SIEMENS

SIMATIC

S7-400
Controller Module FM 455

Operating Manual

04/2009

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Legal information

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⚠WARNING
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⚠CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

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Disclaimer of Liability

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Preface

Purpose of the manual

This manual describes all the steps that are necessary to implement the function module FM 455. It helps you familiarize yourself with the FM 455 functions, quickly and effectively.

Contents of the Manual

This manual describes the hardware and software of the FM 455. It consists of an instruction section and contains reference material (appendices.)

The following subjects are covered:

- Basics of controlling
- Installing and disassembling the FM 455
- Wiring the FM 455
- Parameterizing the FM 455
- Programming the FM 455
- Appendices

Target group

The manual is aimed at the following target groups:

- Fitters
- Programmers
- Commissioning supervisors
- Service and maintenance personnel

Scope of this manual

This manual contains a description of the FM 455 function module that is valid at the time the manual is released. We reserve the right to describe modifications to the functionality of the FM 455 in a separate Product Information.

Position in the information landscape

This manual forms part of the S7-400 documentation.

System	Documentation
S7-400	• *S7-400 automation system, installation* • *S7-400 Automation System CPU Specifications* • *S7-400 Automation System Module Specifications* • *S7-400 Operation List*

Guide

The manual's navigation features outlined below support quick access to specific information:

- At the beginning of the manual you can find a comprehensive list of contents.
- The appendix is followed by a glossary which defines important specialist terminology used in this manual.
- At the end of the manual you will find a literature list and a detailed index which also speeds up access to the information you seek.

Approvals

For detailed information on approvals and standards, refer to the chapter "Technical data".

Standards

The SIMATIC S7-400 product series is compliant with IEC 61131-2.

Recycling and disposal

The FM 455 is low in contaminants and can therefore be recycled. For environmentally sustainable recycling and disposal of your old device, contact a certified disposal service for electronic scrap.

Additional support

If you have any further questions about the use of products described in this manual and do not find the right answers here, contact your local Siemens representative (http://www.siemens.com/automation/partner):

A guide to the technical documentation for the various products and systems is available on the Internet:

- SIMATIC Guide manuals (http://www.siemens.com/simatic-tech-doku-portal)

The online catalog and online ordering systems are also available on the Internet:

- A&D Mall (http://www.siemens.com/automation/mall)

Training center

To help you get started with automation technology and systems, we offer a variety of courses. Contact your regional Training Center or the central Training Center in D-90327 Nuremberg, Germany.

- Internet: SITRAIN homepage (http://www.sitrain.com)

Technical Support

You can access technical support for all A&D projects via the following:

- Online support request form: (http://www.siemens.com/automation/support-request)

Service & Support on the Internet

In addition to our documentation, we offer a comprehensive online knowledge base on the Internet at:

Industry Automation and Drive Technologies - Homepage (http://www.siemens.com/automation/service&support)

There you will find the following information, for example:

- The newsletter that provides up-to-date information on your products.
- The documents you need via our Search function in Service & Support.
- A forum for global information exchange by users and specialists.
- Your local partner for Automation and Drives.
- Information about on-site service, repairs, and spare parts. Much more can be found under "Services".

Table of contents

1 Product overview

1.1 Introduction

FM 455 variants

The FM 455 is available in the following 2 variants:

- C controller (continuous controller with analog outputs)
- S controller (step and pulse controllers with digital outputs)

Order numbers

Product	Part of delivery	Order number
FM 455 C	• FM 455 C module, version ≥ 4 (continuous controller) • CD with configuration package, manual and getting started	6ES7455-0VS00-0AE0
FM 455 S	• FM 455 S module, version ≥ 4 (step and pulse controllers) • CD with configuration package, manual and getting started	6ES7455-1VS00-0AE0

1.2 Functions of the FM 455

Introduction

The FM 455 function module is a controller module for use in the S7-400 automation system.

Control techniques

Two different control techniques are carried out in the FM 455. For both control techniques there is support to optimize the control:

Control techniques	Optimization by means of ...
Temperature controllers (fuzzy controllers)	... the module (self-tuning controller)
PID controllers	... Parameterization interface of PID self tuner

Control structures

You can use the FM 455 for the following control structures:

- Fixed set point control
- Sequence control
- 3-component control
- Cascade control
- Ratio control
- Mixed control
- Split range control

Operating modes

The FM 455 recognizes the following operating modes:

- Automatic
- Manual
- Safety mode
- Follow-up mode (change over to the default security value)
- Manipulated value DDC (direct digital control)
- Sequence / SPC controller (SPC = set point control)
- Backup mode (with CPU in STOP or CPU failure)

Number of channels

The FM 455 has 16 controllers in 16 channels. Each controller acts independently of the others.

Number of inputs and outputs

The following table gives an overview of the number of inputs and outputs of the FM 455.

Table 1- 1 Inputs and outputs of the FM 455

Inputs/Outputs	FM 455 C	FM 455 S
Analog inputs	16*	16*
Digital inputs	16	16
Analog outputs	16	-
digital outputs	-	32
* a Pt 100 occupies two analog inputs. Therefore a maximum of eight Pt 100 can be connected to an FM 455.		

Diagnostic interrupt

The FM 455 can trigger a diagnostic interrupt in the case of the following events:

- The module is incorrectly configured
- Module defective
- Overflow and underflow with analog inputs
- Load break or short-circuit during analog outputs
- Wire break at a measuring range of 4 to 20 mA, at a Pt 100 and at thermocouples

Process interrupts

No process interrupts are required to operate the FM 455.

Reference junction

For operating with thermocouplers, the FM 455 has an additional analog input for connecting to a Pt 100 in 4-conductor technology. This input serves to measure the reference junction temperature and hence acts as compensation for thermocouples.

Parameterization

The FM 455 is configured using a parameterization interface.

1.3 FM 455 fields of application

Where can you use the FM 455?

The FM 455 can be applied universally as a controller module for the following control tasks:

- Temperature control
- Level control
- Fill level control
- Pressure control
- Flow control
- Concentration control

Applications

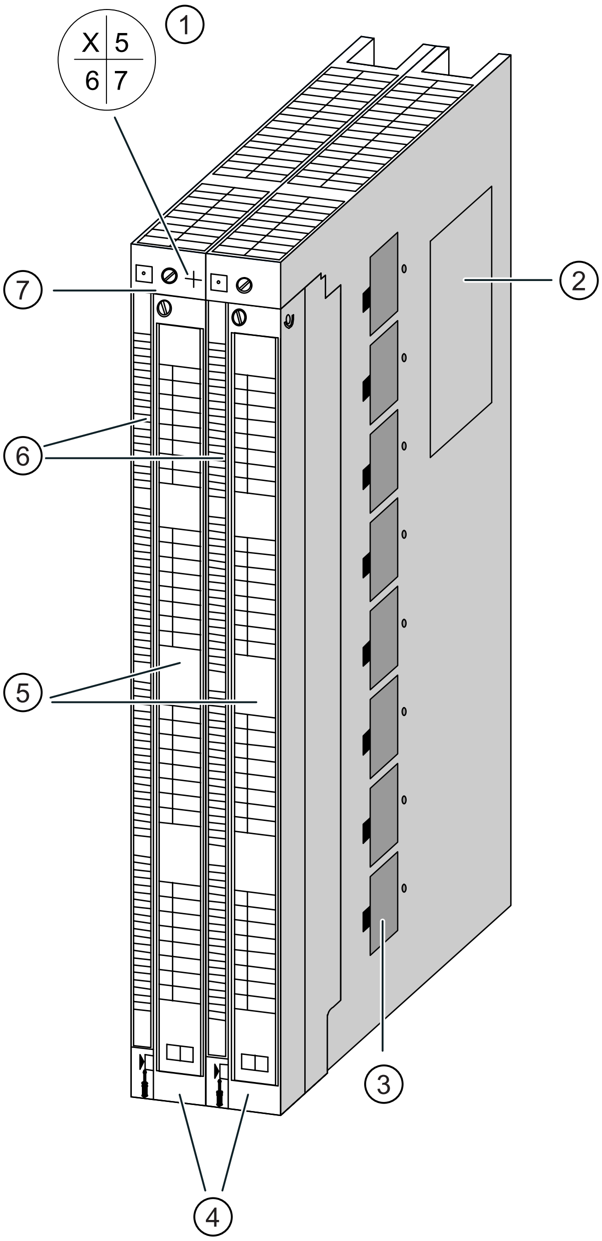
The FM 455 can be applied in control tasks for, among others, the following sectors:

- General machine construction
- Systems engineering
- Industrial furnace construction
- Heating and cooling systems
- Food and beverage industry
- Process engineering
- Environmental technology
- Glass and ceramics production
- Rubber and plastics machines
- Wood and paper industry

1.4 The FM 455 hardware

Module view

The following figure shows the FM 455 module with front connectors.



① Version
② Type plate
③ Measuring range module
④ Front connector with front connector code
⑤ Labeling strips
⑥ Diagnostics and status LEDs
⑦ Order number

Figure 1-1 Module view of the FM 455

Front connectors

The FM 455 offers the following possible connections via the front connectors:

- 16 digital inputs
- 16 analog inputs
- 1 reference junction input
- 32 digital outputs (only S controllers)
- 16 analog outputs (only C controllers)
- 24 V DC supply voltage between L+ and M in order to supply the module and the digital / analog outputs
- Home position of the analog circuit M_{ANA}

The front connectors must be ordered separately (see "Spare parts (Page 261)" appendix).

Front connector code

When you plug in the front connector, the front connector code engages. Then this front connector can only be fitted to an FM 455.

Labeling strips

The module comes with two labelling strips that you can individually label with your signal names.

The labeling strips have the pinout of the FM 455.

Order number and version

The order number and version of the FM 455 are stated at the top next to the left fixing screw.

Measuring range modules

There are eight measuring range on the side of the FM 455. They can be plugged in to four different positions and are used to adapt every two successive analog inputs together to a specific encoder type.

Diagnostics and status LEDs

The FM 455 has 19 LEDs that serve both for diagnostics as well as to display the status of the FM 455 and its digital inputs.

The following table lists the LEDs with their label, color and function.

Table 1- 2 Diagnostics and status LEDs

Labeling	Color	Function
INTF	red	Internal error
EXTF	red	External error
Backup	Yellow	Displays the back-up mode
I1	green	Status of the I1 digital input
I2	Green	Status of the I2 digital input
I3	Green	Status of the I3 digital input
I4	Green	Status of the I4 digital input
I5	Green	Status of the I5 digital input
I6	Green	Status of the I6 digital input
I7	Green	Status of the I7 digital input
I8	Green	Status of the I8 digital input
I9	Green	Status of the I9 digital input
I10	Green	Status of the I10 digital input
I11	Green	Status of the I11 digital input
I12	Green	Status of the I12 digital input
I13	Green	Status of the I3 digital input
I14	Green	Status of the I14 digital input
I15	Green	Status of the I15 digital input
I16	Green	Status of the I16 digital input

The FM 455 S also has 16 additional LEDs that display the status of the digital outputs:

Table 1- 3 Additional FM 455 S LEDs

Labeling	Color	Function
Channel 1	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 2	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 3	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 4	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 5	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 6	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 7	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 8	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 9	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 10	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 11	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 12	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 13	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 14	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 15	Green	Status of the digital output - open
	Green	Status of the digital output - close
Channel 16	Green	Status of the digital output - open
	Green	Status of the digital output - close

1.5 The FM 455 software

The FM 455 software package

To integrate the FM 455 with the S7-400 you require a software package with

- Parameter assignment interface
- Software for the CPU (function blocks)

Parameterization interface

The FM 455 is adapted to the respective task by means of parameters. These parameters are stored in the system data and when the CPU is in STOP they are transferred from the PG/PC to the CPU and to the FM 455. In addition, the CPU transfers these parameters to the module with every STOP to RUN transition.

You can specify the parameters via the parameterization interface. The parameterization interface is installed on your PG/PC and is called from STEP 7.

Online help

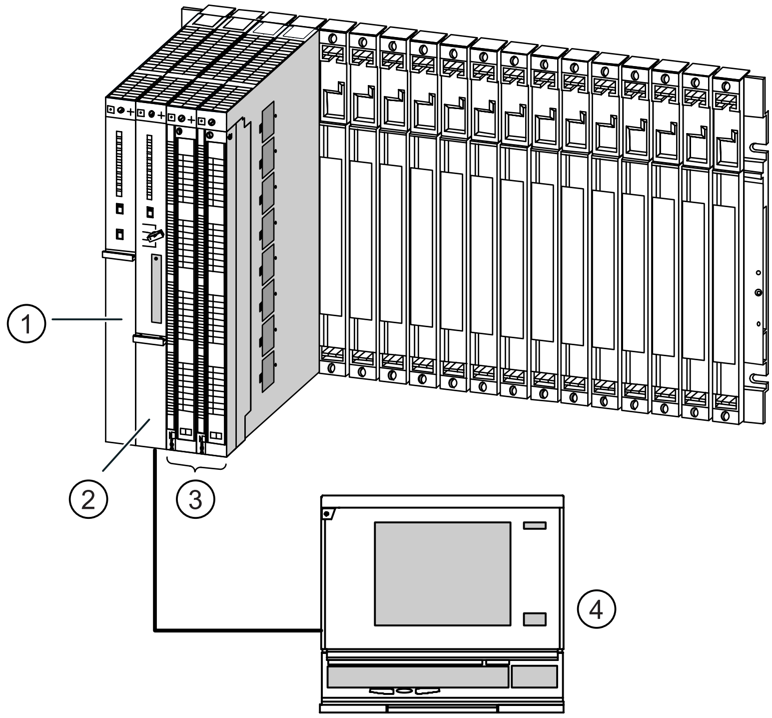
You can obtain further information regarding parameterization from the integrated online help.

Software for the S7-400 CPU (function blocks)

The software for the CPU consists of the function blocks:

- PID_FM for changing parameters and operating modes (for example, setpoint value, manual-automatic changeover) during running operation and for reading process states (for example, process value).
- FORCE455 to force analog and digital inputs during commissioning (force = specify simulation values).
- READ_455 to read the analog / digital input values during commissioning.
- CH_DIAG to read channel-specific diagnostics values during commissioning.
- FUZ_455 to read the parameters of the self-regulating temperature controller (fuzzy controller) and to download these parameters to the FM 455 (e.g. during module replacement or renewed parameter identification of the controller).
- PID_PAR for special applications to change further parameters during operation.

The following figure shows an S7-400 structure with an FM 455 and with connected programming device.



① Power supply module

② CPU with user program and FBs of the FM 455

③ FM 455

④ Programming device (PG/PC) with STEP 7 and the parameterization screens

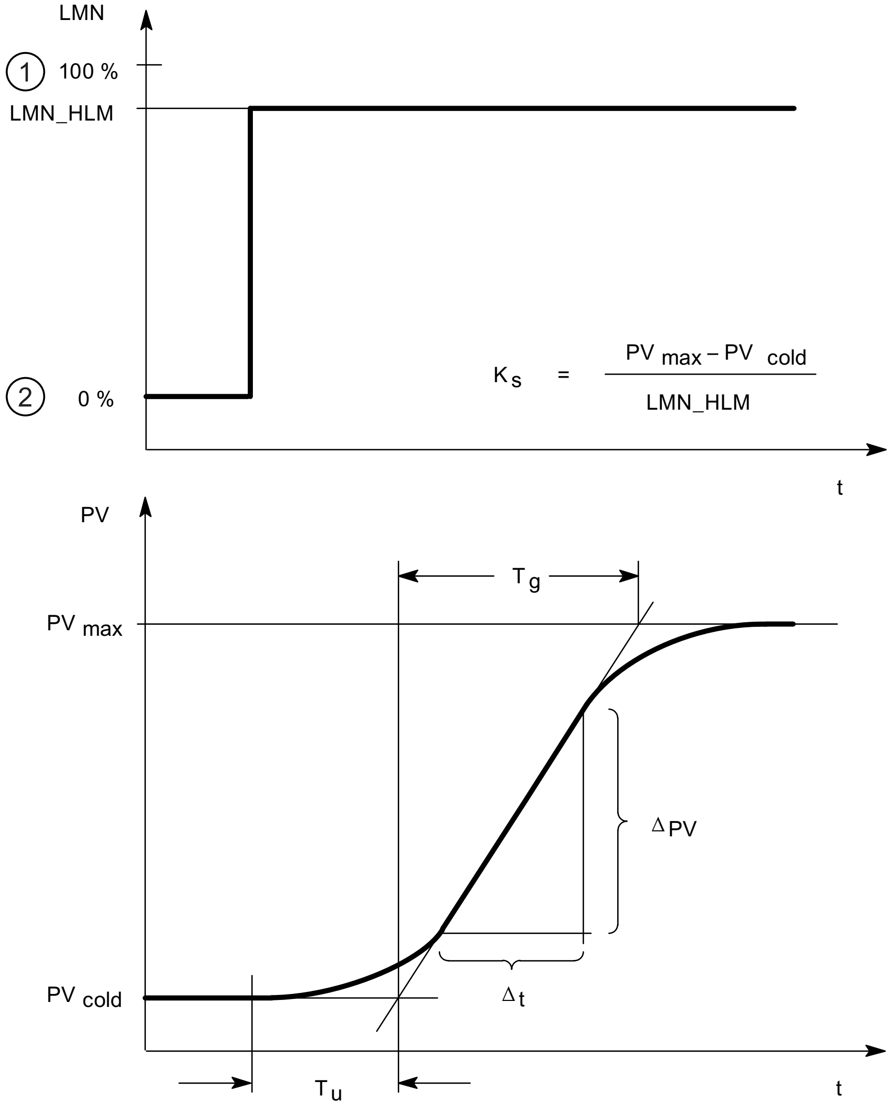
Figure 1-2 Structure of a SIMATIC S7-400 with FM 455

Information for the controller adjustment 2

2.1 Characteristic values of the control section

Establishing the time response from the step response

The time response of the control section can be established by the time progression of the controlled variable PV after the stepped alteration of the manipulated variable from 0 to 100%.



$$Vmax = \frac{PV_{max} - PV_{cold}}{T_g} = \frac{\Delta PV}{\Delta t}$$

①	ON
②	OFF
LMN	Manipulated variable
LMN_HLM	Range of the manipulated variable
T_u	Delay time
T_g	Balancing time
K_s	Transfer factor of the control section
v_{max}	max. increase speed of the controlled variable
PV_{max}	Maximum value of the control section

Figure 2-1 Step response of a control section

Most control sections are so-called control sections with balance (see figure above). The time response can be established approximately by the variables delay time T_u, balancing time T_g and the maximum value PV_{max}. The variables are recorded by positioned tangents on the maximum value and on the turning point of the step response. The assumption of the unit-step response up to the maximum value is not possible in many cases, as the controlled variable may not exceed certain values. Therefore, you use the increase speed v_{max} to gain information about the control section.

From the ratio

$$\frac{T_u}{T_g}$$

or

$$\frac{T_u \times v_{max}}{PV_{max} - PV_{cold}}$$

it is possible to estimate the controllability of the process. The following is in effect:

$\frac{T_u}{T_g}$	Controllability of the control section
< 0,1	easy to control
0.1 to 0.3	still controllable
> 0,3	difficult to control

Control sections can be assessed using these values:

T_u < 0.5 min, T_g < 5 min = fast control section

T_u > 0.5 min, T_g > 5 min = slow control section

Characteristic values of important temperature control sections

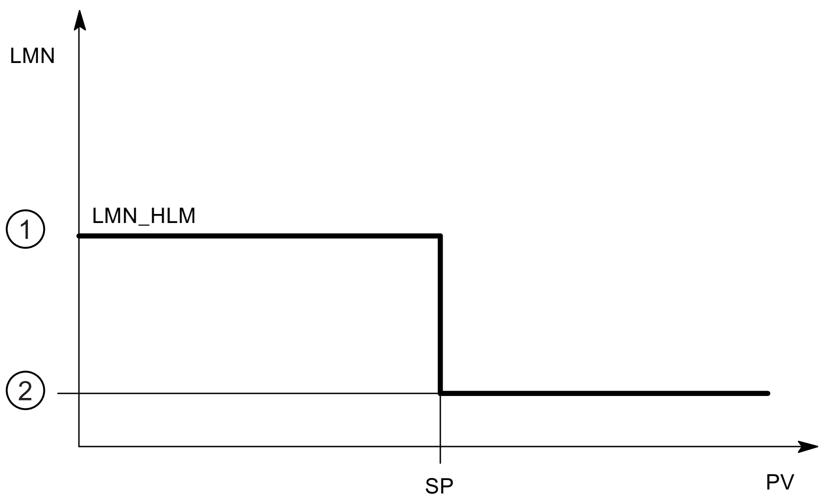
Controlled variable	Type of control section	Delay time T_u	Balancing time T_g	Increase in speed v_{max}
Temperature	small, electrically heated furnace	0.5 to 1 min	5 to 15 min	up to 60 K/min
	large, electrically heated annealing furnace	1 to 5 min	10 to 20 min	up to 20 K/min
	large, gas-heated annealing furnace	0.2 to 5 min	3 to 60 min	1 to 30 K/min
	Autoclaves	0.5 to 0.7 min	10 to 20 min	
	High-pressure autoclaves	12 to 15 min	200 to 300 min	
	Injection molding machines	0.5 to 3 min	3 to 30 min	5 to 20 K/min
	Extruders	1 to 6 min	5 to 60 min	
	Packaging machines	0.5 to 4 min	3 to 40 min	2 to 35 K/min

2.2 Type of controller (2-point / 3-point controllers)

Two-point controllers without feedback

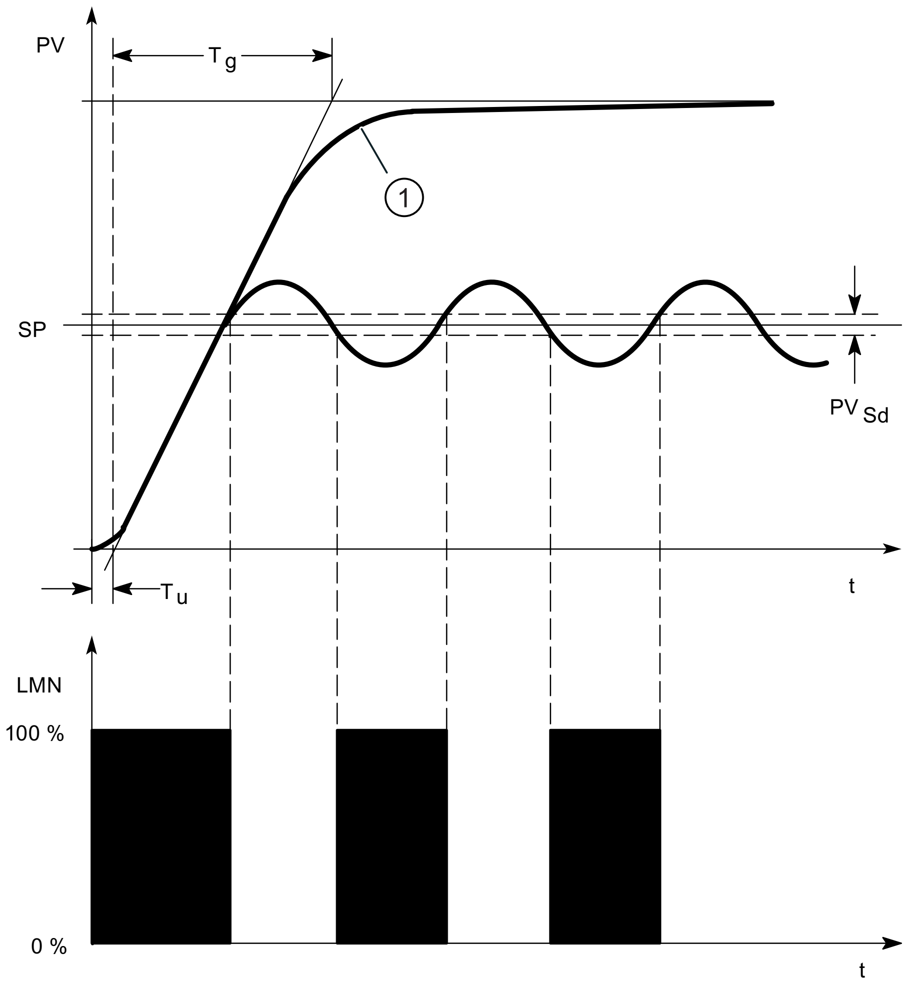
Two-point controllers have the states "ON" and "OFF" as switch functions. This corresponds to 100 % or 0 % output. This causes a continuous oscillation of the controlled variable PV by the set value SP.

The amplitude and the duration of oscillation increases with the relationship of the delay time T_u with the balancing time $T_g$of the control section. These controllers are generally used for simple temperature regulations (e.g. for electrically, directly heated furnaces) or as limit indicators.



①	ON
②	OFF
LMN_HLM	Range of the manipulated variable
SP	Reference value

Figure 2-2 Characteristic curve of a two-point controller



①	Unit-step response without controller
T_u	Delay time
T_g	Balancing time
PV_{Sd}	Switching difference

Figure 2-3 Control function of a two-point controller without feedback

Two-point controllers with feedback

The behavior of two-point controllers in the case of control sections with larger delay times, e.g. furnaces where the functional space is separated from the heating, can be improved by the use of electronic feedback.

With the aid of feedback, the switching frequency of the controller is increased and the amplitude of the controlled variable is reduced. Also, the controller results in dynamic operation can be considerably improved. The limit for the switching frequency is set by the output level. In the case of mechanical actuators like relays and contactors, 1 to 5 switches per minute should not be exceeded. With binary voltage and power outputs with series-connected thyristor or triac controllers you can select higher switching frequencies that lie way in excess of the limit frequency of the control section.

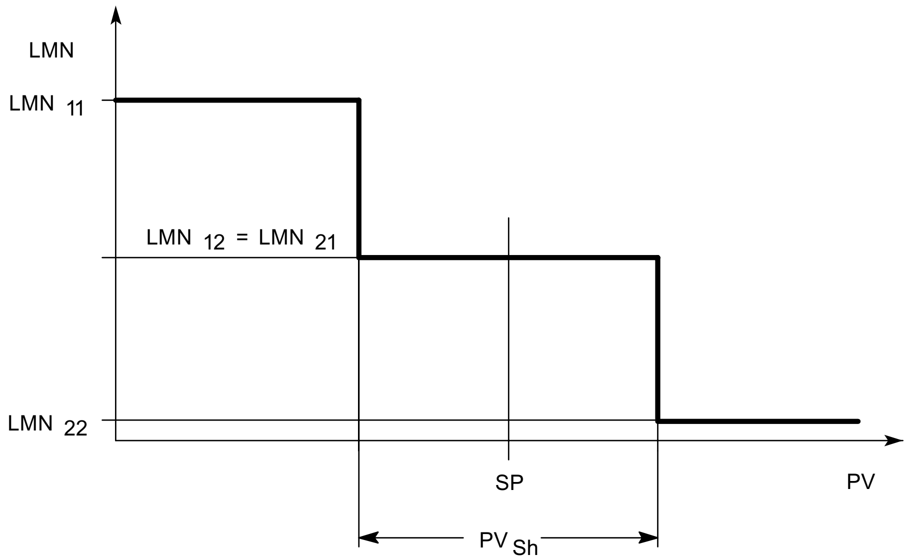
As the switching pulses on the output of the control section are no longer ascertainable, you obtain comparable results as with continuous controllers.

Compared to continuous controllers, with which the amplitude of the output signal represents the manipulated variable, with two-point controllers with feedback the output size is depicted by the pulse width modulation.

Two-point controllers with feedback are used to control temperatures in furnaces, for processing machines in the plastics, textiles, paper, rubber and foodstuffs industries as well as for heating and cooling devices.

Three-point controllers

Three-point controllers are used for heating / cooling. These controllers have two switch points as outputs. The controller results are optimized by means of electronic feedback structures. Application areas for such controllers are thermal, cooling and climatic chambers and tool heating for plastics processing machines.



LMN	Manipulated variable	e.g. LMN_{11} = 100 % heating LMN_{12} = 0 % heating LMN_{21} = 0 % cooling LMN_{22} = 100 % cooling
PV	Control variable	e.g. temperature in °C
SP	Setpoint	
PV_{Sh}	Distance between switch point 1 and switch point 2	

Figure 2-4 Characteristic curve of a three-point controller

2.3 Controlling with different feedback structures

Controller behavior

For the precision of control and for optimum disturbance variable deviation it is necessary to adapt the controller to the time response of the control section.

To do this, you use feedback structures, which, depending on the structure of the feedback have proportional control action (P), proportional derivitive control action (PD), proportional integral control action (PI) or proportional integral derivitive control action (PID). If a jump function to the controller input exists, jump responses arise under the condition that the delay times of the controller are negligibly small and that the controller reacts very rapidly.

P controller

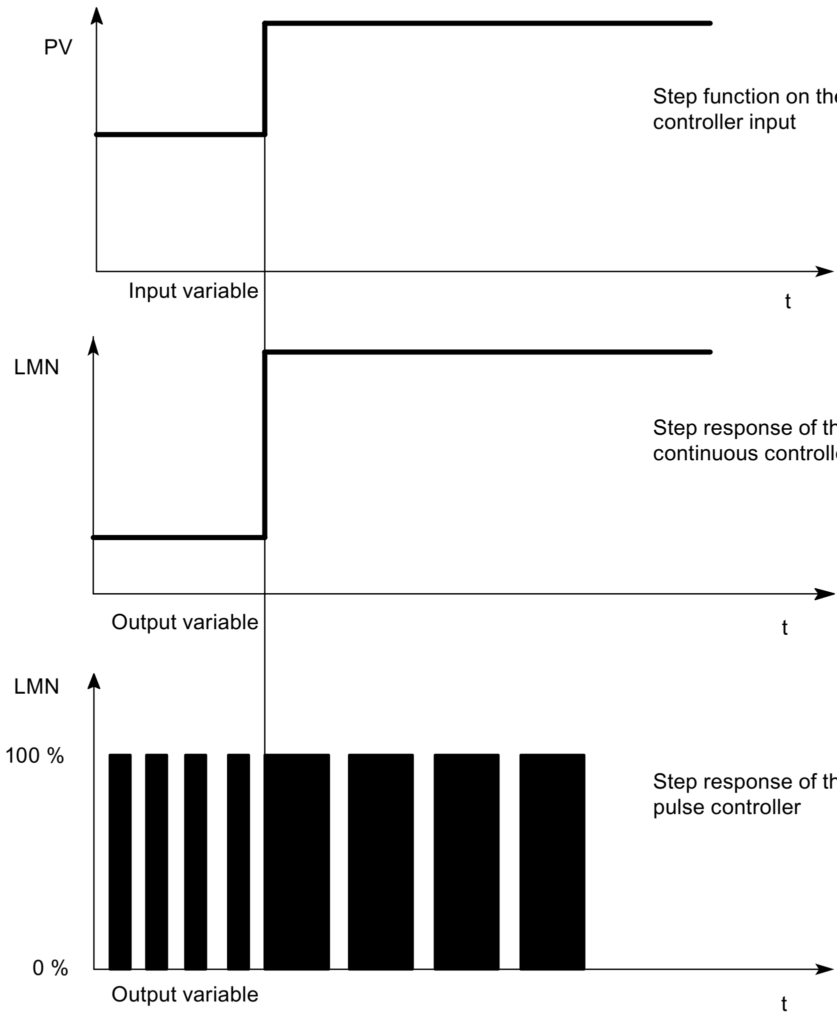


Figure 2-5 The step response of a P controller

Formula for P controllers

Output size and input size are directly proportionate, i.e.:

Change to output size = proportional factor x change to input size

LMN = GAIN x ER

PD controllers

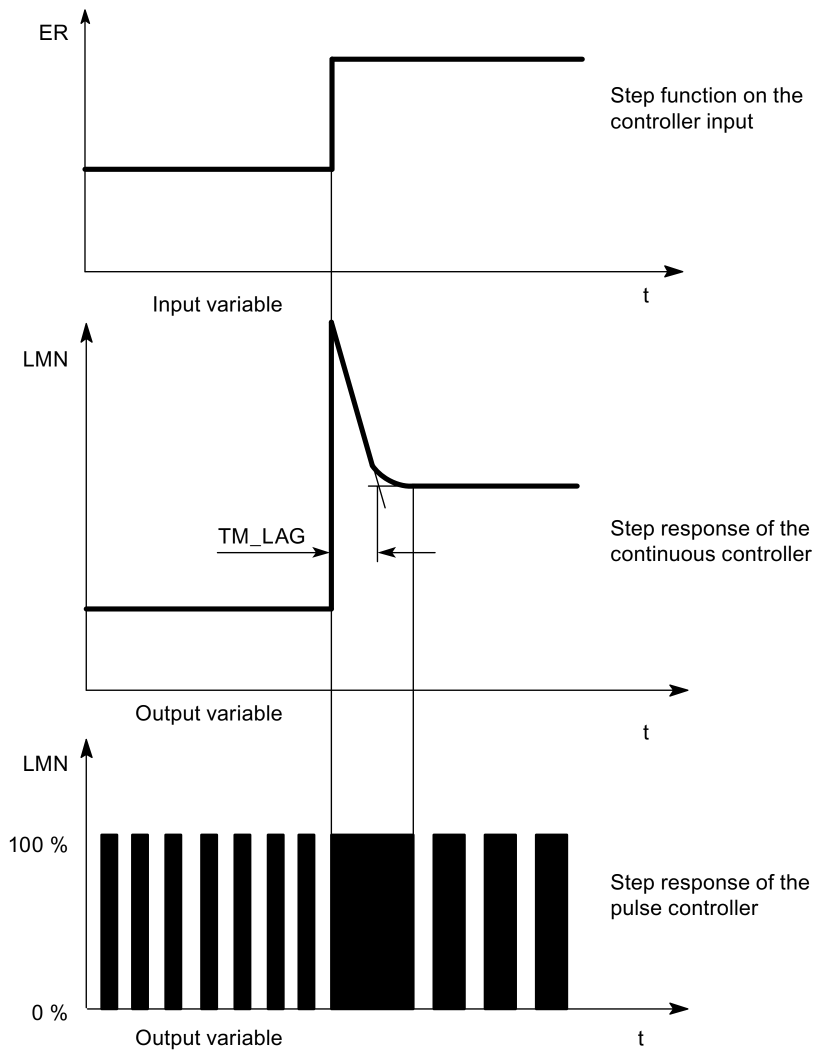


Figure 2-6 The step response of a PD controller

The D control elements are suitable solely for controlling as they no longer issue switch commands when the input size has readjusted itself to a static value.

In connection with P control elements you use the D part in order to generate an appropriate control pulse in dependence on the rate of change of the controlled variable. If a distrubance variable is having an effect on the control section, because of the changed degree of control the PD controller sets itself to another control deviation. Faults will not be fully corrected. The good dynamic behavior is advantageous. When starting and when changing the reference value a well damped, non-oscillating transfer is achieved. However, a controller with D part is not appropriate if a process has oscillating measured variables, e.g. in case of pressure or flow control systems.

Formula for PD controllers

The following applies for the step response of the PD controller in the time range:

$$LMN = GAIN \times ER \times \left(1 + \frac{TD}{TM\_LAG} \times e^{\frac{-t}{TM\_LAG}} \right)$$

t = time interval since the step of the input size

PI controller

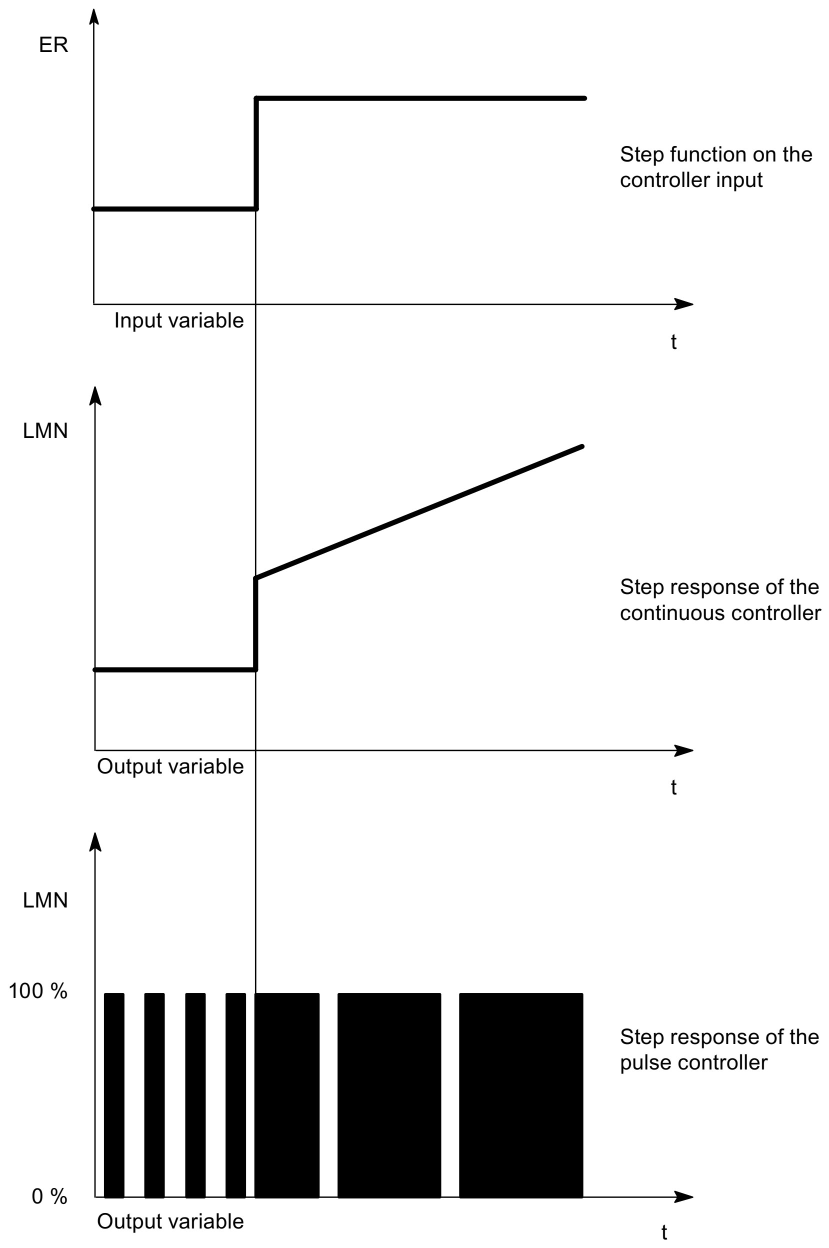


Figure 2-7 The step response of a PI controller

I control elements have the integral of the input size as the output size, i.e. the controller adds up the deviation from the set value over time. This means that the controller continues to adjust until the deviation from the setpoint value has been eliminated. In practice, depending on the demands on the controlling, a combination of the different timing elements is ideal. The time response of the individual elements can be described by the controller parameters Proportional band GAIN, Reset time TI (I-action) and Differential-action time TD (D-action).

Formula for PI controllers

The following applies for the step response of the PI controller in the time range:

$$LMN = GAIN \times ER \times \left(1 + \frac{t}{TI}\right)$$

t = time interval since the step of the input size

PID controllers

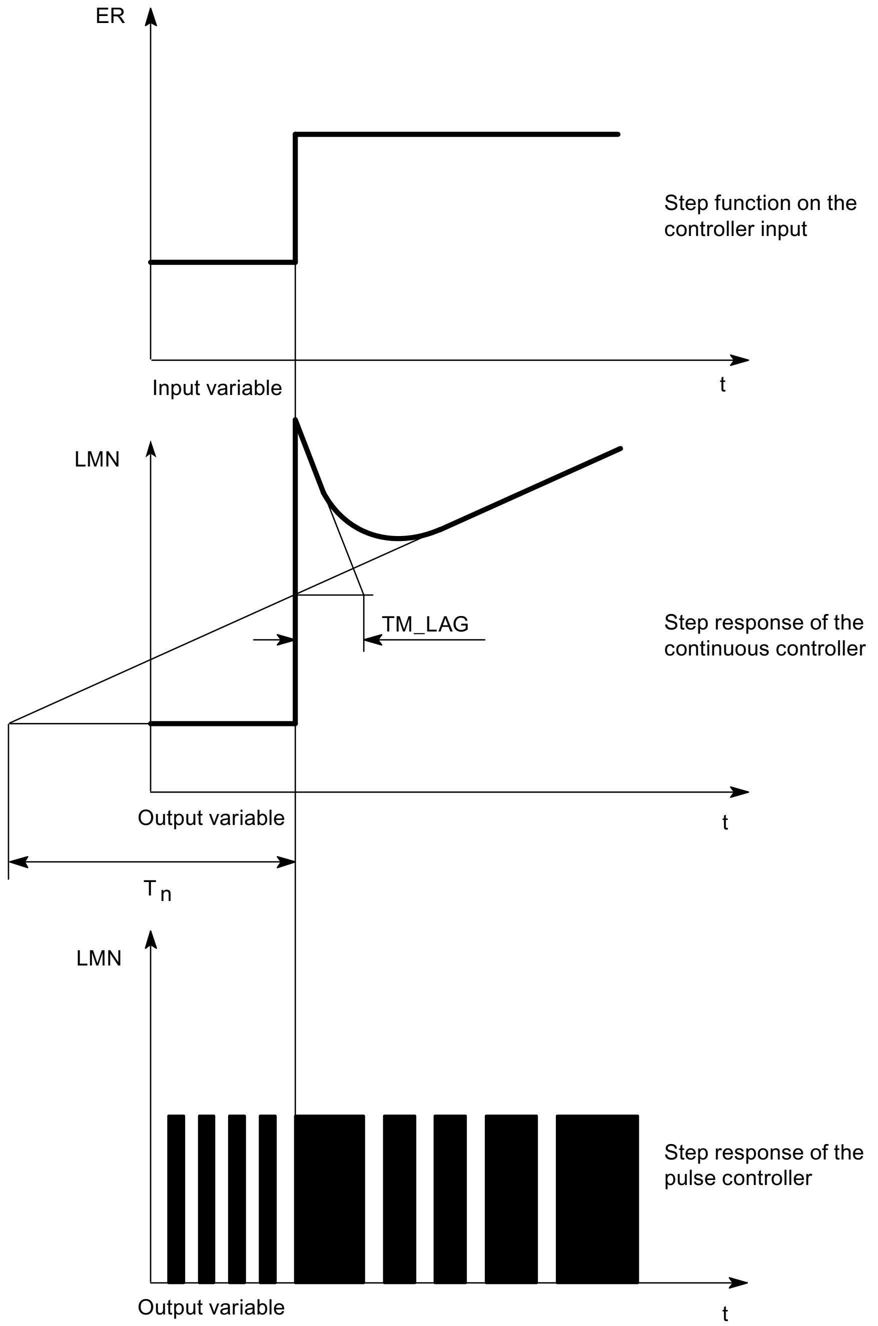


Figure 2-8 The step response of a PID controller

Most of the controlling in process engineering can be governed by means of a controller with PI action. In the case of slow processes with a large dead time, for example temperature control systems, the control result can be improved by means of a controller with PID action.

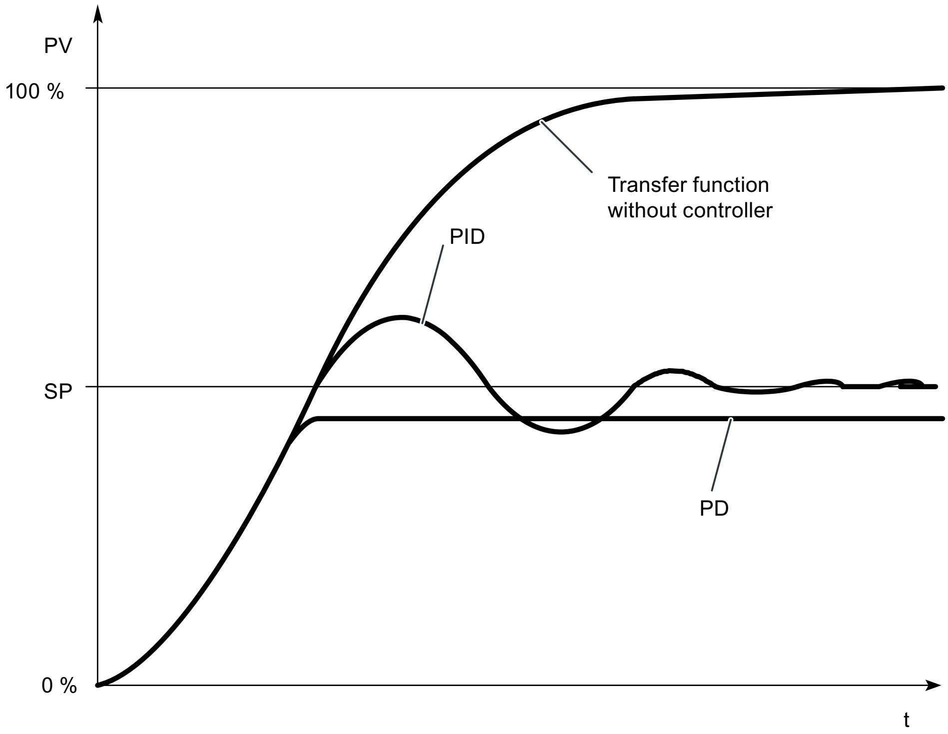


Figure 2-9 Step response with different controlling

Controllers with PI and PID action have the advantage that the process variable does not show a derivation from the setpoint value after the transient condition. The controlled variable oscillates over the set value upon start-up.

Formula for PID controllers

The following applies for the step response of the PI controller in the time range:

$$LMN = GAIN \times ER \times \left(1 + \frac{t}{TI} + \frac{TD}{TM\_LAG} \times e^{\frac{-t}{TM\_LAG}} \right)$$

t = time interval since the step of the input size

2.4 Selection of the controller structure for specified controlled systems

Selection of the Suitable Controller Structures

Amongst the closed-control elements the controlled systems have a special position. Their properties are determined by the process-specific applications and cannot be changed afterwards. An optimal control-action result can thus only be achieved by the selection of a suitable controller whose response can be adapted to the system data within certain limits.

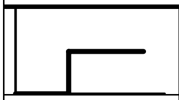
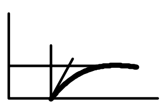
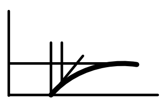
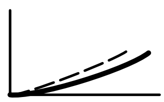
Controlled system		Controller structure			
		P	PD	PI	PID
	Pure dead time	Unusable	Unusable	Control + disturbance	Unusable
	Dead time + first-order time-delay	Unusable	Unusable	Slightly worse than PID	Control + disturbance
	Dead time + second-order time-delay	Not suitable	Bad	Worse than PID	Control + disturbance
	1. Order + very small dead time (delay time)	Control	Control at delay time	Disturbance	Disturbance at delay time
	Higher order	Not suitable	Not suitable	Slightly worse than PID	Control + disturbance
	Not self-regulating	Control (without delay)	Control (with delay)	Error (without delay)	Error (with delay)

Table 2- 1 Suitable Controller for the Most Important Control Variables

Control variable	Controller			
	P	PD	PI	PID
	Steady-state control deviation		No steady-state control deviation	
Temperature	for less demands and with P sections with T_u / T_g < 0.1	Well suited	The most suitable controller types for high-quality requirements (except for specially adapted special controllers)	
Pressure	Suitable, if the delay time is inconsiderable	Unsuitable	The most suitable controller types for high-quality requirements (except for specially adapted special controllers)	
Flow rate	If suitable, because required GAIN range usually too large	Unsuitable	Suitable, but I-action controller alone often better	Hardly required for these control variables

2.5 Establishing parameters by experiment

Procedure

As an alternative to calculating the parameters you can establish the control parameters by means of targeted experimentation:

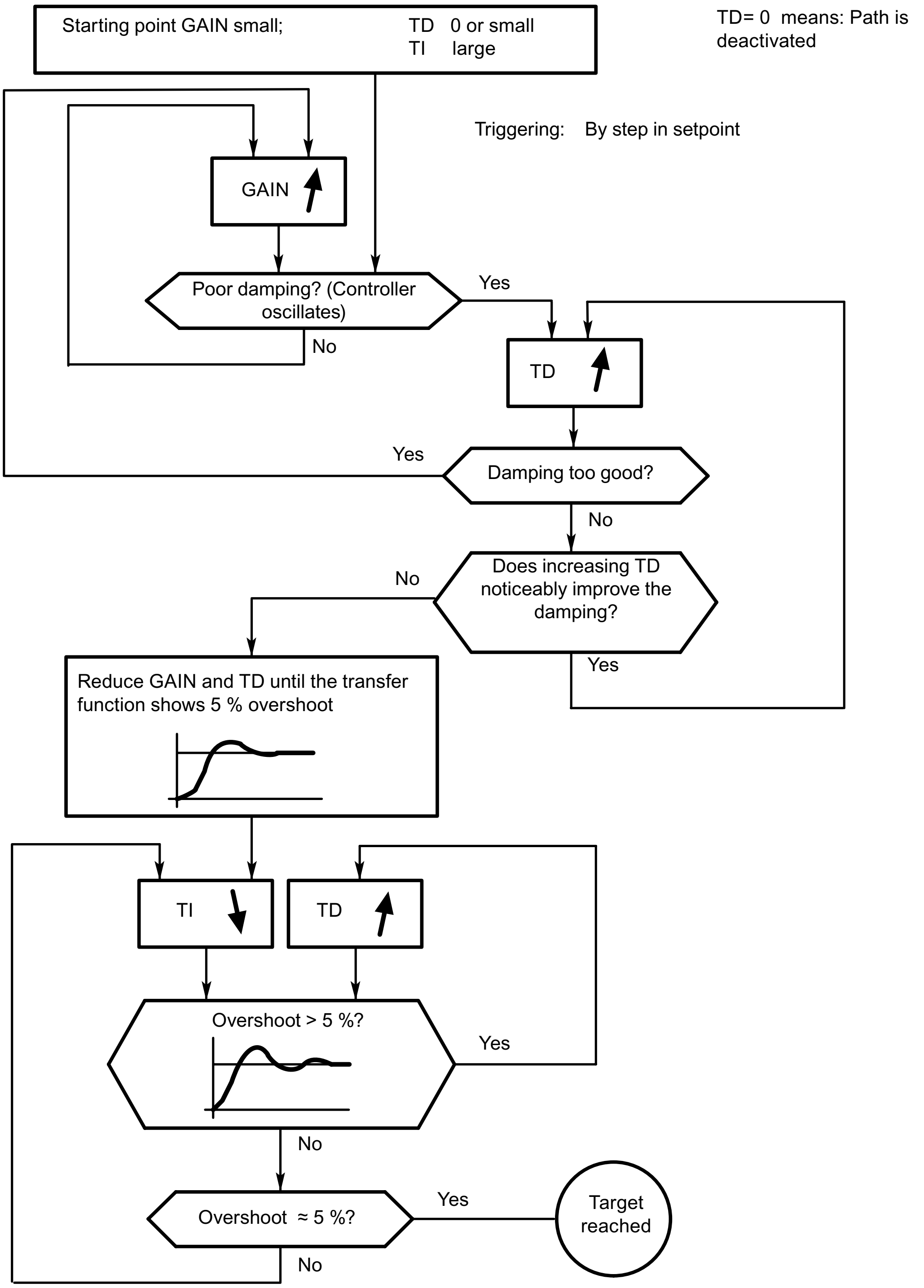


Figure 2-10 Setting the controller by means of targeted experimentation

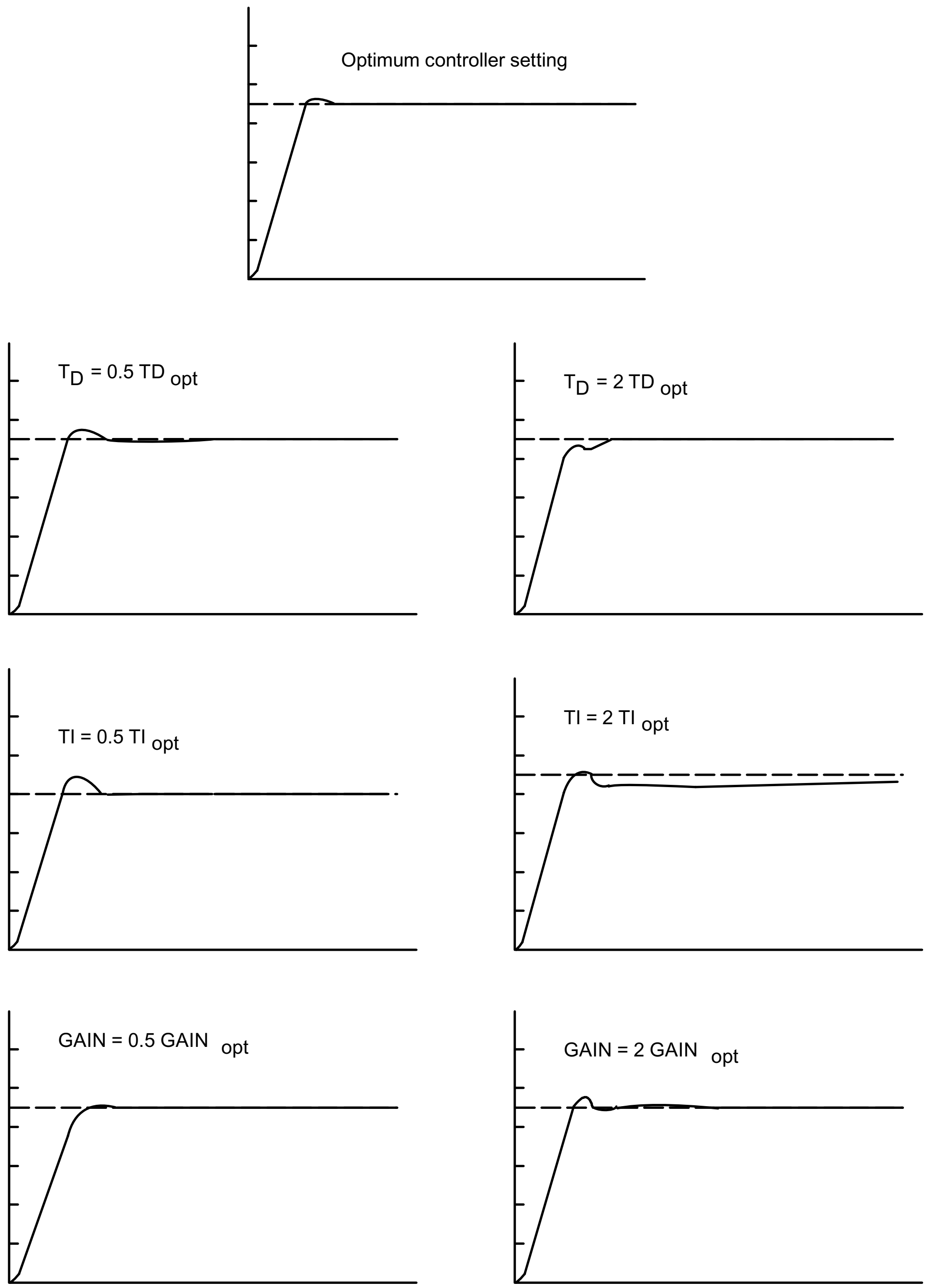


Figure 2-11 Effects on the optimum controller setting when changing the controller parameters

3 How Does the FM 455 Controller Module Work?

3.1 Basic Structure of the FM 455

Introduction

In this section block diagrams are used to explain the basic structure and the interconnection possibilities of the FM 455.

Basic Structure of the FM 455

The FM 455 C and FM 455 S have a similar basic structure. They consist of the following function blocks:

- Inputs of the FM 455
  - 16 analog inputs with analog value conditioning
  - 1 reference junction input for compensating thermoelements
  - 16 digital inputs
- Controller
  - 16 controller channels independent of each other, each subdivided into the units system error formation, control algorithm and controller output
- Outputs of the FM 455
  - 16 analog outputs (only FM 455 C)
  - 32 analog outputs (only FM 455 S)

Block Diagram of the FM 455 C

The following shows the block diagram of the FM 455 C (continuous controller) and the interconnection possibilities between the individual function blocks.

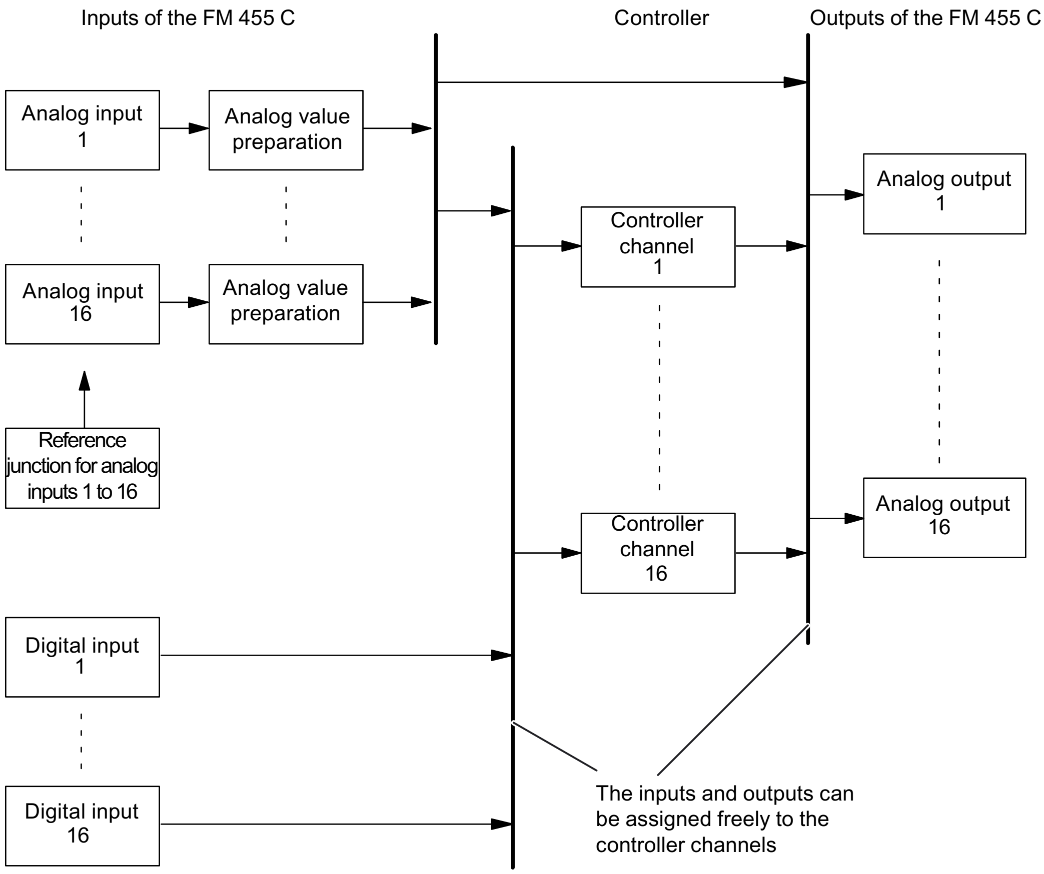


Figure 3-1 Block Diagram of the FM 455 C (continuous controller)

Interconnection Possibilities of the FM 455 C

The function blocks of the FM 455 C do not have a fixed assignment to each other. On the contrary, it is possible to interconnect them by means of configuration.

Each analog input has its own analog value conditioning (filtering, linearization, normalization).

You can assign up to 4 analog inputs and up to 5 digital inputs to each controller channel. Each controller channel can be interconnected to the conditioned analog values, the digital inputs or also the output of another controller channel.

Every analog output can be interconnected to a controller output or to an analog value conditioning. The possibility of interconnecting to an analog value conditioning can be used, for example, to convert a non-linear temperature value into a linear output signal.

Block Diagram of the FM 455 S

The following shows the block diagram of the FM 455 S (step controller) and the interconnection possibilities between the individual function blocks.

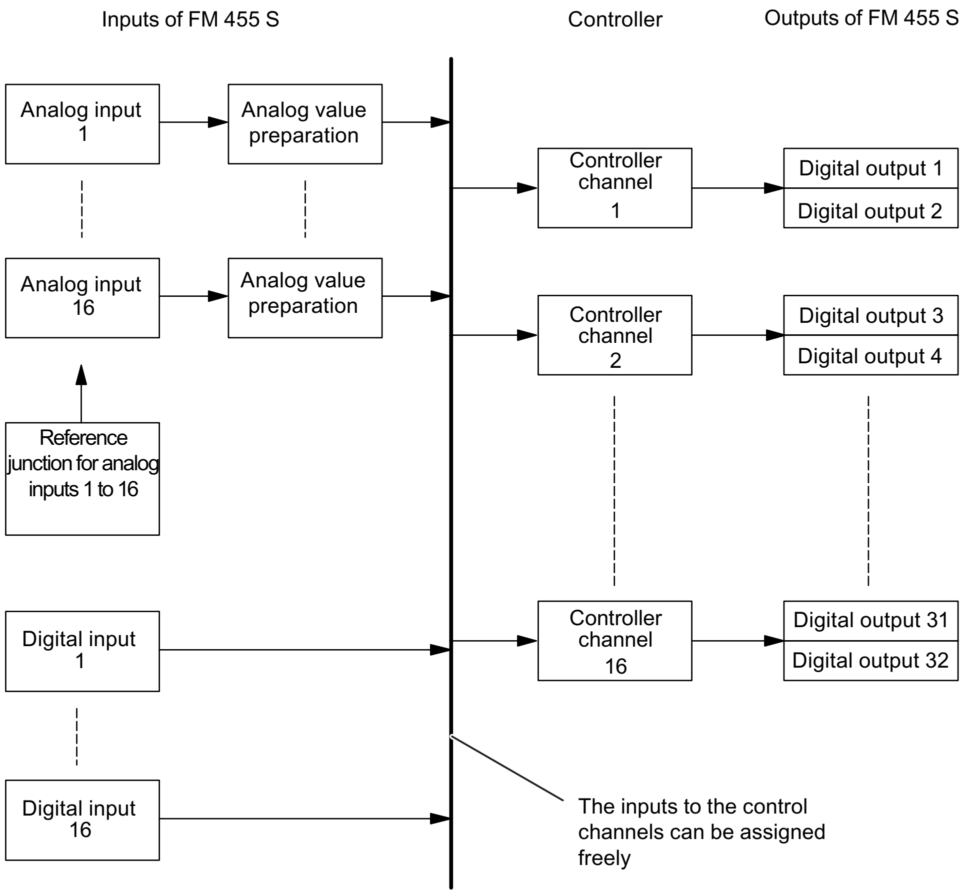


Figure 3-2 Block Diagram of the FM 455 S (step controller)

Interconnection Possibilities of the FM 455 S

The function blocks of the FM 455 S do not have a fixed assignment to each other. On the contrary, it is possible to interconnect them by means of configuration.

Each analog input has its own analog value conditioning (filtering, linearization, normalization).

You can assign up to 4 analog inputs and up to 5 digital inputs to each controller channel. Each controller channel can be interconnected to the conditioned analog values, the digital inputs or also the output of another controller channel.

Two digital outputs are permanently assigned to each of the 16 controller channels.

3.2 Basic parameters

Introduction

The FM 455 has basic parameters that concern the interrupts and the response to CPU STOP.

Basic parameters

The basic parameters can be found in the HW Config in the "basic parameters" tab of the "FM 455 properties ..." window. You have the following options:

Choice of interrupt:

- None
- Diagnostic interrupt

If there is ...		then ...	
Choice of interrupt:	None	Interrupt generation:	None
Choice of interrupt:	Diagnostic interrupt	Interrupt generation:	Display the interrupt management

The response of the FM 455 to the CPU stop is: Continue

3.3 Inputs of the FM 455

Introduction

Different sensor types can be connected to the analog inputs. The input signals of the sensors are then conditioned in accordance with the requirements.

The digital inputs can be used to switch the module into various operating modes.

Continuous-action controllers and step controllers have the same structure at the analog and digital inputs.

3.3.1 Analog inputs

Function Blocks of an Analog Input

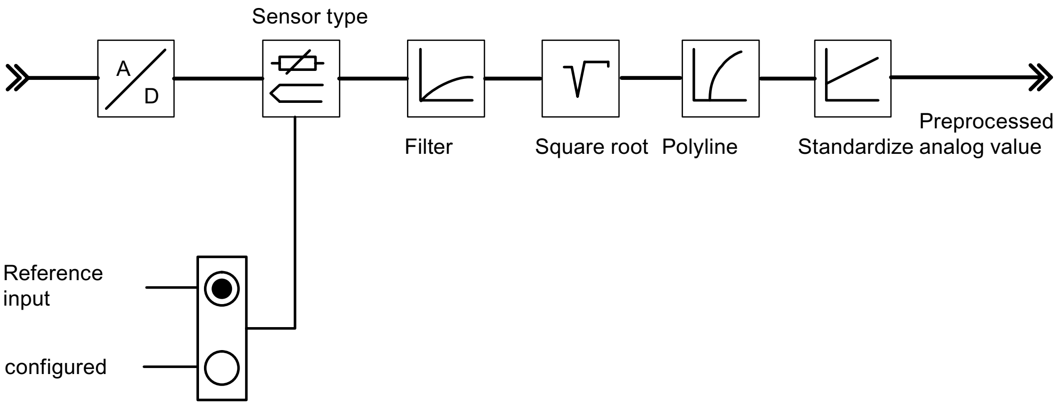


Figure 3-3 Analog value conditioning

Adapting to sensors

The analog inputs can be adapted to various sensors by means of parameter assignment. The following settings are possible:

- Analog input is not being processed (e.g. unused input)
- Power sensors 0 mA to 20 mA
- Power sensors 4 mA to 20 mA
- Voltage sensors 0 V to 10 V
- Pt 100, –200 ... 850 °C
- Pt 100, –200 ... 556 ºC (double resolution)
- Pt 100, –200 ... 130 ºC (quadruple resolution)
- Thermocouple elements type B, J, K, R and S (analog input set to ±80 mV)
- Free thermocouple element (analog input set to ±80 mV)

You configure the analog inputs in the "analog input" screen.

Adapting to line frequency

The input signal processing system can be adapted to the line frequency in order to surprises errors in the measurement of analog signals. The following settings are possible:

- 50 Hz operation
- 60 Hz operation

This configuration is carried out in the parameter configuration interface (button: **Module parameters**).

Toggling between Celsius / Fahrenheit

Temperatures can be measured in either °C or °F.

This configuration is carried out in the parameter configuration interface (button: **Module parameters**).

Reference junction

When a thermal element has been set up as a sensor on an analog input, you can connect a Pt 100 to the differential element input to compensate for the differential element temperature of thermal elements. Alternatively, a fixed reference junction temperature can be configured.

This configuration is carried out in the parameter configuration interface (button: **Module parameters**).

When using the reference junction input, the scanning time of each controller extends by the conversion time for the reference junction input.

Analog value conditioning

The analog processing system offers various configuration options for preparing input signals. The following table offers an overview of these parameters and the programmable values.

Parameters	Values that can be set	Note
Resolution	• 12 bits • 14 bits	Conversion time 20 ms (50 Hz) Conversion time $16^2/_3$ ms (60 Hz) Conversion time 100 ms
Filters	• ON / OFF • Time constant in s	Filter - 1st arrangement the time response of which is established by the time constant
Square root	• ON / OFF	For the linearization of sensor signals, where the actual value is available as a physical quantity and where a quadratic correlation with the measured process quantity is given.

Parameters	Values that can be set	Note
Standardization	• bottom • top	To convert the input signal into a different physical unit by means of linear interpolation between the start value (bottom) and the end value (top)
Polyline	• ON / OFF • 13 control points selectable in – mA with current input – mV with voltage input	To linearize encoder characteristic curves

---

Note

Standardization/polyline: The conversion of the unit mA or mV into a physical unit takes place either via the polyline or - if this is not switched on - via standardization. The polyline is used for the linearization of a free thermal element or for any other linearization.

3.3.2 Digital inputs

Parameterization

The digital inputs are used to change over operating modes of the individual controller channels.

The direction of control action of the digital inputs can be configured. The following settings are possible for each of the 16 digital inputs:

- High active
- Low active or open

This configuration is carried out in the parameter configuration interface:

Command button: Module parameters

The following operating modes can be selected:

- Change over to manipulated value by the FB PID_FM
- Changeover to tracking operation (manipulated-value specification via an analog input)
- Change over to safety manipulated value

You can furthermore specify the following signals via digital inputs for a step controller:

- Feeback: Control device on upper stop
- Feeback: Control device on lower stop

3.4 Controller

Controller structure

The controllers of any channel of the module consist of the following blocks:

- Negative deviation generation
  - Condition of setpoint value and actual value
  - Signal selection for setpoint value, D-action input and disturbance variable
- Control algorithm
  - Temperature controllers
  - PID-action controller with dead band
- Controller output
  - Manipulated value switchover
  - Manipulated value conditioning

The parameter configuration is carried out in the masks "Negative deviation calculation", "Control algorithm" and "Controller output".

The figure below provides an overview of the controller structure.

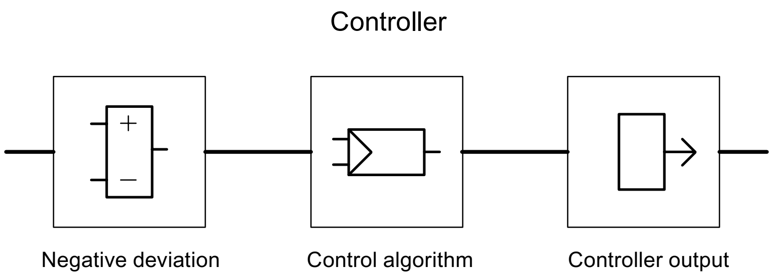


Figure 3-4 Controller structure

Controller Type

You can set different controller types for each controller channel of a C or S controller module

- Fixed setpoint or cascade controller
- Three-component controllers
- Ratio/blending controllers

The following operating modes can furthermore be selected at the step (S) controller:

- Pulse controller
- Step controller with position feedback
- Step controller without position feedback

Negative deviation generation

In the case of all controller types realized in the FM x55 C and FM x55 S, the negative deviation generation is based on the same basic structure.

An effective setpoint value and an effective actual value is formed from the setpoint value and actual value by corresponding conditioning. The negative deviation that is fed to the controller is formed by subtracting the effective setpoint value and effective actual value.

A signal selection can be carried out for the setpoint and actual values. This results in universal application possibilities for the controller module.

The structures of negative deviation generation differ depending on the selected controller type. The differences are shown in the following figures.

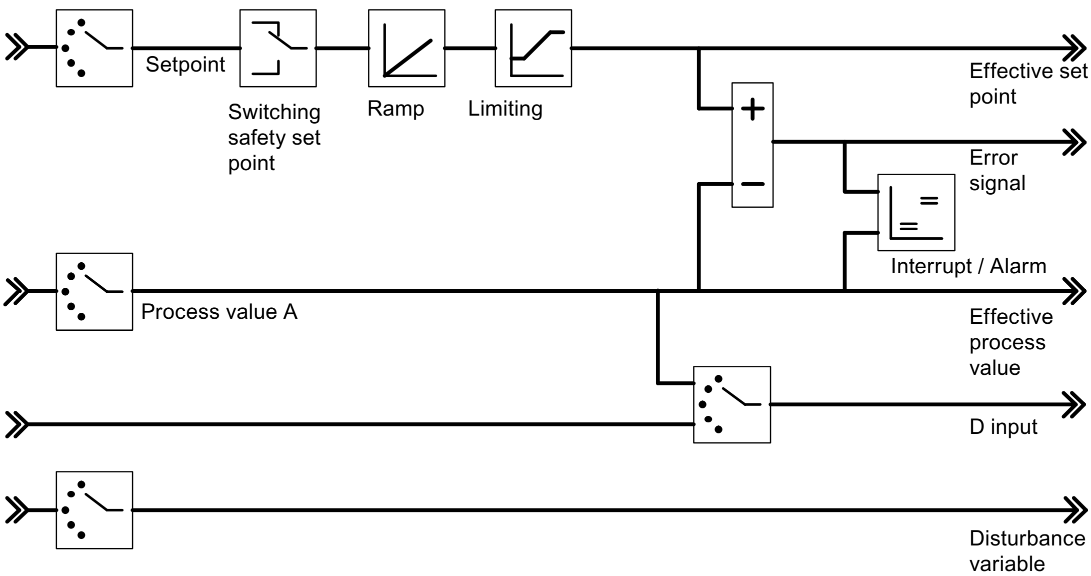


Figure 3-5 Negative Deviation Generation at Fixed Setpoint or Cascade Controller

The manipulated value of a master controller is selected at the setpoint value at the cascade controller. In the example from the figure below the manipulated value of Controller 1 is selected as the setpoint value at Controller 2.

If a slave controller that is configured as a fixed setpoint controller is switched to manual operation (not closed-loop control operation), the master controller is also switched automatically to manual operation by the module and is held to the last manipulated value. As soon as the slave controller returns to closed-loop control operation, the master controller also switches over to closed-loop control operation.

If the manipulated variable of a slave controller enters the limiting function or if the setpoint value increase of a slave controller is limited by the ramp function in the setpoint value branch, the I-action component of the master controller is blocked direction-specifically until the cause for the limitation has been eliminated in the slave controller.

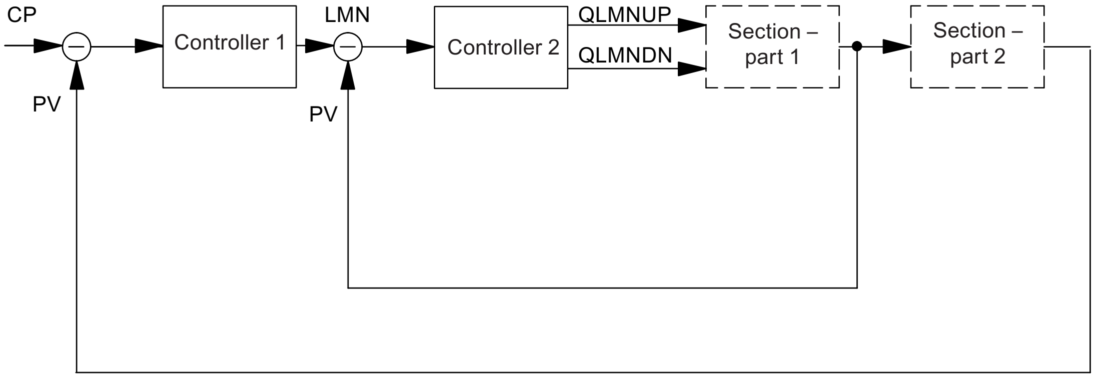


Figure 3-6 Two-loop cascade control

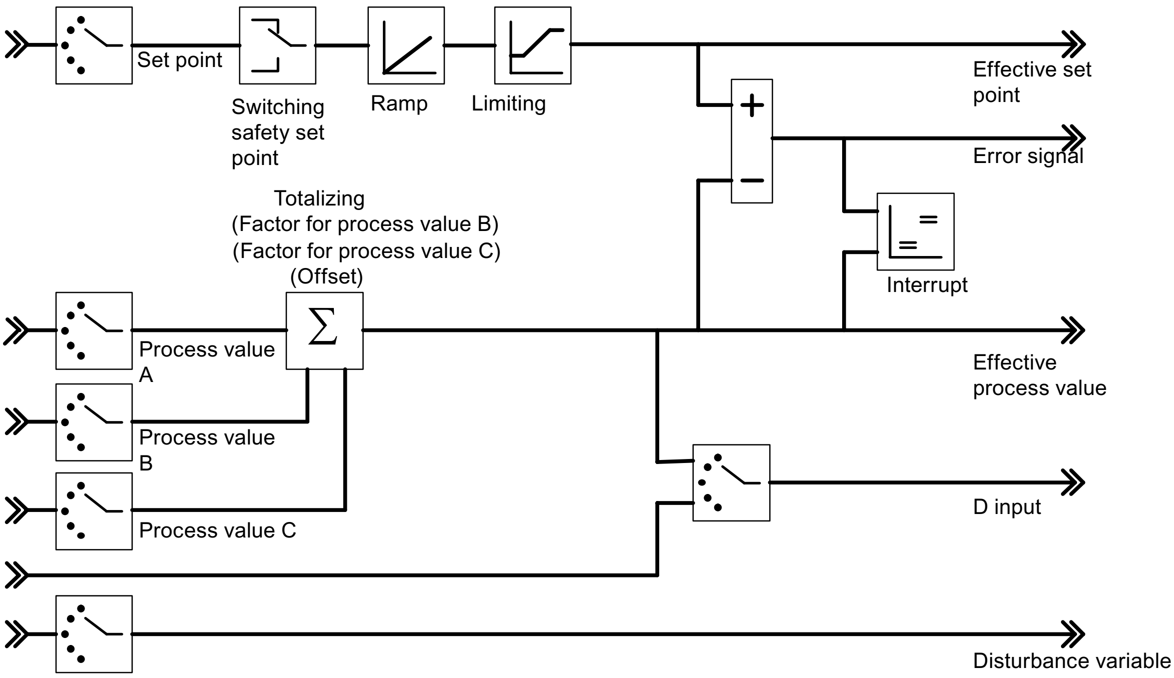


Figure 3-7 Negative deviation generation for three-component controllers

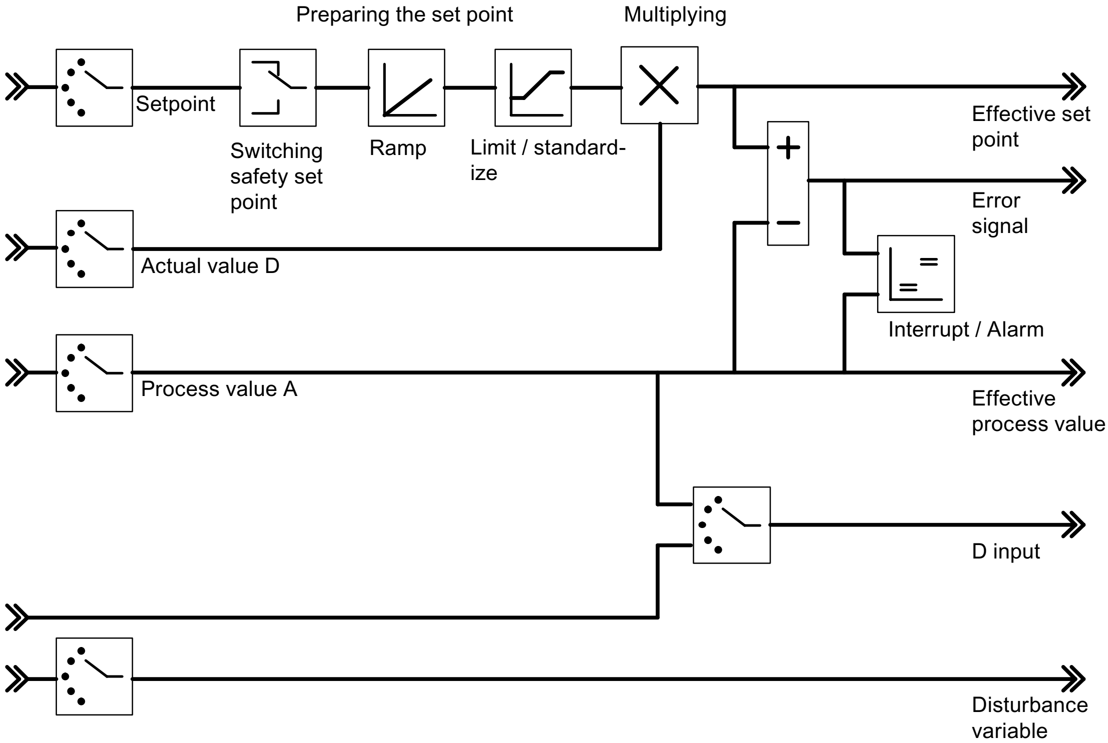


Figure 3-8 Negative deviation generation for ratio or composition controllers

The following figure shows a blending control for three components.

The total quantity controller is implemented as a three-component controller/pulse controller. The total quantity PV is calculated via its inputs "Actual value A", "Actual value B" and "Actual value C".

The slave controllers are configured as ratio/blending controllers. The manipulated variable of the master controller is connected via the "Actual value D" input. The factor FAC1 to FAC3 is specified via the setpoint value input of the controller.

The manipulated variable LMN of the total quantity controller is specified in the range of values 0% to 100%. The slave controller converts this variable at the Actual value input D into the value range of the Actual value A (the value range of the Actual value A consists of the "Upper" and "Lower" normalization values of the selected analog input).

If the manipulated variable of a slave controller enters the limiting function or if the setpoint value increase of a slave controller is limited by the ramp function in the setpoint value branch, the I-action component of the master controller is blocked direction-specifically until the cause for the limitation has been eliminated in the slave controller.

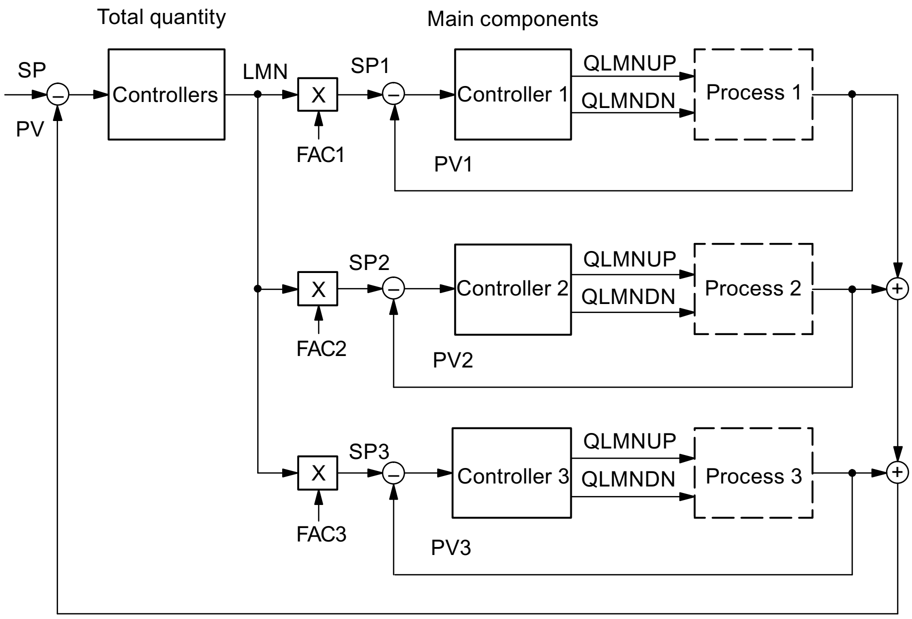


Figure 3-9 Mixed controllers for three components

The following figure shows a ratio control with two control loops.

Controller 1 is configured as a fixed setpoint or cascade controller.

Controller 2 is configured as a ratio/blending controller. The actual value of Controller 1 is selected as the Actual value D of Controller 2. The ratio factor FAC is specified via the setpoint value input of Controller 2. If a controller output is called as ratio factor FAC, then the setpoint will be converted (standardized) with the help of an upper and lower barrier from "0 .. 100%" to the value range "bottom barrier... top barrier" (standardized).

If the manipulated variable of a slave controller enters the limiting function or if the setpoint value increase of a slave controller is limited by the ramp function in the setpoint value branch, the I-action component of the master controller is blocked direction-specifically until the cause for the limitation has been eliminated in the slave controller.

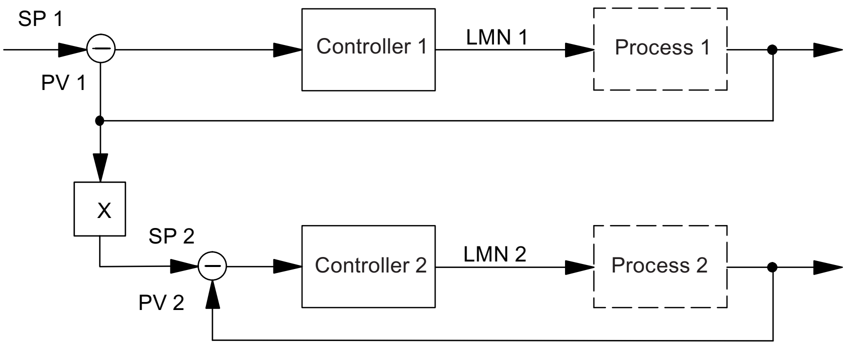


Figure 3-10 Ratio control with two control loops

Signal selection for setpoint value, D-action input and disturbance variable

You can carry out a selection amongst various signal sources for the setpoint value, the actual values, the value of the D-action input (differential input) and the disturbance variable of each controller channel. The following table provides an overview of the signal selection possibilities.

Table 3- 1 Signal selection for setpoint value, D-action input and disturbance variable

Affected values	Selectable signal source
Setpoint	• A value specified by the user program through the function block • The conditioned analog value of an analog input • The manipulated value of another controller channel (when controllers are cascaded)
Actual values A, B and C	• The conditioned analog value of an analog input (Actual values B and C can also be deactivated)
Actual value D	• Zero (Actual value D can also be deactivated)
Value for D-action input (only relevant for PD- or PID-action controllers)	• The negative deviation after the dead band of the own controller channel • The conditioned analog value of an analog input • The negated effective actual value of the own controller channel
Interference	• The conditioned analog value of an analog input (the value zero can also be specified for the disturbance variable)

Setpoint Value Conditioning

Conditioning of the setpoint value to an effective setpoint value can be influenced by the following parameter configuration possibilities:

- Switching the safety setpoint value

  The following can be set here:

  – A safety setpoint value

  – The reaction of the controller module at a CPU failure

  – The reaction of the controller module at a startup

    The alternatives for the reaction of the controller module are:

    Setpoint value = Last setpoint value

    Setpoint value = Safety setpoint value

- Ramp

  You can limit the speed of change of the setpoint value by selecting a ramp-up time from the engineering starting value to end value.
- Limiting/Normalizing

  The setpoint value is limited to a specifiable lower and upper limit when the setpoint value is specified by the function block or when the setpoint value is a conditioned analog value of an analog input.

  If, in the case of ratio controllers, a controller output is chosen as the set value, then this value acts as a factor for the multiplication of the actual value D. The set value that is given at the input in %, is in this case converted (standardized) with the aid of the bottom and top barriers.

  If the manipulated value of another controller is used as the setpoint value at a fixed setpoint or cascade controller (for example at the cascade control function, this is normalized to an engineering value by means of the normalizing constant of the selected actual value channel.
- Multiplication

  At the "ratio controller" controller type, Actual value A is used as the controlled variable, Actual value D as the ratio variable. The setpoint value input serves as the ratio factor. It is conditioned as the effective setpoint value by multiplication with Actual value D and addition of an offset that can be set. If Actual value D is deactivated, only the offset is added to the setpoint value.

Actual Value Conditioning

In the case of the "fixed-setpoint or cascade controllers" and "ratio controllers" control structures the effective actual value is identical with Actual value A.

In the case of the "Three-component controllers" control structure the effective actual value is formed by totaling the three actual values A, B and C and by adding an offset that can be set. Actual values B and C can be evaluated additionally through factors.

Interrupt

A limit monitoring function is implemented in the controller module. This allows

- either the negative deviation or
- the effective actual value

to be monitored to an upper and lower warning limit and an upper and lower interrupt limit. In addition you can set a hysteresis for these limits (refer to the following figure).

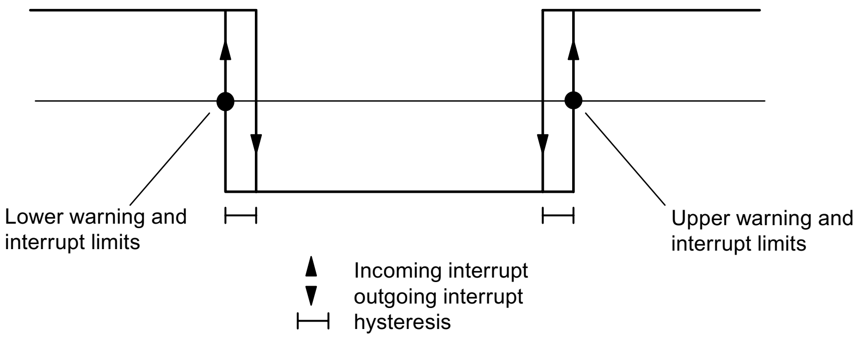


Figure 3-11 Hysteresis for warning and interrupt limits

Overview

The following operating modes can be selected at the control algorithm:

- Temperature controllers (self-regulating fuzzy controllers)
- PID controllers

C and S controllers have the same structure of control algorithm (refer to the following figure).

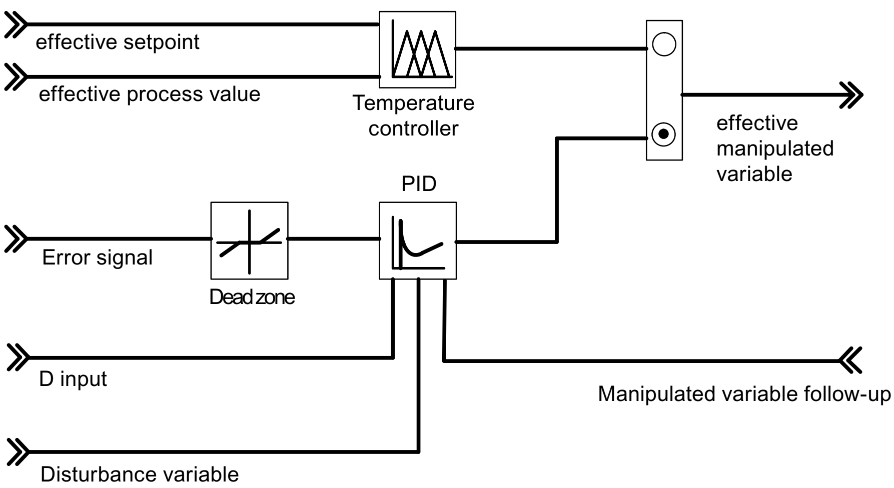


Figure 3-12 Block diagram of the control algorithm

Temperature controller

The temperature controller is a self-regulating fuzzy controller, which, after an identification with the control section, works using control parameters it has ascertained itself.

The following settings can be made on the temperature controller:

- Cooling controller
- Heating controllers
- Aggressivity

  The aggressivity parameter can be used to influence the speed of the transient response.

Possible values for the aggressivity:	
-1 ≤ Aggressivity < 0 :	Slower transient response than determined via identification
Aggressivity = 0	Transient response as determined via identification
0 ≤ Aggressivity < 1	Faster transient response than determined via identification

For a detailed description of the temperature controller, refer to chapter "Parameter Optimization at a Temperature Controller (Page 79)".

Control algorithm and controller structure

In the cycle of the planned sampling time the manipulated variable of the continuously operating controller is calculated from the control deviation in the PID positioning algorithm. The controller is implemented in a pure parallel structure. In each case, the proportional, integral or derivative parts can be switched off individually. With the integral and derivative part this takes place by setting the respective parameter TI or TD to zero.

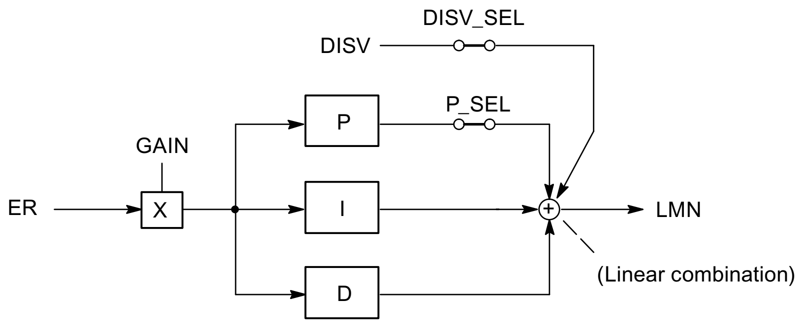


Figure 3-13 Control algorithm of the FM 455 (parallel structure)

Feedforward control

A disturbance variable **DISV** can additionally be applied to the output signal of the controller Activation and deactivation is carried out in the “control difference” window of the configuration tool by means of the switch “Signal selection disturbance variable controller”.

P/D Component in the Feedback

In the parallel structure each component of the control algorithm receives the control deviation as the input signal. In this structure setpoint step changes act directly on the controller. The manipulated variable is influenced directly via the P and the D components by means of setpoint step changes.

However, a different structure of the controller, in which the formation of the P and the D component is laid into the feedback, ensures a smooth course of the manipulated variable at step changes of the reference variable (see the following figure).

In this structure the I component processes the control deviation as the input signal, on the P and the D component only the **negative** controlled variable (factor = -1) is applied.. At the D component, the changeover is carried out in the feedback in the “Control deviation” window via the “D input controller” switch by selecting the negated effective actual value as the input signal. The input variable of the D component can also be selected via the parameter D_EL_SEL of the function block PID_FM.

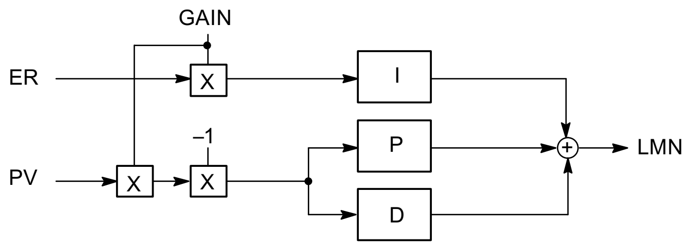


Figure 3-14 Control Algorithm with P and D component in the Feedback Path

P and D components can also be switched individually into the feedback.

Reversing the control

The **reversing** i.e. the changeover of the controller from the classification

- Rising process variable = **rising** manipulated variable
- Rising process variable = **falling** manipulated variable

can be achieved by setting a negative proportional factor on the GAIN parameter. The portent of this parameter value determines the direction of action of the controller.

Examples for the reversal of the controller action are cooling controllers or level controllers.

P control

With P controllers the I and the D parts are switched off. That is, the manipulated variable is also “0” when the control deviation ER = 0. If an operating point is to be ≠ 0, meaning that a numerical value is to be set for the manipulated variable at the control deviation zero, this can be achieved via the operating point:

- Automatic working point:

  When you switch from manual to auto mode, the controller automatically sets the operating point to the value of the current (manual) manipulated variable.

- Operating point not automatic:

  You can configure the operating point parameters.

  Example: Operating point AP = 5% results in a manipulated variable of 5%, with control deviation ER = 0.

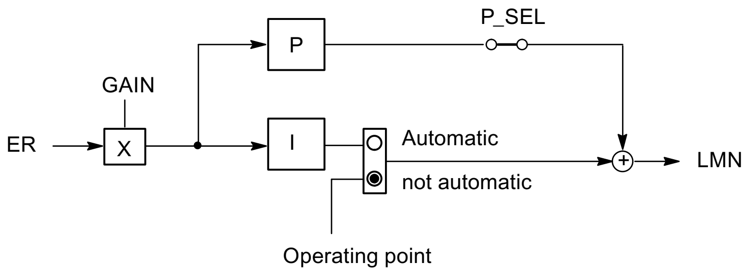


Figure 3-15 Proportional controller with operating point setting via integral action

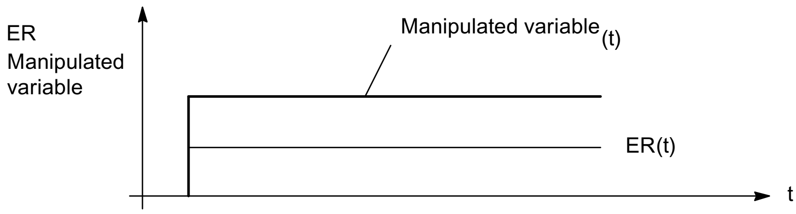


Figure 3-16 Step response of the P controller

PI control

With the PI controller, the D part is switched off. A PI controller adjusts the output variable via the integral action until the control deviation has become ER = 0. However, this only applies if the output variable does not exceed the limits of the manipulating range in the process. If the manipulated value limits are exceeded, the integral action retains the value reached at the limit (anti reset wind-up).

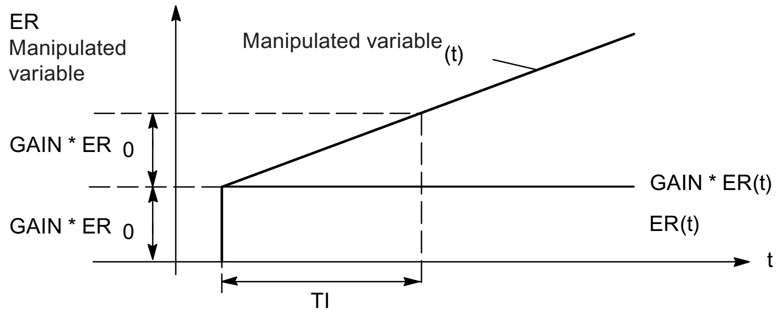


Figure 3-17 Step response of the PI controller

Shock-free manual / automatic toggling

In order to change over ”smoothly” from manual mode to automatic mode of the PI/PID controller, the integrator is tracked in manual mode so that the manipulated variable does not take a step through the proportional and derivative actions during the manual-automatic changeover. An existing control deviation is only compensated slowly via the integral action. If a smooth manual-automatic changeover is not selected, the manipulated variable takes a step which corresponds to the current control deviation from the current manual value during the manual-automatic changeover. An awaiting control deviation is corrected this quickly.

I control

You can deactivate the proportional action in order to realize a pure integral-action control. This is also possible via the parameter P_SEL of the function block PID_FM.

PD control

With the PD controller, the I part is switched off. That is, the output signal = 0 when the control deviation ER = 0. If an operating point is to be ≠ 0, meaning that a numerical value is to be set for the manipulated variable at the control deviation zero, this can be achieved via the operating point:

- Automatic working point:

  When you switch from manual to auto mode, the controller automatically sets the operating point to the value of the current (manual) manipulated variable.

- Operating point not automatic:

  You can configure the operating point parameters.

The PD controller images the input variable ER(t) proportionally to the output signal and adds the differential component formed by the differentiation of ER(t), which is calculated with double precision according to the trapezoid rule (Padé approximation). The time response is determined by the differentiation time constant (derivative action time) TD.

In order to smoothen the signal and to suppress noises a first-order delay (adjustable time constant: TM_LAG) is integrated into the algorithm for forming the derivative action . Usually a small value for TM_LAG is sufficient to achieve the desired effect.

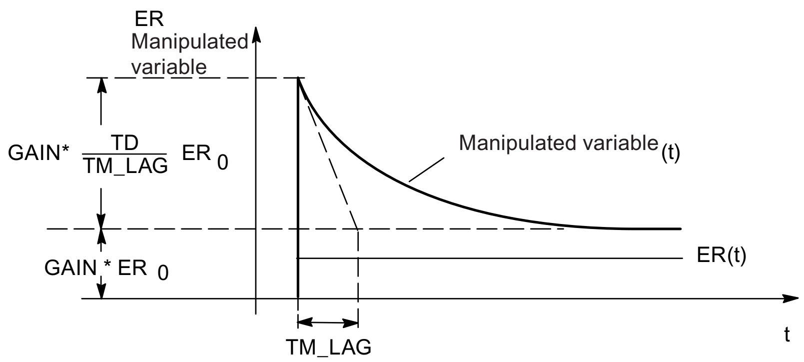


Figure 3-18 Step response of the PD controller

PID control

With PID controllers the P, I and D parts are switched on. A PID controller adjusts the output variable via the integral component until the control difference ER = 0. However, this only applies if the output variable does not exceed the limits of the manipulating range in the process. If the manipulated value limits are exceeded, the integral action retains the value reached at the limit (anti reset wind-up).

The PID controller images the input variable ER(t) proportionally to the output signal and adds the components formed by the differentiation and integration of ER(t), which are calculated with double precision according to the trapezoid rule (Padé approximation). The time response is determined by the differentiation time constant (derivative action time) TD and the integration time constant (reset time).

To smoothen the signal and suppress noises a first-order delay (adjustable time constant: TM_LAG) is integrated into the algorithm for forming the derivative action. Usually a small value for TM_LAG is sufficient to achieve the desired effect.

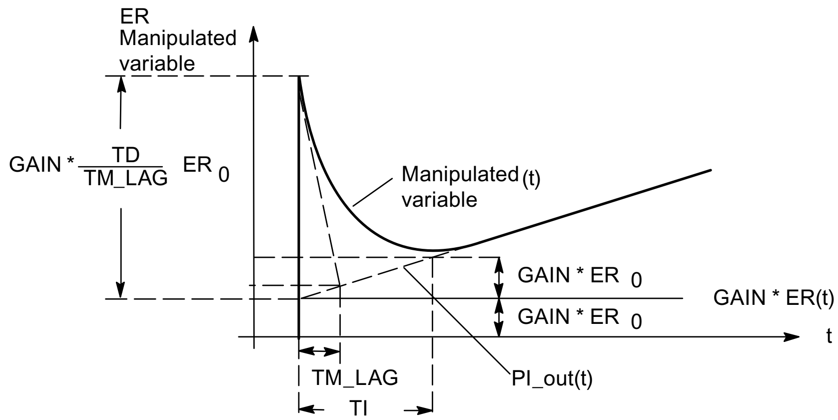


Figure 3-19 Step response of the PID controller

Use and parameterization of the PID controller

The configuration of the PI/PID controller, i.e. finding the ”correct” setting values for the controller parameters, is a great practical problem. The quality of this configuration is of decisive importance for ensuring that the PID closed-loop control functions in accordance with the task and requires either great practical experience, special knowledge or a great amount of time.

The **configuration tool** which houses the **"optimize PIC controller"** function allows the initial setting of the controller parameter by means of adaptive setting up. In this case the process model is determined after a process identification and then the most favorable (optimal) setting values for the controller parameter are calculated from it. This procedure, which is automatic to a great extent, makes it unnecessary for the user to ”trim” the installed PID controller online manually.

Dead zone

A dead band is inserted in the PID controller. In a steady controller state the dead band suppresses the noise component in the signal of the control deviation, which can arise by a higher-frequency noise being superimposed on the controlled or reference variable, and can thus prevent undesired oscillating of the controller output.

The dead band width can be configured. If the control deviation is located within the adjusted dead band width, the value 0 (control deviation = 0) is issued on the output of the dead band. Not until the input variable leaves the sensitivity range does the output change by the same values as the input variable (refer to the following figure).

This results in a corruption of the transferred signal - also outside the dead band. However, this is put up with in order to avoid steps at the limits of the dead band. The corruption corresponds to the value of the dead band width and can therefore be controlled easily.

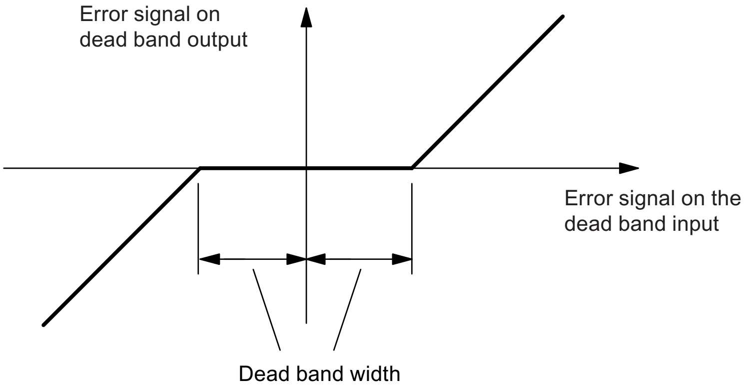


Figure 3-20 Dead zone

See also

Relationship between FB parameters and parameter configuration interface (Page 124)

3.4.1 Controller output

Controller output

The block controller output of the control unit is structured differently with the C controller and with the three operating modes of the S controller.

Various interconnection possibilities are realized for the manipulated value, the tracking input and the safety manipulated value at the controller output (manipulated value changeover).

A limitation is provided in order to ensure that the manipulated value cannot assume invalid values for the process.

The split range function generates from the manipulated value as an input signal two differently standardized output signals - manipulated value A and manipulated value B. This way, for example, two values can be controlled with one manipulated value.

The manipulated value correction prevents a step change at the manipulated value during the changeover from manual to automatic mode.

The manipulated value remains unchanged during the changeover from manual to automatic mode. The control output correction is not active, if a pure P controller with fixed operating point has been implemented (”automatic” is not checked in the PID controller screen).

Controller output of the C controller

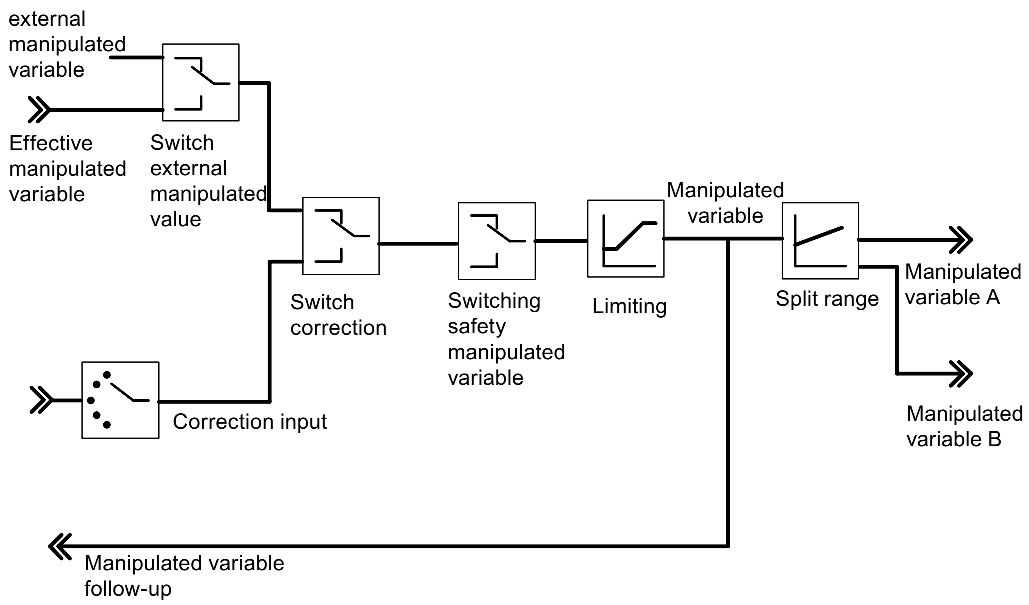


Figure 3-21 Controller output of the continuous-action controller

Split range

The splitrange function allows two control valves to be controlled with one manipulated variable. The split range function generates from the manipulated value LMN as an input signal the two output signals manipulated value A and manipulated value B.

The following figure shows the effect of the parameters for the output manipulated value A.

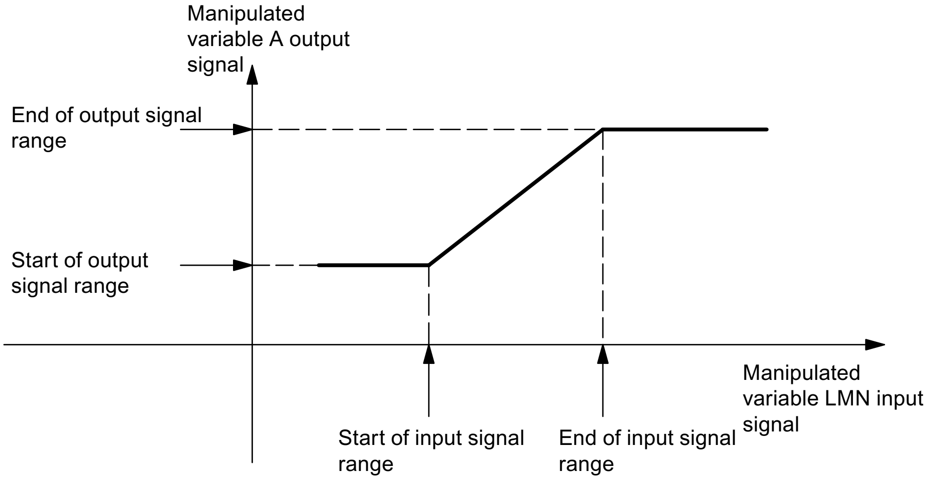


Figure 3-22 Split-range function manipulated value A

The following figure shows the effect of the parameters for the output manipulated value B.

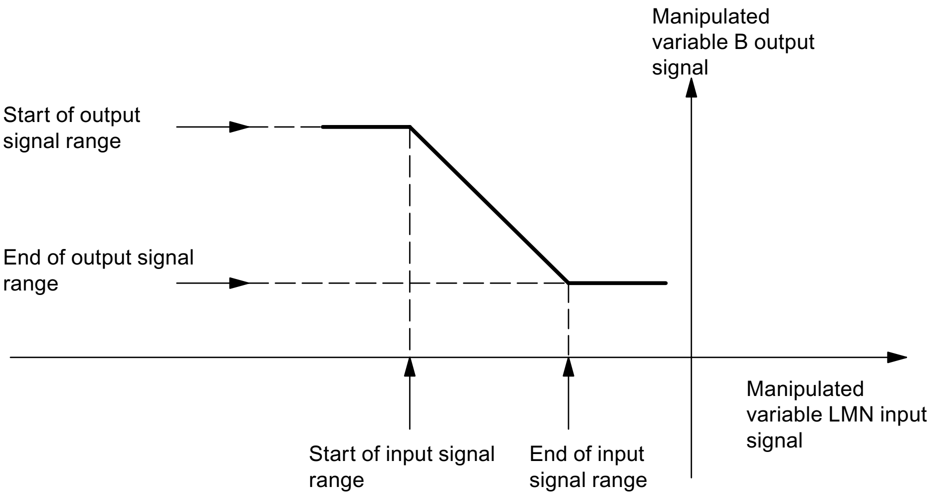


Figure 3-23 Split range function of manipulated value B

The start of the input signal area must be less than the end of the input signal area.

Analog output

At the analog output you can select for each channel which signal is to be output. Usually this is the manipulated value A of a controller. However, you can also select the manipulated value B of a controller or also an analog input value. The latter can be used for the linearization of an analog value. This allows, for example, the signal supplied by a thermocouple to be linearized and converted to 0 V to 10 V.

Controller output of the pulse controller

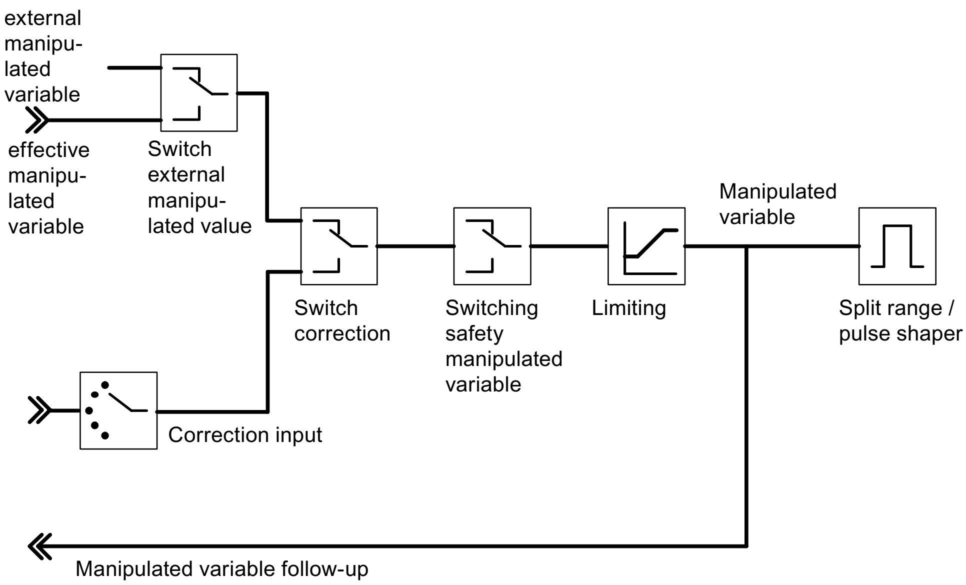


Figure 3-24 Controller output of the S controller (pulse controller mode)

Split range / pulse shaper

The split-range function is the preparation of the analog signal for conversion to a binary signal.

In the case of a two-point controller (e. g. a heating controller), only the manipulated value A is of relevance. The conversion of the manipulate value to the manipulate value A is shown in the following figure. The conversion to a binary output signal is carried out so that the ratio of pulse length to period duration corresponds to the manipulated value A at the assigned digital output.

For example, a manipulated value A of 40% at a period duration of 60 seconds results in a pulse length of 24 seconds and a pause duration of 36 seconds.

The classification of the digital outputs to the controller channels can be found in the table in the section "Inputs of the FM 455 (Page 66)".

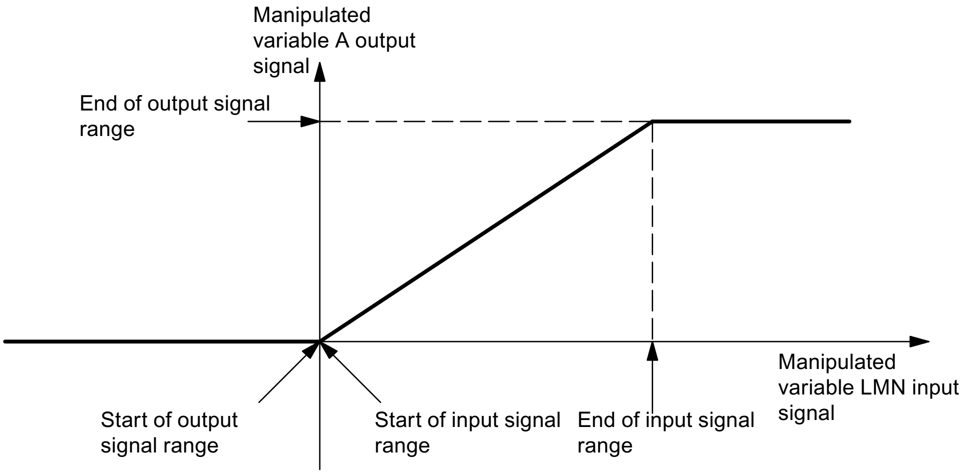


Figure 3-25 Split-range function two-step controllers

In the case of a **three-point controller** (for example, as a heating and cooling controller) the statements above apply for the manipulated value A. The second signal for controlling the cooling is formed via the manipulated value B. The conversion of the manipulated value into the manipulated value A and B is shown in the figure below. The conversion to a binary output signal is carried out so that the ratio of pulse length to period duration corresponds to the manipulated values A and B at the assigned digital outputs.

The classification of the digital outputs to the controller channels can be found in the table in the section "Inputs of the FM 455 (Page 66)".

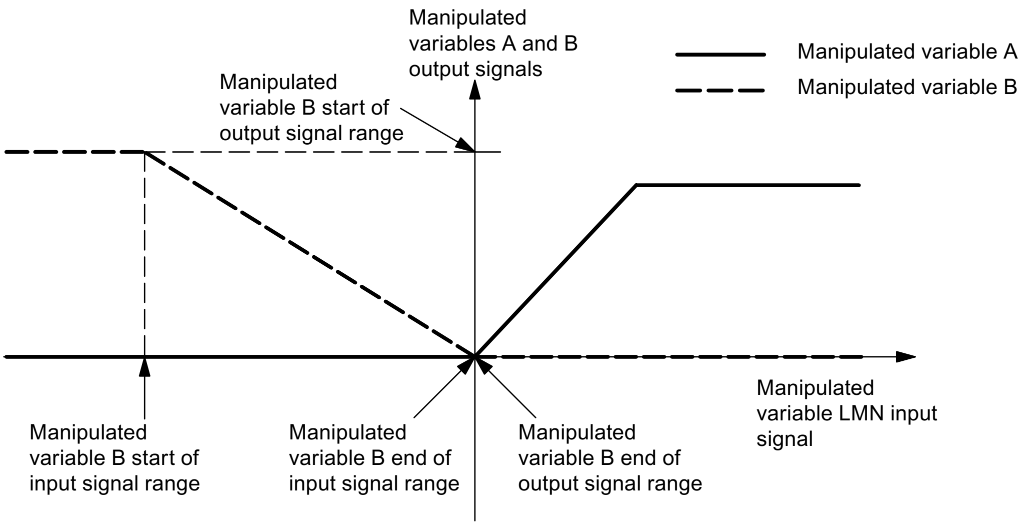


Figure 3-26 Split range function - three-point controllers

Controller output of the step controller

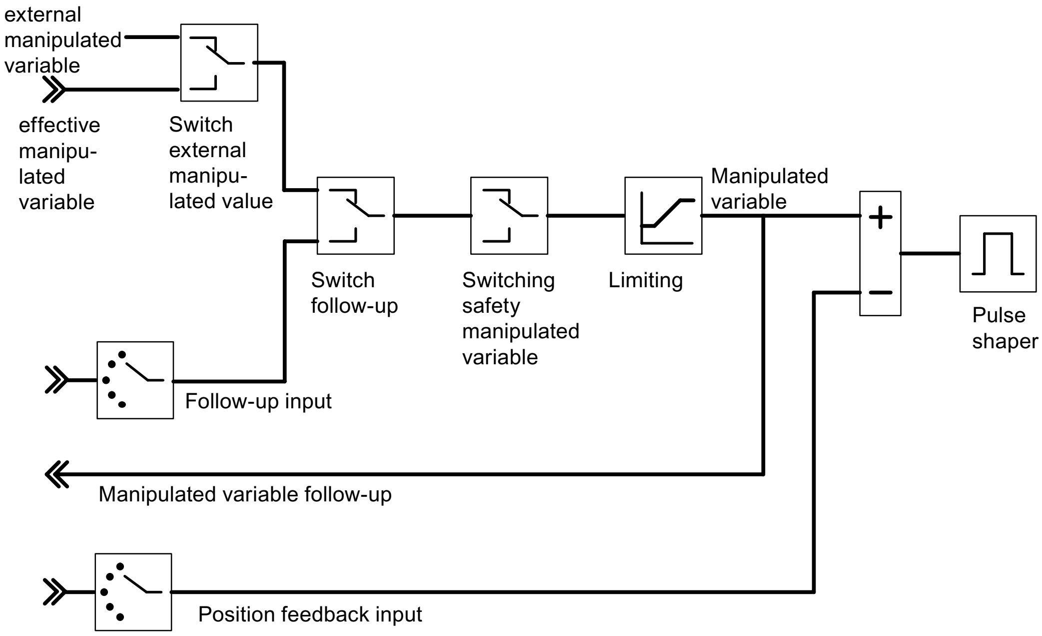


Figure 3-27 Controller output of the step controller (step controller operating mode with position feedback)

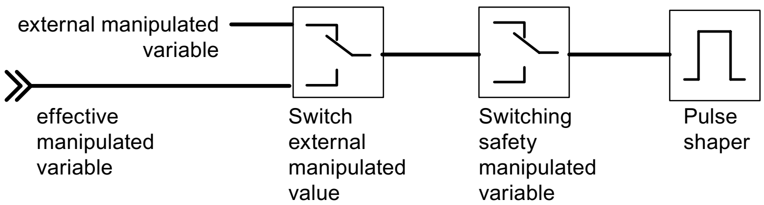


Figure 3-28 Controller output of the step controller (step controller operating mode without position feedback)

At a step controller without analog position feedback the external manipulated value and the safety manipulated value act as follows:

If a value between 40.0% and 60.0% is specified, no binary output is set and the actuating device remains unchanged.

If a value > 60.0% is specified, "Actuating signal high" is output until the checkback "Actuating device at upper limit" is triggered.

If a value < 40.0% is specified, "Actuating signal low" is output until the checkback "Actuating device at lower limit" is triggered.

Functions and parameters of the controller output

The following table lists the functions of the controller output and the setting possibilities.

Table 3- 2 Functions of the controller output and setting possibilities

Functions of the controller output	Settable parameters
Switching external manipulated value	The changeover between external manipulated value and effective manipulated value from the controller can alternatively take place using • A binary value from the function block • A signal that results from the ORing of a binary value from the function block and a digital input
Tracking input	The following alternative settings are available: • The tracking input has the value zero • The tracking input is the conditioned analog value of an analog input
Position feedback input (only step controller)	The following alternative settings are available: • The position feedback input has the value zero • The position feedback input is the conditioned analog value of an analog input
Switching to tracking	The changeover between the manipulated value and the tracking input is carried out alternatively • A binary value from the function block • A signal that results from the ORing of a binary value from the function block and a digital input
Safety manipulated value switching	• Establishing the safety manipulated value • Alternative reaction of the FM 455 during the startup: – The FM 455 changes to closed-loop control – The safety manipulated value is issued as the manipulated value • The changeover to the safety manipulated value can alternatively take place with – A binary value from the function block – A signal that results from the ORing of a binary value from the function block and a digital input • Reaction at a measuring transducer fault of the actual value A: – The operating mode of the controller remains unchanged at the setting "Closed-loop control operation" – With the "manipulated value = safety manipulated value" setting, it changes over to the safety manipulated value • Reaction at a measuring transducer fault of an analog input: – The operating mode of the controller remains unchanged at the setting "Closed-loop control operation" – With the "manipulated value = safety manipulated value" setting, it changes over to the safety manipulated value
Manipulated value boundary	Upper and lower boundary (cannot be switched off)
Formation of the split range manipulated value	• In / out (only C controllers) • Start and end value - input signal • Start and end value - output signal
Pulse shaper (only S controllers)	• Motor control time • Minimum duration of pulse • Minimum cycle duration

3.5 Outputs of the FM 455

Analog outputs of the FM 455 C

You can carry out the following specifications for each analog output of the FM 455 C by means of configuration:

- Signal Selection
- Signal type

The outputs are configured in the screens ”Signal selection analog output” and ”Signal type analog output”.

Signal Selection at the Analog Outputs

With the signal selection you can specify which signal value is output at the analog output.

The following signal values can be configured:

- the value zero
- The conditioned analog value of one of the 16 analog inputs
- The manipulated value A of one of the 16 controller channels
- The manipulated value B of one of the 16 controller channels

Signal Selection at the Analog Outputs

You can determine the signal type for each analog output.

The following signal types can be configured:

- Current output 0 to 20 mA
- Current output 4 to 20 mA
- Voltage output 0 V to 10 V
- Voltage output -10 V to 10 V

Digital outputs of the FM 455 S

The digital outputs of the FM 455 S are used to control integrating or non-integrating final controlling elements.

The following table shows the assignment of the digital outputs to the controller channels and their meaning:

Table 3- 3 Assignment and Meaning of the Digital Outputs

Controller channel	Digital outputs assigned to the controller channel	Meaning of the digital outputs at the step controller	Assignment of the Digital Outputs at the Pulse Controller
1	1	Open	Manipulated value A
	2	Close	Manipulated value B
2	3	Open	Manipulated value A
	4	Close	Manipulated value B
3	5	Open	Manipulated value A
	6	Close	Manipulated value B
4	7	Open	Manipulated value A
	8	Close	Manipulated value B
5	9	Open	Manipulated value A
	10	Close	Manipulated value B
6	11	Open	Manipulated value A
	12	Close	Manipulated value B
7	13	Open	Manipulated value A
	14	Close	Manipulated value B
8	15	Open	Manipulated value A
	16	Close	Manipulated value B
9	17	Open	Manipulated value A
	18	Close	Manipulated value B
10	19	Open	Manipulated value A
	20	Close	Manipulated value B
11	21	Open	Manipulated value A
	22	Close	Manipulated value B
12	23	Open	Manipulated value A
	24	Close	Manipulated value B
13	25	Open	Manipulated value A
	26	Close	Manipulated value B
14	27	Open	Manipulated value A
	28	Close	Manipulated value B
15	29	Open	Manipulated value A
	30	Close	Manipulated value B
16	31	Open	Manipulated value A
	32	Close	Manipulated value B
Open = Open the actuating element Close = close the control device			

3.6 Functional mechanisms and data storage in the FM 455

Overview

This chapter covers important functional mechanisms and the principle of data storage in the controller module.

The parameter configuration interface of the programming device/PC can be used to carry out the following actions on the controller module

- parameter configuration,
- optimizing,
- operator control and monitoring.

The PID_FM function block (FB) that belongs to the scope of delivery can be used to connect the module with a user program.

Parameterization

The FM 455 is configured by means of a parameter configuration interface on the programming device (refer to the chapter "Parameterization of the FM 455 (Page 113)"). All the parameter data is saved in an SDB on the PG.

Note

You can only download the SDB parameter configuration data via an online connection between the PG and the CPU to the CPU and to the FM 455 if the CPU is in STOP mode. This is only possible via the HW config. The parameter configuration interface must have been closed.

The parameters are transferred from the SDB in the CPU to the FM 455 during every startup and during the transition of the CPU from STOP to RUN.

Downloading the parameters directly to the FM 455

You can also download the parameters via the parameter configuration interface directly to the FM 455 so that you do not have to close the parameter configuration interface and set the CPU to STOP mode several times consecutively while testing your configuration during setting up. Please note that the thus downloaded parameters are overwritten by the parameters from the SDB of the CPU when the CPU is started up and during the CPU transition from STOP to RUN. An FB call can also overwrite the parameters downloaded directly from the parameter configuration interface.

Downloading directly to the FM 455 therefore only makes sense in order to test the configuration during the setup.

If you change parameters via the parameter configuration interface and then download them directly to the FM 455, jumps can occur in the manipulated value course. To achieve a controlled course of the manipulated value, we recommend the following procedure:

1. Switch to manual mode (for example via the loop display).
2. Change the parameters.
3. Download directly to the FM 455
4. Switch to manual mode (for example via the loop display).

Flow of Data when Configuring via the Parameter Configuration Interface

The following figure shows the path of the configuration data from the parameter configuration interface to the FM 455.

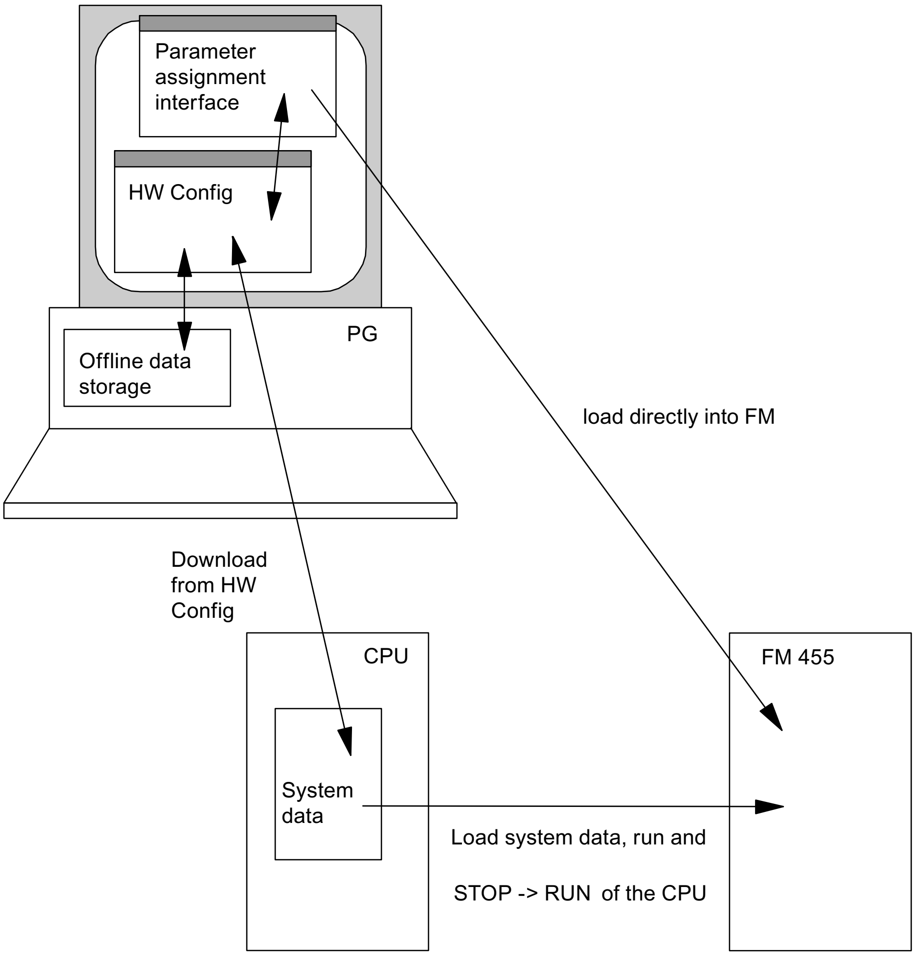


Figure 3-29 Configuring the FM 455 via the PG and via the CPU

Connect the FM 455 with the user program

You have to use the FB PID_FM if you want to change the controller parameters (for example, controller gain, integration coefficient) of the FM 455 from the user program or by operator control on the PG. Assign an instance data module to this FB for each controller channel which you want to use. If the parameter LOAD_PAR is set when the FB PID_FM is called by the user program, all the controller parameters of the FB are transferred to the FM 455. Controller parameters are all the parameters that lie in the instance data block after the cont_par variables.

The parameters in the instance DB have a default. These default settings can be changed with the STL/LAD Editor.

Note

You must first call the FB PID_FM once with COM_RST = TRUE in the CPU startup so that the parameters which you do not want to change are not overwritten with the default values from the instance DB. The FB PID_FB then reads the parameters - which were transferred from the CPU to the FM beforehand - from the FM 455 and saves them in its instance DB. You can now change individual parameters and transfer all the parameters to the FM 455 with LOAD_PAR = TRUE.

Please note that the parameters in the FM 455 are overwritten by the values from the system data whenever the CPU is started up (transition from STOP to RUN).

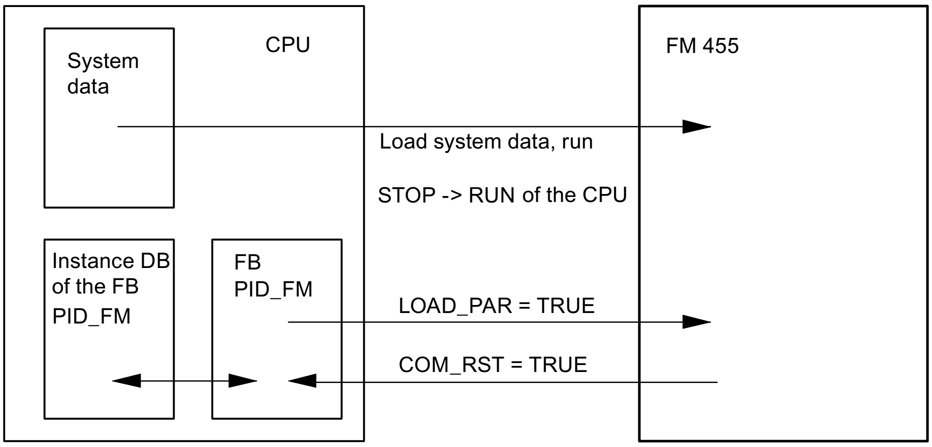


Figure 3-30 Configuration of the FM 455 via the System Data and via the FB PID_FM

The operating parameters (for example, setpoint value, manual manipulated value) of the FM 455 are transferred cyclically from the FB PID_FM to the FM 455. Operating parameters are all the parameters that lie in the instance data block between the op_par and the cont_par variables. In order for the data transfer to be possible without a high run time in the CPU, transferring is normally carried out via direct periphery accesses, not via the SFC WR_REC. The data are multiplexed since only four bytes per channel are available in the periphery address area of the module. It can therefore take up to three cycles of the CPU or of the FM 455 until the operating values have been transferred to the FM 455 - the respectively longer cycle is decisive.

If you set the parameter LOAD_OP = TRUE, the operating parameters are then transferred in one program cycle via the SFC WR_REC to the module. This however costs more time (refer to chapter "Technical Specifications of the Function Blocks (Page 257)").

The process values (for example, actual value, manipulated value) can also be read by the FB PID_FM via direct periphery accesses. This transmission does not require much run time, however the following functional restrictions result. If the parameter READ_VAR = TRUE is set, then the process values are read from the FM 455 by means of the SFC RD_REC. This however costs more time (refer to chapter "Technical Specifications of the Function Blocks (Page 257)").

Functional restrictions when READ_VAR is not set:

- The variables SP (setpoint variable from the FM), ER (control deviation), DISV (disturbance variable), LMN_A and LMN_B are not updated.
- The data are multiplexed. The actual value and manipulated value and the binary displays are not updated again until after four calls of the block.
- If the setpoint value and the manual manipulated variable were operated via the OP, these operating values are not updated (read out of the FM) by the FB during the CPU startup.

Reference

Further information about using instance DBs is available in this documentation in the sections "Integrating the FM 455 with the user program (Page 117)" and "Pin assignment of the DBs (Page 177)".

3.6.1 Operation and Monitoring of the FM 455

Operator Control and Monitoring of the FM 455 by Means of the OP via the FB PID_FM

Operator control and monitoring of the FM 455 is possible via the FB PID_FM.

If one of the following parameters ”Operating setpoint value SP_OP, Operating manipulated variable LMN_OP and the corresponding switches SP_OP_ON and LMNOP_ON was changed by operation via the OP, the FB PID_FM takes over these values from the FM after the CPU has been started up, if the parameter READ_VAR = TRUE is set.

Operator Control and Monitoring of the FM 455 by Means of the OP via MPI

A maximum of three connections from the FM 455 to the OPs can be implemented.

Operator control of the FM 455 with the OP is only possible in the STOP mode of the CPU or at a CPU failure.

Monitoring of the FM 455 with the OP is always possible.

The variable interface of the FM 455 contains 16 data blocks with the block numbers 101 to 116 for the controller channels 1 to 16 (refer to the following figure). These data blocks are described in Chapter "Assignment of the DBs for operating and monitoring via the OP (Page 210)".

Note

The contents of the data blocks 101 to 116 do not automatically reflect the parameter value effective at the FM 455. Parameters changed with the OP are only transferred to the FM 455 after the operating bits LOAD_PAR or LOAD_OP have been set.

If you change a parameter using OP operation without setting the corresponding operating bit, the changed parameter value is entered in the data block, but the FM 455 continues to operate internally with the unchanged old value of the parameter.

After the operating bits have been set and the parameters have been transferred to the FM 455, the operating bits LOAD_PAR or LOAD_OP are reset by the FM 455.

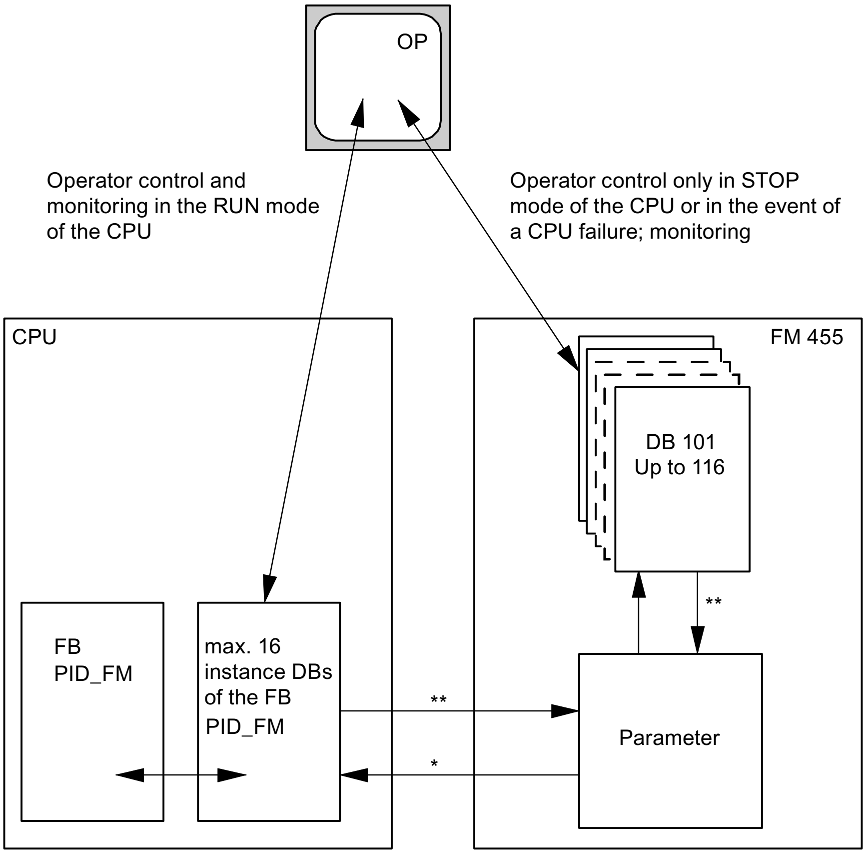


Figure 3-31 Operation and Monitoring of the FM 455

- * controlled by the READ_VAR parameter of the instance DB
- ** controlled by the LOAD_OP and LOAD_PAR parameters

See also

Overview of the function blocks (Page 117)

Instance DB of the FB PID_FM (Page 177)

3.7 Characteristics of the FM 455

Overview

The following topics contain information about

- The processing sequence and sampling time
- Rules for operation
- Startup reaction
- Backup mode
- Firmware update

Sequence of execution

The analog inputs and the controller channels of the FM 455 are combined into two groups of eight each:

Group 1: Analog input 1 to 8 and Controller Channel 1 to 8

Group 2: Analog input 9 to 16 and Controller Channel 9 to 16

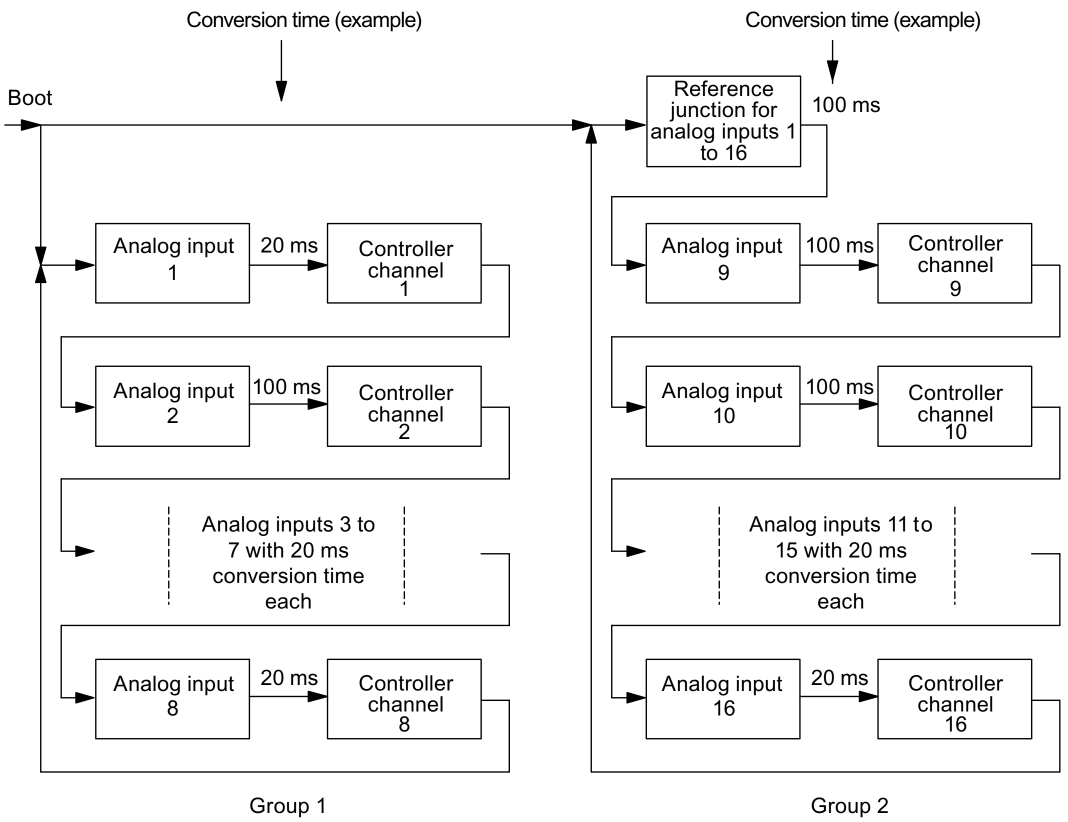


Figure 3-32 Processing sequence of the FM 455

Group 1 and group 2 are processed in parallel. Processing within each group is sequential.

Within each group every controller channel is processed directly after the analog input with the same number has been processed and conditioned. This is followed by the processing of the analog input with the next higher number in the same group, etc.

The reference junction is only processed in group 2 after controller channel 16.

Sampling time

Within each group the common sampling time of all the controllers of the FM 455 results from the sum of the conversion times of the individual analog inputs. The conversion time for the reference junction, if used, has to be added for the controller channels of group 2 (Channels 9 to 16).

The conversion time of an analog input depends on the resolution, the power frequency and controller type used (refer to the following table):

Table 3- 4 Conversion Time of an Analog Input

Resolution	Line frequency	Controller type	Conversion Time of an Analog Input
12 bits	60 Hz	No temperature controller	16 2/3 ms
12 bits	50 Hz	No temperature controller	20 ms
14 bits	50 or 60 Hz	No temperature controller	100 ms
12 or 14 bits	50 or 60 Hz	Temperature controller	100 ms

If an analog input is not processed, the identically-numbered controller will also not be processed (conversion time = 0).

There are no additional conversion times for the analog outputs. The analog output values of the FM 455 are output immediately after calculation of the corresponding initial values.

The following table contains further rules for the conversion time of the reference junction input.

Table 3- 5 Rules for the Conversion Time

<table>
<tr><th>If there is ...</th><th>then ...</th></tr>
<tr><td>a resolution of 12 bits was selected at all the analog inputs,</td><td>the reference junction requires the same conversion time as an analog input.</td></tr>
<tr><td>the higher resolution of 14 bits was selected at even only one analog input,</td><td rowspan="2">the reference junction requires a conversion time of 100 ms.</td></tr>
<tr><td>One of the controllers was configured as a temperature controller.</td></tr>
</table>

The sampling time is indicated in the parameter configuration interface:

Command button: **Module parameters**

In the example in the preceding figure, the following sampling times result for each controller (at 50 Hz power frequency):

For the controllers of group 1 (channelsl 1 to 8):
$t_{sampling}$ = 20 ms + 100 ms + 6 * 20 ms = 240 ms

For the controllers of group 2 (channelsl 9 to 16):
$t_{sampling}$ = 3 * 100 ms + 6 * 20 ms = 420 ms

Particularly short sampling times can be reached for controller channels 1 to 8, since the conversion time of the reference junction does not have to be included.

The following figure shows an example with five controller channels used from Group 1 and four controller channels used from Group 2.

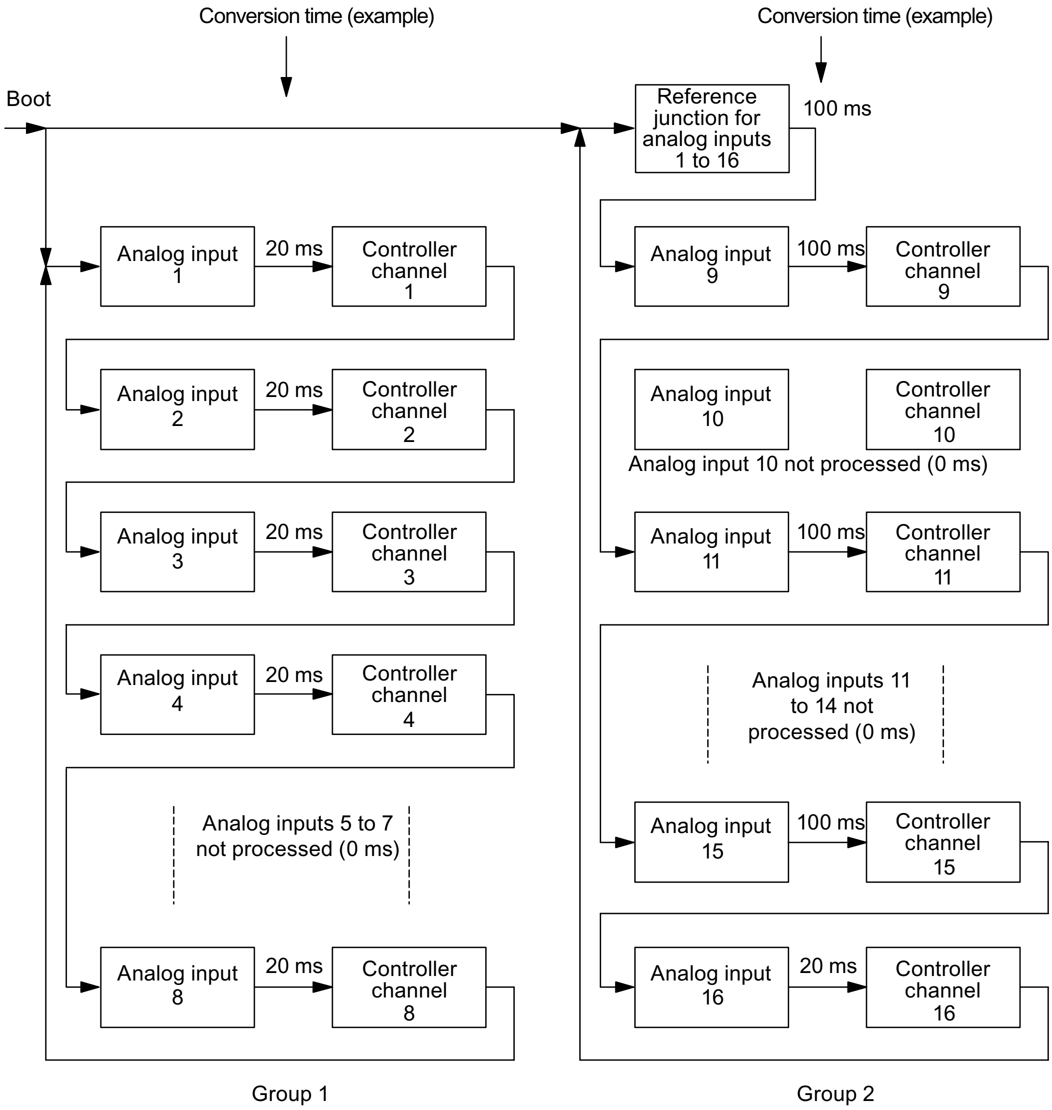


Figure 3-33 Processing sequence of the FM 455

In the example in the preceding figure, the following sampling times result for each controller (at 50 Hz power frequency):

For the controllers of group 1 (channels 1, 2, 3, 4 and 8):
$t_{sampling}$ = 5 * 20 ms = 100 ms

For the controllers of group 2 (channels 9, 11, 15 and 16):
$t_{sampling}$ = 4 * 100ms +20 ms = 420 ms

Rules for Operating the FM 455

The following rules can be summarized for operation with the FM 455:

- The controllers of the FM 455 can be cascaded freely. This means that you can switch the manipulated value of a controller channel to the setpoint value of another controller channel.
- The processing of a controller channel occurs immediately after the processing of the identically numbered analog input.

  Bearing in mind short dead times, should a controller use several analog inputs, you should select the controller channel that corresponds to the highest analog input number being used.

  Example: A controller requires the signals of the analog inputs 1, 2 and 3. The smallest dead time results if controller no. 3 is selected.
- If you select the setting ”Analog input is not processed” at an analog input, the controller channel with the same number is not processed either. This means that no additional sampling time will be required for this analog input.
- If the reference junction input is used, it requires the same conversion time as the analog input with the highest conversion time.
- The sampling time of a controller is the sum of the conversion times of the analog inputs used in the same group. The conversion time for the reference junction input, if used, has to be added for controller channels 9 to 16 (group 2).

Startup reaction

During the startup the FM 455 first takes over the current parameters from its EEPROM and begins to control with these parameters. These are overwritten by the CPU with the parameters from the system data as soon as the P bus connection between the CPU and the FM 455 has been established. If the system data do not contain any parameters for the controller, the module continues to control with the parameters contained in the EEPROM. The FM 455 does not know a change to default parameters.

The following configurable possibilities exist for the **manipulated value** at a restart after a failure of the power supply:

- The controller begins with the safety manipulated value.

  This setting remains effective until it is reversed by the user program via the function block.
- The controller changes over to closed-loop control.

The following configurable possibilities exist for the **setpoint value** at a restart after a failure of the power supply:

- The last setpoint value valid remains effective.
- The system changes over to the safety setpoint value.

  This changeover only remains effective until the setpoint value is specified by the user program via the function block. Otherwise the setpoint value is specified by an analog input or controller output depending on the configuration.

Characteristics of the FM 455 at an Own Power Supply

If the FM 455 has its own 24-V power supply, observe the following points:

- Startup without 24-V power supply at the FM 455:
  - The CPU does not change to RUN if the run-time system error OB (OB 85) does not exist.
- Failure of the 24-V power supply of the FM 455 during RUN mode:
  - The CPU changes to STOP if the insert/remove-module interrupt OB (OB 83) does not exist.
  - The CPU changes to STOP if the periphery access interrupt OB (OB 122) does not exist.
  - The communication link of the CPU to the FM 455 is interrupted. In the FB PID_FM the output parameter RET_VALU contains an error value.

Backup mode

If the CPU goes into STOP mode or fails or the connection of the FM 455 to the CPU fails, the FM 455 changes over to backup mode and continues to control with the parameters applying at the time of the fault. The FM 455 uses either the last setpoint value or the safety setpoint value depending on the configuration.

Firmware update

In order to extend functions and remedy faults it is possible to download firmware updates to the operating system memory of the FM 455. This functionality is described in the online help of the parameter configuration interface.

3.8 Parameter Optimization at a Temperature Controller

Demands on the process in the case of temperature controllers

The process should fulfill the following requirements in order to achieve optimal control using the temperature controller:

- At bath heatings the liquid to be heated has to be mixed thoroughly.
- In case of bath-in-bath control systems both liquids have to be mixed thoroughly. At the same time good heat transitions between all the heat-transferring media have to be ensured. In the case of materials with poor heat-transferring properties large transfer surfaces should ensure good heat transportation.
- In case of room temperature control systems thorough mixing (for example with fans) has to be ensured.
- The controlling system gain may not exceed the factor of 3.
- The delay time may not exceed 3% of the recovery time.
- The temperature to be controlled should change by a maximum of 1‰ of the specified maximum temperature at the maximum manipulated value output within the sampling time of the controller.

Classification of the Controlled Systems

A controlled system or a process to be controlled is characterized by parameters such as the heat output, the heating mass or the heating capacity of the medium to be heated. With regard to the fuzzy controller a difference is made between "critical" and "non-critical" temperature controlled systems as follows: The control system becomes increasingly critical:

- The greater the heat output,
- the greater the heating capacity of the heating,
- The lower the heating capacity of the medium to be heated,
- the greater the heat transition resistance,
- the smaller the heat transfer surface.

After a manipulated value step change has been applied to the controlled system, it reacts with a step response. The controlled system can also be classified on the basis of this step response: The control system becomes increasingly critical the greater the ratio t_u / t_a is and the greater the controlled system gain is. With t_u / t_a < 1/10 you have a non-critical control section, refer to the following figure.

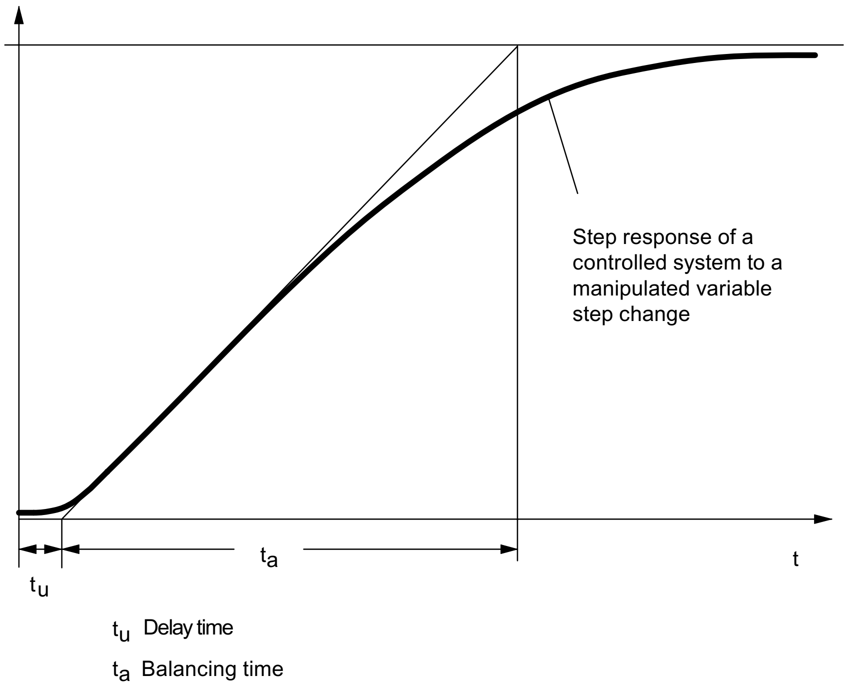


Figure 3-34 Step response of a controlled system to a manipulated value step change

Parameter Optimization at a Temperature Controller

Parameter optimization is based on a self-optimizing fuzzy controller.

In order for the temperature controller to operate optimally, the controlled system has to be identified. To this purpose the identification has to be activated by means of the FUZID_ON = 1 parameter in the instance DB of the PID_FM function block and a setpoint value step change of ≥12% of the maximum setpoint value carried out.

The identification of the controlled system begins with a monitoring phase during which no heat output takes place. The duration of the monitoring phase is as follows:

- Monitoring phase continuous controller: Approx. 1 min
- Monitoring phase step controller: Approx. 1 min + 1/2 x actuating time of final control element

This time is used in order to determine temperature trends in the heating medium. Afterwards the maximum heating output of 100% is output. This is visible at the LMN output parameter in the instance DB of the PID_FM function block.

The range of the first 4% of the temperature increase of the setpoint value range is used for the identification, whereby information about the process response is obtained at 1% and 4% respectively of the temperature increase on the basis of the time that has passed.

The identification is complete when the heating output becomes less than 100%. This behavior can be used, for example, to deactivate the identification via the user program. After the identification phase the controller continues to operate with the determined parameters.

A renewed identification is carried out at every further setpoint value step change ≥12% unless the identification has been deactivated again with FUZID_ON = FALSE.

If the setpoint value step change is not adjusted and if the heating output remains permanently at zero, the identification has been terminated unsuccessfully, meaning that the controller cannot control the connected controlled system.

Preconditions for the Identification

You have to ensure as far as possible that the controlled system has settled (no heating-up or cooling-down process) or is changing slowly and monotonously before the identification is carried out. The criterion can be that the temperature change is to approach a straight during a period of one minute. At faster processes this requirement is particularly relevant.

Since the manipulated variable zero is output for approx. one minute by the controller at the beginning of identification, the temperature to be controlled has to lie near the ambient temperature.

How To Start Identification

In order to start identification you first have to switch the controller to the optimization mode. This is done by setting the FUZID_ON bit in the instance DB of the PID_FM FB, either by the user program or via the parameter configuration tool:

Call: Test >Controller optimization

The identification is started by a positive setpoint value step change, whereby the following conditions have to be fulfilled:

- 1. Condition: The minimum step change size: Setpoint value step change > 5 degrees
- 2. Condition: The setpoint value after the step change:

  Setpoint value $_{after}$ > Actual value + Setpoint value limit x 0.12
  with setpoint value limit = Upper setpoint value limit of the controller

It is also possible to restart the identification by reducing and then increasing the setpoint value. The setpoint value has to fulfill Condition 2 after it has been increased.

Completing the Identification

As long as the bit FUZID_ON = TRUE, the next identification is started whenever the setpoint value step change is sufficiently large. We therefore recommend that the optimization mode be deactivated immediately after the identification has been completed (FUZID_ON = FALSE).

Information about the state of the identification is available through the IDSTATUS parameter of the CH_DIAG FB. More information on this can be found at the end of this section under "Controller State Information".

Canceling Identification

Identification can be canceled in the following cases:

- By the controller if a "critical" controlled system is identified. After canceling the controller is in the error state. This state is indicated by the fact that the manipulated variable is reset permanently by the controller. This is also not changed by deactivating the optimization. The error state is deleted by starting a new identification.

  Information about the state of the identification is available through the IDSTATUS parameter of the CH_DIAG FB. More information on this can be found at the end of this section under "Controller State Information".
- By the operator by generating a negative setpoint value step change, whereby the setpoint value must lie below that of Condition 2 (see above "How To Start identification").

Note

Deactivation of the optimizing mode with FUZID_ON=0 before identification has been completed does not stop the identification. An identification process that has been started continues to run under all circumstances – with the exception of a negative setpoint value step change.

Controller behavior with different control sections

Problems do not arise in case of an "uncritical" controlled system, neither during identification nor during controlling.

The identification of a controlled system that is "too critical" is cancelled. Controlling of an identified "critical" controlled system is carried out very "carefully" or slowly.

Controller State Information

The IDSTATUS parameter of the FB CH_DIAG function block supplies information about the identification state.

X				A				I				F			
2^{15}															2^{0}

Figure 3-35 IDSTATUS parameter of the CH_DIAG FB

The IDSTATUS parameter contains the four hexadecimal values X, A, I and F. They have the following meaning:

X:	Without meaning (always 0)
A:	Action number:
	0 = Manual operation (or no closed-loop control operation);
	2 = Closed-loop control;
	4 = Optimization activated (FUZID_ON = true);
	6 = Transition state from manual operation to 2 or 4;
I:	Display "Identification running" and "Parameters determined, but not yet stored in EEPROM"
	0 = Identification not running, no new parameters determined
	1 = Identification running, no new parameters determined
	2 = Identification not running, new parameters determined, but not yet stored in EEPROM
	3 = Identification running, new parameters determined, but not yet stored in EEPROM
F:	Error number:
	0 = No error
	4 = Excessive step change of the actual value during the identification
	5 = Ratio of delay time to system time constant too large or strongly non-linear behavior of the controlled system.
	6 = Temperature drop or rise during identification start too large. System not settled sufficiently

Installing and disassembling the FM 455 4

4.1 Prepare for installation

Configuring the mechanical structure

Refer to manual /1/ for possibilities for the mechanical structure and how to proceed when configuring. The following offers a little extra information.

- The function module FM 455 occupies two slots. It can be installed in an S7 400 central controller or expansion device at all slots that are not intended for a power supply module or a receive IM.
- The maximum number is restricted only by the memory requirement of the software in the CPU that is required for the communication with the FM 455.

Determining start addresses

The start addresses of the FM 455 are required for the communication between the CPU and the FM 455. The start addresses must be entered in the instance DB of the required FBs (see chapter "Integrating the FM 455 with the user program (Page 117)" and chapter "Pin assignment of the DBs (Page 177)").

The entry takes place either with the aid of the STL / LAD Editor or from the user program.

You specify the start addresses of the FM 455 under STEP 7.

Important safety information

For the integration of an S7 400 with an FM 455 in a system or unit, there are important rules that you must observe. These rules and directives are explained further in the /1/ manual.

4.2 Installing and removing the FM 455

Rules

You do not need to take any particular safety measures (ESD guidelines) to install the FM 455.

Tools required

To install and remove the FM 455 you require a 3.5 mm cylindrical screwdriver.

Before installing

Check before installing the FM 455 whether you have to change the measuring range modules on the side of the module. Using these measuring modules, you can adapt the FM 455 to various sensors (see chapter "Setting the Measurement Type and the Measuring Ranges of the Analog Input Channels (Page 157)").

Installing the FM 455

The following describes how you install the FM 455 in a subrack. You will find further information on installing modules in the /1/ manual.

1. Remove the cover from the slot in which you would like to insert the FM 455.
2. Hang the FM 455 and push it downwards.
3. If you feel resistance when pushing in the module, lift up the module slightly and then continue with the pushing motion.
4. Use the two fixing screws to screw down the FM 455 (tightening torque 0.8 ... 1.1 Nm).
5. Label the FM 455 with its slot number. Use the number wheel supplied with the rack for this purpose.
6. Refer to the /1/ manual to find out the system for carrying out the numbering and for the slot numbers.

Removing the FM 455 or replacing the module

The following describes how you remove the FM 455. You will find further information on removing modules in the /1/ manual.

1. Switch off the supply voltage L+ on the front connector.
2. Remove the fixing screw of the front connector and then pull it off.
3. Remove the module fixing screws.
4. Swing the module out.
5. If necessary, install the new module.
6. Put the front connector back on and then screw it back down.
7. Switch on the supply voltage L+ on the front connector.

Further information

You will find further information on installing and removing modules in the /1/ manual.

Wiring the FM 455

5

5.1 Terminal assignment of the front connector

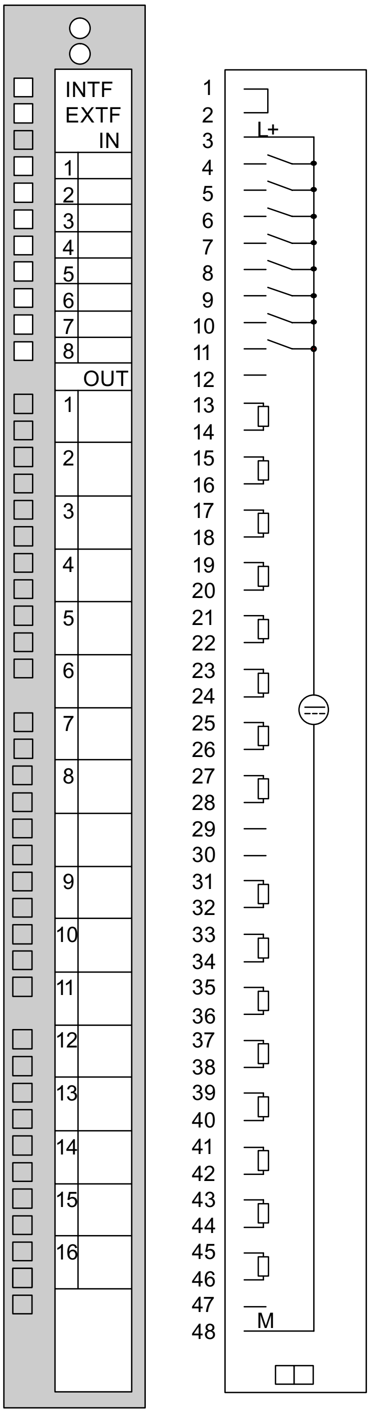
FM 455 C front connector

The two 48-pin front connectors of the FM 455 C connect the digital inputs, the analog inputs and outputs and the supply voltage of the module.

The following figures show the connection diagrams, the connector pinout of the front connector is shown in the following table.

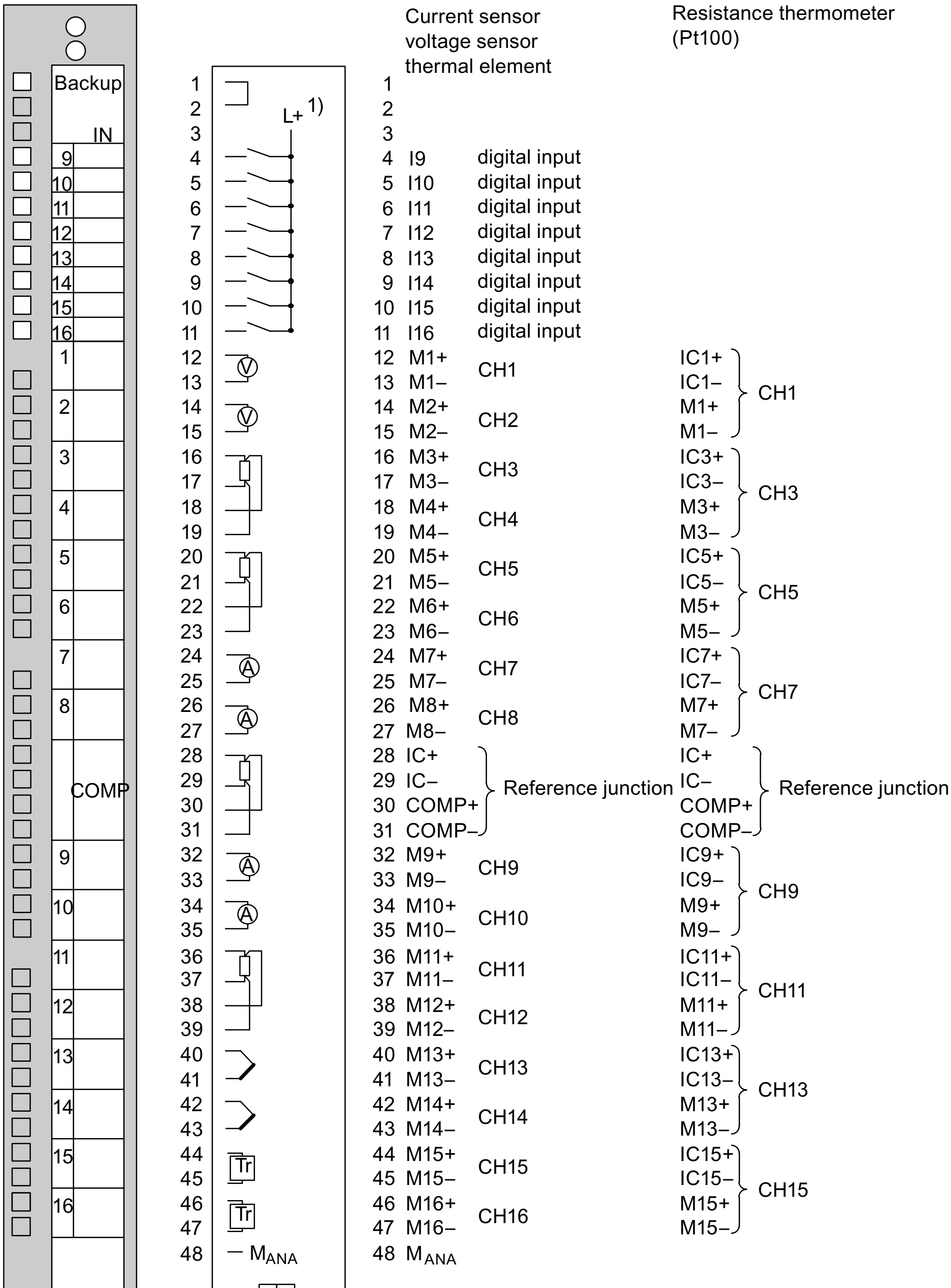
The connection diagram of the FM 455 C, right-hand front connector, shows an example of how the various sensors - current sensors, voltage sensors, thermocouples and resistance thermometers (Pt100) - can be connected to the analog inputs CH1 to CH16. A different assignment of the sensors to the analog inputs is naturally also possible. However, you can only connect sensors of the same type to two adjacent analog inputs (CH1 and CH2, CH3 and CH4, etc.), since these analog inputs are adapted to the sensor type by means of a common coding key (see chapter "Setting the Measurement Type and the Measuring Ranges of the Analog Input Channels (Page 157)").

Please note that resistance thermometers (Pt100) require two adjacent analog inputs for their connection and that they can only be connected in the way shown in the connection diagram for the FM 455 C, right-hand front connector, to the analog inputs CH1, CH3, CH5, CH7, CH9, CH11, CH13 and CH15.



1		
2		
3	L+	supply voltage 24V
4	I1	digital input
5	I2	digital input
6	I3	digital input
7	I4	digital input
8	I5	digital input
9	I6	digital input
10	I7	digital input
11	I8	digital input
12		
13	Q1	analog output 1
14	M_{ANA}	control point of analog circuit's
15	Q2	analog output 2
16	M_{ANA}	control point of analog circuit's
17	Q3	analog output 3
18	M_{ANA}	control point of analog circuit's
19	Q4	analog output 4
20	M_{ANA}	control point of analog circuit's
21	Q5	analog output 5
22	M_{ANA}	control point of analog circuit's
23	Q6	analog output 6
24	M_{ANA}	control point of analog circuit's
25	Q7	analog output 7
26	M_{ANA}	control point of analog circuit's
27	Q8	analog output 8
28	M_{ANA}	control point of analog circuit's
29		
30		
31	Q9	analog output 9
32	M_{ANA}	control point of analog circuit's
33	Q10	analog output 10
34	M_{ANA}	control point of analog circuit's
35	Q11	analog output 11
36	M_{ANA}	control point of analog circuit's
37	Q12	analog output 12
38	M_{ANA}	control point of analog circuit's
39	Q13	analog output 13
40	M_{ANA}	control point of analog circuit's
41	Q14	analog output 14
42	M_{ANA}	control point of analog circuit's
43	Q15	analog output 15
44	M_{ANA}	control point of analog circuit's
45	Q16	analog output 16
46	M_{ANA}	control point of analog circuit's
47		
48	M	mass of the supply voltage

Figure 5-1 Connection diagram for the FM 455 C, left-hand front connector.



1) Connection to L+ of the left-hand front connector

Figure 5-2 Connection diagram for the FM 455 C, left-hand front connector.

Table 5- 1 Terminal assignment of the front connector of the FM 455 C

Left front connector				Right front connector			
Connection	Analog output	Name	Function	Connection	Analog input	Name	Function
1	–	–	–	1	–	–	–
2	–	–	–	2	–	–	–
3	–	L+	Power supply 24 V	3	–	–	–
4	–	I1	Digital input	4	–	I9	Digital Input
5	–	I2	Digital Input	5	–	I10	Digital Input
6	–	I3	Digital Input	6	–	I11	Digital Input
7	–	I4	Digital Input	7	–	I12	Digital Input
8	–	I5	Digital Input	8	–	I13	Digital Input
9	–	I6	Digital Input	9	–	I14	Digital Input
10	–	I7	Digital Input	10	–	I15	Digital Input
11	–	I8	Digital Input	11	–	I16	Digital Input
12	–	–	-	12	1	M +	Measuring cable (pos)
13	1	Q1	Analog output	13		M-	Measuring cable (neg)
14		M_{ANA}	Reference point of the analog circuit	14	2	M +	Measuring cable (pos)
15	2	Q2	Analog output	15		M-	Measuring cable (neg)
16		M_{ANA}	Reference point of the analog circuit	16	3	M +	Measuring cable (pos)
17	3	Q3	Analog output	17		M-	Measuring cable (neg)
18		M_{ANA}	Reference point of the analog circuit	18	4	M +	Measuring cable (pos)
19	4	Q4	Analog output	19		M-	Measuring cable (neg)
20		M_{ANA}	Reference point of the analog circuit	20	5	M +	Measuring cable (pos)
21	5	Q5	Analog output	21		M-	Measuring cable (neg)
22		M_{ANA}	Reference point of the analog circuit	22	6	M +	Measuring cable (pos)
23	6	Q6	Analog output	23		M-	Measuring cable (neg)
24		M_{ANA}	Reference point of the analog circuit	24	7	M +	Measuring cable (pos)
25	7	Q7	Analog output	25		M-	Measuring cable (neg)
26		M_{ANA}	Reference point of the analog circuit	26	8	M +	Measuring cable (pos)
27	8	Q8	Analog output	27		M-	Measuring cable (neg)
28		M_{ANA}	Reference point of the analog circuit	28	–	IC+	Constant current line (positive)
29	–	–	–	29	–	IC-	Constant current line (negative)
30	–	–	–	30	–	COMP+	Reference junction input (positive)

Left front connector				Right front connector			
Connec-tion	Analog output	Name	Function	Connec-tion	Analog input	Name	Function
31	9	Q9	Analog output	31	–	COMP-	Reference junction input (negative)
32		M_{ANA}	Reference point of the analog circuit	32	9	M +	Measuring cable (pos)
33	10	Q10	Analog output	33		M-	Measuring cable (neg)
34		M_{ANA}	Reference point of the analog circuit	34	10	M +	Measuring cable (pos)
35	11	Q11	Analog output	35		M-	Measuring cable (neg)
36		M_{ANA}	Reference point of the analog circuit	36	11	M +	Measuring cable (pos)
37	12	Q12	Analog output	37		M-	Measuring cable (neg)
38		M_{ANA}	Reference point of the analog circuit	38	12	M +	Measuring cable (pos)
39	13	Q13	Analog output	39		M-	Measuring cable (neg)
40		M_{ANA}	Reference point of the analog circuit	40	13	M +	Measuring cable (pos)
41	14	Q14	Analog output	41		M-	Measuring cable (neg)
42		M_{ANA}	Reference point of the analog circuit	42	14	M +	Measuring cable (pos)
43	15	Q15	Analog output	43		M-	Measuring cable (neg)
44		M_{ANA}	Reference point of the analog circuit	44	15	M +	Measuring cable (pos)
45	16	Q16	Analog output	45		M-	Measuring cable (neg)
46		M_{ANA}	Reference point of the analog circuit	46	16	M +	Measuring cable (pos)
47	–	–	–	47		M-	Measuring cable (neg)
48	–	M	Supply voltage ground	48	–	M_{ANA}	Reference point of the analog circuit

Note

The connection M_{ANA} must be connected with low impedance to the reference point at the subrack (CPU grounding) (refer to illustration of supply voltage of the FM 455 and potential bonding in the chapter "Wiring front connector - overview (Page 97)").

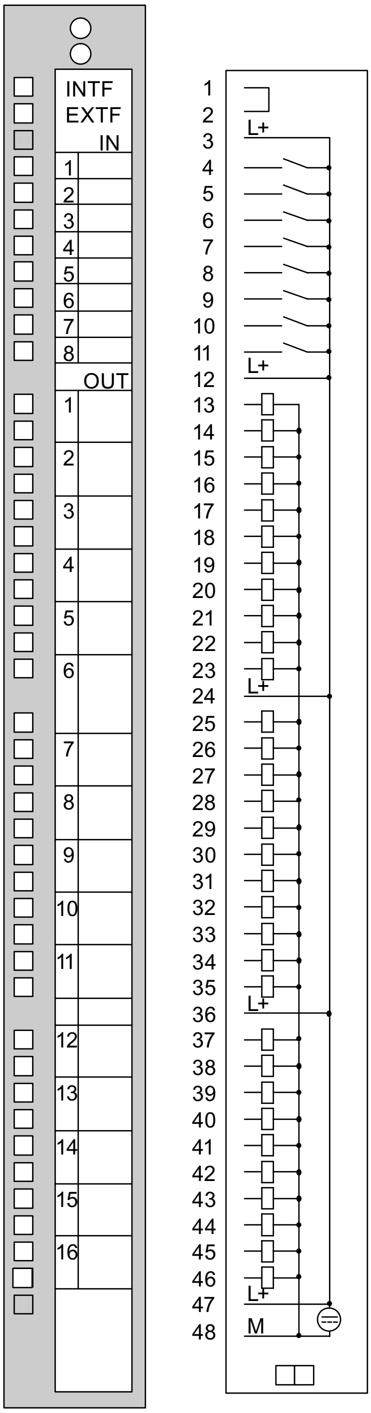
FM 455 S front connectors

The two 48-pin front connectors of the FM 455 S connect the analog inputs, the digital inputs and outputs and the voltage supply of the module.

The following figures show the connection diagrams, the connector pinout of the front connector is shown in the following table.

The connection diagram of the FM 455 S, right-hand front connector, shows an example of how the various sensors - current sensors, voltage sensors, thermocouples and resistance thermometers (Pt100) - can be connected to the analog inputs CH1 to CH16. A different assignment of the sensors to the analog inputs is naturally also possible. However, you can only connect sensors of the same type to two adjacent analog inputs (CH1 and CH2, CH3 and CH4, etc.), since these analog inputs are adapted to the sensor type by means of a common coding key (see chapter "Setting the Measurement Type and the Measuring Ranges of the Analog Input Channels (Page 157)")..

Please note that resistance thermometers (Pt100) require two adjacent analog inputs for their connection and that they can only be connected in the way shown in the connection diagram for the FM 455 S, right-hand front connector, to the analog inputs CH1, CH3, CH5, CH7, CH9, CH11, CH13 and CH15.



Terminal	Name	Function	Control channel
1			
2			
3	L+	Supply voltage 24V	
4	I1	digital input	
5	I2	digital input	
6	I3	digital input	
7	I4	digital input	
8	I5	digital input	
9	I6	digital input	
10	I7	digital input	
11	I8	digital input	
12	L+	Supply voltage 24V	
13		open digital output	Control channel 1
14		close digital output	Control channel 1
15		open digital output	Control channel 2
16		close digital output	Control channel 2
17		open digital output	Control channel 3
18		close digital output	Control channel 3
19		open digital output	Control channel 4
20		close digital output	Control channel 4
21		open digital output	Control channel 5
22		close digital output	Control channel 5
23		open digital output	Control channel 6
24	L+	Supply voltage 24V	
25		close digital output	Control channel 6
26		open digital output	Control channel 7
27		close digital output	Control channel 7
28		open digital output	Control channel 8
29		close digital output	Control channel 8
30		open digital output	Control channel 9
31		close digital output	Control channel 9
32		open digital output	Control channel 10
33		close digital output	Control channel 10
34		open digital output	Control channel 11
35		close digital output	Control channel 11
36	L+	Supply voltage 24V	
37		open digital output	Control channel 12
38		close digital output	Control channel 12
39		open digital output	Control channel 13
40		close digital output	Control channel 13
41		open digital output	Control channel 14
42		close digital output	Control channel 14
43		open digital output	Control channel 15
44		close digital output	Control channel 15
45		open digital output	Control channel 16
46		close digital output	Control channel 16
47	L+	Supply voltage 24V	
48	M	Mass of the supply voltage	

Figure 5-3 Connection diagram for the FM 455 S, left-hand front connector.

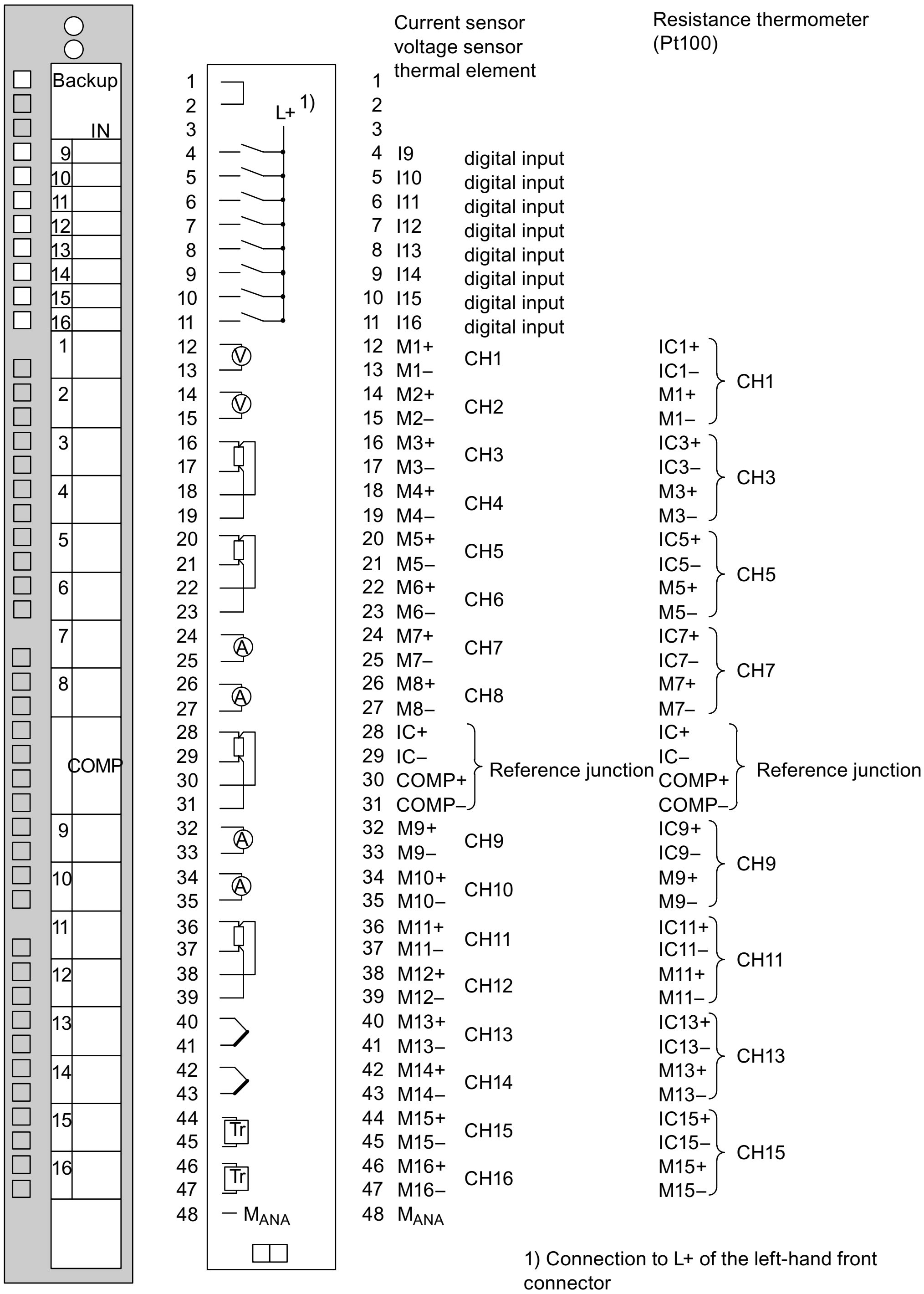


Figure 5-4 Connection diagram for the FM 455 S, right-hand front connector

Table 5- 2 Terminal assignment of the front connector of the FM 455 S

Left front connector				Right front connector			
Connection	Controller channel	Name	Function	Connection	Analog input	Name	Function
1	–	–	–	1	–	–	–
2	–	–	–	2	–	–	–
3	–	L+	Power supply 24 V	3	–	–	–
4	–	I1	Digital Input	4	–	I9	Digital Input
5	–	I2	Digital Input	5	–	I10	Digital Input
6	–	I3	Digital Input	6	–	I11	Digital Input
7	–	I4	Digital Input	7	–	I12	Digital Input
8	–	I5	Digital Input	8	–	I13	Digital Input
9	–	I6	Digital Input	9	–	I14	Digital Input
10	–	I7	Digital Input	10	–	I15	Digital Input
11	–	I8	Digital Input	11	–	I16	Digital Input
12	–	L+	Power supply 24 V	12	1	M +	Measuring cable (pos)
13	1		Open digital output	13		M-	Measuring cable (neg)
14			Close digital output	14	2	M +	Measuring cable (pos)
15	2		Open digital output	15		M-	Measuring cable (neg)
16			Close digital output	16	3	M +	Measuring cable (pos)
17	3		Open digital output	17		M-	Measuring cable (neg)
18			Close digital output	18	4	M +	Measuring cable (pos)
19	4		Open digital output	19		M-	Measuring cable (neg)
20			Close digital output	20	5	M +	Measuring cable (pos)
21	5		Open digital output	21		M-	Measuring cable (neg)
22			Close digital output	22	6	M +	Measuring cable (pos)
23	6		Open digital output	23		M-	Measuring cable (neg)
24	–	L+	Power supply 24 V	24	7	M +	Measuring cable (pos)
25	6		Close digital output	25		M-	Measuring cable (neg)
26	7		Open digital output	26	8	M +	Measuring cable (pos)
27			Close digital output	27		M-	Measuring cable (neg)
28	8		Open digital output	28	–	IC+	Constant current line (positive)
29			Close digital output	29	–	IC-	Constant current line (negative)
30	9		Open digital output	30	–	COMP+	Reference junction input (positive)
31			Close digital output	31	–	COMP-	Reference junction input (negative)
32	10		Open digital output	32	9	M +	Measuring cable (pos)
33			Close digital output	33		M-	Measuring cable (neg)
34	11		Open digital output	34	10	M +	Measuring cable (pos)
35			Close digital output	35		M-	Measuring cable (neg)

Left front connector				Right front connector			
Connec-tion	Con-troller channel	Name	Function	Connec-tion	Analog input	Name	Function
36	–	L+	Power supply 24 V	36	11	M +	Measuring cable (pos)
37	12		Open digital output	37		M-	Measuring cable (neg)
38			Close digital output	38	12	M +	Measuring cable (pos)
39	13		Open digital output	39		M-	Measuring cable (neg)
40			Close digital output	40	13	M +	Measuring cable (pos)
41	14		Open digital output	41		M-	Measuring cable (neg)
42			Close digital output	42	14	M +	Measuring cable (pos)
43	15		Open digital output	43		M-	Measuring cable (neg)
44			Close digital output	44	15	M +	Measuring cable (pos)
45	16		Open digital output	45		M-	Measuring cable (neg)
46			Close digital output	46	16	M +	Measuring cable (pos)
47	–	L+	Power supply 24 V	47		M-	Measuring cable (neg)
48	–	M	Supply voltage ground	48	–	M_{ANA}	Reference point of the analog circuit

Note

The connection M_{ANA} must be connected with low impedance to the reference point at the subrack (CPU grounding) (refer to illustration of supply voltage of the FM 455 and potential bonding in the chapter "Wiring front connector - overview (Page 97)").

5.2 Wiring front connector - overview

Introduction

The 24 V DC power supply of the FM 455 and the connections between the FM 455 and the sensors and actuators of your plant are created in two steps:

1. Wiring front connectors. In doing so, you connect the cables to the power supply and then sensors / actuators to the front connectors.
2. Plug the front connectors into the module.

Supply voltage L+/M

For the voltage supply of the module and the supply of the digital outputs you connect a direct voltage of 24 V to the connections L+ and M (see figure on voltage supply of the FM 455 and non-isolation).

CAUTION

Only an extra-low voltage ≤ 60 V DC which is isolated safely from the network may be used for the 24 V DC power supply. The reliable electrical insulation can be realized in compliance with the following requirements:

- VDE 0100 Part 410 / HD 384-4-41 / IEC 364-4-41 (as function low voltage with safe isolation)
- VDE 0805 / EN 60950 / IEC 950 (as safe electrical low voltage SELV)
- VDE 0106 part 101

An integrated diode protects the module from polarity reversal of the supply voltage.

Input filter for digital inputs

In order to suppress faults, the digital inputs I1 to I16 have input filters (RC elements) with a standardized filter time of 1.5 ms.

Digital outputs

To directly trigger control procedures the FM 455 S has 32 digital outputs.

The digital outputs are supplied via the supply voltage L+.

The digital outputs are P switches and have a loading capacity of 0.1 A. They are protected against overload and short circuits.

Connecting Inductors

Please observe the following points when connecting inductors to digital inputs of the FM 455 S:

Note

The direct connection of inductors (for example, of relays and contactors) is possible without external circuiting. If SIMATIC output power circuits can be switched off by means of additionally installed contacts (e.g. relay contacts), in the case of inductors, additional overvoltage protection devices must be provided (refer to the following example for overvoltage protection).

Example for overvoltage protection

The following figure illustrates an output power circuit requiring additional overvoltage protectors.

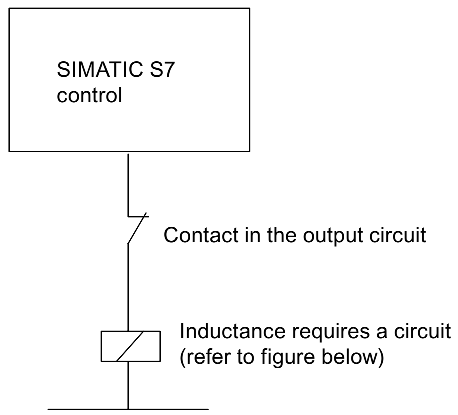


Figure 5-5 Relay contact in the output power circuit

Circuit for coils operated with DC voltage

DC-activated coils will be wired with diodes or Z diodes.

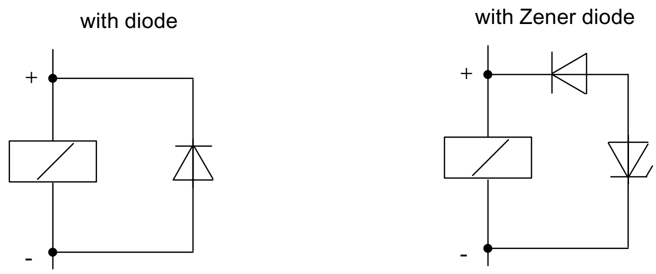


Figure 5-6 Circuit for coils operated with DC voltage

Wiring with diodes / Zener diodes

Diode/Zener diode circuits have the following characteristics:

- Opening surge voltage can be totally avoided.

  Zener diodes have a greater switch-off voltage.
- High switch-off delay (6 - 9 times greater than without suppressor circuits).

  Zener diodes switch off more quickly than diode wiring.

Lines

You must observe a few rules when selecting the lines:

- The cables for the digital inputs I1 to I16 have to be shielded if they are longer than 600 m.
- The lines for the analog signals must be shielded.
- You have to apply the shields of the cables of the analog signals both at the sensor and directly near the module.
- Lay digital and analog signals in separate lines so as to avoid crosstalk.

The following figure shows details for connecting the analog signals.

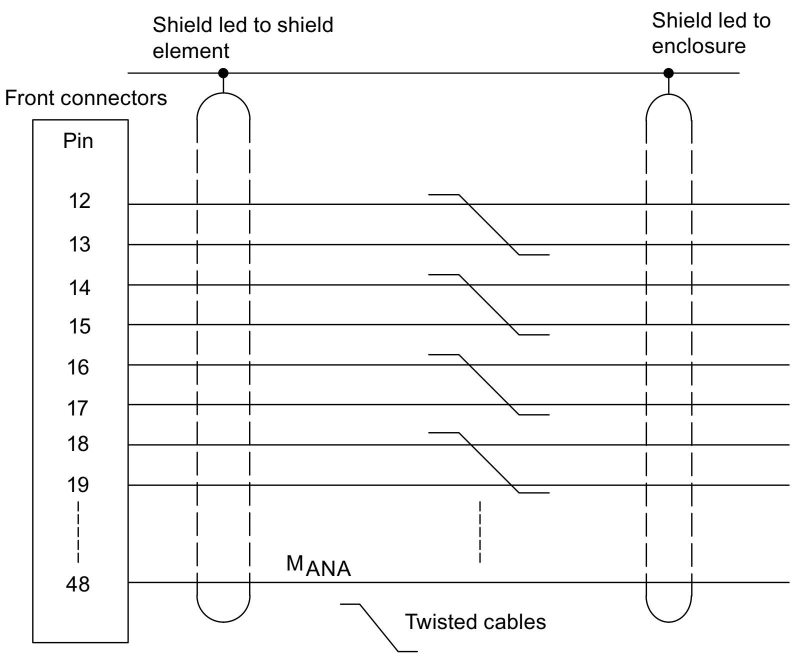


Figure 5-7 Connection of Analog Signals

Potential Bonding

The reference point of the analog circle M_{ANA} (connector 48 of the right-hand front connector) must be connected with low impedance to the reference point on the rack (CPU grounding) (refer to the following figure).

- Use flexible lines with cross-sections of 0.25 to 1.5 mm^2.
- A wire end ferrule is not necessary for connection to the front connector. If you do use ferrules, then use only those that come with or without insulating collars in accordance with DIN 46228, form A, normal design.
- Use a cable lug for M4, a suitable spring lock washer (for example, conical spring washer DIN 6796) and a pan head screw M4 x 6 for connection to the reference point.

Note

Unused analog inputs should be short-circuited and connected with M_{ANA}.

The following figure shows how you supply an FM 455 C or an FM 455 S with voltage and how you wire up the ground connections and the line shields.

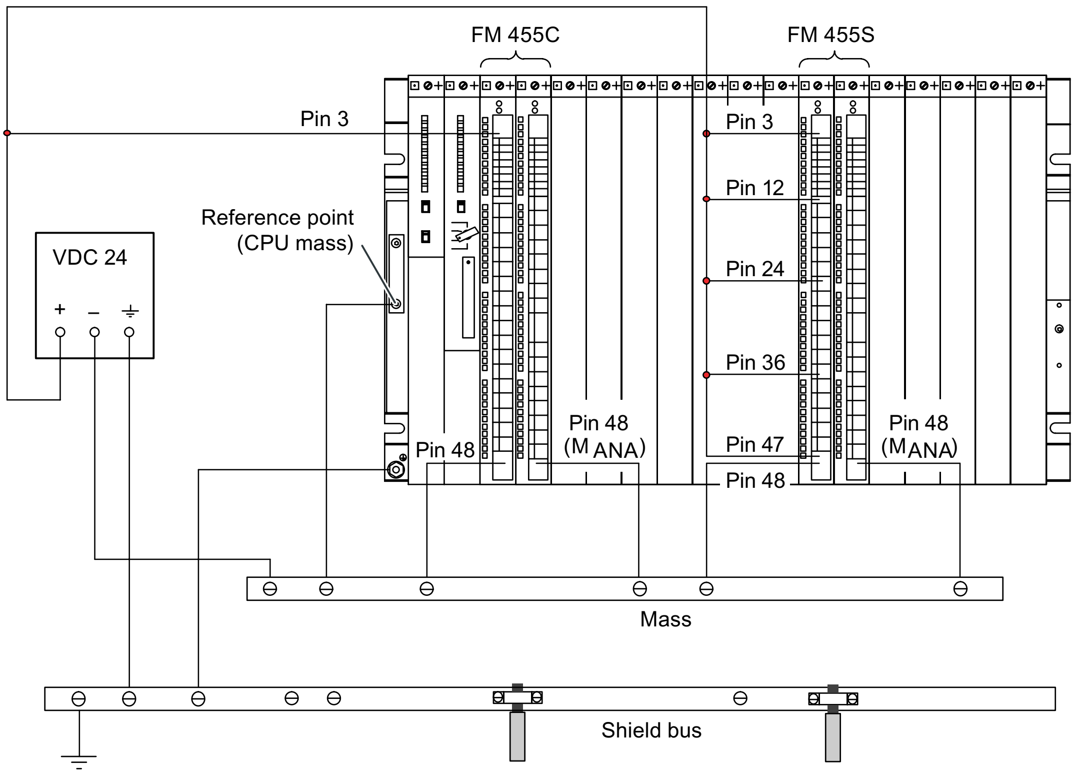


Figure 5-8 Power Supply of the FM 455 and Potential Bonding

The 3 types of front connector

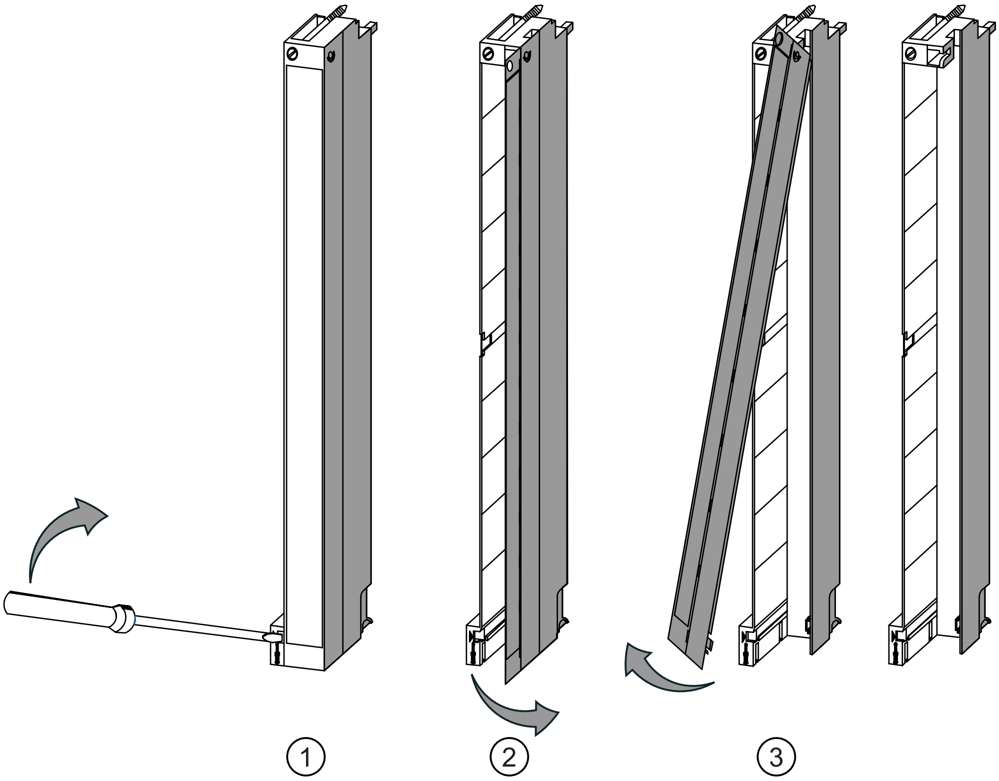
There are 3 different types of front connectors for the FM 455:

- Front connectors with crimp snap-on connector
- Front connector with screw-type terminal
- Front connector with spring-type connector

Preparing for wiring the front connector

1. Insert a screwdriver at the marked point at the bottom left on the front connector and lift the bottom corner of the front connector´s cover.
2. Fold up the entire cover.
3. Pull forward the opened cover at the bottom end and then fold it upwards.
4. Cut the wires to length so that there is no loop in the front connector after wiring has been completed.

The following figure shows how you open the cover and pull it off forwards.



① Lever up the cover

② Fold up the cover

③ Pull off the cover

Figure 5-9 Open the cover and pull it off forwards

Note

The front connectors include a bridge that is functionally necessary for some signal modules. Do not remove this bridge.

5.2.1 Wiring Front Connectors, Crimp Snap-On Connection

Procedure

Proceed as follows in order to wire the prepared front connectors:

1. Strip about 5 mm off the wires.
2. Cap the crimp contacts with the lines. Use crimping pliers to do this. You can order these as accessories to your signal modules.
3. Insert the crimp contacts in the recesses in the front connector. Start at the bottom of the front connector.

   The order numbers of the crimp contacts are detailed in the chapter "Spare parts (Page 261)".

   The following figure shows how to wire a front connector with crimp snap-on connector.

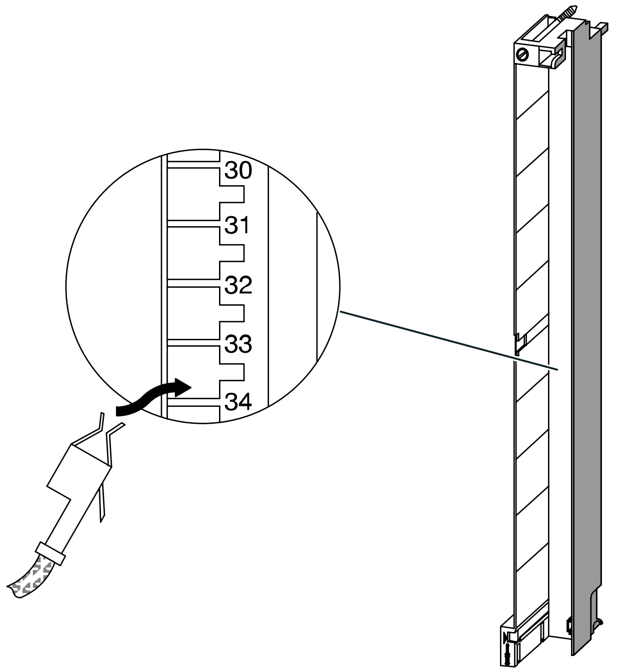


Figure 5-10 Wiring front connectors with crimp snap-on connector

5.2.2 Wiring Front Connectors, Screw-type Terminal

Procedure

Proceed as follows in order to wire the prepared front connectors:

1. Are you using conductor end sleeves?

   If yes: Strip the wires to 10 mm. Squeeze the conductor end sleeves to the conductors.

   If not: Strip about 8 to 10 mm off the wires.
2. Place the cores. Start at the bottom of the front connector.
3. Screw the ends of the lines with the front connector, tightening torque: 0.6 to 0.8 Nm. You should also tighten the unwired terminals.

   The following figure shows how to wire a front connector with screw-type terminal.

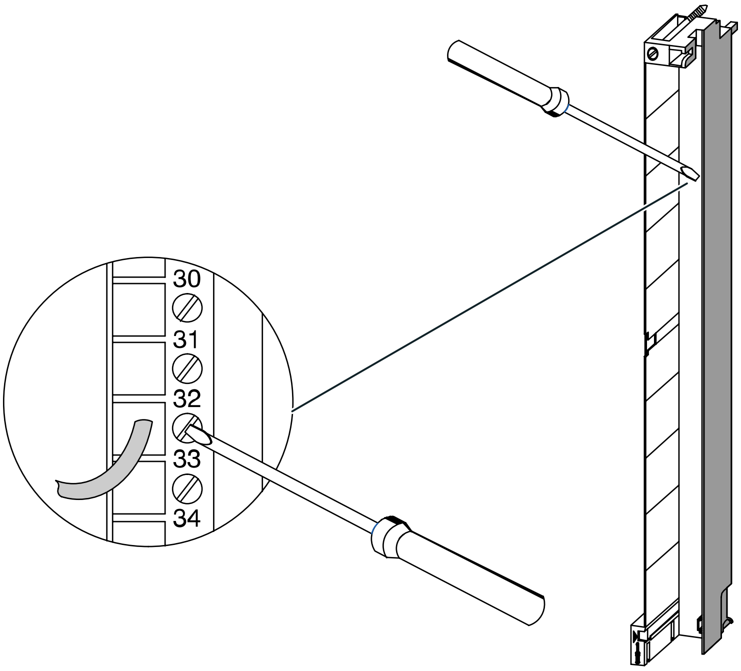


Figure 5-11 Front connector with screw-type terminal

5.2.3 Wiring Front Connectors, Spring-type Connector

Proceed as follows

Proceed as follows in order to wire the prepared front connectors:

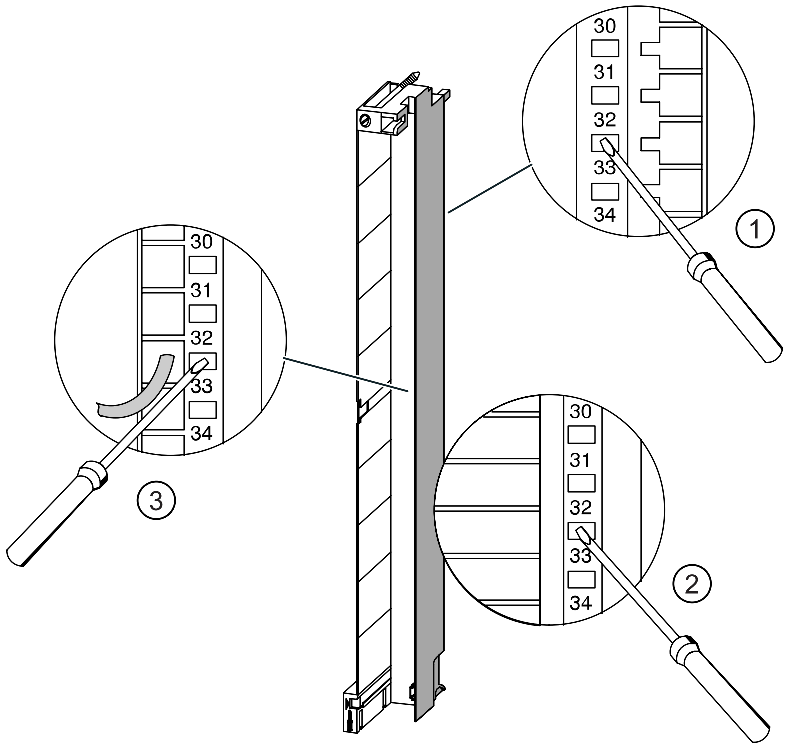
1. Are you using conductor end sleeves?

   If yes: Strip the wires to 10 mm. Squeeze the conductor end sleeves to the conductors.

   If not: Strip about 8 to 10 mm off the wires.
2. Use a screwdriver (0.5 x 3.5 mm DIN 5264) to unlock the spring terminal of the first connection. Start at the bottom of the front connector.

   You can unlock the individual spring terminals at three points, from the front, from the side and from the rear (refer to the following figure).
3. Push the first core into the unlocked spring terminal and then pull back the screwdriver.
4. Repeat steps 2 and 3 for all other cores.

   The following figure shows how to wire a front connector with spring-type connector.



① Unlocking spring terminals from the rear

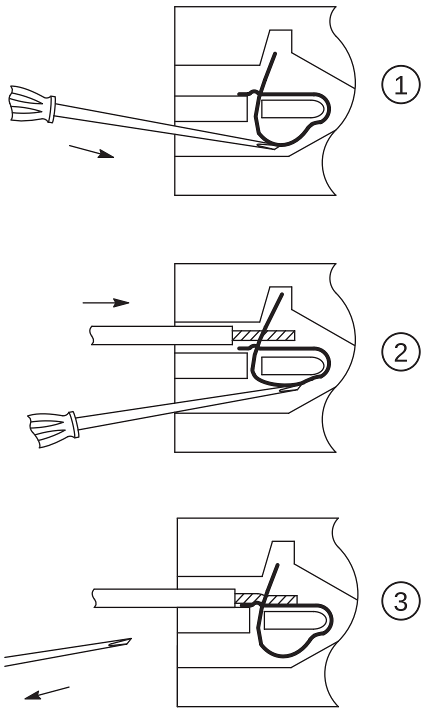
② Unlocking spring terminals from the side

③ Unlocking spring terminals from the front

Figure 5-12 Wiring a front connector with spring-type connector

Principle of the spring terminal

The following figure shows the principle of the spring terminal. It shows the unlocking and locking from the front.



① Insert the screwdriver

② Insert the conductor into the spring terminal up to its stop.

③ Pull the screwdriver: The line clamps on the contact

5.3 Apply strain relief

Cable ties as strain relief

After you have wired the front connectors, attach the enclosed cable ties to the bottom of the front connector - these act as strain relief for the connected lines.

You can attach the strain relief in three variants in accordance with the thickness of the line. To do this there are three openings on the underside of the front connector.

The following figure shows how you can attach a strain relief.

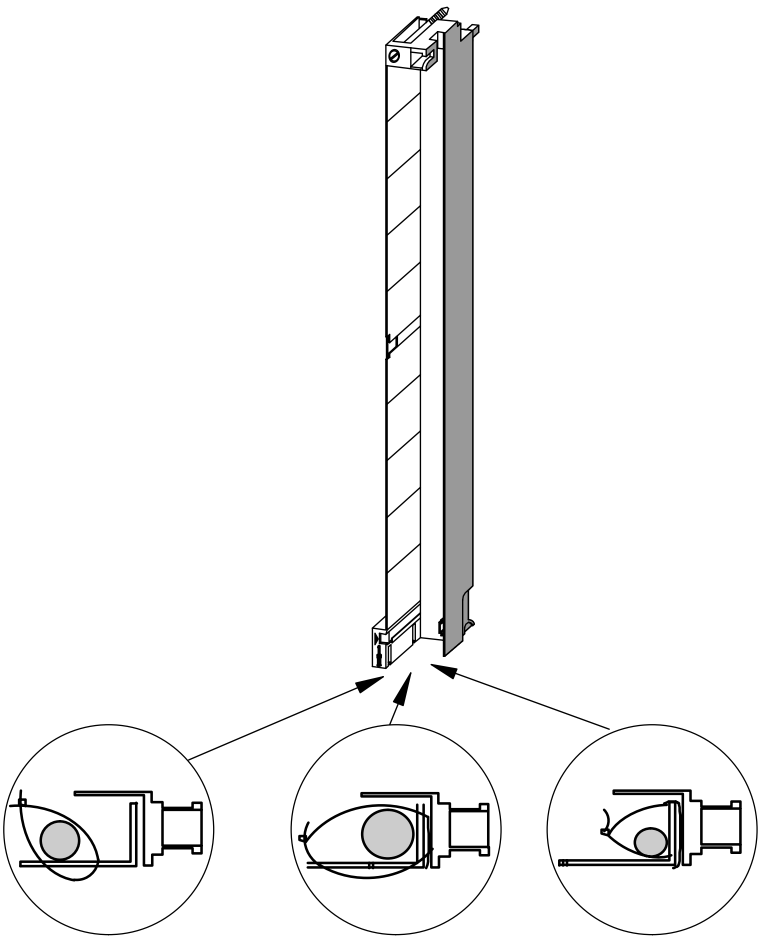


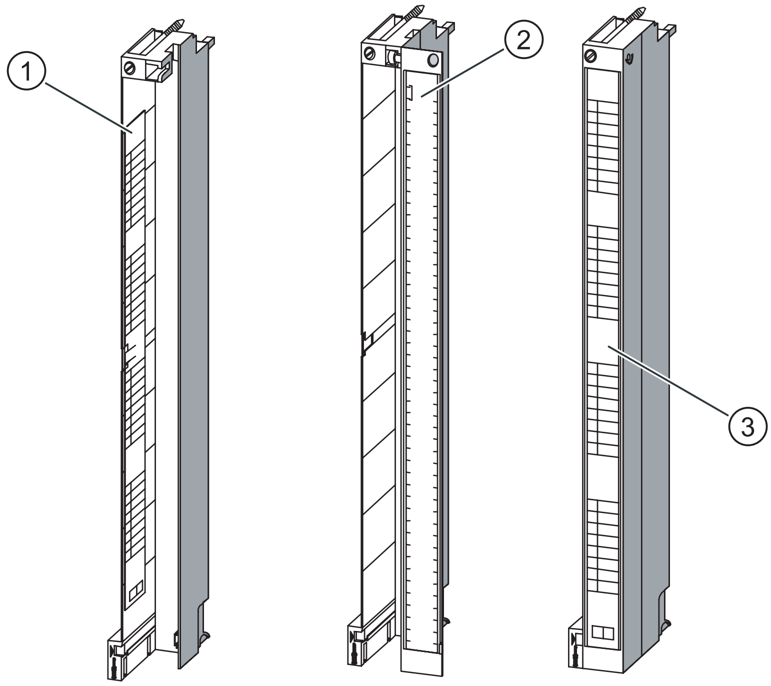
Figure 5-13 Attaching strain relief (viewed from below)

5.4 Labeling the front connectors

Address Labels and Wiring Diagrams

Each FM 455 has three labels, namely 2 address labels and a printed label with the wiring diagram of the inputs and outputs.

The following figure shows you where to attach the individual labels on the front connector.



① Label in the front connector

② Wiring diagram, inside

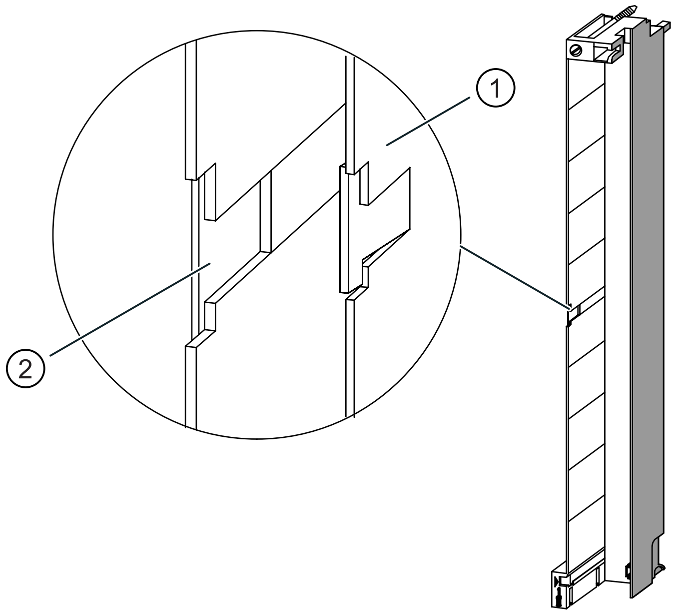
③ External label

Figure 5-14 Attaching labels to the front connector

To label a front connector, proceed as follows:

1. Enter the addresses of the individual channels in the two labels. Not the slot numbers on the labels, in order to record the assignment of the front connector to the module.
2. Attach a label to the left in the opened front connector. The label has a T-shaped punchout in the center. You can use this to fix the label to the front connector housing. Slightly splay the punchout to the side and whilst insetting the label guide the punchout behind the respective punchout on the front connector (refer to the following figure).
3. Attach the cover to the front connector.
4. Slide the label with the wiring diagram of the inputs or outputs into the inside of the front connector cover.
5. Slide an outer label in the cover of the front connector.

The following figure shows in detail how to attach an inner label in the front connector.



① Label with punchout

② Punchout in the front connector

Figure 5-15 Attaching a label in the front connector

5.5 Installing the front connector

Introduction

In the case of rewiring or a module replacement, to reduce the risk of inadvertently connecting a wired front connector to an incorrect type of module, the FM 455 is equipped with a code element for front connectors.

Operating principle of the code element

A code element consists of two parts, as delivered the one part is fixed to the module, the second part is still connected to the first part (refer to the following figure).

If you attach a front connector, the second part of the code element engages in the connector and releases itself from the part that is linked with the signal module. Both parts of the code element are counterparts to one another, you cannot attach a front connector with an incorrect counterpart to this signal module.

Inserting the front connector

You can only insert the front connectors if the module is installed (you must have tightened the upper and lower fixing screws).

CAUTION

Modules can get damaged.

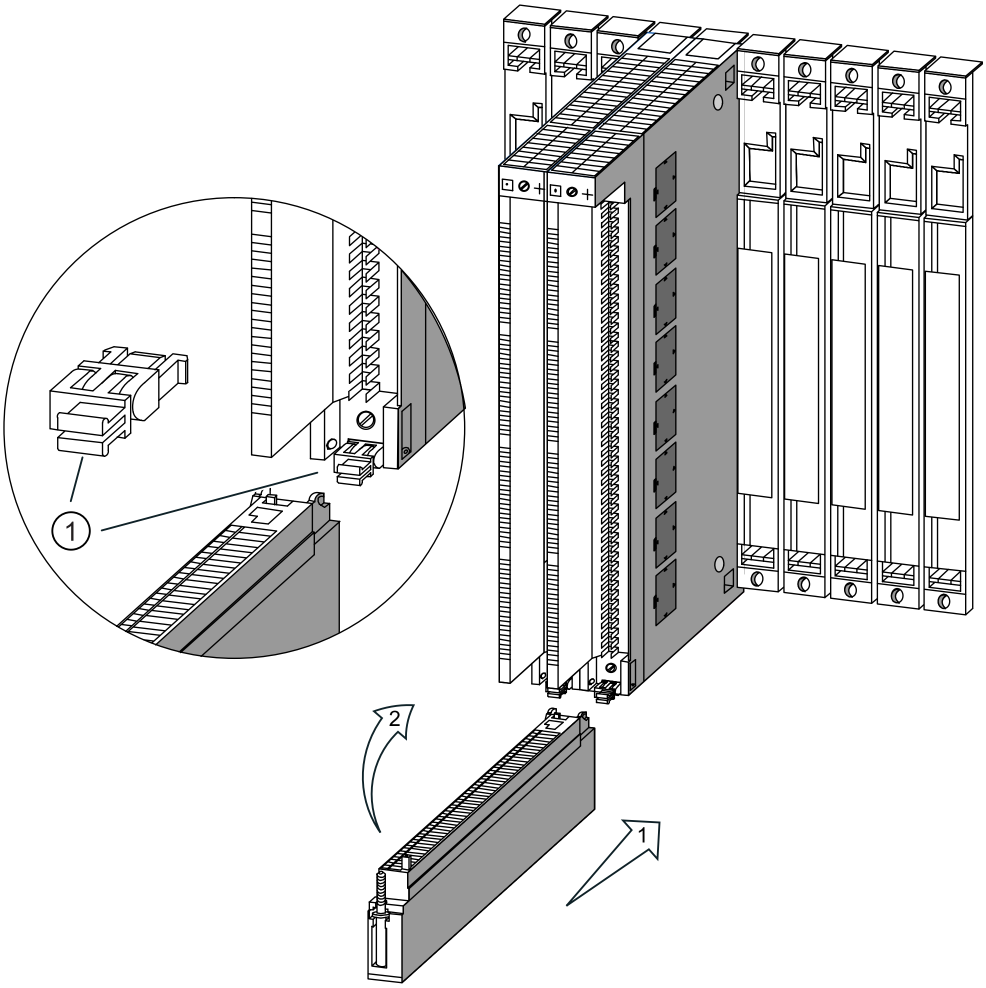
You can damage the module, if for example, you connect a front connector of a digital input module to a digital output module. You can damage the module, if for example, you connect a front connector of an analog input module to an analog output module.

Ensure that the module and the front connector are compatible when you engage the front connector.

To connect the front connector, proceed as follows:

1. Hold the front connector horizontal and engage the front connector into the code element. After an audible click, the front connector engages in the pivot point and can then be swung upwards.
2. Fold up the front connector. In doing so, the two parts of the code element separate from each other.
3. Screw the connector firmly into place.

The following figure shows you how to hang the front connector.



① Code element

Figure 5-16 Hanging the front connector

The FM 455 front connector code

The following table shows the assignment of the front connector code element to the front connectors of the FM 455.

Table 5- 3 Front connector code

Module	Front connectors	Color of the front connector code element	
		Yellow	Green
FM 455 C	Left		●
	Right		●
FM 455 S	Left	●	
	Right		●

Screw the front connector down tightly

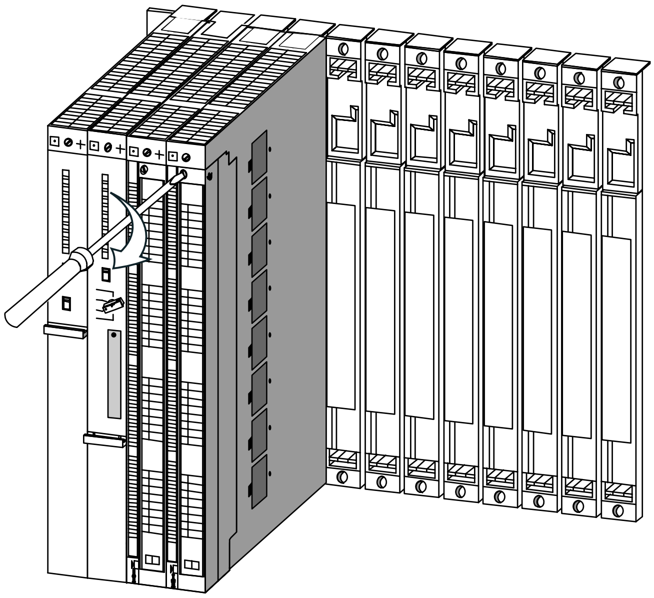


Figure 5-17 Screw the front connector down tightly

6 Parameterization of the FM 455

6.1 Installing the Parameterization Interface

Prerequisites

STEP 7 must be correctly installed on your PG / PC.

Delivery format

The software is delivered on CD ROM.

Proceed as follows

To install the configuration package:

1. Place the supplied CD in the CD drive of your programming device / PC.
2. Start the program "Setup.exe".
3. Follow the operating instructions provided by the installation program.

Important information can be found in the readme file.

The following will be installed on your programming device / PC:

- Parameterization interface
- Function blocks
- Program examples
- Online help

Program examples

The program examples can be found in the STEP 7 catalog in the sub-catalog "Examples" in the project FM_PIDEx.

6.2 Configuring the hardware

Proceed as follows

Configuration assumes that you have set up a project in which you can save the configuration. Further information on configuring modules can be found in the online help for STEP 7. The key steps are explained below.

1. Launch the SIMATIC Manager and then call the configuration table in your project.
2. Select a subrack and arrange this.
3. Open the subrack.
4. Select the FM 455 in your module catalog.
5. Drag the FM 455 to the corresponding row in your configuration table.
6. From the configuration table, note the input address of the module, e.g. 512.

   The value that you read off is displayed in decimal format.

6.3 Parameterization

Procedure

After configuration, you can start with the parameter assignment.

When assigning parameters you set the module parameters.

1. Double click on the order number of the module in the configuration table or select the module and use the menu command Edit > Object properties.

   Result: You end up in the "Properties" dialog box.
2. Click on the "Basic parameters" tab.

   Result: You end up in the "Basic parameters" dialog box.
3. Parameterize the basic parameters of the module.
4. Click on "Parameter ...".

   Result: You end up in the parameterization interface.
5. Parameterize the module and save the parameters entered with File > Save.
6. End the parameterization interface:
7. Save your project in the HW Config with Station > Save and compile.
8. Transfer the parameter data with the CPU in STOP mode by selecting Target system > Download to Module...

   Result: The data is located in the CPU´s memory and will be directly transferred from there to the module.
9. Carry out a CPU start-up.

What you should note with parameterization.

The controller module checks the parameters only to the point at which a secure module function is guaranteed. This applies, e.g. for parameters that are used for address generation, as well as for time-dependent variables (e.g integration time constants > half scanning time). When the controller module detects a parameterization error, then an entry is made in the DS0 and DS1 of the module (see chapter "Errors and diagnostics (Page 225)") and the red error LED EXTF lights up. You can read off parameterization errors in the **Target system > Parameterization error display** menu of the parameterization interface.

Further tests for established thresholds or plausibility (e.g. upper limit > lower limit) are not carried out.

In the parameterization interface you can select the assignment between inputs and controller channels as well as between controller channels and outputs. Note the following:

Note

The parameterization tool does not provide an error message if when assigning the controller channels to the inputs you assign two channels to one input.

Integrated help

Included in the parameterization interface is an integrated help that supports you in the parameterization of the controller module. You have the following possibilities of calling the integrated help:

- Via the menu command **Help > Help topics** ...
- By pressing the F1 key
- By clicking on the help button in the individual parameterization screens

The integrated help´s description of the parameterization of the module goes into more detail than that of the manual.

See also

Technical Specifications of the Function Blocks (Page 257)

Integrating the FM 455 with the user program 7

7.1 Overview of the function blocks

Summary

This chapter contains all the information required to program the FM 455 in the S7-400.

You are provided with six STEP 7 blocks for the integration of the FM 455 in a user program. These enable you to handle the desired functions with ease.

This chapter describes the following blocks:

- FB PID_FM for operator control and monitoring via the CPU as well as online modification of controller parameters
- FB FUZ_455 for reading and writing the parameters of all temperature controllers of the FM 455. The block enables a fast adaptation of the controller to changes in the control section, and a parameterization of the temperature controllers after a module replacement or new identification.
- FB FORCE455 for simulating (forcing) the analog and digital input values (to support the commissioning)
- FB READ_455 for reading off the digital and analog input values (to support the commissioning).
- An FB CH_DIAG for reading off further channel-specific parameters (to support the commissioning)
- The FB PID_PAR for online changing of other parameters.
- The FB CJ_T_PAR for online changing of the configured reference junction temperature

7.2 The function block PID_FM

Purpose

You link the FM 455 to the user program by means of the FB PID_FM. With this FB you can change the operating parameters during runtime. You can, for example, assign a set value and the manipulated value or change over to an external manipulated value.

The data required for the FB PID_FM is stored in an instance DB on the CPU. The FB PID_FM reads program-controlled data from the FM 455 and writes program-controlled data to the FM 455.

The individual parameters are described in the online help and in the chapter "Pin assignment of the DBs (Page 177)".

Setting up and supply the instance DB

Before you program the module with the user program, for each controller channel you wish to use you must set up an instance DB and supply it with important data.

1. Under STEP 7 generate the instance DBs for the controller channels as data blocks with assigned function blocks PID_FM (see chapter "Instance DB of the FB PID_FM (Page 177)").
2. For each instance DB, enter the module address in the MOD_ADDR parameter.

   The module address of the FM 455 is determined by the configuration of your hardware. Take the start address from HW Config.
3. Enter the channel number of the corresponding controller channel (1, 2, 3 to 16) in the CHANNEL parameter for each instance DB.
4. Save the instance DBs.

Call

The FB PID_FM must be called in the same OB as all other FBs that access the same FM 455.

The FB PID_FM is usually called up in the cyclic interrupt OB 35. It requires an initialization run which is arranged by setting the parameter COM_RST = TRUE during the start-up of the CPU. It is possible to call the FB in the OB start-up, but not necessary. After the initialization run, the FB PID_FM sets the COM_RST parameter to FALSE.

7.2.1 Operating via the FB PID_FM

Transferring the operating parameters

The operating parameters (e.g. set value, manual manipulated value) of the FM 455 are cyclically transferred from the FB PID_FM to the FM 455. Operating parameters are all the I/O parameters that lie in the instance DB of the function block between the op_par and the cont_par parameters.

To enable the data transmission without great time expenditure in the CPU, the transmission usually takes place (if LOAD_OP = FALSE) via direct peripheral access. As only four bytes are available for each channel in the peripheral address area of the module, the data is multiplexed. It can therefore take up to three cycles of the CPU or the FM 455 for the operating values for the FM 455 to be transferred and effective there - the longer cycle is decisive in each case.

If you would like the operating values to be transmitted immediately to the FM 455 (in **one** cycle of the CPU or the FM 455), then you can set the LOAD_OP parameter to TRUE. The transmission then takes place by means of SFC WR_REC, the FB requires more time for this (refer to chapter "Technical Specifications of the Function Blocks (Page 257)"). After a successful data transmission, the LOAD_OP parameter of the FB PID_FM is set to FALSE again.

7.2.2 Monitoring via the FB PID_FM

Reading the process values

The FB PID_FM cyclically ready process values (e.g. actual value, manipulated value) from the FM 455. Process values are all output parameters of the function block after the parameter out_par.

The FB PID_FM also reads the process values via direct periphery accesses, if READ_VAR = FALSE. This transfer takes less time, but does result in the function restrictions listed below.

If the parameter READ_VAR = TRUE is set, then the process values are read from the FM 455 by means of the SFC RD_REC. This however costs more time (refer to chapter "Technical Specifications of the Function Blocks (Page 257)"). After a successful data transmission, the READ_VAR parameter of the FB PID_FM is set to FALSE again.

Function in the READ_VAR = TRUE

If one of the following parameters "operating set value SP_OP, "operating set value LMN_OP" and the associated switches "SP_OP_ON" and "LMNOP_ON" are changed by an operation via the OP, then, after the start-up of the CPU, the FB PID_FM adopts these values from the FM.

Function restrictions with READ_VAR = FALSE

- The SP parameters (set value from the FM), ER (control deviation), DISV (disturbance variable), LMN_A and LMN_B are not read from the FM.
- The data will be multiplexed. Actual value, manipulated value and binary displays are then updated with every fourth call of the block.
- If the set value and manual manipulated variable is operated via the MPI, then these operating values are not read from the FB during the start-up of the CPU.

Note

The multiplexing of the data to be transferred via direct peripheral access in the case of access to the FM 455 is controlled via the FB PID_FM. This multiplex control does not function if two instances of the FB PID_FM are accessing the same channel number of a module. The result are incorrect parameters in the FM 455 (e.g. set value and manual manipulated value) and the incorrect display of the FB PID_FM on its output parameters.

Error displays

The output parameter RET_VALU includes the return value RET_VAL of the SFCs 58 and 59. RET_VAL can be evaluated if the READ_PAR and LOAD_PAR parameters are not reset. The values from the RET_VALU are described in the /2/ reference manual.

When calling the FB PID_FM a peripheral access error (PAE) can occur if the FM 455 is not connected or has no voltage supply. In this case, the CPU goes to STOP if no OB 122 is loaded in the CPU.

See also

Assignment of the DBs for operating and monitoring via the OP (Page 210)

7.2.3 Changing controller parameters via the FB PID_FM

Procedure

Controller parameters (e.g. controller gain, integration factor) are all the I/O parameters that lie in the instance DB of the function block after the cont_par parameter. Controller parameters are initially configured via the parameterization interface and transferred via the system data of the FM 455 (refer also to chapter "Functional mechanisms and data storage in the FM 455 (Page 68)").

Changing the controller parameters via the FB PID_FM makes sense if you want to change them during operation depending on the process states. To do this, proceed as follows:

1. During the start-up of the CPU, set the COM_RST parameter of the FB PID_FM to TRUE.

   The FB then reads **all** the controller parameters from the FM 455 and stores them in its instance DB. The instance DB of the FB PID_FM is now compared with the parameters of the parameterization interface (system data). After the successful reading of the parameters, the FB PID_FM sets the COM_RST parameter to FALSE.

2. If COM_RST = FALSE, in the user program you can now change individual controller parameters in the instance DB of the FB PID_FM.

   To do this, call the FB PID_FM with LOAD_PAR = TRUE. The FB PID_FM then transfer **all** the controller parameters from the instance DB to the FM. After the successful transmission of the parameters, the FB PID_FM resets the LOAD_PAR parameter.

Note

Please note that with each start-up of the CPU (goes from STOP to RUN), the parameters in the FM 455 are overwritten with the values from the system data.

7.2.4 Changing controller parameters via the OP

Procedure

If you want to change controller parameters of the FB PID_FM at the OP, proceed as follows:

1. Write the parameters that are to be changed from the OP into an auxiliary DB (see ①).
2. Do not transfer these parameters that are to be changed from the auxiliary DB into the instance DB of the FB PID_FM until **after** the initialization of the FB PID_FM triggered by COM_RST = TRUE (see ②) has been carried out (see ③).
3. Transfer the parameters to the controller module by setting LOAD_PAR (see ④).

Storage of the parameters in an auxiliary DB is necessary, because, after the start-up of the CPU with COM_RST = TRUE, the FB PID_FM reads those parameters from the module that the CPU had transferred beforehand from the system data to the FM.

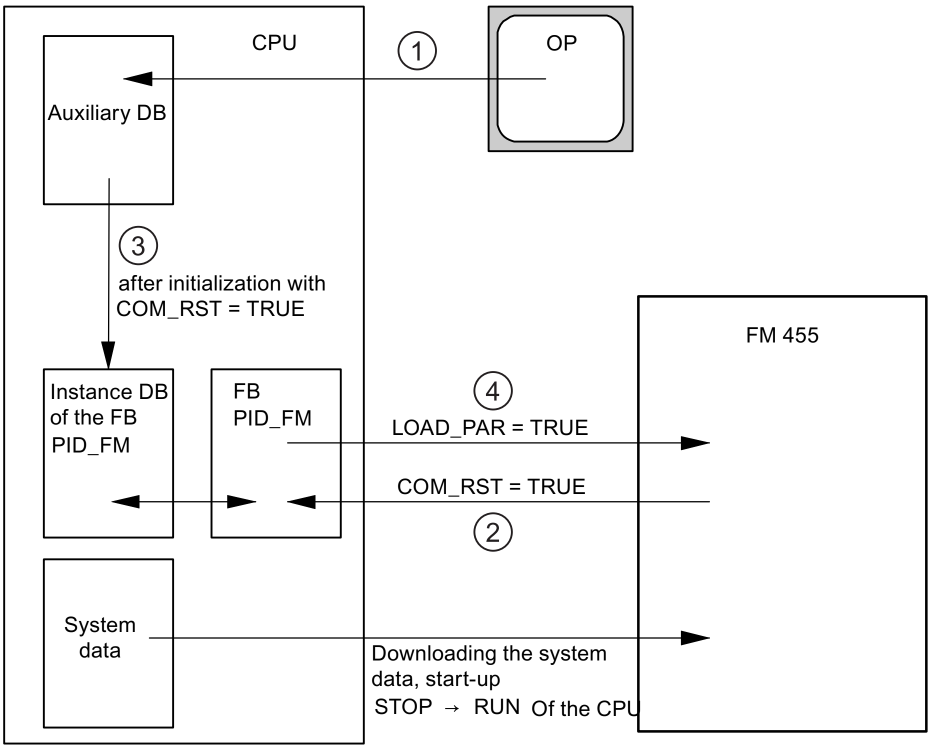


Figure 7-1 07_01_Changing controller parameters via OP

If COM_RST = TRUE is set, the CHANNEL parameter is also checked. If an invalid channel number was configured at the CHANNEL parameter, the outputs QMOD_F and QCH_F are set, COM_RST remains set and no further action of the FB is carried out.

If no error is found during the check and the parameters were read successfully from the module, the COM_RST parameter is reset by the FB PID_FM.

Note

If the FB is called at the first call with COM_RST = FALSE and an invalid channel number is configured at the MOD_ADDR or CHANNEL parameters, the FB accesses an incorrect I/O address without any further check.

7.2.5 Saving the parameters in EEPROM

Principle

In the case of program-controlled reconfiguration (LOAD_PAR, LOAD_OP) of the controller module by the FB PID_FM, the time thereof increases. The new parameters are always immediately effective and are also stored in a non-volatile memory (EEPROM). After saving the parameters in the EEPROM, any resaving is delayed by 30 minutes as the life span of the EEPROM is restricted by the number of write operations. After recovery of the supply voltage, it is possible to immediately save new parameters in EEPROM. Whether the reconfiguration of the controller module takes place by the FB PID_FM shock-free depends on the choice of the parameters.

7.2.6 Relationship between FB parameters and parameter configuration interface

Overview

The following figures show the relationship between the FB PID_FM and the parameter configuration interface of the controller module.

The parameters act at the same point at three-component controllers and ratio/blending controllers as at fixed setpoint or cascade controllers. This also applies for the parameters that exist equally at continuous-action controllers, at controllers with a pulse output as well as at step controllers. As a rule the same command buttons also contain the same parameters. Therefore, in order to obtain a clearly structured overview not all the structure screens are shown and not all the parameters are drawn in all the screens.

However, the parameters of the FB PID_FM are contained in all the figures – with the exception of the parameters MOD_ADDR, CHANNEL, QMOD_F, QPARA_F, QCH_F, QLMNR_ON, RET_VALU, COM_RST, LOAD_PAR, READ_VAR, LOAD_OP.

At which points do the parameters of the FB PID_FM act?

The following figures show at which points in the module the parameters of the FB PID_FM act.

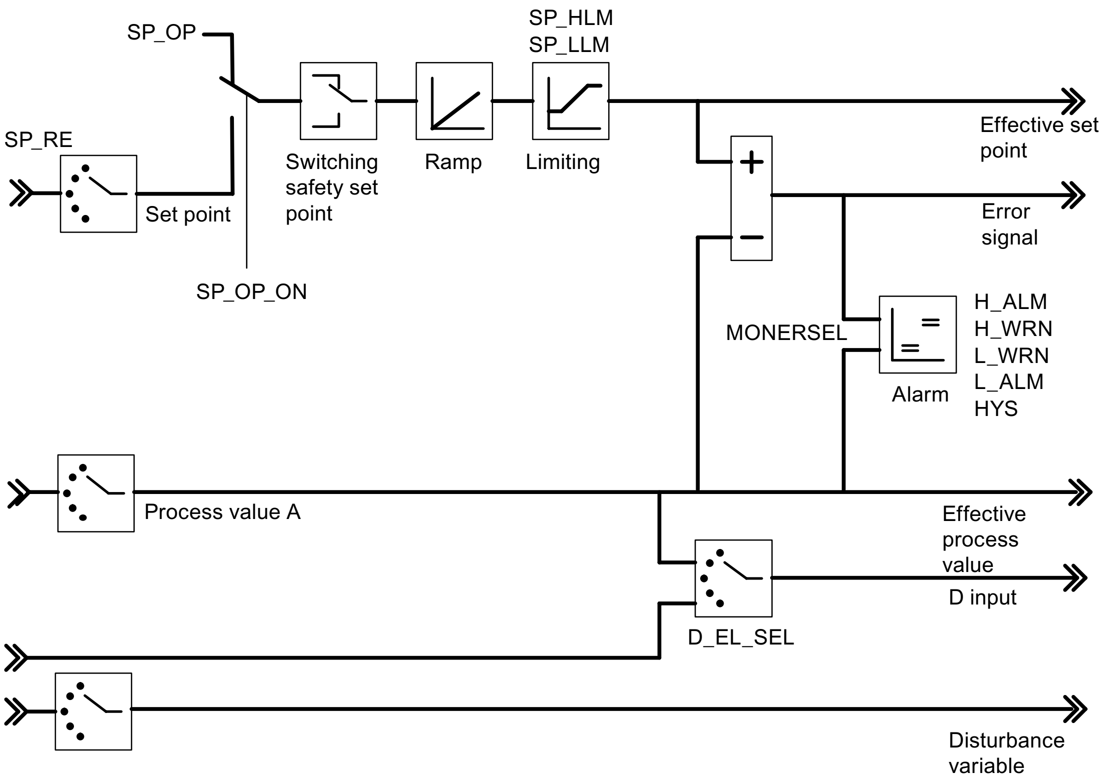


Figure 7-2 Negative deviation generation at fixed setpoint or cascade controller

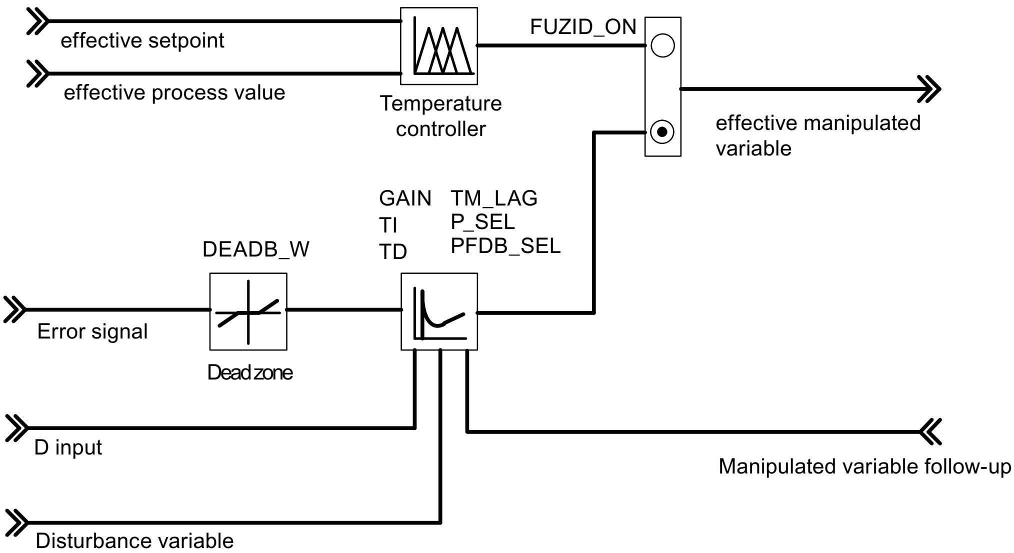


Figure 7-3 Block diagram of the control algorithm

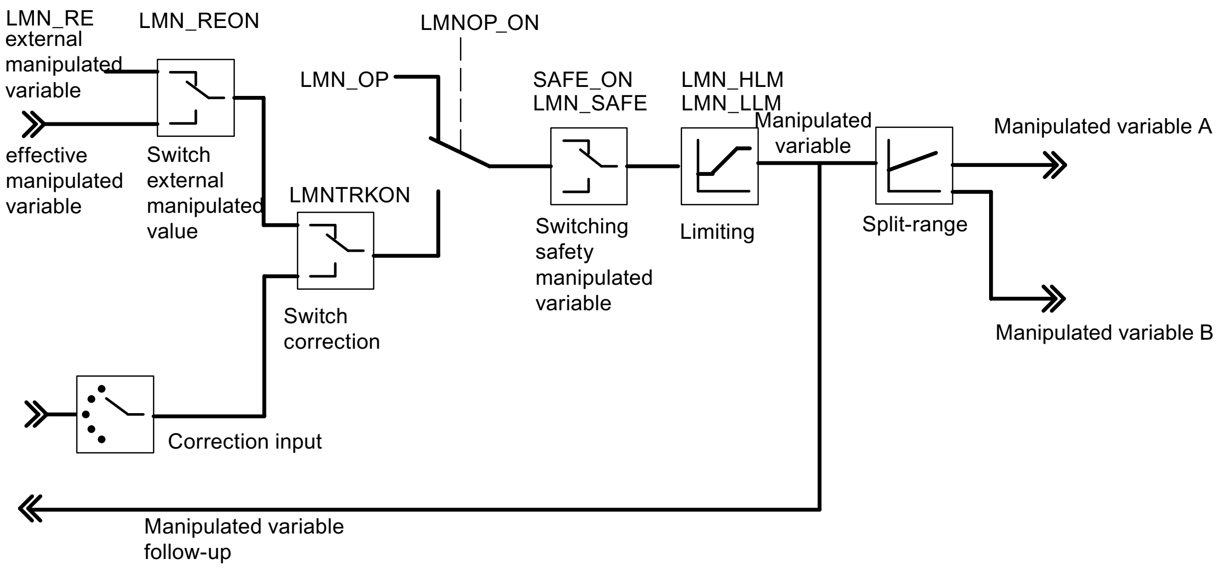


Figure 7-4 Controller output of the continuous-action controller

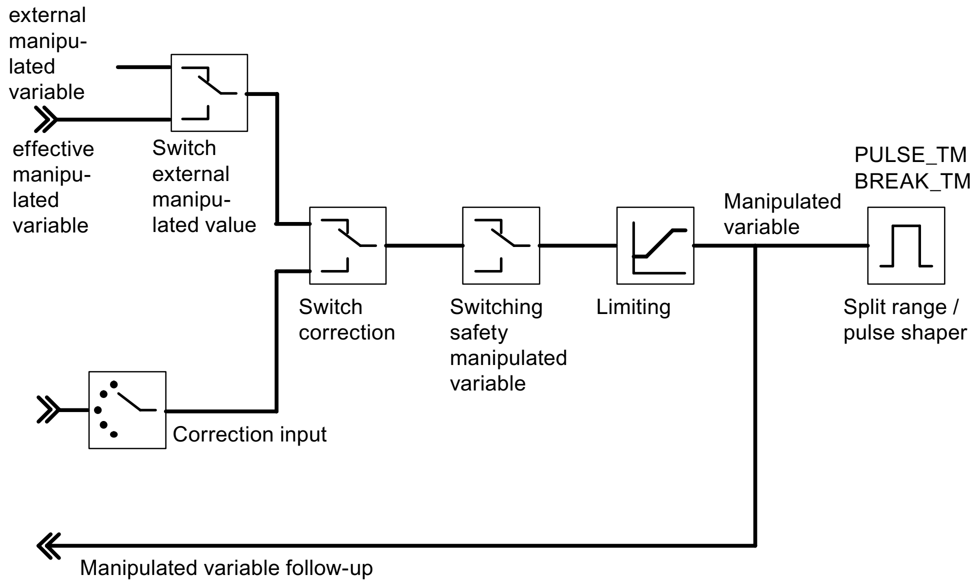


Figure 7-5 Controller output of the step controller (pulse controller operating mode)

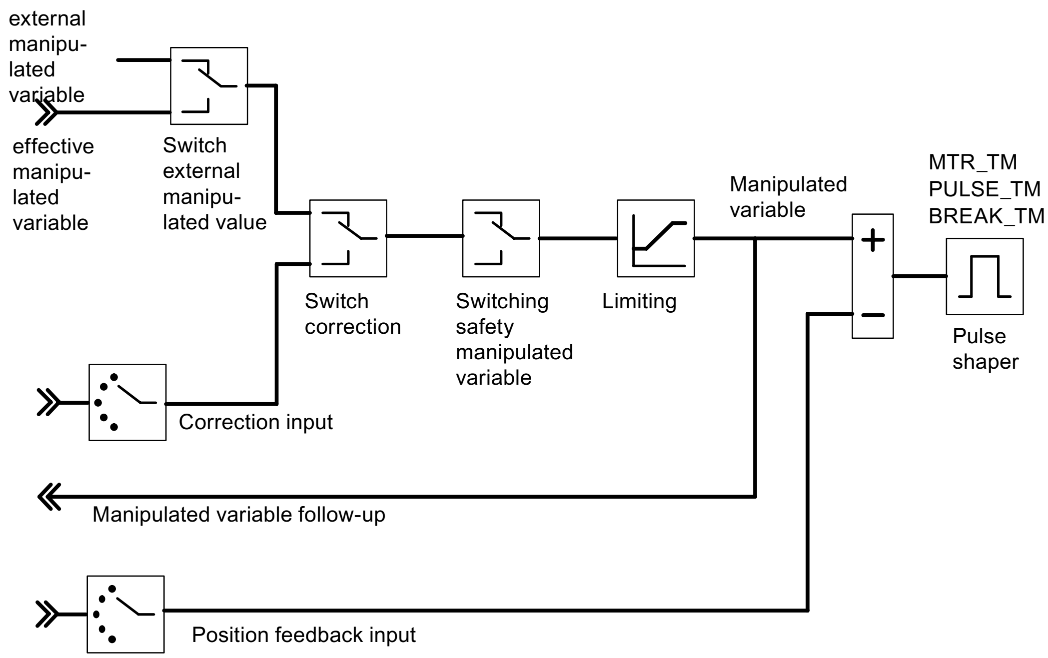


Figure 7-6 Controller output of the step controller (step controller operating mode with position feedback)

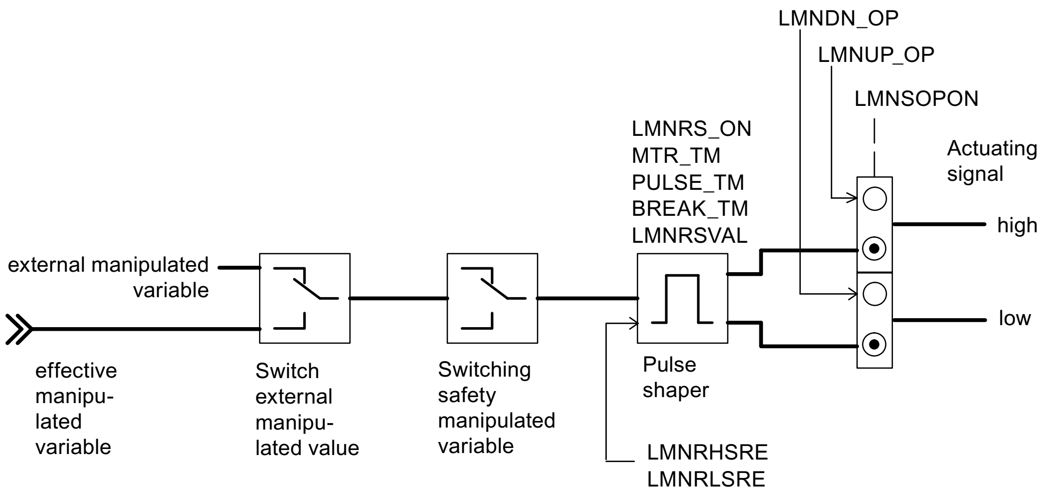


Figure 7-7 Controller output of the step controller (step controller operating mode without position feedback)

At which points are the parameters of the FB PID_FM generated?

The following figures show at which points in the module the output parameters of the FB PID_FM are generated.

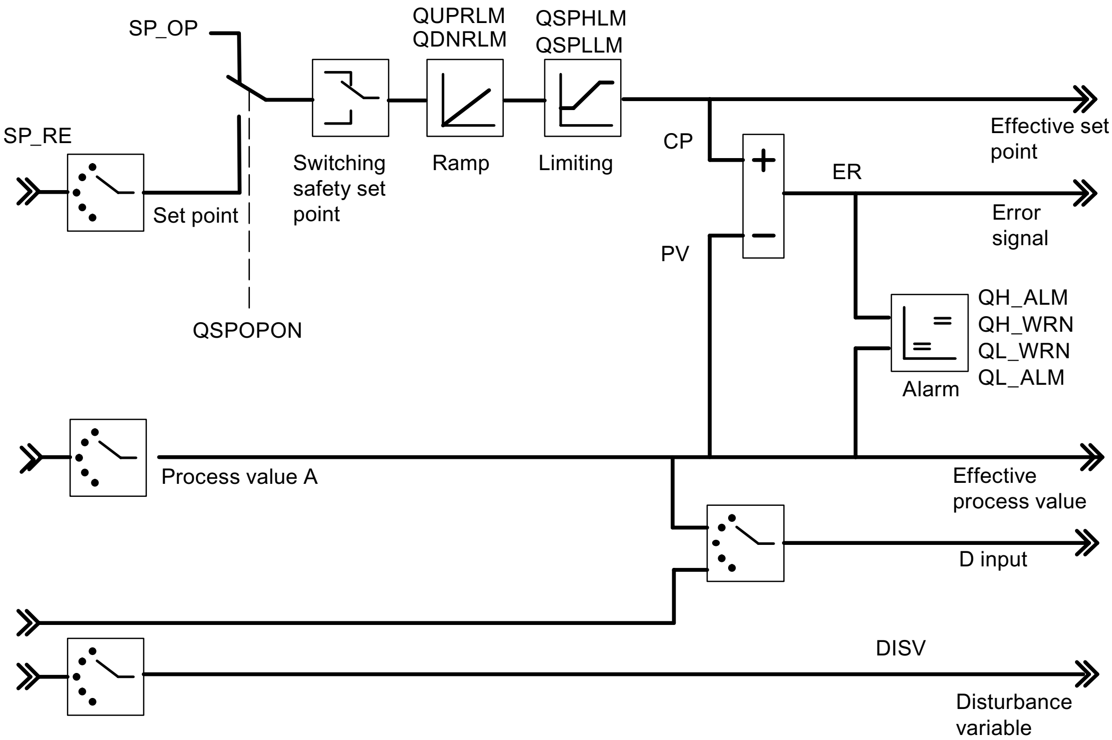


Figure 7-8 Negative deviation generation at fixed setpoint or cascade controller

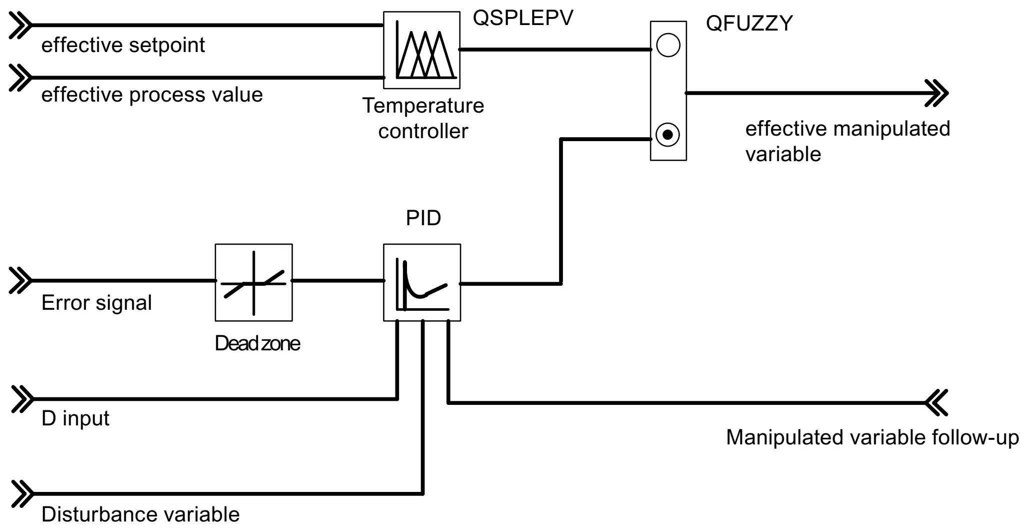


Figure 7-9 Block diagram of the control algorithm

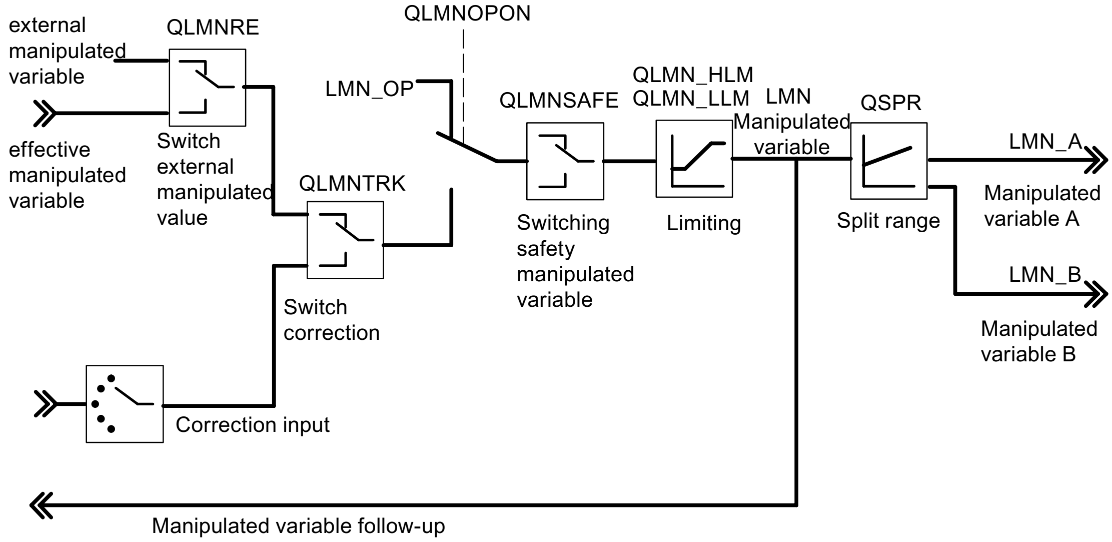


Figure 7-10 Controller output of the continuous-action controller

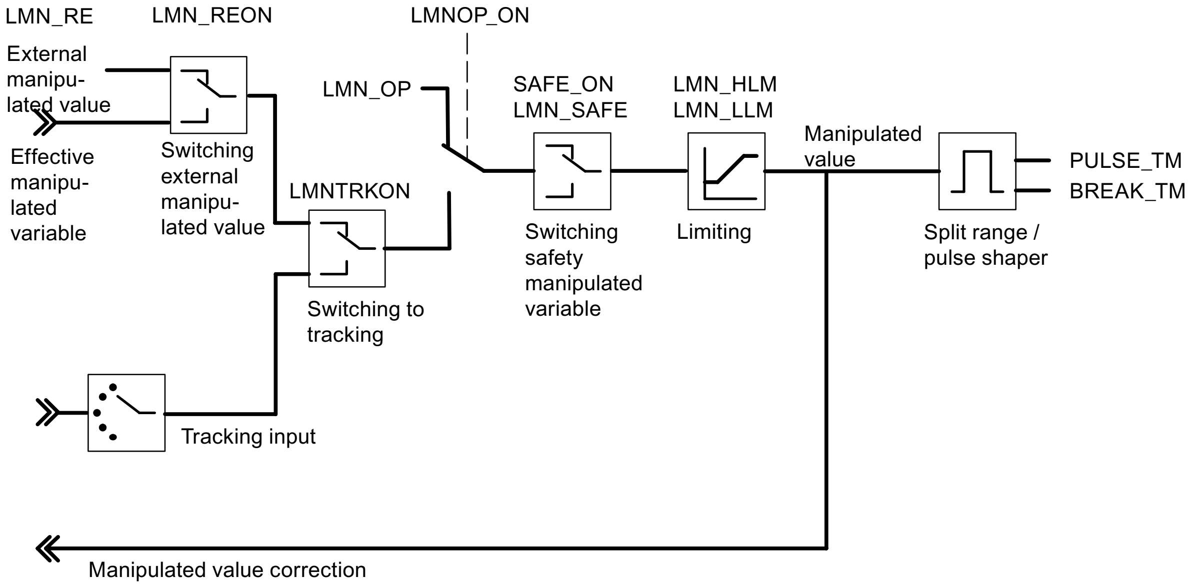


Figure 7-11 Controller output of the step controller (pulse controller operating mode)

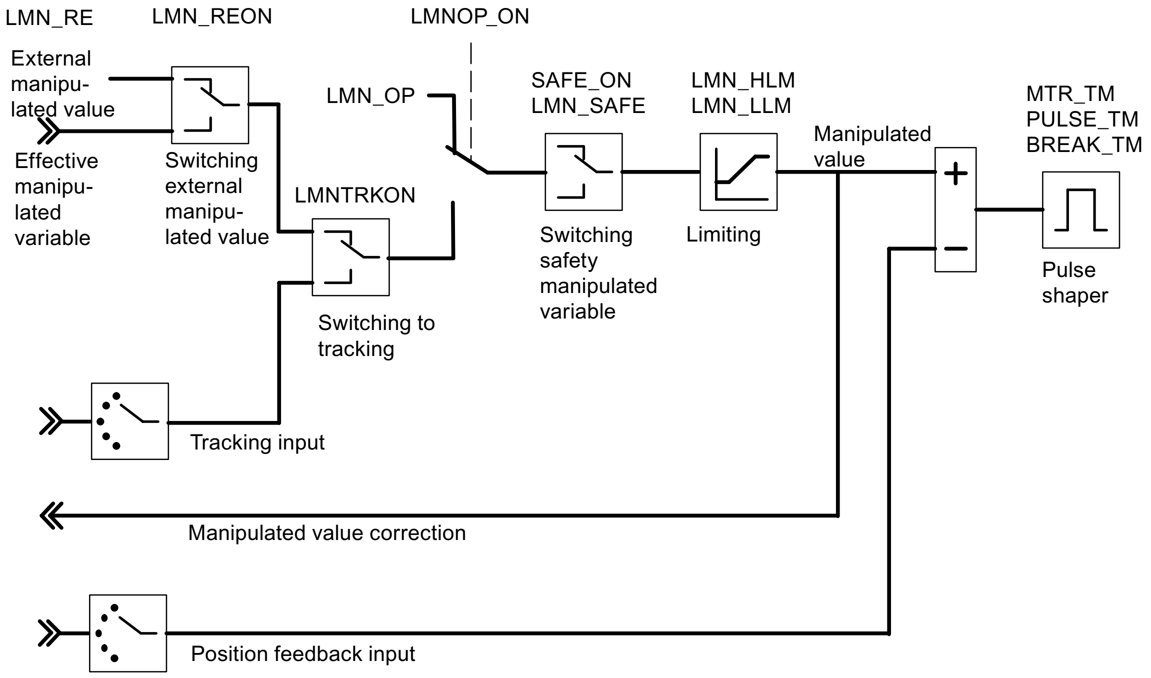


Figure 7-12 Controller output of the step controller (step controller operating mode with position feedback)

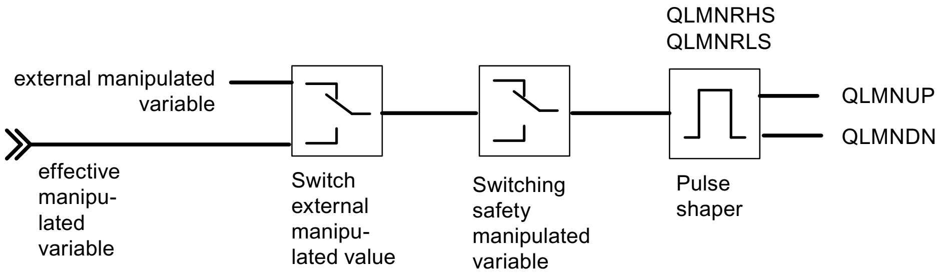


Figure 7-13 Controller output of the step controller (step controller operating mode without position feedback)

See also

Instance DB of the FB PID_FM (Page 177)

7.3 The function block FUZ_455

Use

The FB FUZ_455 is available for the temperature controller of the FM 455 (fuzzy controller). With this FB you can read and write the parameters of all the temperature controllers of the FM 455. This function is suitable for the following application cases:

- Transferring the controller parameters of the FM 455 that have been established by identification after the module replacement
- Adapting the FM 455 to the different control sections

Note

The parameters that have been established by the FM 455 by means of an identification may not be altered as they have been optimized for the control section.

The FB FUZ_455 does not require an initialization run.

Setting up and supply the instance DB

Before you program the module with the user program, you must set up an instance DB and supply it with important data.

1. Under STEP 7 generate the instance DB as a data block with assigned function block FB FUZ_455 (see chapter "Instance DB of the FB FUZ_455 (Page 200)").
2. In the case of an instance DB, enter the module address in the MOD_ADDR parameter.

   The module address of the FM 455 is determined by the configuration of your hardware. Take the start address from HW Config.
3. Save the instance DB.

Call

The FB FUZ_455 must be called in the same OB as all other FBs which access the same FM 455.

Procedure and results

Once you have carried out an identification of the temperature controller and have regulated the control to your satisfaction, then you call the DB FUZ_455 and, in doing so, set the READ_PAR parameter to TRUE.

The FB then reads the parameters of all the temperature controllers of the FM 455 and stores them in its instance DB. After the successful reading of the temperature controller parameters, the FB FUZ_455 sets the READ_PAR parameter to FALSE.

During the start-up of the CPU you should set the LOAD_PAR of the FB FUZ_455 and then call the block in the cyclic program provided LOAD_PAR = TRUE. If the LOAD_PAR = TRUE parameter is set, then the FB writes the parameters of all the temperature controllers of the FM 455 from the instance DB to the FM 455. After a successful transmission of the parameters, the FB PID_FM sets the LOAD_PAR parameter to FALSE.

When reading the temperature controller parameters a parameterization error display of the temperature controller parameters is also displayed in the PARAFFUZ as follows:

High byte of PARAFFUZ unequal to zero means that there is a parameterization error. The low byte includes the byte offset of the faulty parameter, referring to the start of the static variables. Hence, e.g. PARAFFUZ = W#16#0104 means that the second parameters is faulty.

The error display can then only appear if you manipulate the temperature controller parameters in the instance DB and write to the FM 455. You can read off these parameterization errors in the **Target system > Parameterization error display** menu of the parameterization interface.

The output parameter RET_VALU includes the return value RET_VAL of the SFCs 58 and 59. RET_VALU can be evaluated if the READ_PAR and LOAD_PAR parameters are not reset. The values from the RET_VALU are described in the /2/ reference manual.

7.4 The function block FORCE455

Use

The FB FORCE455 serves to simulate (force) the analog and digital input values in order to support the commissioning.

The FB FORCE455 does not require an initialization run. It is usually called cyclically.

Setting up and supply the instance DB

Before you program the module with the user program, you must set up an instance DB and supply it with important data.

1. Under STEP 7 generate the instance DB as a data block with assigned function block FB FORCE455 (see chapter "Instance DB of the FB FORCE455 (Page 202)").
2. In the case of an instance DB, enter the module address in the MOD_ADDR parameter.

   The module address of the FM 455 is determined by the configuration of your hardware. Adopt the start address from the HM Config.
3. Save the instance DB.

Call

The FB FORCE455 must be called in the same OB as all other FBs which access the same FM 455.

Simulation of the Analog Values

The simulation of the analog values for the channels 1 to 16 is switched on via the switches S_AION[i] or S_PVON[i], whereby 1 ≤ i ≤ 16. "The function block FORCE455 (Page 133)" shows the point at which the simulated analog value becomes effective.

The simulation values for the channels 1 to 16 are assigned via the PV_SIM[i] parameter.

You can make the simulation values effective at two points:

- S_AION[i] = TRUE (1 ≤ i ≤ 16)

  The value PV_SIM[i] is used in the place of the value from the analog input i of the module.
- S_PVON[i] = TRUE (1 ≤ i ≤ 16)

  The value PV_SIM[i] is used in the place of the prepared value from the analog input i of the module.

Simulation of the digital values

The simulation of the values for the digital inputs 1 to 16 is switched on via the switches S_DION[i], whereby 1 ≤ i ≤ 16.

The simulation values are specified via the DI_SIM[i] parameter.

- S_DION[i] = TRUE (1 ≤ i ≤ 16)

  The value DI_SIM[i] is used in the place of the value of the digital input i of the module.

Note

The LEDs I1 to I16 always show, even in the case of a simulation, the status of the associated digital input.

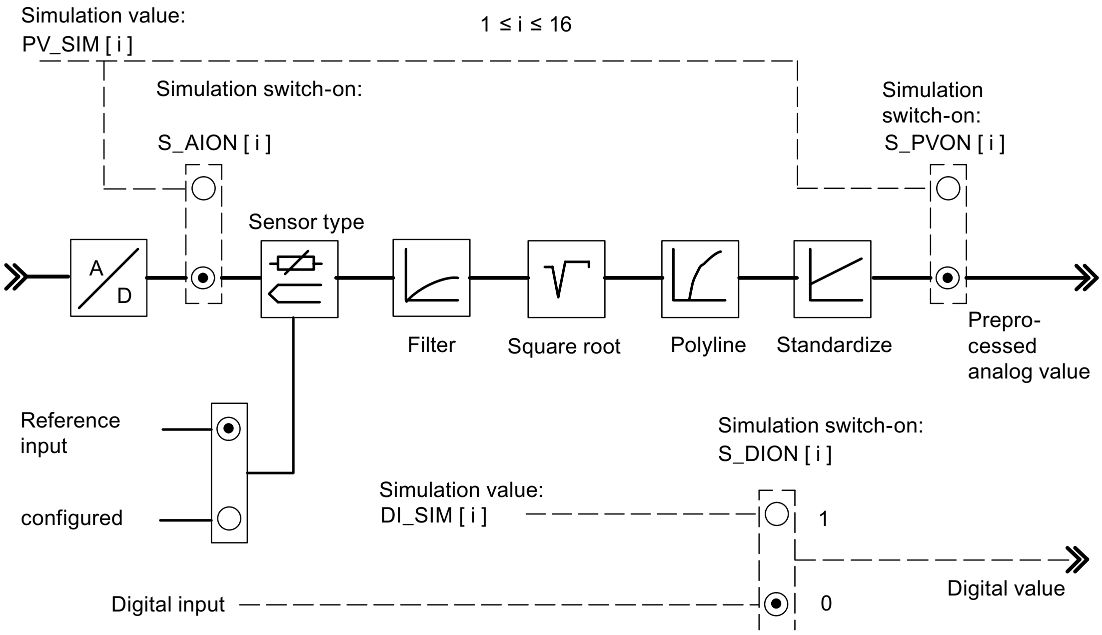


Figure 7-14 Effect of the simulation values

When restarting the FM 455 after power off, the simulation switches on the FM 455 are again set to FALSE.

The output parameter RET_VALU includes the return value RET_VAL of the SFCs 58 and 59. The values of the RET_VALU are described in the /2/ reference manual.

Note

The switching on and the assignment of the simulation values (forcing) does not take place via the parameterization interface. Therefore, the respective switches and connections are illustrated by a dashed line.

7.5 The function block READ_455

Use

The FB READ_455 serves to read off the digital and analog input values so as to support the commissioning.

The FB READ_455 does not require an initialization run. It is usually called cyclically.

Setting up and supply the instance DB

Before you program the module with the user program, you must set up an instance DB and supply it with important data.

1. Under STEP 7 generate the instance DB as a data block with assigned function block FB READ_455 (see chapter "Instance DB of the FB READ_455 (Page 204)").
2. In the case of an instance DB, enter the module address in the MOD_ADDR parameter.

   The module address of the FM 455 is determined by the configuration of your hardware. Take the start address from HW Config.
3. Save the instance DB.

Call

The FB READ_455 must be called in the same OB as all other FBs which access the same FM 455.

Displayed values

The following values are displayed:

- The parameter CJ_TEMP possesses the reference junction temperature that has been measured at the reference junction in either degrees C or degrees F (depending on the temperature unit that has been configured). If on sensor type "thermocouple element" has been configured or if the configured reference junction temperature is chosen with all the analog inputs, then the CJ_TEMP parameter shows 0.0.
- The actual status of the digital inputs 1 to 16 are shown at the parameters STAT_DI[1] to STAT_DI[16], even if these have been simulated.

- The value of the analog inputs 1 to 16 is displayed in the unit mA or mV at the parameters DIAG[1].PV_PER to DIAG[16].PV_PER. If the simulation of the analog input value has been switched on via the FB FORCE455, the simulated value will be shown.
- The prepared analog input value 1 to 16 is shown as a physical unit at the parameters DIAG[1].PV_PHY to DIAG[16].PV_PHY. If the simulation of the prepared physical analog value has been switched on via the FB FORCE455, the simulated value will be shown.

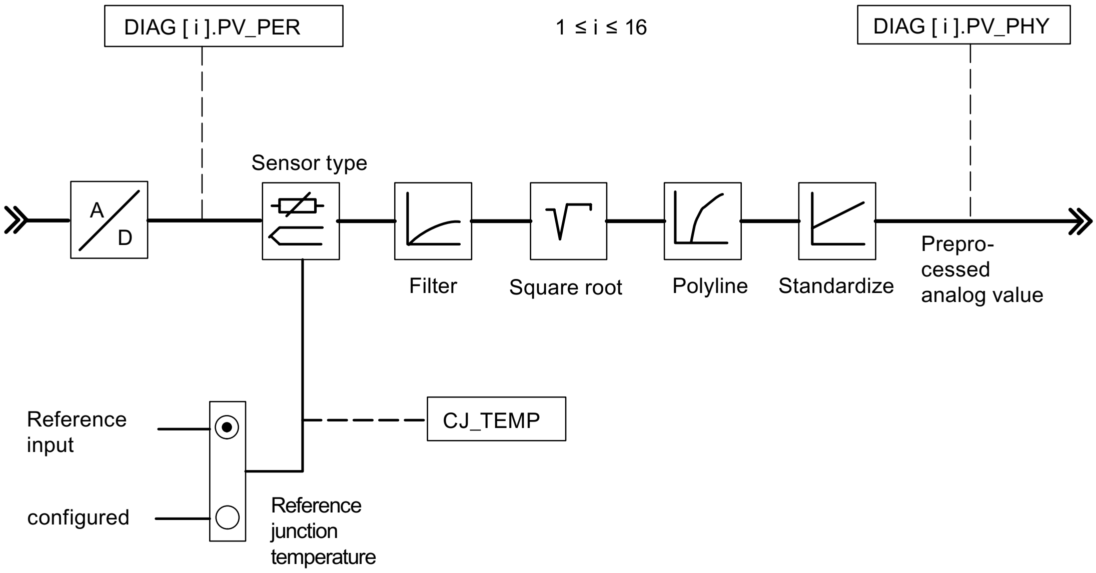


Figure 7-15 Displayed input values

The output parameter RET_VALU includes the return value RET_VAL of the SFCs 58 and 59.

The values from the RET_VALU are described in the /2/ reference manual.

7.6 The function block CH_DIAG

Use

The FB CH_DIAG reads additional channel-specific parameters from the module (to support the commissioning).

The FB CH_DIAG does not require an initialization run. It is usually called cyclically.

Setting up and supplying the instance DB

Before you program the module with the user program, for each controller channel you wish to use you must set up an instance DB and supply it with important data.

1. Under STEP 7 generate the instance DBs for the controller channels as data blocks with assigned function blocks CH_DIAG (see section "Instance DB of the FB CH_DIAG (Page 205)").
2. For each instance DB, enter the module address in the MOD_ADDR parameter.

   The module address of the FM 455 is determined by the configuration of your hardware. Take the start address from HW Config.
3. Enter the channel number of the corresponding controller channel (1, 2, 3 to 16) in the CHANNEL parameter for each instance DB.
4. Save the instance DBs.

Call

The FB CH_DIAG must be called in the same OB as all other FBs that access the same FM 455.

Displayed values

The following values are displayed:

- The SP_R parameter is only relevant in the case of ratio or mixed controllers. It indicates the ratio factor that has been specified by the set value input (see following figure).
- The PV_R parameter is only relevant in the case of ratio controllers. It shows the effect actual value ratio and is calculated as follows: PV_R = (PV - Offset) / PV_D. The offset is the parameter that can be configured by the "Multiplication" button.
- DIF_I is the input value of the D component of the PID controller, not only at ratio or blending controllers (refer to figure "Displayed diagnostic values of the control deviation").
- TRACKPER is the tracking input value of the controller output (refer to figure "Displayed values of the control algorithm").
- IDSTATUS is is the status display of the temperature controller if the controller was configured (refer to figure "Displayed values of the C controller or S controller"). The display IDSTATUS is described in the chapter "Parameter Optimization at a Temperature Controller (Page 79)".

- LMN_P is the P component of the PID controller
  (see figure "Displayed values of the control algorithm").
- LMN_I is the I component of the PID controller
  (see figure "Displayed values of the control algorithm").
- LMN_D is the D component of the PID controller
  (see figure "Displayed values of the control algorithm").

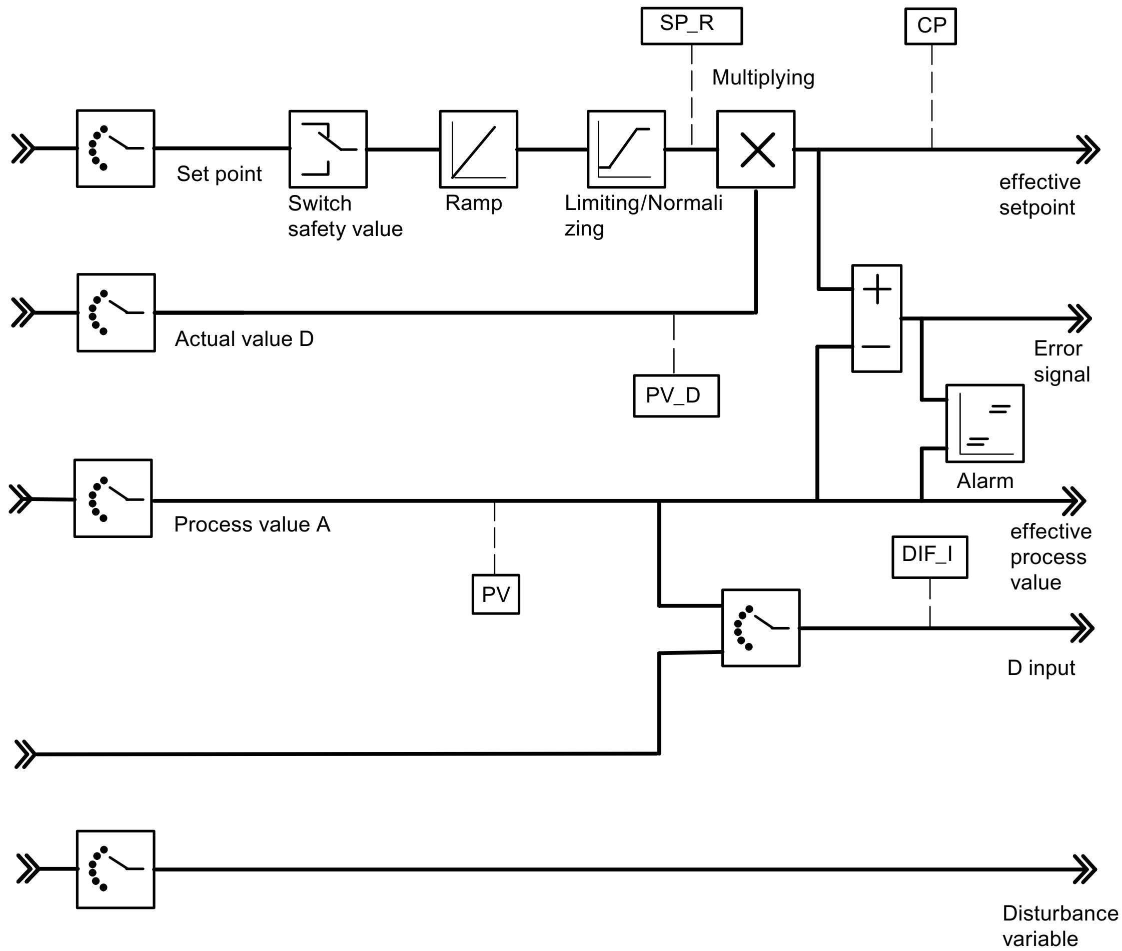


Figure 7-16 Displayed diagnostic values of the control deviation

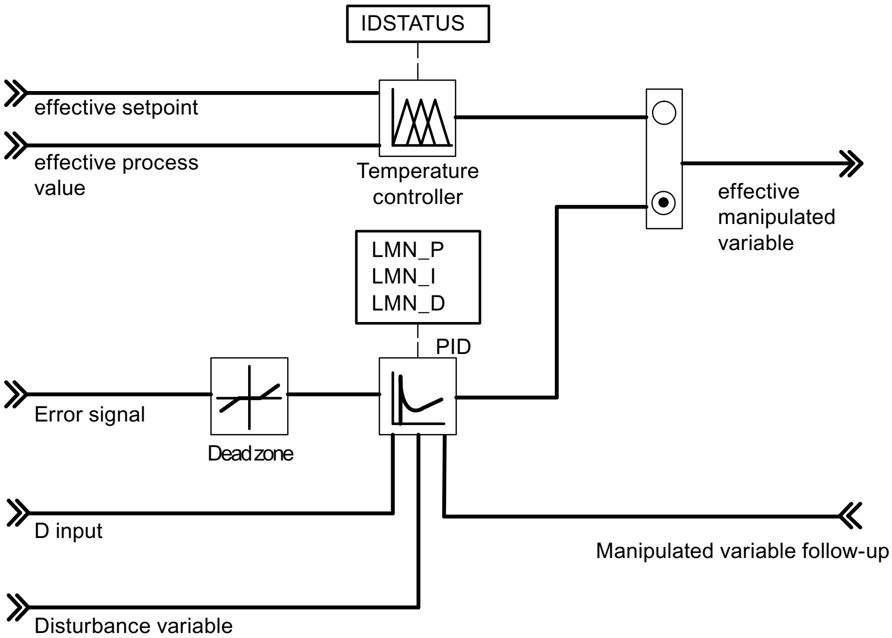


Figure 7-17 Displayed values of the control algorithm

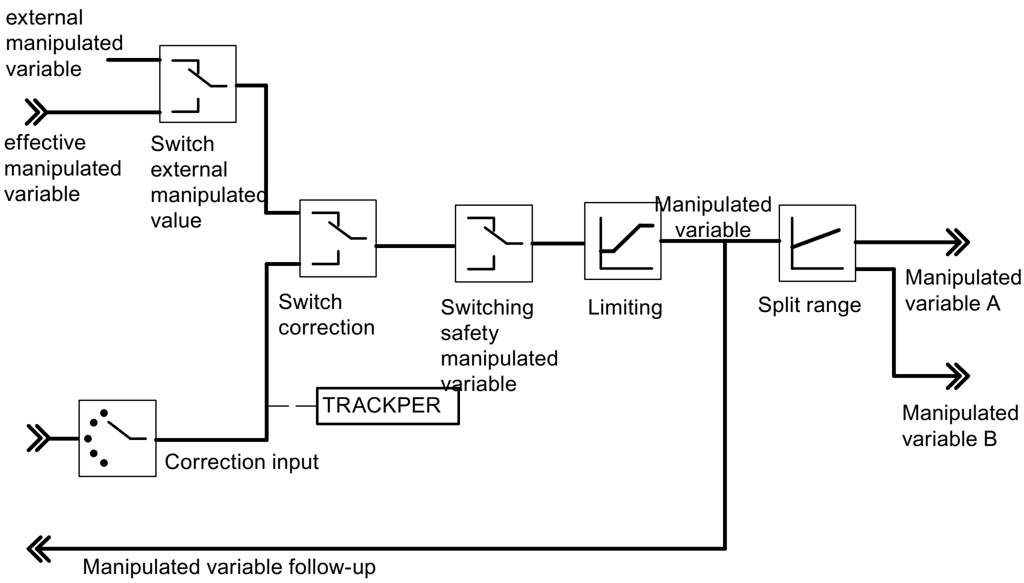


Figure 7-18 Displayed values of the C controller or the S controller

The output parameter RET_VALU includes the return value RET_VAL of the SFCs 58 and 59.

The values from the RET_VALU are described in the /2/ reference manual.

7.7 The function block PID_PAR

Use

The FB PID_PAR serves to make an online change of further parameters that cannot be specified by the FB PID_FM.

The FB PID_PAR requires an initialization run. For this purpose it must be called once here in the startup by using the parameter COM_RST = TRUE. Otherwise, by calling the FB a parameterization error of the module will be generated. You can also read out these parameter assignment errors by using the PLC > Parameter Assignment Error menu of the parameter configuration interface.

To save time, the FB PID_PAR should not be called cyclically, but only when the parameters are to be changed. COM_RST must then be FALSE.

Setting up and supplying the instance DB

Before you program the module with the user program, for each controller channel you wish to use you must set up an instance DB and supply it with important data.

1. Under STEP 7 generate the instance DBs for the controller channels as data blocks with assigned function blocks FB PID_PAR (see chapter "Instance DB of the FB PID_PAR (Page 207)").
2. For each instance DB, enter the module address in the MOD_ADDR parameter.

   The module address of the FM 455 is determined by the configuration of your hardware. Take the start address from HW Config.
3. Enter the channel number of the corresponding controller channel (1, 2, 3 to 16) in the CHANNEL parameter for each instance DB.
4. Save the instance DBs.

Call

The FB PID_PAR must be called in the same OB as all other FBs which access the same FM 455.

Changing Parameter Values

With the FB PID_PAR, with each call you can change in each case one of the REAL parameters listed in the following table and any INT parameters.

The assignment of the specified value to the parameter takes place via the index numbers included in the table. These were specified with INDEX_R or INDEX_I parameters in the instance DB of the FB PID_PAR.

If the input COM_RST = TRUE, then the FB reads the parameters out of the system data and stores them in static variables. The parameters to be changed are overwritten there and then the complete data records are transferred to the FM. As the FB has its own data storage for the parameters in its static variables, additional parameters can also be changed. To do this you must call the same instance DB several times one after the other with COM_RST = FALSE and with different index numbers.

The COM_RST parameter is an input parameter that is not reset by the FB PID_PAR.

The output parameter RET_VALU includes the return value RET_VAL of the SFCs 58 and 59.

The values from the RET_VALU are described in the /2/ reference manual.

Note

Please note that during start-up, the parameters that you have changed with the aid of the FB PID_PAR will be overwritten with the parameters from the system data.

Example

During operation you want to modify the start up time of the ramp for the reference input and, depending on the process state, use different analog input values as the actual value.

- During the start-up of the CPU, call the FB PID_PAR and set with COM_RST = TRUE.
- To configure the starting time of the ramp for the control variable on 10.0, during runtime call the FB PID_PAR with INDEX_R = 30, VALUE_R = 10.0 and INDEX_I = 0.
- If you want to configure the analog input value 4 of the module as the actual value, during runtime call the FB PID_PAR with INDEX_R = 0, INDEX_I = 50 and VALUE_I = 4.

Table 7- 1 List of the REAL and INT parameters to be changed with FB PID_PAR

data type	Description	Index number
-	No parameter selected	0
REAL	Filter time constants for analog input	1
REAL	Measurement end (100%)	2
REAL	Measurement start (0%)	3
REAL	Polyline, support value 1 input side	4
REAL	Polyline, support value 2 input side	5
REAL	Polyline, support value 3 input side	6
REAL	Polyline, support value 4 input side	7
REAL	Polyline, support value 5 input side	8
REAL	Polyline, support value 6 input side	9
REAL	Polyline, support value 7 input side	10
REAL	Polyline, support value 8 input side	11
REAL	Polyline, support value 9 input side	12
REAL	Polyline, support value 10 input side	13
REAL	Polyline, support value 11 input side	14
REAL	Polyline, support value 12 input side	15
REAL	Polyline, support value 13 input side	16
REAL	Polyline, support value 1 output side	17
REAL	Polyline, support value 2 output side	18
REAL	Polyline, support value 3 output side	19
REAL	Polyline, support value 4 output side	20

<table>
<tr><th>data type</th><th colspan="2">Description</th><th>Index number</th></tr>
<tr><td>REAL</td><td colspan="2">Polyline, support value 5 output side</td><td>21</td></tr>
<tr><td>REAL</td><td colspan="2">Polyline, support value 6 output side</td><td>22</td></tr>
<tr><td>REAL</td><td colspan="2">Polyline, support value 7 output side</td><td>23</td></tr>
<tr><td>REAL</td><td colspan="2">Polyline, support value 8 output side</td><td>24</td></tr>
<tr><td>REAL</td><td colspan="2">Polyline, support value 9 output side</td><td>25</td></tr>
<tr><td>REAL</td><td colspan="2">Polyline, support value 10 output side</td><td>26</td></tr>
<tr><td>REAL</td><td colspan="2">Polyline, support value 11 output side</td><td>27</td></tr>
<tr><td>REAL</td><td colspan="2">Polyline, support value 12 output side</td><td>28</td></tr>
<tr><td>REAL</td><td colspan="2">Polyline, support value 13 output side</td><td>29</td></tr>
<tr><td>REAL</td><td colspan="2">Start time of the ramp for control variable</td><td>30</td></tr>
<tr><td>REAL</td><td colspan="2">Security control variable or security control variable ratio</td><td>31</td></tr>
<tr><td>REAL</td><td colspan="2">Offset for the set value link (ratio / mixed controllers)</td><td>32</td></tr>
<tr><td>REAL</td><td colspan="2">Factor for actual value B (three-component controllers)</td><td>33</td></tr>
<tr><td>REAL</td><td colspan="2">Factor for actual value C (three-component controllers)</td><td>34</td></tr>
<tr><td>REAL</td><td colspan="2">Offset for actual value link (three-component controllers)</td><td>35</td></tr>
<tr><td>REAL</td><td colspan="2">Factor for disturbance variable link</td><td>36</td></tr>
<tr><td>REAL</td><td colspan="2">Working point</td><td>37</td></tr>
<tr><td>REAL</td><td colspan="2">Aggressiveness at fuzzy controller</td><td>38</td></tr>
<tr><td>REAL</td><td colspan="2">Corner points for split range function: Start of input signal A area</td><td>39</td></tr>
<tr><td>REAL</td><td colspan="2">Corner points for split range function: End of input signal A area</td><td>40</td></tr>
<tr><td>REAL</td><td colspan="2">Corner points for split range function: Start of output signal A area</td><td>41</td></tr>
<tr><td>REAL</td><td colspan="2">Corner points for split range function: End of output signal A area</td><td>42</td></tr>
<tr><td>REAL</td><td colspan="2">Corner points for split range function: Start of input signal B area</td><td>43</td></tr>
<tr><td>REAL</td><td colspan="2">Corner points for split range function: End of input signal B area</td><td>44</td></tr>
<tr><td>REAL</td><td colspan="2">Corner points for split range function: Start of output signal B area</td><td>45</td></tr>
<tr><td>REAL</td><td colspan="2">Corner points for split range function: End of output signal B area</td><td>46</td></tr>
<tr><td>REAL</td><td colspan="2">Minimum duration of pulse</td><td>47</td></tr>
<tr><td>REAL</td><td colspan="2">Minimum break duration</td><td>48</td></tr>
<tr><td rowspan="4">INT</td><td colspan="2">Selecting the control variable SP or SP_RE for the controllers</td><td rowspan="4">49</td></tr>
<tr><td>0</td><td>Set value SP_RE of the function block</td></tr>
<tr><td>1 to 16</td><td>Analog input value 1 to 16</td></tr>
<tr><td>17 to 32</td><td>Manipulated variable (LMN) from controller 1 to 16</td></tr>
<tr><td rowspan="3">INT</td><td colspan="2">Selecting the main controlled variable actual value A for the controllers</td><td rowspan="3">50</td></tr>
<tr><td>0:</td><td>Actual value A = 0.0</td></tr>
<tr><td>1 to 16:</td><td>Analog input value 1 to 16</td></tr>
<tr><td rowspan="3">INT</td><td colspan="2">Selecting the main controlled variable actual value B for the controllers</td><td rowspan="3">51</td></tr>
<tr><td>0</td><td>Actual value B = 0.0</td></tr>
<tr><td>1 to 16</td><td>Analog input value 1 to 16</td></tr>
<tr><td rowspan="3">INT</td><td colspan="2">Selecting the auxiliary controlled variable actual value C for the controllers</td><td rowspan="3">52</td></tr>
<tr><td>0</td><td>Actual value C = 0.0</td></tr>
<tr><td>1 to 16</td><td>Analog input value 1 to 16</td></tr>
<tr><td>INT</td><td colspan="2">Selecting the auxiliary controlled variable actual value D for the controllers</td><td>53</td></tr>
</table>

data type	Description		Index number
	0	Actual value D = 0.0	
	1 to 16	Analog input value 1 to 16	
	17 to 32	Manipulated variable (LMN) from controller 1 to 16	
INT	Selecting the disturbance variable DISV for the controllers		54
	0	Disturbance variable = 0.0	
	1 to 16	Analog input value 1 to 16	
INT	Selecting the position follow-up TRACK_PER for the controllers		55
	0	Position follow-up = 0.0	
	1 to 16	Analog input value 1 to 16	
INT	Selecting the position follow-up LMNR_PER for the controllers		56
	0	Position follow-up = 0.0	
	1 to 16	Analog input value 1 to 16	
INT	Selecting the signal for changeover to security value for the manipulated value of the controller		57
	0	Only assignment via SAFE_ON parameter of the FB PID_FM	
	1 to 16	Assignment via SAFE_ON parameter of the FB PID_FM specified with digital input 1 to 16	
INT	Selecting the signal for changeover to the follow-up function of the manipulated value of the controller		58
	0	Only assignment via LMNTRKON parameter of the FB PID_FM	
	1 to 16	Assignment via LMNTRKON parameter of the FB PID_FM specified with digital input 1 to 16	
INT	Selecting the signal for changeover of the manipulated value of the controller to LMN_RE		59
	0	Only assignment via LMN_REON parameter of the FB PID_FM	
	1 to 16	Assignment via LMN_REON parameter of the FB PID_FM specified with digital input 1 to 16	
INT	Selecting the upper end signal of the position feedback		60
	0	Only assignment via LMNRHSRE parameter of the FB PID_FM	
	1 to 16	Assignment via LMNRHSRE parameter of the FB PID_FM specified with digital input 1 to 16	
INT	Selecting the lower end signal of the position feedback		61
	0	Only assignment via LMNRLSRE parameter of the FB PID_FM	
	1 to 16	Assignment via LMNRLSRE parameter of the FB PID_FM specified with digital input 1 to 16	

Note

The FB PID_PAR uses the SFC 54 RD_DPARM. Therefore, you can only use the FB PID_PAR in the CPUs listed in the following table:

Table 7- 2 List of CPUs in which the FB PID_PAR can be used

CPU	Order number
CPU 412-1	6ES7 412-1XF02-0AB0
CPU 412-2	6ES7 412-2XG00-0AB0
CPU 413-1	6ES7 413-1XG02-0AB0
CPU 413-2	6ES7 413-2XG02-0AB0
CPU 414-1	6ES7 414-1XG02-0AB0
CPU 414-2	6ES7 414-2XG02-0AB0
CPU 414-2	6ES7 414-2XJ01-0AB0
CPU 414-3	6ES7 414-3XJ00-0AB0
CPU 414-3H	6ES7 414-3HJ00-0AB0
CPU 416-1	6ES7 416-1XJ02-0AB0
CPU 416-2	6ES7 416-2XK01-0AB0
CPU 416-2	6ES7 416-2XL01-0AB0
CPU 416-3	6ES7 416-3XL00-0AB0
CPU 417-4	6ES7 417-4XL00-0AB0
CPU 417-4H	6ES7 417-4HL00-0AB0
All future CPUs	

7.8 The function block CJ_T_PAR

Use

The FB CJ_T_PAR is used to change the configured reference junction temperature online. This is necessary if a temperature control system with several FM 455s with thermoelement inputs is to be operated without having to connect a Pt 100 to each FM 455.

If, for example, with an extruder control with more than 16 hot zones (in the case of Pt 100 more than 8 hot zones), the reference junction temperature is measured with an FM 455, then this can be read off via the FB READ_455 on the parameter CJ_TEMP and then configured with the other FM 455 via the FB CJ_T_PAR.

The FB CJ_T_PAR requires an initialization run. To this purpose it must be called once here in the startup by using the parameter COM_RST = TRUE.

The FB CJ_T_PAR is usually called cyclically. In doing so, COM_RST should be FALSE for reasons of time.

The COM_RST parameter is an input parameter that is not reset by the FB CJ_T_PAR.

Setting up and supplying the instance DB

Before you program the module with the user program, you must set up an instance DB and supply it with important data.

1. Under STEP 7 generate the instance DB as a data block with assigned function block FB CJ_T_PAR (see chapter "Instance DB of the FB CJ_T_PAR (Page 209)").
2. In the case of an instance DB, enter the module address in the MOD_ADDR parameter.

   The module address of the FM 455 is determined by the configuration of your hardware. Take the start address from HW Config.
3. Enter the channel number of the corresponding controller channel (1, 2, 3, ... to 16) in the CHANNEL parameter for the instance DB.
4. Save the instance DB.

The reference junction temperature can be specified on the CJ_T parameter.

The output parameter RET_VALU includes the return value RET_VAL of the SFCs 58 and 59. The values of the RET_VALU are described in the /2/ reference manual.

Call

The FB PID_PAR has to be called in the same OB as all the other FBs that access the same FM 455.

Note

The FB CJ_T_PAR uses the SFC 54 RD_DPARM. Therefore, you can only use the FB CJ_T_PAR in the CPUs listed in the following table.

---

8 Commissioning the FM 455

Introduction

This chapter shows you in a few steps how to commission the FM 455.

Hardware installation and wiring

For a better overview the procedure **Commissioning** is divided into several small steps. In this first section you install the FM 455 in your S7-400 and wire up the external peripheral elements.

Step	Action	√
1	**Establish the slot**	
	Select the slot for the FM 455.	❒
2	**Configure measuring range module**	
	Module for channel 1 and 2: Position	❒
	Module for channel 3 and 4: Position	❒
	Module for channel 5 and 6: Position	❒
	Module for channel 7 and 8: Position	❒
	Module for channel 9 and 10: Position	❒
	Module for channel 11 and 12: Position	❒
	Module for channel 13 and 14: Position	❒
	Module for channel 15 and 16: Position	❒
	(see chapter "Setting the Measurement Type and the Measuring Ranges of the Analog Input Channels (Page 157)")	
3	**Installing the FM 455**	
	• Switch the CPU to STOP mode.	❒
	• Hang the FM 455 and screw it down tight.	❒
	• Apply the slot number.	❒
	(see chapter "Installing and removing the FM 455 (Page 86)")	

Step	Action	√
4	**Wiring up the FM 455** • Analog inputs (right front connector) • Digital inputs (both front connectors) • Analog outputs (only C controller, left front connector) • Digital outputs (only S controller, left front connector) • Wiring the supply voltage – 24 V supply voltage L+: C controller: left front connector pin 3 S controller: left front connector pin 3, 12, 24, 36 and 47 – Ground supply voltage M: left front connector pin 48 • Wiring the reference potential of the analog measuring circuits – M_{ANA}: right front connector pin 20 (see chapter "Terminal assignment of the front connector (Page 87)")	 ❐ ❐ ❐ ❐ ❐ ❐
5	**Front connectors** Insert the front connector and then screw it down.	 ❐
6	**Shielding** Check the shielding of the individual cables.	 ❐
7	**Switch on the voltage supply** Switch on the 24 V supply for the FM 455.	 ❐

Module status after the first switch-on

The status the module is in after the power supply is first switched on, if no data has been transferred yet (delivery state) is characterized by the following properties:

- Analog inputs: No processing
- Analog outputs (C controller): 0 mA
- Digital outputs (S controller): Zero (switched off)
- No controller active
- Diagnostic interrupt disabled

Set up a new project

If you want to insert the FM 455 into an already existing project, proceed to the next section.

If you have not yet set up a project, configure a project in STEP 7 so that parameterization is possible with the parameter assignment menu.

Step	Action	√
1	Set up a new project under STEP 7.	❒
2	Develop a new rack.	❒
3	Enter your hardware structure in the rack in the HW Config.	❒
4	Select the FM 455 from the module catalogue and drag it to the chosen slot.	❒
5	Note the module address that you are shown. This value will be required later on for the processing of the instance DB.	____
6	Now call the parameterization screens for the FM 455 by double-clicking the order number of the FM 455.	❒

Now proceed to the **Parameterization** section.

Inserting FM 455 to an existing project

If you wish to insert the FM 455 into a SIMATIC 400 station of an already existing project, proceed as follows:

Step	Action	√
1	Open the SIMATIC 400 station of your existing project.	❒
2	Select the FM 455 from the module catalogue and drag it to the chosen slot.	❒
3	Note the module address that you are shown. This value will be required later on for the processing of the instance DB.	____
4	Now call the parameterization screens for the FM 455 by double-clicking the order number of the FM 455.	❒

Parameterization

Set the parameters for the module.

Step	Action	√
1	Complete the screens for the basic parameterization: • In the choice of interrupt establish whether or not the FM 455 should trigger interrupts.	❒
2	Click on the **Parameters ...** button.	❒
3	Complete the dialog screens.	❒
4	Save the parameterization under **File > Save**.	❒

Safe the parameter data and transfer to FM 455

When you have finished the parameterization, you must safe the data and prepare the system for operation.

Step	Action	√
1	End the parameterization interface:	❒
2	Save the project under **File > Save and compile**.	❒
3	Switch the CPU to STOP mode.	❒
4	Transfer the data to the CPU by means of **Download target system...** In doing so, the data is transferred directly to the CPU and to the FM 455.	❒

Generate an instance DB

To use the functions of the module, you must generate an instance DB for each controller channel.

Step	Action	√
1	Generate the instance DBs for the controller channels as data blocks with assigned function block FB 31 PID_FM.	❒
2	For each instance DB, enter the module address in the MOD_ADDR parameter. You have noted the address when configuring your hardware with STEP 7.	❒
3	For each instance DB, enter the channel number in the CHANNEL parameter.	❒

Commissioning the FM 455

Now you can optimize and test your control section.

Step	Action	√
1	Switch the CPU to the RUN state.	❒
2	Open the parameterization interface and measure the motor control time: **Test > Measure motor control time**(only with S controllers)	❒
3	Call the controller optimization: **Test > Controller optimization**	❒
4	Carry out the steps of the controller optimization.	❒
5	Monitor and control the control circuit with the circle diagram: **Test > Circle diagram**	❒
6	Monitor the control circuit with the circle diagram: **Test > Circle diagram**	❒

Save the project

When you have successfully completed all tests and FM 455 parameterization has been optimized, you need to save the data again.

Step	Action	√
1	Save all the data in the parameterization interface with **File > Save**.	❒
2	End the parameterization interface:	❒
3	Save the project under **File > Save**.	❒
4	In STOP, transfer the data to the CPU by means of **Download target system...**	❒
5	Switch the CPU to the RUN state.	❒

What you should particularly note

The FM 455 is supplied with voltage solely via the left front connector. In the following cases, the CPU therefore recognizes the "Module removed / cannot respond":

- if the left front connector of the FM 455 is not connected
- if there is no 24 V supply voltage on the left front connector

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Note

If, in the diagnostics buffer of the CPU, the entry "Module removed / cannot respond" is entered, check to see if the left front connector is connected and if the 24 V supply voltage of the FM 455 exists.

Properties of digital and analog inputs and outputs 9

9.1 Characteristics of the digital inputs and outputs

Digital inputs

The FM 455 C and the FM 455 S have 16 digital inputs each (I1 to I16). They are suitable for connecting switches and 2-/3-/4-wire BEROs.

The assignment of digital inputs to controller channels is described in the chapter "Basic Structure of the FM 455 (Page 37)".

Input filter for digital inputs

In order to suppress faults, the digital inputs I1 to I16 have input filters (RC elements) with a standardized filter time of 1.5 ms.

digital outputs

To directly trigger control procedures the FM 455 S has 32 digital outputs. One controller channel is rigidly assigned to every two digital outputs. The assignment is described in the chapter "Basic Structure of the FM 455 (Page 37)".

The digital outputs have the following characteristics.

- Voltage supply via L+ (24 V DC)
- P switches with a loading capacity of maximum 0.1 A
- Suitable for connecting solenoid valves, d.c. contactors an signal lamps
- Isolated against the S7-400 bus
- Protection against overloading and short circuiting

Special feature

When connecting the 24 V supply voltage via a mechanical contact, the outputs of the FM 455 run (depending on switching) for approx. 50 μs "1" signal. You must observe this when you use the FM 455 in connection with fast counters.

Block diagram

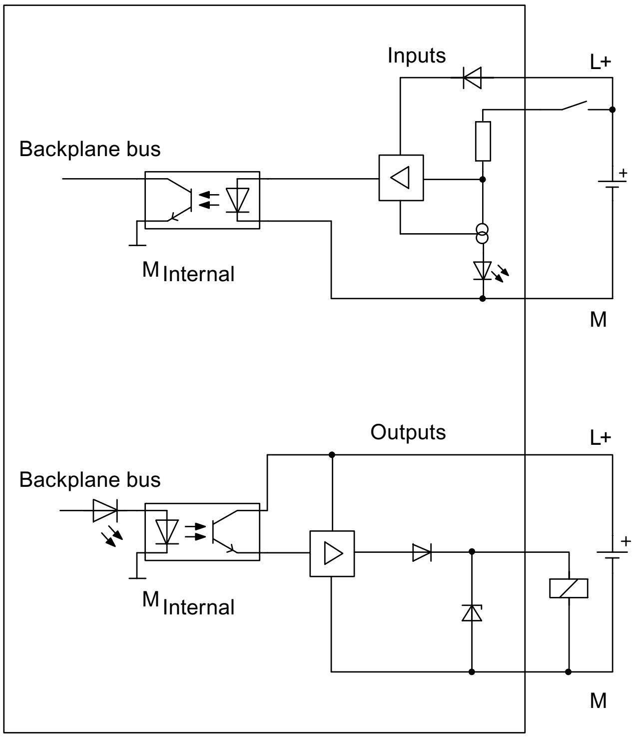


Figure 9-1 Basic circuit diagram of the digital inputs and outputs

9.2 Characteristics of the analog inputs

Characteristics

The analog inputs of the FM 455 are characterized by the following properties:

- 16 inputs
- Measured value resolution
  - 12 bits
  - 14 bits
- Measuring method can be selected per analog input:
  - Voltage
  - Current
  - Resistance
  - Temperature
- Selection of measuring range per analog input
- Assignable diagnostics
- configurable diagnostic interrupt
- Limit monitoring
- configurable limit interrupt

The assignment of analog inputs to controller channels is described in the chapter "Basic Structure of the FM 455 (Page 37)".

Resolution

The integration time results from the selected resolution of the measured value. The more precise the resolution of the measured value, the longer the integration time for the analog input channel (see chapter "Technical Specifications of the FM 455 (Page 249)").

Block diagram

The following figure shows the basic circuit diagram of the analog inputs. The input resistance depends on the set measuring range (see chapter "Technical Specifications of the FM 455 (Page 249)").

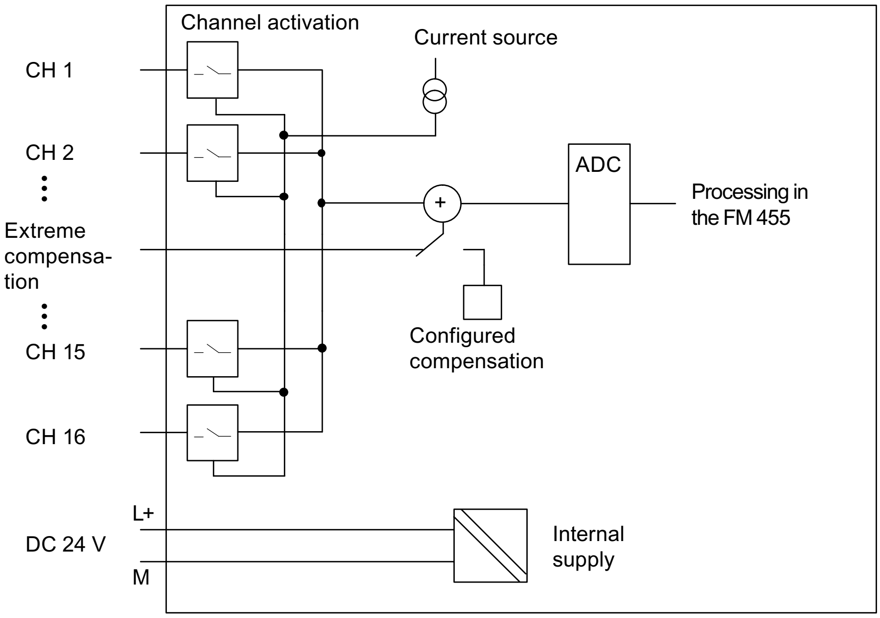


Figure 9-2 Basic circuit diagram of the analog inputs

9.3 Setting the Measurement Type and the Measuring Ranges of the Analog Input Channels

Introduction

You can set various measurement types and measuring ranges at the analog input channels of the FM 455, thus adapting them to various sensors. This adaptation is carried out by means of pluggable coding keys and by parameter assignment under STEP 7.

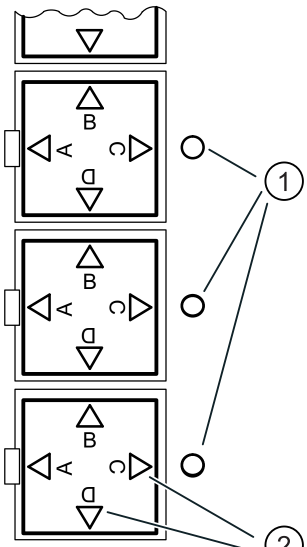
Setting the Measurement Type and the Measuring Ranges via Coding Keys

The FM 455 is supplied with eight plugged coding keys. These coding keys may have to be replugged to suit the measurement type and the measuring range. Please take into account that the coding keys may not be accessible when the FM 455 is installed. Therefore check **before** installing the FM 455 whether the coding keys have to be set to a different measurement type and a different measuring range!

Marks for the Coding Keys

Use the marking points on the FM 455 when replugging the coding key.

The following figure shows the coding keys and the marking points on the FM 455.



① Marks on the FM 455

② Marks on the coding keys

Figure 9-3 Marks for the Coding Keys

A coding key is in the position "A", "B", "C" or "D" when the corresponding letter points in the direction of the marking point on the FM 455.

Adapting to different encoders

You can use the supplied coding keys to adapt two adjacent analog input channels to a common sensor type.

Both the assignment of the keys to the analog input channels and the assignment of the key position to the measuring ranges are printed next to the coding keys on the FM 455.

The assignment of the modules to the channels is shown in the following figure.

The assignment of the individual positions of a coding key to the corresponding sensor types is shown in the following table:

Table 9- 1 Position of the Coding Key

Position	Encoder types
A	Thermocouple elements Resistance sensor in 4-wire technology Resistance thermometer (RTD) in 4-wire technology
B	Voltage sensor 10 V
C	Current sensor 4-wire measuring transducers with current output
D	2-wire transducer

WARNING

The modules can get damaged.

The shunt resistor of a input channel can be destroyed if you connect a voltage sensor to the channel by mistake while the coding key is plugged into position C (current sensor/4-wire measuring transducer).

Ensure that the coding key is in the correct position before you connect a sensor to the module.

The adaptation of the FM 455 to the various encoders is carried out in two steps:

1. Plug the coding key in the correct position into the module.
2. When assigning parameters to the module set the corresponding measuring range for the channels of the module.

Proceed as follows in order to reset a coding key:

1. Use a screwdriver to lever the coding key out of the FM 455.

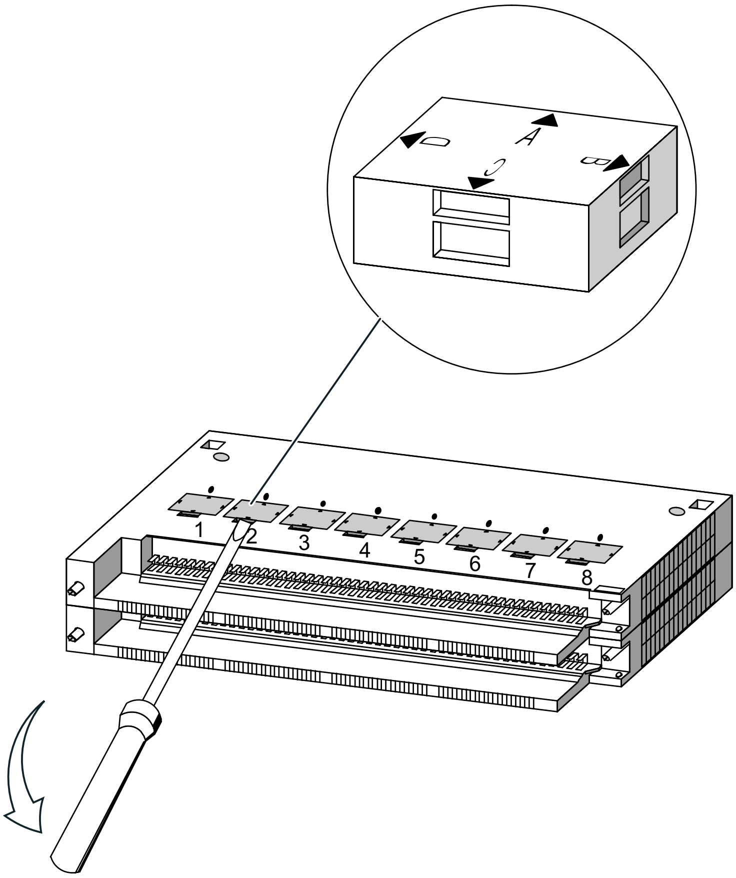


Figure 9-4 Levering the Coding Key out of the FM 455

1: Module for channel 1 and 2

2: Module for channel 3 and 4

3: Module for channel 5 and 6

4: Module for channel 7 and 8

5: Module for channel 9 and 10

6: Module for channel 11 and 12

7: Module for channel 13 and 14

8: Module for channel 15 and 16

2. Plug the coding key in the desired setting (1) into the FM 455.
3. The measuring range which points to the marking point (2) is selected.

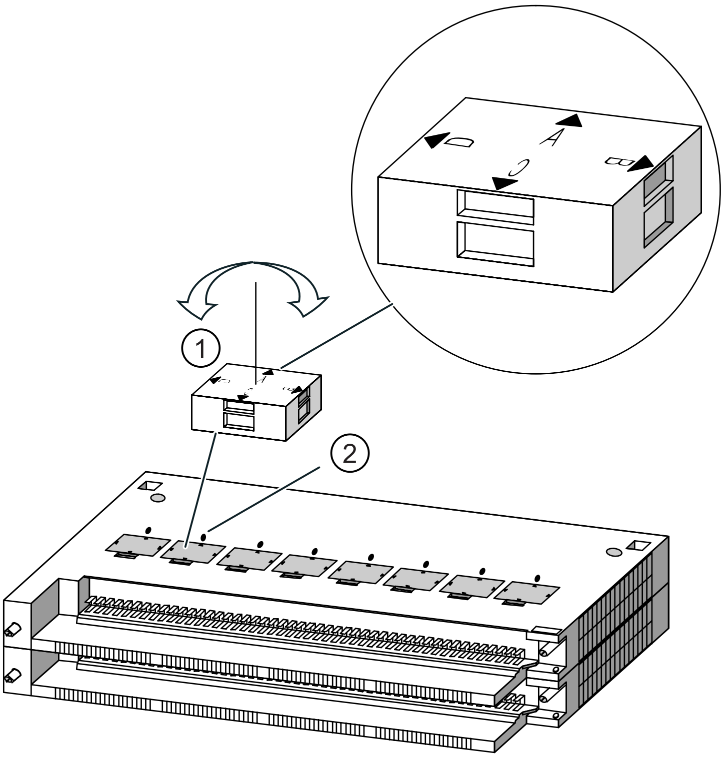


Figure 9-5 Plugging the Coding Key into the FM 455

4. Use the same procedure for all the coding keys.

9.4 Properties of analog outputs (C controller):

Properties

The 16 analog outputs of the FM 455 C have the following characteristics:

- The outputs can be selected per channel as
  - Voltage output
  - Current output
- Resolution 12 bits
- Assignable diagnostics

The assignment of analog inputs to controller channels is described in the chapter "Basic Structure of the FM 455 (Page 37)".

Note

When switching the supply voltage (L+) on and off, incorrect intermediate values can occur at the output for approx. 10 ms.

Block diagram

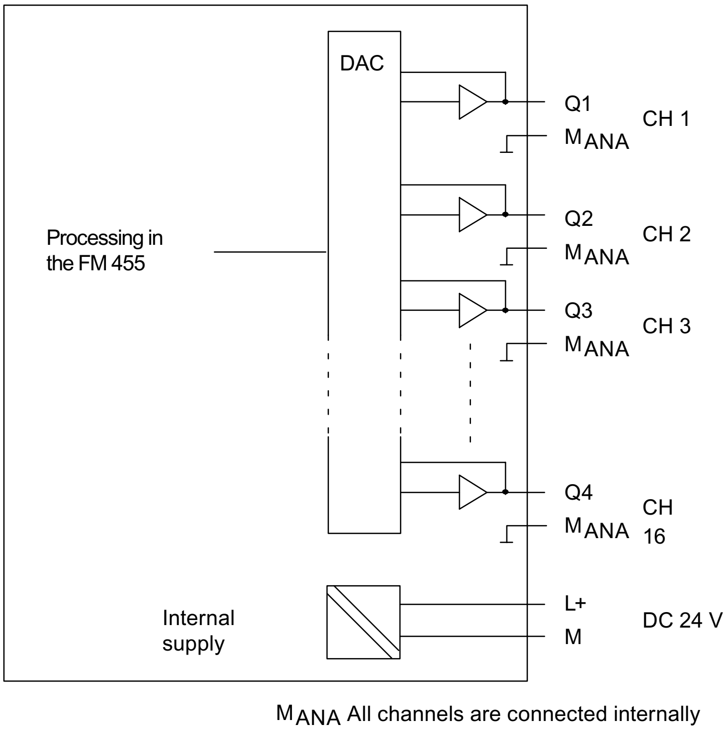


Figure 9-6 Basic circuit diagram of the analog outputs (C controller)

Connecting Measuring Sensors and Loads / Actuators 10

10.1 Using thermocouple elements

Introduction

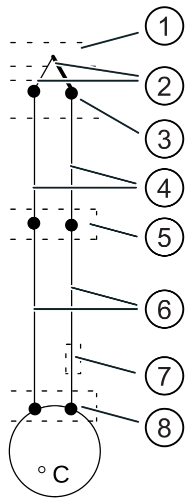
This chapter describes the structure of thermocouple elements and what you must observe when connecting thermocouple elements.

Installation of thermocouple elements

A thermocouple element consists of

- the thermocouple (measuring sensors) and
- the mounting and connection parts required in each case.

The thermocouple is made up of two wires of different metals or metal alloys, which are soldered or welded together at one end. The various types of thermoelements are named after the different material compositions, for example B, J, K. The measuring principle of all the thermoelements is the same, irrespective of the thermoelement type.



① Measuring point
② Thermocouple with positive and negative limbs
③ Connecting point
④ Equalizing conductor
⑤ Reference junction
⑥ Conductor
⑦ Adjustable resistor
⑧ Thermal e.m.f. acquisition point

Figure 10-1 Installation of thermocouple elements

Operating principle of thermocouple elements

If the measuring junction is exposed to a temperature different from that at the free ends of the thermocouple, a voltage is generated between these free ends - the thermoelectric voltage.

The height of the thermal e.m.f. depends on the difference between the temperature of the measuring junction and the temperature at the free ends as well as on the material combination of the thermocouple. Since a thermocouple always detects a temperature difference the free ends of a reference junction have to be kept to a known temperature in order to determine the temperature at the measuring junction.

If this is not possible, the reference junction temperature has to be detected and equalized via the additional input with a Pt 100.

Extension to a reference junction

The thermocouples can be extended from their connecting point by means of equalizing lines to a point with a temperature which remains constant as far as possible (reference junction).

The equalizing conductors are made of the same material as the wires of the thermocouple element. The connecting cables are made of copper. Correct polarity must be ensured on the compensation cables since otherwise large measuring errors will occur.

Compensation of the reference junction temperature

The impact of temperature fluctuations at the reference junction can be compensated by measuring the reference junction temperature outside the module.

Measurement of the reference junction temperature

The influence of temperature at the reference junction of a thermoelement (e.g. terminal box) can be compensated for by means of a Pt 100.

If the actual reference temperature deviates from the compensating temperature, the temperature-dependent resistance will change. A positive or negative compensation voltage is produced which is added to the thermal e.m.f.

Using thermocouple elements

If you connect thermocouple elements, you must observe the following points:

- Configured or external compensation can be used depending on where (locally) you require the reference junction.
- In the case of configured compensation, a configurable reference junction temperature of the module is used as a comparison.
- In the case of external compensation, the temperature of the reference junction for the thermocouple element is taken into consideration by means of a Pt 100.

There is the following restriction:

- External compensation with connection of the Pt 100 to the connections 28 to 31 of the module can only be implemented for **one** thermoelement type. This means that all channels that operate with external compensation must use the same thermoelement type.

Abbreviations used

The abbreviations used in the following figures have the following meanings:

Abbreviation	Meaning
M +	Measuring cable (positive)
M-	Measuring cable (negative)
COMP+	Compensation connection (positive)
COMP-	Compensation connection (negative)
M	Ground terminal
L+	Power supply connection 24 V DC

Options for connecting thermocouple elements

The following figures show the various possibilities of connecting thermoelements with external and configured compensation.

In addition to the following statements, the information from chapter "Connecting measuring sensors to analog inputs (Page 168)" relating to connecting measuring sensors to analog inputs also applies. The subsequent figures do not show the required connecting lines between M_{ANA} and the reference point at the subrack which result from the potential connection of the FM 455 and the sensor (isolated, non-isolated). This means that the information given in the chapter "Connecting measuring sensors to analog inputs (Page 168)" has to be observed and implemented.

Thermocouple elements with external compensation of the reference junction

If all the thermocouple elements that are connected to the inputs of the FM 455 have the same reference junction, you have to compensate as shown in the figure below. The thermocouple elements that use a reference junction must be of the same type.

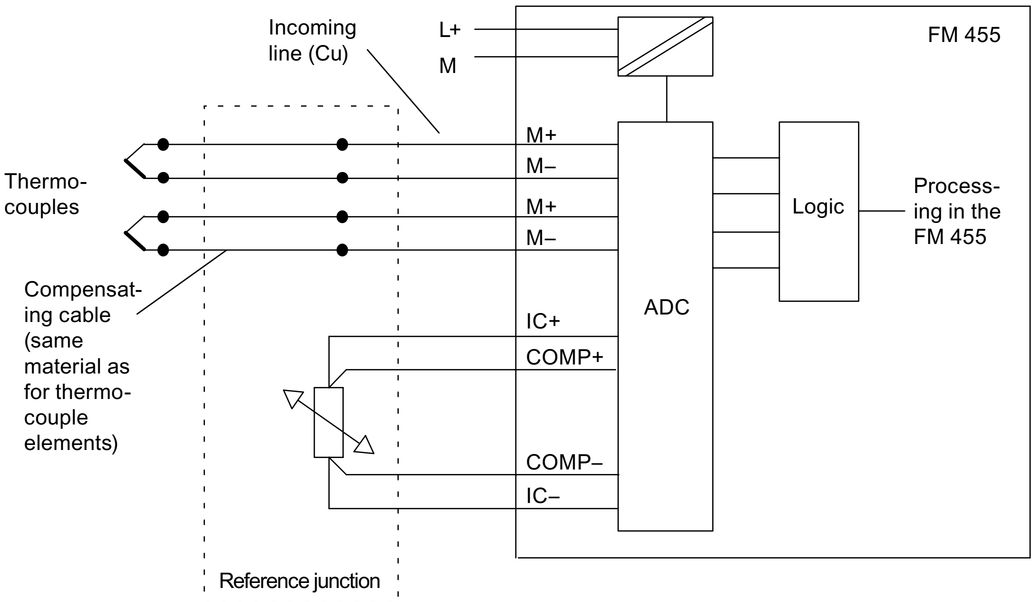


Figure 10-2 Block diagram for connecting thermocouple elements with external compensation

The figures in chapter "Connecting measuring sensors to analog inputs (Page 168)" show how to connect the thermocouple elements to ground.

Thermocouple elements with configured compensation of the reference junction

If thermocouple elements are connected to the inputs of the module either directly or via equalizing conductors, the configured temperature compensation can be used.

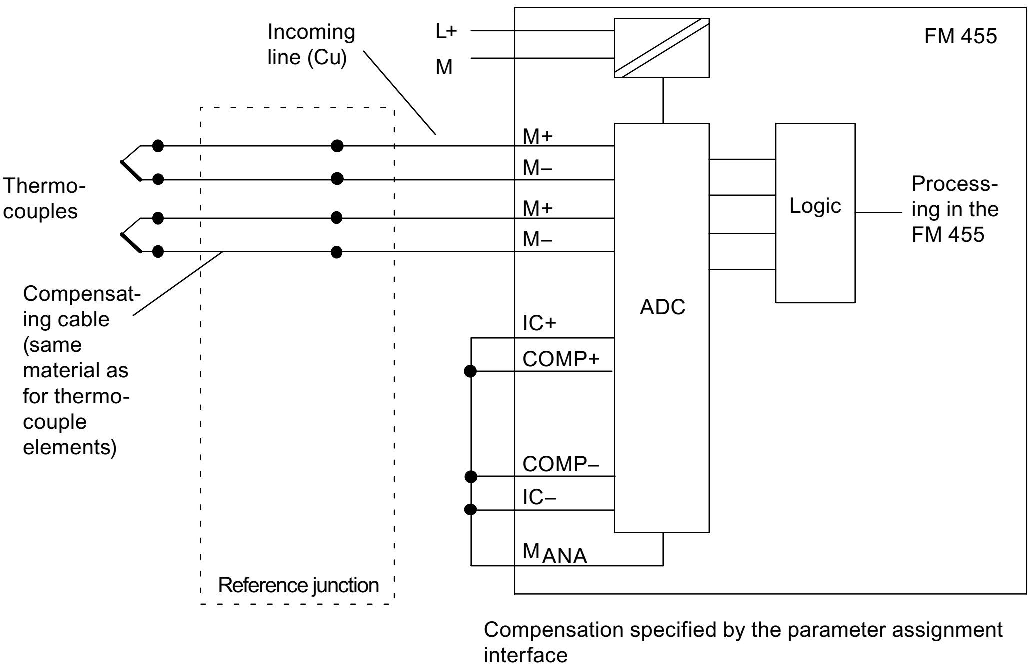


Figure 10-3 Block diagram for connecting thermocouple elements with configured compensation

The figures in chapter "Connecting measuring sensors to analog inputs (Page 168)" show how to connect the thermocouple elements to ground.

10.2 Connecting measuring sensors to analog inputs

Introduction

Depending on the measuring type used you can connect various measuring sensors to the analog inputs of the FM 455:

- Voltage sensor
- Current sensors as 4-wire transducers and 2-wire transducers
- Resistance

This chapter describes how you connect the sensors and what you have to observe when connecting the sensors.

Lines for analog signals

You should use shielded and twisted-pair cables for the analog signals. This reduces interference. You should ground the analog cable shield at both ends of the cables. If there are differences in potential between the ends of the cables, equipotential current may flow across the shield, which could disturb the analog signals. In this case, the shield should only be grounded at one end of the line or an equalizing conductor > 16 mm^2 should be laid.

Reference point M_{ANA}

You must create a connection between the reference point of the analog loop M_{ANA} and the reference point on the subrack in order to operate the FM 455 (refer to the figure pertaining to the FM 455 and potential connection in the chapter "Wiring front connector - overview (Page 97)"). A potential difference between M_{ANA} and the reference point on the subrack could lead to invalidation of the analog signal.

Abbreviations used

The abbreviations used in the following figures have the following meanings:

Abbreviation	Meaning
M +	Measuring cable (positive)
M-	Measuring cable (negative)
M_{ANA}	Reference potential of the analog measuring circuit
M	Ground terminal
L+	Power supply connection 24 V DC
U_{CM}	Potential difference between inputs and reference potential of the measuring circuit M_{ANA}

Connecting measuring transmitters to analog inputs

No potential difference ≥$|U_{CM}|$ (common mode voltage) may arise between the measuring leads M- of the input channels and the reference point of the measuring circuit M_{ANA}. To prevent the permissible value from being exceeded, depending on the potential connection of the encoder (isolated, not isolated), you must perform different actions. These measures are explained in this chapter.

Isolated measuring sensor

The isolated sensors are not connected to the local potential to ground. They can be operated potential-free. Owing to local conditions or interference, differences in potential U_{CM} (static or dynamic) may occur between the M- measuring cables and the reference point of the measuring circuit M_{ANA}.

Note

To ensure the permissible value (U_{CM}) is not exceeded, you must connect M- with M_{ANA}.

But:

When connecting resistance-type sensors and 2-wire measuring transducers you may **not** establish a connection from M- to M_{ANA}.

The following figure shows the connection in principle of isolated sensors to an FM 455.

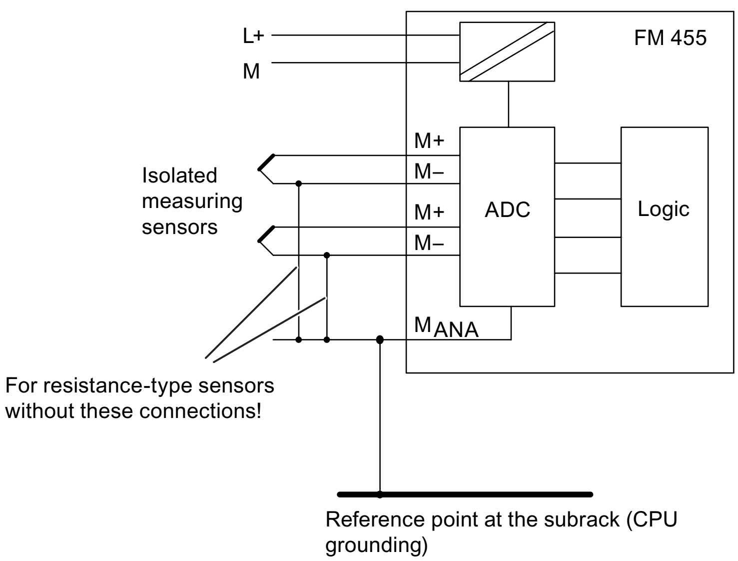


Figure 10-4 Block diagram for connecting isolated measuring sensors

Non-isolated measuring sensors

The non-isolated measuring sensors are connected locally to the potential to ground. You must connect M_{ANA} to the potential to ground. Owing to local conditions or interference, differences in potential U_{CM} (static or dynamic) may occur between the locally distributed measuring points.

If the permissible value for U_{CM} is exceeded, you must provide for potential-compensating cables between the measuring points.

The following figure shows the connection in principle of isolated sensors to an FM 455.

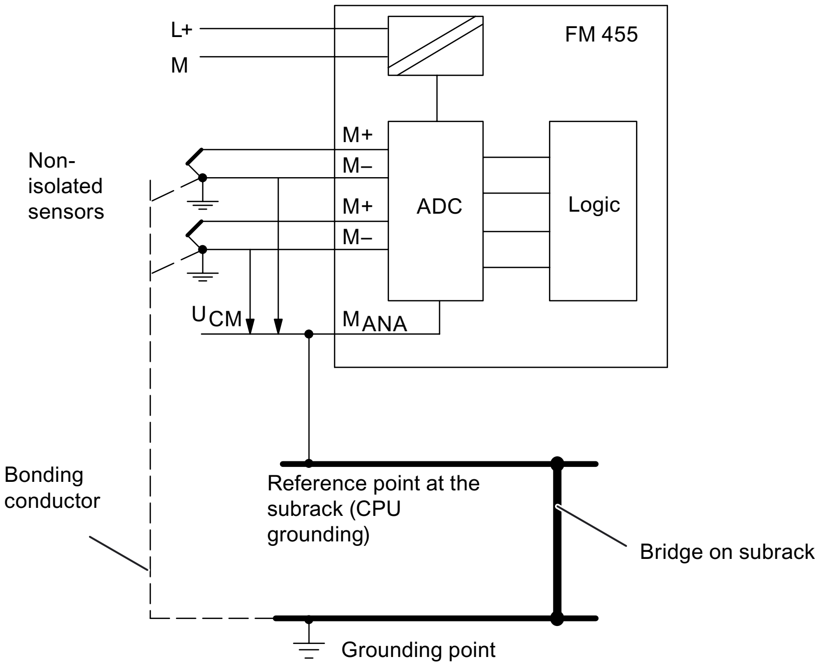


Figure 10-5 Block diagram for connecting non-isolated measuring sensors

10.3 Connecting voltage sensors and current sensors and resistance thermometers

Abbreviations used

The abbreviations used in the following figures have the following meanings:

Abbreviation	Meaning
I_C+	Constant current line (positive)
I_C-	Constant current line (negative)
M +	Measuring cable (positive)
M-	Measuring cable (negative)
M_{ANA}	Reference potential of the analog measuring circuit
M	Ground terminal
L+	Power supply connection 24 V DC

In addition to the following statements, the information from chapter "Connecting measuring sensors to analog inputs (Page 168)" relating to connecting measuring sensors to analog inputs also applies. The subsequent figures do not show the required connecting lines between the reference point at the subrack M-, M_{ANA} and ground potential which result from the potential connection of the FM 455 and the sensor (isolated, non-isolated). This means that the information given in the chapter "Connecting measuring sensors to analog inputs (Page 168)" has to be observed and implemented.

Connection of Voltage Sensors

The following figure shows the connection in principle of isolated sensors to an FM 455.

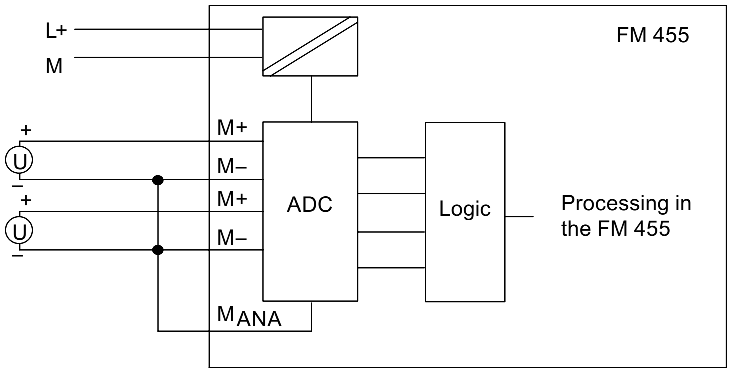


Figure 10-6 Connection of Voltage Sensors

Connection of Current Sensors as 4-Wire Measuring Transducers

4-wire transducers have a separate supply voltage.

The following figure shows the connection of current sensors as 4-wire measuring transducers to an FM 455.

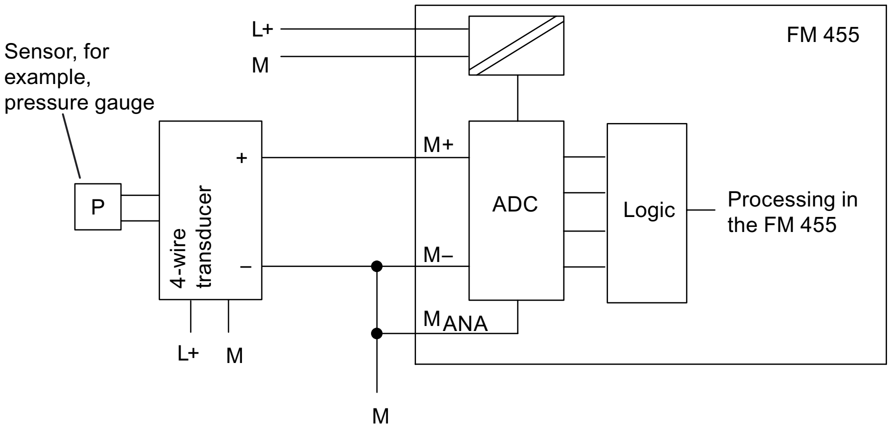


Figure 10-7 Connection of 4-Wire Measuring Transducers

Connection of Current Sensors as 2-Wire Measuring Transducers

The 2-wire measuring transducer converts the supplied measured quantities into current.

2-wire transducers have a separate supply voltage.

The following figure shows the connection of current sensors as 2-wire measuring transducers.

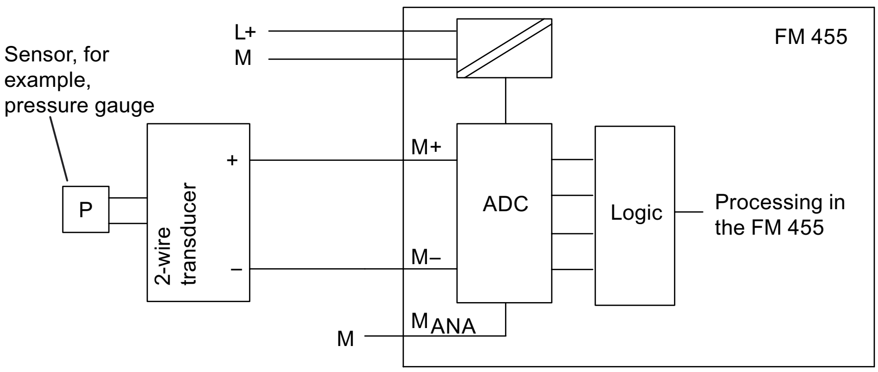


Figure 10-8 Connection of 2-Wire Measuring Transducers

Connection of Resistance Thermometers (e.g. Pt 100) and Resistors

The resistance thermometers/resistors are measured in a four-wire connection. The resistance thermometers/resistance sensors are fed a constant current via terminals I_{C+} and I_C. The voltage produced at the resistance thermometer / resistor is measured via the terminals M+ and M-. This ensures highly accurate measurement results with the four-wire connection.

The following figure shows the connection of resistance thermometers to an FM 455.

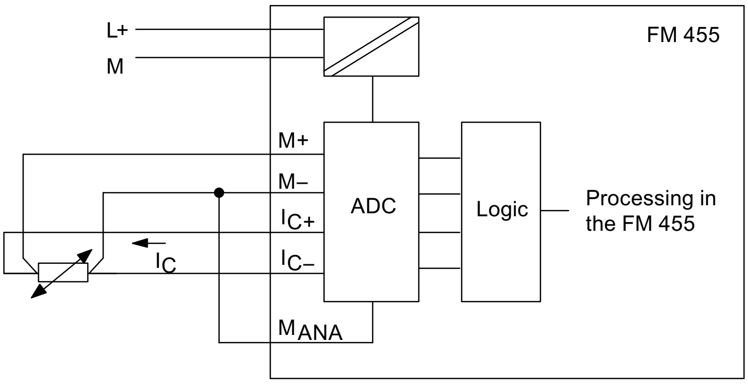


Figure 10-9 Connection of Resistance Sensors

In the case of a 2- or 3-wire connection you must apply corresponding jumpers to the module between M+ and I_{C+} or M- and I_{C-}. However, you have to expect a loss of accuracy in the measurement results.

10.4 Connecting loads / actuators on analog outputs

Introduction

With the FM 455 C you can supply the loads / actuators with current or voltage.

Lines for analog signals

You should use shielded and twisted-pair cables for the analog signals. This reduces interference. You should ground the analog cable shield at both ends of the cables. If there are differences in potential between the ends of the cables, equipotential current may flow across the shield, which could disturb the analog signals. In this case, the shield should only be grounded at one end of the line or an equalizing conductor > 16 mm^2 should be laid.

Reference point M_{ANA}

To operate the FM 455 C you must create a connection between the reference point of the analog circuit M_{ANA} and the reference point on the subrack. To do so connect the connector M_{ANA} to the reference point at the subrack (refer to the figure pertaining to the FM 455 power supply and potential connection in the "Wiring front connector - overview (Page 97)" chapter). A potential difference between M_{ANA} and the reference point on the subrack could lead to invalidation of the analog signal.

Abbreviations used

The abbreviations used in the following figure have the following meanings:

Abbreviation	Meaning
Q	Analog output (current or voltage, depending on configuration)
M_{ANA}	Reference potential of the analog circuit
R_L	Load / actuator
L+	Power supply connection 24 V DC
M	Ground terminal

Connecting Loads to an Analog Output

Loads on an analog output must be connected to Q and the reference point of the analog circuit M_{ANA}.

Loads can only be connected to an analog output with a 2-wire connection.

The following figure shows the connection in principle of loads to an FM 455 C.

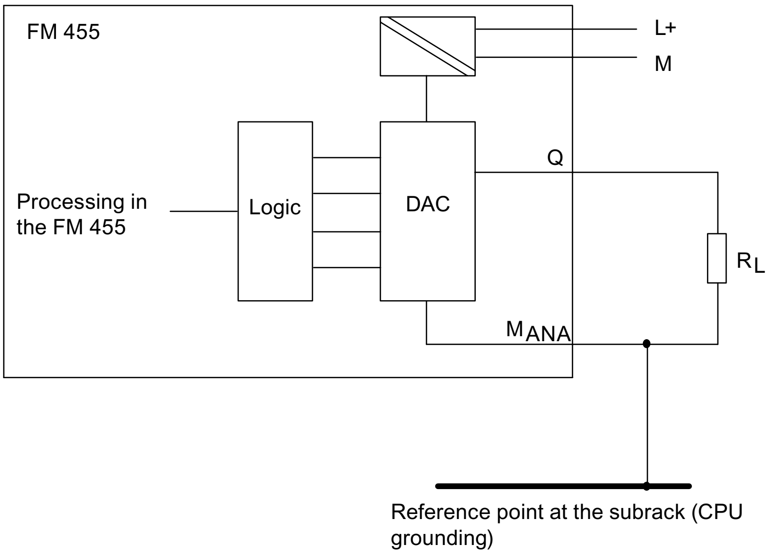


Figure 10-10 Connecting a Load to an FM 455 C

10.5 Connecting loads / actuators to digital outputs

Introduction

With the FM 455 S you can supply the loads / actuators with voltage.

Abbreviations used

The abbreviations used in the following figure have the following meanings:

Abbreviation	Meaning
Q	Digital output
R_L	Load / actuator
L+	Voltage supply connection 24 V DC
M	Ground terminal

Connecting Loads / Actuators to an Analog Output

The following figure shows the connection in principle of loads/actuators to a digital output of an FM 455 S.

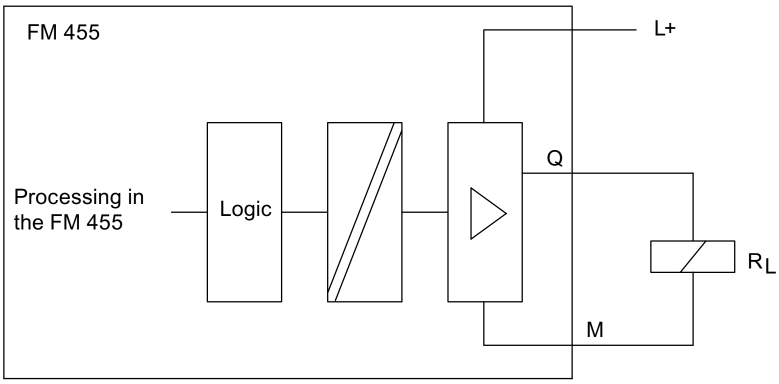


Figure 10-11 Connecting Loads / Actuators to an FM 455 S

11 Pin assignment of the DBs

11.1 Instance DB of the FB PID_FM

Introduction

If you want to communicate with the FM 455 from the user program, you require the FB PID_FM. In addition, you must set up for the used controller channel an instance DB that is assigned to the FB.

Note

After creating an instance DB, all the I/O parameters are set to FALSE.

In order to transfer the parameters from the FM 455 to the instance DB, you must carry out an initialization run during which the I/O parameter is COM_RST = TRUE.

Parameters of the Instance DB

Table 11- 1 Input parameters of the instance DB to the FB PID_FM

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
0.0	MOD_ADDR	INT	FM 355/455 module address		256	The module address that resulted from the configuration with STEP 7 is given at this input.	–
2.0	CHANNEL	INT	channel number	1 to 16	1	On the "channel number" input the number of the controller channel is configured to which the instance DB refers.	–
4.0	PHASE	INT	phase of PID self tuner	Is not configured	0	The PHASE parameter can be switched with the output parameter PHASE of a PID self tuner (program for the self-setting of controller parameters). The phase status of the PID self tuner can be shown in plain English in the circle diagram. This parameter is of no significance for the OP.	–

Table 11- 2 Output parameters of the instance DB to the FB PID_FM

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
6.0	RET_VALU	INT	return value SFC 58/59		0	RET_VALU contains the return value RET_VAL of the SFC58/59. RET_VALU can be evaluated if an error is reported via QMOD_F (see Reference Manual /2/).	–
8.0	out_par	WORD	start of output parameters	W#16#3130	W#16#3130	The out_par parameter may not be altered by the user. It identifies the beginning of the output parameters which are read from the module when READ_VAR = TRUE is set.	–
10.0	SP	REAL	set point	technical value range (physical variable)	0.0	The set value that becomes effective is issued on output "set value".	–
14.0	PV	REAL	process variable	technical value range (physical variable)	0.0	The actual value that becomes effective is issued on the "actual value" output.	–
18.0	ER	REAL	error signal	technical value range (physical variable)	0.0	The control deviation that becomes effective is issued on the "control deviation" output.	–
22.0	DISV	REAL	disturbance variable	-100.0...100.0 (%)	0.0	The interference that becomes effective is issued on the "interference" output.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
26.0	LMN	REAL	manipulated value	-100.0...100.0 (%)	0.0	The effective setpoint is output at the “Setpoint” output. With a step controller without analog position feedback, the unlimited P- + D-component is output at the parameter LMN.	–
30.0	LMN_A	REAL	man. var. A of split range function / repeated man. var.	-100.0...100.0 (%)	0.0	At the output “Manipulated value A of split-range function / position feedback” the manipulated value A of the split-range function for a continuous controller and the position feedback for a step controller with analog position feedback are displayed. The LMN_A output can only be used for an approximate display of a respective simulated manipulated variable. The starting value LMNRSVAL of the simulated position feedback must be configured correspondingly and becomes effective when LMNRS_ON is set.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
34.0	LMN_B	REAL	man. var. B of split range function	-100.0...100.0 (%)	0.0	At the output “Manipulated value B of split-range function” the manipulated value B of the split-range function is displayed for a continuous controller.	–
38.0	QH_ALM	BOOL	high limit interrupt reached		FALSE	The actual value or the controlled variable is monitored on four limits. If the limit H_ALM is violated, this is indicated at the output “High limit alarm reached”.	–
38.1	QH_WRN	BOOL	high limit warning reached		FALSE	The actual value or the controlled variable is monitored on four limits. Exceeding the limit H_WRN is displayed on the output "upper limit warning reached".	–
38.2	QL_WRN	BOOL	process variable low limit warning reached		FALSE	The actual value or the controlled variable is monitored on four limits. Falling short of the limit L_WRN is displayed on the output "lower limit warning reached".	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
38.3	QL_ALM	BOOL	low limit interrupt reached		FALSE	The actual value or the controlled variable is monitored on four limits. If the limit L_WRN is violated, this is indicated at the output "Low limit warning reached".	–
38.4	QLMN_HLM	BOOL	high limit of manipulated value reached		FALSE	The manipulated variable is always limited to an high and a low limit. The output "High limit of manipulated value reached" indicates that the upper limit has been exceeded. (Not for step controllers without analog position feedback)	–
38.5	QLMN_LLM	BOOL	low limit of manipulated value reached		FALSE	The manipulated variable is always limited to an high and a low limit. The output "Low limit of manipulated value reached" indicates that the lower limit has been exceeded. (Not for step controllers without analog position feedback)	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
38.6	QPARA_F	BOOL	parameter assignment error		FALSE	The module checks the parameters for validity. A parameter assignment error is indicated at the output “Parameter assignment error”. You can also read out these parameter assignment errors by using the menu **PLC > Parameter Assignment Error** of the parameter assignment interface.	–
38.7	QCH_F	BOOL	channel error		FALSE	The "channel error" output is set if the controller channel cannot provide valid results. “Channel error” (e.g. wire break) is also set if QPARA_F = 1 or QMOD_F = 1. If QCH_F=TRUE, the exact error information can be read out in the diagnostics data record DS1 of the module (see chapter "Errors and diagnostics (Page 225)") .	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
39.0	QUPRLM	BOOL	limit of positive set value inclination reached		FALSE	The setpoint is limited to a positive and negative gradient. If the output “Limit of positive setpoint inclination reached” is set, the positive setpoint inclination is limited.	–
39.1	QDNRLM	BOOL	limit of negative set value inclination reached		FALSE	The setpoint is limited to a positive and negative gradient. If the output "Limit of negative setpoint inclination reached" is set, the negative setpoint inclination is limited.	–
39.2	QSP_HLM	BOOL	high limit of set value reached		FALSE	The setpoint is always limited to a high and a low limit. The output “High limit of setpoint value reached” indicates that the upper limit has been exceeded.	–
39.3	QSP_LLM	BOOL	low limit of set value reached		FALSE	The setpoint is always limited to a high and a low limit. The output “Low limit of setpoint value reached” indicates that the lower limit has been exceeded.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
39.4	QLMNUP	BOOL	manipulated value signal up		FALSE	This is the "manipulated value signal up" output. (Only applies to step-action or pulse controllers)	–
39.5	QLMNDN	BOOL	manipulated value signal down		FALSE	This is the "manipulated value signal down" output. (Only in the case of step controllers or pulse controllers)	–
39.6	QID	BOOL	identification in work		FALSE	QID = TRUE shows that an identification is running (not that it is switched on). After the end of identification the identification result can be read out via the IDSTATUS parameter of the CH_DIAG FB (see chapter "Parameter Optimization at a Temperature Controller (Page 79)" and chapter "The function block CH_DIAG (Page 137)").	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
40.0	QSPOPON	BOOL	set value operation on		FALSE	The output “Setpoint operation on” indicates whether the setpoint is being operated via the configuration tool. If the bit is set, the value SP_OP is adopted as the set value.	–
40.1	QLMNSAFE	BOOL	safety operation		FALSE	If the output “Safety operation” is set, the safety manipulated value is output as the manipulated value.	–
40.2	QLMNOPON	BOOL	manipulated value operation on		FALSE	The output “Manipulated value operation on” indicates whether the manipulated value is being operated via the configuration tool. If the bit is set, the value LMN_OP is adopted as the manipulated value.	–
40.3	QLMNTRK	BOOL	follow-up operation		FALSE	The output “follow-up operation” indicates whether the manipulated value is matched by an analog input.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
40.4	QLMN_RE	BOOL	manual = 1 automatic = 0		FALSE	The output "manual = 1; automatic = 0" indicates whether or not the manipulated value is set on the external manipulated value LMN_RE (manual = 1).	–
40.5	QLMNR_HS	BOOL	high stop signal of repeated manipulated value		FALSE	The output “High limit signal of position feedback” indicates whether the control valve is at its upper limit. QLMNR_HS = TRUE means: The manipulated valve is located at the high stop. (Only in the case of step controllers)	–
40.6	QLMNR_LS	BOOL	low stop signal of repeated manipulated value		FALSE	The output “Low limit signal of position feedback” indicates whether the control valve is at its lower limit. QLMNR_LS = TRUE means: The control valve is at the low end stop. (Only in the case of step controllers)	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
40.7	QLMNR_ON	BOOL	repeated manipulated value on		FALSE	The output "position feedback on" shows the set mode "step controller with position feedback" or "step controller without position feedback".	–
41.0	QFUZZY	BOOL	PID algorithm = 0 fuzzy = 1		FALSE	If the output parameter QFUZZY=1 is set, the controller works with the fuzzy algorithm.	–
41.1	QSPLEPV	BOOL	fuzzy display: set value < process variable		FALSE	The output "Display of FUZZY controller: Set value < actual value" is set when the fuzzy controller is switched on, if the set value is less than the effective actual value.	–
41.2	QSPR	BOOL	split range operation		FALSE	If the output “Split-range operation” is set, the continuous controller operates in split-range mode.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
41.4	QMAN_FC	BOOL	follow-up mode or anti-reset-windup by slave controller		FALSE	The "QMAN_FC" output is set in the following two cases: • The slave controller is in manual mode and the master controller is followed up to the actual value of the slave controller. • The integral component of the master controller is halted because the setpoint value or manipulated variable of the slave controller is in the limitation or because the slave controller is in manual mode.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
41.7	QPARABUB	BOOL	internal value		FALSE	This parameter is set by the FM when operating parameters are changed via the OP. If READ_VAR = TRUE and if this display is set by the FM, then the FB PID_FM reads the parameters SP_OP_ON, LMNOP_ON, SP_OP and LMN_OP from the FM and stores them in the instance DB. The FB thus takes over the operating state of the FM. After the reading process the parameter is set to FALSE.	–
42.0	QMOD_F	BOOL	module error		FALSE	The function block checks correct reading and writing of a data record. If an error is detected, the output “Module error” is set. The cause of errors can be: An incorrect module address at the parameter MOD_ADDR, an incorrect channel number at the parameter CHANNEL or a defective module.	–

Table 11- 3 I/O parameters of the instance DB to the FB PID_FM

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
44.0	COM_RST	BOOL	read control parameters from FM 355/455		FALSE	If the parameter COM_RST = TRUE, then the FB PID_FM carries out the initialization run. In doing so the controller parameters (this are all the parameters after cont_par) are read from the FM and stored in the instance DB. Furthermore, the parameters MOD_ADDR and CHANNEL are tested for validity. After the initialization process the parameter is set to FALSE.	–
44.1	LOAD_OP	BOOL	load operator parameter to FM 355/455		FALSE	If the in/out parameter “Load operator parameters to FM 355/455” is set, the operator parameters are downloaded to the module and the in/out parameter reset.	–
44.2	READ_VAR	BOOL	read variables from FM 355/455		FALSE	If the in/out parameter “Read variables from FM 355/455” is set, the output parameters are read from the module and the in/out parameter is reset.	–
44.3	LOAD_PAR	BOOL	load control parameter to FM 355/455		FALSE	If the in/out parameter “Load control parameters to FM 355/455” is set, the control parameters are downloaded to the module and the in/out parameter reset.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
46.0	op_par	WORD	start of operation parameters	W#16#3130	W#16# 3130[2)]	The op_par parameter may not be altered by the user. It identifies the beginning of the operating parameters which transferred to the module when LOAD_OP = TRUE was set. The end of the operating parameter is shown by cont_par.	–
48.0	SP_RE	REAL	external set value	technical value range (physical variable)	0.0	An external set value is switched on input "external set value" with the controller.	–
52.0	LMN_RE	REAL	external manipulated value	-100.0...100.0 (%)	0.0	An external manipulated value is switched on input "external manipulated value" with the controller.	–
56.0	SP_OP_ON[1)]	BOOL	set value operation on		FALSE	The configuration tool has access to the in/out parameter “Setpoint operation on”. If the bit is set, the value SP_OP is used as the setpoint.	–
56.1	SAFE_ON	BOOL	safety position on		FALSE	If the input “safety position on” is set, a safety value is used as the manipulated value. Note: The safety operations via LMNDN_OP, LMNUP_OP and LMNSOPON on a step controller are of higher priority than the safety value.	–
56.2	LMNOP_ON[1)]	BOOL	manipulated value operation on		FALSE	The configuration tool has access to the in/out parameter “Setpoint operation on”. If the bit is set, the value LMN_OP is used as the manipulated value.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
56.3	LMNTRKON	BOOL	match (LMN from analog input)		FALSE	If the input “Track (LMN from analog input)” is set, the manipulated value is tracked to an analog input (AI). (this does not apply to step-action controllers without analog position feedback).	–
56.4	LMN_REON	BOOL	external manipulated value		FALSE	If the "external manipulated value on" input is set, the external manipulated value LMN_RE is adopted as the manipulated value.	–
56.5	LMNRHSRE	BOOL	high stop signal of repeated manipulated value		FALSE	The signal “Control valve at upper end stop” is interconnected at the input “High limit signal of position feedback”. LMNRHSRE = TRUE means: The control valve is at the upper endstop. (Only in the case of step controllers)	–
56.6	LMNRLSRE	BOOL	low stop signal of repeated manipulated value		FALSE	The signal “Control valve at lower end stop” is connected at the input “Low limit signal of position feedback”. LMNRLSRE = TRUE means: The manipulated valve is located at the lower stop. (Only in the case of step controllers)	–
56.7	LMNSOPON[1)]	BOOL	manipulated signal operation on		FALSE	If the bit at the input “Manipulated value signal operation on” is set, the signals LMNUP_OP and LMNDN_OP are used as manipulated value signals. (Only in the case of step controllers)	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
57.0	LMNUP_OP1)	BOOL	manipulated value signal up operation		FALSE	If the LMNSOPON is set, the value on the "manipulated value signal up operation" input is adopted as the manipulated value signal. (Only in the case of step controllers)	–
57.1	LMNDN_OP1)	BOOL	manipulated value signal down operation		FALSE	If the LMNSOPON is set, the value on the "manipulated value signal down operation" input is adopted as the manipulated value signal. (Only in the case of step controllers)	–
57.3	LMNRS_ON	BOOL	simulation of the position feedback on		FALSE	If there is no position feedback, this can be simulated. The function is switched on at the input “Simulation of the position feedback on”. The configuration tool (controller optimization) has access to this parameter since at least one simulated manipulated value is required for optimization if a step controller was configured without position feedback. The simulated value is displayed on the LMN_A parameter. When the simulation is activated the value of the parameter LMNRSVAL is set as the starting value. CAUTION: The simulation deviates increasingly from the real position feedback as time passes. (This only applies to step-action controllers without analog position feedback).	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
57.4	FUZID_ON	BOOL	fuzzy identification on		FALSE	On the input "fuzzy identification on" the identification of the fuzzy algorithm is switched on.	–
58.0	SP_OP[1)]	REAL	set value operation	technical value range (physical variable)	0.0	The configuration tool (controller optimization) has access to the in/out parameter “Setpoint operation”. If the bit SP_OP_ON is set, the value "set value operation" is adopted as the set value.	–
62.0	LMN_OP[1)]	REAL	manipulated value operation	-100.0...100.0 (%)	0.0	The configuration tool has access to the in/out parameter “Setpoint operation on”. If the bit LMNOP_ON is set, the value "manipulated value operation" is adopted as the manipulated value.	–
66.0	LMNRSVAL	REAL	start value of the simulated position feedback	-100.0...100.0 (%)	0.0	The configuration tool (controller optimization) has access to the input "Start value of the simulated position feedback". The start value of the simulation is entered at the parameter. (This only applies to step-action controllers without analog position feedback).	–
70.0	cont_par	WORD	start of control parameters	W#16#3130	W#16#3130[2)]	The cont_par parameter may not be altered by the user. It identifies the beginning of the controller parameters which are read from the FM and saved in the instance DB if COM_RST = TRUE and which are transferred to the FM if LOAD_PAR = TRUE is set. The end of the controller parameter is the end of the instance DB.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
72.0	P_SEL	BOOL	P action on		TRUE[2)]	In the PID algorithm, the PID parts can be switched on and off individually. The proportional component is switched on if the input "P action on" is set.	PID Controller
72.1	PFDB_SEL	BOOL	P action in the feedback		FALSE [2)]	In the PID algorithm, the P and D parts can be positioned in the feedback. The P action is in the feedback path if the input "P action in feedback path" is set.	PID Controller
72.2	MONERSEL	BOOL	supervision: process variable = 0 error signal = 1		FALSE [2)]	The controller has a limit value alarm that can either be used for the process variable or the error signal. If the input "Monitoring: Actual value = 0, control deviation = 1" is set, the control deviation will be monitored.	Interrupt controller
74.0	D_EL_SEL	INT	D element input for the controller	0 to 17	0[2)]	The D element in the PID algorithm can be positioned at a separate input. This is selected via the input "D-element input for the controller". 0: Negative deviation 1 to 16: Analog input 1 to 16 17: negative actual value, D part in the feedback	Error Signal (...) Controller
76.0	SP_HLM	REAL	set value high limit	> SP_LLM (physical variable)	100.0[2)]	The set value is always restricted to an upper and lower limit. The input "set value high limit" indicates the upper limit.	Limiting setpoint controller
80.0	SP_LLM	REAL	set value low limit	< SP_HLM (physical variable)	0.0[2)]	The setpoint is always limited to a high and a low limit. The input "set value low limit" indicates the lower limit.	Limiting setpoint controller

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
84.0	H_ALM	REAL	high limit interrupt	> H_WRN (physical variable)	100.0[2)]	Four limits can be set for monitoring the actual value or the error signal. The input "high limit interrupt" indicates the highest limit.	Interrupt controller
88.0	H_WRN	REAL	high limit warning	H_ALM...L_WRN (physical variable)	90.0[2)]	Four limits can be set for monitoring the actual value or the error signal. The input "high limit warning" indicates the second highest limit.	Interrupt controller
92.0	L_WRN	REAL	low limit warning	H_WRN...L_ALM (physical variable)	10.0[2)]	Four limits can be set for monitoring the actual value or the error signal. The input "low limit warning" indicates the second lowest limit.	Interrupt controller
96.0	L_ALM	REAL	low limit interrupt	< L_WRN (physical variable)	0.0[2)]	Four limits can be set for monitoring the actual value or the negative deviation. The input "low limit interrupt" indicates the lowest limit.	Interrupt controller
100.0	HYS	REAL	hysteresis	≥ 0.0 (physical variable)	1.0[2)]	To avoid flickering of the watchdog LEDs, a hysteresis can be set at the input “hysteresis”.	Interrupt controller
104.0	DEADB_W	REAL	dead band width	≥ 0.0 (physical variable)	0.0[2)]	The control deviation is led over a dead band. The input “dead band width” determines the width of the dead band.	Dead band controller
108.0	GAIN	REAL	proportional gain	total value range (dimensionless)	1.0[2)]	The input “Proportional gain” determines the controller gain.	PID Controller
112.0	TI	REAL	reset time (s)	= 0.0 or ≥ 0.5	3000.0[2)]	The input “Reset time” determines the time response of the integrating action element. With TI = 0, the integrator is switched off	PID Controller
116.0	TD	REAL	derivative time (s)	= 0.0 or ≥ 1.0	0.0[2)]	The "derivative time" input determines the time response of the derivative unit. With TD = 0, the derivative unit is switched off	PID Controller

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
120.0	TM_LAG	REAL	time lag of the derivative action (s)	TM_LAG ≥ 0.5	5.0[2)]	The algorithm of the D component contains a time lag that can be set at the input "Time lag of the derivative action".	PID Controller
124.0	LMN_SAFE	REAL	security manipulated value	-100.0...100.0 (%)	0.0[2)]	A safety value can be set for the manipulated value at the input "Safety manipulated value".	Security manipulated value controller switching
128.0	LMN_HLM	REAL	manipulated value high limit	LMN_LLM...100.0 (%)	100.0[2)]	The manipulated value is always restricted to an upper and lower limit. The input "manipulated value high limit" indicates the upper limit. (this does not apply to step-action controllers without analog position feedback).	Limiting setpoint controller
132.0	LMN_LLM	REAL	manipulated value low limit	-100.0...LMN_HLM (%)	0.0[2)]	The manipulated variable is always limited to a high and a low limit. The input "manipulated value low limit" indicates the lower limit. (this does not apply to step-action controllers without analog position feedback).	Limiting setpoint controller
136.0	MTR_TM	REAL	motor manipulated value (s)	MTR_TM ≥ 0.001	60.0[2)]	The time of the manipulated valve from stop to stop is entered on the "motor manipulated time" parameter. (Only in the case of step controllers)	Pulse-shaper controller
140.0	PULSE_TM	REAL	minimum pulse time (s)	≥ 0.0	0.2[2)]	A minimum pulse duration can be set with the parameter "Minimum pulse time". (applies to step-action and pulse controllers only)	Pulse-shaper controller Split-range function/Pulse generator controller

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
144.0	BREAK_TM	REAL	minimum break time (s)	≥ 0.0	0.2[2)]	A minimum pulse duration can be set with the parameter "Minimum pulse time". (Only in the case of step controllers or pulse controllers)	Pulse-shaper controller Split-range function/Pulse generator controller

[1)] You can also change these parameters by means of the circle diagram.

[2)] Default setting values of the module after the first start-up of the FB PID_FM with COM_RST = TRUE

Note

With LOAD_PAR = TRUE all the control parameters are permanently loaded into the EEPROM of the FM 455.

With LOAD_OP = TRUE from the operating parameters only the set value SP_RE is permanently loaded into the EEPROM of the FM 455. All the other operating parameters have default values of 0 or FALSE upon the start-up of the FM 455.

The EEPROM of the module could become damaged in the case of too frequent write operations. To prevent this, after the description of the EEPROM, the module delays another description by 30 minutes.

11.2 Instance DB of the FB FUZ_455

Introduction

The FUZ_455 FB can be used to read the controller parameters of the fuzzy temperature controller out of the FM 455. You can then, for example, after replacing the FM 455, transfer these parameters back to the module.

Note

The parameters that have been established by the FM 455 by means of an identification may not be altered as they have been optimized for the control section.

Parameters of the Instance DB

Table 11- 4 Input parameters of the instance DB to the FB FUZ_455

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
0.0	MOD_ADDR	INT	FM 355/455 module address		512	The module address that resulted from the configuration with STEP 7 is given at this input.	–

Table 11- 5 Output parameters of the instance DB to the FB FUZ_455

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
2.0	RET_VALU	WORD	return value SFC 58/59		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	–
4.0	PARAFFUZ	WORD	parameterization error display		0	A parameter assignment error created by the FB FUZ_455 is displayed at the parameter PARAFFUZ as follows: High byte from PARAFFUZ = 01: there is a parameterization error. High byte from PARAFFUZ = 00: there is no parameterization error. The offset of the parameter that has caused the parameterization error is in the low byte - calculated as of the static variables FUZ_PAR[1].	–
6.0	READ_PAR	BOOL	read fuzzy parameters		FALSE	If the READ_PAR parameter is set, then the fuzzy parameters are read from the module and stored in the static variables of the instance DB.	–
6.1	LOAD_PAR	BOOL	write fuzzy parameters		FALSE	If the LOAD_PAR parameter is set, then the fuzzy parameters are read from the static variables of the instance DB and transferred to the module.	–

11.3 Instance DB of the FB FORCE455

Introduction

If you want to simulate analog or digital input values of the FM 455 then you need the FB FORCE455.

Parameters of the Instance DB

Table 11- 6 Input parameters of the instance DB to the FB FORCE455

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
0.0	S_AION	ARRAY [1..16] of BOOL	switch: simulation of analog input by PV_SIM		FALSE	If, for example, the switch S_AION[1] is set to TRUE, then the value PV_SIM[1] is used in the place of the analog input value 1 of the module (see the figure in chapter "The function block FORCE455 (Page 133)").	–
2.0	S_PVON	ARRAY [1..16] of BOOL	switch: simulation of linearized analog input by PV_SIM		FALSE	If, for example, the switch S_PVON[1] is set to TRUE, then the value PV_SIM[1] is used in the place of the linearized analog input value 1 of the module (see the figure in chapter "The function block FORCE455 (Page 133)").	–
4.0	PV_SIM	ARRAY [1..16] of REAL	simulated analog input value	0.0 to 20.0 [mA] or -1500 to +10000 [mV] or technical value range	0.0	For example, input PV_SIM[1] specifies the simulation value for the analog input 1. If S_PVON = TRUE then the linearized analog input value is specified here. If S_PVON = FALSE and S_AION = TRUE then the analog input value, which is transformed into a preprocessed value by means of the preprocessing functions, is specified in mA or mV.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
68.0	S_DION	ARRAY [1..16] of BOOL	switch: simulation of digital input by DI_SIM		FALSE	If, for example, S_DION[1] is set to TRUE, then the value DI_SIM[1] is used in the place of the digital input value 1 of the module (see figure in chapter "The function block FORCE455 (Page 133)").	–
70.0	DI_SIM	ARRAY [1..16] of BOOL	simulated digital input value		FALSE		–
72.0	MOD_ADDR	INT	FM 355/455 module address		256	The module address that resulted from the configuration with STEP 7 is given at this input.	–

Table 11- 7 Output parameters of the instance DB to the FB FORCE455

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
74.0	RET_VALU	WORD	return value SFC 58/59		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	–

11.4 Instance DB of the FB READ_455

Introduction

If you want to read analog or digital input values from the FM 455 then you need the FB READ_455.

Parameters of the Instance DB

Table 11- 8 Input parameters of the instance DB to the FB READ_455

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
0.0	MOD_ADDR	INT	FM 355/455 module address		512	The module address that resulted from the configuration with STEP 7 is given at this input.	–

Table 11- 9 Output parameters of the instance DB to the FB READ_455

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
2.0	CJ_TEMP	REAL	cold junction temperature		0.0	On the CJ_TEMP output, the measured reference junction temperature is displayed by the module if a thermocouple element input is configured and the reference junction temperature is not configured.	–
6.0	STAT_DI	ARRAY [1..16] of BOOL	status of binary input DI1 to DI8		FALSE	The status of the digital inputs 1 to 8 are displayed on the STAT_DI parameter.	–
(channel number) x 8	DIAG[x].PV_PER	ARRAY [1..16] of STRUCT	analog input (0 to 20 mA, -1500 to 10000 mV)		0.0	The parameter DIAG[1].PV_PER displays, for example, the analog input value of the module in the unit mA or mV.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
(channel number) x 8 + 4	DIAG[x].PV_PHY	ARRAY [1..16] of STRUCT	linearized analog input (physical)		0.0	The parameter DIAG[1].PV_PHY displays, for example, the linearized analog input value of the module in the physical unit.	–
136.0	RET_VALU	WORD	return value SFC 58/59		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	–

11.5 Instance DB of the FB CH_DIAG

Introduction

The FB CH_DIAG is required in order to read additional channel-specific diagnostics variables from the module.

Parameters of the Instance DB

Table 11- 10 Input parameters of the instance DB to the FB CH_DIAG

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
0.0	MOD_ADDR	INT	FM 355/455 module address		256	The module address that resulted from the configuration with STEP 7 is given at this input.	–
2.0	CHANNEL	INT	channel number	1 to 16	1	On the "channel number" input the number of the controller channel is configured to which the instance DB refers.	–
4.0	SP_R	REAL	set point ratio		0.0	When the ratio controller is set, the parameter is occupied with the input value of the set value.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
8.0	PV_R	REAL	process variable ratio		0.0	The following value is only assigned to the parameter value if the ratio controller is set: (Actual value A - set value offset) / actual value D	–
12.0	DIF_I	REAL	derivative unit input		0.0	The parameter DIF_I shows the input size of the D part. This is of interest, for instance, if an analog input has been configured as the input size of the D part.	–
16.0	TRACKPER	REAL	input value for LMN tracking		0.0	The TRACKPER parameter shows the input size at which the set value is being followed up if the controller is switched to set value follow-up.	–
20.0	IDSTATUS	WORD	status of identification		0.0	This parameter is described in chapter "Parameter Optimization at a Temperature Controller (Page 79)".	–
22.0	LMN_P	REAL	proportional part		0.0	The P part of the set value is shown on the LMN_P parameter.	–
26.0	LMN_I	REAL	integral component		0.0	The I part of the set value is shown on the LMN_I parameter.	–
30.0	LMN_D	REAL	derivative component		0.0	The D part of the set value is shown on the LMN_D parameter.	–

Table 11- 11 Output parameters of the instance DB to the FB CH_DIAG

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
34.0	RET_VALU	WORD	return value SFC 58/59 Return value of SFC 58/59		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	–

11.6 Instance DB of the FB PID_PAR

Introduction

The FB PID_PAR is required if you wish to change parameters online that are not included in the FB PID_FM.

Parameters of the Instance DB

Table 11- 12 Input parameters of the instance DB to the FB PID_PAR

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
0.0	COM_RST	BOOL	read parameters from system data		TRUE	If the parameter COM_RST = TRUE, then the FB PID_PAR carries out an initialization run. In doing so, the parameters are read from the system data of the CPU and stored in the instance DB.	–
2.0	MOD_ADDR	INT	FM 355/455 module address		256	The module address that resulted from the configuration with STEP 7 is given at this input.	–
4.0	CHANNEL	INT	channel number	1 to 16	1	On the "channel number" input the number of the controller channel is configured to which the instance DB refers.	–
6.0	INDEX_R	INT	index for REAL parameters	0 to 48	0.0	Refer to chapter "The function block PID_PAR (Page 140)".	–
8.0	VALUE_R	REAL	value for REAL parameters	dependent on the respective parameters	0.0	Refer to chapter "The function block PID_PAR (Page 140)".	–
12.0	INDEX_I	INT	index for INT parameters	0, 49 to 61	0.0	Refer to chapter "The function block PID_PAR (Page 140)".	–
14.0	VALUE_I	INT	value for INT parameters	dependent on the respective parameters	0.0	Refer to chapter "The function block PID_PAR (Page 140)".	–

Table 11- 13 Output parameters of the instance DB to the FB PID_PAR

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
16.0	RET_VALU	WORD	return value SFC 58/59		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	–
18.0	BUSY	BOOL	BUSY value of SFC WR_REC		FALSE	If BUSY = TRUE, the parameters have not yet been taken over by the module. FB PID_PAR should then be called again in the next cycle.	–

11.7 Instance DB of the FB CJ_T_PAR

Introduction

The FB CJ_T_PAR is required if you wish to change the configured reference junction temperature on the module online.

Parameters of the Instance DB

Table 11- 14 Input parameters of the instance DB to the FB CJ_T_PAR

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
0.0	COM_RST	BOOL	read parameters from system data		–	If the parameter COM_RST = TRUE, then the FB CJ_T_PAR carries out the initialization run. In doing so, the parameters are read from the system data of the CPU and stored in the instance DB.	–
2.0	MOD_ADDR	INT	FM 355/455 module address		256	The module address that resulted from the configuration with STEP 7 is given at this input.	–
4.0	CJ_T	REAL	cold junction temperature	dependent on sensor type	0.0	The reference junction temperature can be specified via the parameter CJ_T.	–

Table 11- 15 Output parameters of the instance DB to the FB CJ_T_PAR

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
8.0	RET_VALU	WORD	return value SFC 58/59		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	–
10.0	BUSY	BOOL	BUSY value of SFC WR_REC		FALSE	If BUSY = TRUE, the parameters have not yet been taken over by the module. FB PID_PAR should then be called again in the next cycle.	–

11.8 Assignment of the DBs for operating and monitoring via the OP

Introduction

For operating and monitoring the FM 455 via an OP the variable interface of the FM 455 includes 16 data blocks with the block numbers 101 to 116 for the controller channels 1 to 16.

Parameters of the Instance DB

Table 11- 16 Input parameters of the DBs for operating and monitoring

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
0.0	SP_HLM 1)	REAL	set value high limit	> SP_LLM (physical variable)	100.0	The set value is always restricted to an upper and lower limit. The input "set value high limit" indicates the upper limit.	Limit setpoint controller
4.0	SP_LLM 1)	REAL	set value low limit	< SP_HLM (physical variable)	0.0	The setpoint is always limited to a high and a low limit. The input "set value low limit" indicates the lower limit.	Limit setpoint controller
8.0	H_ALM 1)	REAL	high limit interrupt	> H_WRN (physical variable)	100.0	Four limits can be set for monitoring the actual value or the error signal. The input "high limit interrupt" indicates the highest limit.	Interrupt controller
12.0	H_WRN 1)	REAL	high limit warning	H_ALM...L_WRN (physical variable)	90.0	Four limits can be set for monitoring the actual value or the error signal. The input “High limit alarm” determines the secondary upper limit.	Interrupt controller
16.0	L_WRN 1)	REAL	low limit warning	H_WRN...L_ALM (physical variable)	10.0	Four limits can be set for monitoring the actual value or the error signal. The input “Low limit warning” determines the secondary lower limit.	Interrupt controller
20.0	L_ALM 1)	REAL	low limit interrupt	< L_WRN (physical variable)	0.0	Four limits can be set for monitoring the actual value or the error signal. The input "low limit interrupt" indicates the lowest limit.	Interrupt controller

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
24.0	HYS[1)]	REAL	hysteresis	≥ 0.0 (physical variable)	1.0	To avoid flickering of the watchdog LEDs, a hysteresis can be set at the input “hysteresis”.	Interrupt controller
28.0	DEADB_W[1)]	REAL	dead band width	≥ 0.0 (physical variable)	0.0	The control deviation is led over a dead band. The "dead band width" input determines the size of the dead band.	Dead band controller
32.0	GAIN[1)]	REAL	proportional gain	total value range (dimensionless)	1.0	The input “Proportional gain” determines the controller gain.	PID Controller
36.0	TI[1)]	REAL	reset time (s)	= 0.0 or ≥ 0.5	3000.0	The input “Reset time” determines the time response of the integrating action element. If TI = 0, the integrating action element is deactivated	PID Controller
40.0	TD[1)]	REAL	derivative time (s)	= 0.0 or ≥ 1.0	0.0	The input “Reset time” determines the time response of the integrating action element. With TD = 0, the derivative unit is switched off	PID Controller
44.0	TM_LAG[1)]	REAL	time lag of the derivative action (s)	TM_LAG ≥ 0.5	5.0	The algorithm of the D component contains a time lag that can be set at the input “Time lag of the derivative action”.	PID Controller
48.0	LMN_SAFE[1)]	REAL	security manipulated value	-100.0...100.0 (%)	0.0	For the manipulated value, a security value can be configured on the "Security manipulated value" input.	Switch Safety Manipulated Value Controller
52.0	LMN_HLM[1)]	REAL	manipulated value high limit	LMN_LLM...100.0 (%)	100.0	The manipulated value is always restricted to an upper and lower limit. The input "manipulated value high limit" indicates the upper limit. (this does not apply to step-action controllers without analog position feedback).	Limiting setpoint controller

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
56.0	LMN_LLM[1)]	REAL	manipulated value low limit	-100.0...LMN_HLM (%)	0.0	The manipulated variable is always limited to an high and a low limit. The input "manipulated value low limit" indicates the lower limit. (this does not apply to step-action controllers without analog position feedback).	Limiting setpoint controller
60.0	MTR_TM[1)]	REAL	motor manipulated value (s)	MTR_TM ≥ 0.001	60.0	The time of the manipulated valve from stop to stop is entered on the "motor manipulated time" parameter. (Only in the case of step controllers)	Pulse shaper controller
64.0	PULSE_TM[1)]	REAL	minimum pulse time (s)	≥ 0.0	0.2	A minimum pulse length can be configured on the "minimum pulse time" parameter. (Only in the case of step controllers or pulse controllers)	Pulse shaper controller Split-range / Pulse Shaper Controller
68.0	BREAK_TM[1)]	REAL	minimum break time (s)	≥ 0.0	0.2	A minimum pulse duration can be set with the parameter “Minimum pulse time”. (Only in the case of step controllers or pulse controllers)	Pulse shaper controller Split-range / Pulse Shaper Controller
72.0	SP_RE[2)]	REAL	external set value	technical value range physical variable)	0.0	An external set value is switched on input "external set value" with the controller.	–
76.0	LMN_RE[2)]	REAL	external manipulated value	-100.0...100.0 (%)	0.0	An external manipulated value is switched on input "external manipulated value" with the controller.	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
80.0	LMNRSVAL[2)]	REAL	start value of the simulated position feedback	-100.0...100.0 (%)	0.0	The configuration tool has access to the input "Start value of the simulated position feedback". The start value of the simulation is entered at the parameter. (This only applies to step-action controllers without analog position feedback).	–
84.0	SAFE_ON[2)]	BOOL	safety position on		FALSE	If the input “safety position on” is set, a safety value is used as the manipulated value. Note: The safety operations via LMNDN_OP, LMNUP_OP and LMNSOPON on a step controller are of higher priority than the safety value.	–
84.1	LMNTRKON[2)]	BOOL	match (LMN from analog input)		FALSE	If the input "Follow-up (LMN from AI)" is set, the manipulated value of an analog input (AI) is followed up. (this does not apply to step-action controllers without analog position feedback).	–
84.2	LMN_REON[2)]	BOOL	external manipulated value		FALSE	If the "external manipulated value on" input is set, the external manipulated value LMN_RE is adopted as the manipulated value.	–
84.3	LMNRHSRE[2)]	BOOL	high stop signal of repeated manipulated value		FALSE	The signal “Control valve at upper end stop” is interconnected at the input “High limit signal of position feedback”. LMNRHSRE = TRUE means: The manipulated valve is located at the high stop. (Only in the case of step controllers)	–

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
84.4	LMNRLSRE[2)]	BOOL	low stop signal of repeated manipulated value		FALSE	The signal “Control valve at lower end stop” is connected at the input “Low limit signal of position feedback”. LMNRLSRE = TRUE means: The manipulated valve is located at the lower stop. (Only in the case of step controllers)	–
84.5	LMNSOPON[2)]	BOOL	manipulated value signal operation on		FALSE	If the bit at the input “Manipulated value signal operation on” is set, the signals LMNUP_OP and LMNDN_OP are used as manipulated value signals. (Only in the case of step controllers)	–
84.6	LMNUP_OP[2)]	BOOL	manipulated value signal up operation		FALSE	If the LMNSOPON is set, the value on the "manipulated value signal up operation" input is adopted as the manipulated value signal. (Only in the case of step controllers)	–
84.7	LMNDN_OP[2)]	BOOL	manipulated value signal down operation		FALSE	If the LMNSOPON is set, the value on the "manipulated value signal down operation" input is adopted as the manipulated value signal. (Only in the case of step controllers)	–
85.0	MONERSEL[1)]	BOOL	supervision: process variable = 0 error signal = 1		FALSE	The controller has a limit indicator that can be applied either for the actual value or the control deviation. If the input "Monitoring: If the input “Monitoring: Process variable = 0, Error signal = 1” is set, the error signal is monitored.	Interrupt controller

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
85.1	LMNRS_ON2)	BOOL	simulation of the position feedback on		FALSE	If there is no position feedback, this can be simulated. The function is switched on at the input “Simulation of the position feedback on”. CAUTION: The simulation deviates increasingly from the real position feedback as time passes. (This only applies to step-action controllers without analog position feedback).	–
85.2	FUZID_ON 2)	BOOL	fuzzy identification on		FALSE	Identification of the fuzzy algorithm is switched on at the input “Fuzzy identification on”.	–
85.3	SPINT_EN2)	BOOL	operator input: external = 0 internal = 1		FALSE	The input "operating input: external = 0, internal = 1" determines the input that is transferred as a set value to the module. SPINT_EN = TRUE: SP_INT is transferred. SPINT_EN = FALSE: SP_RE is transferred.	–
85.4	P_SEL1)	BOOL	P action on		TRUE	In the PID algorithm, the PID parts can be switched on and off individually. The proportional part is switched on if the input "P part on" is set.	PID Controller
85.5	PFDB_SEL1)	BOOL	P action in the feedback		FALSE	In the PID algorithm, the P and D parts can be positioned in the feedback. The P action is in the feedback path if the input “P action in feedback path” is set.	PID Controller

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
86.0	D_EL_SEL[1)]	INT	D element input for the controller	0 to 17	0	The D element in the PID algorithm can be positioned at a separate input. This is selected via the input "D-element input for the controller". 0: Negative deviation 1 to 16: Analog input 1 to 16 17: negative actual value	Error Signal (...) Controller

[1)] control parameter:
Control parameters are downloaded to the module if the I/O parameter LOAD_PAR is set.
All control parameters are permanently loaded into the EEPROM of the FM 455.
[2)] operating parameters:
Operating parameters are downloaded to the module if the I/O parameter LOAD_OP is set.
From the operating parameters, only the set value SP_RE is permanently loaded into the EEPROM of the FM 455. All the other operating parameters are issued with the values 0 or FALSE upon the start-up of the FM 455

Note

The EEPROM of the module could become damaged in the case of too frequent write operations. To prevent this, after the description of the EEPROM, the module delays another description by 30 minutes.

Table 11- 17 Output parameters of the DBs for operating and monitoring

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
94.0	SP	REAL	set value	technical value range (physical variable)	0.0	The set value that becomes effective is issued on output "set value".	-
98.0	PV	REAL	process variable	technical value range (physical variable)	0.0	The actual value that becomes effective is issued on the "actual value" output.	-
102.0	ER	REAL	error signal	technical value range (physical variable)	0.0	The control deviation that becomes effective is issued on the "control deviation" output.	-
106.0	DISV	REAL	disturbance variable	-100.0...100.0 (%)	0.0	The interference that becomes effective is issued on the "interference" output.	-

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
110.0	LMN	REAL	manipulated value	-100.0...100.0 (%)	0.0	The manipulated value that becomes effective is issued on the "manipulated value" output. In the case of step controllers without analog position feedback, the unrestricted P + D parts are issued on the LMN parameter.	-
114.0	LMN_A	REAL	man. var. A of split range function / repeated man. var.	-100.0...100.0 (%)	0.0	On the output "Manipulated value A of the split range function / position feedback" in the case of continuous controllers the manipulated value A of the split range function, and with step controllers with analog position feedback, the position feedback is displayed. The simulated position feedback is displayed for a step controller without analog position feedback.	-
118.0	LMN_B	REAL	man. var. B of split range function	-100.0...100.0 (%)	0.0	At the output “Manipulated value B of split-range function” the manipulated value B of the split-range function is displayed for a continuous controller.	-
122.0	QH_ALM	BOOL	high limit interrupt reached		FALSE	The actual value or the controlled variable is monitored on four limits. Exceeding the limit H_ALM is displayed on the output "upper limit interrupt reached".	-

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
122.1	QH_WRN	BOOL	high limit warning reached		FALSE	The actual value or the controlled variable is monitored on four limits. Exceeding the limit H_WRN is displayed on the output "upper limit warning reached".	-
122.2	QL_WRN	BOOL	process variable low limit warning reached		FALSE	The actual value or the controlled variable is monitored on four limits. Falling short of the limit L_WRN is displayed on the output "lower limit warning reached".	-
122.3	QL_ALM	BOOL	low limit interrupt reached		FALSE	The actual value or the controlled variable is monitored on four limits. Falling short of the limit L_ALM is displayed on the output "lower limit interrupt reached".	-
122.4	QLMN_HLM	BOOL	high limit of manipulated value reached		FALSE	The manipulated variable is always limited to an high and a low limit. The output “High limit of manipulated value reached” indicates that the upper limit has been exceeded. (this does not apply to step-action controllers without analog position feedback).	-
122.5	QLMN_LLM	BOOL	low limit of manipulated value reached		FALSE	The manipulated variable is always limited to an high and a low limit. The output “Low limit of manipulated value reached” indicates that the lower limit has been exceeded. (Not for step controllers without analog position feedback)	-

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
122.6	QSPINTON	BOOL	internal set value on		FALSE	The output "internal set value on" indicates that SP_INT is transferred to the module.	-
123.0	QPARA_F	BOOL	parameter assignment error		FALSE	The module checks the parameters for validity. A parameterization error is displayed on the "Parameterization error" output. You can also read out these parameter assignment errors by using the menu **PLC > Parameter Assignment Error** of the parameter assignment interface.	-
123.1	QCH_F	BOOL	channel error		FALSE	The "channel error" output is set if the controller channel cannot provide valid results. Channel error (e.g. line break) is also set with QPARA_F = 1 or QMOD_F = 1. If QCH_F=TRUE, the exact error information can be read out in the diagnostics data record DS1 of the module (see chapter "Errors and diagnostics (Page 225)").	-
123.2	QUPRLM	BOOL	limit of positive set value inclination reached		FALSE	The setpoint is limited to a positive and negative gradient. If the output “Limit of positive setpoint inclination reached” is set, the positive setpoint inclination is limited.	-

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
123.3	QDNRLM	BOOL	limit of negative set value inclination reached		FALSE	The setpoint is limited to a positive and negative gradient. If the output “Limit of negative setpoint inclination reached” is set, the negative setpoint inclination is limited.	-
123.4	QSP_HLM	BOOL	high limit of set value reached		FALSE	The setpoint is always limited to a high and a low limit. The output “High limit of setpoint value reached” indicates that the upper limit has been exceeded.	-
123.5	QSP_LLM	BOOL	low limit of set value reached		FALSE	The setpoint is always limited to a high and a low limit. The output “Low limit of setpoint value reached” indicates that the lower limit has been exceeded.	-
123.6	QSPOPON	BOOL	set value operation on		FALSE	The output “Setpoint operation on” indicates whether the setpoint is being operated via the configuration tool (loop monitor). If the bit is set, the value SP_OP is used as the setpoint.	-
123.7	QLMNSAFE	BOOL	safety operation		FALSE	If the output “Safety operation” is set, the safety manipulated value is output as the manipulated value.	-
124.0	QLMNOPON	BOOL	manipulated value operation on		FALSE	The output “Manipulated value operation on” indicates whether the manipulated value is being operated via the configuration tool (loop monitor). If the bit is set, the value LMN_OP is adopted as the manipulated value.	-

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
124.1	QLMNTRK	BOOL	follow-up operation		FALSE	The "follow-up mode" indicates if the manipulated value is being followed up by an analog input.	-
124.2	QLMN_RE	BOOL	manual = 1 automatic = 0		FALSE	The output “Manual = 1; Automatic = 0” indicates whether the manipulated value is set to the external manipulated value LMN_RE (manual = 1) or not.	-
124.3	QLMNR_HS	BOOL	high stop signal of repeated manipulated value		FALSE	The output “High limit signal of position feedback” indicates whether the control valve is at its upper limit. QLMNR_HS = TRUE means: The manipulated valve is located at the high stop. (Only in the case of step controllers)	-
124.4	QLMNR_LS	BOOL	low stop signal of repeated manipulated value		FALSE	The output “Low limit signal of position feedback” indicates whether the control valve is at its lower limit. QLMNR_LS = TRUE means: The manipulated valve is located at the lower stop. (Only in the case of step controllers)	-
124.5	QLMNR_ON	BOOL	repeated manipulated value on		FALSE	The output "position feedback on" shows the set mode "step controller with position feedback" or "step controller without position feedback".	-
124.6	QFUZZY	BOOL	PID algorithm = 0 fuzzy = 1		FALSE	If the output "PID algorithm = 0; fuzzy = 1", the controller is working with the fuzzy algorithm.	-

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
124.7	QSPLEPV	BOOL	fuzzy display: set value < process variable		FALSE	The output "Display of FUZZY controller: set value < actual value" is set when the fuzzy controller is switched on, if the set value is less than the effective actual value.	-
125.0	QSPR	BOOL	split range operation		FALSE	If the "split range operation" output is set, the continuous controller works in split range operation.	-
125.1	QLMNUP	BOOL	manipulated value signal up		FALSE	Is the output "manipulated value signal up". (Only in the case of step controllers or pulse controllers)	-
125.2	QLMNDN	BOOL	manipulated value signal down		FALSE	Is the output "manipulated value signal down". (Only in the case of step controllers or pulse controllers)	-
125.4	QBACKUP	BOOL	Backup		FALSE	0= no backup status (CPU in RUN) 1= backup status (CPU in STOP or has failed)	-
125.5	QID	BOOL	identification in work		FALSE	QID = TRUE shows that an identification is running (not that it is switched on). After the end of identification the identification result can be read out via the IDSTATUS parameter of the CH_DIAG FB (see chapter "Parameter Optimization at a Temperature Controller (Page 79)" and chapter "The function block CH_DIAG (Page 137)").	-

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
125.6	QMAN_FC	BOOL	follow-up mode or anti-reset-windup by slave controller		FALSE	The controller is a master controller, which, by the manual operation of a slave controller is followed-up to its actual value or its I part is stopped, because the set value or manipulated variable of the slave controller lies in the limit.	-
126.0	RET_VALU	INT	return value SFC 58/59		0	RET_VALU includes the return value RET_VAL of the SFC 58/59. RET_VALU can be evaluated if an error is reported via the QMOD_F (see reference manual /2/).	-

Table 11- 18 I/O parameters of the DBs for operating and monitoring

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
128.0	SP_INT	REAL	internal set value	technical value range (physical variable)	0.0	The in/out parameter “Internal setpoint” is used to assign a setpoint using operator interface functions.	-
132.0	SP_OP[2)]	REAL	set value operation	technical value range (physical variable)	0.0	The configuration tool (controller optimization) has access to the in/out parameter “Setpoint operation”. If the bit SP_OP_ON is set, the value "set value operation" is adopted as the set value.	-
136.0	LMN_OP[2)]	REAL	manipulated value operation	-100.0...100.0 (%)	0.0	The configuration tool (loop monitor) has access to the in/out parameter “Manipulated value operation”. If the bit LMNOP_ON is set, the value "manipulated value operation" is adopted as the manipulated value.	-

Address	Parameter	Data type	Comment	Permitted value range	Default	Explanation	In param. dialog box
140.0	SP_OP_ON[2)]	BOOL	set value operation on		FALSE	The configuration tool (loop monitor) has access to the in/out parameter "Setpoint operation on". If the bit is set, the value SP_OP is used as the setpoint.	-
140.1	LMNOP_ON[2)]	BOOL	manipulated value operation on		FALSE	The configuration tool (loop monitor) has access to the in/out parameter "Setpoint operation on". If the bit is set, the value LMN_OP is adopted as the manipulated value.	-
140.2	LOAD_PAR	BOOL	load control parameter to FM 355/455		FALSE	If the in/out parameter "Load control parameters to FM 355/455" is set, the control parameters are downloaded to the module and the in/out parameter reset.	-
140.3	LOAD_OP	BOOL	load operator parameter to FM 355/455		FALSE	If the in/out parameter "Load operator parameters to FM 355/455" is set, the operator parameters are downloaded to the module and the in/out parameter reset.	-

[1)] Control parameters:
Control parameters become effective in the module if the in/out parameter LOAD_PAR is set.

[2)] Operator parameters:
Operator parameters become effective in the module if the in/out parameter LOAD_OP is set.

Errors and diagnostics 12

12.1 Error Display via the Error LEDs

Where are the errors displayed?

The red LED INTF indicates an internal fault on the module.

The red LED EXTF indicates an external fault, for example fault on the connections.

If the yellow LED flashes, then the firmware has been deleted. This status can only occur in the case of faulty hardware or if the loading procedure of the firmware is aborted.

Which errors are displayed?

The following faults are indicated by the error LEDs lighting up:

Type of error	Diagnostic message	Possible cause	Correction
Internal errors	Module defective	Hardware error	Replace module
	Time monitoring (watchdog) tripped	Hardware error	Replace module
	EEPROM content is invalid	Failure of the supply voltage when configuring	Reconfigure module
External errors	Incorrect parameters in module	Incorrect parameters have been transferred to the module	Reconfigure module
	Errors with the analog inputs or analog outputs	Analog input hardware error	Replace module
		Analog input, wire breakage	Remedy wire break
		Analog input measuring range violation (underrange)	Check the measuring signal
		Analog input measuring range violation (overrange)	Check the measuring signal
		Analog output wire break	Remedy wire break
		Analog output short circuit	Eliminate the short-circuit
	Missing external auxiliary supply	Left-hand front connector not plugged 24 V supply missing	Plug in the left-hand front connector Restore 24 V supply

Diagnostic interrupt in the case of errors

All errors can trigger a diagnostic interrupt if you have enabled the diagnostic interrupt in the respective parameterization screen. From the diagnostic data records DS0 and DS1 you can see which errors have caused the LED to light up. The assignment of the diagnostic data records DS0 and DS1 is described in chapter "Diagnostic data record DS0 and DS1 (Page 228)".

See also

Instance DB of the FB PID_FM (Page 177)

Assignment of the DBs for operating and monitoring via the OP (Page 210)

Parameterization (Page 114)

12.2 Triggering diagnostic interrupts

What is a diagnostic interrupt?

If a user program is to respond to an internal or external fault, you can set a diagnostics interrupt parameter that interrupts the cyclic program of the CPU and calls the diagnostics interrupt OB, OB8 82.

Which events may trigger a diagnostic interrupt?

The list shows which events can trigger a diagnostic interrupt:

- The module has not been configured or is incorrectly configured
- Module defective
- Wire break in analog inputs (4 to 20 mA)
- Overflow and underflow with analog inputs
- Load break and short circuit at analog outputs
- Wire break at thermocouples and Pt 100

Default setting

The diagnostic interrupt is blocked by default.

Enabling the diagnostic interrupt

You disable or enable the diagnostics interrupt for the module in the “Basic parameters” dialog box.

Responses to an interrupt-triggering event

The following happens when an event occurs that could trigger a diagnostic interrupt:

- The diagnostic information is stored in diagnostic data records DS0 and DS1.
- One or both error LEDs light up.
- The diagnostic interrupt OB (OB 82) is called.
- The diagnostic record DS0 is entered in the start information of the diagnostic interrupt OB.
- If there is no hardware fault, the module continues to control.

If no OB 82 is programmed, the CPU goes to STOP.

12.3 Diagnostic data record DS0 and DS1

Introduction

The information as to which event has triggered a diagnostics interrupt is stored in the diagnostics data records DS0 and DS1. The diagnostics data record DS0 comprises four bytes. DS1 comprises 27 bytes with the first four bytes being identical to DS0.

Read data record from the module

The diagnostic data record DS0 is automatically transferred to the start information when the diagnostic OB is called. There these four bytes are stored in the local data (byte 8 - 11) of the OB 82.

The diagnostic data record DS1 (and hence also the content of the DS0) can be read from the module by means of SFC 59 "RD_REC". This only makes sense if an error is reported in a channel in the DS0.

How does the diagnostics text appear in the diagnostics buffer?

If you want to enter the diagnostics report in the diagnostics buffer, you must call the SFC 52 "Enter user-specific report in the diagnostics buffer" in the user program. The event number of the respective diagnostics report is specified on the input parameter EVENTN. The interrupt is entered in the diagnostics buffer with x = 1 as incoming and x = 0 as outgoing. Alongside the time of the entry, the diagnostics buffer also shows the respective diagnostics text that is specified in the "Meaning" column.

Assignment of the diagnostic data record DS0 in the start information

The following table shows the assignment of the diagnostic data record DS0 in the start information. Bits that are not listed are of no significance and are zero.

Table 12- 1 Assignment of the diagnostic data record DS0

Byte	Bit	Meaning	Note	Event no.
0	0	BG fault	Is set for every diagnostic event	8:x:00
	1	Internal error	If set with all internal errors: • Time watchdog tripped • EEPROM content invalid; module continues without controlling and waits for a new configuration by the CPU • EPROM fault • ADC/DAC fault • Analog input hardware error	8:x:01
	2	External error	Is set with all external errors: • Missing external auxiliary supply • Faulty parameters • Analog input wire break (only area 4 to 20 mA) • Analog input measuring range violation (underrange) • Analog input measuring range violation (overrange) • Analog output wire break • Analog output short circuit	8:x:02
	3	Error in a channel	Refer to DS 1, as of byte 7 for a further breakdown	8:x:03
	4	Missing external auxiliary supply	24 V supply of the FM 455 failed	8:x:04
	6	EEPROM content is invalid	Missing supply voltage during a write operation in EEPROM. The module starts with default parameters.	8:x:03
	7	Faulty parameters	The module cannot make use of a parameter. Reason: Parameter unknown or invalid combination of parameters. See menu **Target system > Parameterization error display**	8:x:07
1	0 ... 3	Module class	Is always occupied with 8	–
	4	Channel-specific diagnosis	Is set when the module can provide additional channel information and a channel error exists (see DS 1 byte 7 to 12)	–
2	0	User module incorrect / missing	The position (A, B, C, D) of the coding key does not agree with the parameter assignment in the FM 455	8:x:30
	3	Time monitoring (watchdog) tripped	Hardware error	8:x:33
3	2	EPROM fault	Module defective	8:x:42
	4	ADC/DAC fault	Module defective	8:x:44

Diagnostics Data Record DS 1 of the FM 455

The length of diagnostic data record DS1 is 27 bytes. The first 4 bytes are identical with the diagnostic data record DS0. The following table illustrates the assignment of the remaining bytes. Bits that are not listed are of no significance and are zero.

Table 12- 2 Assignment of the Bytes 4 to 12 of the Diagnostics Data Record DS1 of the FM 455

<table>
<tr><th>Byte</th><th>Bit</th><th>Meaning</th><th colspan="2">Note</th><th>Event no.</th></tr>
<tr><td>4</td><td>0 ... 7</td><td>Channel type</td><td colspan="2">Is always occupied with 75H</td><td>–</td></tr>
<tr><td>5</td><td>0 ... 7</td><td>Length of diagnostics information</td><td colspan="2">Is always occupied with 8</td><td>–</td></tr>
<tr><td>6</td><td>0 ... 7</td><td>Number of channels</td><td colspan="2">17 always assigned (16 controllers + 1 reference channel)</td><td>–</td></tr>
<tr><td>7</td><td>0 … 7</td><td>Channel error vector</td><td colspan="2">One bit each is assigned to channels 1 to 8</td><td>-</td></tr>
<tr><td>8</td><td>0 … 7</td><td>Channel error vector</td><td colspan="2">One bit each is assigned to channels 9 to 16</td><td>-</td></tr>
<tr><td>9</td><td>0</td><td>Error on the reference channel</td><td colspan="2"></td><td>-</td></tr>
<tr><td rowspan="8">10</td><td>0</td><td>Analog input hardware error</td><td rowspan="8">Channel-specific diagnostics channel 1</td><td>–</td><td>8:x:B0</td></tr>
<tr><td>1</td><td>Parameterization error</td><td>The position (A, B, C, D) of the coding key does not agree with the parameter assignment in the FM 455</td><td>8:x:B1</td></tr>
<tr><td>2</td><td>Analog input wire break (only area 4 to 20 mA)</td><td></td><td>8:x:B2</td></tr>
<tr><td>3</td><td>Unused</td><td></td><td>8:x:B3</td></tr>
<tr><td>4</td><td>Analog input measurement range underflow[1]</td><td></td><td>8:x:B4</td></tr>
<tr><td>5</td><td>Analog input measurement range overflow[1]</td><td></td><td>8:x:B5</td></tr>
<tr><td>6</td><td>Analog output wire break</td><td>Only for current output of continuous controller</td><td>8:x:B6</td></tr>
<tr><td>7</td><td>Analog output short circuit</td><td>Only with the current output of the C controller</td><td>8:x:B7</td></tr>
<tr><td>11</td><td>0 ... 7</td><td>See Byte 10</td><td colspan="2">Channel-specific diagnostics channel 2</td><td>See above</td></tr>
<tr><td>12</td><td>0 ... 7</td><td>See Byte 10</td><td colspan="2">Channel-specific diagnostics channel 3</td><td>See above</td></tr>
<tr><td>13</td><td>0 ... 7</td><td>See Byte 10</td><td colspan="2">Channel-specific diagnostics channel 4</td><td>See above</td></tr>
<tr><td>14</td><td>0 ... 7</td><td>See Byte 10</td><td colspan="2">Channel-specific diagnostics channel 5</td><td>See above</td></tr>
<tr><td>15</td><td>0 ... 7</td><td>See Byte 10</td><td colspan="2">Channel-specific diagnostics channel 6</td><td>See above</td></tr>
<tr><td>16</td><td>0 ... 7</td><td>See Byte 10</td><td colspan="2">Channel-specific diagnostics channel 7</td><td>See above</td></tr>
</table>

Byte	Bit	Meaning	Note	Event no.
17	0 ... 7	See Byte 10	Channel-specific diagnostics channel 8	See above
18	0 ... 7	See Byte 10	Channel-specific diagnostics channel 9	See above
19	0 ... 7	See Byte 10	Channel-specific diagnostics channel 10	See above
20	0 ... 7	See Byte 10	Channel-specific diagnostics channel 11	See above
21	0 ... 7	See Byte 10	Channel-specific diagnostics channel 12	See above
22	0 ... 7	See Byte 10	Channel-specific diagnostics channel 13	See above
23	0 ... 7	See Byte 10	Channel-specific diagnostics channel 14	See above
24	0 ... 7	See Byte 10	Channel-specific diagnostics channel 15	See above
25	0 ... 7	See Byte 10	Channel-specific diagnostics channel 16	See above
26	0 ... 7	See Byte 10	Diagnosis for reference channel	See above
[1] refer to the chapter "Measuring transducer fault (Page 232)"				

What you should particularly note

The FM 455 is supplied with voltage solely via the left front connector.

In the following cases, the CPU therefore recognizes the "Module removed / cannot respond":

- if the left front connector of the FM 455 is not connected
- if there is no 24 V supply voltage on the left front connector

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Note

If, in the diagnostics buffer of the CPU, the entry "Module removed / cannot respond" is entered, check to see if the left front connector is connected and if the 24 V supply voltage of the FM 455 exists.

12.4 Measuring transducer fault

Measuring transducer fault

The following faults in measuring transducers can be recognized by the FM 455:

- Measuring range violation (underrange)
- Measuring range violation (overrange)
- Wire break (not with all measuring ranges)

Whenever one of these faults occurs, the group error "External error" is set in the diagnostics data record DS0 and channel-specific error bits are set in the diagnostics data record DS1 (refer to the tables in the previous section). When these errors disappear, the respective bits are reset.

The following table shows at which limits in the individual measuring ranges the error bits are set or reset.

Measuring range	Error bit Measuring Range Underflow at ...	Error bit Measuring Range overflow at ...	Error bit Wire Break Display
	DS1: Byte 10 to 26, bit 4	DS1: Byte 10 to 26, bit 5	DS1: Byte 10 to 26, bit 2
0 to 20 mA	< - 3.5 mA	> 23.5 mA	–
4 to 20 mA	Error bit = 1 at < 3.6 mA Error bit = 0 at < 3.8 mA	> 22.8 mA	Error bit = 1 at < 3.6 mA Error bit = 0 at < 3.8 mA
0 V to 10 V	<- 1.175 V	> 11.75 V	–
Pt 100 (-200 to 850 °C) (-328 to 1562 °F)	< 30.82 mV	> 650.46 mV	Yes, parameter can be set, Display: 650.46 mV
Pt 100 (-200 to 556 °C) (-328 to 1032 °F)	< 30.82 mV	> 499.06 mV	Yes, parameter can be set, Display: 499.06 mV
Pt 100 (-200 to 130 °C) (-328 to 264 °F)	< 30.82 mV	> 254.12 mV	Yes, parameter can be set, Display: 254.12 mV
Thermocouple element type B	< 0 mV	> 13.81 mV	Yes, parameter can be set, the last value will be stored.
Thermocouple element type J	< - 8.1 mV	> 69.54 mV	Yes, parameter can be set, the last value will be stored.
Thermocouple element type K	< - 6.45 mV	> 54.88 mV	Yes, parameter can be set, the last value will be stored.
Thermocouple element type R	< - 0.23 mV	> 21.11 mV	Yes, parameter can be set, the last value will be stored.
Thermocouple element type S	< - 0.24 mV	> 18.7 mV	Yes, parameter can be set, the last value will be stored.
Free thermocouple element	< lower input value of the polyline	> upper input value of the polyline	Yes, parameter can be set, the last value will be stored.

Examples 13

13.1 Application example for the FM 455 S

Introduction

The example “SIMATIC 400 Station1 (S)” is included in the project FM_PIDEx which allows you to operate the FM 455 S on a process simulated in the CPU. This makes it possible to test the module without a real process.

Prerequisites

The following prerequisites must be fulfilled for you to be able to work with the example program:

- CPU 414 is inserted in slot 2
- FM 455 S is inserted in slot 4
- CPU and FM 455 S are supplied with power
- There is an online connection PG / PC to the CPU

If you wish to work with a different CPU or FM 455, you must adapt the example under Configure hardware.

Downloading the example program

To install the program, proceed as follows:

1. Load the “Blocks” user program from Example 455 S to the CPU.
2. Start the parameter assignment application for the FM 455 in the “HW Config: Hardware Configuration” software.
3. Use the **Test > ...> Open instance DB** menu item to open DB 31.

Now you can work with the circle diagram and the controller optimization.

Using the example program

The example (Example 455 S) contains a step controller in connection with a simulated process which consists of a third-order time delay (PT3).

With the aid of the example program you can generate a step controller very simply and configure and test all its properties in the form of an offline comparison with a typical section arrangement.

The example program enables you to easily understand the operating principle and configuration of controllers with a discontinuous output in a way it is often used in the control of sections with mechanically driven actuators. It is therefore also applicable for introduction and training purposes.

By selecting parameters accordingly you approximate the section to the properties of the real process. With the aid of the configuration tool, by identifying the model section you can find a record of suitable controller characteristic data.

Functions of the example program

The example ”Example 455 S” consists mainly of the two function blocks PID_FM (FB 31) and PROC_S (FB 100). In doing so, PID_FM embodies the step controller, and PROC_S simulates a control section with the function elements "valve" and PT3 (refer to the next figure). At the same time, alongside the controlled variable, the controller is transmitted information regarding the position of the actuator and, if necessary, stop signals that have been reached.

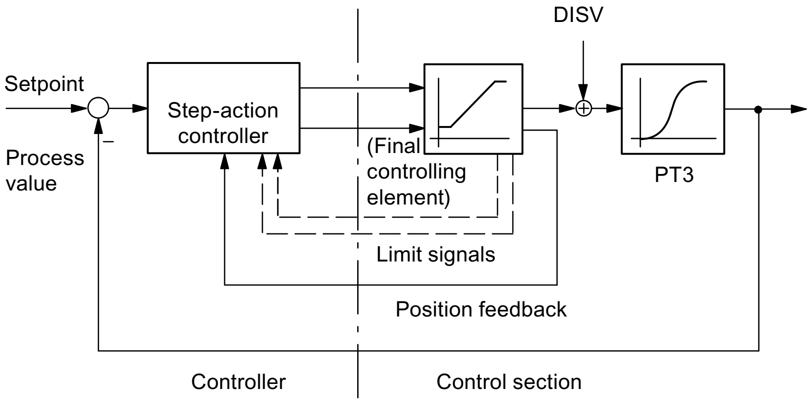


Figure 13-1 Example 455 S, Control Loop

The function block PROC_S replicates a series connection that consists of the integrated actuator and three 1st arrangement delay elements (refer to the next figure). The interference DISV is always added to the output signal of the actuator, so that at this point section faults can be manually switched. The static section gain can be determined by the factor GAIN.

The parameter for the motor manipulated time **MTR_TM** defines the time the actuator requires to run through from stop to stop.

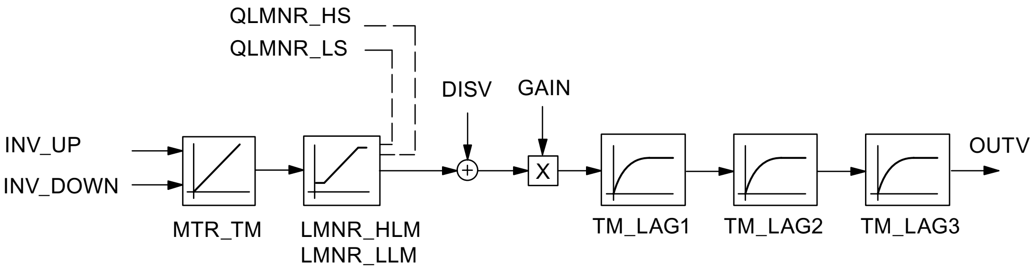


Figure 13-2 Structure and parameters of the section block PROC_S

Block structure

The example 1 comes from the function APP_1, which comprises the block for the controller and the simulated section, and also includes the call block for cold restart (OB 100) and a cyclic interrupt level (OB 35 with 100 ms time unit).

Table 13- 1 Blocks of example 1

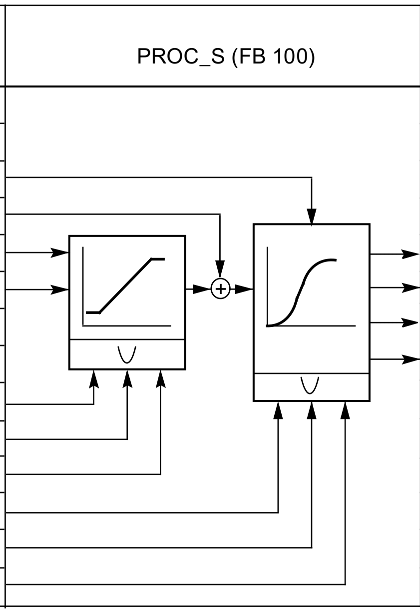
Block	Name (in the toolbar)	Description
OB 100		Restart OB
OB 35		Time-controlled OB: 100 ms
FC 100	APP_1	Example 1
FC 101	SIM_455	Process value transfer in FM 455 S
FB 31	PID_FM	Step controller FM 455 S
FB 100	PROC_S	Section for step controllers
DB 100	PROCESS	Instance DB to the PROC_S
DB 31	DB_PID_FM	Instance DB to the PID_FM

Parameters of the model control section for step controllers

The following figure shows the function diagram and the parameters of the control section.

Input parameters

Parameter	Type	*)
COM_RST	BOOL	FALSE
CYCLE	TIME	T#1s
GAIN	REAL	0.0
DISV	REAL	0.0
INV_UP	BOOL	FALSE
INV_DOWN	BOOL	FALSE
LMNR_HLM	REAL	100.0
LMNR_LLM	REAL	0.0
MTR_TM	TIME	T#30s
TM_LAG1	TIME	T#10s
TM_LAG2	TIME	T#10s
TM_LAG3	TIME	T#10s



Output parameters

Signal	Type	*)
QLMNR_HS	BOOL	FALSE
OUTV	REAL	0.0
QLMNR_LS	BOOL	FALSE
LMNR	REAL	0.0

*) Default in the case of regenerating the instance DB

Figure 13-3 Function diagram and parameters of the section model PROC_S

Parameters and step response

The reaction of a control circuit with simulated 3rd arrangement PT control section is displayed using a concrete parameterization of the step controller with PI effect and switched on dead band. The set section parameters with in each case 10 s delay approximately replicate the behavior of a fast temperature process or a fill level control.

Setting one of the delay times TM_LAGx = 0 s reduces the arrangement of the section by one degree.

The graph (configuration tool) shows the transition and transient recovery behavior of the connected control circuit in accordance with a change to the set value of 60 percent (refer to the next figure). The table includes the current set values of the relevant parameters for controllers and sections.

Parameters	Type	Parameterization	Description
Controller:			
GAIN	REAL	0.31	proportional gain
TI	TIME	19.190 s	Integration time
MTR_TM	TIME	20 s	Motor control time
PULSE_TM	TIME	100 ms	Minimum duration of pulse
BREAK_TM	TIME	100 ms	Minimum cycle duration
DEADB_ON	BOOL	TRUE	Switch on dead band
DEADB_W	REAL	0.5	Dead band width
control section			
CYCLE	TIME	100 ms	Scanning time
GAIN	REAL	1.5	Section gain
MTR_TM	TIME	20 s	Motor control time
TM_LAG1	TIME	10 s	Delay time 1
TM_LAG2	TIME	10 s	Delay time 2
TM_LAG3	TIME	10 s	Delay time 3

Step response

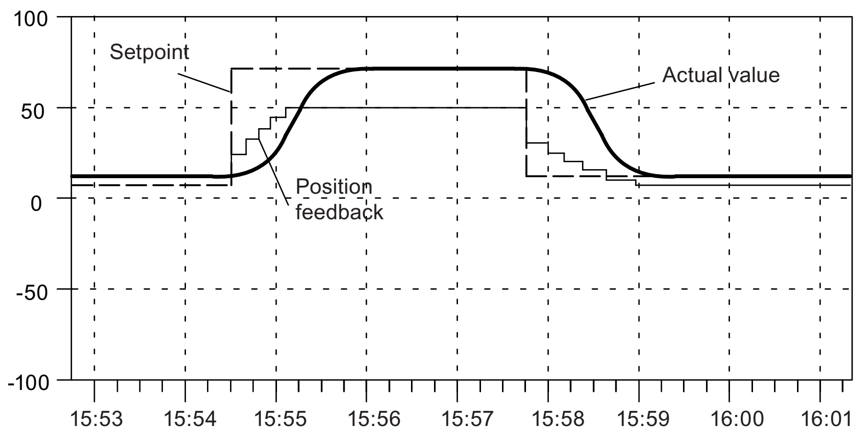


Figure 13-4 Control loop with step controller after setpoint step change

13.2 Application example for the FM 455 C

Introduction

The project FM_PIDEx can be found in the example "SIMATIC 400 Station2 (C)", and it enables you to operate the FM 455 C in a section that is simulated in the CPU. This makes it possible to test the module without a real process.

Requirements

The following prerequisites must be fulfilled for you to be able to work with the example program:

- CPU 414 is plugged in slot 2
- FM 455 C is plugged in slot 4
- CPU and FM 455 C are supplied with power
- There is an online connection programming device / PC to the CPU

If you wish to work with a different CPU or FM 455, you must adapt the example under Configure hardware.

Downloading the example program

To install the program, proceed as follows:

1. Load the “Blocks” user program from Example 455 C to the CPU.
2. Start the parameter assignment application for the FM 455 in the “HW Config: Hardware Configuration” software.
3. Use the **Test > ...> Open instance DB** menu item to open DB 31.

Now you can work with the circle diagram and the controller optimization.

Using the example program

The example (Example 455 C) contains a step controller in connection with a simulated process which consists of a third-order time delay (PT3).

With the aid of the example program you can generate a continuous PID controller very simply and configure and test all its properties in the form of an offline comparison with a typical section arrangement.

The example program enables you to easily understand the operating principle and configuration of controllers with analog output signals in a way that is often used in the control of sections with proportionate actuators. Therefore, it can also be used for introduction and training purposes.

By selecting parameters accordingly you approximate the section to the properties of the real process. With the aid of the configuration tool, by identifying the model section you can find a record of suitable controller characteristic data.

Functions of the example program

The example "Example 455 C" consists mainly of the two function blocks PID_FM (FB 31) and PROC_C (FB 100). In doing so, PID_FM embodies the controller, and PROC_C simulates a control section with a 3rd arrangement balance (refer to the next figure).

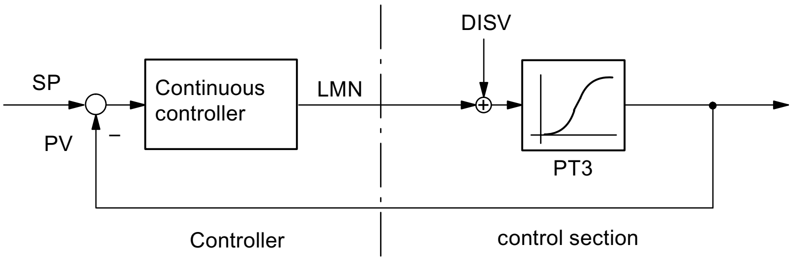


Figure 13-5 Example 455 C, Control Loop

The function block PROC_C replicates a series connection that consists of three 1st arrangement delay elements (refer to the next figure). The interference **DISV** is always added to the output signal of the actuator, so that at this point section faults can be manually switched. The static section gain can be determined by the factor **GAIN**.

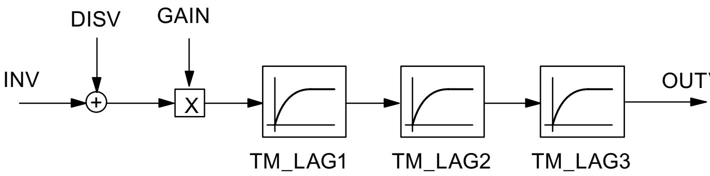


Figure 13-6 Structure and parameters of the section block PROC_C

Block structure

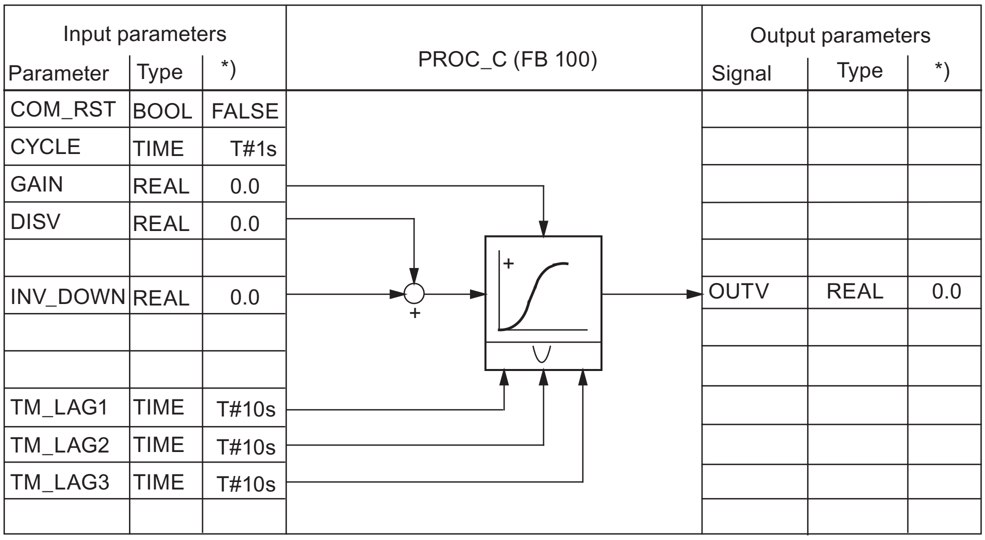
The example 2 comprises the function APP_2, which is composed of the blocks for the controller and the simulated section, and also includes the call block for cold restart (OB 100) and a cyclic interrupt level (OB 35 with 100 ms time unit).

Table 13- 2 Blocks of example 2

Block	Name (in the toolbar)	Description
OB 100		Restart OB
OB 35		Time-controlled OB: 100 ms
FC100	APP_2	Example 2
FC101	SIM_455	Process value transfer in 455 C
FB 31	PID_FM	Continuous controller in 455 C
FB 100	PROC_C	Section for continuous controllers
DB 100	PROCESS	Instance DB to the PROC_C
DB 31	DB_PID_FM	Instance DB to the PID_FM

Parameters of the model control section for continuous controllers

The following figure shows the function diagram and the parameters of the control section.



*) Default in the case of regenerating the instance DB

Figure 13-7 Function diagram and parameters of the section model PROC_C

Parameters and step response

The reaction of a control circuit with simulated 3rd arrangement PT control section is displayed using a concrete parameterization of the continuous controller with PID effect. The set section parameters with in each case 10 s delay approximately replicate the behavior of a pressure control or a fill level control.

Setting one of the delay times TM_LAGx = 0 s reduces the arrangement of the section by one degree.

The graph (configuration tool) shows the transition and transient recovery behavior of the connected control circuit in accordance with a series of set value changes of in each case 20 percent of the measuring range (refer to the next figure). The table includes the current set values of the relevant parameters for controllers and sections.

Parameter	Type	Parameterization	Description
Controller:			
GAIN	REAL	1.535	proportional gain
TI	TIME	22.720 s	Integration time
TD	TIME	5.974 s	Derivative time
TM_LAG	TIME	1.195 s	Delay time of the D part
Control section:			
CYCLE	TIME	100 ms	Scanning time
GAIN	REAL	1.5	Section gain
TM_LAG1	TIME	10 s	Delay time 1
TM_LAG2	TIME	10 s	Delay time 2
TM_LAG3	TIME	10 s	Delay time 3

Step response

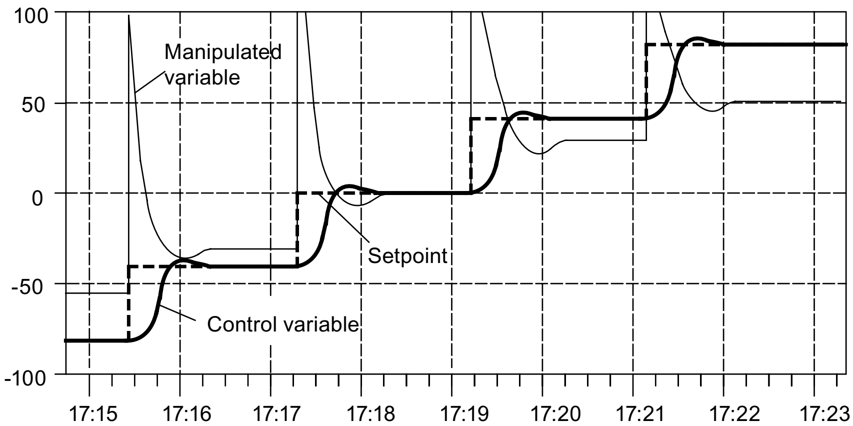


Figure 13-8 Control system with continuous-action controller and setpoint step changes across the entire measuring range

13.3 Application example for the diagnostics

Introduction

The project FM_PIDEx contains the example “SIMATIC 400 Station3 (C)” which shows the application and the evaluation of the diagnostics in the DS1 of the controller module.

Requirements

So that you can work with the example, you must fulfill the following prerequisites:

- CPU 414 is plugged in slot 2
- FM 455 C is plugged into slot 4
- CPU and FM 455 C are supplied with voltage
- There is an online connection programming device / PC to the CPU

If you wish to work with a different CPU or FM 455, you must adapt the example under Configure hardware.

Note

Diagnostics interrupts are only triggered in the CPU if you have selected the following setting at the "Basic parameters" tab card under "Properties - FM 455 C PID Control" in HW Config:

- Choice of interrupt: Diagnosis

Downloading the example program

Download the user program blocks with the system data to the CPU.

Using the example program

If a diagnostic interrupt occurs, the parameter DIAG_ON of FB1 FM_DIAG_455 is set in the OB 82. The FM_DIAG_455 is called in the OB 35. It reads the diagnostic data record DS1 of the module (see chapter "Triggering diagnostic interrupts (Page 227)").

13.4 Interconnection example for a cascade control

Double loop cascade control

The following figure shows a double loop cascade control:

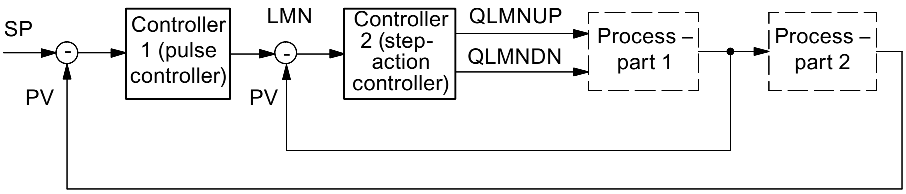


Figure 13-9 Two-loop cascade control

This controller interconnection is implemented with a FM 455 S by configuring a pulse controller as a master controller and by selecting the manipulated variable of the master controller at the setpoint value input of the slave controller.

You can also implement a controller cascade by means of an FM 455 C. The master controller is then not a pulse controller and the slave controller is not a step controller. The interconnection must be realized identically.

In the slave controller, the manipulated value of the master controller is standardized from the value range 0 to 100% to the value range of the actual value A and is then further processed as the set value.

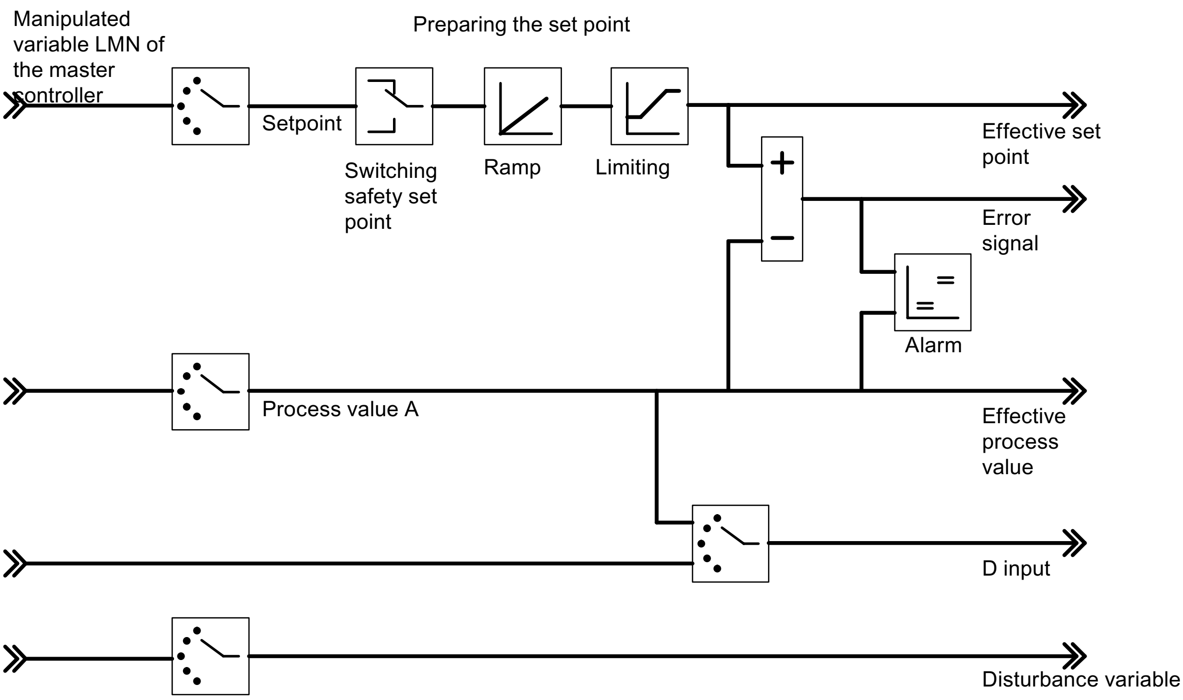


Figure 13-10 Implementation of Cascade Control with FM 455

13.5 Interconnection example for a ratio control

Ratio controlling with two control circuits

The following figure shows a ratio control with two control circuits:

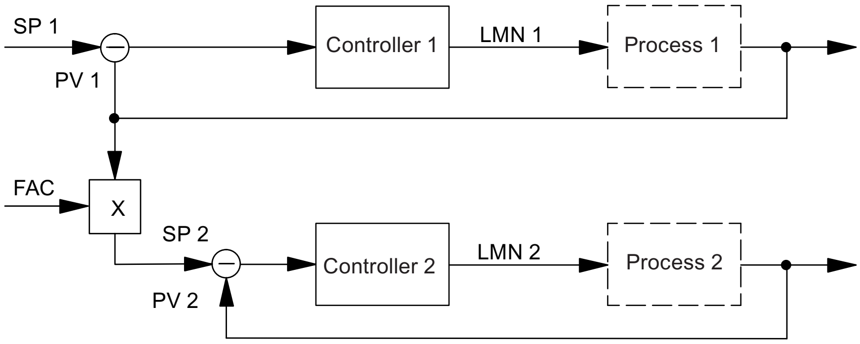


Figure 13-11 Ratio controlling with two control circuits

The controller 1 is configured as the fixed set point controller. Controller 2 is configured as a ratio / mixed controller. The following figure explains its interconnection.

The ratio factor FAC is specified by the set value input of the FB PID_FM (SP_RE or SP_OP).

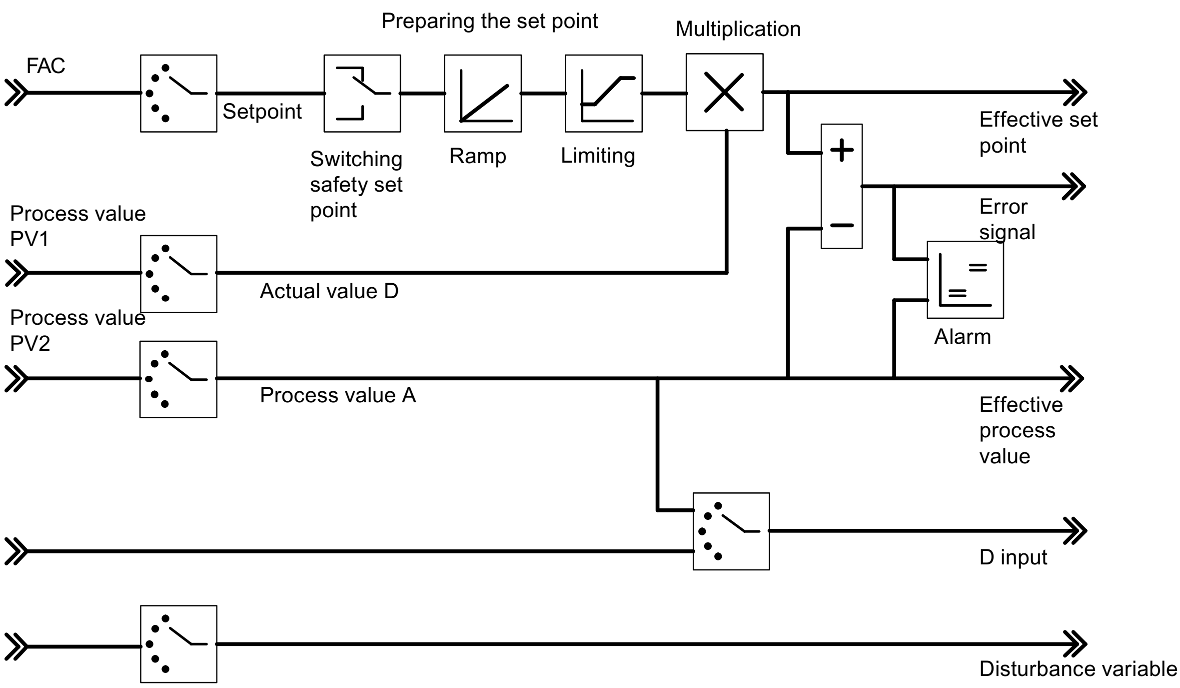


Figure 13-12 Implementation of Ratio Control with FM 455

13.6 Interconnection example for a mixed control

Mixed controllers for three components

The following figure shows a mixed control for three components:

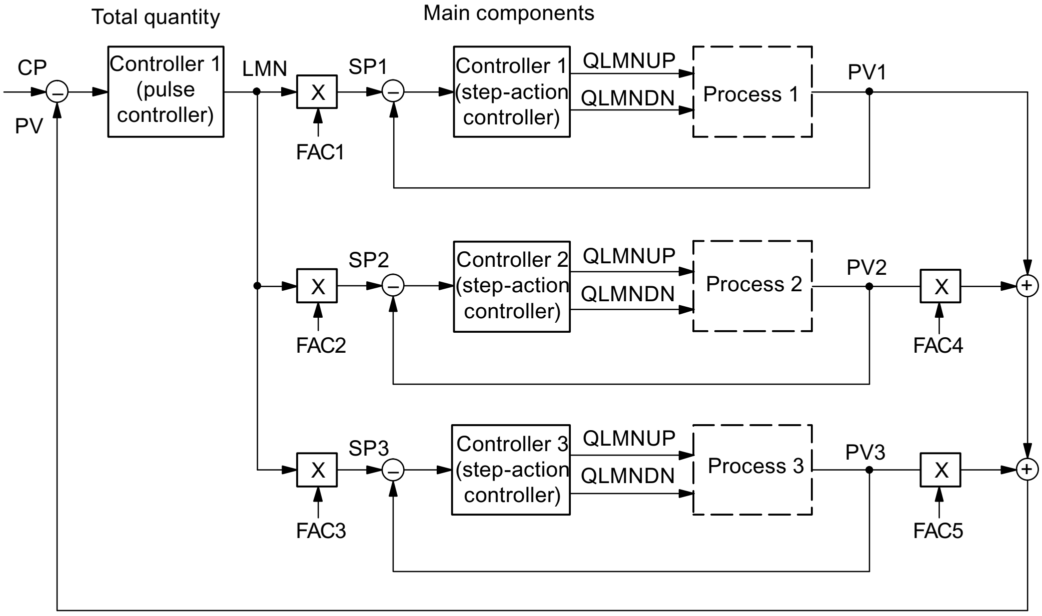


Figure 13-13 Mixed controllers for three components

The master controller is configured as a **three-component controller** and pulse controller. The controllers 1, 2 and 3 are configured as ratio / mixed controllers. The interconnection for the master controller is shown in the following figure.

You can configure the mixing factors for the components PV2 and PV3 via the "add up" button. If you have to change these factors during runtime, it is possible to do this via the FB PID_PAR (see "The function block PID_PAR (Page 140)").

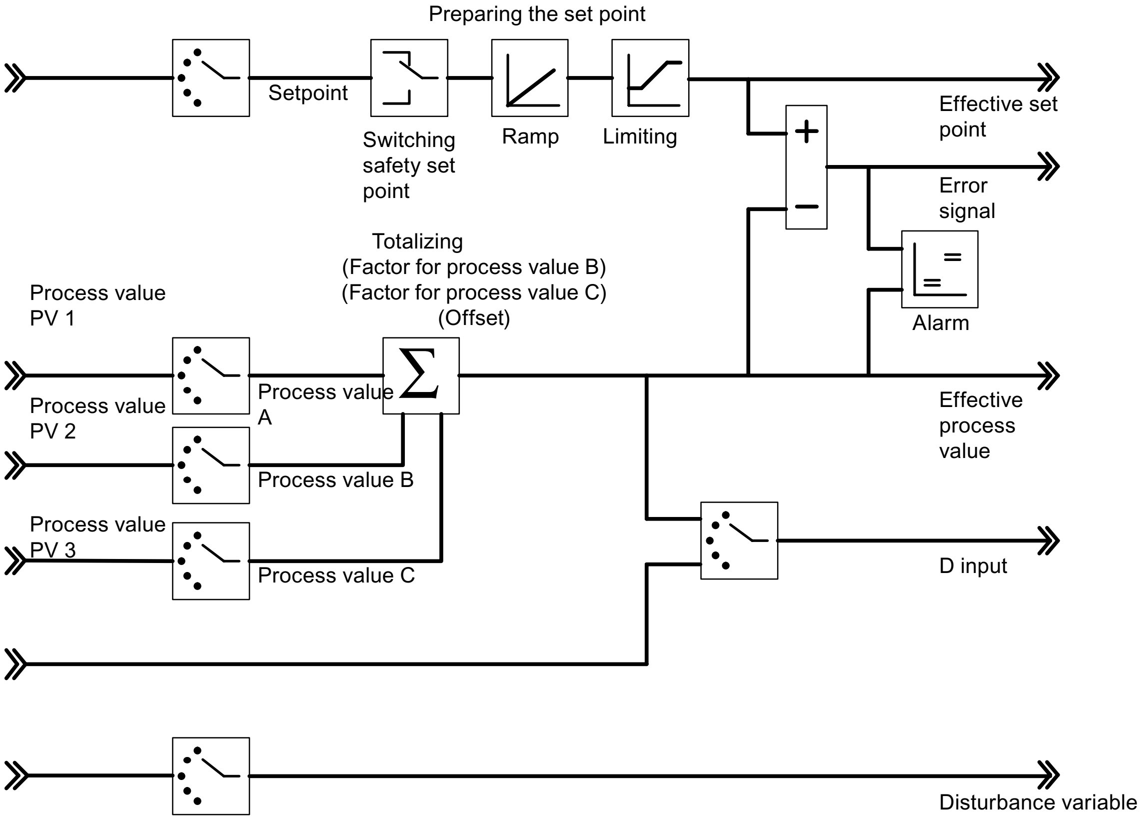


Figure 13-14 Realizing the total amount controller (master controller)

The slave controllers are configured as ratio / mixed controllers. The example of the component PV1 in the figure below shows their interconnection. The mixing factor FAC is specified by the set value input of the FB PID_FM (SP_RE or SP_OP).

In the slave controller (mixed controller), the manipulated variable of the master controller is standardized from the value range 0 to 100% to the value range of the actual value A and is then further processed as the set value D.

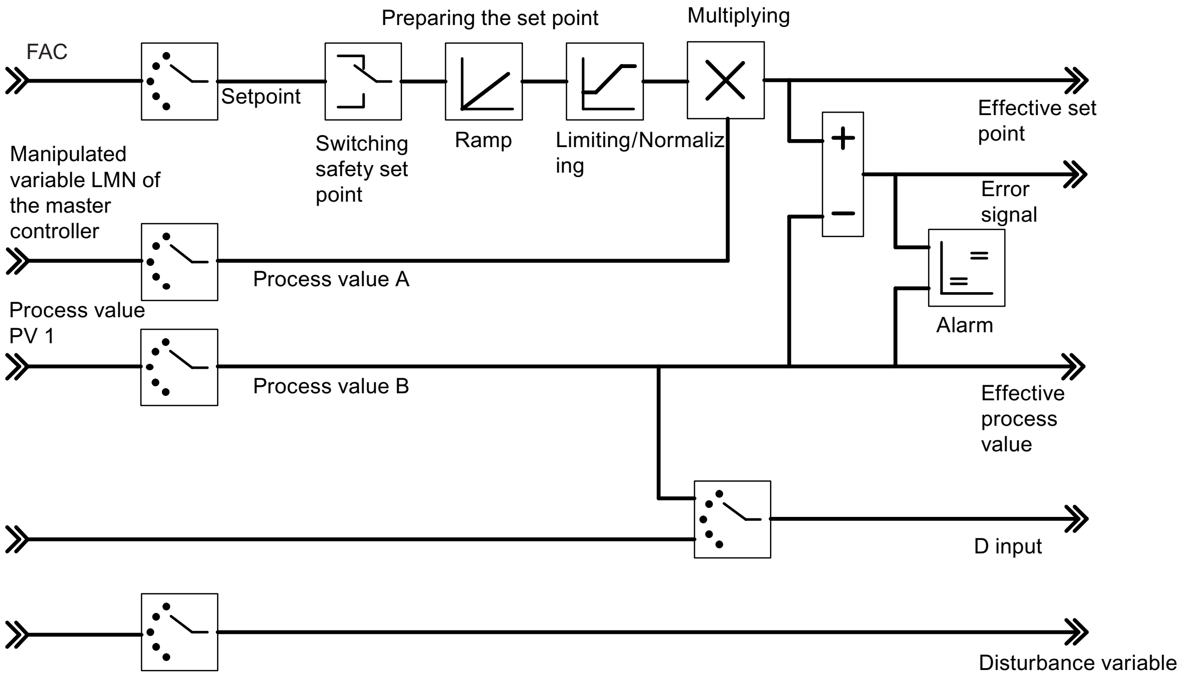


Figure 13-15 Implementation of the components controller (slave controller)

Technical Specifications A

A.1 Technical Specifications of the FM 455

Technical Specifications of the FM 455

Dimensions and weight	
Dimensions W x H x D (mm)	 50 x 290 x 210
Weight	Approx. 1370 g
Module-specific data	
Number of digital inputs Number of digital outputs Number of analog inputs Number of analog outputs	16 32 (only S controllers) 16 16 (only C controllers)
Length of cable • Digital signals unshielded • Digital signals shielded • Analog signals shielded	 max. 600 m max. 1000 m 200 m 50 m with 80 mV and thermocouple elements
Voltages, currents, potentials	
Rated load voltage L+ • Permitted Range • Polarity protection for input voltage • Polarity protection for output voltage	24 VDC 20.4 V to 28.8 V Yes Yes
Number of digital inputs that can be inputs that can be activated simultaneously • Horizontal mounting up to 60° C	16
Total current of digital outputs • Horizontal mounting up to 60° C	Max. 1.6 A
Electrical isolation • to backplane bus • Between the channels	 yes (optocoupler) No

Permissible potential difference • Between the input (M connector) and central grounding point • between the analog inputs and M_{ANA} (U_{CM}) – with signal = 0 V • Insulation tested with	75 VDC AC 60 V DC 2.5 V 500 VDC
Current consumption • From backplane bus • from L+ (without load) – C controller – S controller	 Typically 100 mA typ. 370 mA max. 440 mA typ. 330 mA max. 400 mA
Power loss • C controller • S controller	 typ. 12 W max. 17.3 W typ. 10.7 W max. 16.2 W
Status, interrupts, diagnostics	
Status display	in each case one green LED per digital input channel (S controllers and C controllers) in each case one green LED per digital output channel (S controllers only)
Interrupts • Limit value interrupt • Diagnostic interrupt	 Yes, configurable Yes, configurable
Diagnostic functions • Fault display on the module for internal errors • Fault display on the module for external errors • Diagnostic information readable	Yes, configurable yes, red LED yes, red LED Yes
Back-up operation	yes, display with yellow LED
Interference suppression, error limits (inputs)	
Interference voltage suppression for f = n x (f1 ± 1 %), (f1 = interference frequency) • Common-mode interference (U_{ss} < 2.5 V) • Feedback interference (peak value of the interference < rated value of the input range)	 > 70 dB > 40 dB
Crosstalk between inputs • At 50 Hz • At 60 Hz	 50 dB 50 dB

Operational error limits (across the temperature range, relative to the input range) • 80 mV • from 250 to 1000 mV • from 2.5 to 10 V • from 3.2 to 20 mA	 ± 1 % ± 0.6 % ± 0.8 % ± 0.7 %
Basic error limit (operational limit at 25 °C, in relation to input range) • 80 mV • from 250 to 1000 mV • from 2.5 to 10 V • from 3.2 to 20 mA	 ± 0.6 % ± 0.4 % ± 0.6 % ± 0.5 %
Temperature error (relative to the input range)	±0.005 %/K
Linearity error (relative to the input range)	± 0.05 %
Repeat accuracy (in transient state at 25 °C, in relation to input range)	± 0.05 %
Interference suppression, error limits (outputs)	
Crosstalk between outputs	40 dB
Operational error limits (across the temperature range, in relation to output range) • Voltage • Current	 ± 0.5 % ± 0.6 %
Basic error limit (operational limit at 25 °C, referred to output range) • Voltage • Current	 ± 0.2 % ± 0.3 %
Temperature error (relative to output range)	± 0.02 %/K
Linearity error (relative to output range)	± 0.05 %
Repeat accuracy (in transient state at 25 °C, relative to output range)	± 0.05 %
Output ripple; range 0 to 50 kHz (referred to the output range)	± 0.05 %
Data for sensor selection (digital inputs)	
Input voltage • Rated value • For signal "1" • For signal "0"	 24 VDC from 13 to 30 V from -3 to 5 V
Input current • with "1" signal	typically 7 mA
Input delay time • configurable • at "0" to "1" transitions • at "1" to "0"	 No from 1.2 to 4.8 ms from 1.2 to 4.8 ms
Input characteristics	acc. to IEC 1131, type 2

Connection of 2-wire BEROs • Permissible quiescent current	Possible ≤ 1.5 mA	
Data for sensor selection (analog inputs)		
Input ranges rate values (display area) / input resistance		
• Voltage **	± 80 mV (-80 ... +80 mV)*** 0 V to 10 V (-1.175 ... 11.75 V)	10 MΩ 100 kΩ
• Current **	0 to 20 mA (-3.5 ... 23.5 mA) from 4 to 20 mA (0 ... 23.5 mA)	50 Ω 50 Ω
• Types of thermocouple element **	B (0...13.81 mV) J (-8.1...69.54 mV) K (-6.45..54.88 mV) R (-0.23..21.11 mV) S (-0.24...18.7 mV) for type B: 42.15 °C to 1820.01 °C for type J: -210.02°C to 1200.02 °C for type K:-265.40 °C to 1372.11 °C for type R: - 51.37 °C to 1767.77 °C for type S: - 50.40 °C to 1767.98 °C	10 MΩ 10 MΩ 10 MΩ 10 MΩ 10 MΩ
• Resistance thermometer **	Pt 100 Current 1.667 mA pulsed: (30.82 ... 650.46 mV) -200.01 ... 850.05 °C (single resolution) (30.82 ... 499.06 mV) -200.01 ... 556.26 °C (double resolution) (30.82 ... 254.12 mV) -200.01 ... 129.20 °C (quadruple resolution)	10 MΩ
Data for sensor selection (analog inputs)		
Permissible input voltage for voltage input (destruction limit)	30 V for maximum 2 inputs)	
Permissible input current for current input (destruction limit)	40 mA	
Wiring of the signal transducers • for voltage measurement • for current measurement as 4-wire measuring transducer	 Possible Possible	
Characteristics linearization • for thermocouples • for thermal resistors	Yes, configurable Type B, J, K, R, S Pt 100 (standard range)	

Temperature compensation • Internal temperature compensation • external temperature compensation with Pt 100	Yes, configurable Possible Possible
** for underflow and overflow display the same restrictions apply as for the display area. Exception: Underflow display at 4 to 20 mA; • 1 at < 3.6 mA • 0 at > 3.8 mA In the case of a wire break the underflow display shows between 4 and 20 mA.	
*** or the lower or upper input value of the polyline. The smallest value applies.	

Data for actuator selection (digital outputs)	
Output voltage • with "1" signal	 L+ (- 2.5 V), minimum
Output current • in the case of signal "1" rated value permissible range • in the case of signal "0" residual current	 0.1 A from 5 mA to 0.15 A Max. 0.5 mA
Load resistor	240 Ω to 4 kΩ
Output power • Lamp load	 max. 5 W
Parallel wiring of two outputs • for logical link • for performance increase	 Possible Not possible
Controlling of digital inputs	Possible
Switching frequency • with resistive load / lamp load • on inductive load	 Max. 100 Hz Max. 0.5 Hz
Inductive shut-down voltage limited (internally) to	typically L+ (- 1.5 V)
Short-circuit protection of the output	Yes, electronic
Data for actuator selection (analog outputs)	
Output ranges (rated values)	± 10 V from 0 to 10 V 0 to 20 mA 4 to 20 mA
Working resistance • at voltage outputs – Capacitive load • at current outputs – inductive load	 min. 1 k Ω max. 1 μF max. 500 Ω max. 1 mH

Voltage output • Short-circuit protection • Short-circuit current	 Yes Max. 25 mA
Current output • Open-circuit voltage	 Max. 18 V
Connection of actuators • at voltage output with 2-wire connection • For current output 2-wire connection	 Possible Possible

Analog value generation			
Measuring principle Resolution (incl. overrange)	integrating configurable: • 12 bits • 14 bits		
Conversion time (per analog input) • at 12 bit resolution • at 12 bit resolution • at 14 bit resolution	 $16^2/_3$ ms (at 60 Hz) 20 ms (at 50 Hz) 100 ms (at 50 and 60 Hz)		
Settling time • with resistive load • with capacitive load • with inductive load	 0.1 ms 3.3 ms 0.5 ms		
Input of substitution values	Yes, configurable		
Integration / conversion time / resolution (per channel) • configurable • Integration time in ms • Basic conversion time incl. processing time in ms • additional conversion time for resistance measurement in ms or additional conversion time for reference junction input in ms	 $16^2/_3$ 17 1 $16^2/_3$	 20 22 1 20	 100 102 1 100 *
• Resolution in bits (incl. overrange) Measuring range	12	12	14
• Interference voltage suppression for interference frequency f1 in Hz	60	50	50, 60
* Applies if a resolution of 14 bit has been configured on at least one input.			

A.2 Standards and certifications

General Technical Specifications

General Technical Specifications are

- Electromagnetic compatibility
- Shipping and storage conditions
- Mechanical and Climatic Environmental Conditions
- Information on insulation testing, safety class and degree of protection

These general technical specifications are explained in Manual /1/. They include standards and test specifications that the S7-400 comply with, and the testing criteria according to which the S7-400 was tested.

CE marking

The SIMATIC S7-400 product range meets the requirements and protection objectives of the following EU directives.

- 2006/95/EC "Electrical Equipment Designed for Use within Certain Voltage Limits" (Low-Voltage Directive)
- 2004/108/EC "Electromagnetic Compatibility" (EMC Directive)

The EC declarations of conformity and associated documentation are held on file available to competent authorities at:

Siemens Aktiengesellschaft
Industry Sector
I IA AS RD ST Typetest
P.O. Box 1963
D-92209 Amberg

UL /CSA approvals

The following approvals exist for the S7-400:

UL Recognition Mark
Underwriters Laboratories (UL) in accordance with Standard UL 508

CSA Certification Mark
Canadian Standard Association (CSA) in accordance with standard C22.2 No. 142

FM approval

FM approval available for S7-400:

FM approval in accordance with Factory Mutual Standard Class Number 3611, Class I, Division 2, Group A, B, C, D.

WARNING

Personal injury and damage to property may occur.

In potentially explosive environments, there is a risk of injury or damage if you disconnect any connectors while the S7-400 is in operation.

Always isolate the S7-400 operated in such areas before you disconnect and connectors.

WARNING

WARNING - DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS LOCATION IS KNOWN TO BE NON-HAZARDOUS

Area of application

SIMATIC products are designed for use in industrial environments.

Area of application	Requirements	
	Emitted interference	Noise immunity
Industry	EN 61000-6-4: 2001	EN 61000-6-2: 2001

Note the installation guidelines

SIMATIC products fulfill the requirements provided during installation and operation, the manual´s installation guidelines are followed.

A.3 Technical Specifications of the Function Blocks

Overview

Table A- 1 Technical Specifications of the Function Blocks

Function blocks	Assignment in the			processing time in CPU 414
	RAM	Load memory	Local data area	
PID_FM	1592 bytes	1976 bytes	40 bytes	refer to table below
FORCE455	498 bytes	658 bytes	100 bytes	2.8 ms
READ_455	526 bytes	644 bytes	162 bytes	3.5 ms
CH_DIAG	302 bytes	420 bytes	64 bytes	2.1 ms
FUZ_455	356 bytes	464 bytes	22 bytes	2.6 ms
PID_PAR	918 bytes	1074 bytes	24 bytes	3.8 to 7.2 ms dependent on whether INDEX_R and INDEX_I are both ≠ 0
CJ_T_PAR	274 bytes	354 bytes	22 bytes	1.6 ms

Table A- 2 Processing times of the PID_FM with different marginal conditions

Marginal conditions			processing time in CPU 414-2 DP
READ_VAR	LOAD_OP	LOAD_PAR	
FALSE	FALSE	FALSE	0.077 ms
TRUE	FALSE	FALSE	2.36 ms
*)	TRUE	FALSE	4.48 ms
FALSE	FALSE	TRUE	2.59 ms
TRUE	FALSE	TRUE	5.15 ms
*)	TRUE	TRUE	7.1 ms
*) If LOAD_OP = TRUE, then READ_VAR of the FB PID_FM is also set to TRUE.			

Table A- 3 Technical Specifications of the instance DBs

Instance DBs of the function blocks ...	Assignment in the	
	RAM	Load memory
PID_FM	190 bytes	490 bytes
FORCE455	112 bytes	262 bytes
READ_455	174 bytes	280 bytes
CH_DIAG	72 bytes	178 bytes
FUZ_455	176 bytes	268 bytes
PID_PAR	290 bytes	410 bytes
CJ_T_PAR	58 bytes	130 bytes

A.4 Technical specifications of the parameterization interface

Overview

Technical Specifications	Parameterization interface
Memory requirement (hard disk)	4 Mbytes

Technical Specifications	System data
Memory requirement in the CPU	5430 bytes

B List of RET_VALU messages

RET_VALU messages

JOB_ERR (Hex)	JOB_ERR (Dec)	JOB_ERR (Int)	Meaning
7000	28672	-32624	First call with REQ=0: no data transmission active; BUSY has the value 0.
7001	28673	-32624	First call with REQ=1: data transmission initiated; BUSY has the value 1.
7002	28674	-32624	Interim call (REQ irrelevant). Data transfer already active; BUSY has the value 1.
8090	32912	-32624	Specified logical base address invalid: There is no assignment in the SDB1/SDB2x, or it is not a base address.
80A0	32928	-32608	Negative acknowledgment when reading from the module. Module was removed during the read operation or the module is defective.
80A1	32929	-32607	Negative acknowledgment when writing to the module. Module was removed during the write operation or the module is defective.
80A2	32930	-32606	Protocol error at layer 2
80A3	32931	-32605	Protocol error involving user interface/user
80A4	32932	-32604	Communication bus error
80B1	32945	-32591	Incorrect length specification. FM_TYPE parameter in channel DB not set correctly for the module in use.
80B2	32946	-32590	The configured slot is not being used.
80B3	32947	-32589	Actual module type is not match configured module type.
80C0	32960	-32576	Module data not ready for reading.
80C1	32961	-32575	Data of a write job of the same type have not yet been processed by the module.
80C2	32962	-32574	The module is currently processing the maximum possible number of jobs.
80C3	32963	-32573	Required resources (memory etc.) currently occupied.
80C4	32964	-32572	Communication error
80C5	32965	-32571	Distributed I/O not available.
80C6	32966	-32570	Priority class abort (restart or background).
8522	34082	-31454	Channel DB or parameter DB too short. The data cannot be read off the DB. (Write job)
8532	34098	-31438	DB number of the parameter DB too high (Write job)
853A	34106	-31430	Parameter DB not present. (Write job)
8544	34116	-31420	Error at n-th (n > 1) read access to a DB after an error has occurred. (Write job)

JOB_ERR (Hex)	JOB_ERR (Dec)	JOB_ERR (Int)	Meaning
8723	34595	-30941	Channel DB or parameter DB too short. The data cannot be written to the DB. (Read job)
8730	34608	-30928	Parameter DB in the CPU is write protected. The data cannot be written to the DB (read job)
8732	34610	-30926	DB number of the parameter DB too high (Read job)
873A	34618	-30918	Parameter DB not present. (Read job)
8745	34629	-30907	Error at n-th (n > 1) write access to a DB after an error has occurred. (Read job)
80ff	33023	-32513	Incorrect index specification with block FMT_PAR
Errors 80A2..80A4 and 80Cx are temporary, i.e., they can be rectified automatically after a waiting time. Messages of the 7xxx form indicate temporary operating states of communication.			

Spare parts

C

C.1 Spare parts

Spare parts

Spare parts	Order number
for the FM 455	
Coding key for analog modules	6ES7 974-0AA00-0AA0
Front connector, screw-type terminals	6ES7 492-1AL00-0AA0
Front connector, spring-type connector	6ES7 492-1BL00-0AA0
Front connector, crimp snap-on connector	6ES7 492-1CL00-0AA0
Manual pliers to crimp the crimp contacts	6XX3 071
Crimp contacts (packaging unit x 250)	6XX3 070
Unlocking tool for crimp contacts	6ES5 497-4UC11
Cover foil (10x) for labelling strips	6ES7 492-2XX00-0AA0
for subrack	
Number wheel for slot labelling	C79165-Z1523-A22
Spare slot covers (qty 10)	6ES7 490-1AA00-0AA0

References D

D.1 Basic literature

Additional literature

The following table lists all the manuals to which this manual refers.

No.	Title	Order No.
/1/	SIMATIC; automation system S7-400; structure	• As a hard copy in the package 6ES7 498-8AA05-8AA0 • In electronic form for download from the Internet (http://support.automation.siemens.com/WW/view/de/1117849)
/2/	SIMATIC; System and Standard Functions for S7-300/400	• As a hard copy in the package 6ES7 810-4CA08-8AW1 • In electronic form for download from the Internet (http://support.automation.siemens.com/WW/view/de/1214574)

Basics on control technology is described, among others, in the following books:

Title	Author	Order No.
From a Process to Controlling	Gißler/Schmid	ISBN 978-3-80091-551-4
Controlling with SIMATIC: Practice Book for SIMATIC S7 and SIMATIC PCS7 Control Systems	Müller, Jürgen	ISBN 978-3-89578-255-8

Glossary

Cascade control

The cascade control is a consecutive switching of controllers, whereupon the first controller (master controller) specifies the setpoint for the series-connected controllers (slave controllers) or influences the setpoints in accordance with the current negative deviation of the main control variable.

By involving additional process variables, the controller result can be improved by using a cascade control. To do this, at a suitable point an auxiliary control variable PV2 is recorded and this controls the reference setpoint (output of the master controller SP2). The master controller controls the process value PV1 on the fixed setpoint SP1 and adjusts the SP2 in such a way that this objective is achieved as quickly as possible, and without overshooting.

Configuration

Tool (software) for creating and configuring a control as well as for optimizing the controller with the aid of the data gained from a section identification.

Control device Control device

Totality of the controller, control device and detector (measuring device) for the control variable.

A control device is the part of the control circuit that serves to influence the control variable on the process input. Usually consists of the association of the control drive and actuator.

Control device Control device

Totality of the controller, control device and detector (measuring device) for the control variable.

A control device is the part of the control circuit that serves to influence the control variable on the process input. Usually consists of the association of the control drive and actuator.

Control loop

With the control loop you describe a connection of the section output (control variable) with the controller input and the controller output (manipulated variable) with the process input, so that the controller and process form a closed loop.

Control variable

Process variable (output variable of the control section) that is to be compared to the current value of the reference variable. Your current value is called the process value.

Controlled system

With a controlled system we describe the part of the unit in which the control variable is influenced by the manipulated variable (by changing the control energy or the flow dimension). This enables subdivisions in the control device and the influenced process.

Controller (closed-loop controller)

A controller is a device that constantly records the negative deviation (comparer) and, if necessary generates a time-dependent function to form the control signal (output variable) with the objective of iradicating the negative deviation as quickly as possible and without overshooting.

Controller parameters

Controller parameters are parameters for the static and dynamic adaptation of the controller behavior to the given section or process properties.

D part (derivative component)

The D part is the derivative component of the controller. D elements alone are unsuitable for controlling, as they do not issue an output signal when setting the input variables to a stead value.

Dead time

Dead time is the time delay for the control variable reaction to disturbances or changes to the manipulated variable for transportation processes. The input variable of a dead time element is set to the value of the dead time 1 : 1 is issued on the output.

Digital control (sample controlling) (digital control)

Controller that records a new value for the control variable (process value) at constant intervals 〈→ sampling time, and then, in dependence on the actual negative deviation, calculates a new value for the manipulated variable.

Disturbance variable

All influence variables on the control variable - with the exception of the manipulated variable - are called disturbance variables. Additive influences on the section output signal can be compensated for by superimposing with the actuating signal.

Disturbance variable compensation

The disturbance variable compensation is a procedure for reducing / removing the influence of a dominating (measurable) disturbance variable (e.g. external temperature) on the control circuit. A corrective operation is derived from the measured disturbance variable DISV, so that changes to the DISV can be reacted to more quickly. In the ideal case scenario, the influence is fully compensated for without the controller itself having to execute a corrective process (via the I part).

Fixed setpoint control

A fixed setpoint control is a control with a fixed, only rarely changing reference variable. Controls any disturbance variables that occur during the process.

Follow-up control

Follow-up control is a control where the reference value is constantly influenced from outside (underlaid controller of a multi-loop control). The task of the follow-up controller is to cover the local control variable with the reference variable as quickly and precisely as possible.

I part (integral component)

Integral component of the controller. After a jump-like change to the control variable (or negative deviation), the output variable changes ramp-like over the time, and at a rate of change that is proportionate to the integrated gain KI (= 1/TI). In a closed control loop the integral part adjusts the controller output variable until the negative deviation becomes zero.

Limit alarm monitor

Algorithm (function) for monitoring an analog variable for four specified limits. When reaching or exceeding / falling short of these limits, an associated warning (1st limit) or alarm signal (2nd limit) is generated. To prevent signal flicker the disable threshold (switch-back difference) of the limit signals can be set via a parameter for the hysteresis.

Limiter

Algorithm (function) for restricting the value range of constant variables to specified lower / upper limit values.

Manipulated value correction

The manipulated value correction prevents a step change at the manipulated value during the changeover from manual to automatic mode. The manipulated value remains unchanged during the changeover from manual to automatic mode.

Manipulated variable

The manipulated variable is the output variable of the controller or input variable of the control section. The actuating signal can portray the range of the manipulated variable analogously as a percentage or as a impulse value or pulse width. With integrated actuators (e.g. motor) it is sufficient to provide binary upwards / downwards or forwards / backwards switching signals.

Mixing control

The mixing control is a control structure whereby the setpoint for the entire quantity SP is calculated as a percentage of the desired number of parts of the individual controlled components. The total of the mixing factors FAC must be 1 (= 100%).

Negative deviation

The negative deviation is a function to form the negative deviation ER = SP-PV. At the reference junction, the difference between the desired setpoint and the actual existing process value is formed. This value is transmitted to the control algorithm as an input. Old description: Control deviation.

P controller (P algorithm)

Algorithm for calculating an output signal whereby characteristics exist with a proportionate connection between the negative deviation and the change in manipulated variable. Features: remaining negative deviation, not to be used on dead time sections.

Parallel structure

The parallel structure is a special kind of signal processing in the controller (type of mathematical processing). The P, I and D parts are calculated as interaction-free and parallel and are then added up.

Physical standardization

→ standardization

PI controller (PI algorithm)

Algorithm for calculating an output signal where the change to the manipulated variable is made up from a part proportionate to the negative deviation and from an I part which is proportionate to the value of the negative deviation and the time. Features: no remaining negative deviation, quicker controlling than that with the I controller, suitable for all sections.

PID controller (PID algorithm)

Algorithm for calculating an output signal that is formed by the multiplication, integration and differentiation of the negative deviation. The PID algorithm is designed as a purely parallel structure. Feature: greater quality of control can be achieved, provided the dead time of the control section is not greater than the total of the remaining time constants.

Process identification

The process identification is a function of the configuration tool. It provides information regarding the transmission behavior and the structure of the process. A device-independent process model is conveyed as a result - this describes the process in its static and dynamic behavior. Optimum values for the controller parameters are calculated from this (controller design).

Process value

The current value of the control variable is PV

Ratio control

- single-loop ratio control

  A single-loop ratio control is employed if the ratio of two control variables is more important for a process than the absolute values of the control variables (e.g. speed regulation).

- multiple-loop ratio control

  With a multiple-loop ratio control the relationship of the two process variables PV1 and PV2 is kept constant. To do this, the setpoint of the 2nd control circuit is calculated from the control variable of the 1st control circuit. Even with a dynamic change to the process variable PV1 it is ensured that the specified relationship is maintained.

Reference variable

The reference variable specifies the desired value or course of the process variables of interest. Your current value is → setpoint (SP).

Section

→ control section

Setpoint

The setpoint is the value that the control variable should adopt from the effects of a controller.

Square root

→ square root extraction

Square root extraction

With the square root function SQRT quadratic associations can be linearized.

Standardization

The standardization is a procedure (algorithm) for converting (standardizing) the physical values of a process variable into the (internally processed) percentage value of the control and then converting the other way round to the output. The standardization line is established by the start value and the end value.

Step and pulse controller

The step and pulse controller is a virtually constant controller with two binary output signals. The step controller serves to drive the integrated elements (e.g. step motor for opening and closing a valve). The pulse controller serves to drive the non-integrated elements (e.g. switching a heating on or off).

Three step controller

Controller with which the output variable can accept only three discreet states: e.g. "hot - off - cool" or "right - standstill - left."

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