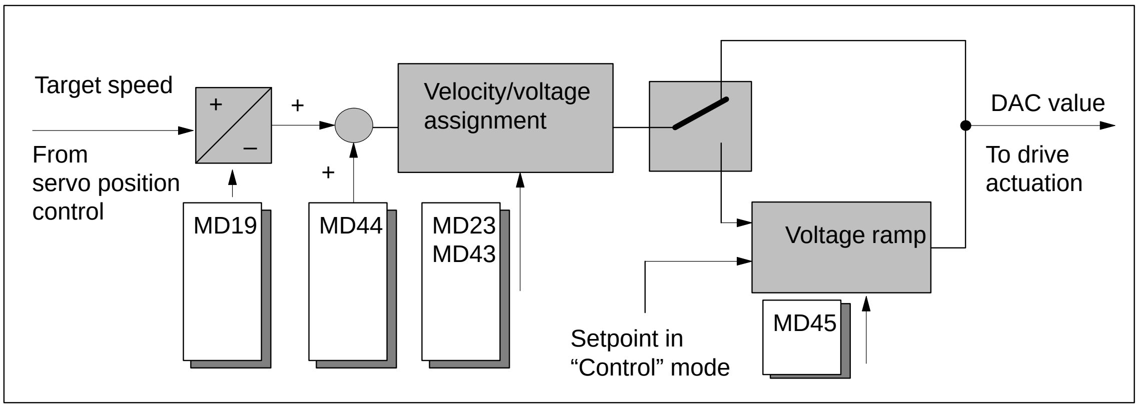


Fig. 9-13 Overview of Analog Setpoint Output

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)

MD	Designation	Value/Meaning	Unit
45	Voltage ramp	0...10,000,000	(mV/s)

Frequency Setpoint Output

(pulse/direction interface)

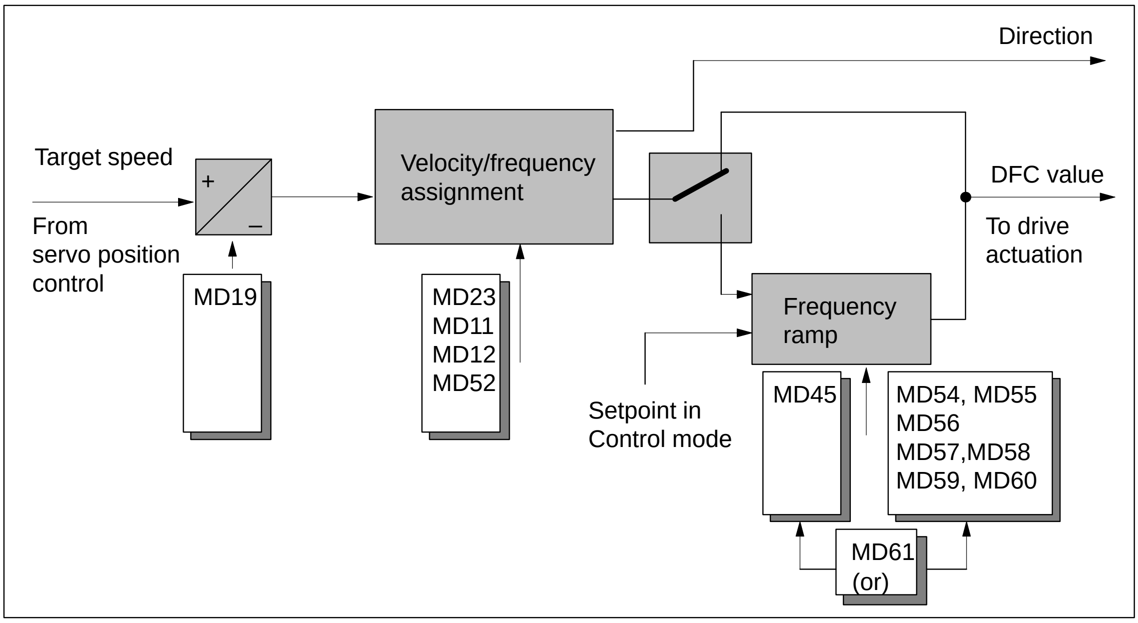


Fig. 9-14 Overview of Frequency Setpoint Output

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 encoder 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)

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.

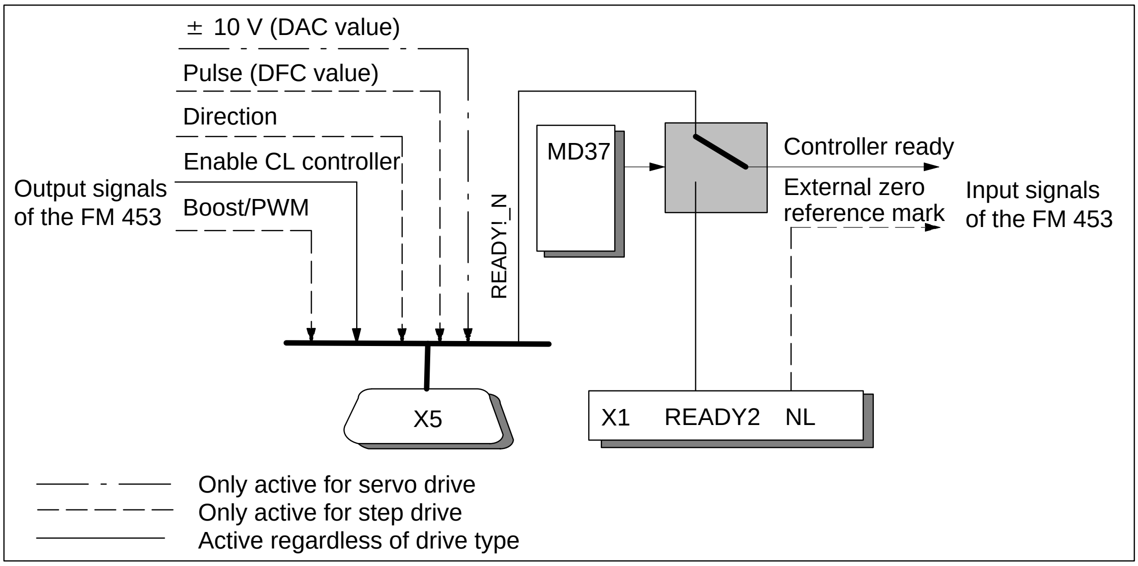


Fig. 9-15 Overview of Drive Actuation

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 X1 connector at TTL level, or X2, 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 11-5, 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 11-5, 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		

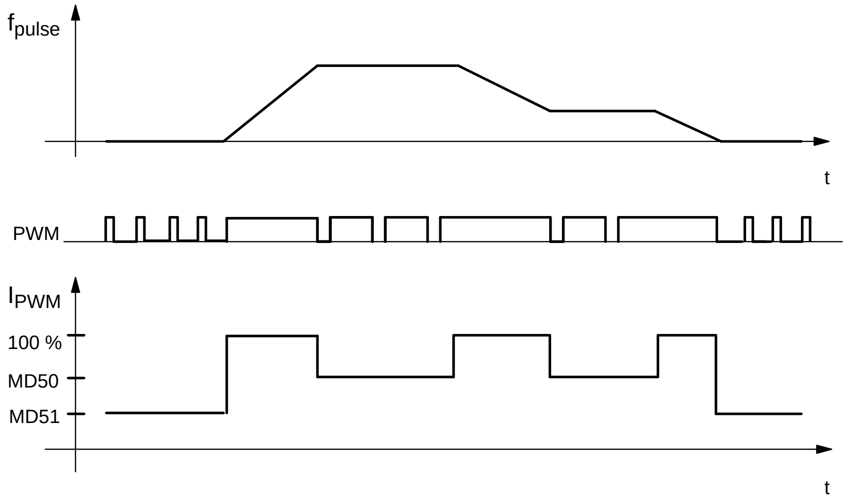
Function, PWM   The signal is generated as a 20 kHz frequency.

Boost function

The signal is monitored with reference to the maximum absolute and relative active phase.

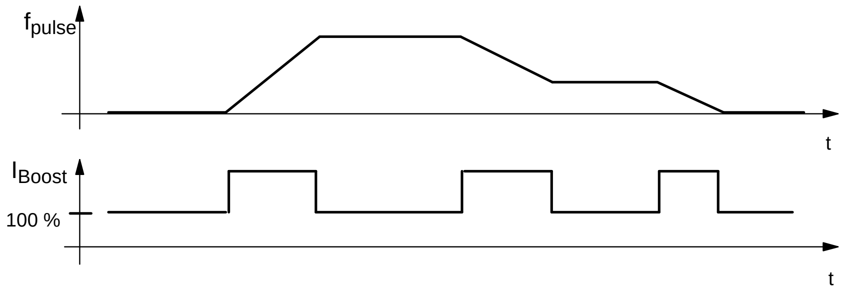
Effect: PWM

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= 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 (Job No. 101)

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 (**job no. 101**).

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

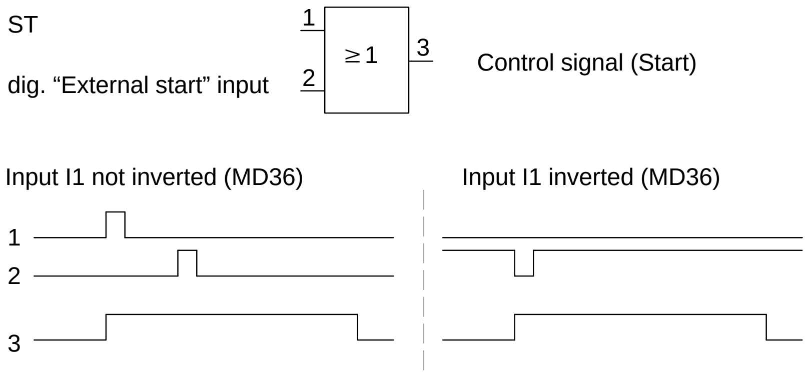
9.8.1 Function Description for Digital Inputs

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



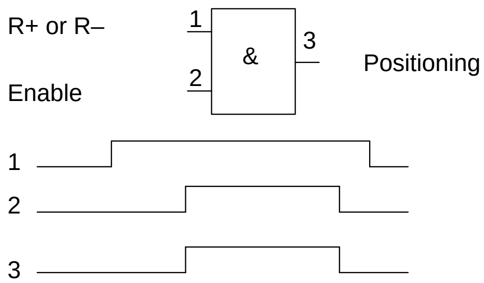
Minimum signal length at the digital input: ≥ 2 · FM cycle

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 and Section 9.3.6

Measurement see Section 9.3.10

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 (Job No. 15)

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 (**job no. 15**) and can also be controlled by the FM 453.

Since the same memory is used in the user DB for job 15 and job 101, 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.

OL 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, OL 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

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 9.3.12), 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. 16 Kbytes) and on the length of the individual programs.

Program length in bytes: 110 + (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

Chapter Overview

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
- G2 – G function of second function group
- G3 – G function of third function group

  (G1–G3: see Table 10-1)
- X/t – Position/dwell time
- F – Speed
- M1 – M function of first function group
- M2 – M function of second function group
- M3 – M function of third function group

  (M1–M3: see Table 10-2)
- D – Tool offset number
- L – Call a program as a subprogram
- P – Number of subprogram calls

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	
87	Turn off measuring system shift for Set Actual Value On-the-Fly	
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	
90	Absolute measure	
91	Incremental dimensions	
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 (+)	
44	Tool offset (–)	
50[1]	External block change	3
60	Block change – exact positioning	
64	Set actual value on-the-fly, continuous-path mode	

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	2	100,000	ms

Odd input values are rounded upward. Dwell times take effect only on a block-by-block basis.

If no value is input for G04 in the block, the lower input limit applies.

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

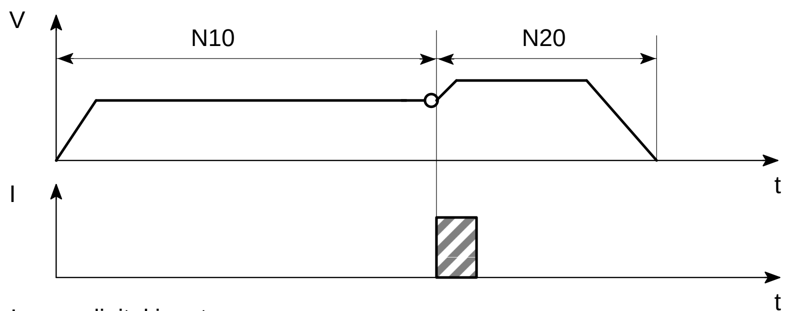
The “external block change” function causes a block change on-the-fly triggered by a digital input. The fast input must be parameterized with the “External block change” function by way of machine data item MD34.

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					
	20									



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).

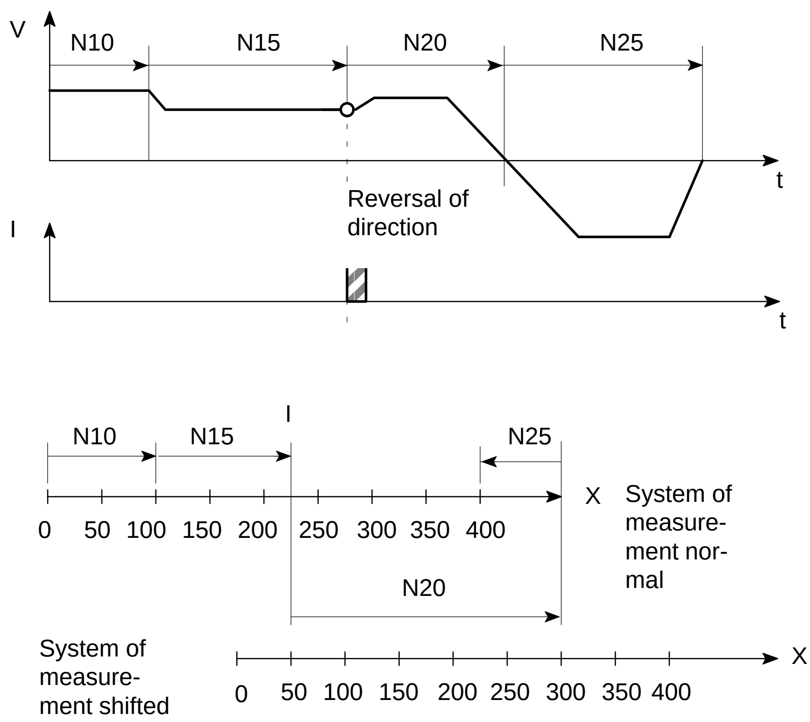
Set Actual Value On-the-fly G87, G88, G89

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.

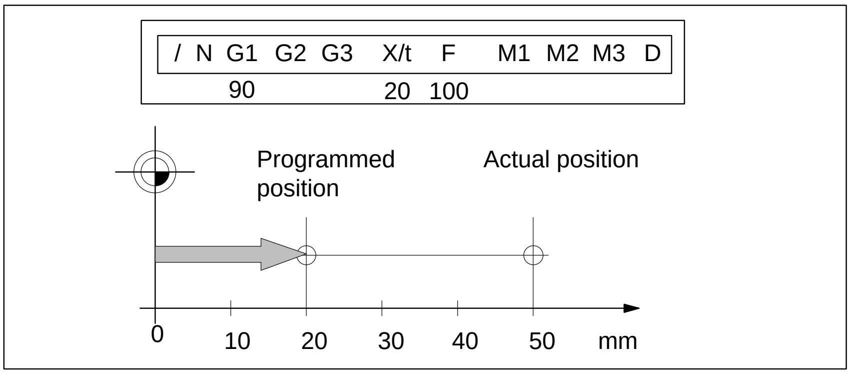


Fig. 10-1 Reference-Measure Input G90

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.

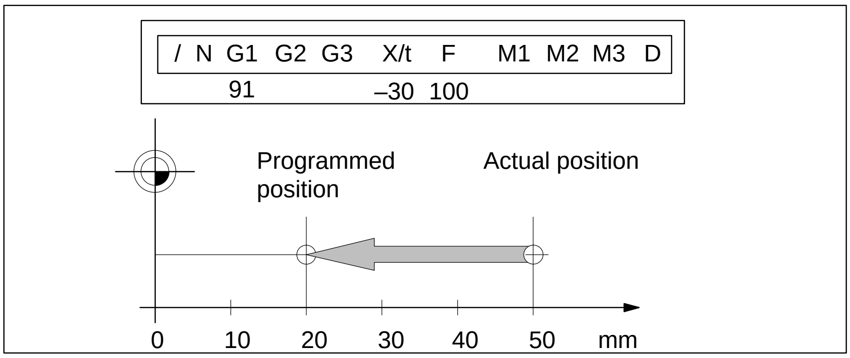


Fig. 10-2 Incremental Input G91

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.

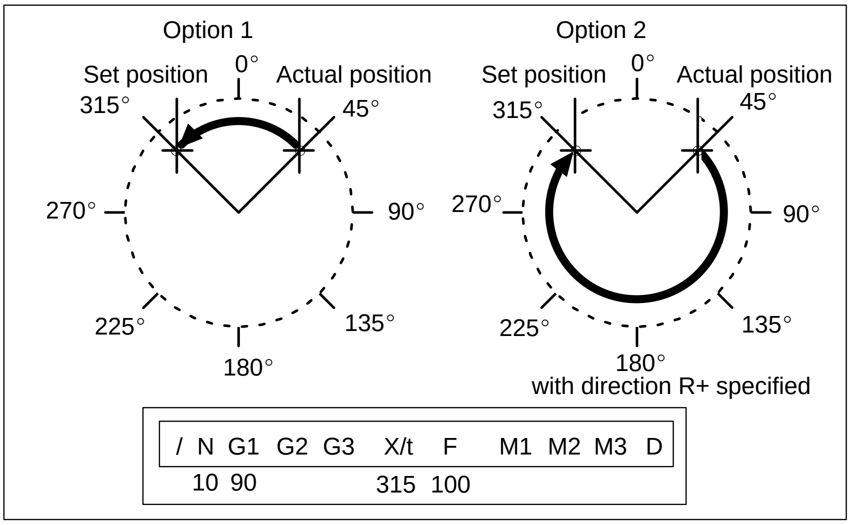


Fig. 10-3 Rotary Axis

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.

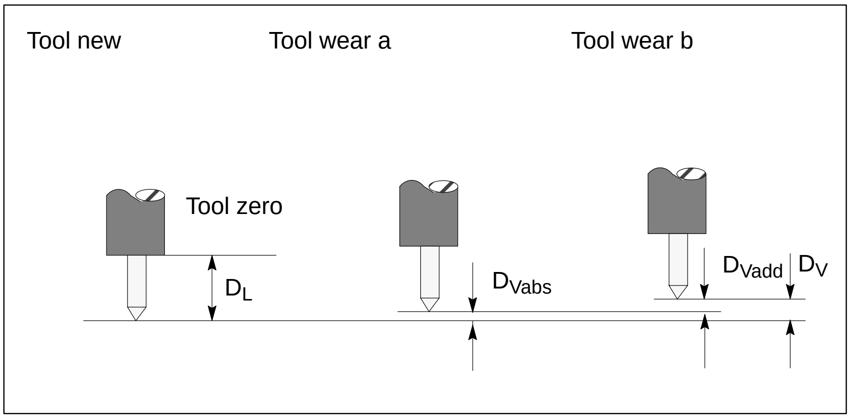


Fig. 10-4 Tool Offset

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)

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
Geschwindigkeit	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 calls”, L is the “program number”) cannot contain any further information.

Name	Lower Input Limit	Upper Input Limit
P = Number of subprogram callup	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

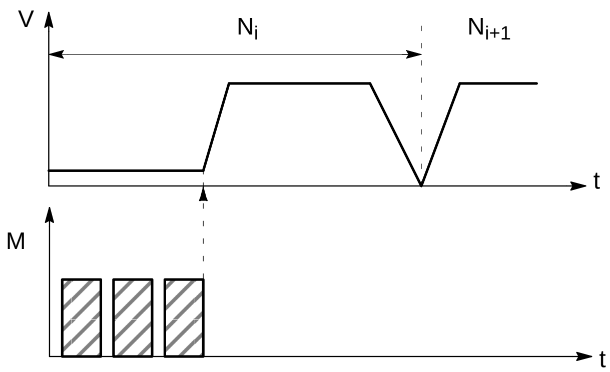
G60 mode is overlaid with G50 and G88 to G89 (force block change on-the-fly).

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.

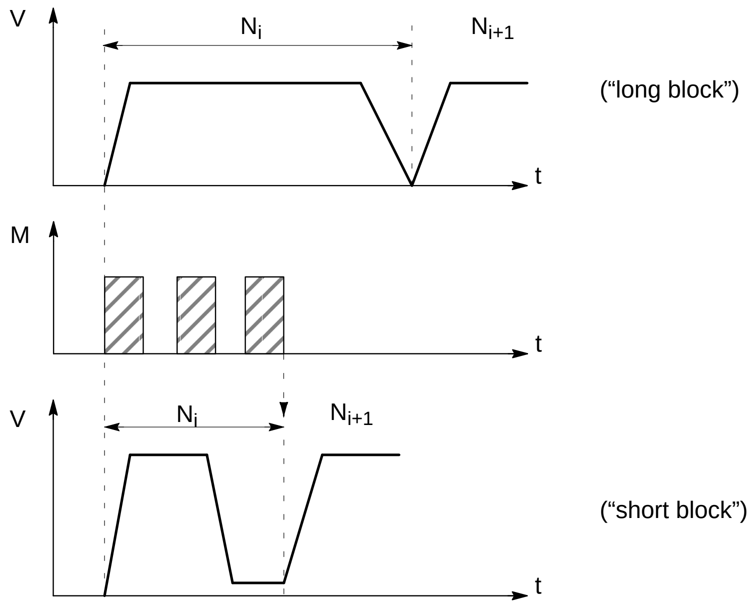
Output of M Function Before Positioning

Case 1



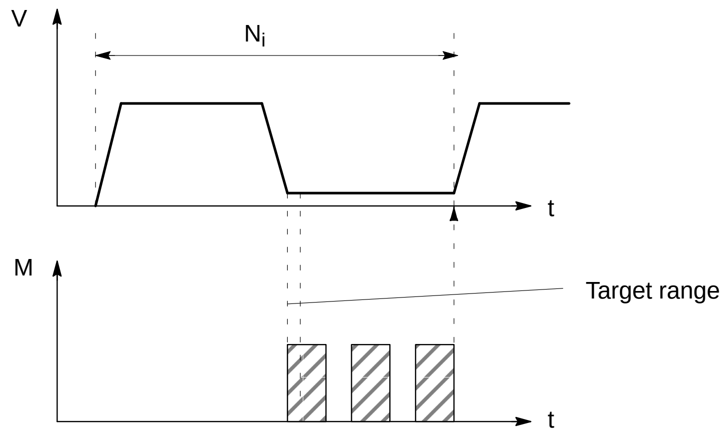
Output of M Function During Positioning

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.

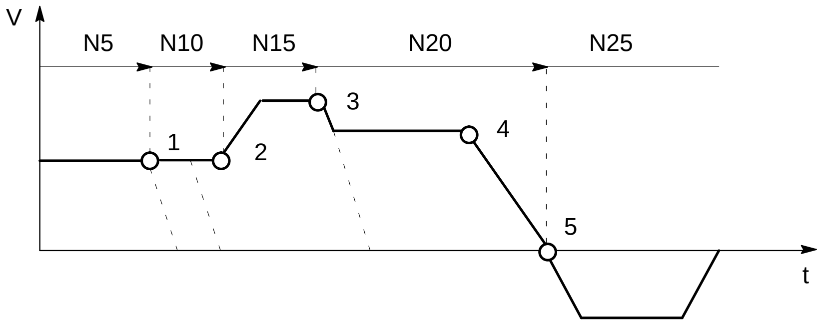
The acceleration and braking function is calculated for multiple blocks when the G64 function is programmed. The number of blocks processed in advance is three.

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.

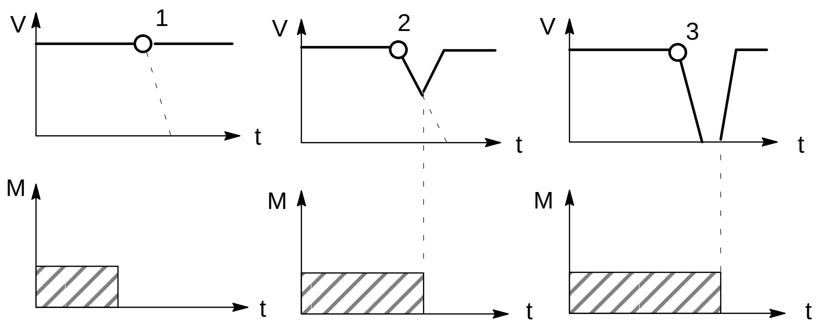
To be able to approach a position correctly, the axis must calculate the point of deceleration. The relevant parameters for this calculation are the residual traversing distance, the deceleration value and the current traversing speed.

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 toacceleration 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.

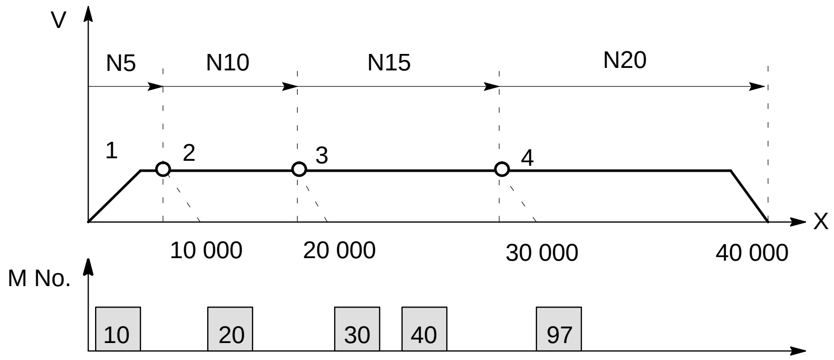
  – M function output after positioning causes exact-positioning response within the block.

- 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	200 00	30	40		
	20			60	40 000	150 00			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

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.

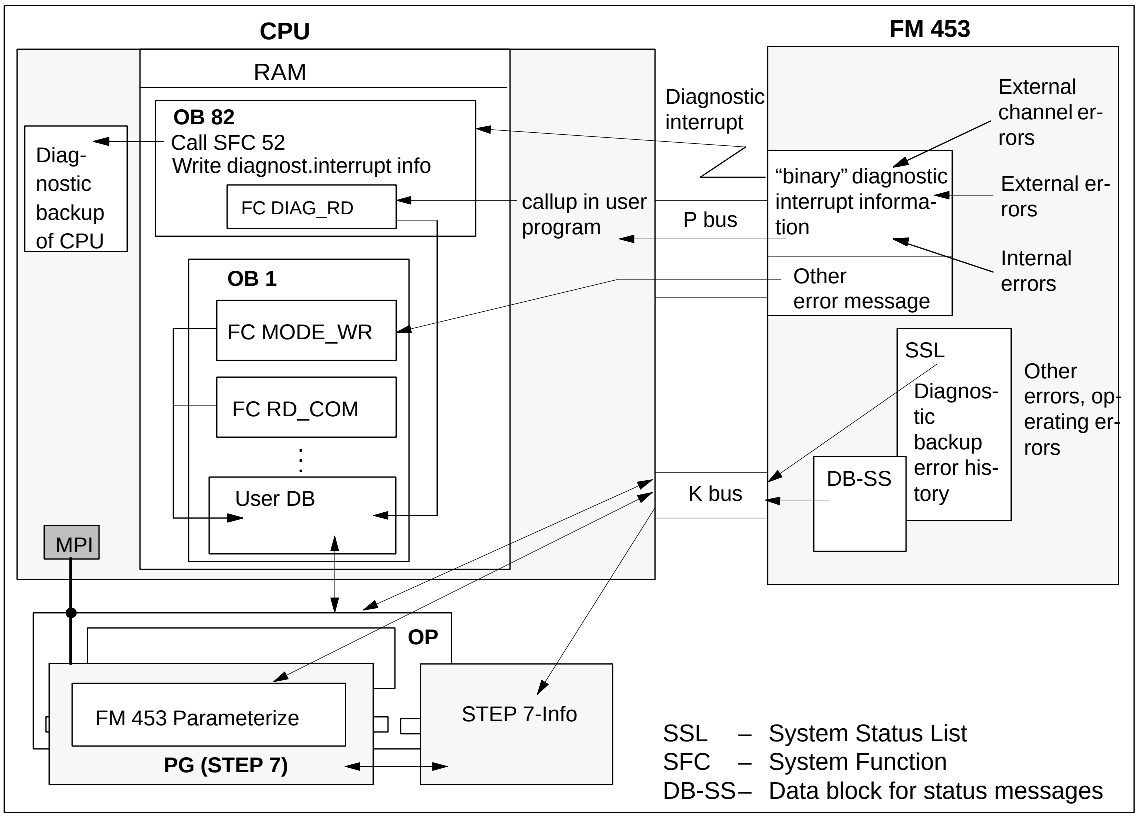


Fig. 11-1 Overview of Diagnostics/Errors

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.

Chapter Overview

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 6.4 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 6.4 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 6.4 for diagnostic interrupt data and error list, Table 11-4 and 11-5)
Checkback signals	Operator control 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 • 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 LED

Status and Error Displays

The FM 453 features the following status and error displays:

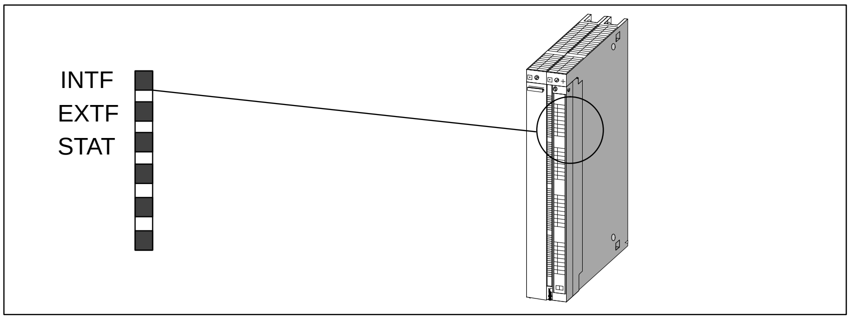


Fig. 11-2 Status and Error Displays of the FM 453

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 error or 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 Table 11-4,). 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 with FC 6.

The diagnostic interrupts are identified by setting the corresponding byte bit number in the data set (see diagnostic interrupt data, Section 6.4) and comprise the signals for all three channels.

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

The operator control errors in the “external channel error” class are specified again, and are stored in data set 164/199/234 or in the diagnostic buffer.

The FM 453 signals a diagnostic interrupt “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="4">Message in the “troubleshooting” display of “Parameterize FM 453”
Menu: Test ▸ Alarms</td><td rowspan="4">Entry in diagnostic buffer</td></tr>
<tr><td rowspan="3">No OB 82 exists → CPU switches to STOP</td><td colspan="2">OB 82</td><td>OB 1</td></tr>
<tr><td rowspan="2">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 72 and calls FC 4</td><td>Calls FC 6</td></tr>
<tr><td colspan="2">On operator control error:
(addr. in user DB 80.7/82.7/84.7)
for further error specification read DS 164/199/234 in OB 1</td></tr>
</table>

Alarm Acknowledgement

If processing is to continue after a diagnostic interrupt, then Restart after the error has been remedied in the appropriate channel (see write job no. 11 Sections 6.2.1 and 9.3.3).

Internal errors cannot be acknowledged. External errors are self-acknowledging.

11.2.3 Error Messages in 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 (FC 2 call). The error-specification is stored in the form of an error number (see Error List in Table 11-6...11-8) in the corresponding data block (DS162/197/232 and DS163/198/233)

Checkback Signals [BF/FS] and [DF] (group error messages)		
Error specification ...		
... in user program (if necessary)	... programming device/PC	
Read out DS 162 for channel 1, DS 197 for channel 2, DS 232 for channel 3 (on BF/FS) or Read out DS 163 for channel 1, DS 198 for channel 2, DS 233 for channel 3 (on DF)	Message in the “troubleshooting” display of “Parameterize FM 453”. Menu: **Test** ▸ **Alarms**	In diagnostic buffer.

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

If a specific error analysis is called for in the user program, then the error numbers can be read out by calling up the corresponding system function (SFC 59, see *Standard and System Functions* Reference Manual*).* See also Section 6.7, user example 2.

Data records:

- Operator and travel errors
  DS 162 for channel 1
  DS 197 for channel 2
  DS 232 for channel 3
- General data errors, machine data errors and traversing program errors
  DS 163 for channel 1
  DS 198 for channel 2
  DS 233 for channel 3
- Operating errors
  DS 164 for channel 1
  DS 199 for channel 2
  DS 234 for channel 3

DS	Data Block, Structure	Significance	
162 163 164	2-byte error number	DEKL	DENR
	2 x 1 byte free	Free	Free

The errors are identified by the detail event class (DEKL) and by the detail event number (DENR).

In the case of operating errors within the “external channel errors” error class, the message is displayed using the bit combination **0.0, 0.2, 0.3, 8.7, 10.7, 12.7** as a diagnostic interrupt (see Section 6.4) and additionally as DEKL and DENR.

Error Technology Class	DEKL	DENR	Message
Operating error	1	1...n	Diagnostic interrupt
Operator control 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 (shaded) 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.	

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**	
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.	
	Elimina-tion	• Check FM 453 power connection. • If FM 453 power supply defective, replace FM 453.	
3.2 (8042)	**FEPROM error**		
	Cause	Memory for firmware code faulty.	
	Effect		
	Elimina-tion	Replace the FM 453.	
3.3 (8043)	**RAM error**		
	Cause	• Faulty RAM data memory. • Faulty flash-EPROM data memory.	
	Effect		
	Elimina-tion	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		
	Elimina-tion	• 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)	**Fronts connector missing**		INTF ▢ EXTF ▢ STAT ▢
	Cause	Front connector X1 is not plugged into the FM 453.	
	Effect		
	Elimina-tion	Plug in front connector X1.	

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**	
8.0 (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		
	Elimina-tion	• Check encoder and measurement system cable. • Observe limit values. • Using the MD20, monitoring can be temporarily skipped, at the responsibility of the owner/operator.	
8.1 (8091) or 10.1 (80B1) or 12.1 (80D1)	**Absolute encoder error**		
	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		
	Elimina-tion	• 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 (80D1)	**Erroneous pulses, incremental encoder or zero reference mark missing**		
	Cause	• 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. • Number of pulses per encoder revolution (MD13) incorrectly input. • Encoder faulty: does not deliver the specified number of pulses. • Zero reference mark faulty or missing altogether. • Pulse length of zero reference mark less than 1.25 μs. • Interference on the measurement system cable.	
	Effect		
	Elimina-tion	• Enter MD13 correctly. • 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). • Disable limit switch monitoring! (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). • Disable limit switch monitoring! (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.	
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.	
		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)	**11 (0B)**	**Drive, direction of rotation**		Diagnostic interrupt.
		Cause	Drive turns in wrong direction.	
		Effect		
		Elimina- tion	• Check drive. • Check or correct MD19. • Following "Restart" continue working using the user program.	
1 (01)	**12 (0C)**	**Stoppage area**		Diagnostic interrupt.
		Cause	The zero speed control range was left when the servo enable was deactivated or when an axis standstill was reached in the PEH target range.	
		Effect		
		Elimina- tion	• 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.	
		Elimina- tion	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		
		Elimina-tion	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		
		Elimina-tion	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		
		Elimina-tion	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, rela-tive," "MDI" and "Automatic" operating modes.	
		Effect		
		Elimina-tion	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 "Ref-erence point operation", the direction setting no longer agrees with the startup direction specified in the MD.	
		Effect		
		Elimina-tion	Correct the direction parameters.	

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		
		Elimina-tion	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		
		Elimina-tion	Parameterize and read in setpoint parameters	
2 (02)	**14 (0E)**	**No program preselected**		CBS
		Cause	No program preselected at "Start."	
		Effect		
		Elimina-tion	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		
		Elimina-tion	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.	
		Elimina-tion	Reselect one of the two measurement functions.	
2 (02)	**21 (15)**	**Activate machine data not allowed**		CBS
		Cause	"Processing in progress" is still active.	
		Effect	Activate machine data not executed.	
		Elimina-tion	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 11-7 Travel Errors

<table>
<tr><th>Cl.</th><th>No.</th><th colspan="2">Error Message,
Error Analysis and Elimination</th><th>Message/
Display</th></tr>
<tr><td colspan="2">Travel errors</td><td colspan="3">Error response : “Feed STOP” see Table 11-2</td></tr>
<tr><td rowspan="4">3 (03)</td><td rowspan="4">1 (01)</td><td colspan="2">Software limit switch, beginning</td><td rowspan="4">CBS</td></tr>
<tr><td>Cause</td><td>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.</td></tr>
<tr><td>Effect</td><td>• Axis movement is stopped at the limit switch position.
• Set actual value is not executed.</td></tr>
<tr><td>Elimina-
tion</td><td>• Following acknowledgment of the error, it is possible to traverse to the working range.
• Alter value of software limit switch (MD21)
• Disable limit switch monitoring!
(With the limit switches (MD21/22) disabled, the travel range limits are established by the maximum allowable values for the limit switches).</td></tr>
<tr><td rowspan="4">3 (03)</td><td rowspan="4">2 (02)</td><td colspan="2">Software limit switch, end</td><td rowspan="4">CBS</td></tr>
<tr><td>Cause</td><td>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.</td></tr>
<tr><td>Effect</td><td>• Axis movement is stopped at the limit switch position.
• Set actual value is not executed.</td></tr>
<tr><td>Elimina-
tion</td><td>• Following acknowledgment of the error, it is possible to traverse to the working range.
• Alter value of software limit switch (MD22).
• Disable limit switch monitoring!
(With the limit switches (MD21/22) disabled, the travel range limits are established by the maximum allowable values for the limit switches).</td></tr>
</table>

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)	**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.	
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). • Disable limit switch monitoring! (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.	

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)	**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.	
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.	

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)	**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		
		Elimina-tion	Input a correct MDI block.	
3 (03)	**40 (28)**	**MDI block on the fly erroneous**		CBS
		Cause	Incorrect block syntax.	
		Effect		
		Elimina-tion	Input a correct MDI block.	
3 (03)	**61 (3D)**	**Controller enable missing**		CBS
		Cause	Traverse command of the axis without controller enable (except for “Control” operating mode). OR Removal of controller enable during “Processing in progress”.	
		Effect	No axis movement. OR Axis stopped (at same time, controller enable is held until axis comes to rest).	
		Elimina-tion	Set controller 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 with actual value transfer after axis comes to rest (internally like “follow-up mode”).	
		Elimina-tion	• 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		
		Elimina-tion	• Check drive. • Match MD24, MD25.	

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)	**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	Acceptance of actual value (internally like “follow-up mode”).	
		Elimina-tion	• Check drive/connecting cables. • Check controller enable signal between FM 453 and drive.	
3 (03)	**66 (42)**	**Following error too great**		CBS
		Cause	Excessive following error during axis movement.	
		Effect		
		Elimina-tion	• Check drive. • Check MD23, MD43.	
3 (03)	**67 (43)**	**Boost duration absolute exceeded**		CBS
		Cause	Acceleration phase too long.	
		Effect		
		Elimina-tion	• 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		
		Elimina-tion	• 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.	
		Elimina-tion	Transmit data in appropriate operating mode.	
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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	Input an allowable incremental value.	

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)	**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.	
		Elimina-tion	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.	
		Elimina-tion	Input a correct MDI block.	
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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	Input a correct value.	

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)	**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.	
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 number.	
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.	

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)	**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.	
		Elimina-tion	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.	
		Elimina-tion	Correct and retransmit.	
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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	Prior to transmission, delete corresponding DB with the program 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
General data errors		**Error response: ”Warning” see Table 11-2**		
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.	
		Elimina-tion	Coding not 0 or 1.	
4 (04)	**125 (7D)**	**DB memory filed**		CBS or DB
		Cause	The available memory is assigned.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimina-tion	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.	
		Elimina-tion	Correct program and retransmit.	
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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	Transmit correct value.	

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)	**131 (83)**	**Not possible to insert block**		CBS or DB
		Cause	Memory full.	
		Effect	Function is not executed.	
		Elimina-tion	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.	
		Elimina-tion	Check program and repeat function with correct block number.	
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.	
		Elimina-tion	• 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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	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)	**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.	
		Elimina-tion	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.	
		Elimina-tion	Correct and retransmit.	
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.	
		Elimina-tion	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.	
		Elimina-tion	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 Nr. 70...75 (see Section 5.3.1).	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimina-tion	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)	**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.	
		Elimina-tion	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.	
		Elimina-tion	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 software 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.	
		Elimina-tion	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).	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimina-tion	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)	**100 (64)**	**Maximum velocity for drive too high**		CBS or DB
		Cause	Based on the MD11, MD12 and MD52 machine data for the maximum velocity MD23, a frequency would be generated that is greater than MD56.	
		Effect	DB does not become effective and is stored non-retentively.	
		Elimination	Correct and retransmit.	
5 (05)	**101 (65)**	**Impermissible increment evaluation factor for step drive**		CBS or DB
		Cause	Impermissible relationship in the assignments for distance per encoder revolution (MD11, 12) and steps per motor revolution (MD52).	
		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 encoder pulse to $0.5 \cdot 10^9$ MSR).	
		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
Traversing program errors Error response: "Warning"				
8 (08)	**1 (01)**	**Program selection, subroutine error**		CBS or DB
		Cause	The subroutine requested in the program is not in place on the FM 453.	
		Effect	Program selection is not executed.	
		Elimina-tion	• Parameterize and read in program, 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.	
		Elimina-tion	• Parameterize and read in program, 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.	
		Elimina-tion	• Correct program. • Select different block number.	
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.	
		Elimina-tion	Correct program.	
8 (08)	**11 (0B)**	**Program selection, direction specification incorrect**		CBS or DB
		Cause	Direction specification incorrect.	
		Effect	Program selection is not executed.	
		Elimina-tion	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.	
		Elimina-tion	Use STOP to stop program in progress, or repeat program selection at end of 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)	**20 (14)**	**Error, program number**		CBS or DB
		Cause	Program numbers in the blocks incorrect.	
		Effect	Program is not stored.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	Correct program.	
8 (08)	**24 (18)**	**G function 1 unacceptable**		CBS or DB
		Cause	• The number 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.	
		Elimina-tion	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.	
		Elimina-tion	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

<table>
<tr><th>Cl.</th><th>No.</th><th colspan="2">Error Message,
Error Analysis and Elimination</th><th>Message/
Display</th></tr>
<tr><td colspan="5">Traversing program errors Error response: “Warning”</td></tr>
<tr><td rowspan="4">8 (08)</td><td rowspan="4">26 (1A)</td><td colspan="2">G function 3 unacceptable</td><td rowspan="4">CBS
or
DB</td></tr>
<tr><td>Cause</td><td>• The number 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 number.
• In selecting a D number, the direction specification is missing for the tool offset (G43, G44).</td></tr>
<tr><td>Effect</td><td>Program/block not stored.</td></tr>
<tr><td>Elimination</td><td>Correct program, per cause.</td></tr>
<tr><td rowspan="4">8 (08)</td><td rowspan="4">27 (1B)</td><td colspan="2">M function unacceptable</td><td rowspan="4">CBS
or
DB</td></tr>
<tr><td>Cause</td><td>• 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.</td></tr>
<tr><td>Effect</td><td>Program/block not stored.</td></tr>
<tr><td>Elimination</td><td>Correct program, per cause.</td></tr>
<tr><td rowspan="4">8 (08)</td><td rowspan="4">28 (1C)</td><td colspan="2">Position/dwell time missing</td><td rowspan="4">CBS
or
DB</td></tr>
<tr><td>Cause</td><td>• No dwell time specified in block with G04.
• Target position missing with external block change (G50).
• No new actual value programmed for the function continuous operation with setting actual value on the fly (G88/89).</td></tr>
<tr><td>Effect</td><td>Program/block not stored.</td></tr>
<tr><td>Elimination</td><td>Correct program, per cause.</td></tr>
<tr><td rowspan="4">8 (08)</td><td rowspan="4">29 (1D)</td><td colspan="2">Incorrect D-NO (>20)</td><td rowspan="4">CBS
or
DB</td></tr>
<tr><td>Cause</td><td>The number for tool offset is greater than 20.</td></tr>
<tr><td>Effect</td><td>Program/block not stored.</td></tr>
<tr><td>Elimination</td><td>Correct program, per cause.</td></tr>
<tr><td rowspan="4">8 (08)</td><td rowspan="4">30 (1E)</td><td colspan="2">Error, subroutine</td><td rowspan="4">CBS
or
DB</td></tr>
<tr><td>Cause</td><td>Subroutine without callup number.</td></tr>
<tr><td>Effect</td><td>Program is not stored.</td></tr>
<tr><td>Elimination</td><td>Correct program, per cause.</td></tr>
</table>

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)	**31 (1F)**	**Velocity missing**		CBS or DB
		Cause	No velocity was programmed.	
		Effect	Program/block not stored.	
		Elimina-tion	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.	
		Elimina-tion	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.	
		Elimina-tion	Correct program, per cause.	
8 (08)	**34 (22)**	**Incorrect program length**		CBS or DB
		Cause	Maximum block number exceeded.	
		Effect	Program is not stored.	
		Elimina-tion	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, File LR 63533

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 is available for the responsible authority from:

SIEMENS Aktiengesellschaft
Automation Group
AUT E 148
PO Box 1963
D–92209 Amberg

Application

SIMATIC products are designed for application in an industrial environment.

Application	Requirement Concerning	
	Noise Emission	**Noise Immunity**
Industry	EN 50081-2 : 1993	EN 50082-2 : 1995
Residential	Individual license	EN 50082-1 : 1992

Observe Installation Guidelines

SIMATIC products meet these requirements, provided you observe the installation guidelines set out in the manuals during installation and operation.

Power Ratings

Technical data: Power ratings

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

Step 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

Technical data for 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

Technical data for 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

Technical data for 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 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)

Connecting Cables

B

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 encoder (built-in encoder 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

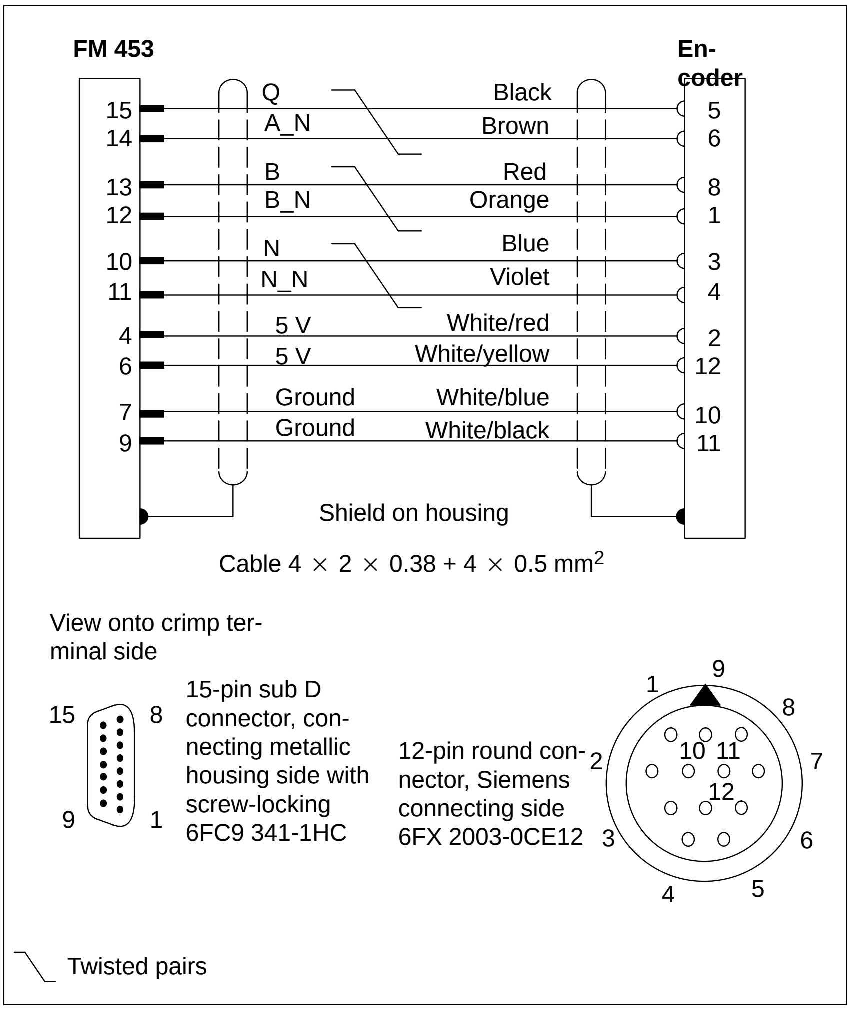
Drive Configuration	Connecting Cable
3 SIMODRIVE 611-A servo drives	6FX2 002-3AD01-1□□□
3 FM STEPDRIVE step drives	6FX2 002-3AB04-1□□□
1 FM STEPDRIVE step drive and 2 SIMODRIVE 611-A servo drives	6FX2 002-3AB02-1□□□
2 FM STEPDRIVE step drives and 1 SIMODRIVE 611-A servo drive	6FX2 002-3AB03-1□□□

Chapter Overview

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.

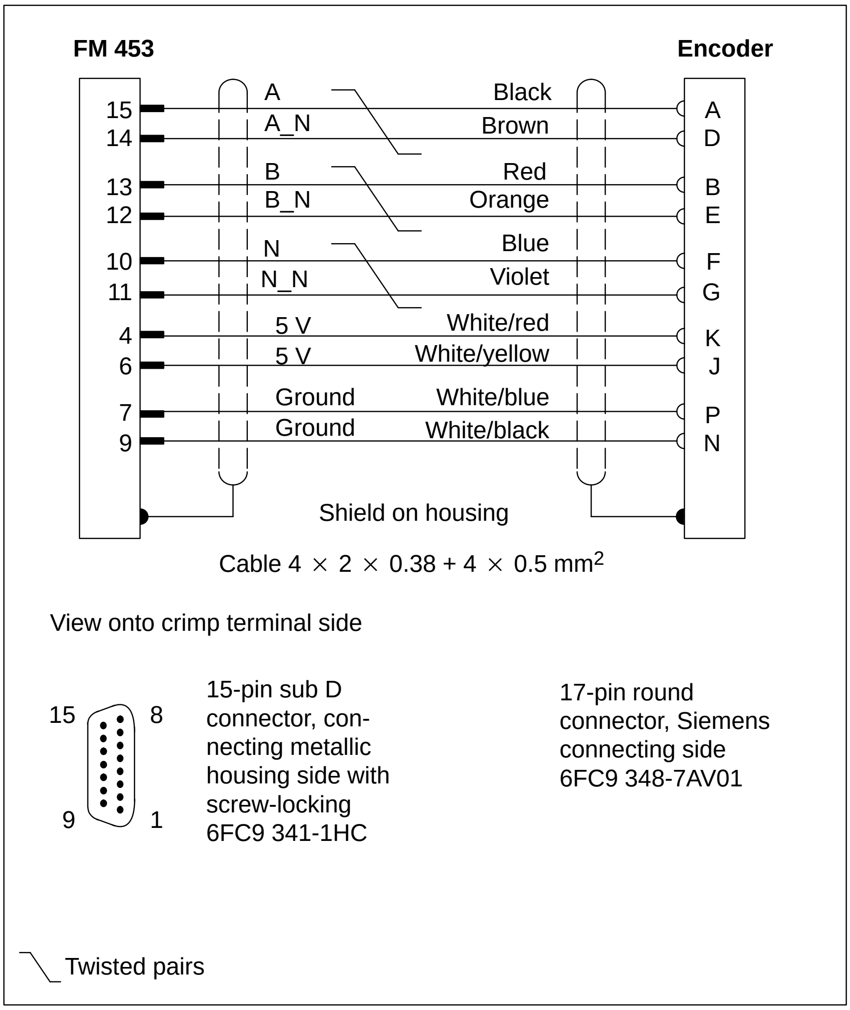
The corresponding order number is:

6FX2 002 2CD01-1□□0 (□□: For length code, see Catalog NC Z Order No. E86060-K4490-A001-A4).

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.

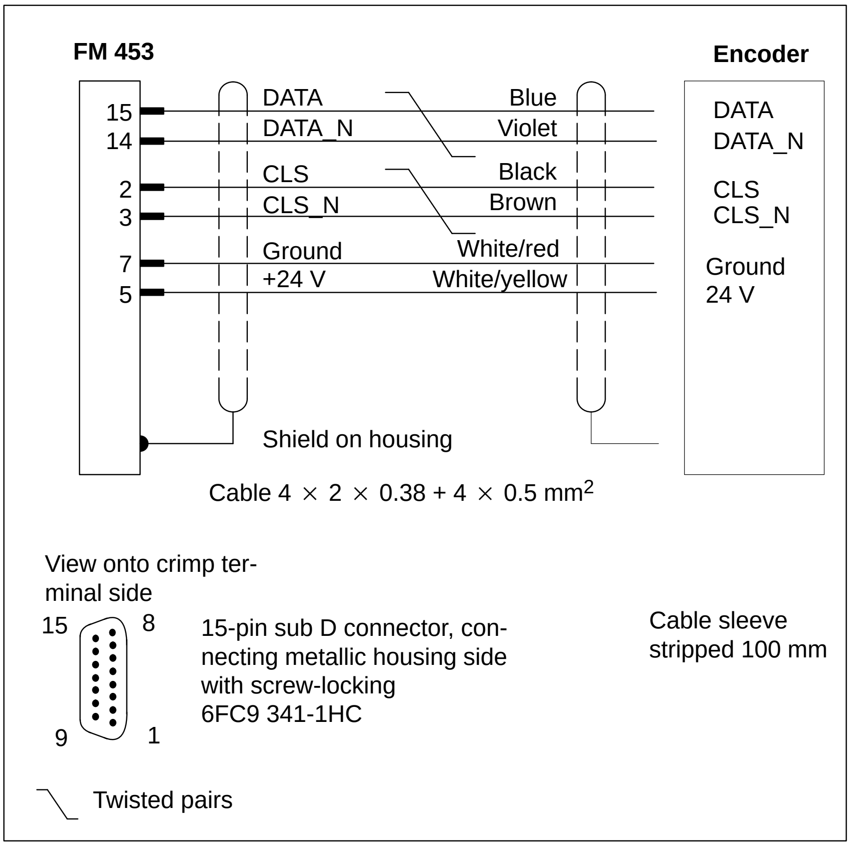
The corresponding order number is:

6FX2 002 2CE01-1□□0 (□□: For length code, see Catalog NC Z Order No. E86060-K4490-A001-A4).

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.

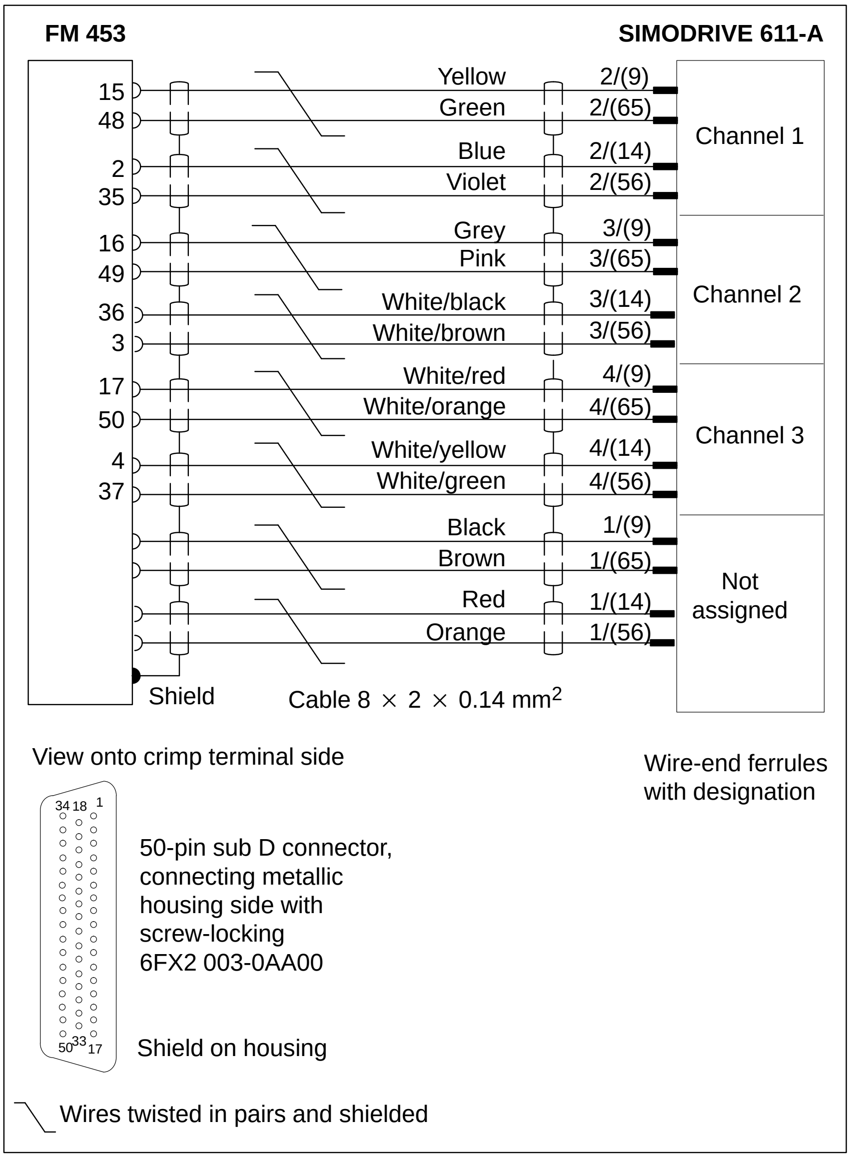
The corresponding order number is:

6FX2 002 2CC01-1□□0 (□□: For length code, see Catalog NC Z Order No. E86060-K4490-A001-A4).

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.

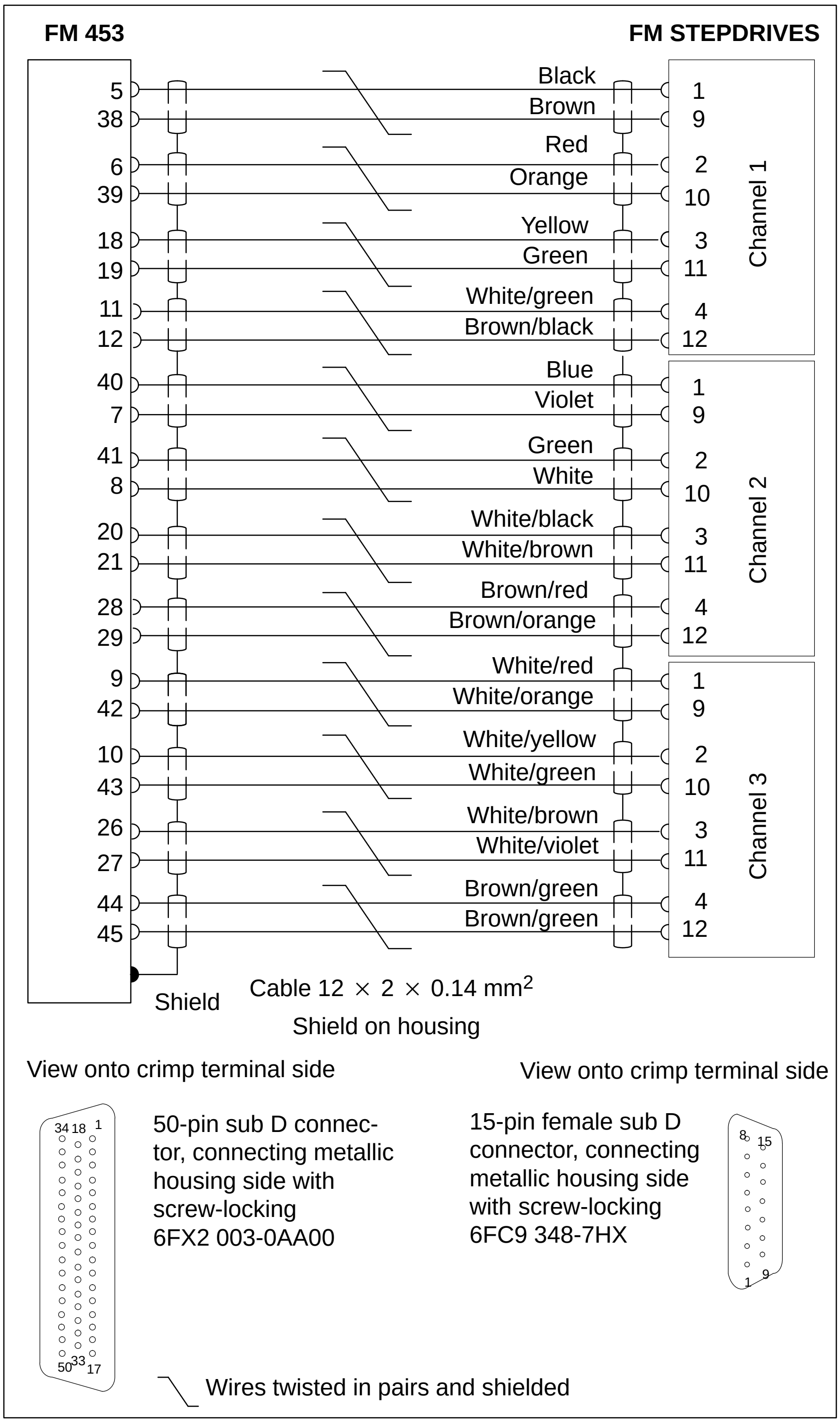
The corresponding order number is:

6FX2 002 3AD01-1□□□ (□□□ : For length code, see Catalog NC Z Order No. E86060-K4490-A001-A4).

B.5 Cable Set for FM STEPDRIVE Step Drive (3 channels)

Connections

The following figure shows the connecting cable between the FM 453 and three FM STEPDRIVE step drives:



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:

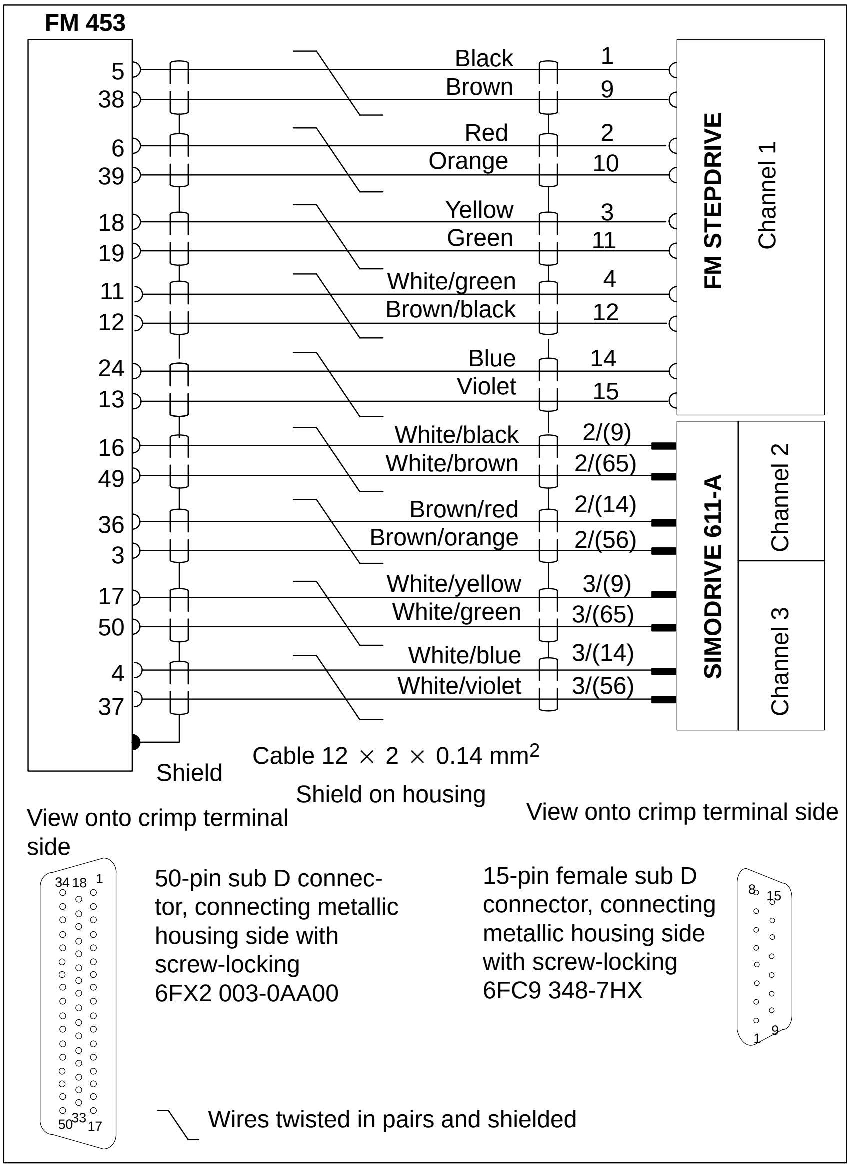
6FX2 002-3AB04-1□□□ (□□□: For length code, see Catalog NC Z Order No. E86060-K4490-A001-A4)[1].

1) Soon to be included in catalog

B.6 Cable Set for One FM STEPDRIVE Step 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 step 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:

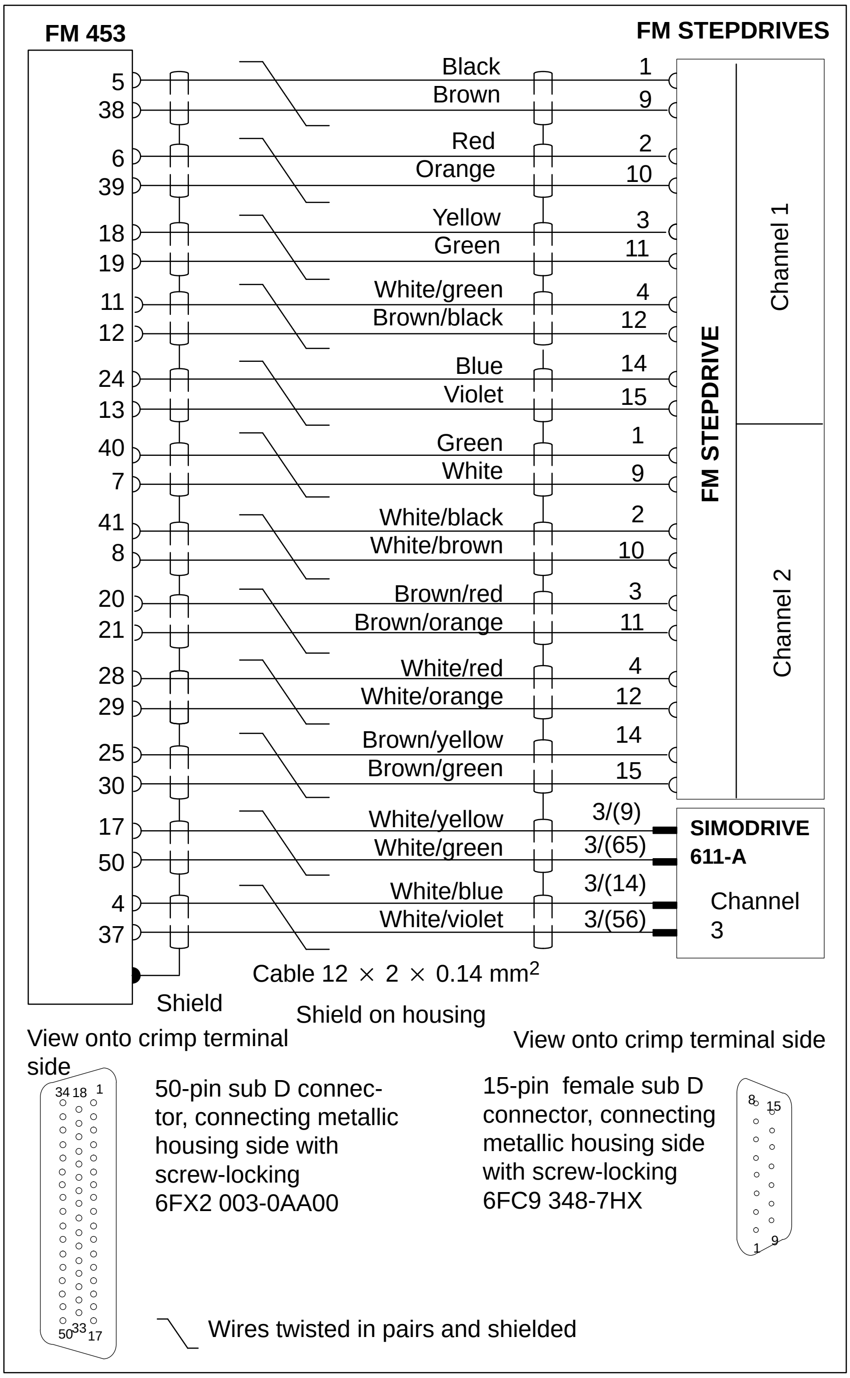
6FX2 002 3AB02-1□□□ (□□□: For length code, see Catalog NC Z Order No. E86060-K4490-A001-A4)[1].

1) Soon to be included in catalog

B.7 Cable Set for Two FM STEPDRIVE Step 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 step 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-A4)[1].

1) Soon to be included in catalog

List of Abbreviations

C

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
BIE	Binary result
BP	Mode parameter
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	In/out 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

Index

S

T

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