SIEMENS

SIMATIC

S7-300
Temperature regulator FM 355-2

Operating Instructions

05/2011

A5E00142771-03

Legal information

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⚠DANGER
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indicates that death or severe personal injury **may** result if proper precautions are not taken.

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

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without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

NOTICE
indicates that an unintended result or situation can occur if the relevant information is not taken into account.

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Preface

Purpose of This Manual

This manual describes all steps that are necessary to use the function module FM 355-2. It supports a quick and effective familiarization in the FM 355-2's functionality.

Contents of the manual

This manual describes both the hardware and software of the FM 355-2. It comprises of a tutorial section and a reference section (see annexes).

The manual covers the following topics:

- Controlling with the FM 355-2.
- Controller optimization
- Installing and removing the FM 355-2
- Wiring the FM 355-2
- Installing the software package
- Programming the FM 355-2
- Appendices

Basic knowledge required

To understand the manual, you require general experience in the field of automation engineering.

You will also need to know how to use computers or PC-like equipment (such as programming devices) under Windows operating systems.

Scope of this manual

This manual contains a description of the function module FM 355-2, as is valid at the time of publishing. We reserve the right to describe changes to the functionality of the FM 355-2 in form of a product information.

Position in the Information Landscape

This manual is a component of the S7-300 and ET 200M documentation.

System	Documentation
S7-300	1. *S7-300 Automation System Installation, CPU Data* 2. *S7-300 Automation Systems; Module Specifications* 3. *S7-300 Instruction List*
ET 200M	1. *ET 200M Distributed I/O Device* 2. *S7-300 Automation Systems; Module Specifications*

Guide

The manual contains various navigation aids that allow you to find specific information more quickly:

- At the beginning of the manual, you will find a detailed table of contents.
- At the end of the manual, you will find a list of references and a detailed keyword index for quick access to the information you need.

Approvals

For detailed information on approvals and standards, please refer to the section "Technical specifications".

Standards

The SIMATIC S7-400 product series complies with the requirements and criteria of IEC 61131-2.

Recycling and disposal

The FM 355-2 has a low pollutant content and can therefore be recycled. Engage a certified electronic scrap disposal company in order to ensure the environmentally-friendly recycling and disposal of your used device.

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 355-2 models

The FM 355-2 is available in the following two versions:

- FM 355-2 C (Continuous-action controller with analog outputs)
- FM 355-2 S (Step and pulse controller with digital outputs)

Order numbers

Product	Delivery components	Order No.:
FM 355-2 C	• Module FM 355-2 C, (continuous controller) • CD with configuring software, manual, Getting Started guide, online help and examples.	6ES7355-2CH00-0AE0
FM 355-2 S	• Module FM 355-2 S (Step and pulse controller) • CD with configuring software, manual, Getting Started guide, online help and examples.	6ES7355-2SH00-0AE0

1.2 Functionality of the FM 355-2

Introduction

The FM 355-2 function module is a controller module for use in the S7-300 and ET 200M automation systems.

Control method

The FM 355-2 contains a PID controller which can be configured by means of the self-optimization function:

Module	Controller type	Optimization by means of...
FM 355-2 C	Continuous-action controller	... the module's self-optimization function
FM 355-2 S	Pulse controller	
	Step controller	

Control structures

The FM 355-2 can be used for the following control structures:

- Fixed setpoint control
- Sequence control
- Cascade control
- Ratio control
- Mix control
- Split-range control (e.g. heating / cooling)

Operating modes

The FM 355-2 supports the following operating modes:

- Automatic
- Manual (external set point)
- Safety mode (safety set point, safety setting)
- Follow-up mode
- Back-up mode (at CPU in STOP or CPU failure)

Number of channels

The FM 355-2 contains four independent controllers in four channels.

Number of inputs and outputs

The following table presents an overview of the number of inputs and outputs for the FM 355-2.

Table 1- 1 Inputs and outputs of the FM 355-2

Inputs/Outputs	FM 355-2 C	FM 355-2 S
Analog inputs	4	4
Digital inputs	8	8
Analog outputs	4	-
digital outputs	-	8

Diagnostics interrupt

The FM 355-2 can trigger diagnostic interrupts for the following events:

- Error in module parameter assignment
- Module defective
- Overflow and underflow at analog inputs
- Load breaks and short circuits for analog outputs

Reference junction

For operation with thermal elements, the FM 355-2 has an additional analog input for connection to a Pt100 in 4-phase technology. This input is used to measure the reference junction temperature and thus to carry out compensation at thermocouples.

For low accuracy requirements, you can use the temperature sensor integrated into the module for measuring the differential element temperature for thermal elements J, K and E or configure the differential element temperature.

Parameter assignment

The FM 355-2 is configured by means of a configuring software.

1.3 Areas of application for the FM 355-2

Where can you use the FM 355-2?

Die FM 355-2 is a controller module that is especially designed for temperature control.

Areas of application

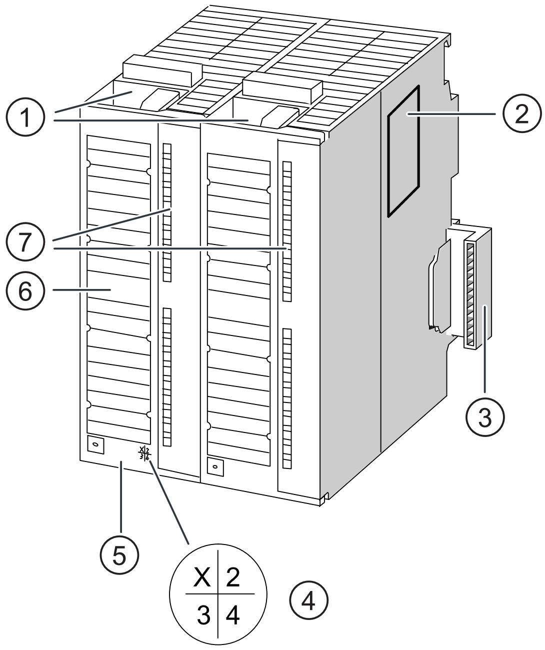
The application area of the FM 355-2 includes among other things, the following branches:

- General machine construction
- Plant construction
- Industrial furnaces
- Cooling and heating unit construction
- Food and beverage industry
- Process engineering
- Environmental technology
- Glass and ceramics manufacture
- Rubber and plastics machines
- Wood and paper processing industry

1.4 The FM 355-2 hardware

Module view

The following picture shows the FM 355-2 module with front connectors and the bus connector with the front doors closed.



① Front connector with front connector coding
② Type plate
③ SIMATIC bus connector interface
④ Product version
⑤ Order number
⑥ Labeling strips
⑦ Diagnosis and status LEDs

Figure 1-1 FM 355-2 module view

Front connectors

The FM 355-2 offers the following connection facilities via the front connector:

- 8 digital inputs
- 4 analog inputs
- 1 reference junction input
- 8 digital outputs (FM 355-2 S only)
- 4 analog outputs (FM 355-2 C only)
- Supply voltages DC 24 V between L+ and M to feed the module and the digital and analog outputs
- Reference point of the analog circuit M_{ANA}

The front connectors must be ordered separately (see "Spare parts list (Page 251)" appendix).

Front connector coding

When the front connector is pressed into the operating position from the wiring position, the front connector coding will snap into place. Subsequently the front connector can only be attached to an FM 355-2.

Labeling strips

The module comes with two labeling strips that can be individually labeled with your signal names.

The inner sides of the front doors are labeled with the appropriate connection assignment.

Order number and version

The order number and the FM 355-2 version are detailed on the lower end of the left hand front door.

Bus connectors

The communication within a S7-300 row takes place via the bus connector. The bus connector is supplied with the FM 355-2.

Diagnosis and status LEDs

The FM 355-2 has 10 LEDs, that serve diagnostic purposes and display the status of the FM 355-2 and the digital inputs.

Table 1- 2 Diagnosis and status LEDs

Labeling	Color	Function
SF	Red	Group error
Backup	Yellow	Back-up mode display
I0	Green	Status of digital input I0
I1	Green	Status of digital input I1
I2	Green	Status of digital input I2
I3	Green	Status of digital input I3
I4	Green	Status of digital input I4
I5	Green	Status of digital input I5
I6	Green	Status of digital input I6
I7	Green	Status of digital input I7

The LEDs next to the FM 355-2 S binary outputs are not controlled and are of no concern.

1.5 The FM 355-2 software

FM 355-2 software package

In order to integrate the FM 355-2 into the S7-300, you will need the software package which is supplied with the module on a CD. The software package comprises of the following components

- Configuration software
- Function blocks
- Online help
- Examples

Configuration software

The configuring software is to be installed on your PG/PC and called from within STEP 7. The parameters can be set via the configuring software.

The configuring software on your PG/PC enables FM 355-2

- parameterize,
- optimize,
- operation and monitoring.

Online help

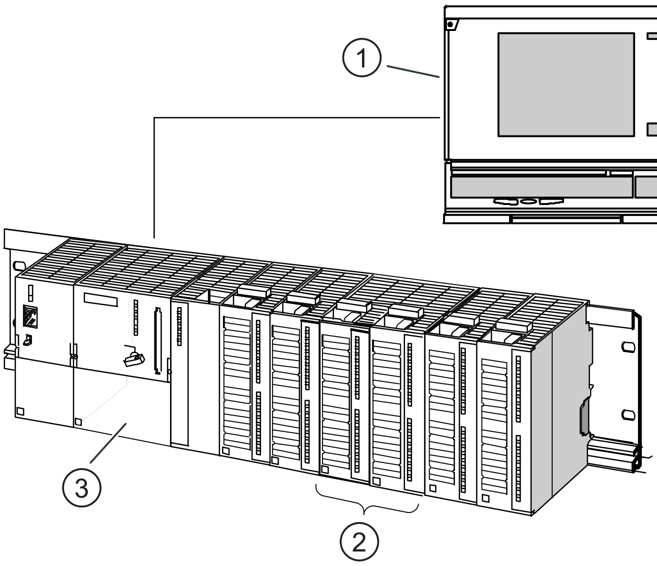
You will find further information on configuration in the integrated online help (F1) or in the help menu > help subjects

Software for the S7-300-CPU (function blocks)

The software for the CPU comprises of the following function blocks:

Function block	Effect
FB 52 FMT_PID	For operating, monitoring and online controller parameter changes.
FB 53 FMT_PAR	For changing further parameters online.
FB 54 FMT_CJ_T	For reading and writing the differential element temperature.
FB 55 FMT_DS1	For reading the diagnostic data record DS1.
FB 56 FMT_TUN	For supporting the controller optimization.
FB 57 FMT_PV	For reading or writing process values (analog and digital input values) for supporting commissioning tasks.

Your CPU must support DPV1 functionalities if you wish to use the function blocks supplied in the "FM 355-2 Temp Control" library.



① Programming device (PG) with STEP 7 and configuring software
② FM 355-2
③ CPU with user program and FBs of FM 355-2

Figure 1-2 Configuration of a SIMATIC S7-300 with FM 355-2

2 Structure of the FM 355-2

2.1 Basic structure of the FM 355-2

Introduction

The FM 355-2 C and FM 355-2 S have a similar basic structure. They comprise of the following function blocks:

- Inputs of the FM 355-2
  - 4 analog inputs with analog value processing
  - 1 differential element input for the compensation of thermal elements
  - 8 digital inputs
- Controller
  - 4 independent controller channels, each subdivided into the groups error signal, control algorithm, and controller output
- Outputs of the FM 355-2
  - 4 analog outputs (FM 355-2 C only)
  - 8 digital outputs (FM 355-2 S only)

Block diagram for the FM 355-2 C

The following diagram depicts the block diagram for the FM 355-2 C together with the interconnection options of the individual inputs, controllers and outputs.

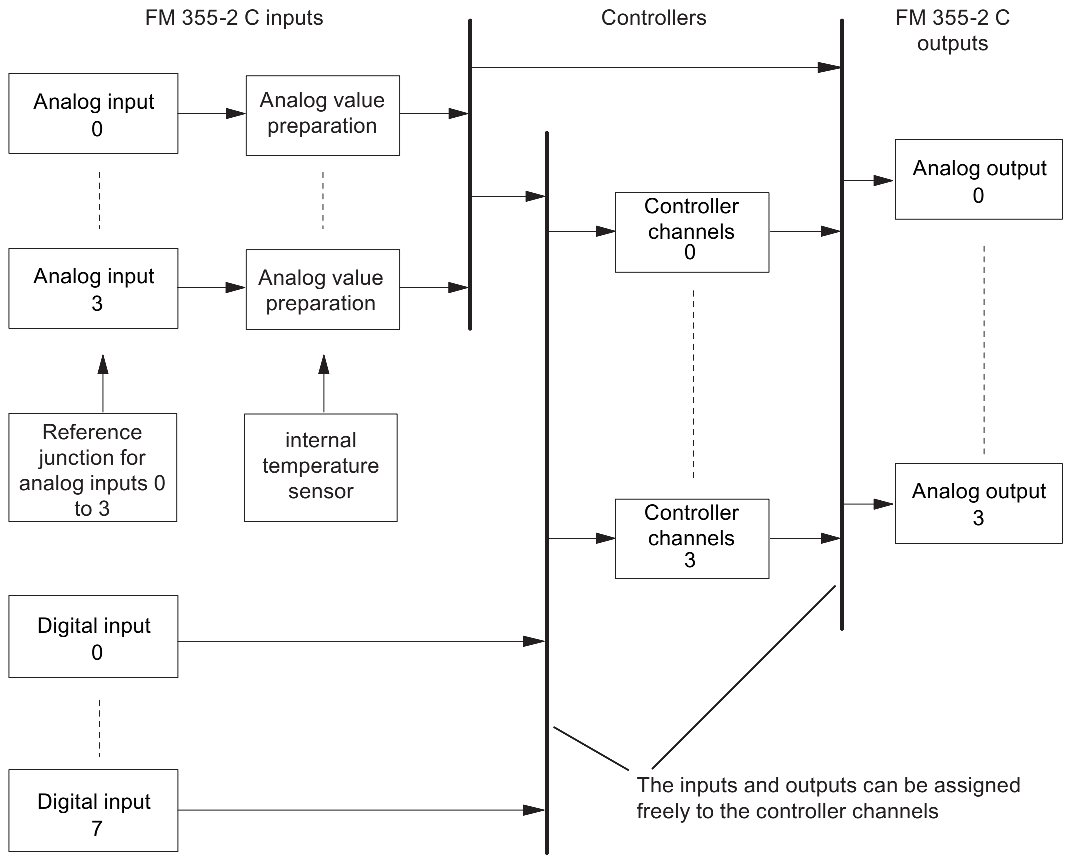


Figure 2-1 Block diagram for the FM 355-2 C

Interconnection options for the FM 355-2 C

The inputs, controllers and outputs of the FM 355-2 C are not permanently assigned to each other and can be assigned arbitrarily by means of parameterization.

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

Each controller channel can be assigned up to 4 analog inputs and up to 3 digital inputs. Each controller channel can be interconnected with processed analog values, the digital inputs or the output of a controller channel.

Each analog output can be interconnected with a controller output or with a processed analog value. The interconnection options with a processed analog value can be used, for example, for the conversion of a non-linear temperature value into a linear output signal.

Block diagram for the FM 355-2 S

The following diagram depicts the block diagram for the FM 355-2 S together with the interconnection options of the individual inputs, controllers and outputs.

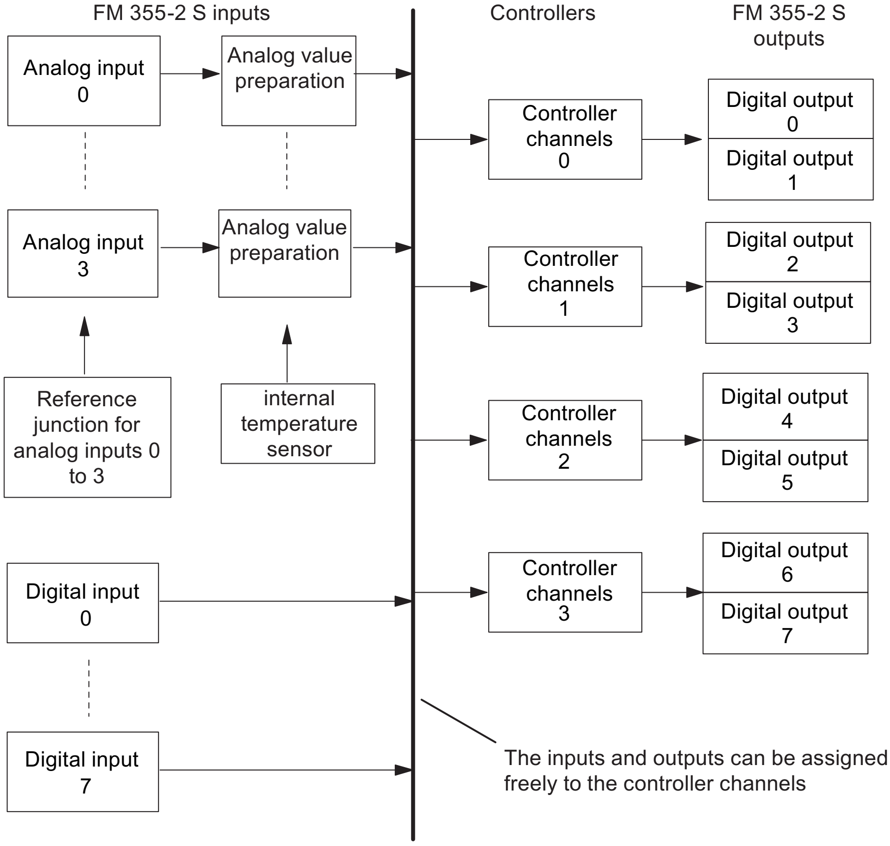


Figure 2-2 Block diagram for the FM 355-2 S

Interconnection options for the FM 355-2 S

The inputs and controllers of the FM 355-2 S are not permanently assigned to each other and can be assigned arbitrarily by means of parameterization.

The 4 controller channels are permanently assigned to 2 digital outputs each.

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

Each controller channel can be assigned up to 4 analog inputs and up to 5 digital inputs. Each controller channel can be interconnected with processed analog values, the digital inputs or the output of a controller channel.

See also

Overview (Page 53)

2.2 FM 355-2 inputs

FM 355-2 C and FM 355-2 S have the same structure at the analog and digital inputs.

2.2.1 Digital inputs

Operating modes

The digital inputs serve to switchover the operating modes of the individual controller channels.

The direction of control action for the digital inputs is configurable. The following settings are possible for each of the 8 digital inputs:

- High active
- Low active or open

For the following operating modes you can set if the switching signal is only to come from the FB or additionally from a digital input:

- Switchover to an external output value (manual operation)
- Switchover to follow-up mode
- Switchover to safety setting

The following signals can also be assigned via digital inputs when using a step controller:

- Checkback: Control equipment on upper endstop
- Checkback: Control equipment on lower endstop

2.2.2 Analog inputs

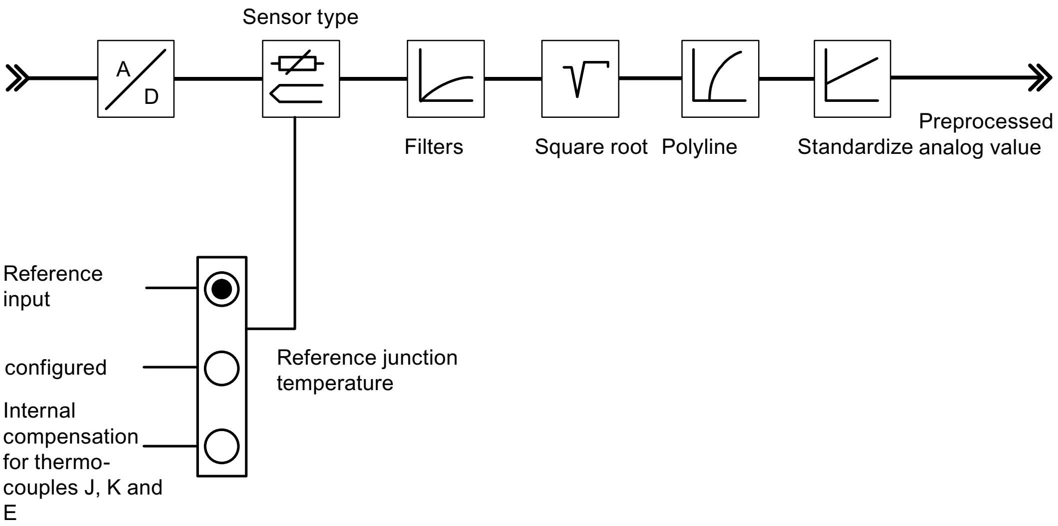


Figure 2-3 Analog value processing

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

- The analog input will not be processed
- Current sensor 0 ... 20mA
- Current sensor 4 ... 20mA
- Voltage sensor 0 ... 10 V
- Pt 100, -200 ... 850 ºC
- Pt 100, -200 ... 556 ºC (double resolution)
- Pt 100, -200 ... 137 ºC (quadruple resolution)
- Thermocouples type B, E, J, K, R and S (analog input set to ±80 mV)
- Free thermocouple (analog input set to ±80 mV)

Adaptation 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

Switchover Celsius / Fahrenheit

Temperatures can be measured in either °C or °F. The reference junction temperature is not converted when changing from °C to °F.

Reference junction

The following can be assigned:

- Reference input: When a thermocouple has been set at an analog input as a sensor, you can connect a Pt 100 to the FM 355-2 reference junction input to compensate for the reference junction temperature of thermocouples.

  If you use the reference junction input, the sampling time for all the controllers is increased by the conversion time for the reference junction input (see the figures in Chapter "Characteristics of the FM 355-2 (Page 31)").
- A fixed reference junction temperature.
- Internal compensation for the thermal elements J, K and E. An internal temperature sensor measures the differential element temperature in the module directly.

Analog value processing

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	Programmable values	Note
Filters	• On / Off • Time constant in s	First level filter, the transient response of which is set 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.
Normalization and offset correction	• Bottom • limiting	• For the conversion of an input signal into another physical unit by means of linear interpolation between the initial value (lower) and final value (upper) • For offset correction of the actual value
Polyline	• On / Off • 13 control points selectable in – mA at current input – mV at voltage input	For linearization of sensor characteristic curves

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Note

Scaling / 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 can be used for the linearization of a free thermocouple or for any other linearization.

2.3 Outputs of the FM 355-2

Analog outputs for the FM 355-2 C

The following functions can be configured for each analog output of the FM 355-2 C:

- Signal Selection
- Signal type

Signal selection on the signal outputs

The signal selection function enables you to define which signal values will be given at the relevant analog outputs.

The following signal values can be assigned:

- the value zero
- the processed analog value of one of the 4 analog inputs
- The output value A of one of the 4 controller channels
- The output value B of one of the 4 controller channels

Signal type on the analog outputs

You can determine the signal type for each of the analog outputs.

The following signal types can be assigned:

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

Digital outputs for the FM 355-2 S

The digital outputs of the FM 355-2 S serve to provide control for integrating or non-integrating final control elements.

Table 2- 1 Assignment and meaning of the digital outputs

Controller channel	The digital outputs assigned to the control channel	Meaning of digital outputs for step controllers	Assignment of digital outputs for pulse controllers
0	0	Open	Output value A
	1	Close	Output value B
1	2	Open	Manipulated value A
	3	Close	Manipulated value B
2	4	Open	Manipulated value A
	5	Close	Manipulated value B
3	6	Open	Manipulated value A
	7	Close	Manipulated value B
Open = open the control equipment Close = close the control equipment			

2.4 Operative mechanism of data storage on the FM 355-2

Data flow during parameter assignment by means of configuring software

The illustration below shows the parameter data route from the configuring software to the FM 355-2.

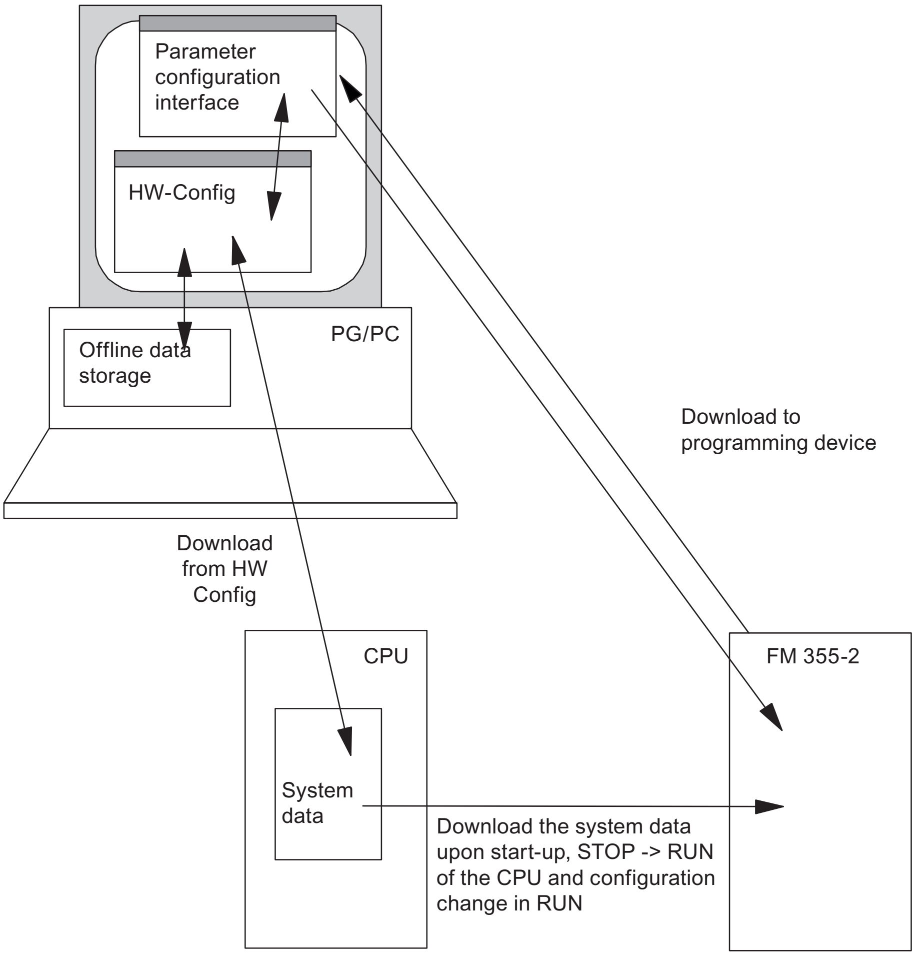


Figure 2-4 Illustration parameterizing the FM 355-2 via the PG/PC and via the CPU

Parameter assignment

The FM 355-2 can be configured with the help of configuring software on a PG/PC. All configuration data is stored in a system database (SDB).

Note

Please note that every time the CPU starts up (transition from STOP to RUN) the parameters in the FM 355-2 will be overwritten with the values from the system database.

Loading the parameters directly into the FM 355-2 (loading into module)

You can load the parameters directly into the FM 355-2 via the configuring software so that it is not necessary to repeatedly close the configuring software and set the CPU to STOP while testing parameters during the commissioning phase.

Loading directly into the FM 355-2 is sensible when testing parameters during the commissioning phase.

If you change parameters via the configuring software and subsequently load the data directly into the FM 355-2, discontinuity can occur in the manipulated value process. We recommend the following procedure in order to ensure a controlled manipulated value process:

1. Switch to manual operation (e.g. via the loop display).
2. Change the parameters.
3. Load the data directly into the FM 355-2.
4. Switch to automatic operation (e.g. via the loop display).

Save all parameters that were changed online.

The FM 355-2 offers the following options to change parameters online:

- by means of FB FMT_PID (controller parameters) and FMT_PAR (further parameters),
- with controller optimization,
- with the configuration software (Upload to module).

Please note that online parameters changed in this way will be overwritten by the parameters in the CPU´s SDB when the CPU starts up or with a STOP-RUN transition.

In order to store changed parameters in the SDB of the CPU, please proceed as follows:

1. Load the parameters from the FM 355-2 with **PLC > Upload to PG** in the configuration software.
2. Save the parameters in the configuring software.
3. Leave the configuration software.
4. Save the project in HW Config with **File > Save** and compile.
5. Transfer the data to the CPU by means of **PLC > Upload** ...

If all the HW components are CiR-capable, you can also transfer the data in RUN.

See also

Installing the configuration package (Page 51)

2.5 Characteristics of the FM 355-2

Sequence of execution

The FM 355-2 processes the analog inputs and controller channels in a predetermined order. Each controller channel is processed immediately after the processing and preparation of the identically numbered analog input. Subsequently the analog input with the next highest number will be processed and so on. The reference junction is processed first.

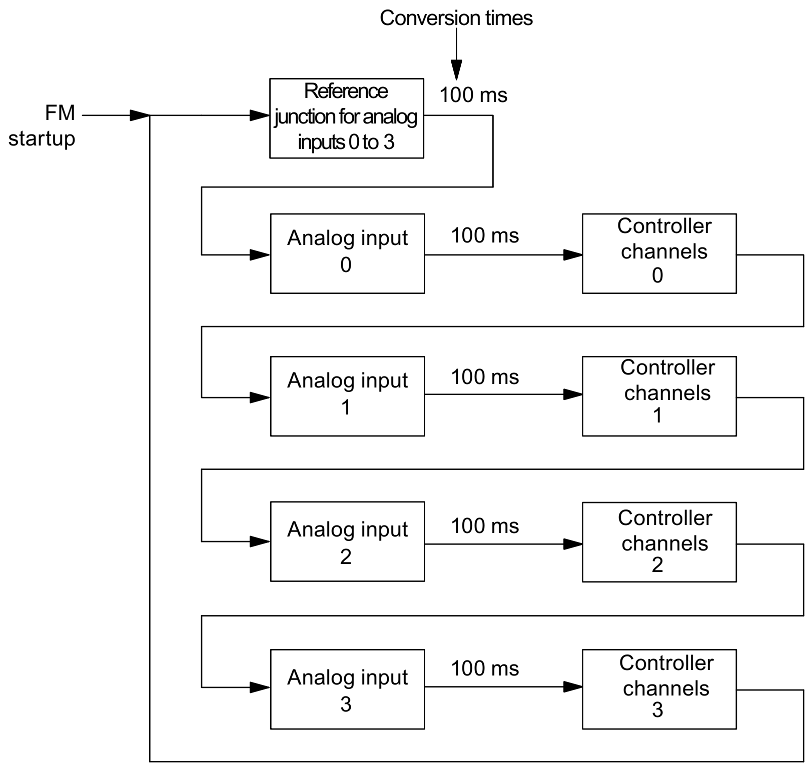


Figure 2-5 FM 355-2 processing sequence

Scan time

The collective scan times for all of the FM 355-2 controllers result from the sum of the conversion times of the individual analog inputs. The conversion time for the reference junction is added to this, if it is used.

The conversion time for an analog input is always 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 manipulated variables of the FM 355-2 are output immediately after the corresponding manipulated variables have been calculated.

They amount to a minimum of 100ms (when only one analog input is processed) and maximum 500 ms (if all 4 analog inputs and the reference junction are to be processed).

The figure below shows an example of the processing sequence of just three active analog inputs.

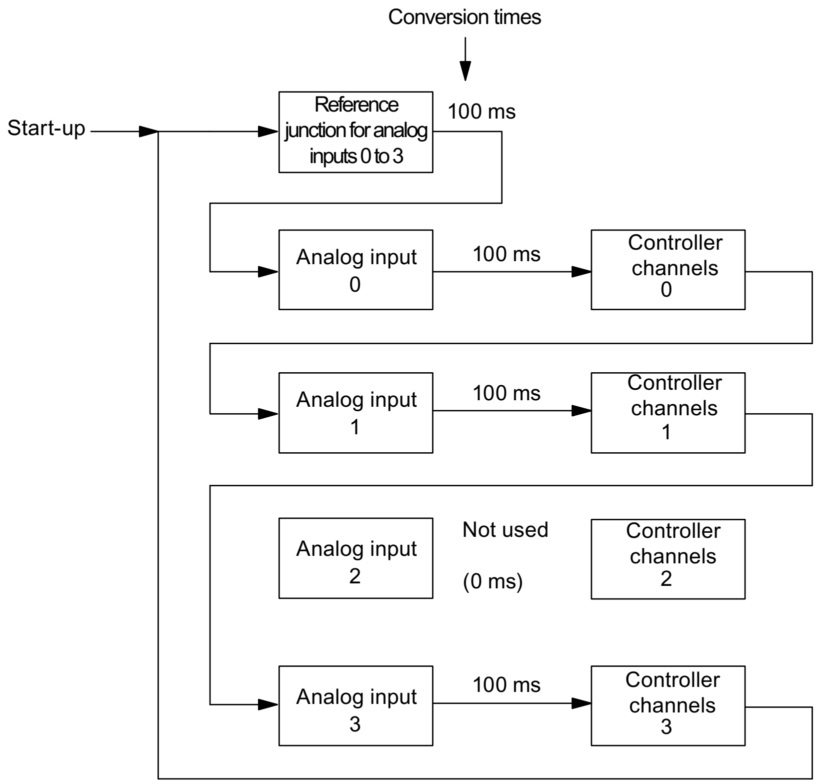


Figure 2-6 FM 355-2 processing sequence

The scan time for each controller from the above example is given as follows:
t_{Scan} = 4 x 100 ms = 400 ms.

Notes regarding FM 355-2 operation

The following notes apply to the operation of the FM 355-2:

- The FM 355-2 controllers are end-stackable, i.e. they can set the manipulated variable of a controller channel to the setpoint 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 from analog inputs 1, 2 and 3. The smallest dead time results from the selection of controller no. 3.
- If the setting "Analog input" on an analog input is set to not be processed, then the identically numbered controller channel will also not be processed. This means that no additional sampling time will be required for this analog input.

- If the reference junction input is used, then the same conversion time is required as for an analog input (100 ms).
- The scan time of a controller results from the sum of the conversion times of the active analog inputs plus the conversion time of the reference junction input.

Startup reaction of the FM 355-2

When the supply voltage is applied, the outputs remain on zero initially. The actual startup operation begins when the FM 355-2 receives its parameter data (SDB) from the CPU. Depending on configuration, either a safety setting will be output or the FM 355-2 will be in automatic mode. The FM 355-2 remains in startup operation until the FB FMT_PID is called for the first time.

Reactions in event of CPU failure

on failure or STOP of the CPU

- The setting "control output = safety setting" will be switched over to safety setting.
- The operating mode for the "standard operation" setting remains unchanged, and you can program the following responses in the "Switch safety setpoint value" window.
  - Last valid setpoint

    If the setpoint selection has been set "by function block", then the setpoint will remain constant at its last set value after a CPU failure. If the setpoint is given by an FM controller or from an analog input, then the setpoint changes correspondingly to the called value.
  - Safety setpoint value

    The FM regulates to the safety setpoint value.

Reaction to failure of the supply voltage

The CPU has to be set to STOP following a failure and return of the supply voltage of the FM355-2 in centralized and in distributed configurations. All of the digital and analog outputs of the FM355-2 remain turned off until the CPU goes to STOP, and access via the configuration software or via the FBs is not possible.

In distributed configurations without active backplane buses a station failure is triggered following a power supply failure, for other FMs only a group error message is issued.

When power is restored, the SDB parameter of the CPU is sent to the FM355-2 and the module starts up with this parameter.

Contrary to other FMs, in HW Config the tab cards for diagnostics buffer and diagnostic interrupt are not shown under "Station > Open ONLINE > PLC > Module Information" if there is a power failure.

Backup mode

If the CPU goes into STOP mode, fails, or the connection between the FM 355-2 and CPU is interrupted, the FM 355-2 goes into backup mode and continues to control with the parameters that were valid at the time of the fault.

The following options are available, depending on configuration:

- Setpoint = safety setpoint value
- Standard operation with last valid setpoint
- Standard operation with safety setting

Safety mode is indicated by the yellow "Backup" LED.

Firmware update

Firmware updates can be downloaded onto the FM 355-2 operating system memory in order to add extended functionality and fix errors. This function can be carried out under HW Config > PLC > Update Firmware.

Installing and removing the FM 355-2 3

3.1 Preparing for Installation

Assign slots

The function module FM 355-2 occupies two slots. They can be installed in any of the slots 4 to 11 in the same way as a signal module.

Configuring mechanical design

You will find information regarding what options are available for the mechanical design together with instructions on configuration in the manual entitled *Automation system S7-300; Configuration, CPU data*. The following section offers a few supplementary notes.

1. A maximum of 8 SMs or FMs per row (rack) are allowed.
2. The maximum number is restricted by the width of the module and the length of the mounting rail. The FM 355-2 requires 80 mm installation width.
3. The maximum is restricted by the sum current consumption of all modules to the right of the CPU from the 5V backplane bus supply. The typical current consumption of the FM 355-2 from the 5V backplane bus supply amounts to 50 mA.
4. The maximum number is restricted by the memory requirements of the software in the CPU, which is required for communication with the FM 355-2.

Determine mounting position

The rack should be mounted horizontally if possible. A restricted ambient temperature applies if the device is mounted vertically (max. 40 °C).

Determining start address

The start addresses must be entered in the instance DBs of the required FBs.

The start addresses for the FM 355-2 can be determined in accordance with the same rules as the start addresses for analog modules.

Fixed addressing

When using fixed addresses, the start address is dependent on the slot. Please refer to the tables in the *Automation system S7-300; Configuration, CPU data* manual for information pertaining to the start addresses for analog modules on various slots.

The fixed start address can also be calculated by means of the following equation:

Adr. = 256 + (rack number * 128) + (slot number - 4) * 16

Free addressing

Enter the start address for the module under STEP 7 in order to assign a free address.

Important safety rules

There are important rules that must be observed when integrating an S7-300 with an FM 355-2 in a plant or system. These rules and regulations are to be found in the *Automation system S7-300; Configuration, CPU data* manual.

See also

Overview of the function blocks (Page 117)

3.2 FM 355-2 installation and removal

Protective measures

No special precautions (ESD directives) are required for the installation of the FM 355-2.

Tools required

A 4.5 mm screwdriver is required to install or remove the FM 355-2.

Procedure for installation

The following describes how the FM 355-2 is to be installed on the mounting rail. Additional information pertaining to the installation of modules is to be found in the *Automation system S7-300; Configuration, CPU data* manual.

1. Switch the CPU to STOP mode.
2. A bus connecter is supplied with the FM 355-2. Connect it to the bus connector on the module to the left of the FM 355-2. (the bus connector is to be found on the back side, if necessary you may need to loosen the neighboring modules again).
3. Hang the FM 355-2 onto the rail and rotate it downwards.
4. Screw the FM 355-2 tight (torque approx. 0.8 to 1.1 Nm).

   If additional modules are to be mounted to the right of the FM 355-2, first connect the bus connector for the next module to the right hand back wall bus connector of the FM 355-2.

   Do not connect a bus connector should the FM 355-2 be the last module in the row.
5. Label the FM 355-2 with its slot number. Use the numbering device included with the CPU for this purpose.

   Please refer to the information in the *Automation system S7-300; Configuration, CPU data* manual for information regarding the fixed order that must be observed for numbering and how the slot numbers are to be inserted.
6. Install the shield connection element.

Procedure for removal

The following describes how to remove the FM 355-2. Additional information pertaining to the removal of modules is to be found in the *Automation system S7-300; Configuration, CPU data* manual.

1. Switch off supply voltage L+ on the front connector.
2. Switch the CPU to STOP mode.
3. Open the front doors. If necessary, remove the labeling strips.
4. Unlock the front connector and remove it.
5. Undo the module fixing screws on the module.
6. Rotate the module out of the mounting rails and unhook it.
7. If necessary install the new module.

Further information

Additional information pertaining to the installation and removal of modules can be found in the *Automation system S7-300; Configuration, CPU data* manual.

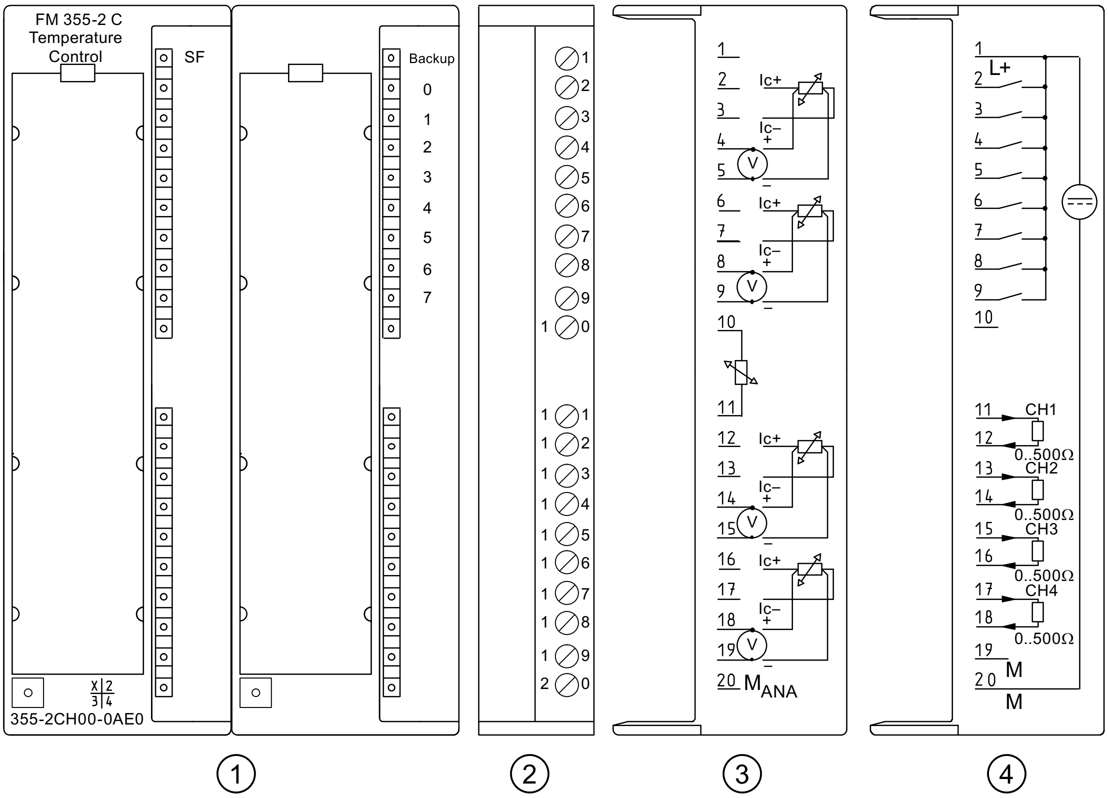
4 Wiring the FM 355-2

4.1 Terminal assignment on the front connector

4.1.1 FM 355-2 C front connector

Both 20-pole front connectors of the FM 355-2 C are used to connect the digital inputs, the analog inputs and outputs, and the supply voltage for the module.

The illustration below shows the front side of the module, a front connector and the inner side of the front doors with the imprint of the terminal assignment.



① Front view of the module

② Front connectors

③ Terminal assignment of the left hand front connector

④ Terminal assignment of the right hand front connector

Figure 4-1 FM 355-2 C front connector terminal assignment

Front connector assignment of the FM 355-2 C

Table 4- 1 FM 355-2 C front connector terminal assignment

<table>
<tr><th colspan="4">Left front connector</th><th colspan="4">Right front connector</th></tr>
<tr><th>Connection</th><th>Analog input</th><th>Name</th><th>Function</th><th>Connection</th><th>Analog output</th><th>Name</th><th>Function</th></tr>
<tr><td>1</td><td>-</td><td>-</td><td>-</td><td>1</td><td>-</td><td>L+</td><td>24 VDC supply voltage</td></tr>
<tr><td>2</td><td rowspan="4">0</td><td>IC+</td><td>Constant current cable (pos)</td><td>2</td><td>-</td><td>I0</td><td>Digital input</td></tr>
<tr><td>3</td><td>IC-</td><td>Constant current cable (neg)</td><td>3</td><td>-</td><td>I1</td><td>Digital input</td></tr>
<tr><td>4</td><td>M+</td><td>Measuring cable (pos)</td><td>4</td><td>-</td><td>I2</td><td>Digital input</td></tr>
<tr><td>5</td><td>M-</td><td>Measuring cable (neg)</td><td>5</td><td>-</td><td>I3</td><td>Digital input</td></tr>
<tr><td>6</td><td rowspan="4">1</td><td>IC+</td><td>Constant current cable (pos)</td><td>6</td><td>-</td><td>I4</td><td>Digital input</td></tr>
<tr><td>7</td><td>IC-</td><td>Constant current cable (neg)</td><td>7</td><td>-</td><td>I5</td><td>Digital input</td></tr>
<tr><td>8</td><td>M+</td><td>Measuring cable (pos)</td><td>8</td><td>-</td><td>I6</td><td>Digital input</td></tr>
<tr><td>9</td><td>M-</td><td>Measuring cable (neg)</td><td>9</td><td>-</td><td>I7</td><td>Digital input</td></tr>
<tr><td>10</td><td>-</td><td>COMP +</td><td>Reference junction input (pos)</td><td>10</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>11</td><td>-</td><td>COMP -</td><td>Reference junction input (neg)</td><td>11</td><td rowspan="2">0</td><td>Q0</td><td>Analog output</td></tr>
<tr><td>12</td><td rowspan="4">2</td><td>IC+</td><td>Constant current cable (pos)</td><td>12</td><td>M_{ANA}</td><td>Reference point of measuring circuit</td></tr>
<tr><td>13</td><td>IC-</td><td>Constant current cable (neg)</td><td>13</td><td rowspan="2">1</td><td>Q1</td><td>Analog output</td></tr>
<tr><td>14</td><td>M+</td><td>Measuring cable (pos)</td><td>14</td><td>M_{ANA}</td><td>Reference point of measuring circuit</td></tr>
<tr><td>15</td><td>M-</td><td>Measuring cable (neg)</td><td>15</td><td rowspan="2">2</td><td>Q2</td><td>Analog output</td></tr>
<tr><td>16</td><td rowspan="4">3</td><td>IC+</td><td>Constant current cable (pos)</td><td>16</td><td>M_{ANA}</td><td>Reference point of measuring circuit</td></tr>
<tr><td>17</td><td>IC-</td><td>Constant current cable (neg)</td><td>17</td><td rowspan="2">3</td><td>Q3</td><td>Analog output</td></tr>
<tr><td>18</td><td>M+</td><td>Measuring cable (pos)</td><td>18</td><td>M_{ANA}</td><td>Reference point of measuring circuit</td></tr>
<tr><td>19</td><td>M-</td><td>Measuring cable (neg)</td><td>19</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>20</td><td>-</td><td>M_{ANA}</td><td>Reference point of measuring circuit</td><td>20</td><td>-</td><td>M</td><td>Supply voltage ground 24 VDC</td></tr>
</table>

Note

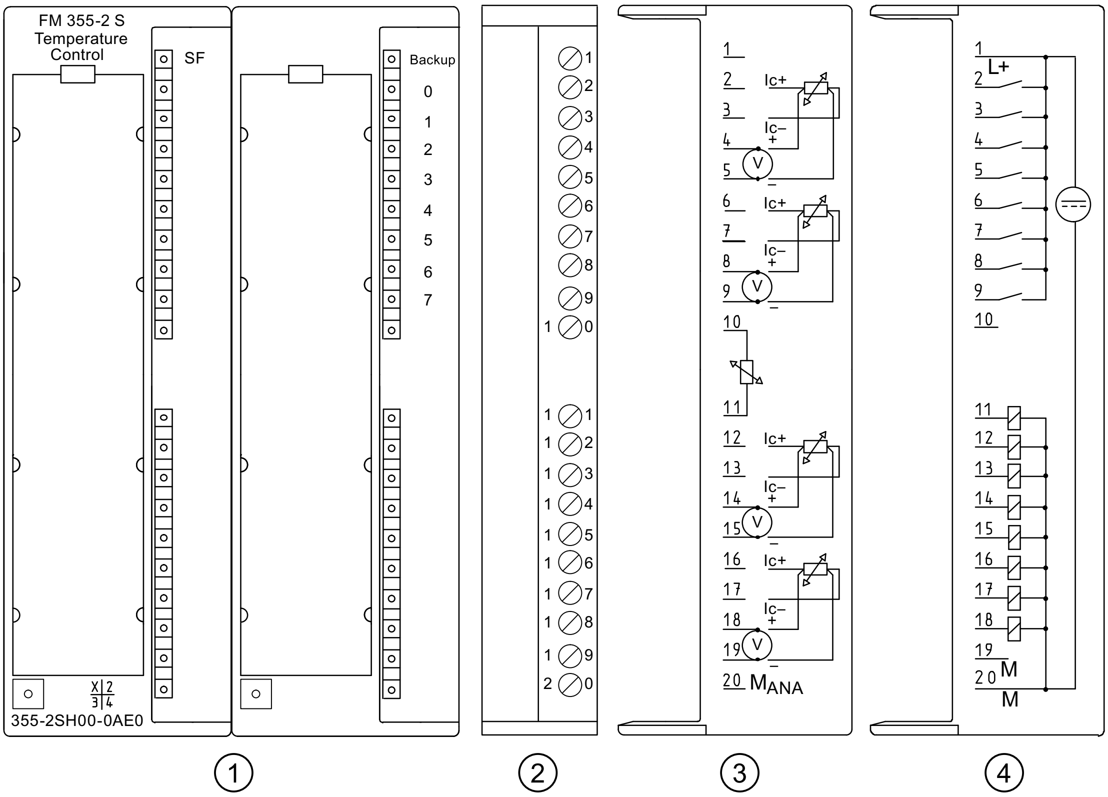
The M_{ANA} connections are to be connected low impedance to the central chassis ground. If you supply the encoders with external voltage, you must also connect the ground of the external voltage source to the CPU ground.

4.1.2 FM 355-2 S front connector

View

Both 20-pole front connectors of the FM 355-2 S are used to connect the digital inputs, the analog inputs and outputs, and the supply voltage for the module.

The illustration below shows the front side of the module, a front connector and the inner side of the front doors with the imprint of the terminal assignment.



① Front view of the module
② Front connectors
③ Terminal assignment of the left hand front connector
④ Terminal assignment of the right hand front connector

Figure 4-2 FM 355-2 S front connector terminal assignment

FM 355-2 S front connector assignment

Table 4- 2 FM 355-2 S front connector terminal assignment

Left front connector				Right front connector			
Connection	Analog input	Name	Function	Connection	Controller channel	Name	Function
1	-	-	-	1	-	L+	Supply voltage 24 VDC
2	0	IC+	Constant current cable (pos.)	2	-	I0	Digital input
3		IC-	Constant current cable (neg.)	3	-	I1	Digital input
4		M+	Measuring cable (pos)	4	-	I2	Digital input
5		M-	Measuring cable (neg)	5	-	I3	Digital input
6	1	IC+	Constant current cable (pos.)	6	-	I4	Digital input
7		IC-	Constant current cable (neg.)	7	-	I5	Digital input
8		M+	Measuring cable (pos)	8	-	I6	Digital input
9		M-	Measuring cable (neg)	9	-	I7	Digital input

Left front connector				Right front connector			
10	-	COMP +	Reference junction input (pos.)	10	-	-	-
11	-	COMP -	reference junction input (neg)	11	0	Q0	Digital output For step controller: Control output signal high For pulse controller: Manipulated variable A
12	2	IC+	Constant current cable (pos.)	12		Q1	Digital output For step controller: Manipulated variable signal low For pulse controller: Manipulated variable B
13		IC-	Constant current cable (neg.)	13	1	Q2	Digital output For step controller: Control output signal High For pulse controller: Manipulated variable A
14		M+	Measuring cable (pos)	14		Q3	Digital output For step controller: Manipulated variable signal low For pulse controller: Manipulated variable B
15		M-	Measuring cable (neg)	15	2	Q4	Digital output For step controller: Control output signal High For pulse controller: Manipulated variable A
16	3	IC+	Constant current cable (pos.)	16		Q5	Digital output For step controller: Manipulated variable signal low For pulse controller: Manipulated variable B
17		IC-	Constant current cable (neg.)	17	3	Q6	Digital output For step controller: Control output signal High For pulse controller: Manipulated variable A
18		M+	Measuring cable (pos)	18		Q7	Digital output For step controller: Manipulated variable signal low For pulse controller: Manipulated variable B
19		M-	Measuring cable (neg)	19	-	-	-
20	-	M_{ANA}	Reference point of measuring circuit	20	-	M	Supply voltage ground 24 VDC

Note

The 20 M_{ANA} terminal is to be connected low impedance to the central chassis ground. If you supply the encoders with external voltage, you must also connect the ground of the external voltage source to the CPU ground.

4.1.3 Special notes regarding wiring

Supply voltage L+/M

A 24V direct current is to be connected to connectors L+ and M for the supply voltage to the module and to supply the digital outputs.

An integrated diode protects the module against reverse polarity in the supply voltage.

CAUTION

Only an extra-low voltage of ≤ 60 VDC which is safely isolated from mains may be used for the 24V supply. Safe isolation can be implemented by adhering to one of the following specifications:

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

Note

The direct connection of inductors (e.g. from relays and contactors) is possible without external wiring. Where the SIMATIC output circuits can be switched off by additional contacts (e.g. relays), the inductors must be provided with additional overvoltage protectors (please see the following illustration for an example of overvoltage protection).

Example of overvoltage protection

The following figure illustrates an output circuit requiring additional overvoltage protection.

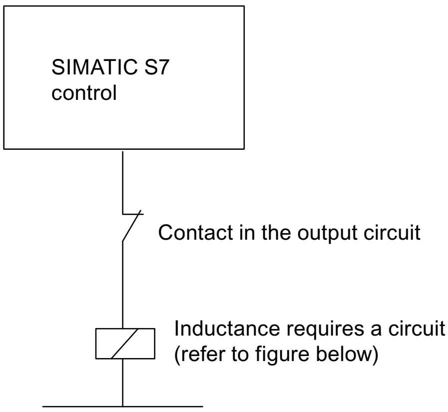


Figure 4-3 Relays in the output circuit

Circuit for coils operated with DC voltage

Coils operated with DC voltage are switched by means of diodes or Zener diodes.

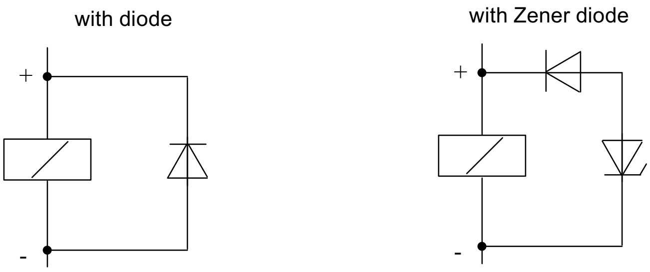


Figure 4-4 Circuit for coils operated with DC voltage

Switching with diodes/Zener diodes

Diode/Zener diode circuits have the following characteristics:

- Opening surge voltage can be totally avoided. The Zener diodes have a higher switch-off voltage capacity.
- High switch-off delay (6 to 9 times higher than without protective circuit). The Zener diodes switch off faster than a diode circuit.

4.2 Wiring Front Connectors

Rules for selecting cables

There are a number of rules that should be adhered to when selecting cables.

- The cables for the digital inputs I0 to I7 must be shielded when longer than 600m.
- Analog signal cables must be shielded.
- The shielding of the analog signal cables must be laid over the shield connection element on the sensor as well as in the immediate vicinity of the module.
- Use flexible cables of 0.25 to 1.5 mm diameter ^{2}.
- Conductor end sleeves are not required. If you use conductor end sleeves, then ensure that only the type without insulating collar are used according to DIN 46228 type A, short version.

Note

Unused analog inputs are to be shorted and connected to M_{ANA}.

Procedure

To wire the front connector, proceed as follows

1. Move the front connector into the wiring position and open the front door.
2. Strip the conductors to a length of 6 mm.
3. Are you using conductor end sleeves?

   If yes: Squeeze the conductor end sleeves to the conductors.
4. Feed the included cable strain relief into the front connector.
5. If you route the wires out downwards, start the wiring at the bottom. If this is not the case, start at the top. Screw also the unused connectors tight (torque 0.6 to 0.8 Nm).
6. Tighten the strain relief for the cable strain relief.
7. Replace the front connector into its operating position.
8. Lay the conductor shield flat on the shield connection element or on the shield end element.
9. Label the terminals with the labeling plate.

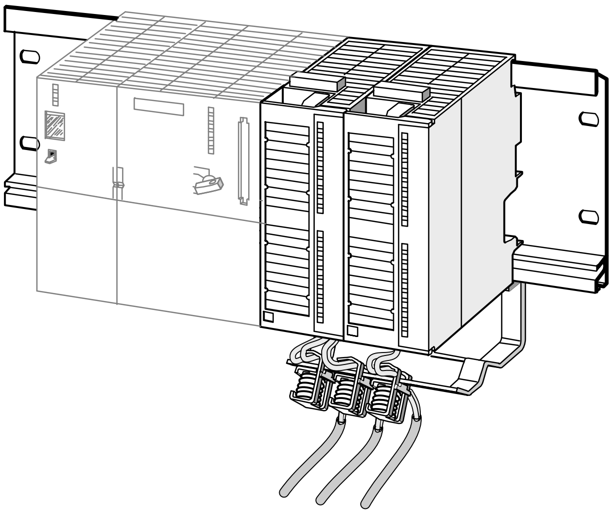


Figure 4-5 Connect the shielded conductors to the FM 355-2.

4.3 Module status after initial activation

Characteristics

The following details characterize the state of the module after initial power activation, when no data has yet been transferred (factory state):

- Analog inputs: No processing
- Analog outputs (FM 355-2 C): 0 mA
- Digital outputs (FM 355-2 S): 0 (disabled)
- No controller active
- Diagnostic interrupt disabled

5 Installing the configuration package

Requirements

STEP 7 version 5.1 service pack 4 or better must be correctly installed on your PG/PC.

Delivery format

The software is provided on a CD-ROM together with the module.

Installation procedure

To install the software:

1. Place the CD into the CD-ROM drive of your PG/PC.
2. Select the CD drive from the dialog window and run the Setup.exe file to start the installation procedure.
3. Follow the on-screen step-by-step instructions of the installation program.

The installation procedure will install the following on your PG/PC:

- Configuration software
- Function blocks
- Program examples
- Online help

Program examples

The programming examples can be found in the STEP 7 catalog, in the "Examples" subsection under project zEn28_01_FMTemp.

Read the readme file

Any important up-to-date information regarding the supplied software will be in the readme file, should the need arise. You can find this file on the CD under Start > Simatic > Product Notes.

Online help

The configuring software includes an online help function to support you in the parameter assignment of the FM 355-2. The online help function can be called up in the following ways:

- via the menu command Help > Help subjects...,
- by pressing the F1 key,
- by pressing the help button from within the individual configuration masks.

The online help function describes the parameterizing of modules in more detail than the manual.

How does the FM 355-2 control? 6

6.1 Overview

Controller

Each controller of every channel on the FM 355-2 comprises the following configurable blocks:

- Error signal
  - Preparation of setpoints and actual values
  - Signal selection for setpoints, actual values, D input and disturbance values.
- Controller algorithm
  - PID controller, dead zone, cooling and control zone
- Controller output
  - Setpoint switchover
  - Setpoint preparation

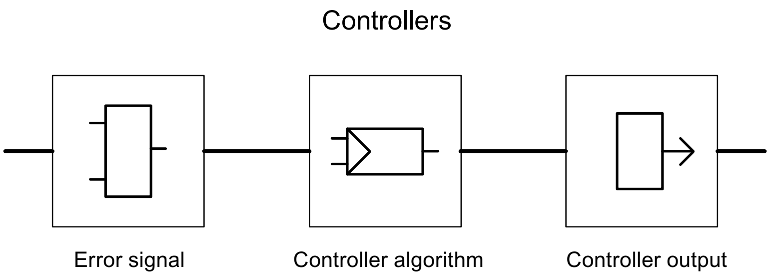


Figure 6-1 Structure of the controller

Controller structures and controller types

For each controller channel on the FM 355-2 C or FM 355-2 S you can create various controller structures:

- Fixed value or cascade controller
- Three-component controller
- Ratio controller or composition controller

The FM 355-2 S enables you to choose between the following controller types:

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

Binary setpoint output signal

All three FM 355-2 S controller types work with binary setpoint output signals.

The step controllers are used for integrating control elements (e.g. servo motors). Two versions are configurable: with or without analog position feedback. An analog position feedback is often not available. They are not to be confused with the endstop signals (binary position feedbacks: upper or lower endstop of control element reached). These are generally available and are to be configured in the controller output block by clicking pulse former.

The pulse controller is used for creating pulse width modulated control signals. The conversion in a binary output signal occurs in such a way that the ratio pulse length to the parameterized period equals the setpoint on the assigned digital output (see Split-range / pulse former button). There are two possibilities for the pulse controller:

- Two-position controller: works with setpoint A and requires only one digital output (e.g. pure filament rheostat)
- Three-position controller: works with setpoints A and B and requires two digital outputs (e.g. combined heating and refrigeration control).

See also

Introduction (Page 55)

6.2 Error signal

6.2.1 Introduction

Principle

The same basic control deviation structures underlie all of the implemented controller structures in the FM 355-2 C and FM 355-2 S.

The effective setpoints and effective actual values are calculated from the setpoints and actual values by means of appropriate processing. The control deviation is achieved by subtracting the effective actual value from the effective setpoint that is supplied to the controller.

You can assign a signal selection for the setpoints and actual values. This means the FM 355-2 has universal application possibilities.

The control deviation structures differ, dependent on the selected controller structure.

See also

Sample application for FM 355-2 C (closed-loop controller) (Page 179)

Fixed value or cascade controller (Page 56)

Three-component controller (Page 57)

Ratio controller or composition controller (Page 58)

6.2.2 Fixed value or cascade controller

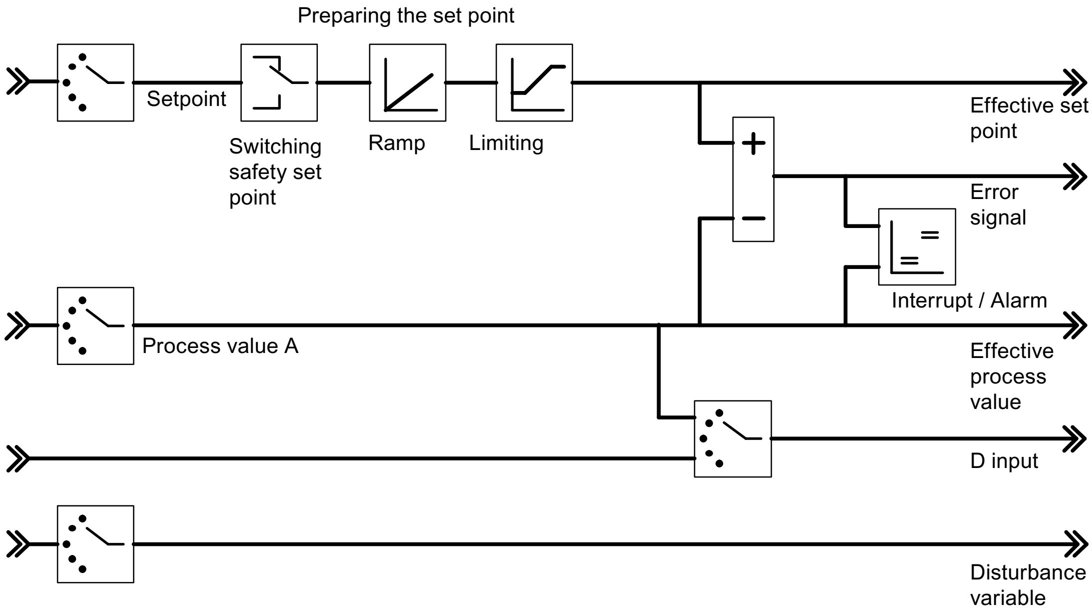


Figure 6-2 Control deviation determination for fixed value or cascade controllers

For the follow-up controller of a cascade controller system, the manipulated variable of a master controller is selected as the setpoint.

If the follow-up controller is set to manual, then the I-action (anti-reset windup) will be halted on the FM 355-2 at the associated master controller. As soon as the follow-up controller is switched back to standard operation, the I-action will be re-released at the master controller.

If the regulated quantity of a follow-up controller reaches its limit or if the setpoint increase on a follow-up controller is limited due to the ramp function of a required value branch, then the I-action of the master controller will be directionally blocked (anti-reset windup) until the cause of the limitation on the follow-up controller has been eliminated.

6.2.3 Three-component controller

The three-component controller is required for the realization of a total quantity control for composition controllers.

The total quantity PV is calculated by means of its inputs "actual value A, actual value B and actual value C".

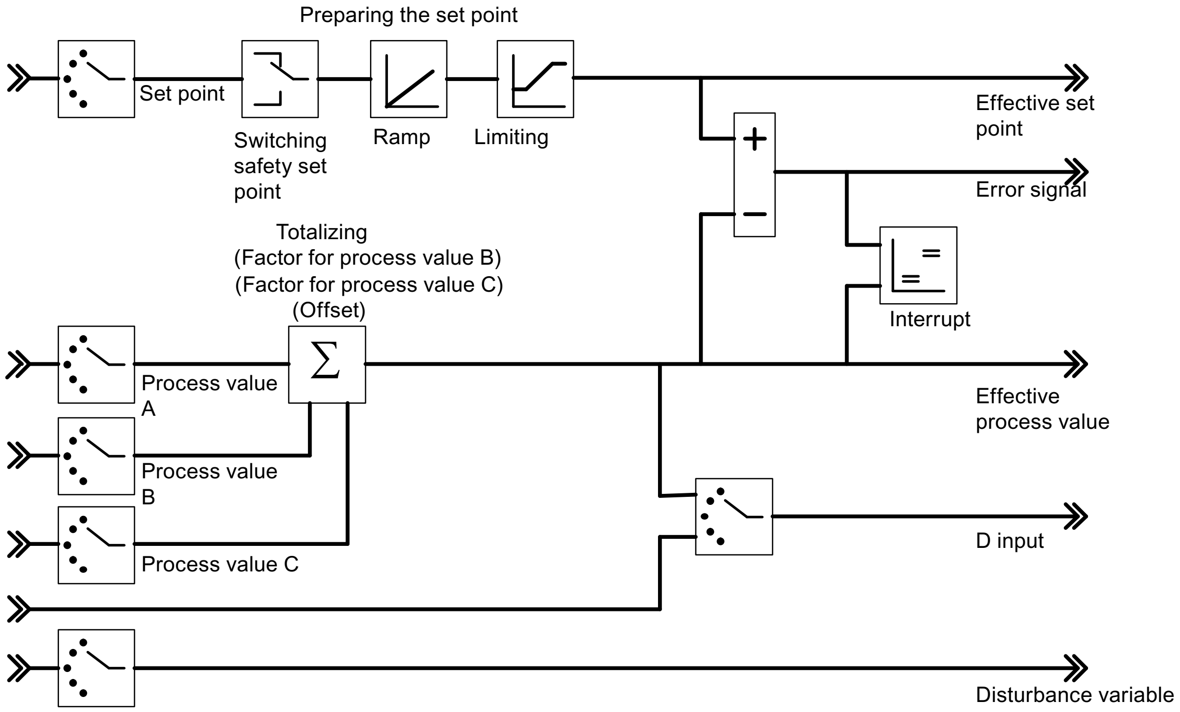


Figure 6-3 Control deviation determination for three-component controllers

See also

Example of a blending control circuit (Page 196)

6.2.4 Ratio controller or composition controller

Ratio or composition controllers are always follow-up controllers. The associated master controller to a ratio controller is a constant value controller.

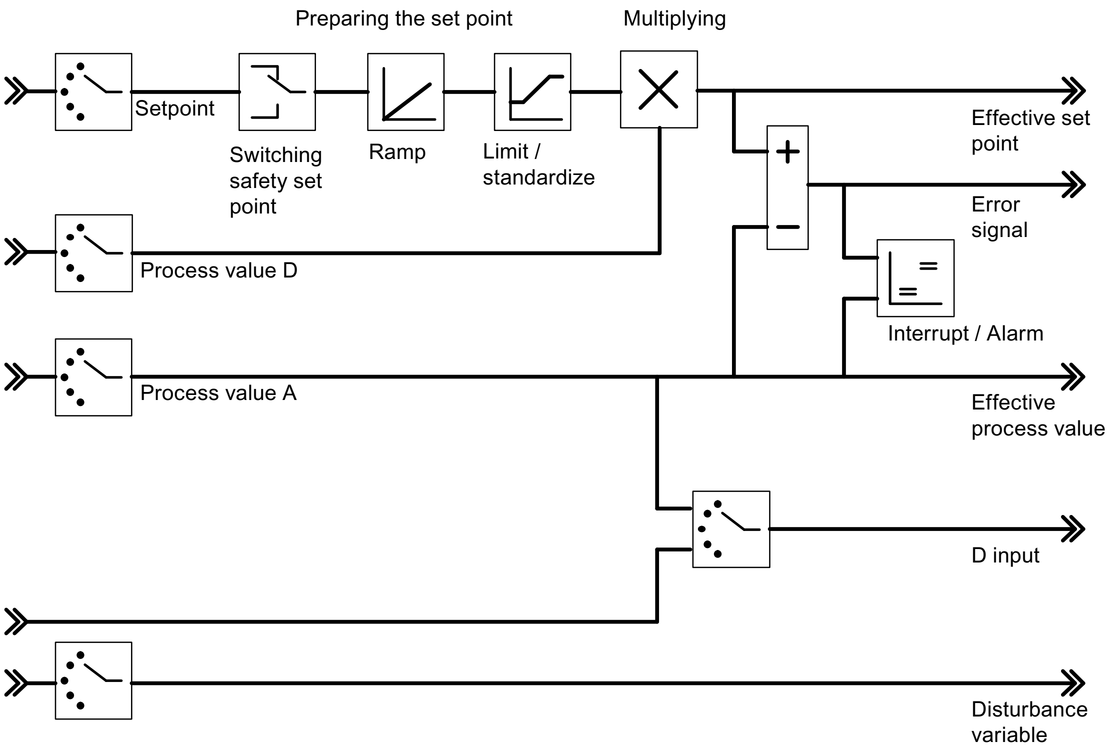


Figure 6-4 Control deviation determination for ratio or composition controllers

The actual value of the master controller is selected as actual value D. The ratio factor is given by means of the reference input. 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%" by means of the value range "lower barrier ... upper barrier".

The associated master controller to a composition controller is a three-component controller.

The regulated quantity of the master controller is switched via the input actual value D. The proportional factor is given via the controller's reference input.

The regulated quantity LMN of the total quantity control is given within the range of values 0% to 100%. From the follow-up controller, these quantities are converted at actual value input D into the actual value A (the value range of actual value A corresponds to the standardized values "upper" and "lower" of the selected analog input).

If the regulated quantity of a follow-up controller reaches its limit or if the setpoint increase on a follow-up controller is limited due to the ramp function of a required value branch, then the I-action of the master controller will be directionally blocked (anti-reset windup) until the cause of the limitation on the follow-up controller has been eliminated.

See also

Example of a ratio control (Page 195)

Example of a blending control circuit (Page 196)

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

You can select from various signal sources for the setpoint, the actual value, the value of the D input (differentiating input) and the disturbance variable of each controller channel. The following table offers an overview of the signal selection options.

Table 6- 1 Signal selection for setpoints, actual values, D input and disturbance variables.

Affected values	Selectable signal sources
Setpoint	• A given value from the user program via the function module • The processed analog value of an analog input • The setpoint (LMN, LMN_A or LMN_B) of another controller channel (when cascading controllers)
Actual values A, B and C	• Zero • The conditioned analog value of an analog input (the actual values B and C can be additionally evaluated by factors)
Actual value D	• Zero • The processed analog value of an analog input • Setpoint of another controller channel
Value for D input (only relevant for PD or PID controllers)	• The control deviation after the dead zone of the controller channel • The conditioned analog value of an analog input • The negated effective actual value of the controller channel
Disturbance variable	• Zero • The conditioned analog value of an analog input

6.2.6 Preparation setpoint

Parameterizing possibilities

The preparation of a setpoint to an effective actual value can be influenced by means of the following configuration options:

- Switch safety setpoint

  Here you can set:

  – a safety setpoint

  – the reaction of the FM 355-2 in the event of CPU failure

    The options for FM 355-2 reactions are:

    Setpoint = last valid setpoint

    Setpoint = safety setpoint

- Ramp

  You can limit the setpoint rate of change by means of the selection of a ramp up time from the physical start to the final value.

- Limiting / standardizing

  If the setpoint of a function block is given or a processed analog value of an analog input exists, the setpoint will be limited to a configurable upper and lower barrier.

  When a controller output has been selected as setpoint for a ratio controller, then this value acts as the factor for the multiplication of the actual value D. In this case the setpoint that is given as a percentage on the input can be adjusted with the help of the upper and lower barrier, via the Limit/Standardize button.

  When a fixed value or cascade controller is used as set value for the setpoint of another controller, then this can be standardized to a physical value with the help of a standardization constant of the called actual value channel.

- Multiplication

  For the ratio type of controller, the actual value A is used as the controlled variable and actual value D as the ration quantity. The setpoint input serves as ratio factor. It is processed to an effective setpoint by multiplication of the actual value D and the addition of a configurable offset. If actual value D is switched off, then the offset will just be added to the setpoint.

6.2.7 Preparation actual value

Effective actual value

The effective actual value is identical to actual value A for control structures on fixed value or cascade controllers and ratio controllers.

The effective actual value for the control structures on three-component controllers is formed by the sum of the 3 actual values A, B and C plus the configurable offset. The actual values B and C can be additionally evaluated by factors.

6.2.8 Interrupt

Limit value monitoring

A limit value monitoring system is realized in the FM 355-2. This enables,

- either the control deviation
- or the effective actual value

to be monitored within an upper and lower warning limit and within an upper and lower alarm limit. Additionally, a hysteresis can be created for these limits.

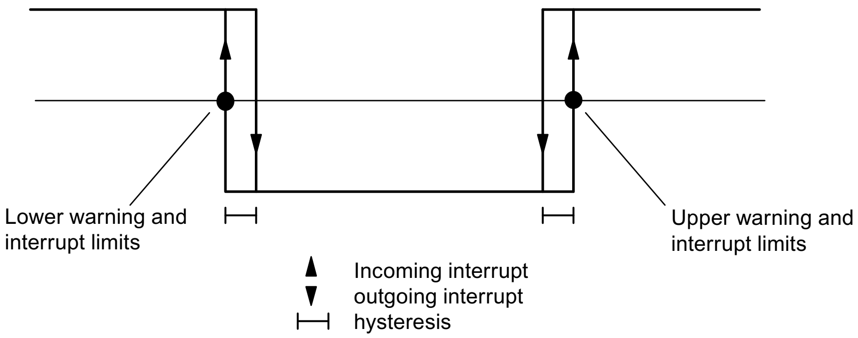


Figure 6-5 Hysteresis for warning and alarm limits

6.3 Controller algorithm

Components of the controller algorithm

Continuous-action controllers (FM 355-2 C) and pulse controllers (FM 355-2 S) have the same controller algorithm structure. The cooling and control zone buttons cannot be selected on the step controller (FM 355-2 S).

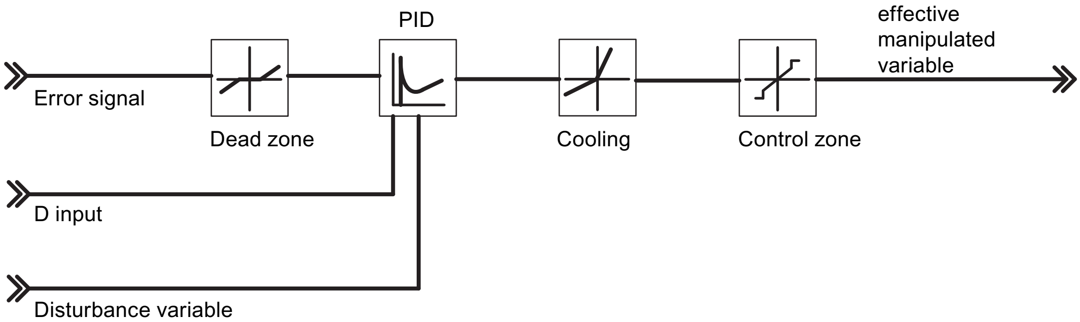


Figure 6-6 Control algorithm block diagram for continuous-action controllers and pulse controllers

6.4 Description of the control algorithm

6.4.1 Dead zone

Purpose of dead zones

A deadzone is interconnected upstream of the PID controller. The deadzone surprises the noise component in the control deviation signal, which can occur if a high-frequency disturbance signal interferes with the controller or reference input variable. This prevents undesirable oscillation in the controller output.

Dead band width

The deadzone range is configurable. If the control deviation lies within the configured deadzone range, the value 0 (control deviation = 0) will be given on the output. Only if the input variable moves outside of the sensitivity range, will the output value change by the same value as the input variable.

This results in a distortion of the transferred signal, also outside of the deadzone. This is however an acceptable trade-off in that it prevents jumps at the deadzone limits. The distortion corresponds to the value of the deadzone range and can therefore be easily controlled.

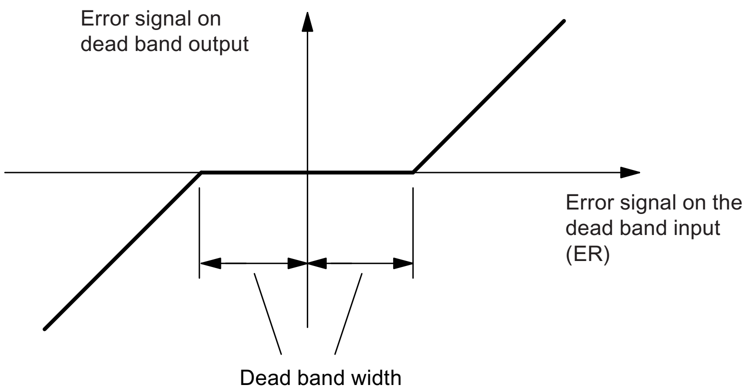


Figure 6-7 Dead zone

6.4.2 PID control algorithm

Control algorithm: PID in parallel structure

During the cycle of the configured sampling time the controller's manipulated value is calculated from the error signal of the PID position algorithm. The algorithm is designed as a purely parallel structure. The proportional, integral and derivative components can each be deactivated individually. For the integral and derivative components this is done by setting the respective parameter TI or TD to zero.

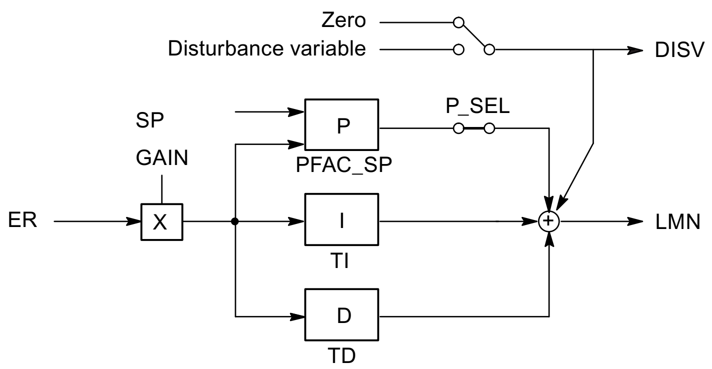


Figure 6-8 Control algorithm of the FM 355-2 (parallel structure)

Disturbance variable selection:

A disturbance variable DISV can be additionally applied to the controller's output signal.

Attenuation of the P component in event of setpoint changes

You can avoid actual value overshoot or an excessive amplitude of the manipulated value with attenuation of the P component via the parameter "Proportional factor at setpoint change" (PFAC_SP). Using PFAC_SP you can select continuously between 0.0 and 1.0 to decide the effect of the P component when the setpoint changes:

- PFAC_SP=1.0: P component has full effect if setpoint changes
- PFAC_SP=0.0: P component has no effect if setpoint changes

There are two possible ways to limit the speed of a setpoint change in the FM 355-2:

- Activate ramp (> 0.0 s)
- Factor for setpoint change < 1.0

Only use one of the two limits. If both limits are activated at the same time, a setpoint jump will cause a manipulated value change in the inverse direction to the setpoint change (step response).

Peculiarities of the step controller

A PFAC_SP value < 1.0 can reduce overshoot if the motor actuating time MTR_TM is small compared to the equivalent time constant TA and if the ratio is TU/TA < 0.2. Should MTR_TM reach 20 % of TA, only a slight improvement can be achieved.

Derivative component in feedback path

When the setpoint changes, you can avoid pulse-shaped peaks of the derivative component of the manipulated value by moving the derivative component into the feedback path.

In this structure only the negative setpoint (Factor = -1) is fed forward to the derivative component. In the D component, the changeover to the feedback is carried out in the "Error signal" window via the "D input controller" switch by selecting the negated effective actual value as the input signal. You can also select the input variable of the derivative component via parameter D_EL_SEL of function block FMT_PID (see Chapter "The function module FB 52 FMT_PID (Page 118)").

Note

If you move the derivative component to the feedback path, you should also reduce the value of PFAC_SP, otherwise you would increase overshoot of the actual value.

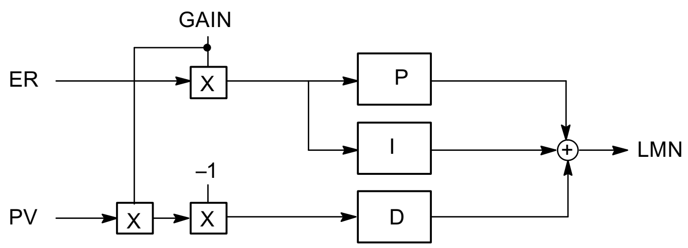


Figure 6-9 Control algorithm with derivative component in the feedback path

Inversion of the controller effect

You can enable controller inversion, that is, conversion from

- rising error signal = rising manipulated value

  to

- rising error signal = rising manipulated value

by setting a negative proportional action coefficient (GAIN). The sign in this parameter value defines the direction of control action of the controller.

P control

The I component and the D component are deactivated in the P controller. This means that the manipulated value also equals 0 when the error signal ER = 0. When an operating point ≠0 - in other words, a numeric value - is set for the manipulated value with an error signal of 0, the following is possible via the operating point:

- Automatic operating point: When you switch from manual to auto mode, the controller automatically sets the operating point to the value of the current (manual) manipulated value.
- Operating point not automatic: You can configure the operating point parameters.
- Example: Operating point OP = 5% results in a manipulated value of 5%, with error signal ER = 0.

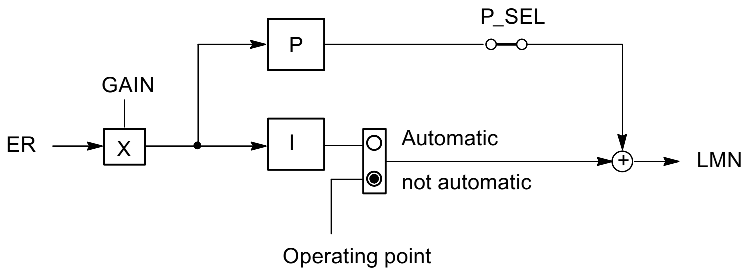


Figure 6-10 P controller with operating point setting via I-action element

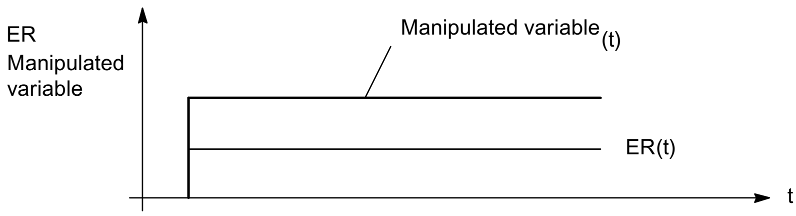


Figure 6-11 Step response of the P controller

PI control

The derivative component is disabled in a PI controller (TD=0.0). A PI controller adjusts the output variable via the I component until the error signal ER = 0. However, this only applies if the output variable does not exceed the limits of the correcting range. The integrator maintains the value it has at the point where the limits of the manipulated value are exceeded (Anti-Reset-Windup).

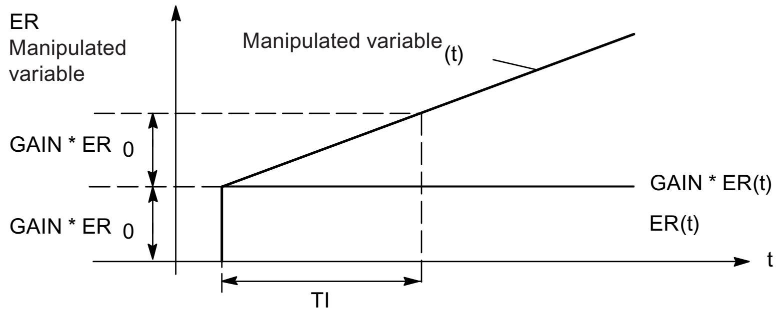


Figure 6-12 Step response of the PI controller

Smooth changeover between manual and automatic mode

If you have selected “Pulse-free manual/auto mode changeover” (not with step controller), the integrator is corrected manually so that the manipulated value does not perform a step across the proportional and derivative component as a result of this manual/auto mode changeover. An existing error signal is only corrected slowly via the I component. If smooth changeover from manual to automatic mode is not selected, the manipulated value will, during a changeover from manual to automatic mode, make a step change starting from the current manual value and corresponding to the current error signal. This way an error signal is quickly corrected.

Note

A step controller is always subject to pulse action at the changeover from manual to automatic mode. The existing error signal and GAIN leads to a jump in the internal manipulated value. The integral effect of the actuator, however, results in a ramp-shaped excitation of the process.

I control

You can switch off the proportional component of a PI action to obtain a purely integral control. This is also possible via the parameter P_SEL of function block FMT_PID.

PD control

The I component is disabled in a PD controller (TI=0.0). This means that the output signal also equals 0 when the error signal ER = 0. When an operating point ≠0 - in other words, a numeric value - is set for the manipulated value with an error signal of 0, the following is possible via the operating point:

- Automatic operating point: When you switch from manual to automatic mode, the controller automatically sets the operating point to the value of the current (manual) manipulated value.
- Operating point not automatic: You can configure the operating point parameters.

The PD controller generates a proportional component of the input variable ER(t) for the output signal and then adds the derivative component that is generated by differentiation of ER(t). The time response (strength of the derivative component or control area) is determined by the derivative action time TD (rate time).

For signal smoothing and interference suppression, the derivative component is realized with a delay circuit of the first order.

The higher the derivative factor D_F,

- the smaller is the effective time constant TD/D_F of the delay and
- the higher is the maximum initial manipulated value
- the better is the control action and
- the higher, however, is noise sensitivity.

D_F is limited to the value range 5.0 through 10.0.

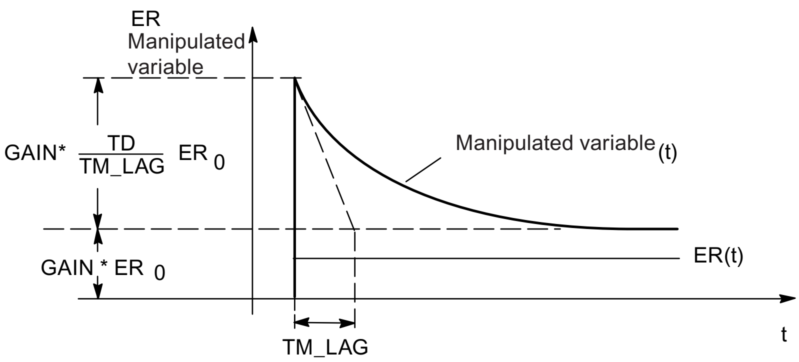


Figure 6-13 Step response of the PD controller

PID control

The P, I and D components are activated at the PID controller. A PID controller adjusts the output variable via the integral component until the error signal ER = 0. However, this only applies if the output variable does not exceed the limits of the correcting range. The integrator maintains the value it has at the point where the limits of the manipulated value are exceeded (Anti-Reset-Windup).

The PID controller generates a proportional component of the input variable ER(t) for the output signal and then adds the derivative action that is generated by differentiation and integration of ER(t). The time response is determined by the derivative action time TD (rate time) and the integration time TI (reset time).

For signal smoothing and interference suppression, the derivative component is realized with a delay circuit of the first order.

The higher the derivative factor D_F,

- the smaller is the effective time constant TD/D_F of the delay and
- the higher is the maximum initial manipulated value
- the better is the control action and
- the higher, however, is noise sensitivity.

D_F is limited to the value range 5.0 through 10.0.

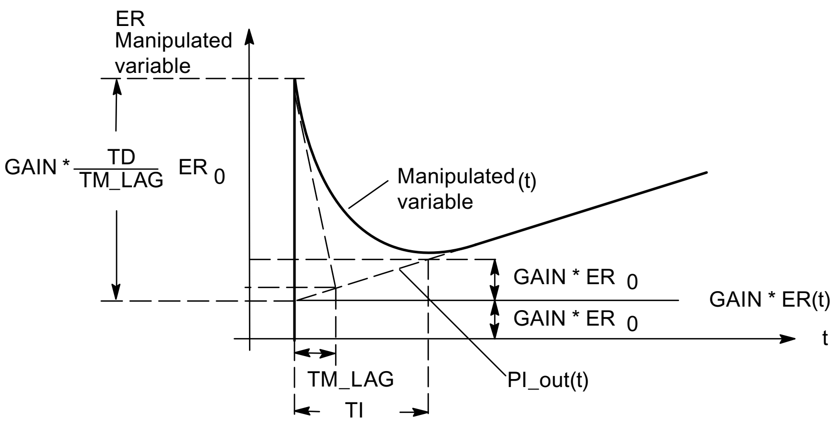


Figure 6-14 Step response of the PID controller

Implementation, configuration and optimization of the PID controller

A major practical problem is the configuration of the PI-/PID controller parameters, i.e. finding the "correct" setting values for the controller parameters. The quality of this parameter assignment is decisive for the intended use of a PID control and demands either substantial practical experience, special knowledge or a large amount of time.

The self-optimization functions of the module can be used to assign the controller parameters. You can start this self-optimization function in your parameter assignment application, at the OP or directly via FB FMT_PID. The process model is determined on the basis of process identification; the most favorable (optimal) setting values for the controller parameters are then calculated.

See also

Overview (Page 83)

6.4.3 Cooling

Controller gain in cooling mode

The different control loop gain of closed-loop controllers and pulse controllers is taken into account via the ratio factor RATIOFAC:

If RATIOFAC <> 0.0, a manipulated value < 0.0 is multiplied by RATIOFAC.

The effective controller gain in the cooling range is therefore RATIOFAC*GAIN.

Note

You require manipulated variable B when you switch on split-range mode for cooling/heating. Therefore, you have to configure the limit of the lower manipulated value LMN_LLM (e.g. -100.0 %) and the split-range function accordingly.

6.4.4 Control zone

Function

If CONZ_ON = TRUE, the closed-loop controller or pulse controller operates with a control zone. This means that the controller is operated according to the following algorithm:

- LMN_HLM is output (manual control) if the error signal is higher than the positive control zone CON_ZONE.
- The value LMN_LLM is output as manipulated variable (manual control) if the error signal is smaller than (-CON_ZONE) or (-CON_ZONE/RATIOFAC if RATIOFAC<>0.0) (negative control zone).
- If the error signal stays within the control zone, the value calculated by the PID algorithm is fed forward without changes (automatic control).
- A hysteresis of 20% of the control zone is maintained for the transition between manual and automatic control.

Note

Before you switch on the control zone manually, make sure the setting of the control zone band is not too small. If the control zone band is too small, oscillations will occur in the manipulated variable and actual value.

Should split-range mode for cooling/heating not be enabled, the ratio factor is to be RATIOFAC=0.0 A RATIOFAC unintentionally set to <> 0.0, may lead to the following problems:

- After tuning or with LOAD_PID, the calculated value of CON_ZONE is increased by 50%.
- The negative control zone (effective with negative step) is additionally divided by the value RATIOFAC.

Advantages of the control zone

When the actual value enters the control zone, the D action causes a very rapid reduction of the manipulated variable. This means that the control zone only makes sense if derivative action is enabled. Without a control zone, basically only the reducing P action would reduce the manipulated variable. The control zone leads to a faster settling time without overshoot and subsequent undershoot, if there is a great distance between the output minimum or maximum manipulated variable and the manipulated variable required for steady state of the new operating point.

6.5 Controller output

6.5.1 Controller output functions

Parameter Assignment

Table 6- 2 Controller output functions and possible configurations

Functions of the controller output	Adjustable parameters
Enabling an external manipulated value (manual mode)	Switching between the external and the effective manipulated value (automatic mode) from the controller can be done in one of the following ways: • via a function block • via logical OR link of a digital value from a function block and a digital input.
Correction input	The following alternative settings are available: • The value at the correction input = zero • The value at the correction input is the pre-processed analog value of an analog input
Switch correction	You can toggle between the manipulated value and the compensation input as follows: • via a function block • via logical OR link of a digital value from a function block and a digital input.
Position feedback input (step-action controllers only)	The following alternative settings are available: • The value at the position feedback input = 0 • The value at the position feedback input is the pre-processed analog value of an analog input

Functions of the controller output	Adjustable parameters
Switch safety setpoint value	• Determination of a safety setpoint value • Response of FM 355-2 during startup: – FM 355-2 goes into auto mode, – the safety setpoint value is output as setpoint value. • The changeover to safety setpoint value can be achieved by means of – a function block – via logical OR link of a digital value from a function block and a digital input. • Reaction in event of CPU failure: – With the setting "closed-loop control" the controller mode remains unchanged. – The setting "control output = safety setpoint value" will be switched over to safety setpoint value. • Reaction to measuring transducer fault of actual value A: – With the setting "closed-loop control" the controller mode remains unchanged. – With the setting "control output = safety setpoint value", the system switches over to the safety setpoint value. • Reaction to measuring transducer fault on an analog input: – With the setting "closed-loop control" the controller mode remains unchanged. – The setting "control output = safety setpoint value" will be switched over to safety setpoint value.
Manipulated value limiting	High and low limit
Generating split-range values	• On/off (continuous controllers only) • High and low limit of the input signal • High and low limit of the output signal
Pulse shaper (FM 355-2 S only)	• Motor actuating time (only step controller) • Minimum pulse time • Minimum break time

The structure of the controller output block of the control unit varies, depending on the type of controller (continuous controller, pulse controller, step controller with/without position feedback.

See also

Characteristics of the FM 355-2 (Page 31)

6.5.2 Controller output for continuous controller

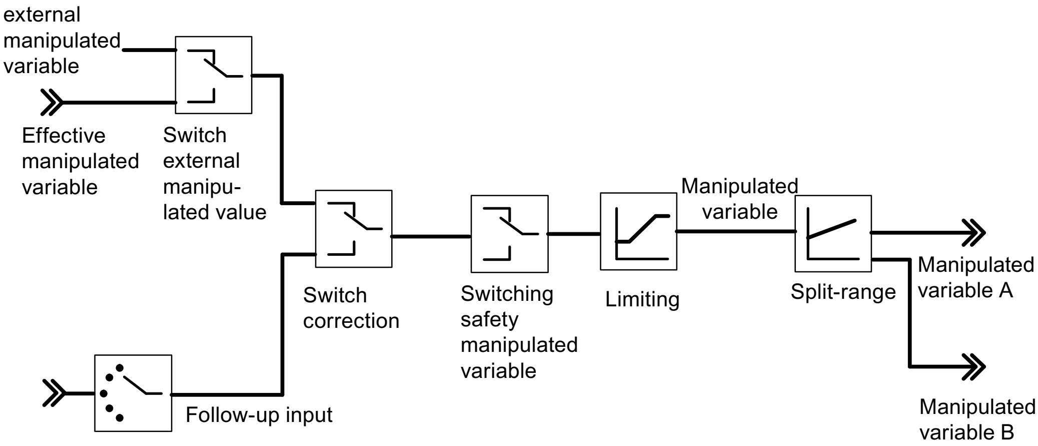


Figure 6-15 Controller output of the continuous controller (FM 355-2 C)

Split-range

With the help of the split-range function you can excite two control valves with only one manipulated variable. The split-range function uses the manipulated value LMN as input signal to generate the two output signals manipulated value A and manipulated value B.

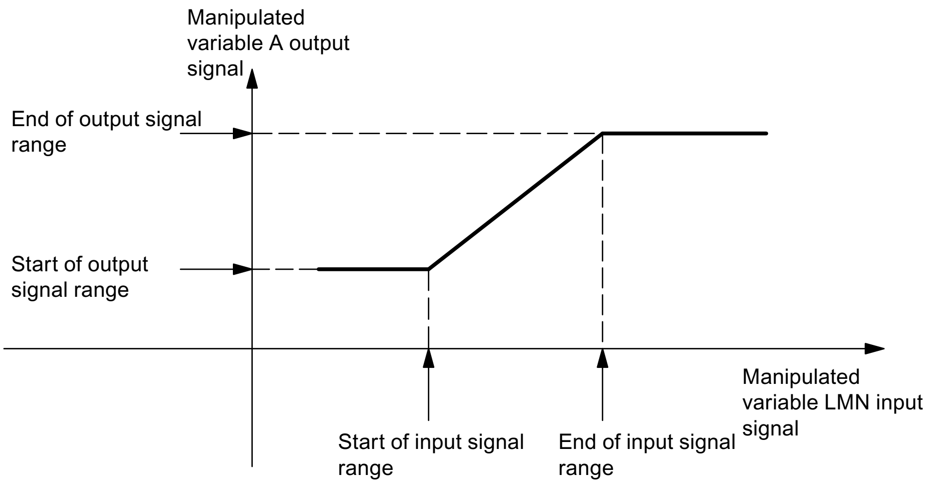


Figure 6-16 Manipulated value A of the split-range function

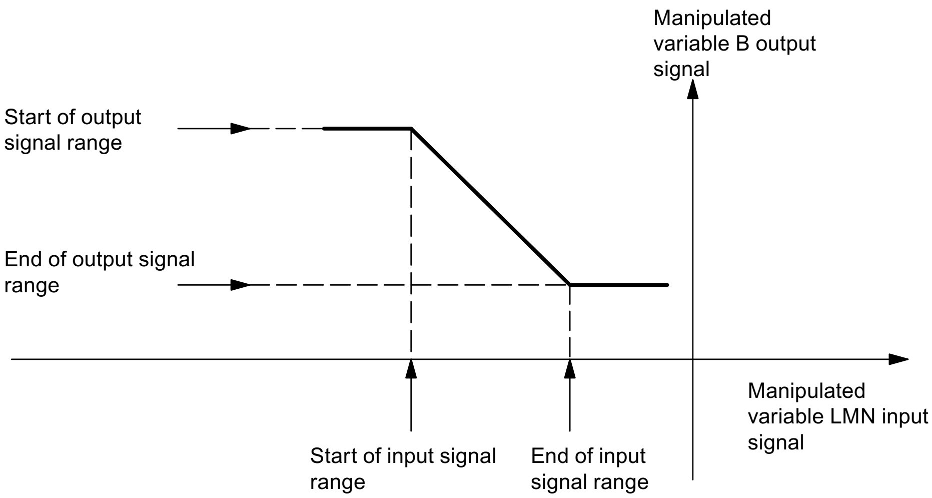


Figure 6-17 Manipulated value B of the split-range function

The start value of the input signal range must be lower than its end value.

Analog output

At the analog output you can select which signal to output for each channel. The latter can be used for the linearization of an output value.

- Output value A
- Output value B
- Analog output values

This can be used, for example, to linearize a thermocouple signal and convert it to a range of 0 to 10 V.

6.5.3 Controller output with pulse controller

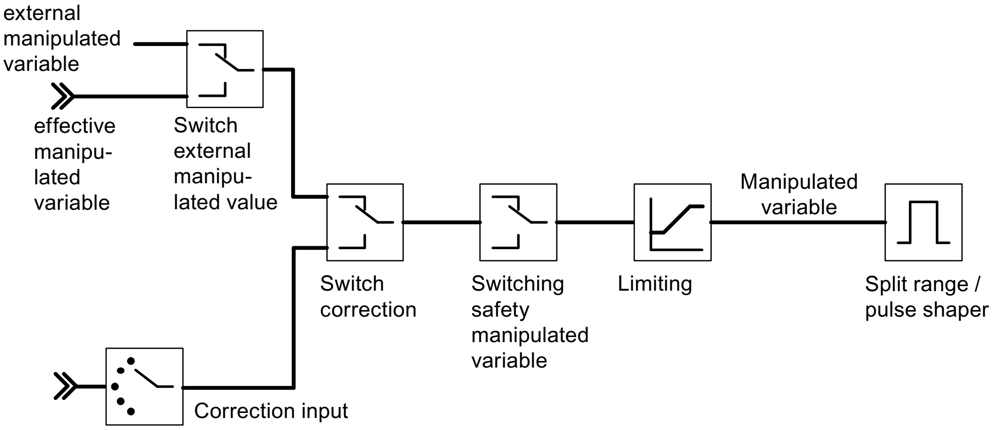


Figure 6-18 Pulse controller output (FM 355-2 S)

Split-range / pulse shaper

The split-range function pre-processes the analog signal for analog to digital conversion. The time period entered is rounded up to the cycle time. The cycle time is approximately 100 ms per active channel. Entering a time period of 600 ms when 4 channels are active would therefore result in an effective time period of 800 ms, for example.

Only manipulated value A is relevant to a two-component controller (e.g. a heating controller). The conversion of the manipulated value to manipulated value A is shown in the following illustration. The output signal is converted to a digital signal, whereby the pulse width / period ratio is proportional to manipulated value A at the assigned digital output.

For example, a manipulated value A of 40% at a 60-second period will result in a pulse width of 24 seconds and an interpulse width of 36 seconds.

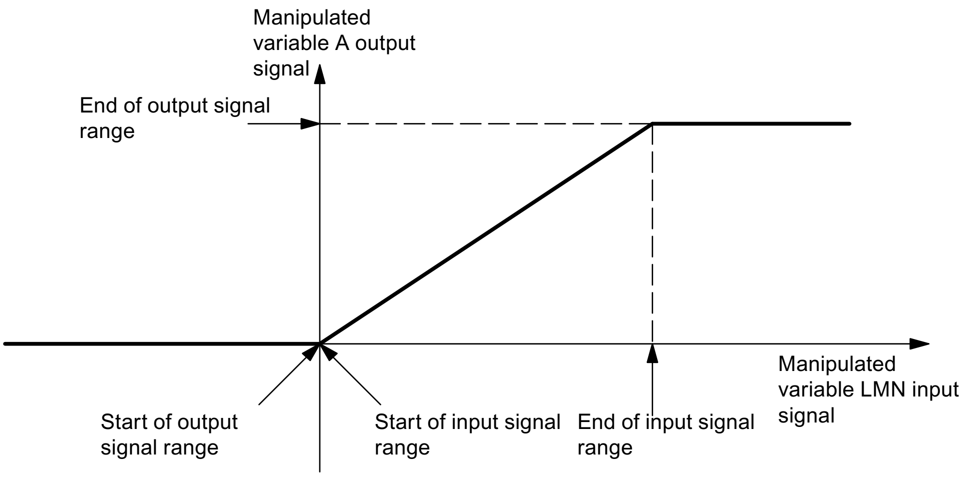


Figure 6-19 Split-range function for two-position controller

With a three-component controller (e.g. a cooling and heating controller) the above specifications apply to manipulated value A. The second signal for cooling control is generated with manipulated value B. The conversion of the manipulated value to manipulated value A and B is shown below. The output signal is converted to a digital signal, whereby the pulse width/period ratio is proportional to manipulated value A or B at the assigned digital outputs.

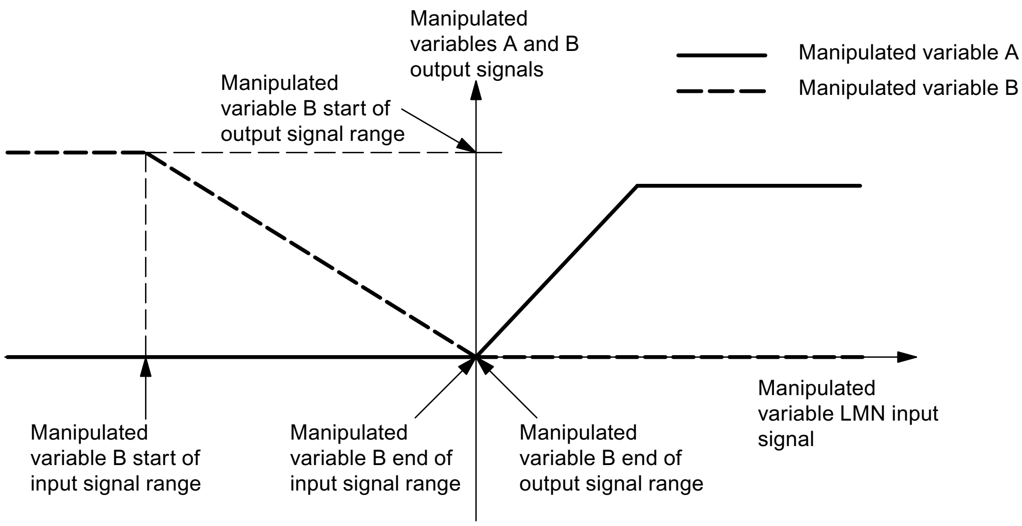


Figure 6-20 Split-range function for three-position controllers

The pulse shaper converts the analog manipulated value LMN_A or LMN_B by means of pulse width modulation to a pulse sequence with its own configurable period.

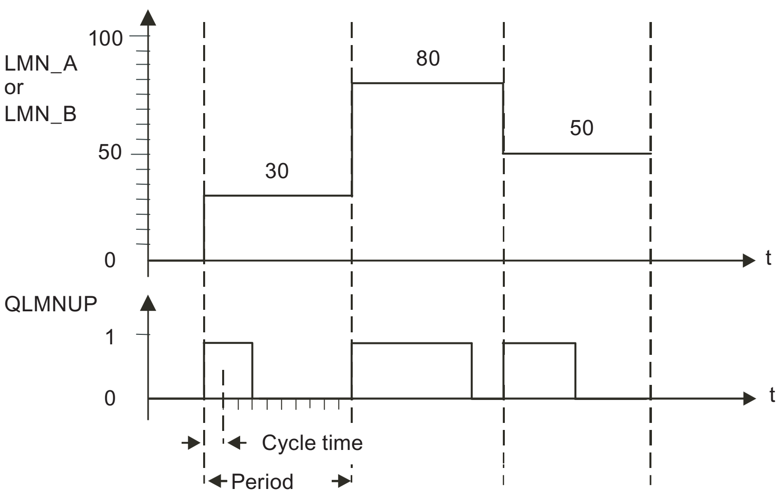


Figure 6-21 Pulse-width modulation

This means, a manipulated value = 30 % with a 60 s period sets:

- QLMNUP = TRUE for 18 seconds,
- QLMNUP = FALSE for the remaining 42 seconds.

The pulse width per period is proportional to the manipulated value and is given as:

Pulse width = Period * manipulated value/100

Due to the suppression of minimum pulse/interpulse width, the conversion curve contains break points in the start and end range.

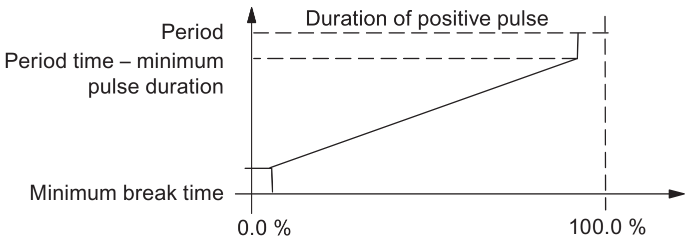


Figure 6-22 Two-step control with unipolar value range

Minimum pulse or minimum break time for pulse shaper

Spike action will reduce the useful life of switching elements and final controlling elements. This negative effect can be avoided by specifying a minimum pulse/break duration.

Small absolute values of the manipulated value which would generate a pulse break shorter than minimum are suppressed.

Higher manipulated values which would generate a pulse width longer than the period - minimum pulse duration, are set to 100%. This reduces pulse shaping dynamics.

We recommend setting the minimum pulse/break duration to minimum pulse/break duration ≤ 0.1 * period.

The break points in the characteristic curves in the figure above are caused by the minimum pulse duration and/or minimum break duration.

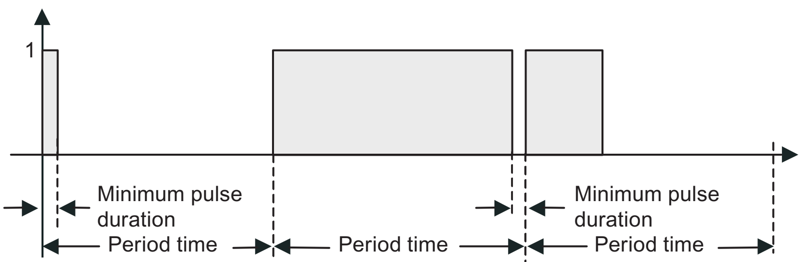


Figure 6-23 Switching behavior of the pulse output

6.5.4 Step controller output

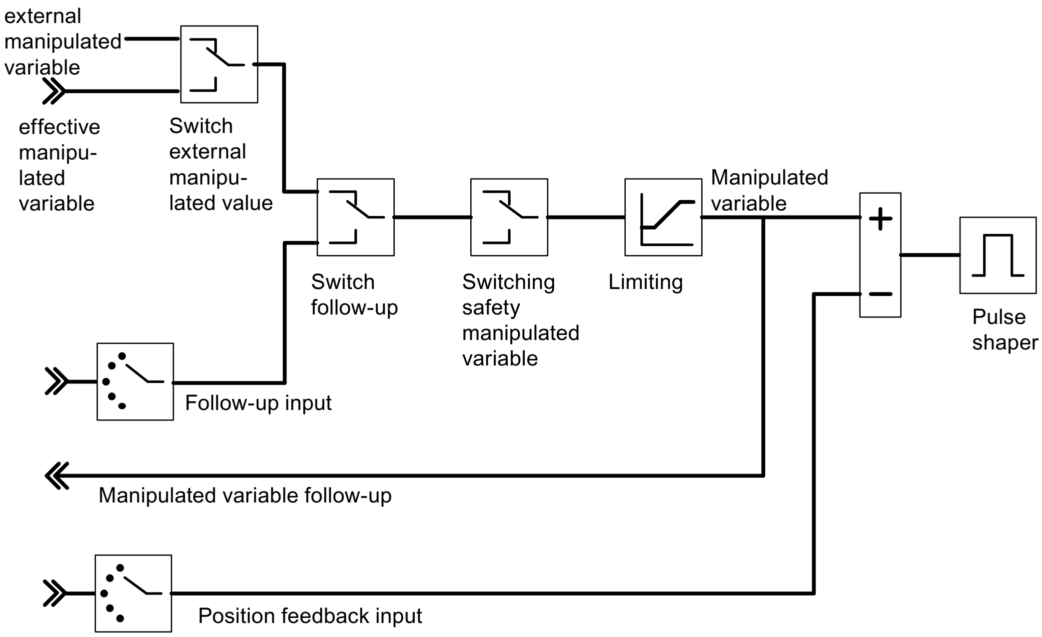


Figure 6-24 Controller output of the S controller (step controller mode with position feedback)

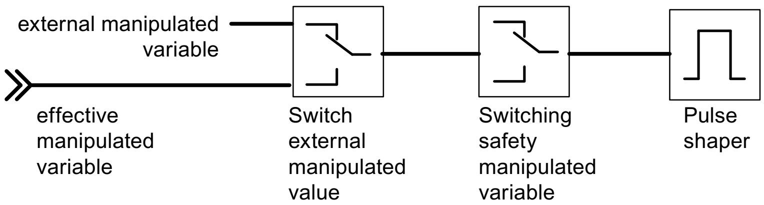


Figure 6-25 Controller output of the S controller (step controller mode without position feedback)

Step controller without position feedback

The external manipulated value and the safety manipulated value have the following effect on a step controller without analog position feedback:

When a value between 40.0% and 60.0% is given, no digital output will be set and the final controlling element remains unchanged.

If a value of > 60.0% is given, “Actuating signal is high” will be output until the feedback signal “Actuator has reached upper end stop” is triggered.

If a value of < 40.0% is given, "Actuating signal is low" will be output until the feedback signal "Actuator has reached upper end stop" is triggered.

Manual mode with step controller

You can toggle the controller to manual mode via the loop monitor. Alternatively, FB FMT_PID may be called. Do so by setting the operator control parameter LMNS_ON = TRUE and increase or reduce the manipulated value by means of LMN_UP or LMN_DN.

On a step controller with analog position feedback you can also enable manual mode via the operator control parameters LMN_REON and LMN_RE (external manipulated value) (as for a closed-loop controller and pulse controller).

Pulse shaper

The pulse shaper of the step controller converts the analog manipulated value to pulse signals. The operating frequency of the controller is reduced through adaptation of the response threshold of the three-step element. Ensure that the physical motor actuating time matches your parameter settings.

6.5.5 Manipulated value limits

Note

To ensure optimal compensation of the controller when it reaches the control limits and for quick release out of the limit range, the limits of the manipulated values LMN_HLM and LMN_LLM must match the limits which actually affect the process. For example, if control output B is not wired (or if the split-range function of a closed-loop controller is disabled), you should configure LMN_LLM according to the low limit of split-range function A. The normal setting is here 0.0%.

Online modification of manipulated value limits (closed-loop controller and pulse controller only)

When you reduce the range of the manipulated value, and if the new unlimited manipulated value is out of limits, the integral action and therefore the manipulated value is shifted (this description applies to the upper limit of the manipulated value):

The reduction of the manipulated value is proportional to the change in the manipulated value limit. If the manipulated value was unlimited before it was modified, it will be limited precisely to the new value.

7 Controller optimization

7.1 Overview

PI/PID controller parameters

The FM 355-2 auto-tuning feature automatically sets the PI/PID controller parameters. You can tune the heating and cooling processes as well as split-range processes with two counteracting final controlling elements (e.g. the final controlling elements for heating and cooling processes).

There are two tuning options:

- Tuning by operating point approach with a setpoint jump (e.g. when heating up the ambient temperature to the operating point)
- Tuning at the operating point by setting a start bit.

In both cases, the process is excited by a configurable setpoint jump. After a point of inflection is found, the PI/PID controller parameters are available, the controller switches to automatic mode and continues control with these parameters.

The controller can be tuned with the help of the wizard included in your parameter assignment application, or via FB FMT_PID and OP.

- Cooling tuning

  For controls operating with two counteracting final controlling elements (final controlling element for the heating and cooling process), FM 355-2 determines the process gain ratio (heating/cooling gain) after a manipulated value jump, using the cooling final controlling element.

- Tuning the response of the reference variable controller

  The controller is designed for optimum response to interference. The parameter values determined in this operation would cause an overshoot between 10% to 40% of the step amplitude as a response to setpoint jumps. In order to avoid this, the proportional action is attenuated by the PFAC_SP parameter when a setpoint jump occurs. As an additional measure, you can reduce overshoot in typical temperature processes caused by high setpoint jump amplitudes via temporary, controlled minimum or maximum manipulated value preset (control operation via the control zone).

- Saving controller parameters (SAVE_PAR or UNDO_PAR)

  Controller parameters are saved before tuning starts. After tuning, you can retrieve and enable the old parameter settings by means of UNDO_PAR.

7.2 Process types

Step response

Besides process gain GAIN_P, the parameters shown in the figure are characteristic for a process: Equivalent delay time TU and equivalent time constant TA.

The figure below shows the step response:

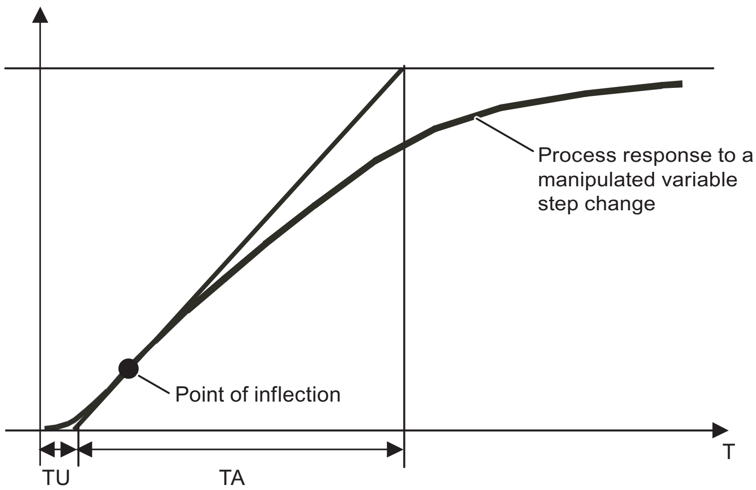


Figure 7-1 Step response

With a manipulated variable excitation of 0 to 100%, you can read the maximum actual value ramp response time per second at the inflection point: KIG = 100*GAIN_P / TA.

The table below shows the various processes you can use on the FM 355-2:

Table 7- 1 Process types

Process type I	Process type II	Process type III
Typical temperature process (ideal situation)	Intermediate range	Higher order temperature process (sluggish)
TU/TA < 0.1	TU/TA approx. 0.1	TU/TA > 0.1
One dominating time constant	Two approximately equivalent time constants	Multiple time constants

The FM 355-2 is conceived for use in typical temperature processes of process type I. However, it can also be used for higher order processes of type II or III.

Note

Controlled systems with TU/TA>0.3 are normally difficult to control.

Characteristics of important temperature control systems

Controlled variable (actual value) PV	Type of process	Delay time TU	Time constant TA	Ramp response time KIG
Tempe-rature	Small, electrically heated furnace	0.5 to 1 min	5 to 15 min	up to 1 KIG
	Large, electrically heated furnace	1 to 5 min	10 to 20 min	up to 0.3 KIG
	Large, gas-heated furnace	0.2 to 5 min	3 to 60 min	0.02 to 0.5 KIG
	Autoclaves	0.5 to 0.7 min	10 to 20 min	
	High-pressure autoclaves	12 to 15 min	200 to 300 min	
	Injection mould machines	0.5 to 3 min	3 to 30 min	0.1 to 0.3 KIG
	Extruders	1 to 6 min	5 to 60 min	
	Packaging machines	0.5 to 4 min	3 to 40 min	0.03 to 0.6 KIG
	Distilling column	1 to 7 min	40 to 60 min	0.1 to 0.5 KIG
	Steam superheater	0.5 to 2.5 min	1 to 4 min	0.03 KIG
	Room heating	1 to 5 min	10 to 60 min	0.02 KIG

7.3 Application area

Transient response

The process must have a stable, asymptotic transient response with time lag.

The actual value must settle to steady state after a jump of the manipulated variable. This therefore excludes processes that already show an oscillating response without control, as well as processes with no compensation (integrator in the control system).

Linearity and operating range

The process response must be linear across the operating range. Non-linear response occurs, for example, when a state of aggregation changes. Optimization must take place in a linear part of the operating range.

This means, during optimization and normal control operation non-linear effects within the operating range must be insignificant. It is, however possible to retune the process when the operating point changes, providing optimization is repeated in the close vicinity of the new working point and non-linearity does not occur during the optimization.

If a specific static non-linearity (e.g. valve characteristics) is known, it is always advisable to compensate this with a polyline to linearize the process response.

Disturbance in temperature processes

Disturbances such as the transfer of heat to neighboring zones must not affect the overall temperature process too much. For example, when optimizing the zones of an extruder, all zones must be heated simultaneously.

For information on measurement noise and low-frequency interference refer to Chapter "Error images and remedies (Page 107)".

7.4 Overall controller tuning process

We shall first describe tuning of a heating process only.

The tuning process runs through several phases. At the PHASE parameter you can view the current phase of the FM 355-2 block.

Prepare for tuning as follows:

- Set TUN_ON = TRUE to set the controller ready for tuning. Tuning changes from phase 0 to phase 1.
- After a waiting time in phase 1, specify a setpoint jump at parameter SP_RE or set TUN_ST = TRUE. The controller is then going to output a manipulated value jump at TUN_DLMN and then starts to track an inflection point.

Table 7- 2 Tuning phases

Phase	Description
0	No tuning mode; automatic or manual mode
1	Ready to start tuning; check parameters, wait for excitation, measure the sampling times
2	Actual tuning: Tracking of the inflection point, with constant manipulated value
3 (1 cycle)	Calculation of the process parameters. Saving currently valid controller parameters prior to tuning
4 (1 cycle)	Controller design
5 (1 cycle)	Correcting the controller to the new manipulated variable
6 (1 cycle)	Correcting the controller to the new manipulated variable
7	Check of process type, if process type II or III was determined (heating tuning only).

The following illustration shows the phases for tuning the ratio between the ambient temperature and the operating point, initiated by a setpoint jump:

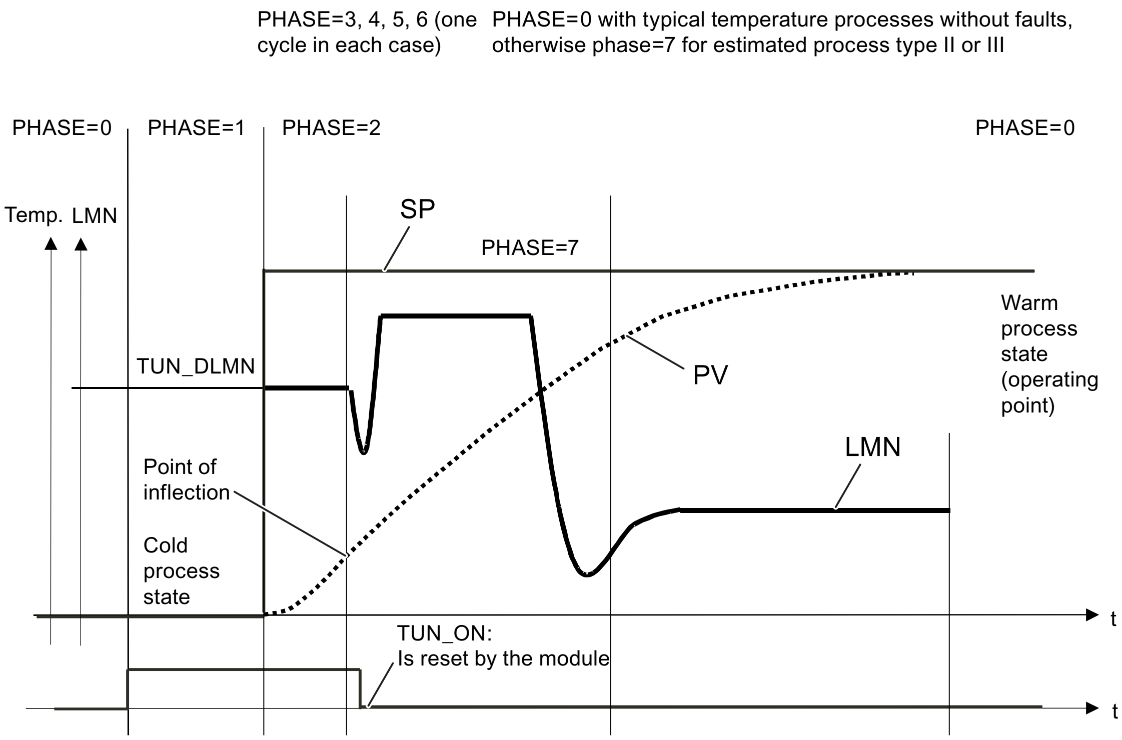


Figure 7-2 Tuning phases

The following illustration shows the phases of tuning at the operating point, initiated by TUN_ST = TRUE:

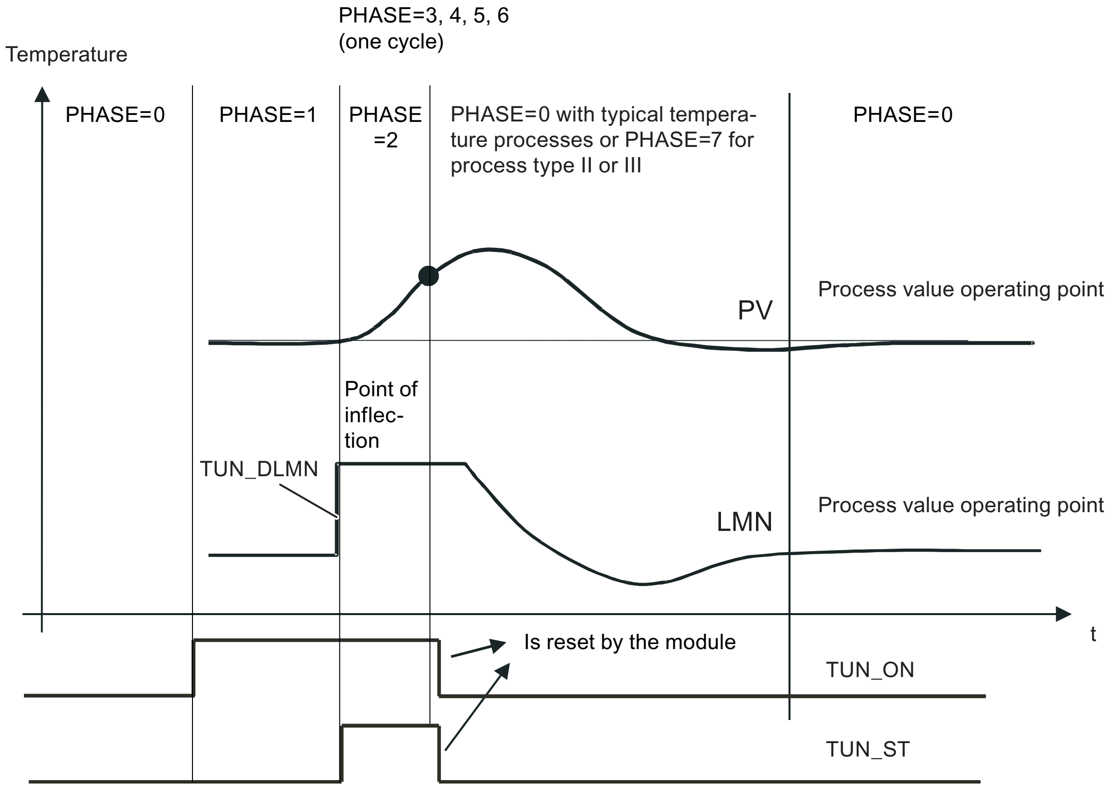


Figure 7-3 Phases of tuning at the operating point

At the end of tuning and when the block returns to phase 0 and sets TUN_ON=FALSE, you can verify error-free tuning at parameter STATUS_H/C.

Operator controlled setpoint preset (not with cooling tuning)

The setpoint signal selection must have been set to “Preset by function block FMT_PID”.

The setpoint value is specified at parameter SP_RE and must not be interfered with by any circuits during the tuning.

Note

During phase 1 a tuning process can also be triggered by minor setpoint changes (e.g. measurement noise at an analog input). In this case, tuning is terminated very quickly (wrong controller parameters; risk of instability).

See also

Cooling tuning (Page 99)

Starting tuning (Phase 1 → 2) (Page 93)

7.5 Preparations

SIMATIC and the controller

Tuning is started via the parameters TUN_ON, TUN_ST or SP_RE. You can configure these parameters in the following ways:

- with the configuring software
- with an operator control and monitoring device
- in your user program

Write access the parameters for one cycle only.

You require FB 52 FMT_PID to perform a controller tuning. The FB 56 FMT_TUN returns additional details.

No tuning in safety mode

You can not initiate tuning in safety mode ! If you do so, FM 355-2 resets TUN_ON. A current tuning process is aborted (STATUS_H/C=3009) when safety mode is switched on (SAFE_ON=TRUE).

WARNING
Death, serious injury or substantial damage to assets may occur. The LMN_REON parameter is disabled during tuning. Also, compensation circuits derived of interrupt limits have no effect. This can cause unwanted - even extreme - changes of manipulated values or actual values. The manipulated value is determined in the tuning process. To abort tuning, you must set TUN_ON = FALSE. This re-enables LMN_REON.

Ensuring a quasi-static initial state (Phase 0)

When low-frequency oscillation of the controlled variable occurs, e.g. because of wrong controller parameters, you must tune the controller manually before you start auto-tuning and wait until the oscillation has decayed.

You can also choose to switch to a PI controller that has a low controller gain and high integration time.

You must now wait until steady state is reached, that is, until both the actual value and the manipulated value have settled. An asymptotic transition or a slow drift of the actual value is also permissible (quasi-static state, see illustration below). The manipulated variable must be constant or fluctuate close to a constant mean value.

Note

Do not modify the manipulated variable shortly before you start tuning. A change of the manipulated variable may also be caused unintentionally by an attempt to establish test conditions (e.g. closing a furnace door)! If this has happened nonetheless, you must wait at least for the actual value to settle to steady state after an asymptotic transition. You will, however, improve controller parameters by waiting until the transients have decayed completely.

Preparing for tuning (phase 0 → 1)

Set the parameter TUN-ON = TRUE. This switches the FM 355-2 ready for tuning (Phase 1). The TUN_ON bit must only be set in steady state or during periodic transition to steady state.

If the quasi-static state changes after the TUN_ON bit was set, you must reset this bit and report the new quasi-static state to FM 355-2 by setting the TUN_ON bit again.

The figure below shows the transition to steady state:

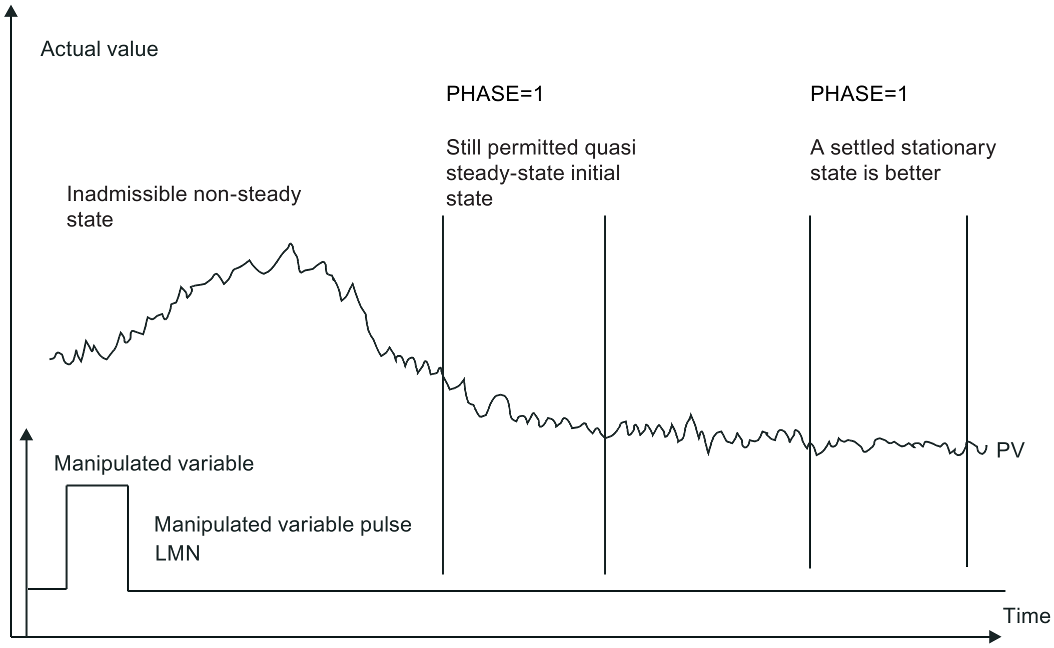


Figure 7-4 Settling to steady state range

In Phase 1, the time prior to process excitation is used by FM 355-2 to calculate the actual value noise NOISE_PV, the initial rise PVDT0 and the mean value of the manipulated variable (initial value of the manipulated variable LMN0).

Note

In Phase 1 you should only delay process excitation until the module was able to determine the mean value of the manipulated variable and the initial rise of the actual value (typically: 1 Minute).

7.6 Starting tuning (Phase 1 → 2)

Requirements

You can start tuning in manual/compensation mode or in automatic mode. In split-range heating/cooling mode you can start tuning of the heating process (manipulated variable > 0%) as well as of the cooling process (manipulated variable < 0%).

Prerequisite for the start of heating tuning during the cooling process is that the heating and cooling signals can simultaneously affect the process.

In this case the manipulated variable LMN0 determined in phase 1 is held constant and TUN_DLMN is directly applied in the split-range function, thus adjusting only the heating power (Example: LMN0=-20%, TUN_DLMN=50% -> LMN_B remains at 20%, LMN_A is switched from 0% to 50%).

If you	the controls operate after tuning
have set PID_ON = TRUE,	with PID parameters.
have set PID_ON = FALSE,	with PI parameters.

Tuning by approaching the operating point with setpoint jump

The tuning manipulated variable (LMN0 + TUN_DLMN) is activated by a setpoint jump (transition phase 1 → 2). The setpoint, however, will not be effective until the inflection point has been reached (automatic mode is not enabled until this point is reached).

The user is responsible for deciding on the excitation (TUN_DLMN) according to the permitted actual value change. The sign of TUN_DLMN must be set depending on the intended actual value change (take into account the direction in which the control is operating).

The setpoint jump and TUN_DLMN must be suitably matched. When the value of TUN_DLMN is too high, you run the risk that the point of inflection is not found before 75% of the setpoint jump is reached.

Note

If excitation is too sharp compared to the setpoint jump, the actual value can overshoot heavily (up to factor 3).

TUN_DLMN must nonetheless be high enough to ensure that the actual value reaches at least 22% of the setpoint jump. Otherwise, the process would remain in tuning mode (Phase 2).

Remedy: Reduce the setpoint value during inflection point tracking.

Extremely sluggish processes

If processes are extremely sluggish, it is advisable during tuning to specify a target setpoint that is somewhat lower than the desired operating point and to monitor the status bits and PV (risk of overshooting).

Tuning only in the linear range

The signals of certain processes (e.g. zinc or magnesium smelters) will pass a non-linear area at the approach of the operating range (change of the state of aggregation).

By selecting a suitable setpoint jump, tuning can be limited to the linear range. When the actual value has passed 75% of the setpoint jump (SP_INT-PV0), tuning is terminated.

At the same time, TUN_DLMN should be reduced so that the point of inflection is guaranteed to be found before reaching 75% of the setpoint jump.

Tuning at the operating point without setpoint jump

The tuning manipulated variable (LMN0 + TUN_DLMN) is activated by setting the start bit TUN_ST (transition Phase 1 → 2). When you subsequently modify the setpoint value, the new value will not take effect until the point of inflection has been reached (automatic mode will not be enabled until this point has been reached)

The user is responsible for deciding on the excitation (TUN_DLMN) according to the permitted actual value change. The sign of TUN_DLMN must be set depending on the intended actual value change (take into account the direction in which the control is operating).

CAUTION

When you start tuning by setting TUN_ST/TUN_CST as well as a setpoint jump, the following priority applies: set TUN_ST before TUN_CST, before the setpoint jump.

Safety off at 75% is not available when you excite the process via TUN_ST. Tuning is terminated after the point of inflection is reached. However, in noisy processes the point of inflection may be significantly exceeded.

Compensating operator control errors

Tuning is aborted when one of the errors listed in this table occurs.

Table 7- 3 Possible operator control errors and counter measures

Fault	STATUS and measures	Comment
TUN_ON and TUN_ST or TUN_CST are set simultaneously	STATUS_H/C = 30001 • Transition in Phase 0 • TUN_ON = FALSE	Can not occur in the wizard, as the status of TUN_ST and TUN_CST is set to FALSE in the first screen form.
The sign of the setpoint jump does not match the actual value change.	Tuning termination at the point of inflection Safety off at 75% disabled	
|TUN_DLMN| or |Effective TUN_DLMN| < 5 % (End of phase 1) Special case STATUS_H=30004: Effective manipulated value difference is limited by split-range limits, rather than by manipulated value limits	STATUS_H/C = 30002/30004 • Transition in phase 99 (Phase 0 in a parallel tuning process) • Output LMN = LMN0	Either your configured value for TUN_DLMN is too low, or the manipulated variable was near a control limit prior to tuning. If STATUS_H=30004: Please note, for example, that heating tuning is not possible with negative TUN_DLMN if LMN_A < 5% (Reason: cooling power must not be adjusted). In this case, you must prevent the controller from settling to the new setpoint value and from leaving the stationary operating point without having any reason to do so (not possible in a parallel tuning process). You should now proceed as follows: • Reduce the setpoint value • TUN_ON = FALSE • Correct TUN_DLMN • Restart tuning
For step controllers without analog position feedback: |Effective TUN_DLMN| < 5 % (Start of phase 2)	STATUS_H = 30002 • Transition in Phase 0 • TUN_ON = FALSE	Although |TUN_DLMN| >= 5 %, the error occurs when the value of the manipulated variable was close to a control limit prior to the start of tuning.
If TUN_CST: |TUN_CLMN| or |Effective TUN_CLMN| < 5 % (End of phase 1) Special case STATUS_H=30004: Effective manipulated value difference is limited by split-range limits, rather than by manipulated value limits	STATUS_C = 30002/30004 • Transition in Phase 0 • TUN_ON = FALSE	Either your configured value for TUN_CLMN is too low, or the manipulated variable was near a control limit prior to tuning.

Fault	STATUS and measures	Comment
If TUN_CST: Special case of "|Effective TUN_CLMN| < 5 % (End of phase 1)": TUN_CLMN <= -5%, but LMN_LLM > -5%.	STATUS_C = 30003 • Transition in Phase 0 • TUN_ON = FALSE	The low limit value LMN_LLM is too high (e.g. 0%) and therefore prevents output of cooling power.
TUN_CST, but without previous heating tuning	STATUS_C = 30008 • Transition in Phase 0 • TUN_ON = FALSE	
Safety mode	STATUS_C = 30009 • Transition in Phase 0 • TUN_ON = FALSE	If in PHASE > 2 the FM 355-2 goes to safety mode, this will be displayed by STATUS_C=30009.

See also

Error views and corrective actions (Page 107)

7.7 Identifying the point of inflection (Phase 2) and calculating control parameters (Phase 3, 4, 5)

Traversing

The point of inflection is identified in phase 2, with constant manipulated value. The process forms an average of the actual value to prevent premature recognition of the point of inflection due to noise on the PV signal:

This mean value is not active initially, that is, the average is always calculated across one cycle only. As long as the noise exceeds a certain level, the number of cycles is doubled.

The noise period and amplitude will also be determined. The search for the point of inflection is canceled and Phase 2 is exited only when the gradient is always smaller than the maximum rise during the estimated period. TU and T_P_INF are, however, calculated at the actual point of inflection.

Tuning is only terminated if both of the following conditions also apply:

1. The actual value is more than 2*NOISE_PV away from the point of inflection.
2. The actual value has exceeded the point of inflection by 20% of P_INF.

Note

When the process is excited by a setpoint jump, tuning is terminated when the actual value exceeds 75% of the setpoint jump (SP-PV0) (see below).

Phase 3, 4, 5 and 6 are then executed once. Tuning mode is then terminated and tuning is returned to phase 0. The controller now always starts in automatic mode, with LMN = LMN0 + 0.75*TUN_DLMN (this applies, too, if you have operated with manual control prior to the start of tuning).

Now check the controller function.

See also

The FB 56 FMT_TUN function block (Page 134)

7.8 Checking the process type (phase 7)

Traversing

In typical temperature processes (process type I), there is a danger that the point of inflection will be found too early due to noise. As a result of the shorter time at which the point of inflection was found T_P_INF, it is possible that a process type II or III will be determined.

Phase 7 therefore checks whether or not the process type is correct. This check is performed in automatic mode, using the recently calculated new controller parameters. It ends at least 6*TA (equivalent time constant) after the point of inflection. If process type I is detected, the controller parameters are recalculated (STATUS_D = 122). Otherwise, the controller parameters remain unchanged.

The checking of the process type is canceled during tuning at the operating point when the actual value reaches the actual value PV0 which was valid at the start of tuning.

If Phase 7 is aborted by TUN_ON=FALSE, the controller parameters that have already been determined are retained!

Note

It is possible to start heating tuning during the cooling process. However, the order will not be checked in phase 7.

The reverse case (to start cooling optimization during the heating process) is not critical, as phase 7 is never executed in the cooling tuning process!

7.9 Cooling tuning

Principle of operation

After a step of the manipulated value, FM 355-2 uses the final cooling controlling element to determine the process gain ratio RATIOFAC (heating/cooling gain) for controls operating with two counteracting final controlling elements (final controlling element for the heating and cooling process). The width of the control zone CON_ZONE is also recalculated. The other controller parameters remain unchanged.

Requirements

You can only tune cooling following a successful heating tuning process. You must repeat heating tuning if the voltage supply to the FM 355-2 fails.

- Manipulated variable A must be used for heating, manipulated variable B for cooling.
- RATIOFAC is effective when LMN<0.0. Thus, the split-range function must be defined accordingly: A for LMN>=0 .0 and B for LMN<0.0.
- The user is responsible for deciding on the excitation (TUN_CLMN) according to the permitted actual value change. The sign of TUN_CLMN must be set depending on the intended actual value change (take into account the direction in which the control is operating). Please note that a negative TUN_CLMN increases cooling power. You can, however, also activate a manipulated value step with TUN_CLMN > 0.0 by reducing cooling power.
- You can start cooling tuning during the heating process (steady state LMN > 0%) as well as during the cooling process (steady state LMN < 0%): Prerequisite for the start of heating tuning during the cooling process is that the heating and cooling signals can simultaneously affect the process.

Thermally coupled temperature zones

In a plant operated with multiple thermally coupled temperature zones (e.g. plastic processing machines), you should always start cooling tuning after all (!) zones have completed heating tuning and are settled at the operating point. Otherwise, tuning results can be corrupted.

Start

- After the actual value has settled at the operating point, set tuning mode on the FM 355-2 with TUN_ON=TRUE. Tuning changes from phase 0 to phase 1.
- After a waiting time in phase 1, start cooling tuning with TUN_CST = TRUE.

Identifying the point of inflection

The FM 355-2 changes to PHASE 2, TUN_CST is then instantaneously reset. LMN0+TUN_CLMN is output as tuning manipulated variable. The previously determined manipulated variable LMN0 is held constant and TUN_CLMN is applied directly to the split-range function.

If you modify the setpoint value during phase 2, the new value is not activated until the point of inflection has been reached (automatic mode will not be enabled until this point is reached).

End of cooling tuning

Safety off at 75% is not available when you excite the process via TUN_CST. Tuning is terminated after the point of inflection is reached. However, in noisy processes the point of inflection may be significantly exceeded.

FM 355-2 returns to control mode (PHASE 0) when a point of inflection has been found in the range of the process variable. FM 355-2 calculates a ratio factor RATIOFAC (heating/cooling gain) that is taken into account when the manipulated variable for the cooling range is determined in control mode.

Contrary to heating tuning, the old controller parameters will not be saved (the old RATIOFAC has already been saved during heating tuning) and phase 4 is not executed.

That is, STATUS_D remains unchanged (still refers to heating tuning). The PI and PID data records of the last heating tuning process are retained so that you can also load these after cooling tuning via LOAD_PID.

Split-range function

During tuning, the gradient of the split-range function is added to the process. If you want to modify the gradient of the split-range function after tuning, you must accordingly adapt the controller's GAIN or RATIOFAC parameter.

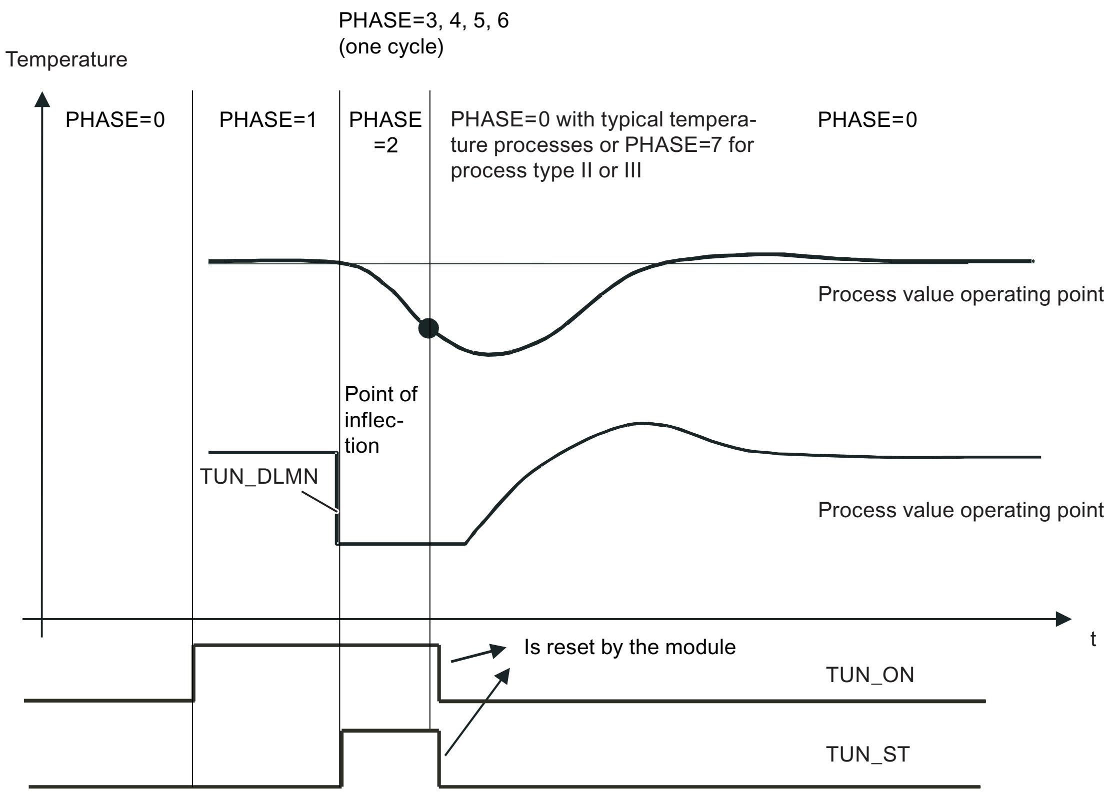


Figure 7-5 Phases of cooling tuning

7.10 Tuning with step controller

Introduction

The general information on controller optimization applies.

Peculiarities of step controllers

- Step controllers on the FM 355-2 operate without control zone.
- Phase 7 is not executed.
- No cooling optimization.

Note

The motor actuating time is not determined in the optimization process. Rather, it must be measured or determined prior to the start of optimization using the “Test > Determine motor actuating time” function of your parameter assignment application.

Controller design

The motor actuating time MTR_TM should be as small as possible compared to the inflection point time T_P_INF and the equivalent dead time TU.

Controllers with a softer action are automatically generated for longer motor actuating times.

The higher the process excitation TUN_DLMN, the higher is the influence of the motor actuating time on the controller design.

PI or PID parameters

PI parameters are attenuated by 25% compared to a controller designed for closed-loop controllers and pulse controllers. PID parameters are also determined (but without the 25% safety margin). The PID parameters should only be used if the motor actuating time is not too high compared to the process parameters and when the load on the final controlling element stays within the hysteresis due to the derivative component.

Step controller without position feedback

The output of Open/Close instructions is stopped right at the start of phase 1 (quasi manual mode).

The mean value of the manipulated variable in phase 1 (LMN0) will not be calculated.

At the start of phase 2 and during the time MTR_TM * TUN_DLMN / 100, an Open instruction (or with negative TUN_DLMN, a close instruction) is output.

When an end stop signal is triggered during the pulse action in phase 2, the effective TUN_DLMN is calculated as: 100 * time / MTR_TM.

When the value of the effective TUN_DLMN < 5%, the error message STATUS_H=30002 is output and optimization is canceled. This error can only occur if the final controlling element is unexpectedly close to a limit.

End or cancellation of optimization

The controller starts with LMN = LMN0 + TUN_DLMN.

See also

The FB 56 FMT_TUN function block (Page 134)

7.11 Tuning result

Optimization result

The left numeral of STATUS_H/C indicates the optimization status (for details refer to the appendix "Assignment of DBs (Page 211)"):

Table 7- 4 Optimization result

STATUS_H/C	Result
0	Default or new controller parameters have not yet been found.
10000	Suitable controller parameters were found
2xxxx	Control parameters have been found via estimated values; check the control response or check the STATUS_H/C diagnostic message and repeat controller optimization.
3xxxx	An operator input error has occurred; check the STATUS_H/C diagnostic message and repeat controller optimization.

After the recognition of the inflection point in phase 6, the following controller parameters are updated on the FM 355-2 and at the online instance DB of FB FMT_PID:

- Factor for the attenuation of the proportional component PFAC_SP = 0.8
- Controller GAIN
- Integration time TI (limited to ≥0.5 s)
- Integration time TD (limited to ≥1.0 s)
- Derivative factor D_F = 5.0
- Control zone on/off CONZ_ON=TRUE/FALSE
- Control zone width CON_ZONE=250/GAIN
- P_SEL = TRUE (even if it was previously a controller with integral action only)

If RATIOFAC<>0.0, then CON_ZONE is multiplied by the factor 1.5.

If a value TD<1.0 s is calculated in the optimization process, only a PI controller is determined and PID_ON as well as the PID parameters will be set to zero.

The control zone is only enabled for matching process types (process type I and II) and PID controllers (CONZ_ON = TRUE).

Depending on PID_ON, control is implemented either with a PI or a PID controller. The old controller parameters are saved and can be retrieved with UNDO_PAR. A PI and a PID parameter record is saved additionally. Using LOAD_PID and making a suitable setting for PID_ON, it is also possible to switch later between the tuned PI or PID parameters.

A previously split structure (derivative component in the feedback path) will be maintained.

Note

Verify correct operation of your controller parameters immediately after the controller optimization process is completed.

Split-range function

During optimization, the gradient of the split-range function is added to the process. If you want to modify the gradient of the split-range function after optimization, you must adapt the controller's GAIN parameter accordingly.

Saving tuned controller parameters permanently

The new controller parameters are effective on the FM 355-2 immediately after the point of inflection has been reached, and they are also transferred to the online instance DB of FB 52 FMT_PID.

After a CPU restart, however, these parameters are overwritten with SDB parameter data (System data).

You have two options of ensuring that the FM 355-2 resumes operation after a restart with the parameters previously determined in the optimization process:

- Set LOAD_PAR=TRUE to load (after every restart of FM 355-2) the tuned controller parameters from the instance DB of FMT_PID into the FM 355-2.
- At the end of the optimization process, upload the controller parameter data to your parameter assignment application (upload to PG); save, compile and download your hardware configuration; the tuned controller parameters are now stored in the SDB.

Regardless of this, you should also save the tuned controller parameters to the offline storage area of your project.

Note

The PI, PID and SAVE parameter records cannot be stored in the SDB.

The relationship between the SDB (system data), instance DB, configuration software and FM 355-2 are described in Chapter "Operative mechanism of data storage on the FM 355-2 (Page 29)".

See also

Instance DB of the 52 FMT_PID FB (Page 211)

7.12 Tuning aborted by the operator

Tuning aborted by the operator prematurely

In phase 1, 2 or 3 you can reset TUN_ON = FALSE to cancel tuning without calculating new parameters. The controller start in automatic mode with LMN = LMN0. If the controller was operated in manual mode prior to tuning, the old manual value will be output.

Controller parameters determined up to the time a tuning process is cancelled in phase 4, 5, 6 or 7 with TUN_ON = FALSE will be retained.

7.13 Error views and corrective actions

Point of inflection not reached (only with excitation by setpoint jump)

When the actual value has passed 75% of the setpoint jump (SP-PV0), tuning is terminated. This is signaled by "Inflection point not reached" in STATUS_H/C (2xx2x).

In this case the currently valid setpoint always applies. By reducing the setpoint value it is possible to achieve an earlier termination of the tuning function.

In typical temperature processes, terminating the tuning at 75% of the setpoint jump is normally adequate to prevent overshoot. In processes with a greater lag (TU/TA > 0.1, process type III) caution is advised. If excitation is too sharp compared to the setpoint jump, the actual value can overshoot heavily (up to factor 3).

In processes of a higher order there will be significant overshoot if the point of inflection is still a long way off after reaching 75% of the setpoint jump. In addition to this, the control parameters are too sharp. You should then weaken the controller parameters and repeat the attempt.

The following schematic illustrates the overshoot of the actual value when the excitation is too strong (process type III):

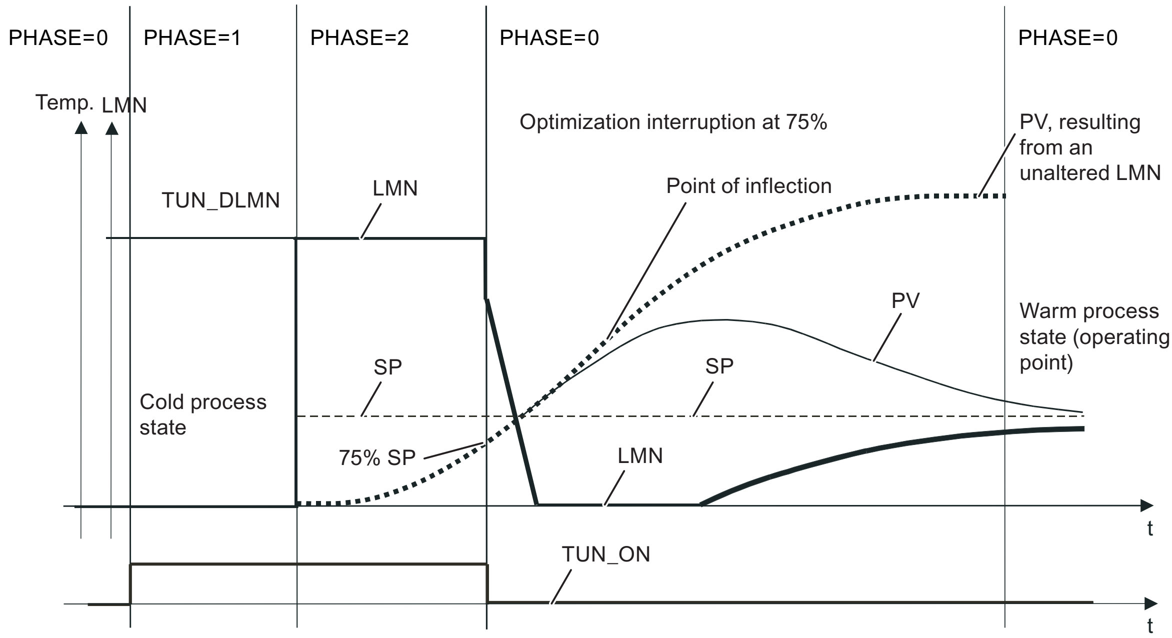


Figure 7-6 Actual value overshoot due to excess excitation

In typical temperature processes, aborting shortly before reaching the point of inflection is not critical in terms of the controller parameters.

If you repeat the attempt, reduce TUN_DLMN/ TUN_CLMN or increase the setpoint jump.

Principle: The tuning manipulated value must match the setpoint jump.

Errors estimating the lag or order

The lag (STATUS_H/C = 2x1xx, 2x2xx or 2x3xx) or the order (STATUS_H/C = 21xxx or 22xxx) could not be determined correctly. Tuning then continues with an estimated value that cannot lead to optimum controller parameters.

Repeat tuning and make sure that there is no disturbance of the actual value.

Note

A special case of a pure PT1 process is indicated by STATUS_H/C = 2x2xx (TU < sampling time). In this case it is not necessary to repeat the attempt. Weaken the parameters if the controller oscillate.

Quality of the measurement signals (measurement noise, low-frequency interference)

Tuning results can be distorted by measurement noise or by low-frequency interference. Please note the following:

- The actual value should be sampled at least twice within one noise period. The degree of noise should not exceed 5% of the useful signal change.
- High-frequency interference can no longer be filtered out by a software block. An anti-aliasing filter should rather be applied upstream in the measuring transducer.

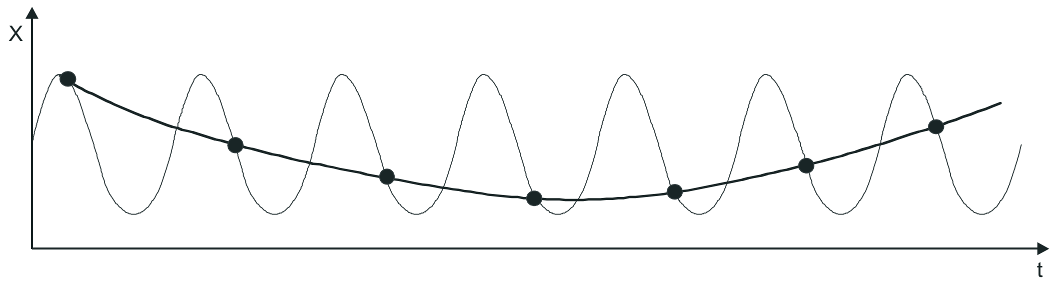


Figure 7-7 Aliasing effect due to exceptionally long sampling time

- If low-frequency interference occurs, you can assume that the sampling time of the FM 355-2 is low enough. On the other hand, the FM 355-2 must then generate a uniform measuring signal by having a large interval in the mean value filtering. Mean value filtering must extend over at least two noise periods. Internally in the block, this soon results in higher sampling times so that the accuracy of the tuning is adversely affected. Adequate accuracy is guaranteed with at least 40 noise periods to the point of inflection. Possible measure when you repeat the test: increase TUN_DLMN/TUN_CLMN.

Overshoots

Overshoot can occur in the following situations:

Table 7- 5 Cause/remedy in case of overshoot

Situation	Cause	Remedy
End of tuning	• Excitation by a manipulated variable step which is too strong compared to the setpoint jump (see above). • PI controller activated by PID_ON = FALSE	• Increase the setpoint jump or reduce the manipulated value jump • If the process allows a PID controller, start tuning with PID_ON = TRUE.
Tuning in Phase 7	Initially, less aggressive controller parameters were obtained (process type III) that can lead to overshoot in Phase 7.	-
Control mode	PI controller and with PFAC_SP = 1.0 for process type I	If the process allows a PID controller, start tuning with PID_ON = TRUE.

7.14 Manual fine tuning in control mode

Introduction

The following measures can be employed in order to achieve a non-overshooting response to setpoint changes:

Adapt control zone

During tuning, the FM 355-2 determines the control zone width CON_ZONE and, with an appropriate process type (process type I and II), a PID controller is activated: CONZ_ON = TRUE. During control mode, you can modify the control zone or switch it off completely (with CONZ_ON = FALSE).

No control zone for process type III, PI controller, step controller

Activating the control zone with higher order processes (process type III) does not normally bring any benefit since the control zone is then larger than the control range that can be achieved with a 100% manipulated variable. There is also no advantage in activating the control zone for PI controllers.

Note

Before you switch on the control zone manually, make sure that the control zone width is not too small. This means, the manipulated variable and actual value will oscillate if the control zone width is too small.

Weakening control response continuously with PFAC_SP

The control zone offers the best dynamic option of achieving a control response that is free of overshoot. Use it wherever possible, so for PID controllers for process types I and II.

For PI controllers, process type III or setpoint jumps within the control zone you can weaken the control response with parameter PFAC_SP. This parameter specifies the amount of P action that is affective for setpoint jumps.

Regardless of the process type, PFAC_SP is set to a default value of 0.8 by the tuning function; you can later modify this value if required. To limit overshoot during setpoint jumps (with otherwise correct controller parameters) to approximately 2%, the following values are adequate for PFAC_SP:

	Process type I	Process type II	Process type III
	Typical temperature process	Intermediate range	Higher order temperature process
PI	0.8	0.82	0.8
PID	0.6	0.75	0.96

Adapt the default factor (0.8) especially under the following situations:

- Process type I with PID (0.8 →0.6): With PFAC_SP = 0.8, setpoint jumps will still lead to approx. 18% overshoot.
- Process type III with PID (0.8 →0.96): With PFAC_SP = 0.8, the setpoint jumps is attenuated too heavily. This leads to a significant loss of tuning time.

Example of control response attenuation with PFAC_SP

Table 7- 6 Parameter list for the example

Process parameters	Controller parameters
GAIN = 6	GAIN = 1.45
T1 = 50 s	TI = 19.6 s
T2 = 5 s	

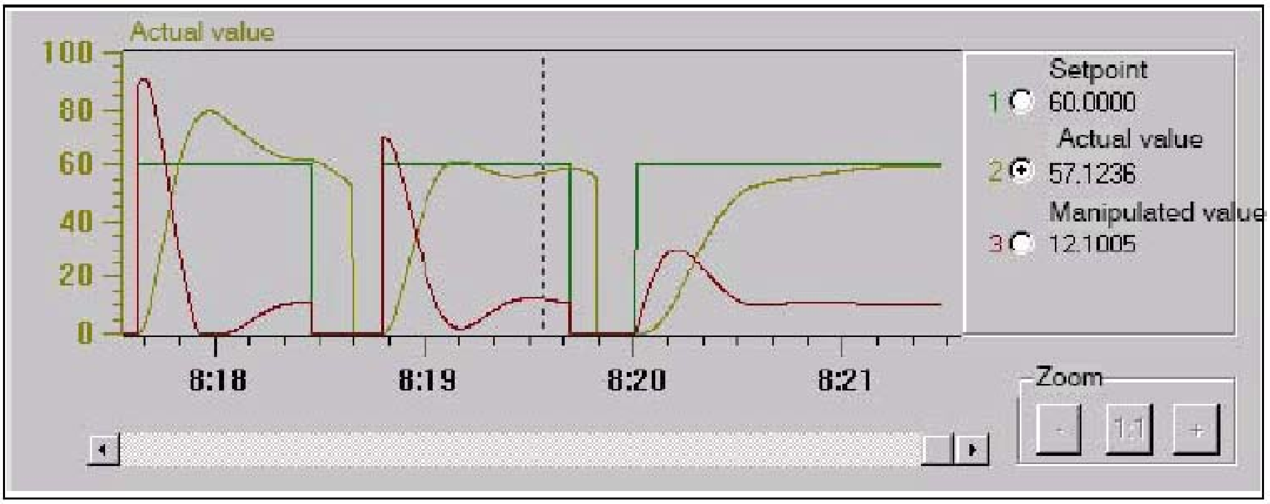


Figure 7-8 Trend showing three attempts, each with a setpoint jump from 0 to 60

The table below shows - for PFAC_SP = 1.0, 0.8 and 0.0 - the respective overshoot of the actual value following a setpoint jump from 0 to 60:

PFAC_SP	Comment	Overshoots
1.0	No proportional action in the feedback path; control response not attenuated	32%
0.8	20% proportional action in the feedback path; optimum control response	2%
0.0	Proportional action only in the feedback path; too strongly damped, long transient response	-

Note

In all three cases, the manipulated variable has not reached the limit. The overshoot percentage would be reduced when the limit is reached.

Attenuation of control parameters

When a closed-loop control circuit oscillates or if overshoot occurs after setpoint jumps, you can reduce the controller's GAIN (e.g. to 80% of the original value) and increase the integration time TI (e.g. to 150% of the original value). If the analog manipulated variable of the closed-loop controller is converted to binary actuating signals by a pulse shaper, quantization noise may cause minor permanent oscillation. You can eliminate this effect by increasing the dead band width DEADB_W.

Control parameter modification

Proceed as follows to modify control parameters:

1. Save the current parameters with SAVE_PAR.
2. Change the parameters.
3. Test the control action.

If the new parameter settings are worse than the old ones, retrieve the old parameters with UNDO_PAR.

7.15 Parallel tuning of controller channels

Neighboring zones (strong temperature coupling effect)

When two or multiple controllers of a module are used to control the temperature, for example, on a plate (e.g. two heaters and two measured actual values with strong temperature coupling), you have the option of parallel controller tuning. Proceed as follows:

1. Define the channel group in Zone A or Zone B.
2. Start tuning in one of these channels. Tuning of the other channels will then be started automatically.

Note

The user must ensure that the setpoint jumps are set concurrently when the process is excited via setpoint jump. You can use the wizard to specify the parameters PID_ON and TUN_DLMN/TUN_CLMN for one channel only. You must specify the parameters for the other channels in the corresponding instance DBs of FB FMT_PID before you start tuning.

Tuning is aborted

Tuning of all channels is aborted if an error occurs in one of the channels (Phase 0 or end of phase 1).

The user can reset tuning by setting TUN_ON=FALSE at any of the participating channels.

When a channel goes into safety mode, tuning of all other participating channels is also switched off.

The wizard shows only the status information of the selected channel. For all other channels, the causes of error are found in the corresponding instance DBs.

Advantage

Each participating controller will output its tuning manipulated variable until all controllers have exited phase 2. This avoids that the controller that completes tuning first corrupts the tuning result of the other controller due to the change in its manipulated variable.

⚠ CAUTION
When 75% of the setpoint jump is reached at one of the participating channels, tuning is not terminated (risk of overshoot). Automatic mode is only started after all participating controllers have terminated tuning.

Neighboring zones (weak temperature coupling effect)

As a general rule, tuning should be carried out to reflect the way in which the control will work later. When zones are operated in parallel during production so that the temperature differences between the zones remain the same, the temperature level of the neighboring zones ought to be increased accordingly during tuning.

Temperature differences at the beginning of a trial are irrelevant since they will be compensated in the initial heating process (→initial rise = 0).

7.16 Saving and retrieving controller parameters

Back-up file records

The FM 355-2 features an effective parameter record system as well as a backed up parameter record system. Save and retrieval operations are performed by means of SAVE_PAR or UNDO_PAR in OP structure of FB FMT_PID.

For example, prior to a manual change you can save the current parameters via SAVE_PAR = TRUE. You can retrieve the last saved controller parameters via UNDO_PAR = TRUE and enable them for the controller. SAVE_PAR or UNDO_PAR is reset by FMT_PID at the end of this action.

If you want to know the values in the current parameter record or in the backed up parameter record, you can retrieve this information via FB FMT_PID (READ_PAR = TRUE) or FMT_TUN (READ_OUT = TRUE):

Current parameters in the PAR structure of FMT_PID:	Parameters included in the backup of the FMT_TUN output parameters:
PFAC_SP	SAV_PFAC
GAIN	SAV_GAIN
TI	SAV_TI
TD	SAV_TD
D_F	SAV_D_F
CON_ZONE	SAV_CONZ
RATIOFAC	SAV_RATI
CONZ_ON	SAV_CZON
P_SEL	SAV_PSEL

Note

At the end of controller tuning, the saved parameters are overwritten with parameter data that were valid prior to tuning (Exception: this intermediate saving operation is discarded in a cooling tuning process).

Change between PI and PID parameters

After tuning, the PI and PID parameters are saved on the FM355-2. These parameter records are loaded by setting LOAD_PID in the structure OP of FB FMT_PID. If PID_ON in the structure PAR = TRUE, the PID parameter record is copied to the effective controller parameters; otherwise, the PI parameter record is copied. LOAD_PID is reset by FMT_PID at the end of this action. Of course, the value of PID_ON is retained, as it is not an operator control parameter.

If you want to know which values are stored in the PI or PID parameter record, you can view these data via FB FMT_TUN by setting READ_OUT = TRUE:

	PI parameter record	PID parameter record
Controller GAIN	PI_GAIN	PID_GAIN
Integration time	PI_TI	PID_TI
Derivative time	0.0	PID_TD

Note

Please note the following:

- Controller parameters are only written back with UNDO_PAR or LOAD_PID if the controller gain (SAV_GAIN, PID_GAIN or PI_GAIN) is not equal to zero:
- This strategy takes into account the situation that no tuning has yet been made or that PID parameters are missing. For example, if PID_ON was TRUE and PID_GAIN = 0.0, PID_ON is set to FALSE and the PI parameters will be copied.
- D_F, PFAC_SP are set to default values by the tuning. The user can later modify them. LOAD_PID does not modify these parameters.
- With LOAD_PID, the control zone is always recalculated (CON_ZONE = 250/GAIN or 375/GAIN if RATIOFAC <> 0.0), irrespective of the status CONZ_ON = FALSE.

Pulse-free changeover with LOAD_PID and UNDO_PAR

The changeover is performed so that the sum of the proportional action and integral action stays equal. A changeover from PID to PI triggers a jump of the manipulated variable, as the derivative action is disabled. Initially, the changeover from PI to PID is pulse-free. After a few cycles, however, the derivative action will lead to a fast change.

Integrating the FM 355-2 into the user program 8

8.1 Overview of the function blocks

Overview of the function bocks

Function block	Effect
FB 52 FMT_PID	for operating and observing controller parameters via the CPU as well as online changes to them
FB 53 FMT_PAR	for online changes to further parameters
FB 54 FMT_CJ_T	for reading or writing the reference junction temperature from/into the module.
FB 55 FMT_DS1	for reading the DS 1 diagnosis data set off the module
FB 56 FMT_TUN	for supporting controller optimization.
FB 57 FMT_PV	for reading or writing process values (analog and digital input values) to support commissioning.

Note

Downloading the controller and operating parameters with FB FMT_PID

After downloading the controller parameters with LOAD_PAR = TRUE or the operating parameters with LOAD_OP = TRUE the parameters do not take effect immediately. Only after the cycle time of the FM 355-2 (depending on the number of channels up to 500 ms) are the controller parameters available to read back with READ_PAR or the output parameters available with READ_OUT. This also applies after downloading the system data (CPU transition from STOP to RUN) as well as when reading the output parameters via the FB FMT_TUN.

Creating and supplying power to instance DB

Before you program the module with the user program you must create an instance DB for each controller channel you intend to use and supply it with data.

1. Under STEP 7 generate the instance DBs for the controller channels as data blocks with assigned function block (e.g. FMT_PID).
2. For each instance DB enter the module address in the MOD_ADDR parameter.

   The FM 355-2 module address is defined when your hardware is configured. Adopt the start address from the HW Config.
3. Enter the channel number of the corresponding controller channel (0,1,2 or 3) into the CHANNEL parameter for the instance DBs of the FMT_PID, FMT_PAR and FMT_TUN.
4. Store the instance DBs.

8.2 The FB 52 FMT_PID - General

How FB 52 FMT_PID is used

The FM 355-2 is linked to the user program via the FB FMT_PID. You can use this FB to modify operating parameters during operation. For example, you can specify a set point and the output value or switch to external output value specification (manual operation).

The data required for the FMT_PID are stored in an instance DB on the CPU The FMT_PID is program controlled to read data from and write data to the FM 355-2.

The individual parameters are described in the online help and in the appendix "Assignment of DBs (Page 211)".

Call

The FMT_PID must be called in the same OB as all other FBs that access the same FM 355-2.

The FMT_PID is called in the time interrupt OB. It requires and initialization run, which is triggered in the CPU start up by setting the COM_RST=TRUE parameter. After the initialization run, the FB FMT_PID sets the COM_RST parameter to FALSE.

Call in distributed I/O

Please note the following for distributed configuration and the simultaneous call of FB FMT_PID and FB FMT_TUN:

- LOAD_OP must not be set simultaneously for FMT_PID and FMT_TUN.
- READ_OUT must not be set simultaneously for FMT_PID and FMT_TUN.

Reason: the two FBs access FM 355-2 via the same data records.

Therefore, you must ensure that only one of the two FBs reads or writes a data record at any given time.

See also

Instance DB of the 52 FMT_PID FB (Page 211)

8.3 The FB 52 FMT_PID function block - Details

8.3.1 Control using the FB 52 FMT_PID

Transferring the operating parameters

The operating parameters (e.g. setpoint, manual manipulated variable) of the FM 355-2 are transferred cyclically from the FMT_PID to the FM 355-2. Operating parameters are all static variables of instance DB in the structure OP.

If you set LOAD_OP = TRUE, the operating parameters are transferred to the FM 355-2 by means of SFB WRREC.

After data transfer as been completed the LOAD_OP parameter of the FB FMT_PID is set at FALSE again. When using the FM 355-2 in a decentralized periphery, this may take a few call cycles.

When transferring data with LOAD_OP, the output parameters are also read from the FM.

Note

You can reduce the running time of the block (see Chapter "Technical data of function blocks (Page 206)") if you do not set LOAD_OP. In this case the block uses the input and output ranges of the module for fast data transfer. The following restrictions apply:

- The data transfer of the OP parameters via the input and output range takes place up to and including LMN_DN only.
- Even with a centralized configuration the data transfer requires 3 to 4 cycles.
- During automatic operation only the SP_RE setpoint and during manual operation only the LMN_RE manual manipulated variable are transferred.
- Data transfer via the input and output ranges does not work if two instances of the FB FMT_PID access the same channel number of a module.
- The FB FMT_PID automatically sets LOAD_OP to TRUE,
  - if you have set one of the following parameters: TUN_ST, TUN_CST, SAVE_PAR, UNDO_PAR and LOAD_PID,
  - if you modify TUN-ON
  - and if you modify the manipulated variable SP_RE

  in the aforementioned cases the operating values are transferred once via SFB WRREC.

8.3.2 Monitoring using the FB 52 FMT_PID

Reading the process values

The FB FMT_PID reads output parameters cyclically (e.g. actual value, manipulated variable or internal states) off the FM 355-2

They are stored in the static variables of the instance DB in the OUT structure.

If you set READ_OUT = TRUE, the output parameters are transferred to the FM 355-2 by means of SFB RDREC. With LOAD_OP = TRUE the operating and output parameters are transferred.

After data transfer as been completed the READ_OUT parameter of the FB FMT_PID is set at FALSE again. When using the FM 355-2 in a decentralized periphery, this may take a few call cycles.

Note

You can reduce the running time of the block (see Chapter "Technical data of function blocks (Page 206)") if you do not set READ_OUT or LOAD_OP. In this case the block uses the input and output ranges of the module for fast data transfer. The following restrictions apply:

- The parameter SP (setpoint from the FM), ER (error signal), DISV (disturbance variable), LMN_A, LMN_B, PHASE, STATUS_H, STATUS_C, STATUS_D and ZONE_TUN are not read from the FM (see appendix "Assignment of DBs (Page 211)").
- Even with a centralized configuration the data transfer requires 3 to 4 cycles.
- Data transfer via the input and output ranges does not work if two instances of the FB FMT_PID access the same channel number of a module.
- The FB FMT_PID automatically sets READ_OUT to TRUE,
  - during an optimization procedure QTUN_ON = TRUE,
  - and if you modify the manipulated variable SP_RE.

Error displays

The output parameter RET_VALU contains the feedback value STATUS (byte 2 and 3) of the SFBs 52 and 53 (corresponding to the RET_VAL of the SFCs 58/59). The RET_VALU can be evaluated if the READ_PAR and LOAD_PAR parameters have not been reset.

A peripheral access error can occur when calling the FMT_PID if the FM 355-2 is not plugged in or has no voltage supply. In the case the CPU goes into STOP, if no OB 122 is loaded onto the CPU.

If an error occurs when reading/writing a data set, QMOD_F and QCH_F must be set. If parameters have been assigned incorrectly, QPAR_F and QCH_F must be set.

See also

List of RET_VALU messages (Page 243)

8.3.3 Modify controller parameters via the FB 52 FMT_PID

Procedure

Controller parameters (e.g. controller gain, integration time) are to be found in the PAR structure. Controller parameters are first assigned via the project planning software and are transferred to the FM 355-2 via the system data.

Modifying controller parameters via the FMT_PID makes sense if you want to modify them during operation depending on process states. To do this, proceed as follows:

1. Set the READ_PAR parameter of the FMT_PID to TRUE.

   The FB then reads all controller parameters off the FM 355-2 and stores them in its instance DB. The instance DB of the FMT_PID has now been matched with the project planning software (system data). When the parameters have been read successfully, the FMT_PID sets the READ_PAR parameter to FALSE. When using the FM 355-2 in a decentralized periphery, this may take a few call cycles.
2. If READ_PAR = FALSE, you can now modify individual controller parameters in the instance DB of the FMT_PID in the user program.

   For this purpose call the FB FMT_PID with LOAD_PAR = TRUE. The FMT_PID then transfers all controller parameters out of the instance DB to the FM. Once the parameters have been transferred successfully, the FMT_PID resets the LOAD_PAR parameter. When using the FM 355-2 in a decentralized periphery, this may take a few call cycles.

Note

Please not that each time the CPU starts up (transition from STOP to RUN), the parameters in the FM 355-2 are overwritten with the values from the system data.

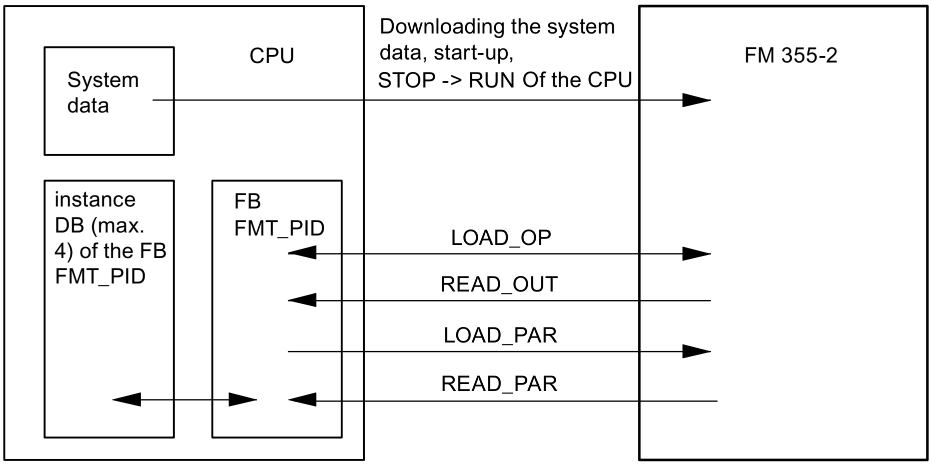


Figure 8-1 Operating, observing and assigning parameters via the FB FMT_PID and via system data

See also

Operative mechanism of data storage on the FM 355-2 (Page 29)

8.3.4 Program-controlled reparameterization

Effects

By means of program-controlled modification of parameter assignments (LOAD_PAR, LOAD_OP) of the FM 355-2 by the FMT_PID, its running time is increased. The new parameters always take immediate effect.

8.3.5 Relation between FB parameters and parameter configuration interface

Overview

The following figures show the relation between the FMT_PID and the parameter assignment interface of the controller module.

As far as three-component controllers and ratio/mixing controllers are concerned, the parameters affect the same point as with fixed setpoint or cascade controllers. This also applies to the parameters that are equally in place for continuous controllers, controllers with pulse output as well as step-action controllers. It is generally correct that the buttons of the same time contain the same parameters. Hence, for reasons of clarity, not all structure diagrams are depicted and not all parameters are marked in all figures.

However, the parameters of FMT_PID are contained in all figures, except the MOD_ADDR, CHANNEL, QMOD_F, QPAR_F, QCH_F, QLMNR_ON, RET_VALU, COM_RST, LOAD_PAR, READ_PAR, READ_OUT and LOAD_OP parameters.

The following figures show the places in the module affected by the parameters of the FMT_PID.

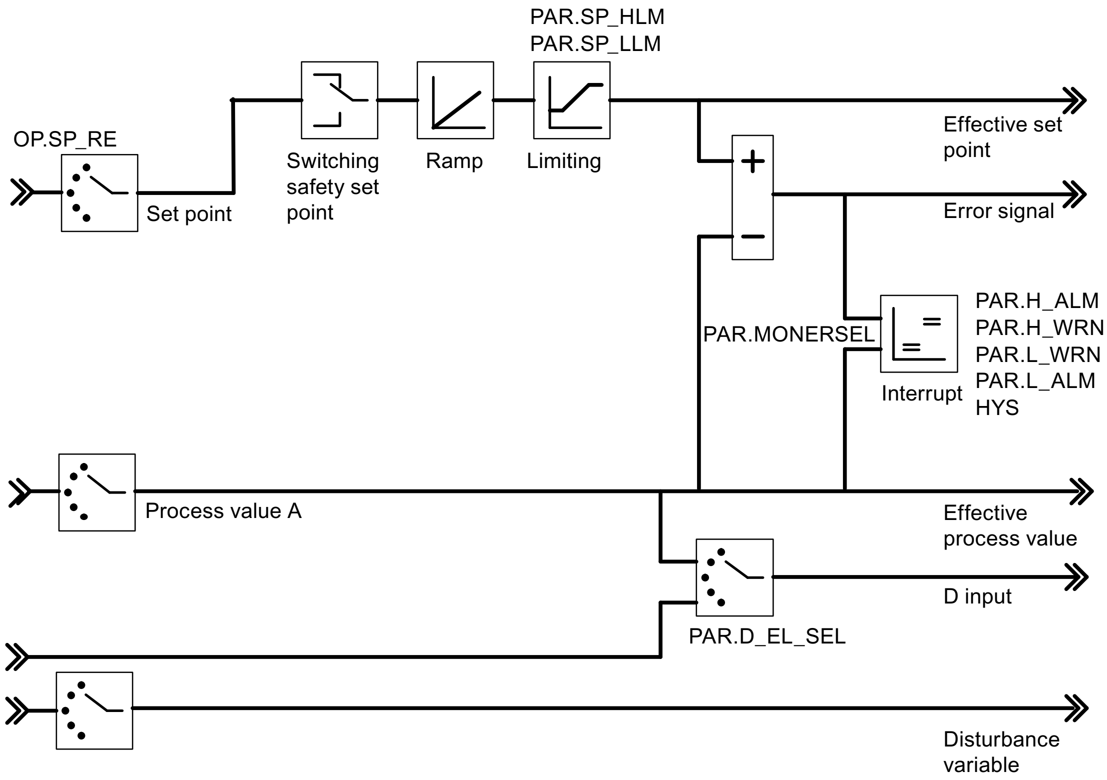


Figure 8-2 Control deviation with the fixed setpoint or cascade controllers

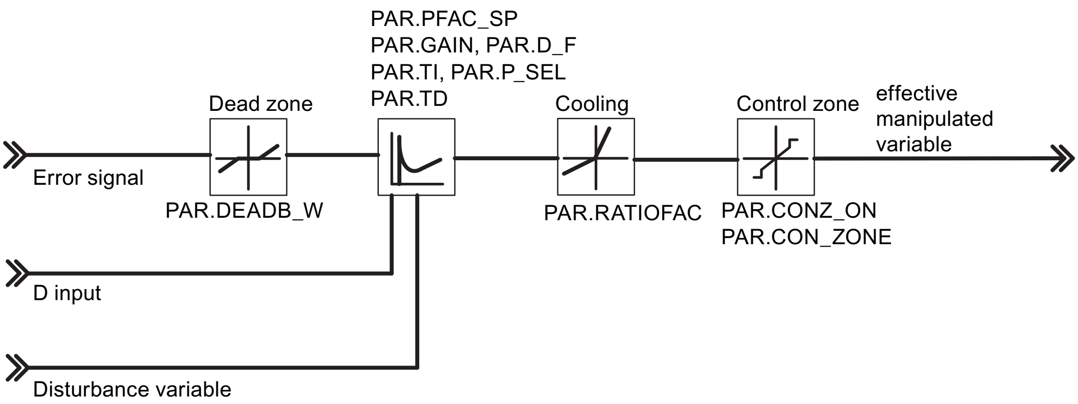


Figure 8-3 Block diagram of the control algorithm

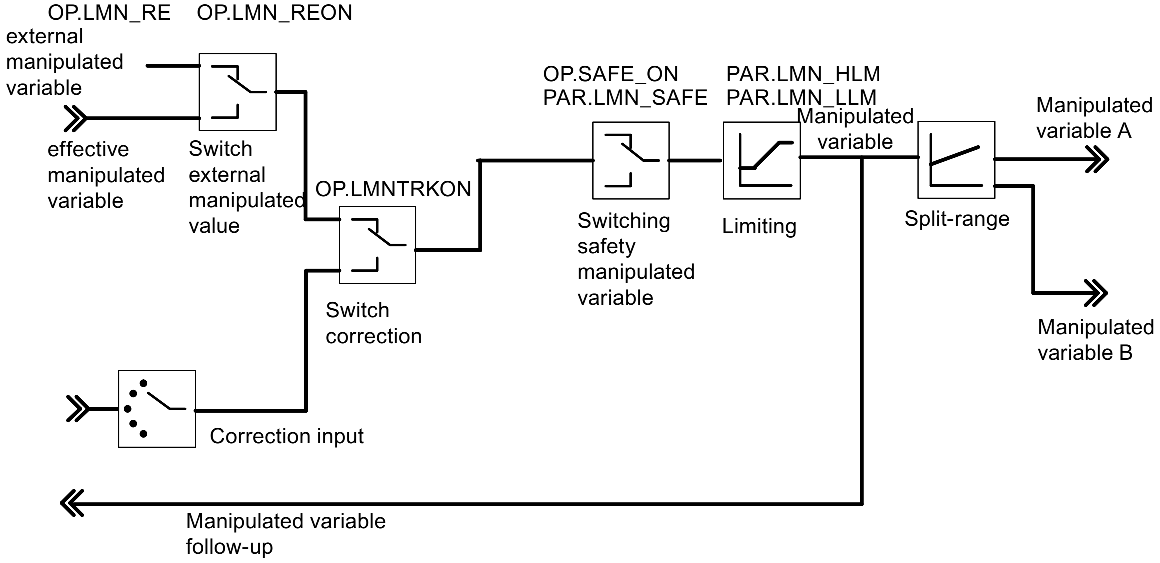


Figure 8-4 Controller output of the continuous-action controller (FM 355-2C)

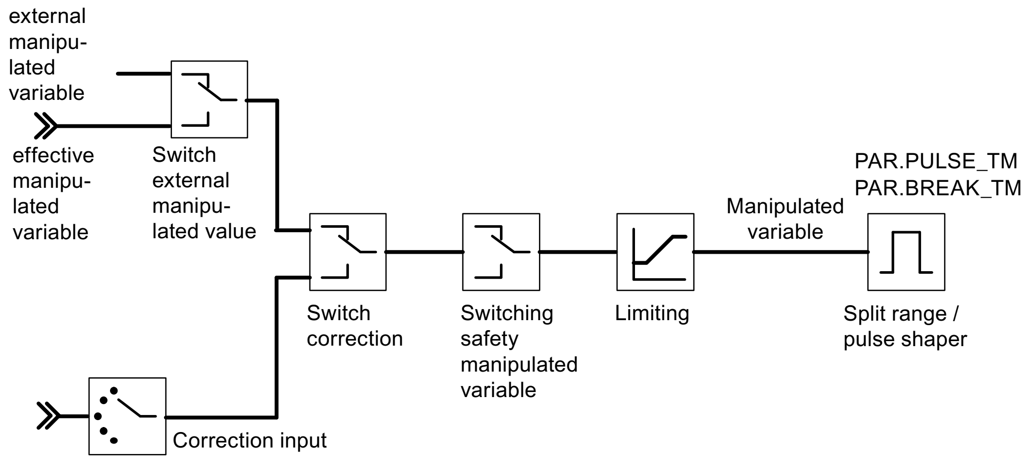


Figure 8-5 Controller output of the pulse controller (FM 355-2 S)

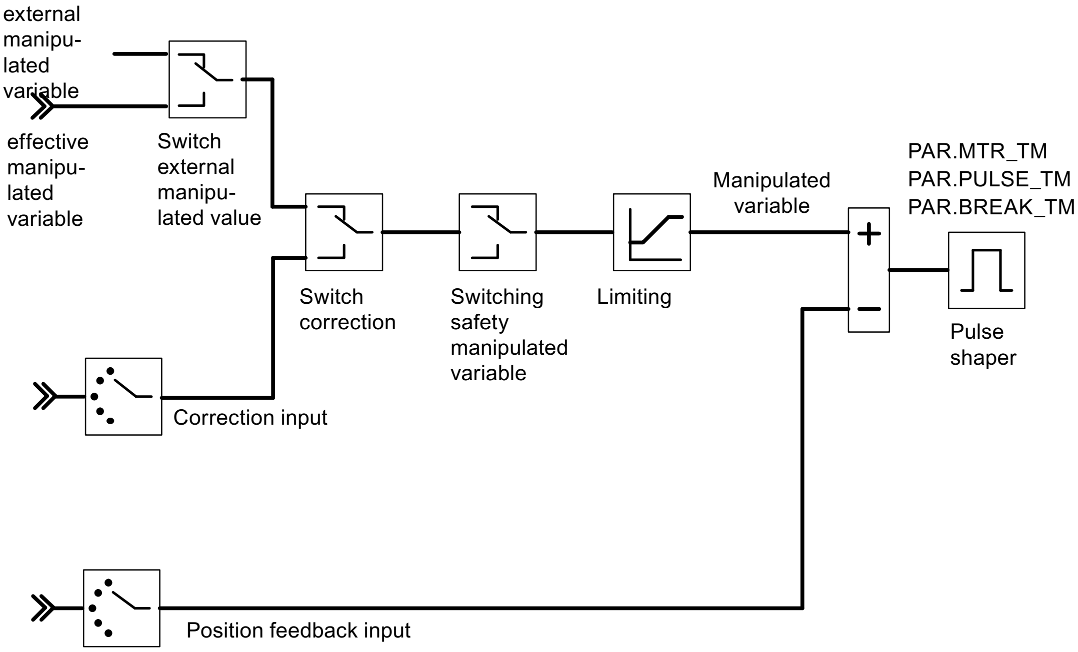


Figure 8-6 Controller output of the step-action controller with position feedback (FM 355-2 S)

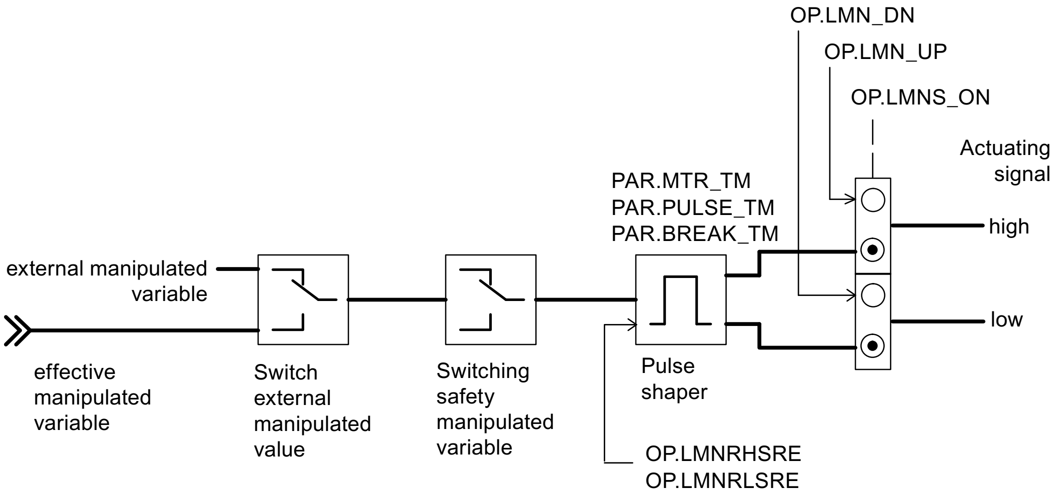


Figure 8-7 Controller output of the step-action controller without position feedback (FM 355-2 S)

The following figures show the points in the module the output parameters of the FB FMT_PID are generated.

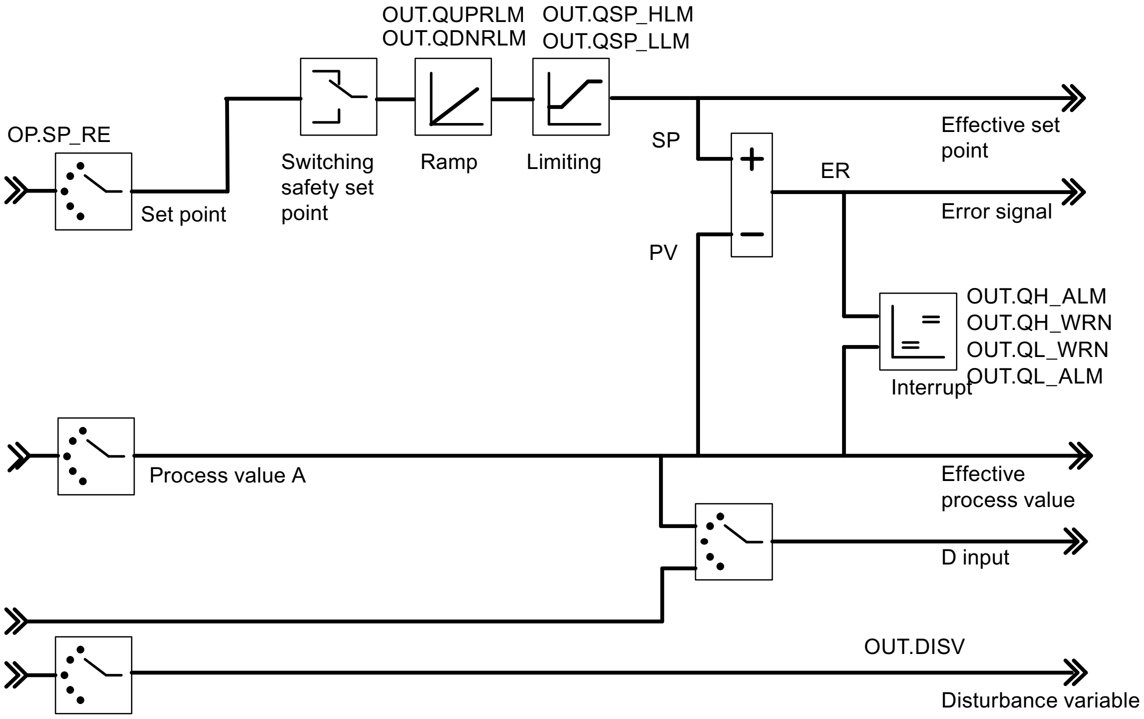


Figure 8-8 Control deviation determination for fixed value or cascade controllers

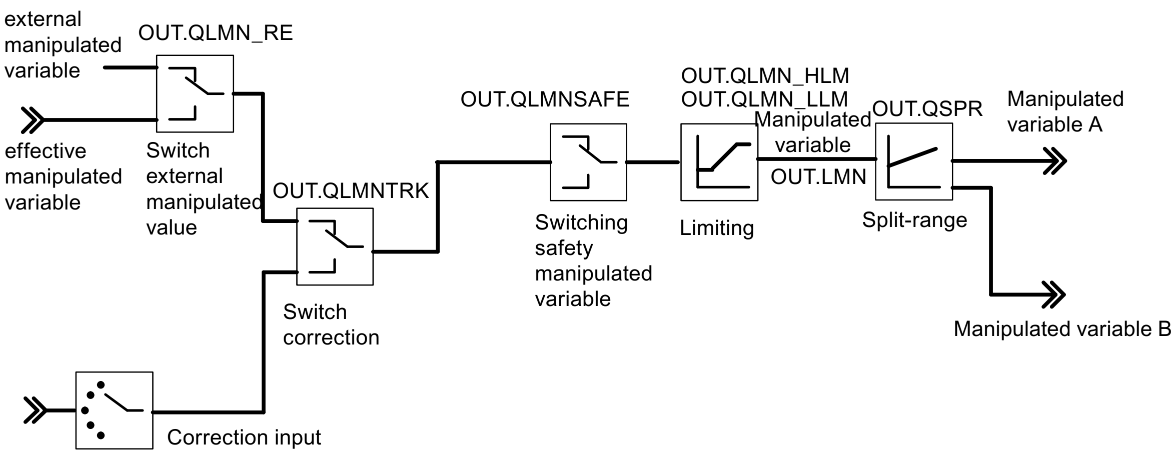


Figure 8-9 Controller output of the continuous-action controller (FM 355-2 C)

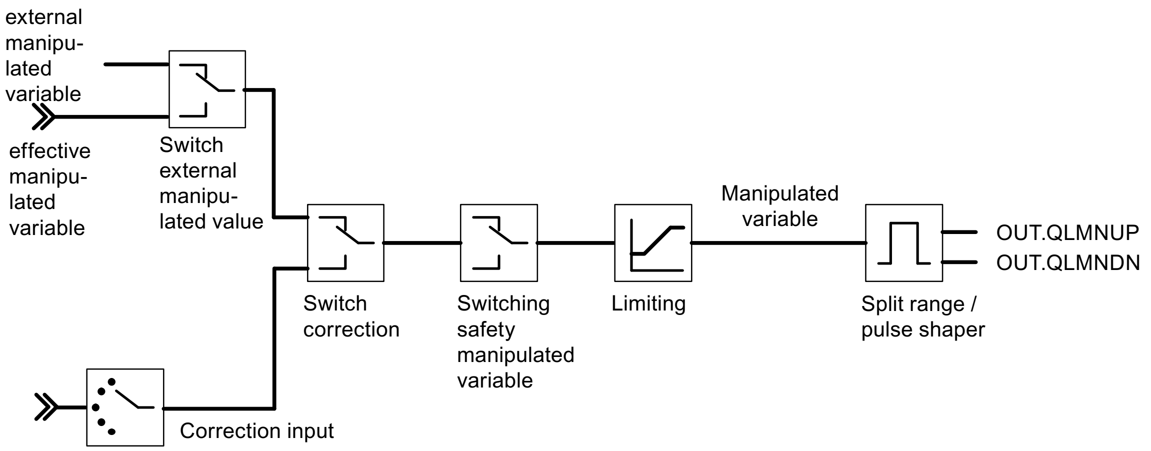


Figure 8-10 Controller output of the pulse controller (FM 355-2 S)

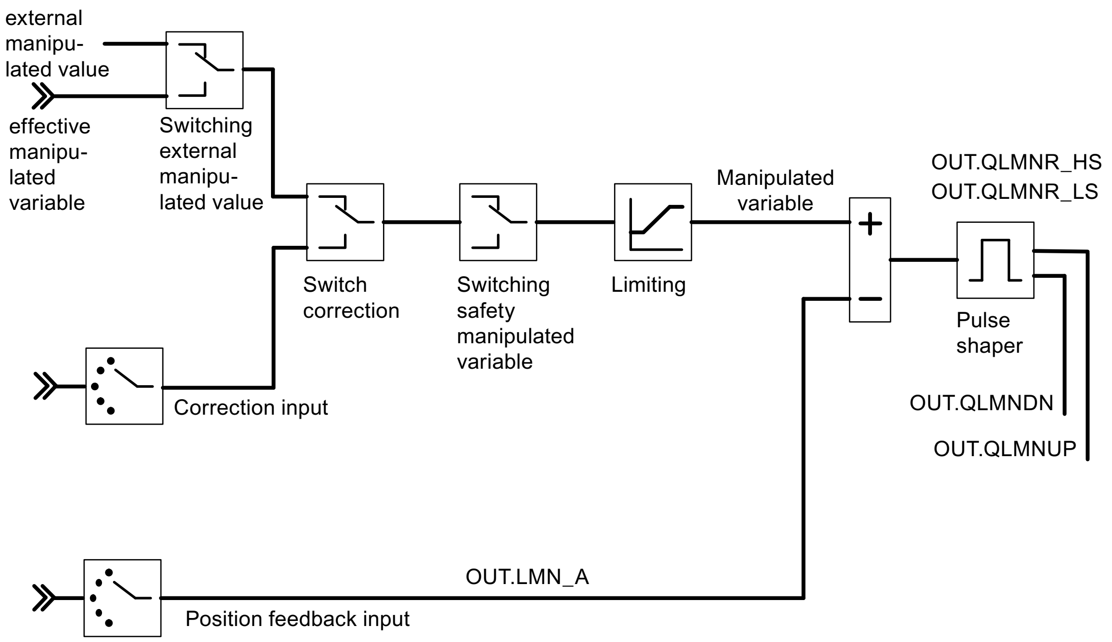


Figure 8-11 Controller output of the step-action controller with position feedback (FM 355-2 S)

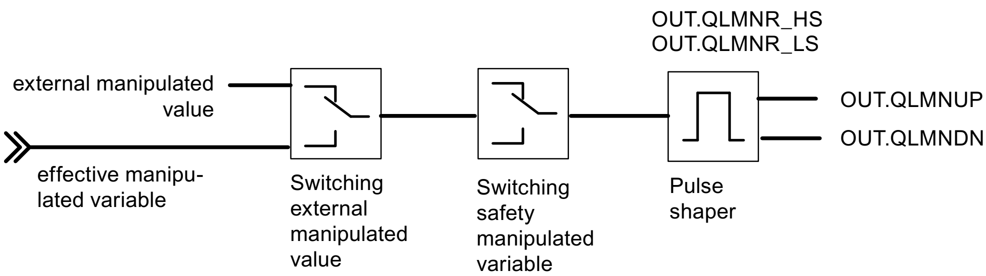


Figure 8-12 Controller output of the step-action controller without position feedback (FM 355-2 S)

8.4 The FB 53 FMT_PAR function block - General information

Use

The FMT_PAR supports the online modification of further parameters which cannot be defined via the FMT_PID.

To save running time, the FMT_PAR should only be called using LOAD = TRUE if parameters are to be modified.

Call

The FMT_PAR must be called in the same OB as all other FBs that access the same FM 355-2.

With the FMT_PAR each call enables you to modify one each of the REAL parameters listed in the following table as well as one of the INT parameters.

The prescribed value is assigned to the parameter via the index numbers from the table below, which you specify for the INDEX parameter in the instance DB of the FMT_PAR.

If you wish to modify several parameters, you must call the same instance DB several times in succession using LOAD_PAR=TRUE and different index numbers.

The output parameter RET_VALU contains the feedback value STATUS (byte 2 and 3) of the SFBs 52 and 53 (corresponding to the RET_VAL of the SFCs 58/59).

When using the FM 355-2 in a decentralized periphery, this may take a few call cycles until the parameters are transferred to the FM 355-2. As long as the transfer has not been completed, the LOAD_PAR parameter retains the value TRUE. So keep repeating your call of FB FMT_PAR when modifying parameters until LOAD_PAR is = FALSE.

Note

Please not that each time the CPU starts up (transition from STOP to RUN), the parameters in the FM 355-2 are 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.

- In order to parameterize the start-up time of the ramp for the reference input at 10.0, during operation you call the FMT_PAR with INDEX = 30 and VALUE_R = 10.0.
- If you wish to parameterize the analog input value 4 of the module as the actual value, call the FMT_PAR with INDEX = 50 and VALUE_I = 4 during operation.

Table 8- 1 List of the REAL and INT parameters to be modified with FMT_PAR

Data type	Description	Index number
-	no parameter selected	0
REAL	Filter time constant for the analog input	1
REAL	Standardization of analog input end of measuring range equivalent to 100%	2
REAL	Standardization of analog input end of measuring range equivalent to 0%	3
REAL	Polyline, interpolation point 1 supply side	4
REAL	Polyline, interpolation point 2 supply side	5
REAL	Polyline, interpolation point 3 supply side	6
REAL	Polyline, interpolation point 4 supply side	7
REAL	Polyline, interpolation point 5 supply side	8
REAL	Polyline, interpolation point 6 supply side	9
REAL	Polyline, interpolation point 7 supply side	10
REAL	Polyline, interpolation point 8 supply side	11
REAL	Polyline, interpolation point 9 supply side	12
REAL	Polyline, interpolation point 10 supply side	13
REAL	Polyline, interpolation point 11 supply side	14
REAL	Polyline, interpolation point 12 supply side	15
REAL	Polyline, interpolation point 13 supply side	16
REAL	Polyline, interpolation point 1 output side	17
REAL	Polyline, interpolation point 2 output side	18
REAL	Polyline, interpolation point 3 output side	19
REAL	Polyline, interpolation point 4 output side	20
REAL	Polyline, interpolation point 5 output side	21
REAL	Polyline, interpolation point 6 output side	22
REAL	Polyline, interpolation point 7 output side	23
REAL	Polyline, interpolation point 8 output side	24
REAL	Polyline, interpolation point 9 output side	25
REAL	Polyline, interpolation point 10 output side	26
REAL	Polyline, interpolation point 11 output side	27
REAL	Polyline, interpolation point 12 output side	28
REAL	Polyline, interpolation point 13 output side	29
REAL	Start-up time of the ramp for the reference input	30
REAL	Safety manipulated value	31

Data type	Description	Index number
REAL	Offset for setpoint link (ratio/mixing controller)	32
REAL	Factor for actual value B (three component controller)	33
REAL	Factor for actual value C (three component controller)	34
REAL	Offset for actual value link (three component controller)	35
REAL	Factor for disturbance link	36
REAL	Operating point	37
REAL	unused	38
REAL	Vertices for split range function Start of input signal A range	39
REAL	Vertices for split range function End of input signal A range	40
REAL	Vertices for split range function Start of output signal A range	41
REAL	Vertices for split range function End of output signal A range	42
REAL	Vertices for split range function Start of input signal B range	43
REAL	Vertices for split range function End of input signal B range	44
REAL	Vertices for split range function Start of output signal B range	45
REAL	Vertices for split range function End of output signal B range	46
REAL	Minimum pulse time	47
REAL	Minimum break time	48
INT	Choice of reference input SP or SP_RE for the controller -1: Manipulated variable SP_RE of the function block 0 to 3: Analog input value 0 to 3 16 to 19: Control variable (LMN) of controllers 0 to 3 32 to 35: Control variable A of controllers 0 to 3 48 to 51: Control variable B of controllers 0 to 3	49
INT	Selection of the main control variable actual value A for the controller -1: Actual value A = 0.0 0 to 3: Analog input value 0 to 3	50
INT	Selection of the auxiliary control variable actual value B for the controller -1: Actual value B = 0.0 0 to 3: Analog input value 0 to 3	51
INT	Selection of the auxiliary control variable actual value C for the controller -1: Actual value C = 0.0 0 to 3: Analog input value 0 to 3	52
INT	Selection of the auxiliary control variable actual value C for the controller -1: Actual value D = 0.0 0 to 3: Analog input value 0 to 3 16 to 19: Control variable (LMN) of controllers 0 to 3	53
INT	Selection of the DISV disturbance variable for the controller -1: Disturbance variable = 0.0 0 to 3: Analog input value 0 to 3	54
INT	Selection on the correction input switch. On the measuring point MP TRACKER the value can be read off with tool tip. -1: Position adjustment = 0.0 0 to 3: Analog input value 0 to 3	55

Data type	Description	Index number
INT	Selection on the position feedback input switch for step controllers with position feedback. -1: Position adjustment = 0.0 0 to 3: Analog input value 0 to 3	56
INT	Selecting the signal for transition to safety value for the manipulated variable of the controller -1: only entry via parameter SAFE_ON of the FB FMT_PID 0 to 7: Entry via parameter SAFE_ON of the FB FMT_PID OR with digital input 0 to 7.	57
INT	Selecting the signal for switching over to adjustment function of the manipulated variable of the controller. -1: only entry via parameter LMNTRKON of the FB FMT_PID 0 to 7: Entry via parameter LMNTRKON of the FB FMT_PID OR with digital input 0 to 7.	58
INT	Selecting the signal for switching over the manipulated variable of the controller to LMN_RE. -1: only entry via parameter LMN_REON of the FB FMT_PID 0 to 7: Entry via parameter LMN_REON of the FB FMT_PID OR with digital input 0 to 7.	59
INT	Selecting the upper end signal of the position feedback -1: only entry via parameter LMNRHSRE of the FB FMT_PID 0 to 7: Entry via parameter LMNRHSRE of the FB FMT_PID OR with digital input 0 to 7.	60
INT	Selecting the lower end signal of the position feedback -1: only entry via parameter LMNRLSRE of the FB FMT_PID 0 to 7: Entry via parameter LMNRLSRE of the FB FMT_PID OR with digital input 0 to 7.	61

See also

List of RET_VALU messages (Page 243)

8.5 The FB 54 FMT_CJ_T function block

Use

The FMT_CJ_T is for reading the measured reference junction temperature and for changing the parameterized reference junction temperature online. This is necessary of a temperature control system with more than one FM 355-2 with thermal element inputs is to be operated without a Pt 100 having to be connected to each FM 355-2.

If, for example, an FM 355-2 measures the reference junction temperature of an extruder control system with more than four heating zones, it can be read with READ_CJ = TRUE on the CJ_T_OUT parameter and can be parameterized for the other FM 355-2 via the CJ_TEMP and LOAD_CJ.

On parameter CJ_T_OUT the reference junction temperature measured at the reference point is expressed degrees C or in degrees F (depending on which temperature unit has been parameterized).

On parameter CJ_T_OUT 0.0. is shown if:

- no sensor of the "thermoelement" type has been parameterized,
- the parameterized reference junction temperature was selected on all analog inputs,
- the internal compensation was selected on all analog inputs,

The output parameter RET_VALU contains the feedback value STATUS (byte 2 and 3) of the SFBs 52 and 53 (corresponding to the RET_VAL of the SFCs 58/59). The values of RET_VALU are described in the reference manual *System software for S7-300/S7-400 system and standard functions*.

When using the FM 355-2 in a decentralized periphery, it may take a few call cycles until the parameters are transferred to the FM 355-2. As long as the transfer has not been completed, the LOAD_CJ parameter retains the value TRUE. So keep repeating your call of FMT_CJ_T when modifying parameters until the block sets LOAD_CJ = FALSE.

Call

The FMT_PAR must be called in the same OB as all other FBs that access the same FM 355-2.

8.6 The FB 55 FMT_DS1 function block

Use

The FB 55 FMT_DS1 is available to you for reading the diagnostic data set DS1.

For further details on diagnostics refer to the Chapter "Errors and diagnoses (Page 171)".

Call

The FB 55 FMT_DS1 must be called in the same OB as all other FBs that access the same FM 355-2.

The FB 55 FMT_DS1 does not require an initialization run.

To always obtain the updated diagnostic values, set the READ_DS1 parameter cyclically to TRUE.

Once the diagnostic values have been read successfully, the FB FMT_DS1 resets the READ_DS1 parameter.

8.7 The FB 56 FMT_TUN function block

Use

With this FB you obtain additional detailed information (e.g. back up controller parameters) during controller optimization (see appendix "Assignment of DBs (Page 211)").

Note

However, the FB 52 FMT_PID is adequate for performing controller optimization. You can start optimization and observe the status information with this FB.

Call

The FB 56 FMT_TUN must be called in the same OB as all other FBs that access the same FM 355-2.

The FB 56 FMT_TUN does not require an initialization run.

Set the READ_OUT parameter cyclically to TRUE to receive the constantly updated values.

Once the parameters have been read successfully, the FB FMT_TUN resets the READ_OUT parameter.

Call in distributed configuration

Please note the following for distributed configuration and the simultaneous call of FB FMT_PID and FB FMT_TUN:

- LOAD_OP must not be set simultaneously for FMT_PID and FMT_TUN.
- READ_OUT must not be set simultaneously for FMT_PID and FMT_TUN.

Reason: the two FBs access the FM355-2 via the same data records. Therefore, you must ensure that only one of the two FBs reads or writes a data record at any given time.

8.8 The 57 FMT_PV function block

Use

This FB is for reading or writing process values (analog and digital input values) to support start up.

Call

The FB 57 FMT_PV must be called in the same OB as all other FBs that access the same FM 355-2.

The FB 57 FMT_PV does not require an initialization run.

Set the LOAD_PV parameter cyclically to TRUE if you wish to write cyclically simulated process values on the FM 355-2.

Set the READ_PV parameter cyclically to TRUE to receive the constantly updated values.

Once the parameters have been written or read successfully, the FB FMT_PV resets the LOAD_PV or READ_PV parameter.

Simulation of the analog values (LOAD_PV = TRUE)

The simulation of the analog values for channels 0 to 3 is switched on via the S_AION[i] or S_PVON[i] switch, with $0 \leq i \leq 3$. The figure below shows the point at which the simulated analog value becomes effective.

You lay down the simulation values for channels 0 to 3 via the parameter PV_SIM[i].

You can have the simulation values become effective at two points:

- S_AION[i] = TRUE ($0 \leq i \leq 3$)

  Instead of the value of analog input i of the module, the value PV_SIM[i] is used.
- S_PVON[i] = TRUE ($0 \leq i \leq 3$)

  Instead of the preprocessed value of analog input i of the module, the value PV_SIM[i] is used.

Simulation of the digital values (LOAD_PV = TRUE)

The simulation of the values for the digital inputs 0 to 7 is switched on via the S_DION[i] switch, with 0 ≤ i ≤ 7.

You lay down the simulation values via parameter DI_SIM[i].

- S_DION[i] = TRUE (0 ≤ i ≤ 7)

  Instead of the value of digital input i of the module, the value DI_SIM[i] is used.

Note

LEDs I0 to I7 always display the state of the associated digital input, also during simulation.

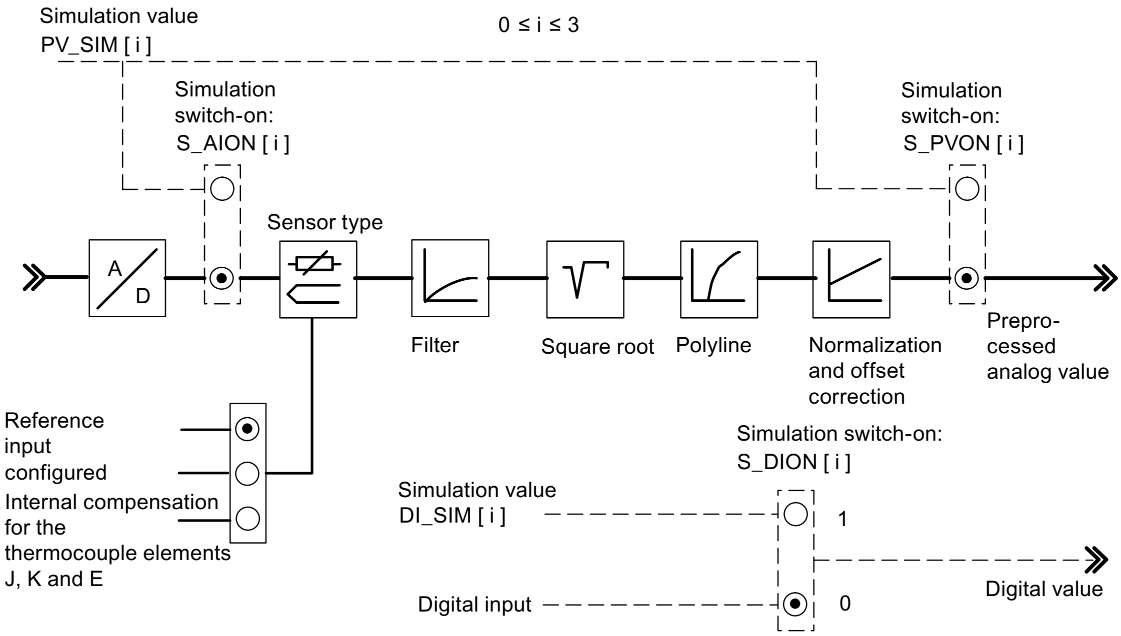


Figure 8-13 Effect of the simulation values

When the FM is restarted, following Mains Off, the simulation switches on the FM 355-2 are again positioned on FALSE.

Note

Switching on and laying down the simulation values (Force) does not take place via the configuration software. This is why the relevant switches and connecting lines are drawn as dotted lines.

Displaying the process values (READ_PV = TRUE)

The following values are displayed:

- The actual status of digital inputs 0 to 7 is displayed on the STAT_DI[0] to STAT_DI[7] parameters, even if these are simulated.
- The value of analog inputs 0 to 3 is displayed on the DIAG[0].PV_PER to DIAG[3].PV_PER parameters in mA or mV units. If the simulation of the analog input value was switched on, the simulated value is displayed.
- The preprocessed analog input value 0 to 3 is displayed in a physical unit on parameters DIAG[0].PV_PHY to DIAG[3].PV_PHY. If the simulation of the preprocessed physical analog input value was switched on, the simulated value is displayed.

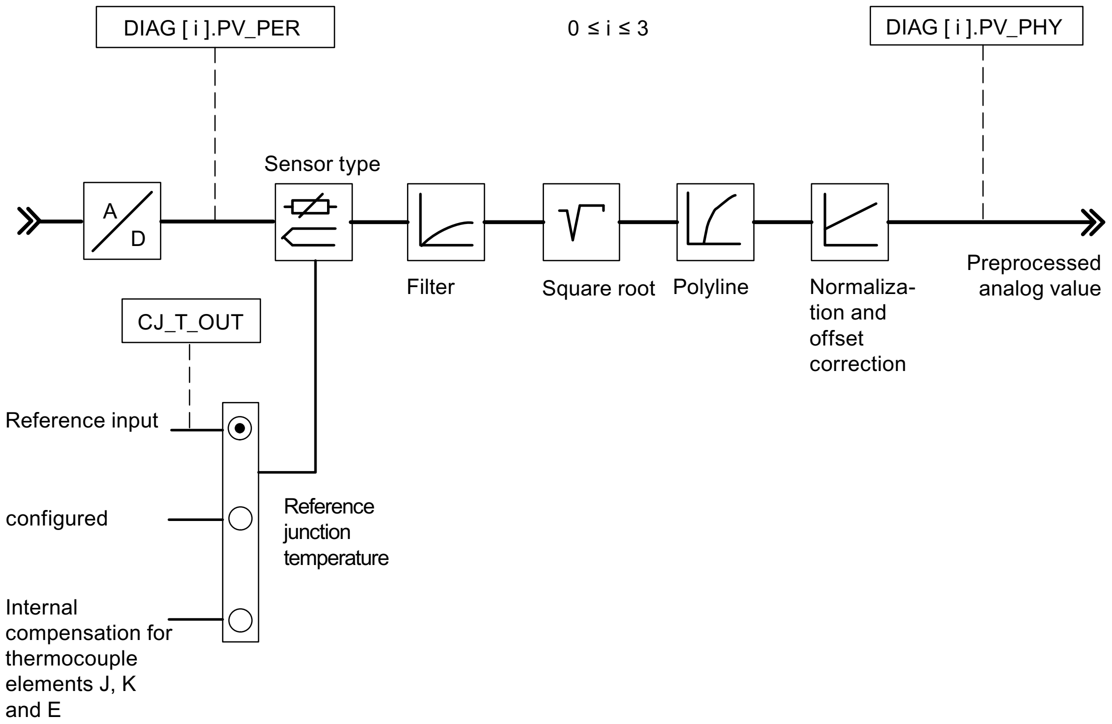


Figure 8-14 Displayed input values

The output parameter RET_VALU contains the feedback value STATUS (byte 2 and 3) of the SFBs 52 and 53 (corresponding to the RET_VAL of the SFCs 58/59).

Note

The updating of the process values can be delayed if the FM 355-2 is loaded compared to the FB_FMT_PID.

See also

List of RET_VALU messages (Page 243)

Commissioning the FM 355-2 9

9.1 Commissioning the FM 355-2

Hardware installation and wiring

For the sake of clarity the commissioning procedure is subdivided into several small steps. In the first section, you install the FM 355-2 in your S7-300 and wire the external peripheral elements.

Step	What should be done?	✓
1	**Installing the FM 355-2** (see chapter "Installing and removing the FM 355-2 (Page 35)") • Switch the CPU to STOP state. • Detach the neighboring module and attach the bus connector. • Hook in the FM 355-2 and screw it on tightly. • Attach the slot number. • Mount the shield supporting element.	 ❐ ❐ ❐ ❐ ❐
2	**Wiring the FM 355-2** (see chapter "Wiring the FM 355-2 (Page 39)") • Analog inputs (left-hand front connector) • Digital inputs (right-hand front connector) • Analog outputs (FM 355-2 C, right-hand front connector) • Digital outputs (FM 355-2 S, right-hand front connector) • Wire supply voltage – 24 V Supply Voltage L+: right-hand front connector pin 1 – Supply voltage ground M: right-hand front connector pin 20 • Wiring the reference potential of the analog measuring circuits – M_{ANA}:left-hand front connector pin 20	 ❐ ❐ ❐ ❐ ❐ ❐
3	**Front connectors** The front connectors must snap into place.	 ❐
4	**Shield** Check the shielding of the individual cables.	 ❐
5	**Switch on the power supply** Switch on the 24 V power supply for the FM 355-2.	 ❐

Creating a new project

If you do not yet have a project, create a new project now under STEP 7 so that parameter assignment with the parameter assignment screen forms is possible.

Step	What should be done?	✓
1	Create a new project under STEP 7.	❐
2	Mount a new module rack.	❐
3	In HW Config enter your hardware configuration in the module rack.	❐
4	Select the FM 355-2 from the module catalog and drag it to the selected slot.	❐
5	Make a note of the module address that is now displayed. This value is required later for preparing the instance DB.	❐

Now move on to the section "Parameter assignment".

Inserting FM 355-2 in existing project

If you wish to insert the FM 355-2 into a SIMATIC 300 station of an existing project, proceed as follows:

Step	What should be done?	✓
1	Open the SIMATIC 300 station of your existing project.	❐
2	Select the FM 355-2 from the module catalog and drag it to the selected slot.	❐
3	Make a note of the module address that is now displayed. This value is required later for preparing the instance DB.	❐

Parameter assignment

Step	What should be done?	✓
1	In the configuration table select the FM 355-2 and use the menu command.	❐
2	Click the Basic Parameters tab.	❐
3	Fill out the screen forms for the basic parameter settings: • In the interrupt selection you determine if the FM 355-2 is to trigger interrupts.	❐
4	Save the entries by clicking OK.	❐
5	Now call the parameter assignment screen forms for the FM 355-2 by double clicking on the FM 355-2.	❐
6	Fill out the dialog screens.	❐
7	Save the parameter settings with the menu item File > Save.	❐

Save the parameter data and transfer to the FM 355-2.

Step	What should be done?	✓
1	Terminate the configuration tool.	❒
2	Save the project with File > Save and Compile. Edit > Object properties.	❒
3	Bring the CPU to the STOP state.	❒
4	Transfer the data to the CPU with load target system ... The data will be transferred directly to the CPU and to the FM 355-2.	❒

Creating instance DB and integrating user data

To be able to utilize the functions of the module, you must create an instance DB for each controller channel.

Step	What should be done?	✓
1	Create the instance DBs for the controller channels as data blocks with assigned function block FB 52 FMT_PID.	❒
2	For each instance DB enter the module address in the MOD_ADDR parameter. You noted down the address when configuring your hardware with STEP 7.	❒
3	Enter the channel numbers (0...3) into the CHANNEL parameter for each instance DB.	❒
4	Call the instance DBs cyclically in the user program (e.g. in an OB).	❒
5	Transfer the user program onto the CPU.	❒

Commissioning the FM 355-2

Now you can optimize and test your controlled system.

Step	What should be done?	✓
1	Bring the CPU to the RUN state.	❒
2	Open the configuration software and measure the motor actuating time: Test > measure motor actuating time. (only for step-action controllers)	❒
3	Call controller optimization: Test > controller optimization.	❒
4	Perform the steps for controller optimization (described in detail in the following).	❒
5	Observe and control the control circuit with the loop display: Test > loop display.	❒
6	Observe the control circuit with the graphic plotter: Test > graphic plotter.	❒

Controller optimization using the configuration software

Step	What should be done?	✓
1	Open the instance DB of the FMT_PID with Test > controller optimization.	❐
2	Check that manipulated variable and actual value are almost transient on the graphic plotter and click on Continue.	❐
3	Set the "PID parameter" and click on Continue.	❐
4	Set "Optimize by approach to the operating point with setpoint step-change" and click on Continue.	❐
5	Set the operating point to 90 and the manipulated variable difference to 80 and click on Continue.	❐
6	If the end of controller optimization is signalized, click on Close.	❐

Now you can test the controller parameters found by feedforwarding a setpoint step-change or a disturbance to the process.

Feedforwarding a setpoint step-change

Step	What should be done?	✓
1	Open the graphic plotter under menu item Test.	❐
2	Open the loop display screen form under menu item Test.	❐
3	Enter a setpoint step-change to 70 on the setpoint parameter and actuate the Send button.	❐
4	Observe the transient response of actual and manipulated variable.	❐

Feedforwarding a disturbance to the process

Step	What should be done?	✓
1	Open the VAT_Process variable table in the SIMATIC Manager	❐
2	Enter a process disturbance of 30 on the DISV parameter.	❐
3	Observe the transient response of actual and manipulated variable.	❐

Backup project

When you have completed all the tests successfully and the parameter settings of the FM 355-2 have been optimized, you must backup the data again.

Step	What should be done?	✓
1	Save all data in the configuration software with File > Save.	❐
2	Terminate the configuration software.	❐
3	Save the program using HW Config with File > Save and Compile.	❐
4	Transfer the data to the CPU in the STOP state, load onto module with the target system.	❐
5	Bring the CPU to the RUN state.	❐

9.2 Configuration change in RUN

CiR: Configuration change in RUN

The FM 355-2 is CiR-capable to a limited extent, i.e. when the configuration is changed while the CPU is in RUN, the majority of the FM 355-2 parameters can be changed without this having any effect on the output signals of the remaining channels. Upon a parameter change of this nature, all the parameters of the FM 355-2 are saved to the SDBs of the CPU and then transferred to the FM 355-2. Please refer to the "Modifying the system during operation via CiR" electronic manual for more information on using CiR.

Note

Upon certain hardware-related parameter changes which impact the entire module, short-term effects on all controller channels cannot be avoided. With "Configuration change in RUN" of the HW Config or with "Download to module" from the configuration software, in this case the output signals on the analog and digital outputs return to zero for 100 to 500 ms (depending on the number of active channels).

Module-specific parameters	Configuration software
Line frequency: 50 Hz/60 Hz	Module parameters > General parameters
Unit of temperature: Celsius / Fahrenheit	Module parameters > General parameters
Digital input 1...8: 13 ... 35 V (H active)/0 to 4 V or open (L active)	Module parameters > Direction of control action of digital inputs

This effect also occurs with the following channel-specific parameters.

Channel-specific parameters	Configuration software
Reference junction temperature switch: Reference input / configured / internal compensation for thermocouple elements J, K and E	Analog input
Square root switch-on: On/off	analog input > square root
Polyline switch-on: On/off	Analog input > Polyline
Wire break monitoring switch-on: On/off	Analog input > sensor type
Sensor type switch: Analog input will not be processed/power/voltage/PT100/thermocouple element	Analog input > sensor type
Controller type: Fixed setpoint or cascade controller / three-component controller / ratio or mixed controller	Basic screen
Reaction in event of CPU failure: setpoint = last valid setpoint/setpoint = safety setpoint	Error signal > switching safety setpoint
Response to module startup: setpoint = last valid setpoint/setpoint = safety setpoint	Error signal > switching safety setpoint

Channel-specific parameters	Configuration software
Reaction in event of CPU failure: Manipulated value = last valid manipulated value / manipulated value = safety manipulated value	Controller output > switching safety manipulated value
Response to module startup: Manipulated value = last valid manipulated value / manipulated value = safety manipulated value	Controller output > switching safety manipulated value
Response in case of transducer failure actual value A: Control mode/manipulated value = safety manipulated value	Controller output > switching safety manipulated value
Response to measuring transducer failure at an input: Control mode/manipulated value = safety manipulated value	Controller output > switching safety manipulated value
Split-range function switch-on: On/off (only for FM 355-2 C)	Controller output > split-range
Automatic operating point setting: On/off	Controller algorithm > PID controller
Automatic operating point setting, smooth change from manual/automatic: On/off	Controller algorithm > PID controller
(Analog output signal selection) switch: Zero/preprocessed analog value/manipulated value A controller/manipulated value B controller (only for FM 355-2 C)	Signal Selection Analog Output
Switches: 0 to 20 mA / 4 to 20 mA / 0 to 10 V / -10 to 10 V (only for FM 355-2 C)	Signal type analog output

Properties of digital and analog inputs and outputs 10

10.1 Properties of the digital inputs and outputs (FM 355-2 S)

Properties

The digital inputs and outputs of the FM 355-2 S are characterized by the following properties:

- 8 inputs
- 8 outputs
- 0.1 A output current
- Rated load voltage: 24 V DC
- suitable for switches, 2, 3, 4-wired approximation switches (BEROs) magnetic valves, DC contactors and signal lights

Special feature

When the 24 V supply voltage is connected via a mechanical contact, the outputs of the FM carry the signal for approx. 50 µs "1", depending on the circuit. You must take this into account if you use the FM combined with fast counters.

Input filter for digital inputs

To suppress errors inputs IO have up to 17 input filters (RC elements) with a uniform filter time of 1.5 ms.

Digital outputs

To trigger control processes directly the FM 355-2 S has eight digital outputs, Q0 to Q7.

The digital outputs receive power via power supply L+.

The digital outputs are current-sourcing switches and can carry load current of 0.1 A. They are protected against overload and short circuits.

Terminal and block diagram

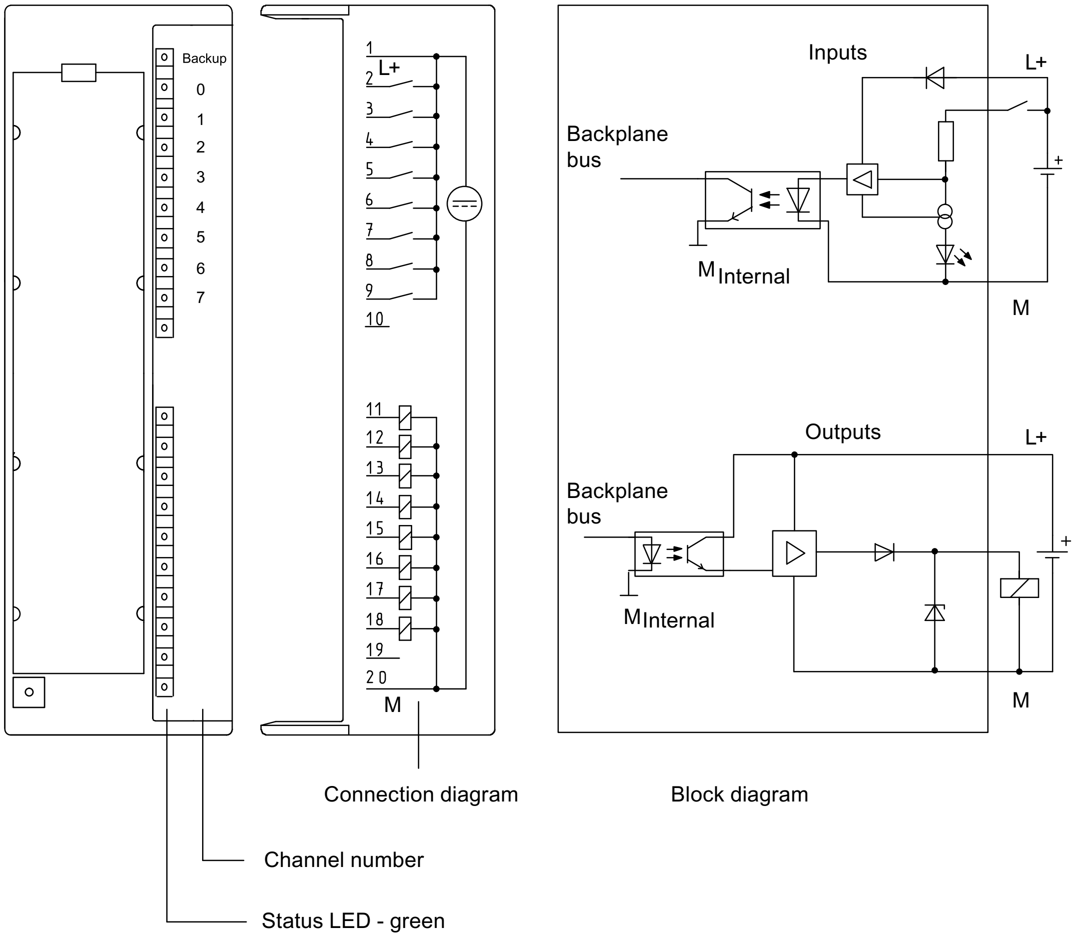


Figure 10-1 Terminal and block diagram of the digital inputs and outputs (FM 355-2 S)

The digital output LEDs are not controlled and are without significance.

10.2 Characteristics of the analog inputs

Introduction

The analog inputs of the FM 355-2 are characterized by the following properties:

- 4 inputs
- Measured Value Resolution
  - 14 bits
- Measuring method can be selected per analog input:
  - Voltage
  - Current
  - Resistance
  - Temperature
- Selection of measuring range per analog input
- parameterizable diagnostic interrupt (e.g. if measuring range is exceeded)
- Limit value monitoring
- parameterizable limit value interrupt

Current measurement

An external measurement resistor of 50 Ω has to be connected, for current measurement of the analog inputs between M+ and M-.

Reference input COMP+, COMP-

If you connect a Pt 100 in order to measure the reference junction temperature on the analog inputs COMP+ and COMP-, you must supply this Pt 100 with current from input CH3 (connections IC3+ and IC3-). It is no longer possible to connect a Pt 100 to input CH3. However, input CH3 can still be used for measuring current or voltage or for connecting a thermocouple element (see figure below).

Resolution

The integration is the result of the 14 bit resolution of the measured value and is 100 ms.

Terminal diagram

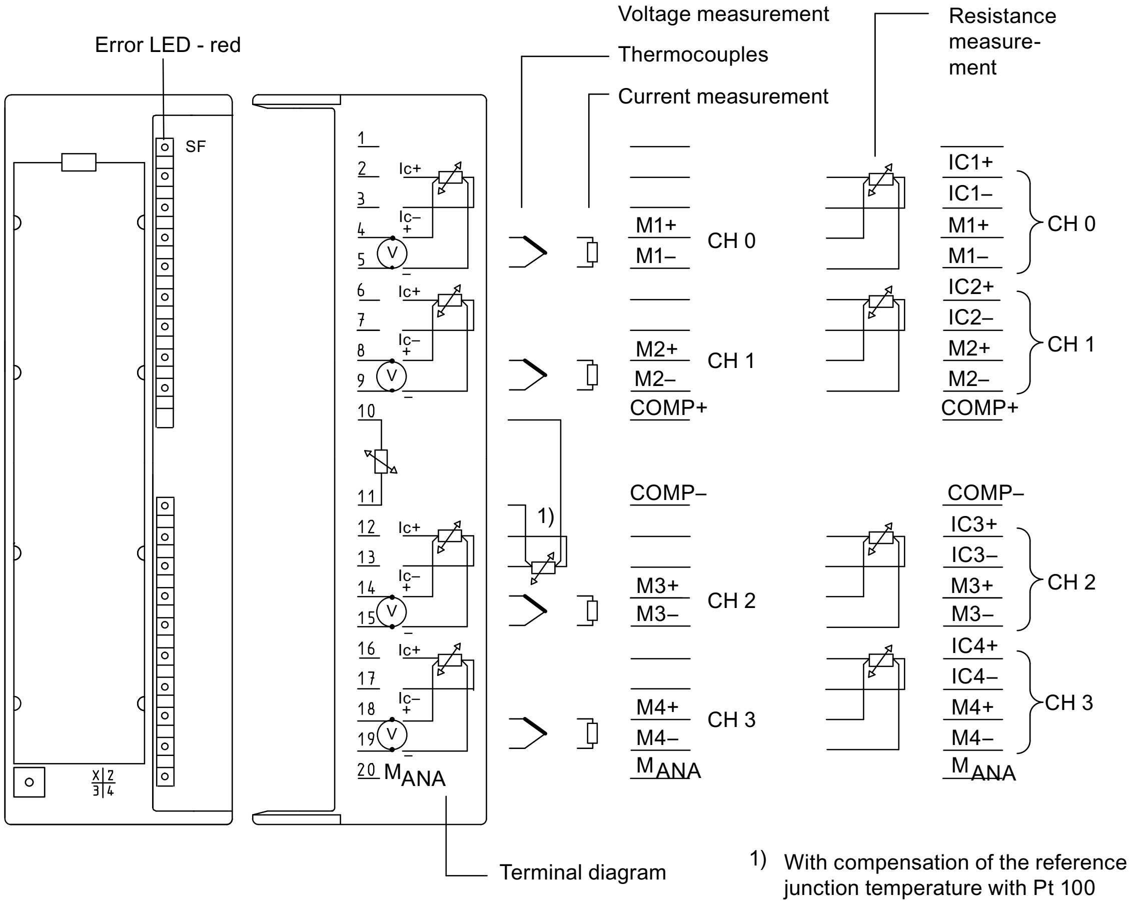


Figure 10-2 Terminal diagram of the analog inputs

Block diagram

The figure below shows the block diagram of the analog inputs. The input resistance depends on the set measuring range.

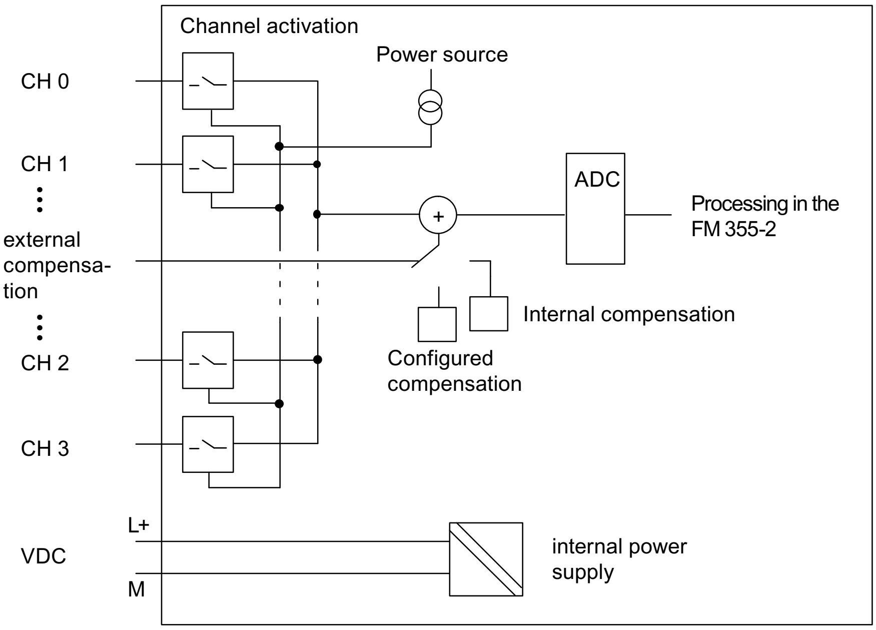


Figure 10-3 Block diagram of the analog inputs

See also

Basic structure of the FM 355-2 (Page 21)

Technical Specifications S7-300 (Page 197)

10.3 Properties of the analog outputs (FM 355-2 C)

Properties

The analog outputs of the FM 355 2 C are characterized by the following properties:

- 4 outputs
- the outputs can be selected channel by channel as
  - Voltage output
  - Current output
- Resolution 12 bits
- parameterizable diagnostic interrupt (short circuit, load break)

Note

When switching on/off the power supply (L+), incorrect intermediate values may appear on the output for approx. 10 ms.

Terminal diagram

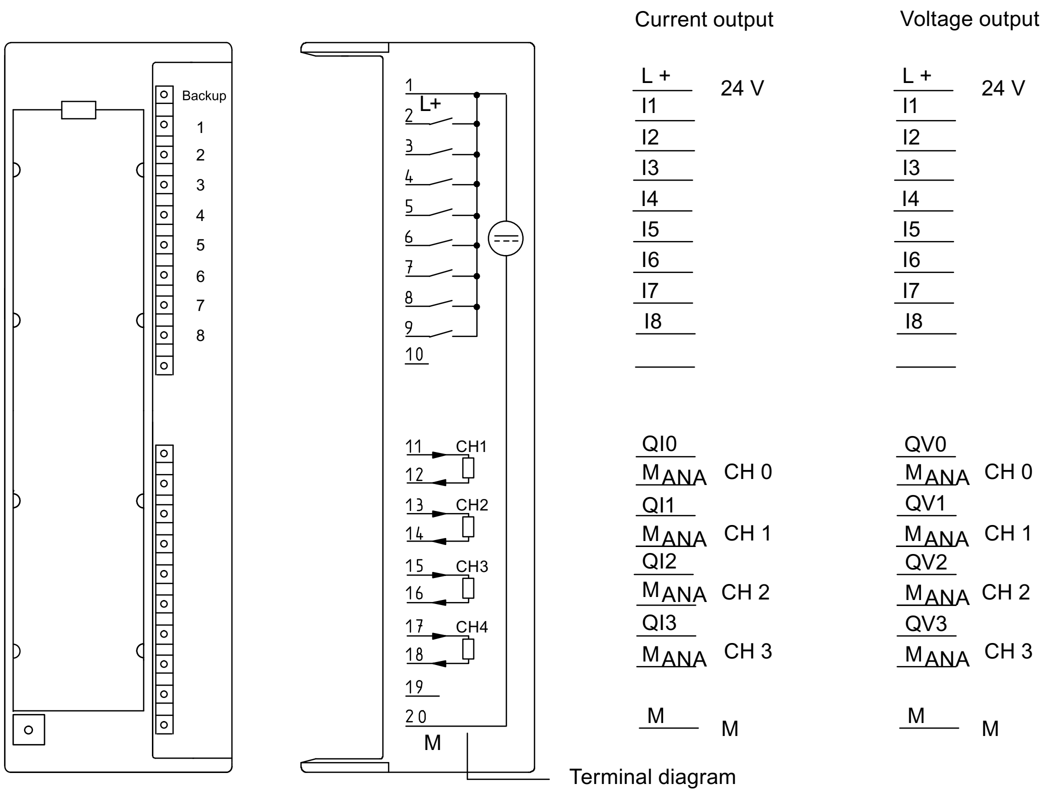


Figure 10-4 Terminal diagram of the analog outputs (FM 355-2 C)

Block diagram

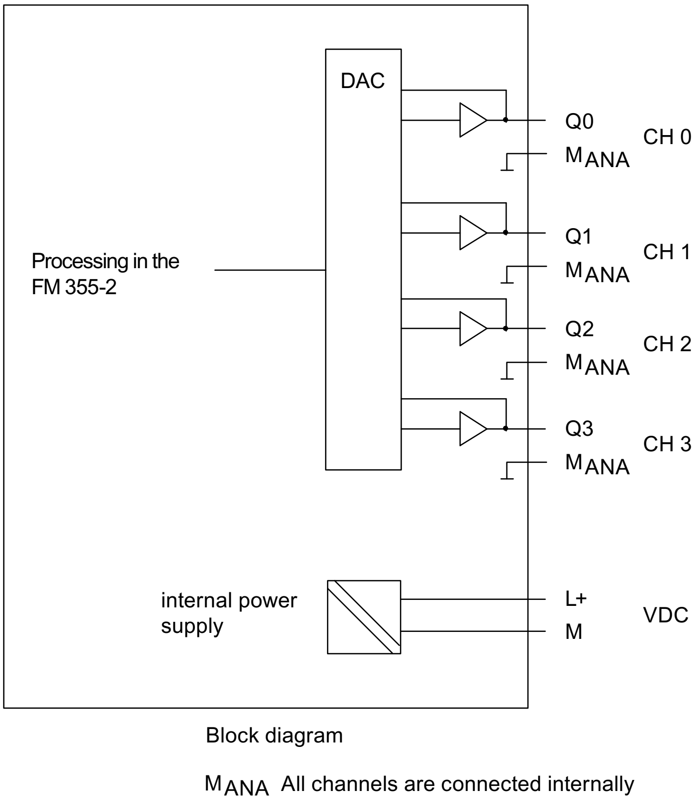


Figure 10-5 Block diagram of the analog outputs (FM 355-2 C)

See also

Basic structure of the FM 355-2 (Page 21)

Connecting measuring transmitters and loads/actuators

11

11.1 Connecting measuring sensors to analog inputs

Introduction

Depending on the measuring method, you can connect different measuring sensors to the analog inputs of the FM 355-2:

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

This chapter describes how to connect the measuring transmitters and what you have to watch out for when connecting them.

Cables 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 event you should ground the shield at one end of the cable only.

Reference point M_{ANA}

In order to operate the FM 355-2 you must create a connection between the reference point of the analog circuit M_{ANA} and the M connection of the CPU. A difference in potential between M_{ANA} and the M connection of the CPU might give rise to a corruption of the analog signal.

Abbreviations used

In both figures below the abbreviations used have the following meanings:

M+	Measuring cable (positive)
M–	Measuring cable (negative)
M_{ANA}	Reference potential of the analog measuring circuit
M	Connection to ground
L+	Power supply 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 difference in potential $\geq |U_{CM}|$ (Common Mode) may occur between the M- measuring cables 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.

Isolated measuring sensor

The isolated measuring sensors are not connected to the local potential to ground. They can be operated floating potential. 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 prevent the permissible value (U_{CM}) from being exceeded you must connect M- to M_{ANA}.

Also when connecting resistance sensors, you must create a connection for M- to M_{ANA}. This also applies to inputs with the corresponding parameter settings but which are unused.

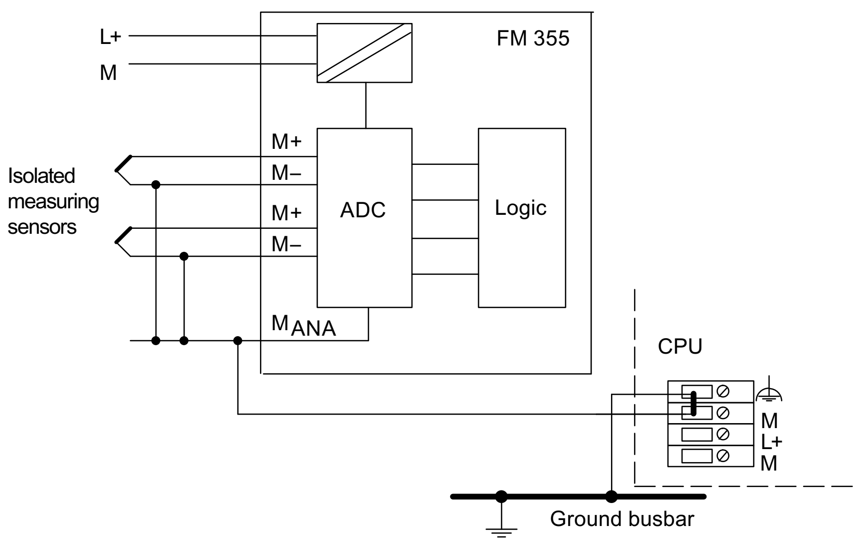


Figure 11-1 Block diagram for connecting isolated measuring sensors

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.

You must operate the CPU grounded, i.e. you must provide a jumper on the CPU between ⏚ and M.

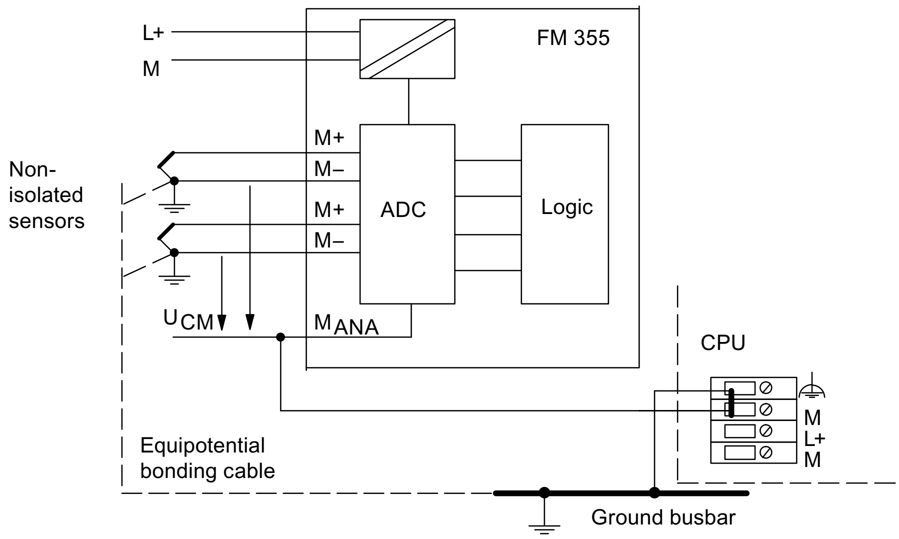


Figure 11-2 Block diagram for connecting non-isolated measuring sensors

11.2 Connecting Loads/Actuators to Analog Outputs

Introduction

This module can be used to supply current or voltage to loads/actuators. The figure below illustrates the principle.

Cables for analog signals

You should use shielded and twisted-pair cables for the analog signals. This reduces the effect of interference. You should ground the shield of the analog cables at both ends of the cable. 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. If this is the case, you should only ground the shield at one end of the cable.

Reference Point M_{ANA}

When operating the module always interconnect the reference point M_{ANA} of the measuring circuit with terminal M of the CPU. Connect the M_{ANA} terminal to the M terminal of the CPU. A difference in potential between M_{ANA} and the M connection of the CPU might give rise to a corruption of the analog signal.

Abbreviations Used

The abbreviations used in the figure below have the following meaning:

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

Connecting Loads to an Analog Output

Loads at an analog output have to 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 illustrates the connection of loads to an analog output of the module.

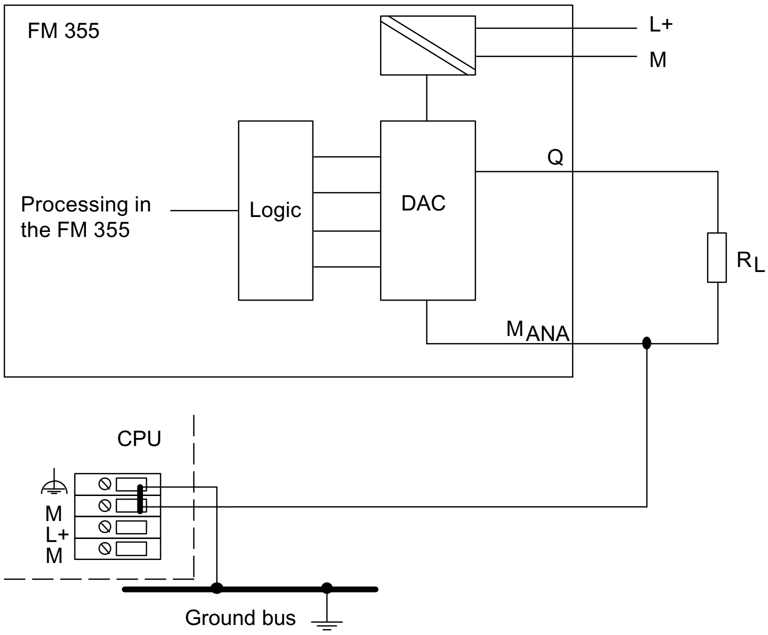


Figure 11-3 Connection of a load to the module

11.3 Use of thermocouple elements

Structure of thermocouples

A thermocouple comprises

- 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. Owing to the different compositions of the materials used, different types of thermocouples result, e.g. B, J, K. Irrespective of the type of thermocouple, the measuring principle is the same for all thermocouples.

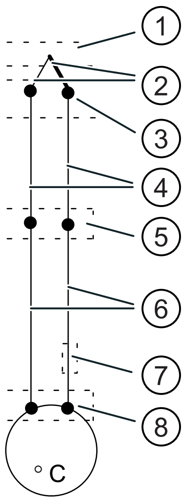


Figure 11-4 Structure of thermocouples

①	Measuring point
②	Thermocouple with plus and minus thermo wires
③	Connection point
④	Compensating cable
⑤	Reference junction
⑥	Incoming cable
⑦	Trimming resistor
⑧	Sensing point for the thermoelectric voltage

The way thermocouples work

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 magnitude of the thermoelectric voltage depends on the difference in temperature between the measuring junction and the free ends, and on the combination of materials in the thermocouple. Since a thermocouple always measures a temperature difference, to determine the temperature of the measuring point the free ends must be connected to a reference junction, held at a known temperature.

If this is not possible for technical reasons the reference junction temperature must be recorded and compensated by means of a Pt 100 via the additional input.

Extension to a reference junction

The thermocouples are extended from their connection point to a point where the temperature is as constant as possible (reference junction) by means of compensation cables.

The compensation cables are made of the same material as the wires of the thermocouple. 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.

Measuring the reference junction temperature

The impact of the temperature on the reference junction of a thermocouple (e.g. terminal box) can be compensated by measuring the reference junction temperature with a Pt 100.

If the actual comparison temperature deviates from the compensation temperature, then the thermal resistance will change. A positive or negative compensation voltage is generated and added to the thermal voltage.

Note:

- You must use the current source of channel 2 as the constant current source for the Pt 100.
- Channel 2 can then no longer be utilized for a Pt 100 measurement.

Use of thermocouples

When connecting thermocouples, you must take the following into account:

Depending on where you need the reference junction (locally), you can work with a configured or an external compensation.

If a configured compensation is used, a configurable reference juction temperature of the module is used for comparison.

With an external compensation the temperature of the reference junction of the thermocouples is taken into account by using a Pt 100.

This Pt 100 is connected to terminals 10 and 11 on the left-hand front connector of the module, whereby the Pt 100 must be located at the reference junction of the thermocouples. You must take its power supply from Channel 2 (terminals 12 and 13 of the left-hand front connector).

The following restriction applies:

- External compensation with the Pt 100 connected to terminals 10 and 11 of the module can only be carried out for one type of thermocouple. This means that all channels operating with external compensation must use the same type.

Abbreviations used

In both figures below the abbreviations used have the following meanings:

M+	Measuring cable (positive)
M–	Measuring cable (negative)
COMP+	Compensation connection (positive)
COMP–	Compensation connection (negative)
M	Connection to ground
L+	Power supply connection 24 VDC

Options for connecting thermocouples

The figures below show the various possible connections for thermocouples with external and configured compensation.

In addition to the following statements, the information from chapter "Connecting measuring sensors to analog inputs (Page 155)" also applies. The following figures do not contain the necessary connecting cables between the M terminal of the CPU, M-, M_{ANA} and ground potential, that result from the potential bonding of the FM 355-2 and the transducers (isolated, non-isolated). This means that you must continue to pay heed to the statements made in the chapter "Connecting measuring sensors to analog inputs (Page 155)" and implement them.

Thermocouples with external compensation of the reference junction

If all thermocouples connected to the inputs of the FM 355-2 have the same reference junction, you compensate as shown in the figure below. Thermocouples using the same reference junction must be of the same type.

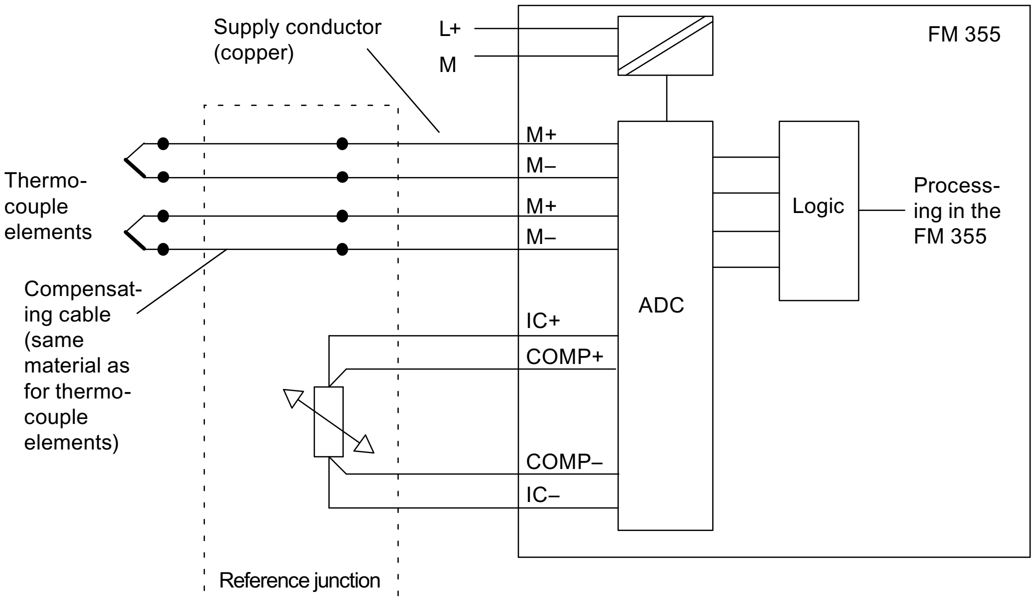


Figure 11-5 Block diagram for connecting thermocouples with external compensation

Thermocouples with configured or internal compensation of the reference junction

If thermocouples are connected directly to the inputs of the module by means of compensation cables, the configured or internal temperature compensation can be used.

The figures above show how to connect the thermocouples to ground.

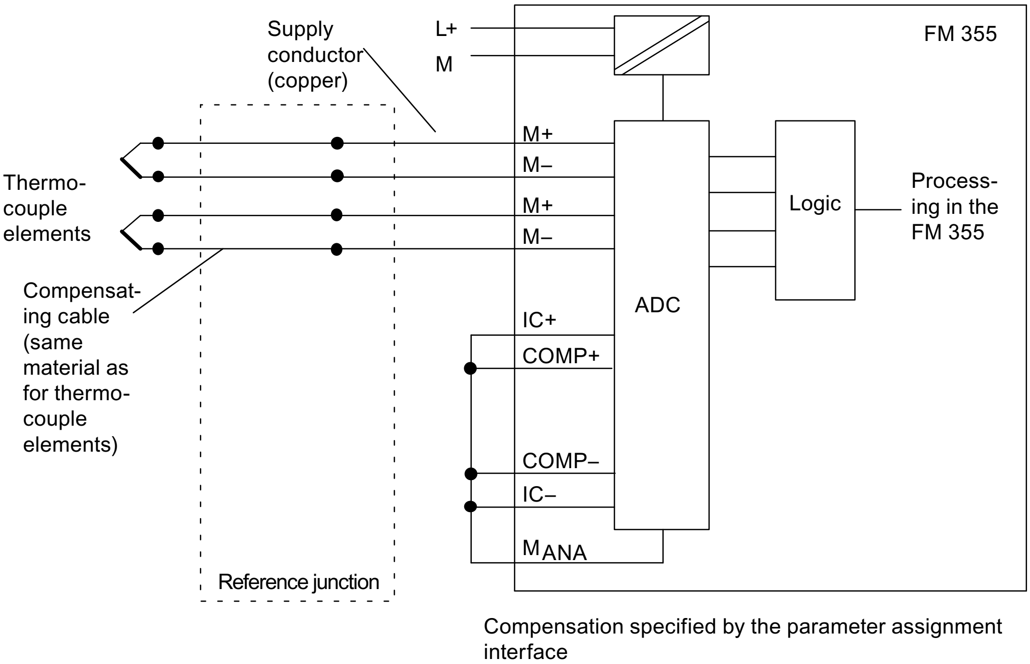


Figure 11-6 Block diagram for connecting thermocouple elements with configured or internal compensation

11.4 Connecting voltage and current transducers with resistance thermometers

Abbreviations used

In both figures below the abbreviations used have the following meanings:

I+	Constant current cable (positive)
I–	Constant current cable (negative)
M+	Measuring cable (positive)
M–	Measuring cable (negative)
M_{ANA}	Reference potential of the analog measuring circuit
M	Connection to ground
L+	Power supply connection 24 VDC

In addition to the following statements, the information from chapter "Connecting measuring sensors to analog inputs (Page 155)" also applies.

The following figures do not contain the necessary connecting cables between the M terminal of the CPU, M-, $M_{ANA}$and ground potential, that result from the potential bonding of the FM 355-2 and the transducers (isolated, non-isolated). This means that you must continue to observe and implement the information given in Chapter "Connecting measuring sensors to analog inputs (Page 155)".

Connecting voltage sensors

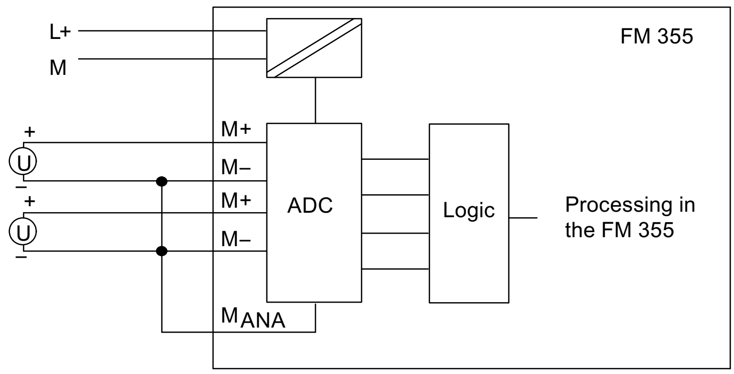


Figure 11-7 Connecting voltage sensors

Connecting current transducers to operate as 4-wire measuring transducers

4-wire measuring transducers possess a separate voltage supply

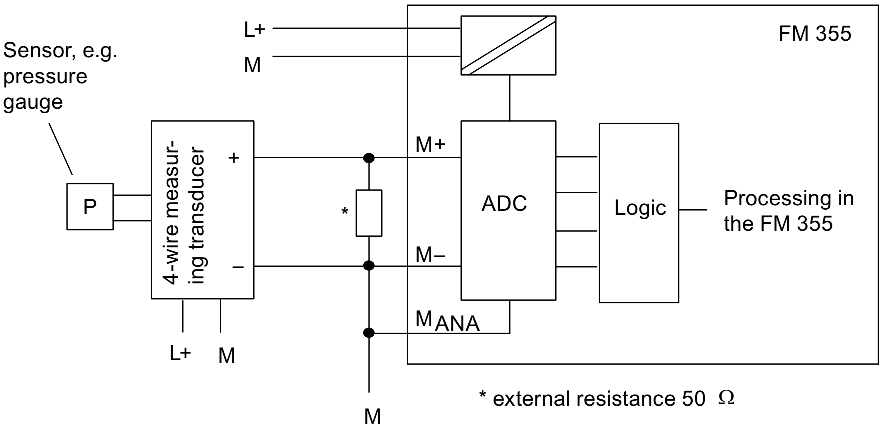


Figure 11-8 Connection of 4-wire measuring transducers

Connecting current transducers to operate as 2-wire measuring transducers

The 2-wire measuring transducer converts the input measuring quantity into current.

Supply voltage to the 2-wire measuring transducer must be short-circuit proof. Provide a fuse shown in the figure below.

2-wire measuring transducers must be isolated measuring sensors.

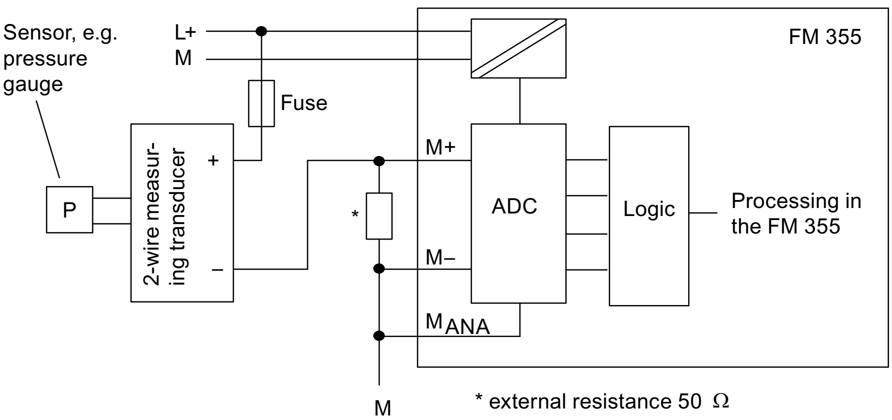


Figure 11-9 Connection of 2-wire transducers

Connecting of resistance thermometers (e.g. Pt 100) and resistors

The resistance thermometers/resistors are measured in a 4-conductor terminal. The resistance thermometers/resistors are supplied with constant current via terminals I_{C+} and I_{C-}. The voltage generated at the resistance/resistor is measured via terminals M + and M -. This makes it possible to achieve great accuracy in the measuring results of a 4-conductor terminal.

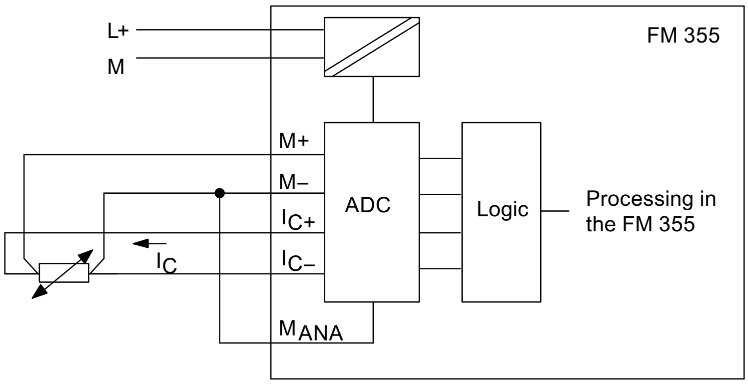


Figure 11-10 Connecting resistance thermometers

With a 2- or 3-conductor terminal you have to install appropriate jumpers between M+ and I_{C+} or M - and I_{C-} on the module. However, in so doing you must anticipate loss of accuracy in the measuring results.

11.5 Connecting loads/actuators to digital outputs

Introduction

The FM 355-2 S enables you to supply loads/actuators with voltage.

Abbreviations used

the abbreviations used have the following meanings:

Q	Digital output
R_L	Load/actuator
L+	24V DC voltage supply
M	Connection to ground

Connecting loads/actuators to an analog output

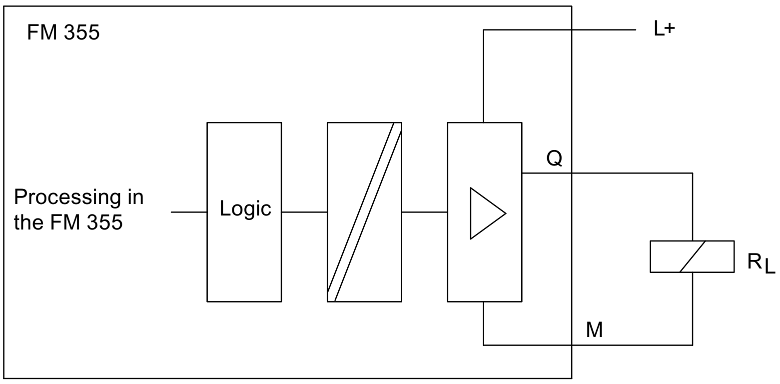


Figure 11-11 Connecting loads/actuators to an FM 355-2 S

Errors and diagnoses 12

12.1 Error display from the group error LED

When does the group error LED light up?

If the red group error LED lights up, there is either an error on the module (internal error) or in the line connections (external error).

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 errors are displayed by the group error LED lighting up:

Type of error	Diagnostic message	Possible cause	Correction
Internal errors	Module defective	Hardware error	Replace the module
	Time watchdog tripped	Hardware error	Replace the 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 the module
		Analog input wire break	Remedy wire break
		Analog input measuring range violation (underrange)	Check measuring signal
		Analog input measuring range violation (overrange)	Check measuring signal
		Analog output wire break	Remedy wire break
		Analog output short circuit	Eliminate short circuit
	Missing external auxiliary supply	24 V supply missing	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 the next section.

12.2 Triggering diagnostic interrupts

What is a diagnostic interrupt?

If the user program is to react to an internal fault or external error, you can configure a diagnostic interrupt. The cyclical CPU program is interrupted and the diagnostic interrupt OB, OB 82 is called.

Which events may trigger a diagnostic interrupt?

The list shows you which events can trigger a diagnostic interrupt:

- Module configuration missing or faulty
- Module defective
- Wire break when analog inputs are made (4 up to 20 mA only)
- Overflow and underflow during analog inputs
- Load break or short-circuit during analog outputs

Enabling the diagnostic interrupt

You can enable or disable the diagnostic interrupt for the module in the basic parameter tab.

The default setting for the diagnostic interrupt is disabled.

Reactions to an event triggering an interrupt

If an event occurs that can trigger a diagnostic interrupt, the following occurs:

- The diagnostics information is written to the diagnostics data records DS0 and DS1 on the module.
- The group error LED lights up.
- Diagnostic interrupt OB is called (OB 82).
- Diagnostic data record DS0 is written to the start information of diagnostic interrupt OB.
- If there is no hardware defect, the module resumes control operation.

If no OB 82 is programmed, the CPU goes into STOP.

Diagnostics data record DS0 and DS1

The information about which event triggered a diagnostic interrupt is written to the diagnostic data records DS0 and DS1. The length of the diagnostic data record DS0 is four bytes; the record length of DS1 is 16 bytes of which the first 4 bytes are identical with DS0.

12.3 Diagnostic data records DS0 and DS1

Reading a data record from the module

Diagnostic data record DS0 is automatically transferred to the start information when the diagnostic OBs are called. These four bytes are written to the local date (bytes 8-11) of the OB 82.

You can read out diagnostic data record DS1 (and hence also the content of DS0) from the module by means of the FB 55 FMT_DS1 (see appendix "Instance DB of the FB 55 FMT_DS1 (Page 233)"). This only makes sense if an error is reported in a channel in the DS0.

The FB 55 FMT_DS1 must be called in the same OB as an FB FMT_PID that might be present (e.g. OB 35). You can do this as follows: While OB 82 is being processed, set the READ_DS1 bit. The FMT_DS1 in OB 35 then reads the diagnostic data record DS1.

How does the diagnosis text appear in the diagnostics buffer?

To enter the diagnostic message in the diagnostics buffer you must call the SFC 52 "Write user-specific message to diagnostics buffer" in the user program. The event number of the respective diagnosis message is specified on the input parameter EVENTN. The interrupt is entered in the diagnostics buffer defined as x = 1 for incoming and x = 0 for outgoing. In addition to the time of the entry, the appropriate diagnosis text is displayed in the "Meaning" column.

The assignment of the diagnostic data records DS0 and the Start information

The following table shows the assignment of the diagnostic data record DS0 in the Start information. Any bits not listed have no meaning and are zero.

Table 12- 1 Assignment of diagnostic data record DS0

Byte	Bit	Meaning	Remark	Event no.
0	0	Module fault	Is set at each diagnostics event	8:x:00
	1	Internal error	Is set at every internal error: • Watchdog timeout • EPROM error • ADC/DAC error • Analog input hardware error	8:x:01
	2	External error	Is set at every external error: • Missing external auxiliary voltage • Faulty parameter assignment • Analog input wire break (only in range 4 to 20 mA) • Analog input below measuring range • Analog input measuring range exceeded • Analog output load break • Analog output short circuit	8:x:02
	3	Error in one channel	See DS1, from byte 7 for further breakdown	8:x:03
	4	Missing external auxiliary voltage	24 V supply for FM 355-2 has failed	8:x:04
	6	Unused	-	-
	7	Faulty parameter assignment	The module is unable to use a parameter. Reason: Parameters unknown or illegal combination of parameters. See menu PLC > Parameter assignment error display.	8:x:07
1	0 ... 3	Module class	8 is always assigned.	-
	4	Channel-specific diagnosis	If set, the module can provide additional channel information and a channel error exists (see DS1, byte 7 to 12)	-
2	3	Time watchdog responds	Hardware fault	8:x:33
3	2	EPROM error	Module defective	8:x:42
	4	ADC/DAC error	Module defective	8:x:44

Diagnostic data record DS1

The length of diagnostic data record DS1 is 16 bytes. The first 4 bytes are identical to diagnostic data record DS0. The table below shows the assignment of the remaining bytes. Any bits not listed have no meaning and are zero.

Diagnostic data record DS1 of the FM 355-2

Table 12- 2 Assignments of bytes 4 to 12 of diagnostic data record DS1 of the FM 355-2

<table>
<tr><th>Byte</th><th>Bit</th><th>Meaning</th><th colspan="2">Remark</th><th>Event no.</th></tr>
<tr><td>4</td><td>0 ... 7</td><td>Channel type</td><td colspan="2">75H is always assigned.</td><td>-</td></tr>
<tr><td>5</td><td>0 ... 7</td><td>Length of the diagnostics information</td><td colspan="2">8 is always assigned.</td><td>-</td></tr>
<tr><td>6</td><td>0 ... 7</td><td>Number of channels</td><td colspan="2">5 always assigned (4 controllers + 1 reference channel)</td><td>-</td></tr>
<tr><td>7</td><td>0 ... 4</td><td>Channel error vector</td><td colspan="2">One bit is assigned to each channel (0...3; 4 for reference channel).</td><td>-</td></tr>
<tr><td rowspan="8">8</td><td>0</td><td>Analog input hardware error</td><td rowspan="8">Channel-specific diagnostics channel 0</td><td></td><td>8:x:B0</td></tr>
<tr><td>1</td><td>Unused</td><td></td><td>8:x:B1</td></tr>
<tr><td>2</td><td>Analog input wire break (only in range 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 below measuring range</td><td></td><td>8:x:B4</td></tr>
<tr><td>5</td><td>Analog input measuring range exceeded</td><td></td><td>8:x:B5</td></tr>
<tr><td>6</td><td>Analog output wire breakage</td><td>Only with the current output of the C controller</td><td>8:x:B6</td></tr>
<tr><td>7</td><td>Analog output short circuit</td><td>Only with the voltage output of the C controller</td><td>8:x:B7</td></tr>
<tr><td>9</td><td>0 ... 7</td><td>see Byte 8</td><td colspan="2">Channel-specific diagnostics channel 1</td><td>See above</td></tr>
<tr><td>10</td><td>0 ... 7</td><td>see Byte 8</td><td colspan="2">Channel-specific diagnostics channel 2</td><td>See above</td></tr>
<tr><td>11</td><td>0 ... 7</td><td>see Byte 8</td><td colspan="2">Channel-specific diagnostics channel 3</td><td>See above</td></tr>
<tr><td>12</td><td>0 ... 5</td><td>see Byte 8</td><td colspan="2">Diagnostics for reference channel</td><td>See above</td></tr>
</table>

12.4 Measuring transducer fault

Measuring transducer faults

The FM 355-2 can identify the following measuring transducer faults:

- Measuring range violation (underrange)
- Measuring range violation (overrange)
- Wire break (not for all measuring ranges)

If one of these faults occur, the group error bit "external error" is set in diagnostic data record DS0 and channel-specific error bits are set in diagnostic data record DS1 (see table above). Once these faults disappear, the respective bits are reset.

The following table shows the specific measuring range limits at which the error bits are set or reset:

Measuring range	Error bit measuring range violation (underrange) at...	Error bit measuring range violation (overrange) 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 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	-
Pt 100 (-200 to 556 °C) (-328 to 1032 °F)	< 30.82 mV	> 499.06 mV	-
Pt 100 (-200 to 130 °C) (-328 to 264 °F)	< 30.82 mV	> 254.12 mV	-
Type B thermocouple	< 0 mV	> 13.81 mV	-
Type E thermocouple (-270.0 to 1,000.03 °C)	< -9.84 mV	> 76.36 mV	-
Type J thermocouple	< -8.1 mV	> 69.54 mV	-
Type K thermocouple	< -6.45 mV	> 54.88 mV	-
Type R thermocouple	< -0.23 mV	> 21.11 mV	-
Type S thermocouple	< -0.24 mV	> 18.7 mV	-
Free thermocouple	< lower input value of the polyline	> upper input value of the polyline	-

Examples 13

13.1 Introduction

Prerequisites

- You have set up and wired an S7 station consisting of a power supply module and a CPU.
- STEP 7 (>= V5.1 SP4) is installed on your programming device or PC.
- Your programming device or PC is connected to the CPU.
- The CPU and FM 355-2 are supplied with voltage

Preparations for the examples

1. With SIMATIC Manager open the zEn28_01_FMTemp sample project in the ...\STEP7\EXAMPLES directory and copy it into your project directory using an appropriate name (File > Save as). Use the View > detail display for full information.
2. Create a new project.
3. Select one of the temperature samples and copy it into your project (including hardware).
4. Adapt the hardware (if necessary replace the CPU).
5. Configure the hardware with HW Config (set time interrupt OB).
6. Save the hardware configuration and download it to the CPU.
7. Download the block folder to the CPU.

Sample code

The samples are written in STL. You can view them directly via the KOP/STL/FUP Editor. In this editor select via View > Displays with "Symbolic view", "Symbol selection" and "Comments" If you have sufficient space on the screen you can also have the "symbol information" displayed.

Sample application

The sample programs contain variable tables (VAT) with which you can view and change the values. You can view curve traces using the graphic plotter in the configuration software.

Further use of a sample

The sample code has not been optimized and is not designed for all eventualities.

In order to keep the size of the programs down, error evaluation has not been programmed in detail in the example programs.

13.2 Sample application for FM 355-2 C (closed-loop controller)

Introduction

In the zEn28_01_FMTemp project you will find the example "closed-loop controller FM 355-2 C", which permits you to operate the FM 355-2 C in a simulated process on the CPU. This enables you to test the module without running a physical process.

Loading the example program

To install the program, proceed as follows:

1. Download the configuration to the CPU.
2. Start the "HW Config program: Configure hardware", start the FM 355-2 parameter assignment application.
3. In order to be able to work with the loop display, the graphic plotter and controller optimization, open the DB 52 with the menu item Test > ...> instance DB.

Sample program application

The example contains a closed loop controller in conjunction with a simulated control system consisting of a

The example program permits you to easily generate a closed-loop PID controller, and enables you to configure and test all its properties offline in a typical control process.

The sample program enables you to easily understand the operation and configuration of controllers with analog output signal as well as the way they are used for controlling processes with proportional action final control elements. Hence it can be also utilized for introductory or training purposes.

Appropriate selection of parameters gives you a process that represents an approximation of the real process. You can use the controller tuning feature to determine a controller parameter record to match your process model.

In this example the FB FMT_PID with READ_OUT = TRUE is called because the process model LMN_A and LMN_B is being used which cannot be read via direct I/O access. When used for a physical process, it is not necessary to set READ_OUT cyclically to TRUE.

Functions of the example program

Essentially, the example comprises the two function blocks FMT_PID (FB 52) and PROC_HCC (FB 100). Here PROC_HCC simulates the control process with third order compensation. The FB FMT_PV (FB 57) transfers the process values to the FM.

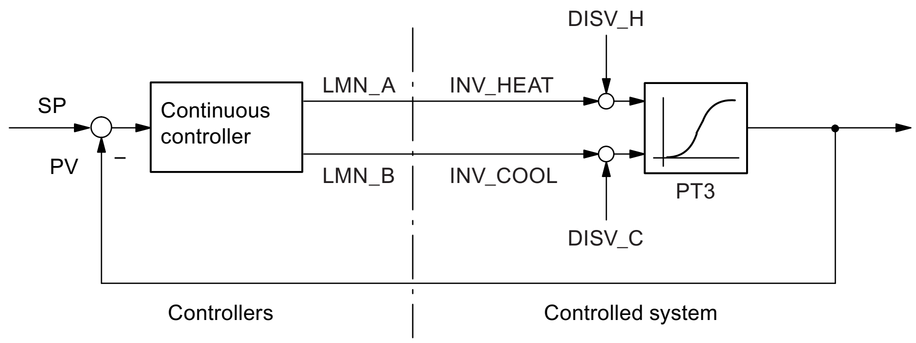


Figure 13-1 Example 355-2 C, control loop

Function block PROC_HCC simulates a series circuit comprising three lag elements of the first order (figure below). The disturbance variable DISV is always added to the output signal of the lag element enabling process disturbances to be activated manually at this point. The static process gain can be set via the GAIN factor.

The process structure is set up twice to implement an additional cooling section.

When initializing COM_RST = TRUE the output variable of the simulated control process is set to OUTV = (INV_HEAT+DISV_H) * GAIN_H - (INV_COOL+DISV_C) * GAIN_C + AMB_TEM.

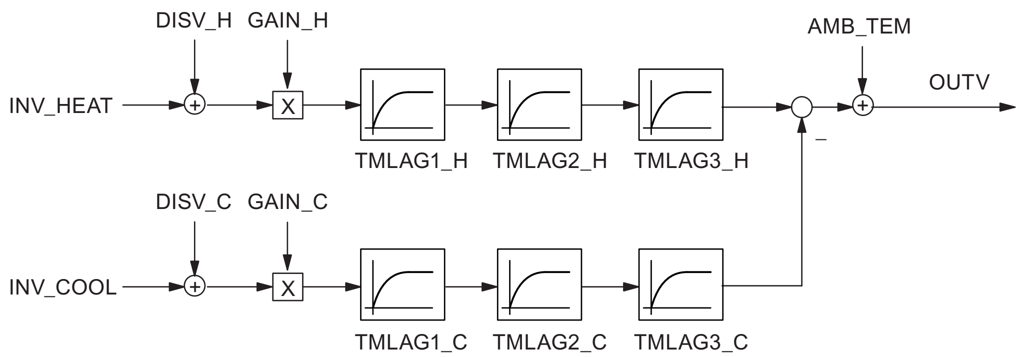


Figure 13-2 Structure and parameters of the process block PROC_HCC

Block structure

Table 13- 1 Example modules

Block	Name (on toolbar)	Description
OB 100	COMPLETE_RESTART	Restart OB
OB 35	CYC_INT5	time-controlled OB (100 ms) with example
FB 52	FMT_PID	closed-loop controller FM 355-2 C
FB 57	FMT_PV	Process value transfer to FM 355-2 C
FB 100	PROC_HCC	Process for closed-loop controllers
DB 52	DB_FMT_PID	Instance DB to FMT_PID
DB 57	DB_FMT_PV	Instance DB to FMT_PV
DB 100	DB_PROC_HCC	Instance DB to PROC_HCC

Parameter tuning and simulation

A practical configuration of a closed-loop controller with PID action shows you the response of a control loop with a simulated PT control system of the second order. The set process parameters represent an approximation of the behavior of a fast temperature process.

The following table contains the currently set values of the relevant parameters relevant to controller 0 and process.

Parameters	Type	Parameter Assignment	Description
Controller:			
GAIN	REAL	12.0	P-action coefficient
TI	REAL	12.0s	Integration time
TD	REAL	3.0s	Derivative time
PFAC_SP	REAL	0.8	Proportional factor
RATIOFAC	REAL	0.5	Ratio factor
CON_ZONE	REAL	31.0	Control zone width
Control process:			
CYCLE	REAL	100 ms	Scan time
GAIN_H	REAL	1.5	Heating process gain
TMLAG1_H	REAL	60s	Heating time lag 1
TMLAG2_H	REAL	10s	Heating time lag 2
TMLAG3_H	REAL	0s	Heating time lag 3
GAIN_C	REAL	3.0	Cooling process gain
TMLAG1_C	REAL	60s	Cooling time lag 1
TMLAG2_C	REAL	10 s	Cooling time lag 2
TMLAG3_C	REAL	0s	Cooling time lag 3

The controller parameters above were determined in a tuning process (TUN_DLMN = 80.0 and setpoint step change from 0 to 90). You should now perform this tuning operation.

After you have tuned heating, tune the cooling using the new setpoint value (TUN_CLMN = -20.0).

Note

Every time you perform a tuning operation, you will receive slightly different parameter values for the controller. The reason is that the clock cycle of the watchdog interrupt OBs (e.g. 100 ms) and the cycle time of the FM 355-2 (e.g. 100.5 ms) never match completely. This is why the process model in the CPU does not return a smooth process variable for your tuning operations on the FM 355-2.

Thereafter you can test the control response by means of set point step change and activating disturbances (parameter DISV_H/C at DB_PROC_HCC). Also test the effect of the PFAC_SP parameter: If, for example, you raise PFAC_SP from 0.8 to 1.0, this will also increase overshoot.

Please note that you must also set LOAD_PAR = TRUE when you modify parameters via FMT_PID.

Note

With enabled control zone (CONZ_ON = TRUE), activate setpoint jumps > CON_ZONE (or < -CON_ZONE/RATIOFAC for negative setpoint jumps) to test control response. In this case PFAC_SP has no effect.

13.3 Application example for the FM 355-2 S (pulse controller)

Introduction

In project file zEn28_01_FMTemp you will find the example "Pulse controller FM 355-2 S", which makes it possible to operate the FM 355-2 S on the CPU simulation processes. This makes it possible to test the module without a real process.

Load the sample program

To install the program, proceed as follows:

1. Download the configuration to the CPU.
2. In "HW Config: Configure hardware", start the configuration software of the FM 355-2.
3. In order to enable work with the loop monitor, the curve recorder and controller tuning, open DB 52 under menu item Test > ...> Instance DB.

Sample program application

The sample contains a pulse controller (three-component controller), in conjunction with a simulated control system consisting of two lag elements of the third order (PT3) for heating and cooling.

With the help of this sample program, you can easily generate a closed-loop PID controller and configure and test all properties of this controller offline in a typical process.

The sample program helps you to understand the operation and configuration of controllers with pulse output and the way they are used to control processes with binary inputs. Hence, the sample is also suitable for system introduction and training courses.

Appropriate selection of parameters gives you a process that represents an approximation of the real process. You can use the controller tuning feature to determine a controller parameter record to match your process model.

In the sample we shall call FB FMT_PID with READ_OUT = TRUE, to ensure that the pulses QLMNUP and QLMNDN affect every cycle of the process model in the CPU. This would not be ensured with direct I/O access. When used in a real process, there is no need to set READ_OUT = TRUE periodically.

Sample program functions

The sample primarily consists of the two function blocks FMT_PID (FB 52) and PROC_HCP (FB 102). PROC_HCP simulates a control system with a compensation element of the third order. FB FMT_PV (FB 57) transfers the actual values in the FM.

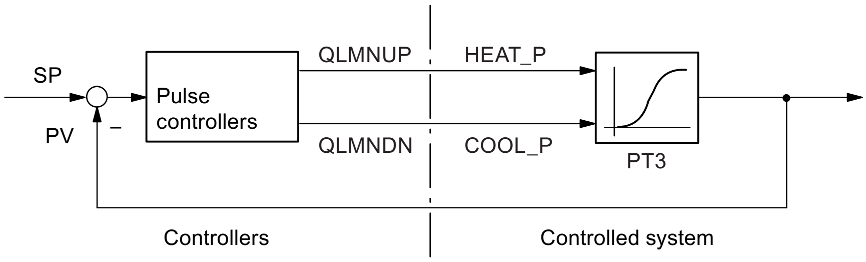


Figure 13-3 Sample application for FM 355-2 S, closed-loop controller

Function block PROC_HCP forms an image of a heating/cooling process with binary inputs (see illustration below). The binary input signals are converted into continuous floating-point values (0.0 or 100.0). After the activation of the disturbance variable and multiplication by the process gain value, the actual values are passed through three lag elements of the first order. This procedure is performed separately in the heating and cooling process. Finally, the value of the ambient temperature is added.

When initialized with COM_RST = TRUE, the output variable of the simulated process is set to the value OUTV = DISV_H * GAIN_H - DISV_C * GAIN_C + AMB_TEM.

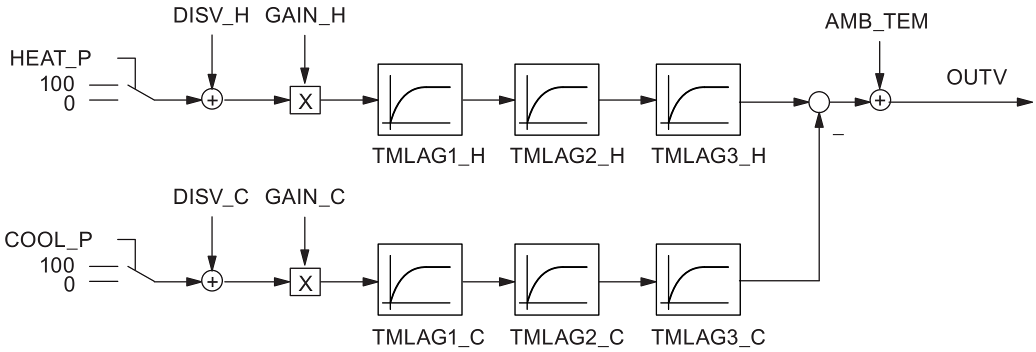


Figure 13-4 Structure and parameters of the process module PROC_HCP

Block structure

Table 13- 2 Example modules

Block	Name (on toolbar)	Description
OB 100	COMPLETE_RESTART	Restart OB
OB 35	CYC_INT5	Time-controlled OB (100 ms) with example
FB 52	FMT_PID	Pulse controller FM 355-2 S
FC 57	FMT_PV	Process value transfer in FM 355-2 S
FB 102	PROC_HCP	Process for pulse controllers
DB 52	DB_FMT_PID	Instance DB to FMT_PID
DB 57	DB_FMT_PV	Instance DB to FMT_PV
DB 102	DB_PROC_HCP	Instance DB to PROC_HCP

Parameter tuning and simulation

We shall use a practical configuration of a controller with PID action to show you the response of a control loop with a simulated PT control system of the second order. The set process parameters approximately represent the response of a fast temperature control process.

The following table contains the currently set values of the relevant parameters for controller 0 and for the process.

Parameter	Type	Parameterization	Description
Controller:			
GAIN	REAL	12.0	P-action coefficient
TI	REAL	12 s	Integration time
TD	REAL	3 s	Derivative time
PFAC_SP	REAL	0.8	Proportional factor
RATIOFAC	REAL	0.5	Ratio factor
CON_ZONE	REAL	31.0	Control zone width
Control process:			
CYCLE	REAL	100 ms	Scan time
GAIN_H	REAL	1.5	Heating process gain
TMLAG1_H	REAL	60s	Heating time lag 1
TMLAG2_H	REAL	10 s	Heating time lag 2
TMLAG3_H	REAL	0s	Heating time lag 3
GAIN_C	REAL	3.0	Cooling process gain
TMLAG1_C	REAL	60s	Cooling time lag 1
TMLAG2_C	REAL	10 s	Cooling time lag 2
TMLAG3_C	REAL	0s	Cooling time lag 3

The controller parameters above were determined in a tuning process (TUN_DLMN = 80.0 and setpoint step change from 0 to 90). You should now perform this tuning operation.

After you have tuned heating, tune the cooling using the new setpoint value (TUN_CLMN = -20.0).

Note

Every time you perform a tuning operation, you will receive slightly different parameter values for the controller. The reason is that the cycle time of the cyclic interrupt OBs (e.g. 100 ms) and the cycle time of the FM 355-2 (e.g. 100.5 ms) never match completely. This is why the process model in the CPU does not return a smooth process variable for your tuning operations on the FM 355-2.

You can subsequently activate setpoint jumps and disturbance variables to test control response (Parameter DISV at DB_PROC_HCP). Also test the effect of parameter PFAC_SP: For example, when you increase the value in PFAC_SP from 0.8 to 1.0, you will likewise increase overshoot.

Please note that you must also set LOAD_PAR = TRUE when you modify parameters via FMT_PID.

Note

With enabled control zone (CONZ_ON = TRUE), activate setpoint jumps > CON_ZONE (or < -CON_ZONE/RATIOFAC for negative setpoint jumps) to test control response. In this case PFAC_SP has no effect.

13.4 Application example for the FM 355-2 S (step controller)

Introduction

In project file zEn28_01_FMTemp you will find the example "Step controller FM 355-2 S", which makes it possible to operate the FM 355-2 S on the CPU simulation processes. This makes it possible to test the module without a real process.

Load the sample program

To install the program, proceed as follows:

1. Download the configuration to the CPU.
2. Start the "HWConfig program: Configure hardware" start the FM 355-2 parameter assignment application.
3. In order to enable work with the loop monitor, the curve recorder and controller tuning, open DB 52 under menu item Test > ...> Instance DB.

Sample program application

The sample contains a step controller without analog position feedback, in conjunction with a simulated control system that consists of a lag element of the third order (PT3).

With the help of this sample program, you can easily generate a step controller and configure and test all properties of this controller offline in a typical process.

The sample program helps you to understand the operation and configuration of controllers with stepping output signals and the way they are used to control processes with binary inputs. Hence, the sample is also suitable for system introduction and training courses.

Appropriate selection of parameters gives you a process that represents an approximation of the real process. You can use the controller tuning feature to determine a controller parameter record to match your process model.

Sample program functions

The sample primarily consists of the two function blocks FMT_PID (FB 52) and PROC_S (FB 101). PROC_S simulates a control system which contains the function elements “Valve” and PT3. The controller is supplied with information, the controlled variable and, if applicable, limit signals.

FB FMT_PV (FB 57) transfers the actual values in the FM.

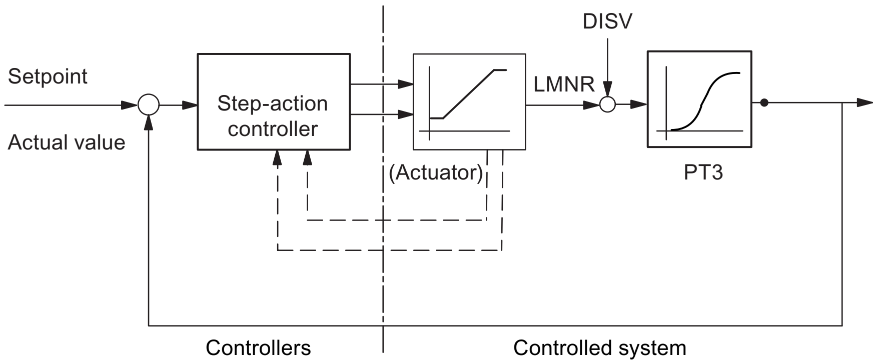


Figure 13-5 Sample FM 355-2 S, closed-loop controller

Function block PROC_S forms a series circuit that consists of an integrated final controlling element and three lag elements of the first order. A disturbance variable DISV is always added to the output signal of the final controlling element, so that process disturbances can be activated manually at this location. The static process gain can be set via the GAIN factor.

The motor actuating time parameter MTR_TM defines the time required by the final controlling element to cover the distance between two limits.

When initialized with COM_RST = TRUE, the output variable of the simulated process is set to OUTV = (LMNR+ DISV) * GAIN + AMB_TEM.

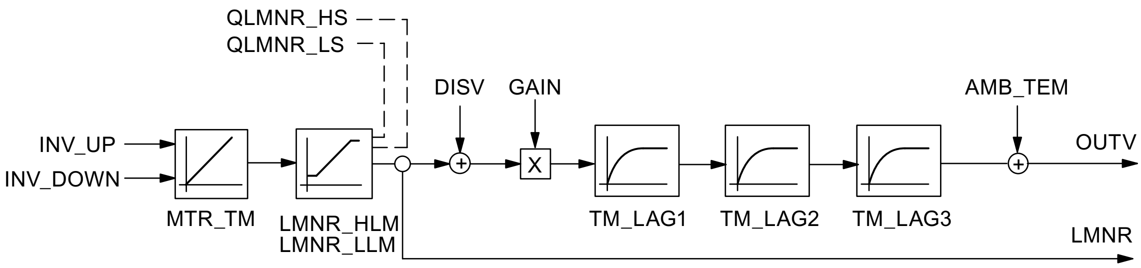


Figure 13-6 Structure and parameters of the process module PROC_S

Block structure

Table 13- 3 Example modules

Block	Name (on toolbar)	Description
OB 100	COMPLETE_RESTART	Restart OB
OB 35	CYC_INT5	Time-controlled OB (100 ms) with example
FB 52	FMT_PID	Step controller FM 355-2 S
FB 57	FMT_PV	Actual value transfer in FM 355-2 S
FB 101	PROC_S	Process for step controller
DB 52	DB_FMT_PID	Instance DB to FMT_PID
DB 57	DB_FMT_PV	Instance DB to FMT_PV
DB 101	DB_PROC_HCC	Instance DB to PROC_HCC

Parameter tuning and simulation

We shall use a practical configuration of a controller with PI action to show you the response of a control loop with a simulated PT control system of the second order. The set process parameters approximately represent the response of a fast temperature control process.

The order of the process is reduced by one degree when one of the lag times TM_LAGx is set to 0 s.

The following table contains the currently set values of the relevant parameters for controller 0 and for the process.

Parameters	Type	Parameterization	Description
Controller:			
GAIN	REAL	2.2	P-action coefficient
TI	REAL	52.0 s	Integration time
PFAC_SP	REAL	0.8	Proportional factor
MTR_TM	REAL	20 s	Motor actuating time
Control process:			
CYCLE	REAL	100 ms	Scan time
GAIN	REAL	1.5	Servo gain
MTR_TM	REAL	20 s	Motor actuating time
TM_LAG1	REAL	60 s	Lag time 1
TM_LAG2	REAL	10 s	Lag time 2
TM_LAG3	REAL	0 s	Lag time 3

The controller parameters above were determined in a tuning process (TUN_DLMN = 80 and setpoint step change from 0 to 90). You should now perform this tuning operation.

Note

Every time you perform a tuning operation, you will receive slightly different parameter values for the controller. The reason is that the clock cycle of the watchdog interrupt OBs (e.g. 100 ms) and the cycle time of the FM 355-2 (e.g. 100.5 ms) never match completely. This is why the process model in the CPU does not return a smooth process variable for your tuning operations on the FM 355-2.

You can subsequently activate setpoint jumps and disturbance variables to test control response (Parameter DISV at DB_PROC_S). Also test the effect of parameter PFAC_SP: For example, when you increase the value in PFAC_SP from 0.8 to 1.0, you will likewise increase overshoot.

Please note that you must also set LOAD_PAR = TRUE when you modify parameters via FMT_PID.

Note

The curve recorder shows the simulated position feedback of the process model. This improves visualization of the sample, but does not exist on a physical step controller without position feedback.

13.5 Sample application for diagnostics

Introduction

In project zEn28_01_FMTemp you can find the sample “Diagnose DS1 FM 355-2 C”, demonstrating the application and evaluation of diagnostics in DS1 of the controller module.

Prerequisites

- Diagnostic interrupts are only triggered in the CPU if you make the following settings in the ”Basic parameter” tab, under HW Config in the “Properties - FM 355-2 C PID Control” window:
  - Generate interrupt: Yes
  - Selected interrupt: Diagnosis

Load the sample program

Using the system data, download the configuration to the CPU.

Sample program application

Parameter READ_DS1 of FMT_DS1 will be set in OB 82 when an interrupt occurs. OB 35 calls FMT_DS1. It reads the diagnostics data record DS1 of the module.

Block structure

Table 13- 4 Example modules

Block	Name (on toolbar)	Description
OB 35	CYC_INT5	Time-controlled OB (100 ms) with example
OB 82	I/O_FLT1	Precise diagnostics of errors
FB 55	FMT_DS1	Reading diagnostic record DS1
DB 55	DB_FMT_DS1	Instance DB to FMT_DS1

See also

Triggering diagnostic interrupts (Page 172)

13.6 Operating the sample with OP 27

Introduction

The sample project contains the object “FM355-2 BuB”, which is of the type “SIMATIC OP” This represents an operator panel OP27 configuration that is compatible to your sample program. If an OP27 is available to you, you can operate the sample programs by means of “FM355-2 BuB”.

In order to do so, load "FM355-2 BuB" with the configuring software ProTool in the OP 27. Please refer to the OP documentation for the necessary connections and measures.

Home screen

A start screen appears after the OP startup: Here you select the corresponding view for your sample. The loop monitor opens.

Loop monitor

The loop monitor contains operator control elements for the manual input of setpoints and values as well as for manual/auto changeover. In the step controller sample, you can preset the manipulated value signals for opening and closing the control valve.

Out of this loop monitor you can change to one of the following operator control screens:

- PID parameters
- Curve recorder
- Controller optimization

PID parameters

In this window you can input the PID controller parameters and control zone parameters. In the step controller sample you replace the control zone parameters with the motor actuating time.

Curve recorder

The curve shows the setpoint, as well as the actual value and the manipulated value. In the step controller sample, the display shows the position feedback value, rather than the manipulated value.

Note

The controller type “Step controller without position feedback” we have used in our sample does not have a position feedback element. In the example, it is read from FB PROC_S.

Controller optimization

In this window you can start controller tuning.

1. Monitor the curve recorder until the quasi-static state is reached.
2. Press F6 to set the controller ready for tuning.
3. Check the manipulated value difference.
4. Specify a suitable setpoint step change.
5. Monitor the curve.
6. Check the result by means of parameter PHASE and STATUS_H.

See also

Overview (Page 83)

13.7 Example of a cascade control circuit

Dual-loop cascade circuit

The figure below shows the dual-loop cascade control of a module:

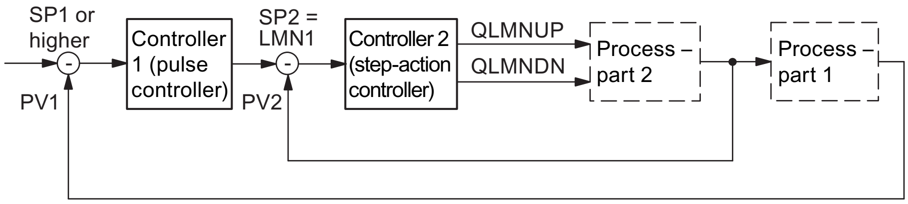


Figure 13-7 Dual-loop cascade circuit

To create this controller circuit with an FM 355-2 S, configure a pulse controller with reference variable algorithm and select the manipulated value of the reference variable controller at the setpoint input of the follow-up controller.

You can also generate a cascade control with an FM 355-2 C. In this case, the reference variable controllers are closed-loop controllers and the follow-up controllers are configured as “Set-value or cascade controller”. The circuit is identical.

In the follow-up controller, the manipulated value of the reference variable controller is scaled to 0 to 100% of the value range of actual value A, and is then further processed as setpoint value.

13.8 Example of a ratio control

Ratio control with two control loops

The figure below shows a ratio control with two control loops in a module:

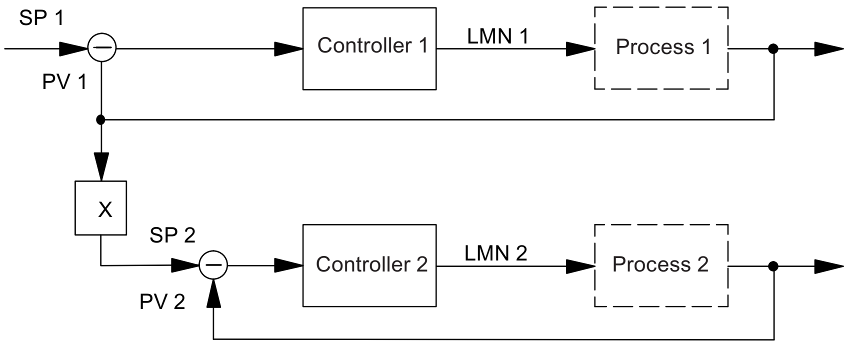


Figure 13-8 Ratio control with two control loops

Controller 1 is configured with fixed setpoint algorithm. Controller 2 is configured with a ratio or blending algorithm.

Generate the circuit for controller 2 in the “Error variable” block as follows:

- Specify ratio factor FAC via the setpoint input of the FB FMT_PID (SP_RE).
- Connect actual value PV1 to actual value D.
- Connect actual value PV2 to actual value A.

13.9 Example of a blending control circuit

Blending control with three components

The figure below shows a blending control with three components in a module.

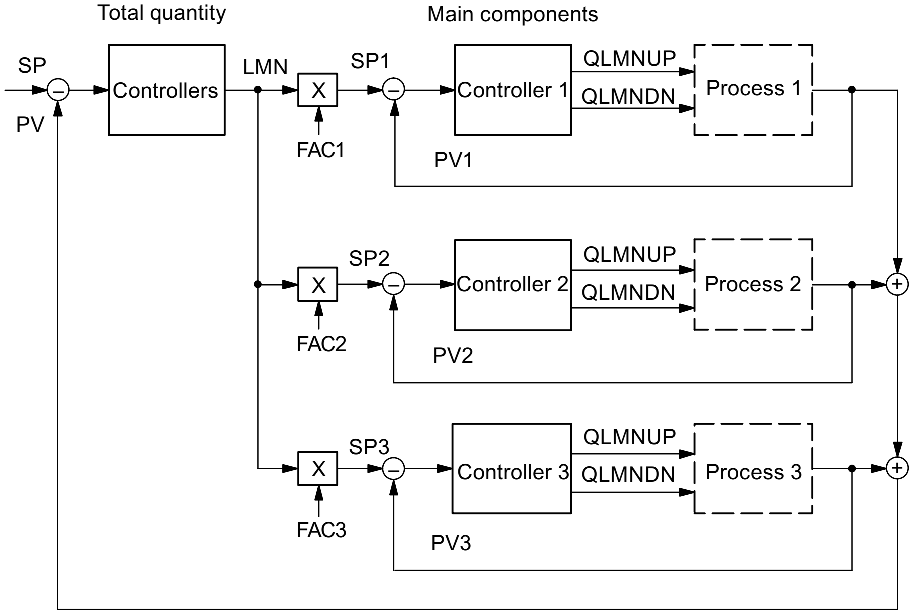


Figure 13-9 Blending control with three components

The reference variable controller is configured with three-component and pulse algorithm.

In the “Error variable” block, connect the three actual values PV1, PV2 and PV3 to actual values A, B and C.

You can click on the “Sum” button to open the dialog for the configuration of the proportional factors (FAC4, FAC5) for process variables PV2 and PV3. If necessary, you can modify these factors during runtime by means of FB FMT_PAR.

The follow-up controllers 1, 2 and 3 are configured with a ratio or blending algorithm. In the “Error signal” block, connect the manipulated value of the reference variable controller to actual value D, and the actual value of the respective follow-up controller (e.g. PV1) to actual value A.

The proportional factor FAC 1 to 3 is preset via setpoint value input at FB FMT_PID (SP_RE).

In the follow-up controller, the manipulated value of the reference variable controller is scaled to 0 to 100% of the value range of actual value A, and is then further processed as actual value D.

See also

The FB 53 FMT_PAR function block - General information (Page 128)

Technical data A

A.1 Technical Specifications S7-300

General technical data

General technical data are

- Electromagnetic compatibility
- Shipping and storage conditions
- Mechanical and climatic environmental conditions
- Specifications for insulation tests, protection class and degree of protection

These general technical data are explained in Manual /1/. They contain standards and test values that the S7-300 fulfils and the criteria used to test the S7-300.

Approbations

The S7-300 has the following approvals:

UL Recognition Mark
Underwriters Laboratories (UL) in accordance with Standard UL 508

CSA-Certification-Mark
Canadian Standard Association (CSA) to Standard C22.2 No. 142

FM approval complying with Factory Mutual Approval Standard Class Number 3611, Class I, Division 2, Group A, B, C, D

WARNING
Personal injury and material damage may occur. In hazardous environments, there is a risk of injury or damage if you disconnect any connectors while the S7-300 is in operation. Always isolate the S7-300 operated in such areas before you disconnect and connectors.

WARNING
DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS LOCATION IS KNOWN TO BE NONHAZARDOUS

CE Marking

Our products fulfill the requirements of the EU Directive 89/336/EEC "Electromagnetic compatibility".

The EU conformity certificates are available for the relevant authorities and are kept at the following address in accordance with the above-mentioned EU Directive. Article 10:

Siemens Aktiengesellschaft
Industry Sector
I IA AS RD ST Typetest
P.O. Box 1963
D-92209 Amberg

Area of application

SIMATIC products are designed for use in industrial environments.

SIMATIC products may be also used in combination with an individual license in residential areas (residential, commercial and industrial areas, small enterprises).

Area of application	Requirements in respect of	
	Emitted interference	Interference immunity
Industry	EN 50081-2 : 1993	EN 50082-2 : 1995

Observe the Installation Guidelines

SIMATIC products fulfill the requirement if you observe the installation guidelines described in the manuals during installation and operation.

A.2 Technical data of FM 355-2

Technical data FM 355-2

Table A- 1 Technical data

Dimensions and Weight	
Dimensions W x H x D (mm)	 80 x 125 x 120
Weight	Approx. 470 g
Module-Specific Data	
Number of digital inputs Number of digital outputs Number of analog inputs Number of analog outputs	8 8 (only FM 355-2 S) 4 4 (only FM 355-2 C)
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 thermocouples
Voltages, Currents, Potentials	
Rated load voltage L+ • Permitted range • Polarity protection for the input supply • Polarity protection for the output supply	24 VDC 20.4 to 28.8 V Yes Yes
Number of simultaneously controlled digital inputs • Horizontal arrangement up to 60 °C • Vertical arrangement up to 40 °C	 8 8
Total current of the digital outputs • Horizontal arrangement To 40 °C To 60 °C • Vertical arrangement up to 40 °C	 Max. 0.4 A Max. 0.4 A Max. 0.4 A
Galvanic isolation • To the rear panel bus • Between channels	 Yes (optocoupler) No

Permissible potential difference • Between input (M terminal) and central grounding point • Between the analog inputs and M_{ANA} (U_{CM}) – When signal = 0 V	 75 VDC 60 VAC 2.5 VDC
Current consumption • From the rear panel bus • From L+ (without load) – FM 355-2 C – FM 355-2 S	 Typ. 50 mA Max. 75 mA Typ. 260 mA Max. 310 mA Typ. 220 mA Max. 270 mA
Power loss of the module • FM 355-2 C • FM 355-2 S	 Typ. 6.5 W Max. 7.8 W Typ. 5.5 W Max. 6.9 W
Status, interrupts, diagnostics	
Status display	Yes, green LED per digital input channel
Interrupts • Limit value interrupt • Diagnostic interrupt	 Yes, configurable Yes, configurable
Diagnostic functions • Fault indication on the module in the event of a group fault • Reading diagnostic information	Yes, configurable Yes, red LED Yes
Backup mode	Yes, display yellow LED
CiR	Module is CiR-capable with restriction.
Disturbance suppression, error limits (Inputs)	
Interference voltage suppression for f = n × (f1 ± 1 %), (f1 = interference frequency) • Commonmode interference (U_{ss} < 2.5 V) • Series-mode 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	 ± 0.25 % ± 0.25 % ± 0.25 % ± 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	 ± 0.06 % ± 0.04 % ± 0.06 % ± 0.5 %
Temperature error (referenced to input range)	±0.005 %/K
Linearity error (referenced to input range)	± 0,05 %
Repeat accuracy (in transient state at 25 °C, referenced to input range)	± 0,05 %
Disturbance suppression, error limits (outputs)	
Crosstalk between outputs	40 dB
Operational error limits (across the temperature range, referenced to output range) • Voltage • Current	 ± 0.5 % ± 0.6 %
Basic error limit (operational limit at 25 °C, referenced to output range) • Voltage • Current	 ± 0.4 % ± 0.5 %
Temperature error (referenced to output range)	± 0,02 %/K
Linearity error (referenced to output range)	± 0.05 %
Repeat accuracy (in transient state at 25 °C, referenced to output range)	± 0.05 %
Output ripple; range 0 to 50 kHz (refernced to output range)	± 0.05 %
Data for Selecting a Sensor (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	 Typ. 7 mA

Input delay times • Configurable • At "0" to "1" • At "1" after "0"	 No From 1.2 to 4.8 ms From 1.2 to 4.8 ms	
Input characteristics	To IEC 1131, Type 2	
Connection of 2-wire BEROs • Permissible quiescent current	Possible ≤ 1.5 mA	
Data for Selecting a Sensor (analog inputs)		
Input ranges (rated values) / input resistance		
• Voltage	± 80 mV (-80 to +80 mV)*** 0 to 10 V / -1.175 V to 11.75 V	10 MΩ 100 kΩ
• Current **	0 mA to 20 mA (-3.5 to 23.5 mA) 4 to 20 mA (0 to 23.5 mA)	50 Ω * 50 Ω *
• Thermocouple type **	B (0 to 13.81 mV) E (-9.84 to 76,36 mV) J (-8.1 to 69.54 mV) K (-6.45 to 54.88 mV) R (-0.23 to 21.11 mV) S (-0.24 to 18.7 mV) Type B: 42.15 °C to 1820.01 °C Type E: -270.00 °C to 1000.03 °C Type J: -210.02 °C to 1200.02 °C Type K: -265.40 °C to 1372.11 °C Type R: - 51.37 °C to 1767.77 °C Type S: - 50.40 °C to 1767.98 °C	10 MΩ 10 MΩ 10 MΩ 10 MΩ 10 MΩ
• Resistance thermometers **	Pt 100 Current 1.667 mA pulsed: (30.82 ... 650.46 mV) -200.01 ... 850.05 °C (simple resolution) (30,82 ... 499.06 mV) -200.01 ... 556.26 °C (double resolution) (30,82 ... 254.12 mV) -200.01 ... 137.06 °C (quadruple resolution)	10 MΩ

Data for Selecting a Sensor (analog inputs)	
Permissible input voltage for voltage input (destruction limit)	30 V (for maximum 2 inputs)
Permissible input current at current input (destruction limit)	40 mA
Connection of signal sensor • for voltage measurement • for current measurement as 4-wire measuring transducer	 Possible Possible
Characteristics linearization • For thermal elements	Yes, configurable • Type B, E, J, K, R, S
• for thermal resistors	• Pt 100 standard range
Temperature compensation • Internal temperature compensation • External temperature compensation with Pt 100	Yes, configurable Possible Possible
* External measuring resistance ** The display range limits also apply to underflow and overflow display. Exception: Underflow display at 4 to 20 mA: 1 at < 3.6 mA 0 at > 3.8 mA If a wire break occurs in the 4 mA to 20 mA range triggers an underflow indication. *** Or the lower or upper input limit of the polyline. The lower value is valid.	

Actuator selection data (Digital outputs)	
Output voltage • With "1" signal	 Min. L+ (- 2.5 V)
Output current • At signal "1" Nominal value Permitted range • At signal "0" (residual current)	 0.1 A from 5 mA to 0.15 A Max. 0.5 mA
Load resistance range	240 Ω to 4 kΩ
Output power • Lamp load	 Max. 5 W
Parallel wiring of two outputs • For logical links • For performance increase	 Possible Not possible
Controlling of digital inputs	Possible

Switching frequency • With resistive load/lamp load • At inductive load	 Max. 10 Hz Max. 0.5 Hz
Inductive shut-down voltage limited (internally) to	Typ. - 1.5 V
Short-circuit protection of outputs	Yes, electronic
Actuator selection data (analog outputs)	
Output ranges (rated values)	± 10 V From 0 to 10 V From 0 to 20 mA From 4 to 20 mA
Load resistance • At voltage outputs – Capacitive load • At current outputs – Inductive load	 Min. 1 kΩ Max. 1 μF Max. 500 Ω Max. 1 mH
Voltage output • Short-circuit protection • Short-circuit voltage	 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 (including overshoot range) Conversion time (per analog input)	integrating 14 bits 100 ms
Settling time • For resistive load • For capacitive load • For 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 including the processing time in ms • Additional conversion time for resistance measurement in ms or additional conversion time for reference junction input in ms	 100 102 1 100
• Resolution in bits (including overshoot range) measuring range	14
• Interference voltage suppression at interference frequency f1 in Hz	50, 60

A.3 Technical data of function blocks

Technical data of function blocks

Table A- 2 Technical data of function blocks

Function blocks	Allocation in			Processing time in	
	RAM	Load memory	Local data area	CPU 315-2 DP	CPU 416-2 DP
FMT_PID	1804 bytes	2296 bytes	32 bytes	(see table below)	
FMT_PAR	324 bytes	416 bytes	32 bytes	1.7 ms	0.19 ms
FMT_CJ_T	410 bytes	506 bytes	40 bytes	1.8 ms	0.19 ms
FMT_DS1	216 bytes	452 bytes	22 bytes	1.9 ms	0.19 ms
FMT_TUN	332 bytes	590 bytes	22 bytes	4.5 ms	0.19 ms
FMT_PV	1108 bytes	1334 bytes	92 bytes	3.2 ms*) 2.9 ms**)	0.28 ms*) 0.35 ms**)
*) READ_PV=TRUE **) LOAD_PV=TRUE					

Table A- 3 FMT_PID processing times under various marginal conditions

Marginal conditions			Processing time in	
READ_OUT	LOAD_OP	LOAD_PAR/(READ_PAR)	CPU 315-2 DP	CPU 416-2 DP
FALSE	FALSE	FALSE	0.65 ms	0.04 ms
TRUE	FALSE	FALSE	2.85 ms	0.30 ms
*)	TRUE	FALSE	4.56 ms	0.55 ms
FALSE	FALSE	TRUE	3.58 ms**)	0.30 ms
TRUE	FALSE	TRUE	5.8 ms**)	0.56 ms
*)	TRUE	TRUE	7.41 ms**)	0.82 ms
*) If LOAD_OP = TRUE, FB FMT_PID also sets READ_OUT = TRUE. **) If READ_PAR is set instead of LOAD_PAR, the CPU 315-2 DP processing time is increased by 0.35 ms.				

Table A- 4 Technical data of the instance DBs

Instance DBs of the function blocks ...	Allocation in	
	RAM	Load memory
FMT_PID	210 bytes	610 bytes
FMT_PAR	52 bytes	128 bytes
FMT_CJ_T	50 bytes	130 bytes
FMT_DS1	282 bytes	56 bytes
FMT_TUN	254 bytes	502 bytes
FMT_PV	100 bytes	302 bytes

Optimization status B

B.1 Optimization status

Overview

The second column shows whether the status is relevant for cooling optimization.

Table B- 1 Status

STATUS_H/C	Cooling optimization	Description	Remedy
0	relevant	Default and/or no or no new controller parameters	
10000	relevant	Suitable controller parameters found	
2xxxx	relevant	Indefinite controller parameters	
2xxx1		Effective motor actuating time >= 65% of the point of inflection time T_P_INF	TU and T_P_INF are not compensated. This leads to the design of a softer controller
2xx2x		Point of inflection not reached (only if excited via setpoint step-change)	If the controller oscillates tone down the controller parameters or repeat test with lower TUN_DLMN.
2x1xx		Estimation error (TU <= 3* sampling time)	Repeat test.
2x2xx		Serious estimation error (TU < sampling time)	Repeat test. A pure PT1 process is a special case: Do not repeat the test; tone down the controller parameters if need be.
2x3xx	relevant	Estimation error TU too great	Repeat test under better conditions.
21xxx	relevant	Estimation error N_PTN < 1	Repeat test under better conditions.
22xxx	relevant	Estimation error N_PTN > 10	Repeat test under better conditions.
3xxxx	relevant	Optimization interrupted in phase 1 owing to faulty parameter assignment	
30001	relevant	TUN_ON and TUN_ST or TUN_CST are set simultaneously	Restart optimization.

STATUS_H/C	Cooling optimization	Description	Remedy
30002	relevant	|TUN_DLMN| or | TUN_CLMN| or effective LMN change < 5 %	If necessary cancel manipulated variable and set TUN_ON to FALSE. Correct TUN_DLMN and/or TUN_CLMN or check manipulated variable limits if the value of TUN_DLMN or TUN_CLMN >= 5% and the sign was correct. Restart optimization
30003	relevant	TUN_CLMN <= - 5%, but LMN_LLM > -5 %.	Correct lower limit value LMN_LLM. Restart optimization
30004	relevant	The effective manipulated variable difference limited by split–range limits rather than by manipulated variable limits.	See STATUS_H=30002: furthermore, bear in mind that e. g. if LMN_A < 5 % it is not possible to optimize heating with a negative TUN_DLMN (The reason: the cooling power must not be adjusted).
30008	relevant	TUN_CST, but without previous heating tuning	First optimize the heating
30009	relevant	Safety mode	Close safety mode and restart optimization.

Table B- 2 Status_D and description

STATUS_D	Description
0	No controller parameters have been calculated.
110	N_PTN < = 1.5 process type I fast
121	N_PTN > 1.5 process type I
122	N_PTN = 1.9 process type I after phase 7 (previously N_PTN > 1.9)
200	N_PTN > 1.9 process type II (transition zone)
310	N_PTN >= 2.1 process type III fast
320	N_PTN > 2.6 process type III

Note

At the end of phase 1 STATUS_H = 0 is reset.

If you cancel optimization in phase 2: STATUS_H = 0. However, STATUS_D still displays the status of the last controller calculation.

The higher the value of STATUS_D, the higher the order of the control process, the greater the TU/TA ratio and the gentler the controller parameters will be.

Assignment of DBs C

C.1 Instance DB of the 52 FMT_PID FB

Introduction

To keep the call interface small, most of the parameters have been assigned in the internal static area (see below: OP, PAR and OUT structures).

The parameters of the instance DB are listed in the following tables:

- Input parameters
- Output parameters
- In/out parameters
- Internal parameters in OP structure
- Internal parameters in PAR structure
- Internal parameters in OUT structure

Table C- 1 Input parameters of the instance DB for the FMT_PID

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assignment screen form
0.0	MOD_ADDR	INT	FM 355-2 module address		256	At this input you will find the module address resulting from configuration under STEP 7.	-
2.0	CHANNEL	INT	Controller channel number	0 to 3	0	Number of the controller channel to which the instance DB is referenced.	-

Table C- 2 Output parameters of the instance DB for the FMT_PID

Address	Parameter	Data type	Comment	Permitted range of values	Default setting	Explanation	In parameter assignment screen
4.0	QMOD_F	BOOL	Module faults		FALSE	The function block checks correct reading and writing of a data record. If errors are identified, the QMOD_F output is set. The cause of errors can be: an incorrect module address on the MOD_ADDR parameter, an incorrect channel number on the CHANNEL parameter or a defective module.	-
6.0	RET_VALU	WORD	Return value of SFB 52/53		W#16#0	Output STATUS (bytes 2 and 3) of SFB52/53; corresponding to the error code RET_VAL of SFC58/59	-

Table C- 3 In/Out parameters of the instance DB for the FMT_PID

Address	Parameter	Data type	Comment	Permitted range of values	Default setting	Explanation	In parameter assignment screen
8.0	COM_RST	BOOL	Cold restart		FALSE	When COM_RST = TRUE the FB FMT_PID performs an initialization run and resets COM_RST This initialization is imperative every time the CPU starts up.	-
8.1	LOAD_OP	BOOL	Download operator parameters to FM 355-2		FALSE	If the LOAD_OP I/O parameter has been set, the operating parameters are downloaded to the module, the output parameters are read and the I/O parameters are reset.	-
8.2	READ_OUT	BOOL	Read output parameters from FM 355-2		FALSE	If the READ_OUT parameter has been set, the output parameters are read from the module and written to the OUT structure of the instance DB and the I/O parameters are reset.	-
8.3	LOAD_PAR	BOOL	Download controller parameters to FM 355-2		FALSE	If the LOAD_PAR I/O parameter has been set, the controller parameters are uploaded to the module, and the I/O parameter is reset.	-
8.4	READ_PAR	BOOL	Read controller parameters from FM 355-2		FALSE	If the parameter is READ_PAR = TRUE, then the control parameters are read off the FM 355-2 and written to the instance DB in the PAR structure. Thereafter the I/O parameter is reset.	-

Table C- 4 Internal parameters of the instance DB for FMT_PID (operating parameters in OP structure)

Address	Parameter	Data type	Comment	Permitted range of values	Default setting	Explanation	In parameter assign-ment screen
10.0	vers_no	WORD	Version, always 16#3230, do not change	W#16#3230	W#16#3230	The parameter vers_no may not be changed by the user. It identifies the start of the operator parameters that are transferred to the module, if LOAD_OP = TRUE is set.	-
12.0	SP_RE	REAL	external setpoint	technical value range (physic. variable)	0.0	An external setpoint is interconnected with the controller at input SP_RE. *)	-
16.0	LMN_RE	REAL	external manipulated variable	-100.0...100.0 (%)	0.0	An external manipulated variable is interconnected with the controller at input LMN_RE. *)	-
20.0	SAFE_ON	BOOL	Setting safety mode		FALSE	When SAFE_ON is set, a safety value is adopted as the manipulated variable.	-
20.1	LMNTRKON	BOOL	Correct (LMN via AI)		FALSE	If LMNTRKON is set, the manipulated variable is corrected to an analog input (AI) (does not apply to step-action controllers without analog position feedback)	-
20.2	LMN_REON	BOOL	enable external manipulated variable		FALSE	If LMN_REON is set, the external manipulated variable LMN_RE is applied (manual mode).	-

Address	Parameter	Data type	Comment	Permitted range of values	Default setting	Explanation	In parameter assign-ment screen
20.3	LMNRHSRE	BOOL	upper end signal of the position feedback		FALSE	The "control valve at high stop" signal can be interconnected with a digital input of the FM 355-2 or at the LMNRHSRE input. LMNRHSRE = TRUE means: The control valve is at the high stop. (Applies to step-action controllers only).	-
20.4	LMNRLSRE	BOOL	lower end signal of the position feedback		FALSE	The "manipulated valve on low stop" signal can be interconnected with a digital input of the FM 355-2 or at the LMNRLSRE input. LMNRLSRE = TRUE means: The control valve is at the low stop. (Applies to step-action controllers only).	-
20.5	LMNS_ON	BOOL	Enable operator control of manipulated variables		FALSE	Enable operator control of manipulated variables (applies only to step-action controller, manual mode)	-
20.6	LMN_UP	BOOL	Manipulated variable High signal operation		FALSE	Manipulated variable High signal operation (applies to step-action controllers only).	-
20.7	LMN_DN	BOOL	Manipulated variable Low signal operation		FALSE	Manipulated variable Low signal operation (applies to step-action controllers only).	-

Address	Parameter	Data type	Comment	Permitted range of values	Default setting	Explanation	In parameter assign-ment screen
22.0	SAVE_PAR	BOOL	Save controller parameters		FALSE	Saves current controller parameters: (SAV_PFAC=PFAC_SP, SAV_GAIN =GAIN, SAV_TI =TI, SAV_TD = TD, SAV_D_F =D_F, SAV_CONZ = CON_ZONE, SAV_RATI =RATIOFAC, SAV_CZON=CONZ_ON, SAV_PSEL=P_SEL) **).	-
22.1	UNDO_PAR	BOOL	Undoing controller parameter changes		FALSE	The saved controller parameters are retrieved again, also in automatic mode. (PFAC_SP=SAV_PFAC, GAIN = SAV_GAIN, TI =SAV_TI, TD = SAV_TD, D_F = SAV_D_F, CON_ZONE = SAV_CONZ, RATIOFAC = SAV_RATI, CONZ_ON= SAV_CZON, P_SEL= SAV_PSEL) **).	-
22.2	LOAD_PID	BOOL	Load optimized PI/PID parameters		FALSE	When PID_ON=TRUE it loads the PID parameters (PID_GAIN, PID_TI, PID_TD). When PID_ON=FALSE the PI parameters (PI_GAIN, PI_TI) are loaded. (also in automatic mode) **).	-

Address	Parameter	Data type	Comment	Permitted range of values	Default setting	Explanation	In parameter assign-ment screen
22.3	TUN_ON	BOOL	Enable controller optimization		FALSE	TUN_ON=TRUE puts the FM 355-2 at the ready for optimization (PHASE=1): The manipulated variable is averaged until the manipulated variable excitation is applied.**).	-
22.4	TUN_ST	BOOL	Starting controller optimization		FALSE	If the setpoint is to remain constant at the operating point during controller optimization,TUN_ST =TRUE applies a manipulated variable step-change by TUN_DLMN (PHASE 1 - 2) **).	-
22.5	TUN_CST	BOOL	Starting cooling optimization		FALSE	Starts cooling optimization by applying a manipulated variable step-change by TUN_CLMN (PHASE 1 - 2) **).	-

*) In the case of fast data transfer via the input/output areas of the FM 355-2 (LOAD_OP = FALSE) in automatic mode only the setpoint SP_RE is transferred and in manual mode only the manual manipulated variable.

**) With fast data transmission via the input / output areas of the FM 355-2 these parameters are not transferred. The FB FMT_PID automatically sets LOAD_OP = TRUE.

Table C- 5 Internal parameters of the instance DB for FMT_PID (controller parameters in PAR structure)

Address	Parameter	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assignment screen
24.0	vers_nr	WORD	Version, always 16#3230, do not change	W#16#3230	W#16#3230	The parameter vers_no may not be changed by the user. It identifies the start of the controller parameters, which are read from the FM with READ_PAR = TRUE and stored in the instance DB or uploaded to the FM with LOAD_PAR=TRUE.	-
26.0	P_SEL	BOOL	Enable proportional component		TRUE	It is possible to activate and deactivate PID components individually in the PID algorithm. The P-action component is enabled if the input P_SEL is set.	PID Controller
26.1	MONERSEL	BOOL	Monitoring: Process variable = 0 Error signal = 1		FALSE	The controller possesses a limit value detector that can be applied either for the actual value or for the error signal. If MONERSEL is set, the error signal is monitored.	Interrupt Controllers
26.2	PID_ON	BOOL	Enable PID mode		TRUE	After optimization or in the case of LOAD_PID = TRUE the PID parameters are activated. In the case of PID_ON = FALSE the PI parameters are taken. It may be that with some process types, in spite of PID_ON = TRUE only one PI controller is designed.	-
26.3	CONZ_ON	BOOL	Enable control zone		FALSE	TRUE = control zone enabled FALSE = control zone disabled	Control zone

Address	Parameter	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assignment screen
28.0	D_EL_SEL	INT	Input for derivative action element	0 to 3, 16, 17	16	In the PID algorithm the derivative action element can be connected to a separate input This is selected on the D_EL_SEL parameter. 16: Error signal 0 to 3: Analog input 0 to 3 17: negative actual value	Error signal controller
30.0	SP_HLM	REAL	Upper setpoint limit	> SP_LLM (physic. variable)	100.0	The setpoint is always limited to a high and a low limit. The SP_HLM parameter specifies the high limit.	Limiting setpoint controller
34.0	SP_LLM	REAL	Setpoint low limit	< SP_HLM (physic. variable)	0.0	The setpoint is always limited to a high and a low limit. The SP_LLM parameter specifies the low limit.	Limiting setpoint controller
38.0	H_ALM	REAL	high limit value interrupt	> H_WRN (physic. variable)	100.0	Highest limit for monitoring the actual value or the error signal.	Interrupt controller
42.0	H_WRN	REAL	high limit value warning	> H_ALM (physic. variable)	90.0	Second to highest limit for monitoring the actual value or the error signal.	Alarm controller
46.0	L_WRN	REAL	low limit value warning	> H_WRN ... L_ALM (physic. variable)	10.0	Second to lowest limit for monitoring the actual value or the error signal.	Alarm controller
50.0	L_ALM	REAL	low limit value interrupt	> L_WRN (physic. variable)	0.0	Lowest limit for monitoring the actual value or the error signal.	Alarm controller
54.0	HYS	REAL	Hysteresis	>= 0.0 (physic. variable)	1.0	The parameters can be assigned for a hysteresis to prevent the monitoring displays from flickering.	Alarm controller
58.0	DEADB_W	REAL	Dead band width	>= 0.0 (physic. variable)	0.0	The error signal is routed over a dead band. The DEADB_W parameter determines the size of the dead band.	Dead zone Controller

Address	Parameter	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assignment screen
62.0	PFAC_SP	REAL	Proportional factor	0.0 ...1.0	1.0	PFAC_SP specifies the effective proportional action element when setpoints are changed.	PID Controller
66.0	GAIN	REAL	P-action coefficient	%/phys. variable	1.0	The GAIN parameter specifies the controller gain. The control direction is inverted by means of a negative sign of GAIN.	PID Controller
70.0	TI	REAL	Integration time (s)	= 0.0 or >= 0.5	3000.0	The TI (integral-action time) parameter determines the dynamic response of the integrator. If TI = 0.0 the integrator is disabled.	PID Controller
74.0	TD	REAL	Derivative-action time (s)	= 0.0 or > = 1.0	0.0	The TD (rate time) determines the time action of the derivative action element (D-element). If TD = 0.0, the derivative-action element is disabled.	PID Controller
78.0	D_F	REAL	Derivative-action factor	5.0 ... 10.0	5.0	The time constant TD/D_F which is effective for the D-element is limited internally to ≥ sampling time/2	PID Controller
82.0	LMN_SAFE	REAL	Safety manipulated variable	-100.0 ... 100.0 (%)	0.0	A safety value can be parameterized for the manipulated variable.	Enabling safety manipulated variable Controller
86.0	LMN_HLM	REAL	Upper limit of manipulated variable	LMN_LLM ... 100.0 (%)	100.0	The manipulated variable is always limited to an high and a low limit. The LMN_HLM parameter specifies the high limit. (this does not apply to step-action controllers without analog position feedback).	Limiting Manipulated variable Controller

Address	Parameter	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assignment screen
90.0	LMN_LLM	REAL	Low limit of manipulated variable	-100.0 ... LMN_HLM (%)	0.0	The manipulated variable is always limited to an high and a low limit. The LMN_LLM parameter specifies the low limit. (this does not apply to step-action controllers without analog position feedback).	Limit Manipulate d value Controller
94.0	MTR_TM	REAL	Motor actuating time (s)	MTR_TM >= 0.001	60.0	Limit-to-limit runtime of the control valve (applies to step-action controllers only).	Pulse shaper Controller
98.0	PULSE_TM	REAL	Minimum pulse width (s)	>= 0.0	0.0	Minimum pulse width (applies to step-action controllers or pulse controllers only)	Impulsform er Split-range controller/ Pulse-shaper controller
102.0	BREAK_TM	REAL	Minimum interpulse width (s)	>= 0.0	0.0	Minimum interpulse width (applies to step-action controllers or pulse controllers only)	Impulsform er Split-range controllers/ pulse shaper Controller
106.0	RATIOFAC	REAL	Ratio factor	= 0.0 or 0.01 ... 100.0	0.0	Ratio of heating gain/cooling gain for the process. RATIOFAC <> 0.0 has the effect: • LMN = LMN * RATIOFAC for LMN < 0.0; • CON_ZONE 50 % greater	Cooling
110.0	CON_ZONE	REAL	Control zone width	> 0.0 technical value range physic. variab le)	100.0	If ER >= CON_ZONE, then LMN = LMN_HLM. If ER <= -CON_ZONE (or-CON_ZONE/RATIOFA C for RATIOFAC<>0.0), then LMN = LMN_LLM.	Control zone

Address	Parameter	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assignment screen
114.0	TUN_DLMN	REAL	Delta manipulated variable for process excitation	-100.0 ... 100.0 (%)	20.0	Process excitation for controller optimization takes place via a manipulated variable step-change by TUN_LMN	PID Controller
118.0	TUN_CLMN	REAL	Delta manipulated variable for cooling optimization	-100.0 ... 100.0 (%)	-20.0	Manipulated variable step-change after cooling optimization is started by TUN_CST.	PID Controller

Table C- 6 Internal parameters of the instance DB for FMT_PID (output parameters in OUT structure)

Address	Parameter	Data type	Comment German	Permitted range of values	Default setting	Explanation	In parameter assign-ment screen
122.0	vers_nr	WORD	Version, always 16#3230, do not change	W#16#3230	W#16#3230	The parameter vers_no may not be changed by the user. It identifies the start of the output parameters which are read by the module if READ_OUT = TRUE is set.	-
124.0	PV	REAL	Actual value	technical range of values (physic. variable)	0.0	Effective actual value.	-
128.0	LMN	REAL	Manipulated value	-100.0 ... 100.0 (%)	0.0	The effective manipulated variable that is currently in effect is output at the LMN output. In the case of step-action controllers without analog position feedback, the unlimited P- + D-element is output on the LMN output.	-
132.1	QLMNSAFE	BOOL	Safety mode		FALSE	If the QLMNSAFE output is set, the safety manipulated variable is output as the manipulated variable.	-
132.3	QLMNTRK	BOOL	Follow-up mode		FALSE	Output QLMNTRK indicates if the manipulated variable is being compensated via an analog input.	-
132.4	QLMN_RE	BOOL	Enable external manipulated variable		FALSE	The QLMN_RE output indicates if LMN_REON is set and the external manipulated variable LMN_RE is applied as the manipulated variable.	-
132.5	QLMNR_HS	BOOL	upper end signal of the position feedback		FALSE	QLMNR_HS = TRUE means: The control valve is at the upper endstop. (applies to step-action controllers only).	-

Address	Parameter	Data type	Comment German	Permitted range of values	Default setting	Explanation	In parameter assign-ment screen
132.6	QLMNR_LS	BOOL	lower end signal of the position feedback		FALSE	QLMNR_LS = TRUE means: The control valve is at the low end stop. (applies to step-action controllers only)	-
132.7	QLMNR_ON	BOOL	Position feedback enabled		FALSE	QLMNR_ON = TRUE means: Step-action controller with position feedback	-
133.0	QSTEPCON	BOOL	Step-action controller		FALSE	Step-action controller / pulse controller 0 = pulse controller or continuous controller and 1 = step-action controller	-
133.1	QSPR	BOOL	Split-range mode		FALSE	If the QSPR output is set, the continuous controller works in the split-range mode.	-
133.3	QMAN_FC	BOOL	Follow-up mode or anti-reset windup by slave controller		FALSE	This controller is a master controller. It is manually compensated to the actual value of a slave controller, or its I-element is disabled because the setpoint or manipulated variable of the latter has reached the limit.	-
134.0	QH_ALM	BOOL	upper limit value interrupt triggered		FALSE	High limit H_ALM exceeded by actual value or error value.	-
134.1	QH_WRN	BOOL	high limit value warning triggered		FALSE	Actual value or error value exceeds second to highest limit H_WRN.	-
134.2	QL_WRN	BOOL	lower limit value warning triggered		FALSE	Actual value or error value has dropped below the second to lowest limit L_WRN.	-
134.3	QL_ALM	BOOL	lower limit value interrupt triggered		FALSE	Actual value or error value has dropped below the lowest limit, L_ALM.	-

Address	Parameter	Data type	Comment German	Permitted range of values	Default setting	Explanation	In parameter assign-ment screen
134.4	QLMN_HLM	BOOL	Upper output value limit triggered		FALSE	The QLMN_HLM output reports that the high manipulated variable limit LMN_HLM has been reached. (this does not apply to step-action controllers without analog position feedback).	-
134.5	QLMN_LLM	BOOL	Low limit of manipulated variable triggered		FALSE	The QLMN_LLM output reports that the low manipulated variable limit LMN_LLM has been reached. (this does not apply to step-action controllers without analog position feedback).	-
134.6	QPAR_F	BOOL	Programming error		FALSE	The module checks the reliability of the parameters. A parameter assignment error is indicated on output QPAR_F You can also read out this parameter assignment error in the menu PLC > parameter assignment error of the configuration application.	-
134.7	QCH_F	BOOL	Channel fault		FALSE	The QCH_F output is set if the controller channel is unable to supply any valid results. Channel error (e.g. line break) is also set for QPAR_F = 1 or QMOD_F = 1. If QCH_F = TRUE, then the precise error information in the diagnostic record DS1 of the module is read off.	-

Address	Parameter	Data type	Comment German	Permitted range of values	Default setting	Explanation	In parameter assign-ment screen
135.0	QUPRLM	BOOL	Setpoint gradient limit triggered		FALSE	The setpoint is limited to a positive and negative gradient. If the QUPRLM output is set, the setpoint rise is limited.	-
135.1	QDNRLM	BOOL	negative setpoint gradient limit triggered		FALSE	The setpoint is limited to a positive and negative gradient. If the QDNRLM output is set, the setpoint drop is limited.	-
135.2	QSP_HLM	BOOL	High setpoint limit triggered		FALSE	The QSP_HLM output reports that the high setpoint limit SP_HLM has been reached.	-
135.3	QSP_LLM	BOOL	Low setpoint limit triggered		FALSE	The QSP_LLM output reports that the low setpoint limit SP_LLM has been reached.	-
135.4	QLMNUP	BOOL	Manipulated variable High signal		FALSE	"Manipulated variable High signal" output (applies to step-action controllers only)	-
135.5	QLMNDN	BOOL	Manipulated variable signal Low		FALSE	"Manipulated variable Low signal" output (applies to step-action controllers only)	-
135.6	QTUN_ON	BOOL	Optimization in progress		FALSE	QTUN_ON = TRUE indicates that optimization is in progress.	-
135.7	PAR_ACT	BOOL	Updating controller parameters		FALSE		-
136.0	SP	REAL	Setpoint	technical range of values (physic. variable)	0.0	Effective actual setpoint. *)	-
140.0	ER	REAL	Error signal	technical range of values (physic. variable)	0.0	*)	-
144.0	DISV	REAL	Disturbance variable	-100.0...100.0 (%)	0.0	Effective disturbance variable *)	-

Address	Parameter	Data type	Comment German	Permitted range of values	Default setting	Explanation	In parameter assign-ment screen
148.0	LMN_A	REAL	Manipulated variable A of the split-range function / position feedback	-100.0...100.0 (%)	0.0	On output "LMN_A" in the case of continuous or pulse controllers of manipulated variable A of the split-range function is displayed and for step-action controllers with analog position feedback, the position feedback is displayed there. *)	-
152.0	LMN_B	REAL	Manipulated variable B of the split-range function	-100.0 ... 100.0 (%)	0.0	On output "LMN_B" in the case of continuous or pulse controllers manipulated variable B of the split-range function is displayed. *)	-
156.0	PHASE	INT	Optimization phases	0..7	0	Indicates the controller optimization phases. *)	-
158.0	STATUS_H	INT	Heating optimization status		0	Diagnostics value for inflection point identification during heating optimization *)	-
160.0	STATUS_C	INT	Cooling optimization status		0	Diagnostics value for inflection point identification during cooling optimization *)	-
162.0	STATUS_D	INT	Controller design status		0	Diagnostics value for controller design during heating optimization *)	-
164.0	ZONE_TUN	WORD	Controller channels which can be grouped in one zone for the purpose of parallel optimization		W#16#0	In HEX code, each one of the four digits represents one channel, arranged in the following order from left to right: Channel 0, 1, 2, 3 ZONE_TUN = 0 means that the channel selected will not be optimized together with other channels. A value <> 0000 shows - in each case with a 1 - the channels which will be optimized as a group. *)	

*)With fast data transmission via the input / output areas of the FM 355-2 (READ_OUT = FALSE), these parameters are not transferred.

See also

Instance DB of the 52 FMT_PID FB (Page 211)

The function block "FMT_PID" automatically updates all controller parameters in the parameter structure after...

- controller optimization,
- a change between PI and PID parameters,
- controller parameter changes are undone with the "UNDO_PAR" parameter,
- the controller parameters have been loaded via the configuration software.

This procedure requires multiple call cycles of the "FMT_PID" function block and is completed once the parameter "PAR_ACT" at the function block "FMT_PID" has been set and reset. The user program must therefore record the edges 0/1 and 1/0.

Parameters are checked in the following four steps:

1. Following changes to the effective controller parameters in one of the cases detailed above, the FM355-2 sets the output parameter "PAR_ACT" from 0 to 1.
2. The function block "FMT_PID" reads the controller parameters from the module using the system function SFC59 "RD_REC".
3. The function block "FMT_PID" writes the controller parameters to the module for verification using the system function SFC58 "WR_REC".
4. The module FM355-2 compares the sent and received controller parameters and resets the parameter "PAR_ACT" from 1 back to 0 if they are identical.

C.2 Instance DB of the FB 53 FMT_PAR

Table C- 7 Input parameters of the instance DB for the FMT_PAR

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assign-ment screen
0.0	MOD_ADDR	INT	FM 355-2 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	0 to 3	0	Number of the controller channel to which the instance DB is referenced.	-
4.0	INDEX	INT	Index for parameters	0 to 100	0	See section "Controller optimization (Page 83)."	-
6.0	VALUE_R	REAL	Value for REAL parameter	Depending on respective parameter	0.0		-
10.0	VALUE_I	INT	Value for INT parameter	Depending on respective parameter	0		-

Table C- 8 Output parameters of the instance DB for the FMT_PAR

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assign-ment screen
12.0	RET_VALU	WORD	Return value of SFB 53		W#16#0	Output STATUS (Bytes 2 and 3) of SFB53; corresponding to the error code RET_VAL of SFC58	-

Table C- 9 Output parameters of the instance DB for the FB FMT_PAR

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assignment screen
+14.0	LOAD_PAR	BOOL	Load parameters onto FM 355-2		FALSE	If the I/O parameter LOAD_PAR is set, VALUE_R or VALUE_I are written onto the module. INDEX specifies which parameter is overwritten (see Chapter "Process types (Page 84)"). Thereafter LOAD_PAR is reset.	-

C.3 Instance DB of the FB 54 FMT_CJ_T

Table C- 10 Input parameters of the instance DB for the FMT_CJ_T

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In the parameter assign-ment screen form
0.0	MOD_ADDR	INT	FM 355-2 module address		256	The module address resulting from configuration with STEP 7 is to be found at this input.	-
2.0	CJ_TEMP	REAL	Reference junction temperature	depending on sensor type	0.0	The reference junction temperature can be specified on parameter CJ_TEMP	-

Table C- 11 Output parameters of the instance DB for the FMT_CJ_T

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In the para-meter screen form
6.0	CJ_T_OUT	REAL	Reference junction temperature (output)		0.0	The reference junction temperature measured by the module is displayed on output CJ_T_OUT if a thermocouple element input has been configured and there is no default configuration of the reference junction temperature.	-
10.0	RET_VALU	WORD	Return value of SFB 52/53		W#16#0	Output STATUS (bytes 2 and 3) of SFB52/53; corresponding to the error code RET_VAL of SFC58/59	-

Table C- 12 I/O parameters of the instance DB for the FMT_CJ_T

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In the para-meter screen form
12.0	LOAD_CJ	BOOL	Load reference junction temperature to FM 355-2		FALSE	If the I/O parameter LOAD_CJ has been set, the configure reference junction temperature on the module is overwritten with the value CJ_TEMP and the I/O parameter is reset.	-
12.1	READ_CJ	BOOL	Reading the reference junction temperature from FM 355-2		FALSE	If the parameter READ_CJ = TRUE, the reference junction temperature is read from the module. Thereafter the I/O parameter is reset.	-

C.4 Instance DB of the FB 55 FMT_DS 1

Table C- 13 Input parameters of the instance DB for the FMT_DS1

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assign-ment screen
0.0	MOD_ADDR	INT	Module address FM 355-2		256	The module address that resulted from the configuration with STEP 7 is given at this input.	-

Table C- 14 Output parameters of the instance DB for the FMT_DS1

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assign-ment screen
2.0	DS1	STRUCT	Diagnostic data record DS1			Includes bytes 0 to 12	-
16.0	RET_VALU	INT	Return value of SFB 52		W#16#0	Output STATUS (Bytes 2 and 3) of SFB52; corresponding to the error code RET_VAL of SFC59	-

Table C- 15 I/O parameters of the instance DB for the FMT_DS1

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assign-ment screen
18.0	READ_DS1	BOOL	Reading DS1 from FM 355-2		FALSE	If parameter READ_DS1 = TRUE, then diagnostic data record DS1 is read off the FM 355-2 and written to the DS1 structure of the instance DB. Thereafter the I/O parameter is reset.	-

C.5 Instance DB of the FB 56 FMT_TUN

Table C- 16 Input parameters of the instance DB for the FMT_TUN

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assign-ment screen
0.0	MOD_ADDR	INT	FM 355-2 module address		256	The module address that results from the configuration in STEP 7 is set at this input.	-
2.0	CHANNEL	INT	Channel number	0 to 3	0	The number of the controller channel to which the instance DB is referenced is configured at input "Channel number".	-

Table C- 17 Output parameters of the instance DB for the FMT_TUN

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In the parameter screen form
4.0	PI_GAIN	REAL	PI controller gain		0.0	PI controller parameters	-
8.0	PI_TI	REAL	PI controller integration time (s)		0.0	PI controller parameters	-
12.0	PID_GAIN	REAL	PID controller gain		0.0	PID controller parameters	-
16.0	PID_TI	REAL	PID controller integration time		0.0	PID Controller parameters	-
20.0	PID_TD	REAL	PID controller derivative time (s)		0.0	PID Controller parameters	-
24.0	SAV_PFAC	REAL	Old proportional factor		0.0	Saved controller parameters	-
28.0	SAV_GAIN	REAL	Old controller gain		0.0	Saved controller parameters	-
32.0	SAV_TI	REAL	Old controller integration time (s)		0.0	Saved controller parameters	-

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In the parameter screen form
36.0	SAV_TD	REAL	Old controller derivative time (s)		0.0	Saved controller parameters	-
40.0	SAV_D_F	REAL	Old derivative factor		0.0	Saved controller parameters	-
44.0	SAV_RATI	REAL	Old ratio factor		0.0	Saved controller parameters	-
48.0	SAV_CONZ	REAL	Old control zone width		0.0	Saved controller parameters	-
52.0	SAV_PSEL	BOOL	Old value of P_SEL		FALSE	Saved controller parameters	-
52.1	SAV_CZON	BOOL	Old value for control zone enabled		FALSE	Saved controller parameters	-
54.0	RET_VALU	WORD	Return value of SFB 52		W#16#0	Output STATUS (Bytes 2 and 3) of SFB52; corresponding to the error code RET_VAL of SFC59	-

Table C- 18 Input parameters of the instance DB for the FMT_TUN

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In the para-meter screen form
56.0	READ_OUT	BOOL	Read output parameters from the FM 355-2		FALSE	If the I/O parameter READ_OUT is set, the output parameters are read off the FM 355-2.	-

Note

The parameters between the addresses 56.0 and 152.0 are described in Chapter "Instance DB of the 52 FMT_PID FB (Page 211)" in the table "Internal parameters of the instance DB for the FMT_PID (output parameter in the structure OUT)".

Table C- 19 Internal parameters of the instance DB for the FMT_TUN (in OUT structure)

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assign-ment screen
152.0	GAIN_P	REAL	Process gain	(phys. variable) /%	0.0	Identified process gain. In the case of process type I, GAIN_P tends to be estimated too low.	-
156.0	TU	REAL	Delay time (s)	≥ 3*scan time	0.0	Identified process delay.	-
160.0	TA	REAL	Recovery time (s)	≥ 0.0	0.0	Identified recovery time of process. In the case of process type I, TA tends to be estimated too low.	-
164.0	KIG	REAL	Maximum actual value rise at manipulated variable excitation from 0 to 100%.	(phys. variable) /s	0.0	Maximum possible gain of the actual value. GAIN_P = 0.01 * KIG * TA	-
168.0	N_PTN	REAL	Process order	1.01 ... 10.0	0.0	Order of the process "Non-integer values" are also possible.	-
172.0	TM_LAG_P	REAL	Time constant of a PTN model (s)	≥ 0.0	0.0	Time constant of a PTN model. (practical values for N_PTN>=2 only).	-
176.0	T_P_INF	REAL	Time to inflection point (s)	≥ 0.0	0.0	Time from process excitation to inflection point.	-
180.0	P_INF	REAL	Actual value at inflection point - PV0 - PV0	(phys. variable)	0.0	Change in actual value from process excitation to inflection point.	-
184.0	LMN0	REAL	Manipulated variable at the beginning of optimization	-100.0 ... 100.0 (%)	0.0	Is established in phase 1 (average)	-
188.0	PV0	REAL	Actual value at the beginning of optimization	(phys. variable)	0.0	Is established in phase 1 (average).	-
192.0	PVDT0	REAL	Actual value gain at the beginning of optimization	(phys. variable) /s	0.0	Sign is adapted.	-
196.0	PVDT	REAL	Current actual value gain	(phys. variable) /s	0.0	Sign is adapted.	-

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assign-ment screen
200.0	PVDT_MAX	REAL	Max. actual value change	(phys. variable) /s	0.0	Maximum derivative of the actual value at the point of inflection (sign adapted, always > 0); is used to calculate TU and KIG.	-
204.0	NOI_PVDT	REAL	Proportion of noise in PVDT_MAX in %		0.0	The larger the noise fraction, the less precise (softer) are the controller parameters.	-
208.0	NOISE_PV	REAL	Absolute actual value noise	(phys. variable) /s	0.0	The difference between maximum and minimum actual value in phase 1.	-
212.0	FIL_CYC	INT	Number of cycles of the mean value filter	1 ... 1024	0	The actual value is averaged over FIL_CYC cycles. When required, FIL_CYC is automatically raised from 1 max. 1024.	-
214.0	POI_CMAX	INT	Maximum number of cycles after inflection point	≥ 0	0	This time is used to find another (i.e. better) inflection point in case of measuring noise. Only then is optimization completed.	-
216.0	POI_CYCL	INT	Number of cycles after inflection point	≥ 0	0	The aforementioned parameters are to be found in the OUT structure following SAV_CZON	-

C.6 Instance DB of the FB 57 FMT_PV

Table C- 20 Input parameters of the instance DB for the FMT_PV

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In the para-meter screen form
0.0	S_AION	ARRAY [0..3] of BOOL	Switch: Simulation of the analog input value via 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 57 FMT_PV function block (Page 135)").	-
2.0	S_PVON	ARRAY [0..3] of BOOL	Switch: Simulation of the preprocessed analog input value via 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 57 FMT_PV function block (Page 135)").	-

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In the para-meter screen form
4.0	PV_SIM	ARRAY [0..3] 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, the simulation value for analog input 1 is specified at the PV_SIM [1] input. If S_PVON = TRUE, then the preprocessed analog input value is specified in this case. 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.	-
20.0	S_DION	ARRAY [0..7] of BOOL	Switch: Simulation of the digital input with 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 57 FMT_PV function block (Page 135)").	-
22.0	DI_SIM	ARRAY [0..7] of BOOL	Simulation value for the digital input		FALSE		-
24.0	MOD_ADDR	INT	Module address FM 355-2		256	The module address that resulted from the configuration with STEP 7 is given at this input.	-

Table C- 21 Output parameters of the instance DB for the FMT_PV

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assignment screen
26.0	STAT_DI	ARRAY [0..7] of BOOL	Status of digital inputs DI0 to DI7		FALSE	The states of digital inputs 0 to 7 are shown on the STAT_DI parameters.	-
28+ (Channel number x8)	DIAG[x].PV_PER	ARRAY [0..3] of STRUCT	Analog input value 0 to 20 mA; -10000 to 10000 mV		0.0	The analog input value of the module is shown, for example, in the units mA or mV, on the DIAG[x].PV_PER parameter.	-
32+ (Channel number x8)	DIAG[x].PV_PHY	ARRAY [0..3] of STRUCT	Preprocessed analog value in a physical unit		0.0	The parameter DIAG[x].PV_PHY displays, for example, the linearized analog input value of the module in the physical unit.	-
60.0	RET_VALU	WORD	Return value of SFB 52/53		W#16#0	Output STATUS (bytes 2 and 3) of SFB52/53; corresponding to the error code RET_VAL of SFC58/59	-

Table C- 22 I/O parameters of the instance DB for the FMT_PV

Address	Parameters	Data type	Comment	Legal value range	Default setting	Explanation	In parameter assignment screen
62.0	LOAD_PV	BOOL	Load process values to FM 355-2		FALSE	When the LOAD_PV I/O parameter is set, the simulation values in PV_SIM and DI_SIM are written to the FM 355-2 in accordance with the switch positions and the I/O parameter is reset.	-
62.1	READ_PV	BOOL	Reading process values from FM 355-2		FALSE	If the parameter READ_PV = TRUE, the reference junction temperature is read from the module. Thereafter the I/O parameter is reset.	-

See also

List of RET_VALU messages (Page 243)

List of RET_VALU messages D

D.1 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 transmission 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	DP protocol error at layer 2
80A3	32931	-32605	DP protocol error in 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 DBs too high. (Write job)
853A	34106	-31430	Parameter DB not present. (Write job)

JOB_ERR (Hex)	JOB_ERR (Dec)	JOB_ERR (Int)	Meaning
8544	34116	-31420	Error at n-th (n > 1) read access to a DB after an error has occurred. (Write job)
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 DBs 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. after a waiting period they can be eliminated without any action on your part. Messages of the 7xxx form indicate temporary operating states of communication.			

List of abbreviations

E

E.1 List of abbreviations

Abbreviations

The parameter names of FMT_PID and FMT_TUN are used in the text in a similar way to abbreviations. The following table shows the assignment to the parameters of the FBs. The "Structure" column remains empty if the parameter is not to be found in a structure.

Abbreviation	Explanation	FB	Structure
BREAK_TM	Minimum break time [s]	FMT_PID	PAR
COM_RST	Cold restart	FMT_PID	-
CON_ZONE	Control zone width	FMT_PID	PAR
CONZ_ON	Enable control zone	FMT_PID	PAR
D_EL_SEL	Selection of the input for derivative action element	FMT_PID	PAR
D_F	Derivative-action factor	FMT_PID	PAR
DEADB_W	Dead band width	FMT_PID	PAR
DISV	Disturbance variable	FMT_PID	OUT
ER	Error signal	FMT_PID	OUT
FIL_CYC	Number of cycles of the mean value filter	FMT_TUN	OUT
GAIN	Controller gain (proportional coefficient)	FMT_PID	PAR
GAIN_P	Process gain	FMT_TUN	OUT
H_ALM	upper limit value interrupt	FMT_PID	PAR
H_WRN	upper limit value warning	FMT_PID	PAR
HYS	Hysteresis	FMT_PID	PAR
KIG	Maximum actual value rise at manipulated variable excitation from 0 to 100% [1/s]	FMT_TUN	OUT
L_ALM	low limit value interrupt	FMT_PID	PAR
L_WRN	lower limit value warning	FMT_PID	PAR
LMN	Manipulated variable	FMT_PID	OUT
LMN_A	Manipulated variable A of the split-range function	FMT_PID	OUT
LMN_B	Manipulated variable B of the split-range function	FMT_PID	OUT
LMN_DN	Manipulated variable signal Low operation (for step-action controllers only).	FMT_PID	OP
LMN_HLM	Upper limit of manipulated variable	FMT_PID	PAR
LMN_LLM	Lower limit of manipulated variable	FMT_PID	PAR
LMN_RE	external manipulated variable	FMT_PID	OP
LMN_REON	enable external manipulated variable (manual mode)	FMT_PID	OP
LMN_UP	Manipulated variable signal High operation (for step-action controllers only)	FMT_PID	OP

Abbreviation	Explanation	FB	Structure
LMN0	Manipulated variable at the beginning of optimization	FMT_TUN	OUT
LMNRHSRE	upper end signal of the position feedback	FMT_PID	OP
LMNRLSRE	lower end signal of the position feedback	FMT_PID	OP
LMNS_ON	Enable operation of manipulated variables (for step-action controllers only) (manual mode)	FMT_PID	OP
LMNTRKON	Correction of the manipulated variable via analog input	FMT_PID	OP
LOAD_OP	Download operator parameters to FM 355-2	FMT_PID	-
LOAD_PAR	Download controller parameters to FM 355-2	FMT_PID	-
LOAD_PID	Load optimized PI/PID parameters	FMT_PID	OP
MONERSEL	Monitoring: Process variable = 0; error signal = 1	FMT_PID	PAR
MTR_TM	Motor actuating time [s]	FMT_PID	PAR
N_PTN	Process order	FMT_TUN	OUT
NOI_PVDT	Proportion of noise in PVDT_MAX in %	FMT_TUN	OUT
NOISE_PV	absolute noise in actual value	FMT_TUN	OUT
P_INF	Actual value at inflection point - PV0	FMT_TUN	OUT
P_SEL	Enable proportional component	FMT_PID	PAR
PFAC_SP	Proportional factor for setpoint changes	FMT_PID	PAR
PHASE	Phase display of controller optimization	FMT_PID	OUT
PID_ON	Enable PID mode	FMT_PID	PAR
POI_CMAX	maximum number of cycles after inflection point	FMT_TUN	OUT
POI_CYCL	Number of cycles after inflection point	FMT_TUN	OUT
PULSE_TM	Minimum pulse duration [s]	FMT_PID	PAR
PV	Actual value	FMT_PID	OUT
PV0	Actual value at the beginning of optimization	FMT_TUN	OUT
PVDT	current actual value gain [1/s]	FMT_TUN	OUT
PVDT_MAX	Max. change in the actual value per second [1/s]	FMT_TUN	OUT
PVDT0	Actual value gain at the beginning of optimization [1/s]	FMT_TUN	OUT
QDNRLM	negative gain limitation of the setpoint triggered	FMT_PID	OUT
QH_ALM	upper limit value interrupt triggered	FMT_PID	OUT
QH_WRN	upper limit value warning triggered	FMT_PID	OUT
QL_ALM	lower limit value interrupt triggered	FMT_PID	OUT
QL_WRN	lower limit value warning triggered	FMT_PID	OUT
QLMN_HLM	Upper manipulated variable limit triggered	FMT_PID	OUT
QLMN_LLM	lower manipulated variable limit triggered	FMT_PID	OUT
QLMN_RE	external manipulated variable enabled	FMT_PID	OUT
QLMNDN	Manipulated variable signal Low output (pulse and step-action controllers)	FMT_PID	OUT
QLMNR_HS	upper end signal of the position feedback	FMT_PID	OUT
QLMNR_LS	lower end signal of the position feedback	FMT_PID	OUT
QLMNSAFE	Safety mode	FMT_PID	OUT
QLMNTRK	Follow-up mode	FMT_PID	OUT
QLMNUP	Manipulated variable signal Low output (pulse and step-action controllers)	FMT_PID	OUT

Abbreviation	Explanation	FB	Structure
QSP_HLM	Upper setpoint limit triggered	FMT_PID	OUT
QSP_LLM	Setpoint low limit triggered	FMT_PID	OUT
QSPR	Split-range mode	FMT_PID	OUT
QUPRLM	Gain limitation of the setpoint triggered	FMT_PID	OUT
RATIOFAC	Ratio of heating/cooling gain of the process.	FMT_PID	PAR
READ_OUT	Read output parameters from FM 355-2	FMT_PID	-
READ_PAR	Read controller parameters from FM 355-2	FMT_PID	-
SAFE_ON	Set safety mode	FMT_PID	PAR
SAVE_PAR	Back up current controller parameters	FMT_PID	OP
SP	effective setpoint on module	FMT_PID	OUT
SP_HLM	Upper setpoint limit	FMT_PID	PAR
SP_LLM	Setpoint low limit	FMT_PID	PAR
SP_RE	external setpoint	FMT_PID	OP
STATUS_C	Status of cooling optimization	FMT_PID	OUT
STATUS_D	Status of controller design for controller optimization	FMT_PID	OUT
STATUS_H	Heating optimization status	FMT_PID	OUT
T_P_INF	Time to inflection point [s]	FMT_TUN	OUT
TA	Process delay time [s]	FMT_TUN	OUT
TD	Derivative action time or rate time [s]	FMT_PID	PAR
TI	Integration time or correction time [s]	FMT_PID	PAR
TM_LAG_P	Time constant of a PTN model [s]	FMT_TUN	OUT
TU	Delay time [s]	FMT_TUN	OUT
TUN_CLMN	Delta manipulated variable for cooling optimization	FMT_PID	PAR
TUN_DLMN	Delta manipulated variable for process excitation	FMT_PID	PAR
TUN_ON	Enable controller optimization	FMT_PID	OP
TUN_CST	Start cooling optimization	FMT_PID	OP
TUN_ST	Starting controller optimization	FMT_PID	OP
UNDO_PAR	Undo controller parameter change	FMT_PID	OP
ZONE_TUN	Controller channel group in one zone for parallel optimization	FMT_PID	OUT

Further Information F

F.1 Literature

Supplementary references

The following table lists all the manuals to which this manual refers.

Title	Order number
SIMATIC S7; S7-300 Automation System; Installation, CPU Data	• As a hard copy in the package 6ES7 398-8FA10-8AA0 • In electronic form for download from the Internet: Installation (http://support.automation.siemens.com/WW/view/en/13008499) CPU data (http://support.automation.siemens.com/WW/view/en/12996906)
SIMATIC; System Software for S7-300/S7-400 System and Standard Functions	• As a hard copy in the package 6ES7810-4CA08-8AW1 • In electronic form for download from the Internet System and standard functions (http://support.automation.siemens.com/WW/view/en/1214574)
Product information on the response of signal modules to parameter changes in RUN	• In electronic form for download from the Internet CiR (http://support.automation.siemens.com/WW/view/en/14867391)

Basics

You can refer to the following books, among others, for basic information on control technology:

Title	Author	Order number
Vom Prozess zur Regelung	Gießler/Schmid	ISBN 978-3-80091-551-4
Controlling with SIMATIC: Practice Book for SIMATIC S7 and SIMATIC PCS7 Control Systems	Müller, Jürgen	ISBN 978-3-89578-248-0

F.2 Spare parts list

Spare parts

The table below lists the S7-300 parts which you can order separately or at a later date for FM 355-2.

Table F- 1 Accessories and spare parts

Parts for the S7-300	Order number
Bus connectors	6ES7390-0AA00-0AA0
Label sheet	6ES7392-2XX00-0AA0
Slot number label	6ES7912-0AA00-0AA0
Screw-on front connector (20-pole)	6ES7392-1AJ00-0AA0
Shield support element (with 2 threaded bolts)	6ES7390-5AA00-0AA0
Shield terminals for	
• 2 cables, each with 2 to 6 mm shield diameter	6ES7390-5AB00-0AA0
• 1 cable with 3 to 8 mm shield diameter	6ES7390-5BA00-0AA0
• 1 cable with 4 to 13 mm shield diameter	6ES7390-5CA00-0AA0

Index

D

E

F

G

H

I

L

M

N

O

P