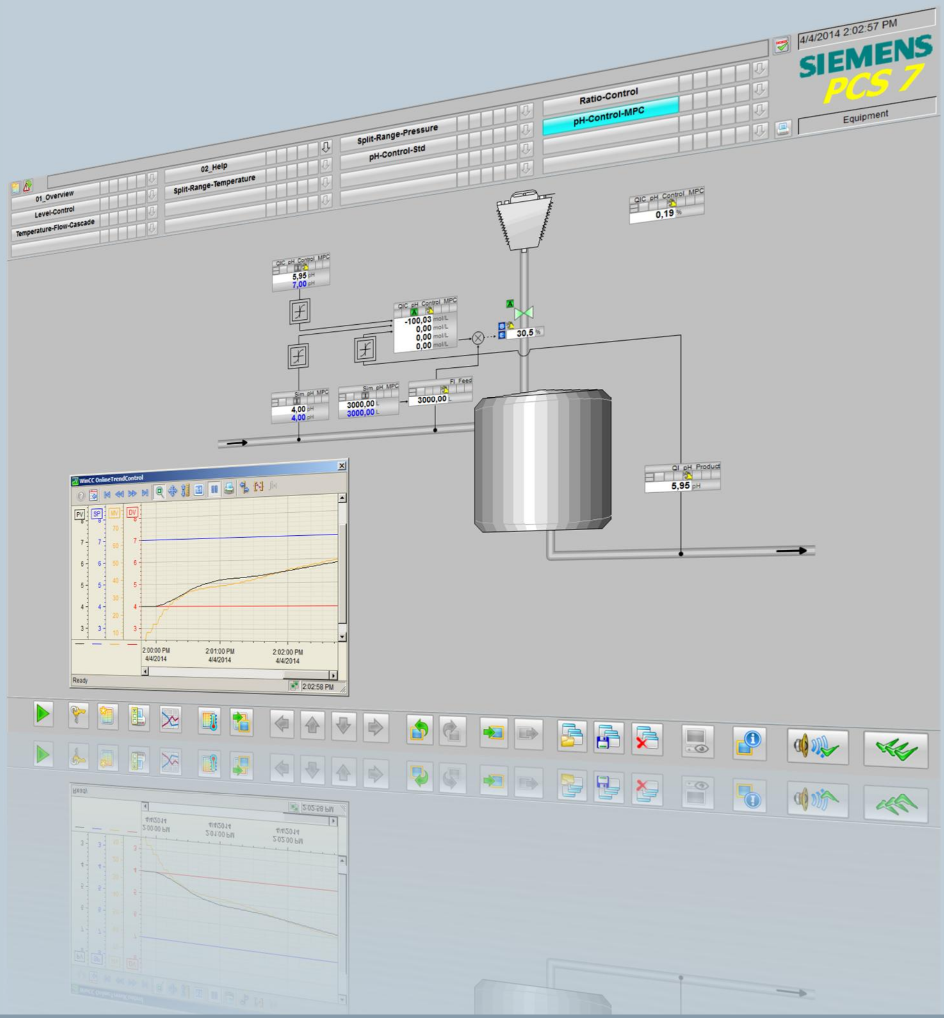
SIEMENS



Application example • 09/2016

Equipment Modules for PCS 7 using the example of the Chemical Industry

SIMATIC PCS 7

https://support.industry.siemens.com/cs/ww/en/view/53843373

Warranty and liability

Note

The Application Examples are not binding and do not claim to be complete regarding configuration, equipping and any eventuality. The Application Examples do not represent customer-specific solutions. They are only intended to provide support for typical applications. You are responsible for proper operation of the described products. These application examples do not relieve you of the responsibility to use safe practices in application, installation, operation and maintenance. When using these Application Examples, you recognize that we cannot be made liable for any damage/claims beyond the liability clause described. We reserve the right to make changes to these Application Examples at any time without prior notice. If there are any deviations between the recommendations provided in these Application Examples and other Siemens publications – e.g. Catalogs – the contents of the other documents have priority.

We do not accept any liability for the information contained in this document.
Any claims against us – based on whatever legal reason – resulting from the use of the examples, information, programs, engineering and performance data etc., described in this Application Example shall be excluded. Such an exclusion shall not apply in the case of mandatory liability, e.g. under the German Product Liability Act ("Produkthaftungsgesetz"), in case of intent, gross negligence, or injury of life, body or health, guarantee for the quality of a product, fraudulent concealment of a deficiency or breach of a condition which goes to the root of the contract ("wesentliche Vertragspflichten"). The damages for a breach of a substantial contractual obligation are, however, limited to the foreseeable damage, typical for the type of contract, except in the event of intent or gross negligence or injury to life, body or health. The above provisions do not imply a change of the burden of proof to your detriment.
Any form of duplication or distribution of these Application Examples or excerpts hereof is prohibited without the expressed consent of the Siemens AG.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines, and networks.

To protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and to continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions form only one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines, and networks Systems, machines, and components should only be connected to the enterprise network or the Internet if necessary and only to the extent necessary, and with appropriate protective measures in place (e.g., use of firewalls and network segmentation).

In addition, you should pay attention to Siemens' recommendations on appropriate protective measures For more information about industrial security, visit http://www.siemens.com/industrialsecurity.

The products and solutions from Siemens undergo continuous development to make them even more secure. Siemens strongly recommends applying product updates as soon as they are available and to always use the latest product versions. Using versions that are obsolete or are no longer supported can only increase the risk of cyber threats.

To ensure that you are always kept informed about product updates, subscribe to the Siemens industrial security RSS feed at http://www.siemens.com/industrialsecurity.

Table of contents

1 Task and solution

1.1 Task

The standardization of automation engineering for processing plants, such as in the chemical industry, is a major challenge. Different process steps and procedures, different equipment and flexibility in the production make the task even more difficult.

One approach for standardization is structuring the plant according to the physical model of ISA 106. This specifies the lower four levels, i.e. plant, unit, plant unit and control module. A plant always consists of plant sections. The plant sections can, in turn, contain standardized plant sections that are based on equipment modules. An equipment module comprises both the user program and the physical equipment.

1.2 Solution

1.2.1 Overview

This application example contains standardized equipment modules in the form of software typicals that are provided in SIMATIC PCS 7 as a multiproject.

Using them offers the following benefits:

- A reduction in the expertise necessary to develop applications
- Less effort needed for configuration
- Demonstration of typical control strategies
- Harmonized structures
- Flexible structuring and adjustment of partial automation solutions

The equipment modules offer a template that comprises the typical components of a partial automation solution, their open- and closed-loop control, the necessary logic and visualization.

An equipment module is configured independently of the automation hardware and is a component of a pre-configured PCS 7 project including the process visualization system. Due to hardware-independent configuration and the modular structure, it is possible to integrate and use the equipment modules in PCS 7 projects in any way you like.

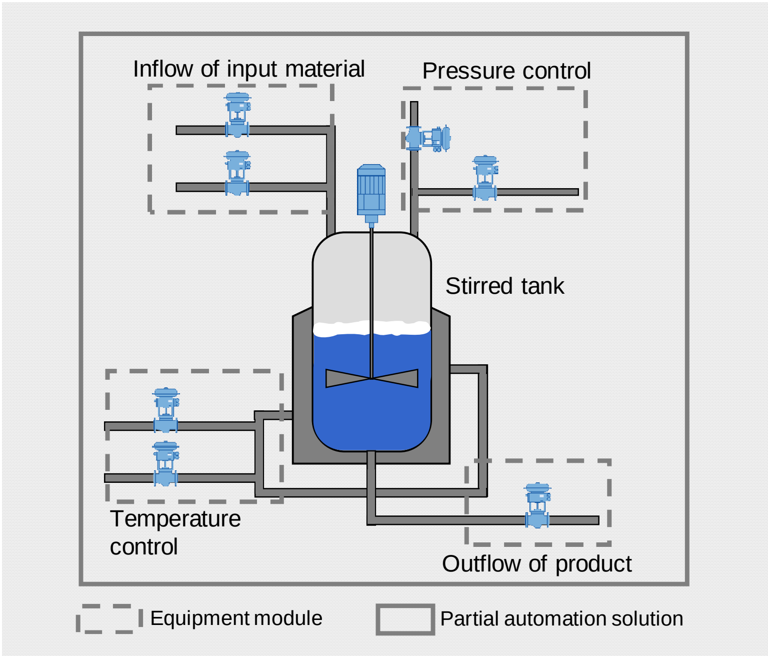
Equipment modules are composed of control modules (CMs). Function blocks of the PCS 7 Advanced Process Library (APL) were used to create a control module.

1.2.2 Overview of complete solution

Diagram

The diagram below shows the equipment modules as a component of a partial automation solution as an example.

Figure 1-1: Structured set-up of a partial automation solution



Description

The concept of equipment modules provides preengineered and unified components for creating an automation solution, e.g. metering or temperature control.

The equipment modules are implemented in the PCS 7 multiproject as follows:

- One project for the automation system (AS) and one project for the operator station (OS) are contained in the component view.
- A hierarchy folder has been created in the technological hierarchy for each equipment module.
- The master data library contains all of the control module types in use

In the AS project, all of the open- and closed-loop control functions are implemented in the form of Continuous Function Charts (CFCs). Apart from this, the AS project contains a simulation that simulates a procedure, e.g. a filling level change within an equipment module.

The OS project contains visualization by means of one process picture per equipment module and shows:

- Schematic representation of the equipment module
- Simulated process response
- The relevant Key Performance Indicators (KPIs)
- Display of the control performance

Delimitation

The process behavior is not simulated within the equipment modules.

Required knowledge

A fundamental knowledge of the specialist fields below is required:

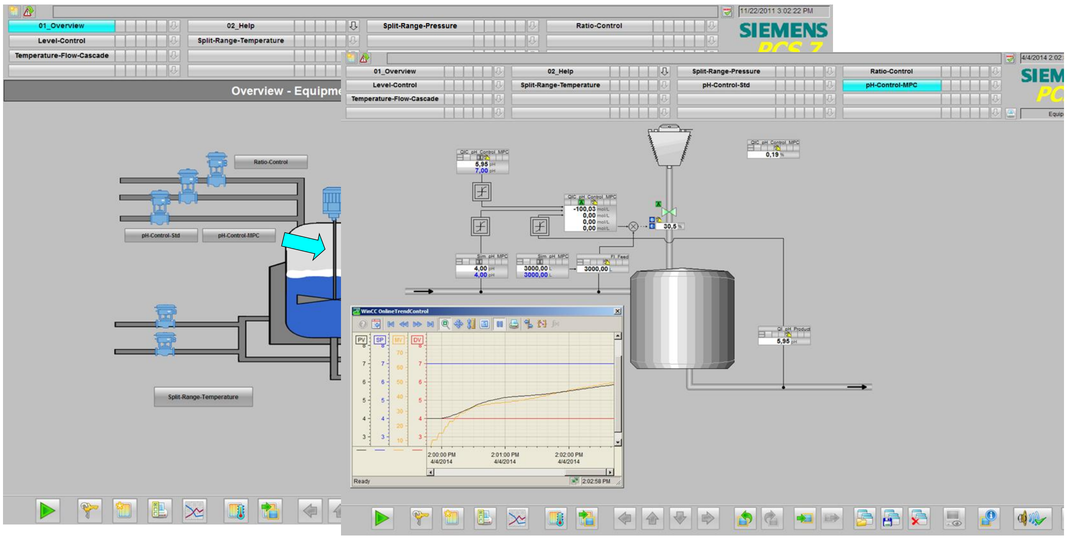
- Configuring using SIMATIC PCS 7 CM technology and the APL
- Knowledge of control technology
- Basic knowledge of process technology

1.2.3 Core functionality

The overview picture and the structure of a process picture of an equipment module are described below. For a detailed description of the core functionality of an equipment module, please refer to Chapter 5 “Equipment Module”.

Visualization interface

Figure 1-2 : Visualization interface in SIMATIC PCS 7



Overview picture **Process picture**

The visualization interface of the equipment modules consists of an overview picture and a process picture for each equipment module.

Overview picture

The overview picture contains a schematic representation in the form of a material flow diagram of the process engineering system that includes all the equipment modules in the example project.

Using the pushbutton of an equipment module, you switch to the respective process picture that contains the functionality and the specific information of an equipment module. The system represents the process pictures in the form of an appropriate section of the P&ID of a system.

Process picture

The process picture of an equipment module consists of the following parts:

- The schematic representation (P&ID)
- Simulation
- Faceplates for controlling the individual components (units)
- A curve representation to visualize the controller response

In the process picture, operators are provided with an overview of the respective equipment module and can understand the runtime response on a time basis.

1.2.4 Validity

This application is created with SIMATIC PCS 7 V8.2.

1.2.5 Hardware and software components used

Note Take heed of the minimum requirements for installing the software components. The minimum requirements can be found in the Readme file of the PCS 7.

Software components

Table 1-1

Component	Note
S7 PLCSIM	The license does not form part of the SIMATIC PCS 7 ES/OS

Example files and projects

The following list contains all the files and projects used in this example.

Table 1-2

Component	Note
53843373_EquipmentModules_PROJ_PCS7V82.zip	PCS 7 V8.2 example project
53843373_EquipmentModules_DOC_en.pdf	This document

2 Basics

2.1 General Information

Automation technology

Industrial processes in the chemicals or pharmaceuticals sectors, for example, are controlled and regulated using automation technology.

The degree of automation of systems varies considerably and depends on the system type and the process.

In general, an automation solution includes the following aspects:

- Measurement and control
- Possibly, control of higher quality control strategies
- Transferring, processing and representing information
- Complying with defined steps and procedures
- Observing complex contexts
- Guaranteeing constant product quality
- Strategies in the case of deviations from or exceeding of process parameters or of component failures

Process control

The operator's main task is to carry out operative process control on the basis of process and plant information from process engineering production and its logistics and auxiliary processes.

Using process control guarantees the operating conditions are set on a selective and reproducible basis and compliance with defined tolerance ranges. After disturbances have occurred, you must implement measures to restore the process to the desired operating state. In addition, the process sequence should be continuously optimized with regard to costs, quality, and safety.

Using SIMATIC PCS 7 Advanced Process Graphics (APG), it is possible to make process visualization more efficient for operators. When doing this, the system places the information in the plant overview that is relevant to orientation and navigation. The information that is necessary for operator control and monitoring of a plant unit, e.g. a reactor, is made available in a lower-level process picture. This procedure provides the great advantage of dispensing information and making it available in a way that is optimized for process operation.

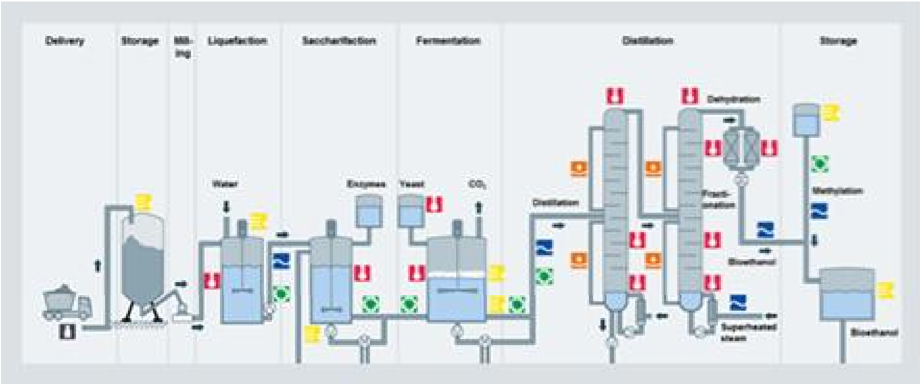
Note You can find detailed information and the procedure for configuring APG in the Siemens Industry Online Support in the entry entitled "Integration of Advanced Process Graphics in SIMATIC PCS 7" under https://support.industry.siemens.com/cs/ww/en/view/89332241.

2.2 Standardized plant units

Partial automation solution

The figure below shows the components of an automation solution for a process engineering system. The process is divided into several steps, e.g. fermentation and distillation. In this connection, one process step corresponds to one plant unit, which, for its part, can consist of different equipment modules, e.g. addition of starting material or agitation.

Figure 2-1: Process steps of a process plant



Unit

The term plant unit represents a "unit" in process engineering plants (e.g. stirred tank reactor, fermenter) which includes the device, sensor technology, actuators and automation (hardware and software).

There are structured units for both continuous and discontinuous processes.

Package units are variants of a plant unit. Examples of package units include refrigeration systems, vacuum systems and packaging machines. In this case, the manufacturer of the mechanical or technical device includes automation, specially tailored for this device, and which is mounted locally on the device of a separate hardware. The package unit is integrated as a whole into a higher-level process control system.

Equipment module

An equipment module forms part of a unit and contains sensors, actuators and the automation system (hardware and software). Equipment modules are designed and configured for use in concrete applications, such as process technology (dosing device, level or temperature control).

The automation solution of an equipment module is structured as follows:

- Connected and parameterized process tags
- Simulation to demonstrate the mode of operation

Each equipment module is combined in a hierarchy folder and can be integrated into existing projects.

Control module

Actuators and sensors are used at the control module level as control modules. In PCS 7, the control module is implemented with software typicals (control module types) such as a valve, motor, or controller, for example.

The implementation in the CFC contains all the relevant building blocks, interconnections, and basic parameters. A control module type is produced from the CFC, which is then stored in the PCS 7 master data library. You can create as many instances as you like from this control module type using the Automation Interface, for example. There can be major differences between the instances, e.g. you can select options for functions as well as for the process link.

Each designation of a control module follows a uniform naming convention. This means that the name provides information about the function and the job of the control module.

Unit Template

A unit template is composed of several equipment modules. In a unit template, equipment modules are grouped into a partial automation solution.

In addition, it is possible to display other information in a unit template, such as economic or process engineering parameters (KPIs) or the operating times of equipment.

A unit template is grouped in a hierarchy folder and you can easily integrate it into existing projects and adapt it.

By contrast with package units, no local “isolated control systems" with their own hardware are set up; rather, pre-assembled software solutions are created in a central process control system in the unit concept for frequently occurring units. Partial automation solutions for process engineering systems are provided on a uniform pre-assembled basis and can be edited by users. This means that it is only necessary to adapt the templates to the existing process engineering and automation hardware. This significantly reduces the engineering effort required for several similar automation tasks.

Configuration with templates

You can carry out configuration using templates at the equipment module or control module level.

At the control module level, you use control module types in PCS 7 to create a template for creating instances. It is possible to compare and match the instances of the control module types with the PCS 7 Automation Interface.

Equipment modules or plant units are duplicated as a unit and adapted to the corresponding process engineering.

The equipment module and the unit template consist of all of the functions that are needed for automation in the form of:

- CFC (instances of control module types)
- SFCs
- OS pictures

3 Design and structure

3.1 CFC naming convention

A uniform naming convention was used to identify the control modules with the function being named according to European standard EN 62424 or to ISO 3511. The figure below shows how a label is composed:

Figure 3-1

FIC_Reflux

Function → FIC; Designation → Reflux

Function		Designation
F =	Flow	(First letter)
I =	Indication	(Next letter)
C =	Control	(Next letter)

The table below contains all of the letters that are used in the Application Example and their meanings:

Table 3-1

First letter	
Letter	**Meaning**
F	Flow
L	Level
N	Motor
P	Pressure
Q	Quantity
S	Speed (velocity, rotational speed, frequency)
T	Temperature
X	Freely selectable first letter
Y	Control valve
Subsequent letter	
C	Control
F	Fraction
I	Indication
S	Binary control function or switching function (not safety-oriented) ("switching")

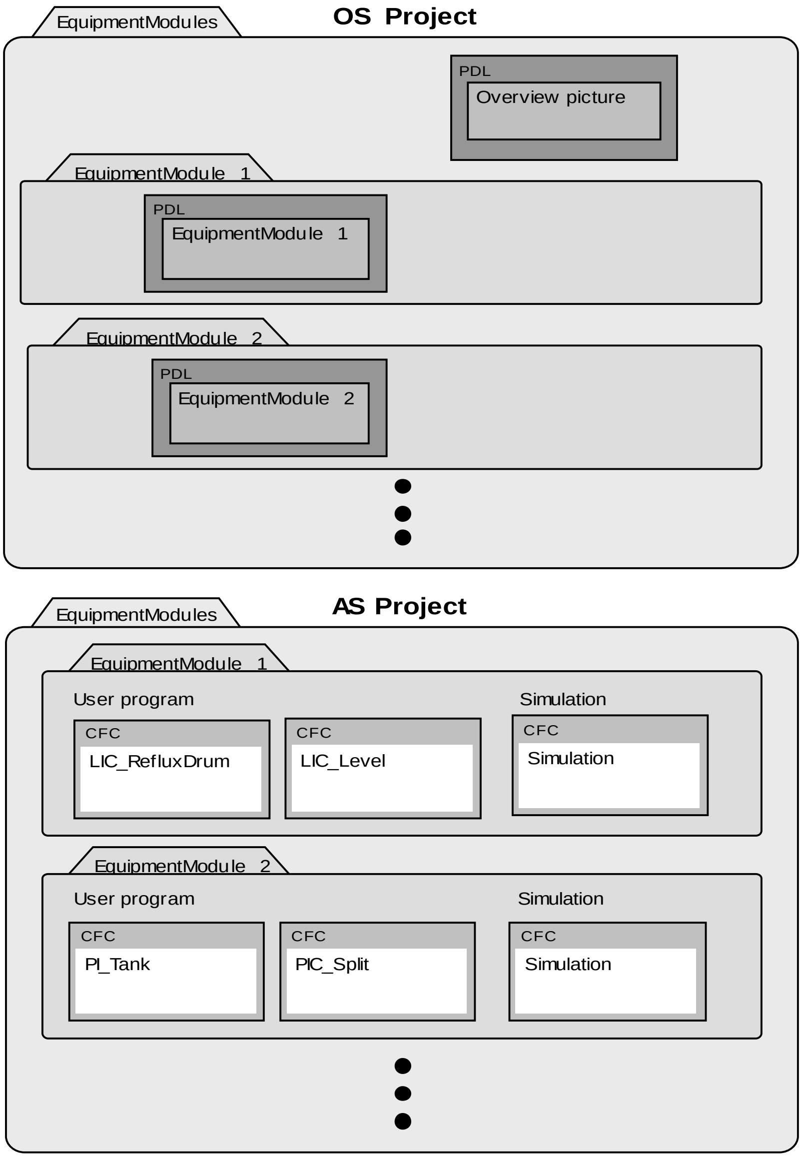
3.2 Plant view

In the plant view, the equipment modules are implemented on two hierarchy levels.

In the “EquipmentModules_AS_Prj" AS project, the first hierarchy level is empty and on the lower hierarchy level there is one hierarchy folder for each equipment module that contains the necessary CFC.

On the first hierarchy level of the “EquipmentModules_OS_Prj" OS project, there is the overview picture of all the equipment modules “EquipmentModules.pdl”. On the lower hierarchy level there is one hierarchy folder for each equipment module that contains a process picture. The illustration below shows the folder structure on a schematic basis, i.e. the designations of the sub-folders differ from the folder designations of the PCS 7 project.

Figure 3-2: Example of folder structure in the multiproject



4 Control Modules

4.1 Introduction

A control module is used to control individual pieces of equipment, like motors, valves, and controllers, for example. The necessary blocks for carrying out this job, e.g. controlling a valve, are grouped in a control module (CM). If a control module is used several times in the project, e.g. with different characteristics, you create a control module type (CMT) from it in PCS 7 and store it in the master data library. You can use this CMT on a flexible basis in the project as an instance with different characteristics.

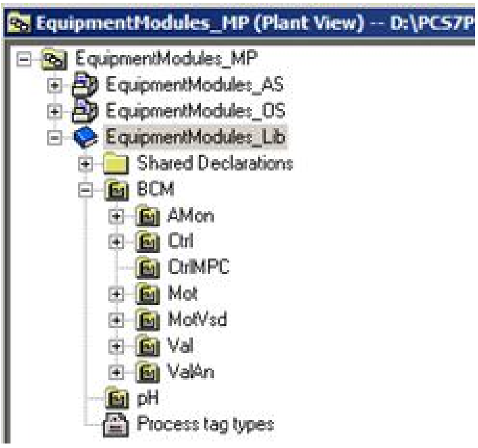
Using the technology makes it possible to test automation projects using the program logic even if you do not have the real hardware.

Note The application example "Control Module (CM) Technology - Efficient Engineering with SIMATIC PCS 7" gives you a general overview of how to create, extend, and instantiate a CMT. The application example is available at the following link:
https://support.industry.siemens.com/cs/ww/en/view/109475748

Master data library

This chapter gives you detailed information about the structure and mode of operation of the CMTs on which the equipment modules are based. All of the CMTs are stored in the “EquipmentModules_Lib" master data library of the PCS 7 projects.

Figure 4-1: Master datal library of the PCS 7 project



The CMTs are sub-divided as follows:

- Measured value display in the “AMon" folder
- Standard controller in the “Ctrl" folder
- Multivariable controller in the “CtrlMPC" folder
- Binary-switched motor in the “Mot" folder
- Motor with variable speed in the “MotVsd" folder
- Binary-switched valve in the “Val" folder
- Analalog control valve in the “ValAn" folder

CMTs are of compact structure, i.e. all the relevant blocks are at defined locations. For example, channel blocks are always in chart partition B of a CFC.

Note

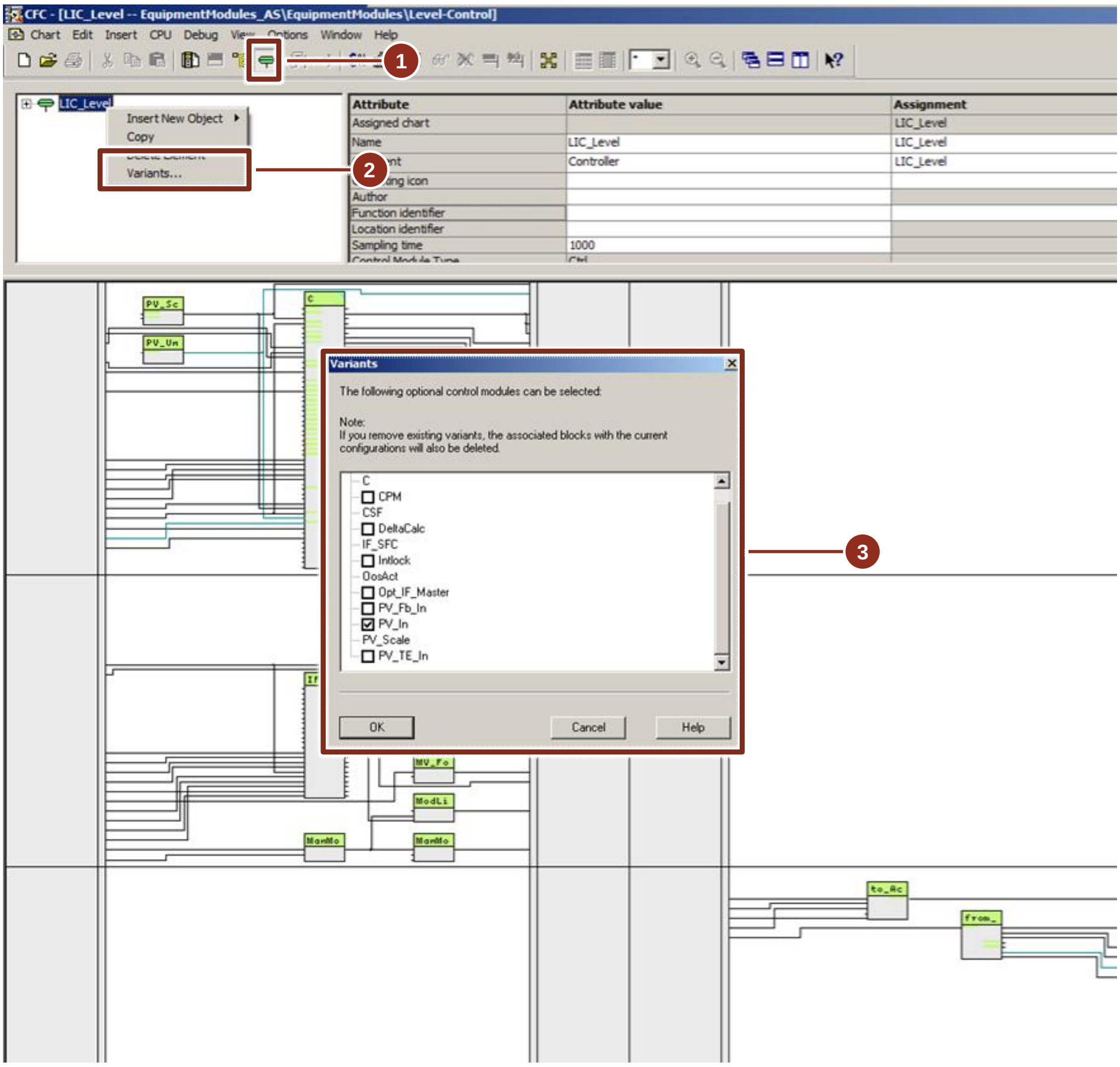
Folder "pH" contains the source files of the pH simulation and the conversion block for pH to concentration difference. The functions and structure of the block are described in Chapter 10.

Selecting a variant

A variant and the options that are necessary for solving an automation task are determined in the instance.

1. To do this, the technological I/Os are displayed in the CFC.
2. The available variants are displayed via the shortcut menu.
3. The functionality that is necessary for the automation task is determined by selecting the options.

Figure 4-2: Selecting a variant in CFC



4.2 "AMon" measurement

The measured value display monitors a measured value, e.g. pressure or temperature. In addition, you can set up limit monitoring for the process value.

The CMT is pre-configured for different areas of application.

Using variants, the corresponding channel block is selected or deselected based on measured value transfer.

In addition, it is possible to use options to activate further functions without configuration on the instance.

Below, variants and options are listed and described.

Variant 1: Measurement for analog value (4-20 mA)

Variant 1 is activated by selecting functions PV_In and Opt_PV_Scale on the instance.

Variant 2: Measurement for thermocouples

This variant is used for thermocouples that are connected to an analog input module for temperature measurement.

Variant 2 is activated by selecting function PV_TE_In on the instance.

Note Scaling on the channel block has already been preset for the range 0 to 1. You must carry out process value scaling at input "NormPV" of display block "I".

Variant 3: Measurement for digital measured value (fieldbus)

This variant is used if you are using measuring devices with PROFIBUS PA or Fieldbus Foundation (FF).

Variant 3 is activated by selecting functions PV_Fb_In and Opt_PV_Scale on the instance.

Variant 4: Measurement for software signal

Variant 4 is the default setting without additionally activated functions. In this connection, it is possible to apply the display value by directly interconnecting other process tags. Using the optional DeltaCalc function, it is possible to carry out difference measurement.

Optional functions for all variants:

to_Indicate: Link to a controller e.g. a multivariable controller

The figure below contains the available options.

Figure 4-3: Variants of AMon

AMon (CMT Master data library)	Opt_PV_Scale	to_Indicate	DeltaCalc	PV_In	PV_Fb_In	PV_TE_In	
Variants	**Function**			**Channel block**			**Description**
AMon_Std	x	o		x			Standard display (analog)
AMon_TE		o				x	Measured value display for thermocouples
AMon_FB	x	o			x		Measured value display fieldbus
AMon_SW	o	o					Program logic without channel blocks
AMon	o	o	o				Measured value display (without channel blocks)

x = Selecting a variant   o = Selectable functions

Structure

Figure 4-4: Structure of the AMon CMT

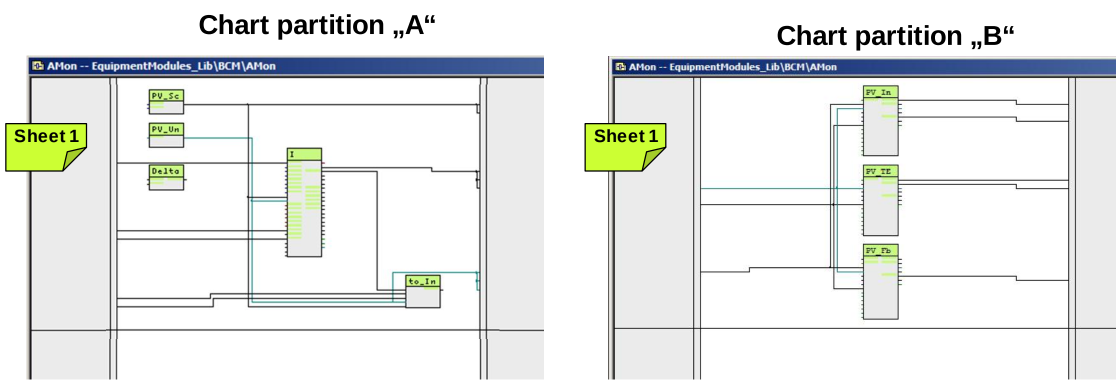


Chart partition A

The block below is located on sheet 1:

- PV_Scale: Standardization of the process value for a channel block and measured value display
- PV_Unit: Unit of measured-value display
- DeltaCalc (“Sub02”): Formation of a difference value from two process values, e.g. differential pressure
- I (“MonAnL”): Block for display and monitoring of the analog measured value
- to_Indicate: Communication block for structured transfer of signals (measured value, unit, scaling, and status) to the MPC controller, for example

Chart partition B

The channel blocks are located on sheet 1:

- PV_In (“Pcs7AnIn”): Channel block for signal processing of an analog measured value transfer, e.g. 0/4 to 20
- PV_TE_In (“Pcs7AnIn”): Channel block for signal processing of a thermocouple and use of an analog input module for temperature measurement

- PV_FB_In ("FBAnIn"): Channel block for signal processing of a digital measured value transfer (PROFIBUS PA or Fieldbus Foundation)

Parameter assignment

Enter the tolerance, warning, and alarm limits that are to be monitored on block I (MonAnL) on sheet 1. In addition, each limit value at input "xx_xx_En" must be activated.

The system then generates messages in the case of limit violations and outputs them on the operator station.

Note	If a thermocouple is used, you must carry out scaling at channel block "PV_TE_In" measured value display in addition to scaling at block PV_Scale (process value scaling).

NOTICE	**The channel block for the thermocouple has already been preset for the range 0.0 to 1.0.**

4.3 “Ctrl” controller

The CMT controllers contain controller blocks, additional monitoring and interlock functions, link blocks (master/actuator) and the link to a sequence controller.

The CMTs are pre-configured for different areas of application.

The controller CMTs below are available:

- “Ctrl” for standard PID controllers
- “CtrlRatio” for ratio controllers
- “CtrlSplitRange” for controllers with one manipulated variable and two actuators

Using variants, the corresponding channel block is selected or deselected based on measured value transfer.

In addition, it is possible to use options to activate further functions without configuration on the instance.

Below, variants and options are listed and described.

Variant 1: Controller for analog measurement and manipulated variable (4-20 mA)

Variant 1 is activated by selecting functions PV_In and Opt_PV_Scale on the instance.

Variant 2: Controller for thermocouples

This variant is used for thermocouples that are connected to an analog input module for temperature measurement.

Variant 2 is activated by selecting function PV_TE_In on the instance.

Note Scaling on the channel block has already been preset for the range 0 to 1. You must carry out process value scaling at input “NormPV” of display block “C”.

Variant 3: Controller for digital measured value (fieldbus)

This variant is used if you are using measuring devices with PROFIBUS PA or Fieldbus Foundation (FF).

Variant 3 is activated by selecting functions PV_Fb_In and Opt_PV_Scale on the instance.

Variant 4: Controller for software signal

Variant 4 is the default setting without additionally activated functions on the instance. In this connection, it is possible to apply the control value by directly interconnecting other process tags. Using the optional DeltaCalc function, it is possible to carry out difference measurement for the controlled variable.

Optional functions for all variants:

- Opt_PV_Scale: Standardization of the process value including the channel block
- CPM: Monitoring of the control performance
- Opt_IF_Master: Connection to a master controller (cascade)
- DeltaCalc: Differentiation
- Interlock: Interlocking block

4.3.1 Standard controller

The “Ctrl” CMT is used for fixed-value and cascade controllers.

The figure below contains the available options.

Figure 4-5: Variants of Ctrl

Ctrl (CMT Master Data library)	Opt_PV_Scale	CPM	Opt_IF_Master	DeltaCalc	Intlock	PV_In	PV_Fb_In	PV_TE_In	
Variants	**Function**					**Channel block**			**Description**
Ctrl_Std	x	o	o		o	x			Standard display (analog)
Ctrl_TE		o	o	o	o			x	Measured value display for thermocouples
Ctrl_Fb	x	o	o		o		x		Measured value display fieldbus
Ctrl_SW	o	o	o	o	o				Program logic without channel blocks

x = Selecting a variant   o = Selectable functions

Examples of standard controllers include:

- Fill level controller with inflow and outflow
- Temperature control

Note In “plant view”, you activate master/slave operation by selecting “Opt_IF_Master”. After activation, the “to_Master” and “from_Master” link blocks are available.

Figure 4-6: Status diagramm using standard control

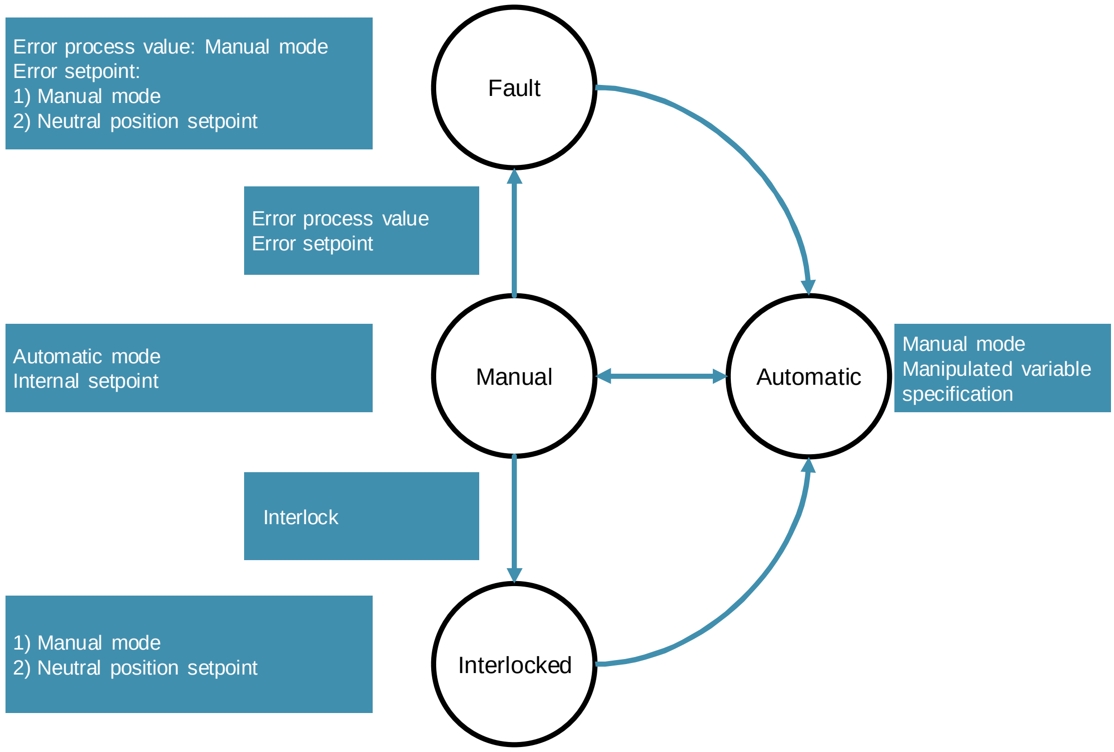
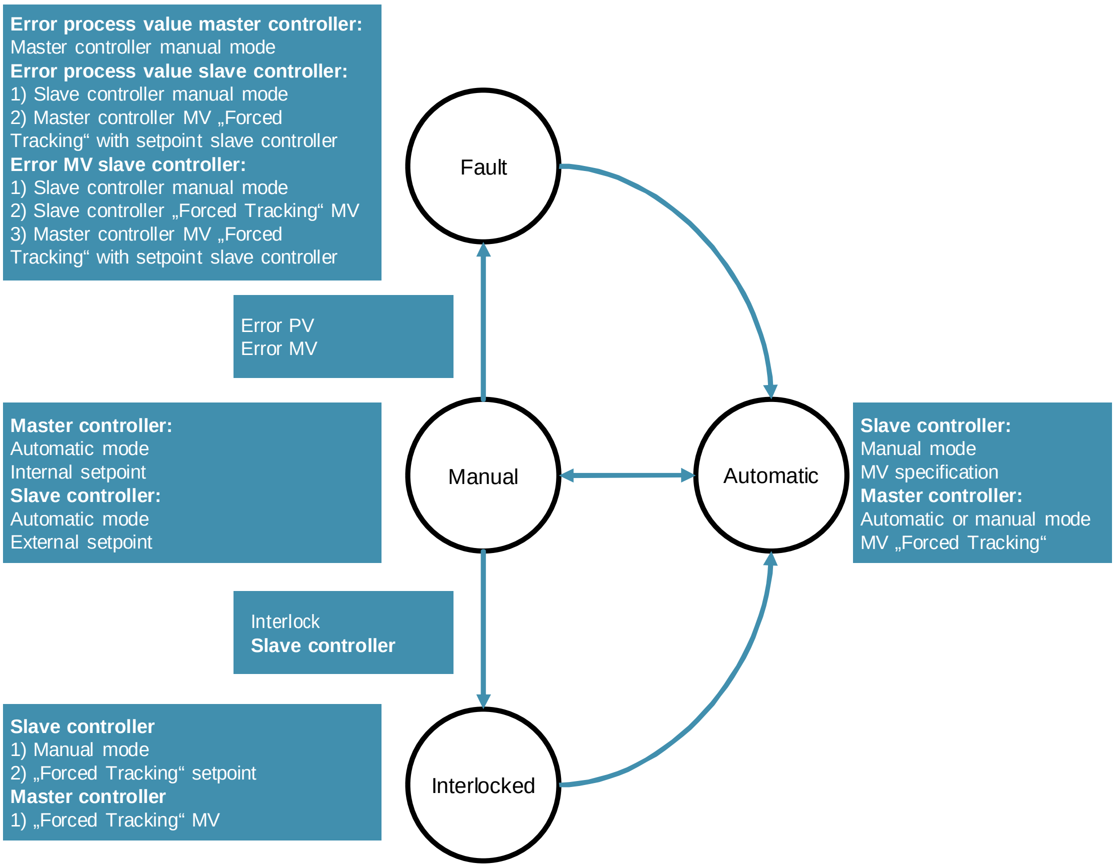


Figure 4-7: Status diagramm using cascade control



4.3.2 Ratio controller

The “CtrlRatio” control module type is used for ratio controllers. Ratio controllers are composed of a flow regulator (for the main component) and a flow regulator for each added component. The instance of “CtrlRatio” is used for the component that is to be added in a defined ratio, e.g. the blended component.
The figure below contains the available options.

Figure 4-8: Variants of CtrlRatio

CtrlRatio (CMT Master Data Library)	Opt_PV_Scale	CPM	Opt_IF_Master	DeltaCalc	Intlock	PV_In	PV_Fb_In	PV_TE_In	
Variants	**Function**					**Channel block**			**Description**
CtrlRatio_Std	x	o	o		o	x			Standard display (analog)
CtrlRatio_TE		o	o	o	o			x	Measured value display for thermocouples
CtrlRatio_Fb	x	o	o		o		x		Measured value display fieldbus
CtrlRatio_SW	o	o	o		o				Program logic without channel blocks
CtrlRatio_SW_DeltaCalc	o	o	o	x	o				Program logic for differation without channel blocks

x = Selecting a variant   o = Selectable functions

Examples of ratio controllers include:

- Blending control of liquids or gases with a defined mixing ratio
- Fuel infeed in a defined ratio to the air infeed with gas burners

4.3.3 Split range controller

The “CtrlSplitRange” control module type is used for controllers where one manipulated variable controls several actuators (with a limited effective range and possibly the opposite direction of control action).
The figure below contains the available options.

Figure 4-9: Variants of CtrlSplitRange

CtrlSplitRange (CMT Master Data library)	Opt_PV_Scale	CPM	Opt_IF_Master	DeltaCalc	Intlock	PV_In	PV_Fb_In	PV_TE_In	
Variants	**Function**					**Channel block**			**Description**
CtrlSplitRange_Std	x	o	o		o	x			Standard display (analog)
CtrlSplitRange_TE		o	o	o	o			x	Measured value display for thermocouples
CtrlSplitRange_Fb	x	o	o		o		x		Measured value display fieldbus
CtrlSplitRange_SW	o	o	o		o				Program logic without channel blocks
CtrlSplitRange_SW_DeltaCalc	o	o	o	x	o				Program logic for differation without channel blocks

x = Selecting a variant o = Selectable functions

Examples of split-range controllers include:

- Temperature controllers with separate actuators for heating and cooling
- Pressure regulation with separate valves for gas feed and venting

Note In “plant view”, you activate master/slave operation by selecting “Opt_IF_Master”. After activation, the “to_Master” and “from_Master” link blocks are available.

The control module type is preconfigured for the following setpoint range:

- Manipulated variable 0 to 100 (from the controller)
- Manipulated variable 50 to 100 corresponds to travel range 0 to 100 with actuator 1
- Manipulated variable 50 corresponds to the neutral position, i.e. both actuators are closed
- Travel range 0 to 50 corresponds to travel range 100 to 0 with actuator 2

4.3.4 Structure

The structure of CMTs is mainly standardized with the main difference being in chart partition "A" Sheet 6.

Figure 4-10: Structure of a CMT using CtrlSplitRange as an example

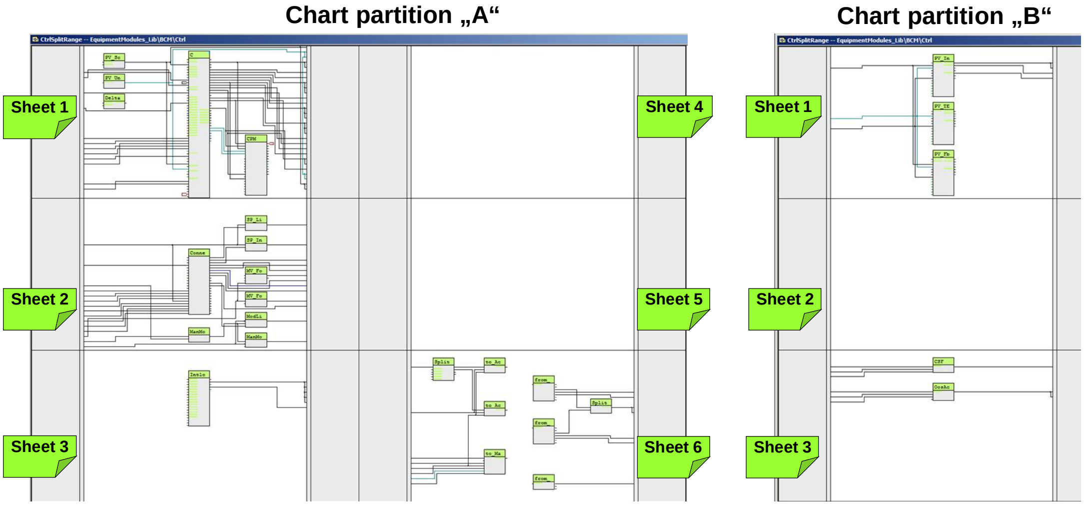


Chart partition A

The following blocks are located on sheet 1:

- PV_Scale: Standardization of the process value for a channel block and measured value display
- PV_Unit: Standardization of the unit for a channel block and displaying measured values
- DeltaCalc (“Sub02”): Formation of a difference value from two process values, e.g. offset of the process value
- C ("PIDConL"): PID controller
- CPM ("ConPerMon"): Block for permanent monitoring of control performance

The operating mode, setpoint and actual values, and the manipulated variable of the PID controller are interconnected with the CPM block.

The following blocks are located on sheet 2:

- AIF_SFC ("ConnPID"): A free block for SFC linking (not a component of the APL or the standard library)
- Logic blocks for selecting the operating mode and for interlocking
  - SP_LiOp ("Or04"): Setpoint source internal/external
  - SP_IntLi ("Or04"): Internal setpoint via interconnection
  - MV_Forced ("SelA02In"): Forced manipulated variable with selection ("In1" undefined, "In2" SFC link)
  - MV_ForOn (“Or04"): Activates forced manipulated variable "In2" (MV_Forced) on the PID controller
  - ManModOpLi ("Or04"): Formation of an OR output signal from field device in maintenance (channel blocks PV and MV) and invalid process value (channel block PV in chart partition "B", Sheet 1)

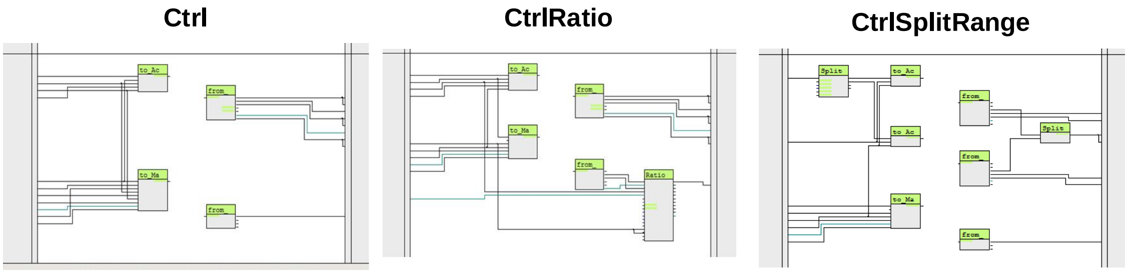
- ModLiOp ("Or04"): Operating mode selection between operator and interconnection or SFC
- ManModLi ("Or04"): Manual mode via interconnection or SFC (controlled via ModLiOp = 1)

Using the SFC link, data that is relevant to production is transferred to the PID controlling via the logic blocks. In addition, channel blocks and the interlocking block (chart partition "A", Sheet 3) affect the output signals of the logic blocks.

The interlocking block – which gathers signals for standardized locking with the option of display on the OS – is located on Sheet 3.

The link blocks below, used for rapid engineering, are located on sheet 6.

Figure 4-11: Differentiation of the controllers in chart partition A sheet 6



Ctrl controller

- to_Actor_Slave ("ComStruIn"): Transfer of the manipulated variable (MV), setpoint value (SP), process value (PV), and the locking status to the actuator or slave (slave in the case of cascade control)
- from_Actor_Slave ("ComStruOu"): Reception of the actuating signal feed back (Rbk), the message with invalid process values, and field device maintenance of channel blocks MV and Rbk, of the out unit and scaling of the actuating display and travel range (ScaleOut) of the actuator or slave (slave in the case of cascade control)
- to_Master ("ComStruIn"): The communication block forms a structure consisting of outputs (setpoint, block is "out of service" message, message for cascade switching, process value), of the PID controller, of the CSF block (message of the channel blocks in the case of an invalid process value), and of channel blocks PV and MV (unit and scaling of the process value).
- from_Master ("ComStruOu"): The communication block receives from the controller process tag of the main component the signals of the CSF block and the setpoint of the PID controller that are relevant to interlocking.

CtrlRatio controller compared to the Ctrl controller

- In addition to the ratio block ("Ratio") for forming a ratio for the slave controller

CtrlSplitRange controller compared to the Ctrl controller

- In addition to the SplitRange block ("SplRange") for splitting the manipulated variable MV of the PID controller. Splitting is carried out based on the set parameters.
- Additional block to_Actor2 ("ComStruIn") for transferring the split manipulated variable (MV) and the locking status to the second actuator
- Additional block from_Actor2 ("ComStruOu") for receiving the messages in the case of invalid process values and field device maintenance of channel blocks

MV and Rbk, of the out unit (OutUnit) and travel range of the actuator (ScaleOut)

- Additional SplitRangeCut block ("Or04") that forces a specified manipulated variable on interruption of the cascade to one valve at the controller

Chart partition B

The channel blocks are located on sheet 1:

- PV_In ("Pcs7AnIn"): Channel block for signal processing of an analog measured value, e.g. 0/4 to 20mA
- PV_TE_In (“Pcs7AnIn”): Channel block for signal processing of a resistance thermometer
- PV_FB_In (“FBAnIn”): Channel block for signal processing of a digitized process value (PA or FF processing unit)

NOTICE	**The channel block for the thermocouple has already been preset for the range 0.0 to 1.0.**

On sheet 3, the system additionally acquires the messages of the valve process tag channel block at blocks CSF and OosAct and transfers them to the controller.

In the case of a positive "OosAct" signal, the controller switches to manual mode.

4.4 "CtrlMPC" 4x4 multivariable controller

The multivariable controller CMTs contain controller blocks, a control performance monitoring system, link blocks (slave/actuator) and the link to a sequence controller.

The CMTs are pre-configured for different areas of application. Using options, you select or deselect the blocks, e.g. the channel block, that are needed for the application.

The following CMTs are available:

- "CtrlMPC" for multivariable control using up to four controlled variables
- "CtrlMPC4Valve" for a controlled variable with several disturbance variables

4.4.1 Standard multivariable controller

CMT "CtrlMPC" is used for multivariable controllers. Unlike the "Ctrl", multivariable controllers master up to four manipulated and controlled variables that are linked with one another.

The instance receives the process variable with standardization from the "Amon" process tag via "from_Indicate_x". The number of controlled variables is determined by activating options “Ctrl_PV_3” and “Ctrl_PV_4”. It is not possible to deselect "Ctrl_PV_1" and "Ctrl_PV_2" and they correspond to the smallest configuration. Each "Ctrl_PV_x" option contains the monitoring of the control performance, link blocks for the process variable ("Amon") and controller process tag as well as the setpoint tolerance limits and manipulated variable tracking.

Due to the complex control tasks involved (affected by up to four controlled variables), the quantity controller is used by preference for slow controls.

Examples of multivariable controllers include:

- Control of drying processes (product quality)
- Regulating a distillation process (rectification)

Structure

Figure 4-12: Structure of the CtrlMPC control module type

Chart partition „A“

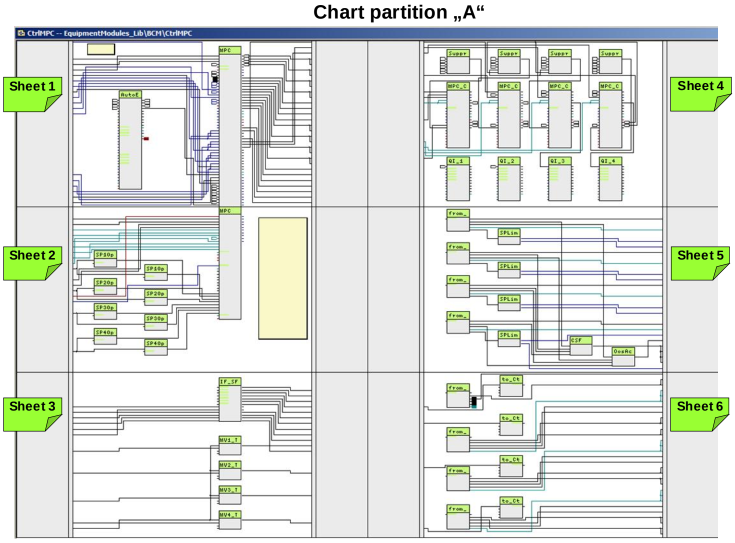


Chart partition A

The following blocks are located on sheet 1:

- MPC ("ModPreCon"): Multivariable controller
- AutoExcitation ("AutoExci"): Process excitation signals for the predictive MPC (during commissioning of the controller only)

Blocks for static operating point optimization of controlled variables of the MPC controller are located on sheet 2:

- SP1OptHiLim ("Add04"): Adaptation of the upper tolerance limit for SP1
- SP1OptLoLim ("Add04"): Adaptation of the lower tolerance limit for SP1
- SP2OptHiLim ("Add04"): Adaptation of the upper tolerance limit for SP2
- SP2OptLoLim ("Add04"): Adaptation of the lower tolerance limit for SP2
- SP3OptHiLim ("Add04"): Adaptation of the upper tolerance limit for SP3
- SP3OptLoLim ("Add04"): Adaptation of the lower tolerance limit for SP3
- SP4OptHiLim ("Add04"): Adaptation of the upper tolerance limit for SP4
- SP4OptLoLim ("Add04"): Adaptation of the lower tolerance limit for SP4

Note In the case of operating point optimization, you do not specify an exact setpoint (e.g. SP1) for a controlled variable; rather, a tolerance range is specified. The associated command value (CV1) may be within this tolerance. Due to this tolerance definition, the controller works more flexibly and more economically, since it does not have to control continuously to a fixed value.

The following blocks are located on sheet 3:

- IF_SFC ("CTRL_Conn"): A free block for SFC linking (not a component of the APL or the standard library)
- MV1_TrkOn ("Or04"): Forced manipulated variable (MV1) for the MPC controller in the case of a hardware fault (CV_Bad) or if cascade switching is interrupted between the MV1 PID controller and the slave controller
- MV2_TrkOn ("Or04"): Forced manipulated variable (MV2) for the MPC controller in the case of a hardware fault (CV_Bad) or if cascade switching is interrupted between the MV2 PID controller and the MV2 slave controller
- MV3_TrkOn ("Or04"): Forced manipulated variable (MV3) for the MPC controller in the case of a hardware fault (CV_Bad) or if cascade switching is interrupted between the MV3 PID controller and the MV3 slave controller
- MV4_TrkOn ("Or04"): Forced manipulated variable (MV3) for the MPC controller in the case of a hardware fault (CV_Bad) or if cascade switching is interrupted between the MV4 PID controller and the MV4 slave controller

With the SFC link the setpoint and the operating mode can be specified centrally. The link option is the same as that for standard controllers.

Note By linking the SPxOut output of the IF_SFC with the SPx input of the MPC, the setpoint specification is only possible by means of SFC on the IF_SFC.

The blocks below for monitoring and display of the control performance and the control deviation are located on sheet 4:

- Suppr_CPM_Calc_1 ("Or04"): Suppression of CPI calculation and message if message suppression was caused at an "MPC_CPM_x" (CPI_SuRoot = 1) or a warning is active due to low control performance (CPI_WL_Act = 1).
- Suppr_CPM_Calc_2 ("Or04"): Suppression of CPI calculation and message if message suppression was caused at an "MPC_CPM_x" (CPI_SuRoot = 1) or a warning is active due to low control performance (CPI_WL_Act = 1).
- Suppr_CPM_Calc_3 ("Or04"): Suppression of CPI calculation and message if message suppression was caused at an "MPC_CPM_x" (CPI_SuRoot = 1) or a warning is active due to low control performance (CPI_WL_Act = 1).
- Suppr_CPM_Calc_4 ("Or04"): Suppression of CPI calculation and message if message suppression was caused at an "MPC_CPM_x" (CPI_SuRoot = 1) or a warning is active due to low control performance (CPI_WL_Act = 1).
- MPC_CPM_1 ("ConPerMon"): Block for permanent monitoring of control performance (SP1Out, MV1 and CV1Out)
- MPC_CPM_2 ("ConPerMon"): Block for permanent monitoring of control performance (SP2Out, MV2 and CV2Out)
- MPC_CPM_3 ("ConPerMon"): Block for permanent monitoring of control performance (SP3Out, MV3 and CV3Out)
- MPC_CPM_4 ("ConPerMon"): Block for permanent monitoring of control performance (SP4Out, MV4 and CV4Out)
- QI_1 ("MonAnL"): Display and limit monitoring of the average value of control deviation for the TimeWindow specified in "MPC_CPM_1"
- QI_2 ("MonAnL"): Display and limit monitoring of the average value of control deviation for the TimeWindow specified in "MPC_CPM_2"
- QI_3 ("MonAnL"): Display and limit monitoring of the average value of control deviation for the TimeWindow specified in "MPC_CPM_3"
- QI_4 ("MonAnL"): Display and limit monitoring of the average value of control deviation for the TimeWindow specified in "MPC_CPM_4"

The following blocks are located on sheet 5:

- from_Indicate_1 ("ComStruOut"): Reception of signals (measured value, unit, scaling and messages) of the first process value to be controlled
- from_Indicate_2 ("ComStruOut"): Reception of signals (measured value, unit, scaling and messages) of the second process value to be controlled
- from_Indicate_3 ("ComStruOut"): Reception of signals (measured value, unit, scaling and messages) of the third process value to be controlled
- from_Indicate_4 ("ComStruOut"): Reception of signals (measured value, unit, scaling and messages) of the fourth process value to be controlled
- SPLim_1 ("StruScIn"): Upper and lower setpoint limit of the first process value
- SPLim_2 ("StruScIn"): Upper and lower setpoint limit of the second process value
- SPLim_3 ("StruScIn"): Upper and lower setpoint limit of the third process value
- SPLim_4 ("StruScIn"): Upper and lower setpoint limit of the fourth process value
- CSF ("Or04"): Formation of an OR output signal of the hardware faults of the channel blocks of the process values for tracking the respective controller

- OosAct ("Or04"): Formation of an OR output signal of the "OosAct" message of the channel blocks (field device is being maintained) of the controlled variables for the MPC

The link blocks below, which are used for rapid engineering, are located on sheet 6:

- from_CTRL_1 ("ComStruOu"): Reception of control commands of the lower level PID controller for the MPC controller parameters ("MV1ManHiLim", "MV1ManLoLim", and "MV1Trk") and the "MV1_TrkOn" block.
- to_CTRL_1 ("ComStruIn"): Output of the manipulated variable as a setpoint to the lower-level PID controller.
- from_CTRL_2 ("ComStruOu"): Reception of control commands of the lower level PID controller for the MPC controller parameters ("MV2ManHiLim", "MV2ManLoLim", and "MV2Trk") and the "MV2_TrkOn" block.
- to_CTRL_2 ("ComStruIn"): Output of the manipulated variable as a setpoint to the lower-level PID controller.
- from_CTRL_3 ("ComStruOu"): Reception of control commands of the lower level PID controller for the MPC controller parameters ("MV3ManHiLim", "MV3ManLoLim", and "MV3Trk") and the "MV3_TrkOn" block.
- to_CTRL_3 ("ComStruIn"): Output of the manipulated variable as a setpoint to the lower-level PID controller.
- from_CTRL_4 ("ComStruOu"): Reception of control commands of the lower level PID controller for the MPC controller parameters ("MV4ManHiLim", "MV4ManLoLim", and "MV4Trk") and the "MV1_TrkOn" block.
- to_CTRL_4 ("ComStruIn"): Output of the manipulated variable as a setpoint to the lower-level PID controller.

Note The process value is made available to the MPC by linking the AMon control module ("to_Indicate" block) with the "from_Indicate_x" block.

4.4.2 Multivariable controller for a controlled variable

The "CtrlMPC4Valve" CMT is used for fixed value controllers where the controlled variable is affected by one or more disturbance variables, e.g. pH value control.

The MPC gets the units and standardization automatically from the interconnected link blocks, from the controlled and manipulated variables, and from at least one disturbance variable.

Note

The number of disturbance variables is determined by activating option "'Opt_DVx" and interconnecting the respective process value. The disturbance variables are interconnected with the following MPC inputs:

- 1st disturbance variable at the DV1 input of the MPC (activated as standard)
- 2nd disturbance variable at the MV2Trk input of the MPC (optional)
- 3rd disturbance variable at the MV3Trk input of the MPC (optional)
- 4th disturbance variable at the MV4Trk input of the MPC (optional)

Structure

Figure 4-13: Structure of the CtrlMPC4 valve control module type

Chart partition „A“

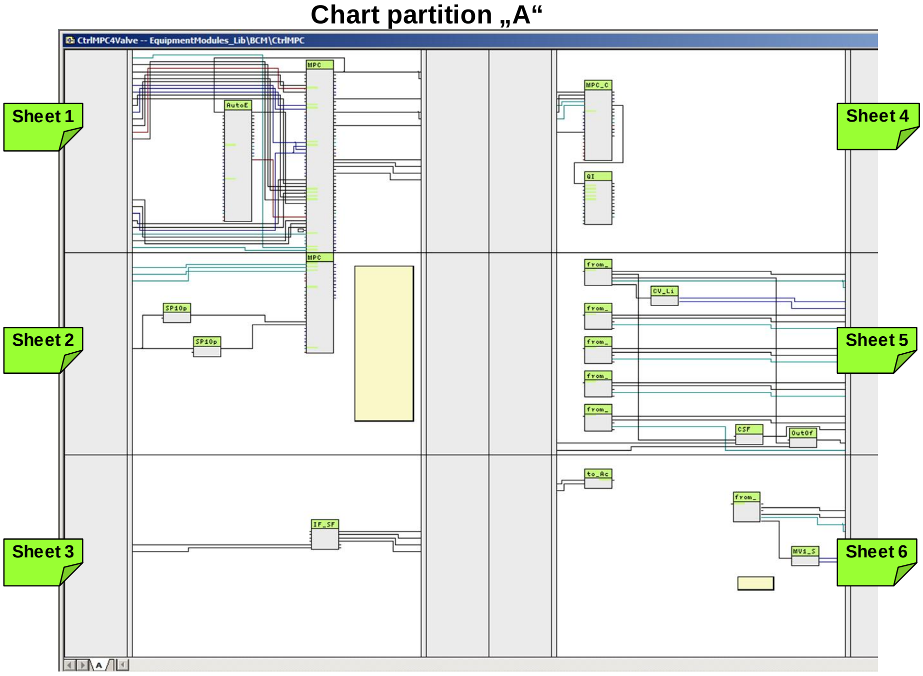


Chart partition A

The following blocks are located on sheet 1:

- MPC ("ModPreCon"): Multivariable controller
- AutoExcitation ("AutoExci"): Process excitation signals for the predictive MPC (during commissioning of the controller only)

Blocks for static operating point optimization of the controlled variable of the MPC controller are located on sheet 2:

- SP1OptHiLim ("Add04"): Adaptation of the upper tolerance limit for SP1
- SP1OptLoLim ("Add04"): Adaptation of the lower tolerance limit for SP1

Note In the case of operating point optimization, you do not specify an exact setpoint (e.g. SP1) for a controlled variable; rather, a tolerance range is specified. The associated command value (CV1) may be within this tolerance. Due to this tolerance definition, the controller works more flexibly and more economically, since it does not control continuously to a fixed value.

The following blocks are located on sheet 3:

- IF_SFC ("CTRL_Conn"): A free block for SFC linking (not a component of the APL or the standard library)

With the SFC link the setpoint and the operating mode can be specified centrally. The link option is the same as that for standard controllers.

Note By linking the SP1Out output of the IF_SFC with the SP1 input of the setpoint specification is only possible by means of SFC on the IF_SFC.

The blocks below for monitoring and display of the control performance and the control deviation are located on sheet 4:

- MPC_CPM ("ConPerMon"): Block for permanent monitoring of control performance (SP1Out, MV1 and CV1Out)
- QI ("MonAnL"): Display and limit monitoring of the average value of control deviation for the TimeWindow specified in "MPC_CPM"

The following blocks are located on sheet 5:

- from_CV ("ComStruOut"): Receiving of signals (measured value, unit, scaling and messages) of the controlled variable
- CV_Lim ("StruScIn"): Upper and lower setpoint limit of the controlled variable
- from_DV1 ("ComStruOut"): Receiving of signals (measured value, CSF-signal and unit) of the first disturbance variable
- from_DV2 ("ComStruOut"): Receiving of signals (measured value, CSF-signal and unit) of the second disturbance variable
- from_DV3 ("ComStruOut"): Reception of signals (measured value, CSF-signal and unit) of the third disturbance variable
- from_DV4 ("ComStruOut"): Reception of signals (measured value, CSF-signal and unit) of the fourth disturbance variable
- CSF ("Or04"): Formation of an OR output signal of the hardware faults of the controlled variable channel blocks and the control valve for tracking the manipulated variable
- OosAct ("Or04"): Formation of an OR output signal of the "OosAct" message of the channel blocks (field device is being maintained) of the controlled variables and the control valve for the MPC

Note The process values of the controlled variable and the disturbance variables are made available to the MPC by linking the AMon control modules ("to_Indicate" block) with the "from_CV", "from_DVx" block.

The link blocks below, used for rapid engineering, are located on sheet 6.

- to_Actor ("ComStruIn"): Transfer of the manipulated variable (MV), and the locking status (OosAct) to the actuator.
- from_Actor ("ComStruOu"): Reception of signals and standardization and unit of the actuator for the MPC (CSF, OosAct, ScaleOut, Unit).
- MV1_Scale ("StruScIn"): Upper and lower manipulated variable limit for limiting the manipulated variable in the controller in manual and automatic modes.

4.5 Valves "Val"

The valve CMTs are for controlling and monitoring open/closed valves and control valves. They contain the control block, additional monitoring and interlock functions, and a standardized controller connection (with analog values only).

The CMTs are pre-configured for different areas of application. Using options, you select or deselect the blocks, e.g. channel blocks, that are needed for the application.

The following CMTs are available:

- "Val" for opening and closing valves
- "ValAn" for analog control valves

Using variants, the corresponding channel block is selected or deselected based on measured value transfer or the number of available signals (control, servo position, etc.) of the corresponding channel block.

4.5.1 Opening and closing valve "Val"

The "Val" CMT is used to control and monitor opening and closing valves. Control is via an SFC or by the system operator.

Below, variants and options are listed and described.

Variant 1:

Variant 1 is activated by selecting function "Opt_1Ctrl" on the instance and it is used for valves with a control signal. With this variant, the system starts from the set neutral (de-energized) position and uses a command signal to open or close the valve.

Variant 2:

Variant 2 is activated by selecting function "Opt_2Ctrl" on the instance and it is used for valves with two control signals (open/close). With this variant, the system uses the two command signals to open and close the valve.

Optional functions for all variants:

- BypassAct: Message with activated bypass
- Intlock: Interlocking without resetting
- Permit: Activation enable
- Protect: Protective interlock with reset
- FailLock: Neutral position corresponds to command signal
- FbkClose: Feedback valve closed
- FbkOpen: Feedback valve open

The figure below contains the available options.

Figure 4-14: Variants of Val

Val (CMT Master Data Library)	BypassAct	Intlock	Permit	Protect	FailLock	FbkClose	FbkOpen	Opt_1Ctrl	Opt_2Ctrl	
Variants	**Function**					**Channel block**				**Description**
Val_1Ctrl	o	o	o	o	o	o	o	x		Opening or closing the valve (1 signal)
Val_2Ctrl	o	o	o	o	o	x	x		x	Signal processing for opening or closing the valve (2 signals)

x = Selecting a variant o = Selectable functions

Application examples include:

- Metering of solid, liquid, and gaseous materials
- Protection device, e.g. forced draining on exceeding fill level
- Venting of containers

Structure

Figure 4-15: Structure of the VAL control module type

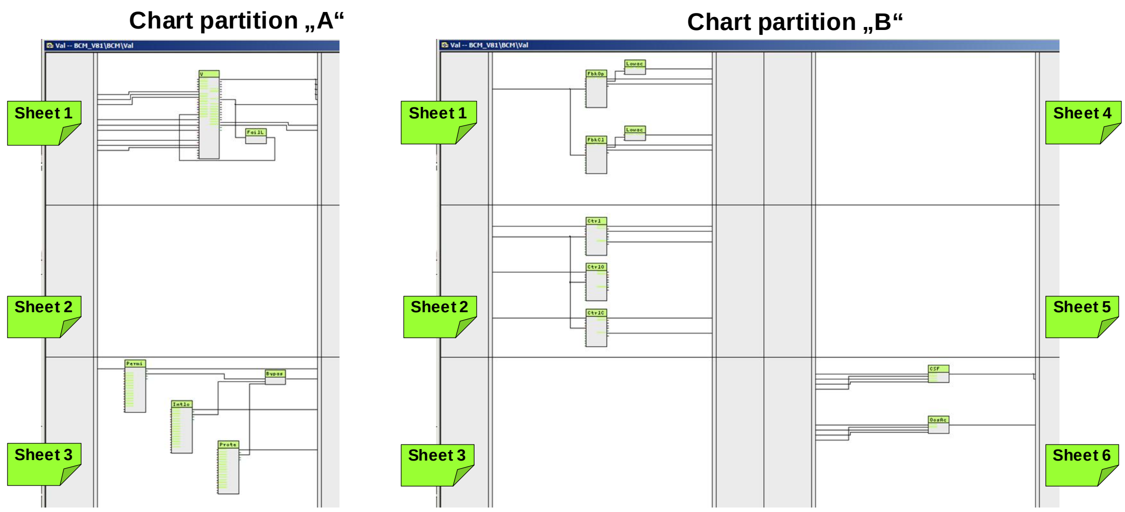


Chart partition A

The following blocks are located on sheet 1:

- V ("VlvL"): A valve block for controlling one valve with two positions and a settable neutral position
- FailLock: Passing on of the neutral position from the Ctrl output to the SafePos of the valve block (0= closed, 1=open)

The following blocks are located on sheet 3:

- Permit ("Intlk08"): Activation enable for the valve ("1"= Enable for opening/closing of the valve from the neutral position)
- Intlock ("Intlk08"): Block for calculating a standardized locking with the option of display on the OS.
- Protect (“Intlk08"): Protective interlock that requires resetting of the valve block after the active signal ("0") has gone

- BypassAct ("Or04"): Formation of an OR output signal of the BypAct outputs (Permit, Intlock, and Protect). With Bypass active ("1"), the valve block outputs a configurable message ("Bypass active").

Locking is activated in the case of an invalid process value of the Rbk, Fbk, and MV channel blocks.

Chart partition B

The following blocks are located on sheet 1:

- FbkOpen ("Pcs7DiIn"): Channel block for signal processing of the "Open" valve feedback signal
- LowactFbkOpen "SwLowact": Parameterizable signal inversion (block description in the Appendix)
- FbkClose ("Pcs7DiIn"): Channel block for signal processing of the "Closed" valve feedback signal
- LowactFbkClosen "SwLowact": Parameterizable signal inversion (block description in the Appendix)

Note The position feedback is optionally selected in the technological connections

The following blocks are located on sheet 2:

- Ctrl ("Pcs7DiIn"): Channel block for signal processing for opening or closing the valve (1 signal)
- CtrlOpen ("Pcs7DiIn"): Channel block for signal processing for opening the valve (valve is opened)
- CtrlClose ("Pcs7DiIn"): Channel block for signal processing for closing the valve (valve is closed)

Note In the technological connections, one of the two variants is selected using one command signal (Opt_1Ctrl) or two command signals (Opt_2Ctrl).

The following blocks are located on sheet 6:

- CSF ("Or04"): Formation of an OR output signal from the "Bad" output (process value not valid) of the channel blocks and reporting to the valve block and the Permit group block.
- OosAct ("Or04"): Formation of an OR output signal from the "OosAct" output (device is being maintained) of the channel blocks and reporting to the valve block.

4.5.2 "ValAn" analog control valve

The "ValAn" CMT is used to control an analog valve with a checkback signal. Typically, a controller specifies the manipulated variable. It is possible to generate the control signal via a ramp function.

Below, variants and options are listed and described.

Variant 1: Control valve for analog manipulated variable transfer (4-20 mA)

This variant is used for positioners with a 4-20mA signal.

Variant 1 is activated by selecting functions MV_Out and Opt_MV_Scale on the instance.

Variant 2: Control valve for digital manipulated variable transfer (fieldbus)

This variant is used for positioners with PROFIBUS PA or Fieldbus Foundation (FF).

Variant 2 is activated by selecting functions MV_Fb_Out and Opt_MV_Scale on the instance.

Optional functions:

The following options are available for selection for the variants:

- BypassAct: Message with activated bypass
- Intlock: Interlocking without resetting
- Permit: Activation enable
- Protect: Protective interlock with reset
- Opt_MV_Scale: Standardization of the manipulated variable including the channel block
- Opt_IF_Ctrl: Link to a controller
- RbkReturn: Position feedback corresponds to the command signal

The figure below contains the available options.

Figure 4-16: Variants of ValAn

ValAn (CMT Master Data Library)	BypassAct	Intlock	Permit	Protect	Opt_MV_Scale	Opt_IF_Ctrl	RbkReturn	Opt_AuxVal_Connect	FbkClose	FbkOpen	MV_Fb_Out	MV_Out	Ctrl	Rbk	Rbk_Fb	
Varianten	**Funktion**								**Kanalbaustein**							**Beschreibung**
ValAn_Std	o	o	o	o	x	x	x	o	o	o		x	o			Controlling of a valve without position feedback (analog signal)
ValAn_StdRbk	o	o	o	o	o	o		o	o	o		x	o	x		Controlling of a valve with position feedback (analog signal)
ValAn_FbRbk	o	o	o	o	o	o		o	o	o	x		o		x	Controlling of a valve with position feedback (Fieldbus)

x = Selecting a variant   o = Selectable functions

A typical application example is setting of a flow rate via the valve setting (solid, liquid, and gaseous substances).

Structure

Figure 4-17: Structure of the ValAn control module type

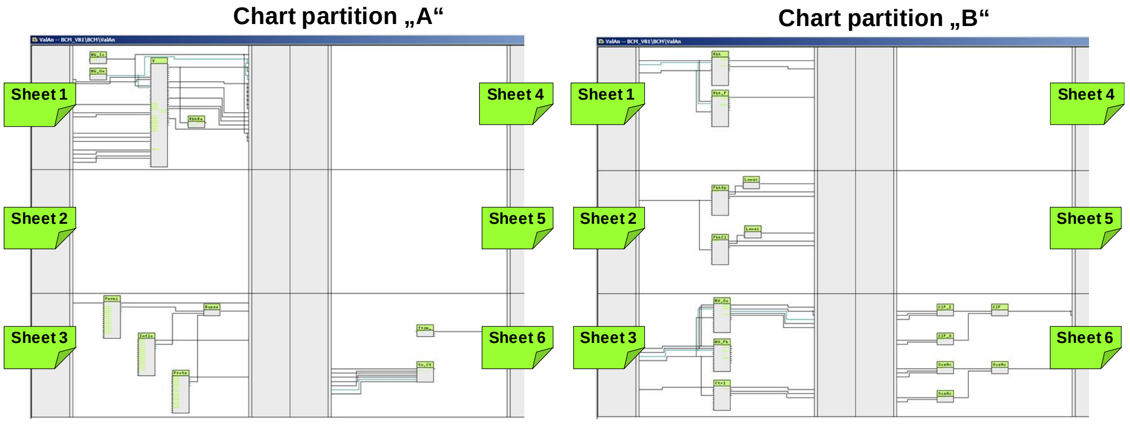


Chart partition A

The following blocks are located on sheet 1:

- MV_Scale: Standardization of the manipulated variable for channel blocks and display
- MV_Unit: Determination of the unit for a channel block and display
- V ("VlvAnL"): Valve block for control of an analog control valve and positioner
- RbkReturn: Passing on of the manipulated variable from the MV output to the Rbk input of the valve block (only if no checkback signal from the channel block is present)

The valve block receives the external manipulated variable from the controller via a communication block (from_Ctrl in chart partition "A", sheet 6) that is transferred to channel block MV_Out or MV_Fb_Out (chart partition "B", sheet 3) control. Channel block Rbk or Rbk_Fb (chart partition "B", sheet 1) feeds back the manipulated variable.

Note

> The lower limit value (MV_LoLim = "0") and the top limit value (MV_HiLim= "100") for limited output of the manipulated variable is pre-parameterized. If a limited manipulated variable is needed, interconnect output MV_ExtOut.

The following blocks are located on sheet 3:

- Permit ("Intlk08"): Activation enable for the valve ("1"= Enable for opening/closing of the valve from the neutral position)
- Intlock ("Intlk08"): Block for calculating a standardized locking with the option of display on the OS.
- Protect (“Intlk08"): Protective interlock that requires resetting of the valve block after the active signal ("0") has gone
- BypassAct ("Or04"): Formation of an OR output signal of the interlock block BypAct outputs (Permit, Intlock, and Protect). With Bypass active ("1"), the valve block outputs a configurable message ("Bypass active").

Locking is activated in the case of an invalid process value of the Rbk, Fbk, and MV channel blocks.

The link blocks below, used for rapid engineering, are located on sheet 6.

- from_Ctrl ("ComStruOu"): Reception of the manipulated variable (MV) from the control.
- to_Ctrl ("ComStruIn"): Transfer of the manipulated variable (Rbk) with the unit and the travel range, cascade interruption (CascaCut), active locking (LockAct), and the messages in the case of invalid process values and field device maintenance of channel blocks MV, Fbk, and Rbk.

Chart partition B

The following blocks are located on sheet 1:

- Rbk ("Pcs7AnIn"): Channel block for signal processing of the position feedback of an analog input value
- Rbk_Fb ("FBAnIn"): Channel block for signal processing of the position feedback of a digitized process value (fieldbus)

The following blocks are located on sheet 2:

- FbkOpen ("Pcs7DiIn"): Channel block for signal processing of an "Open" valve feedback signal
- LowactFbkOpen "SwLowact": Parameterizable signal inversion (block description in the Appendix)
- FbkClose ("Pcs7DiIn"): Channel block for signal processing of a "Closed" valve feedback signal
- LowactFbkClosen "SwLowact": Parameterizable signal inversion (block description in the Appendix)

Note The position feedback can be optionally selected in the technological connections

The following blocks are located on sheet 3:

- MV_Out ("Pcs7AnOu"): Channel block for signal processing of an analog output value
- MV_Fb_Out ("FbAnOu"): Channel block for signal processing of a digitized process value (fieldbus)
- Ctrl ("Pcs7DiIn"): Channel block for signal processing for opening or closing the valve (binary signal)

Note In the technological connections, a variant is selected that is dependent on the transfer technology and the signals that are available on the device.

The following blocks are located on sheet 6:

- CSF_In ("Or04"): Formation of an OR output signal from the "Bad" output (process value not valid) of the input channel blocks.
- CSF_Out ("Or04"): Formation of an OR output signal from the "Bad" output (process value not valid) of the output channel blocks.
- CSF ("Or04"): Grouping of the "Bad" signals (process value not valid) and reporting to the valve block and the Permit group block.

- OosAct_In ("Or04"): Formation of an OR output signal from the "OosAct" output (device is being maintained) of the input channel blocks.
- OosAct_Out ("Or04"): Formation of an OR output signal from the "OosAct" output (device is being maintained) of the output channel blocks.
- OosAct ("Or04"): Grouping of the "OosAct" signals (device being maintained) and reporting to the valve block.

4.6 "Mot" motors

The "MOT" CMT is used to control and monitor a motor starter or a frequency-controlled motor.

The motor CMTs contain the control block, additional monitoring and interlock functions, a controller connection (with speed-controlled motors only).

The CMTs are pre-configured for different areas of application. Using options, you select or deselect the blocks, e.g. channel blocks, that are needed for the application.

The following control module types are available:

- "Mot" motor with fixed speed
- "MotVsd" motor with variable speed

Using variants, the corresponding channel block is selected or deselected based on measured value transfer or the number of available signals (control, local mode, etc.) of the corresponding channel block.

4.6.1 "Mot" motor with fixed speed

The "Mot" CMT is used to monitor motors with fixed speed. The plant operator or an SFC carry out control.

Below, variants and options are listed and described.

Variant 1:

Variant 1 is activated by selecting the “Opt_1Fbk” function on the instance; it monitors the feedback via a signal input.

Variant 2:

Variant 2 is activated by selecting the “Opt_2Fbk” function on the instance; it monitors the feedback via two signal inputs (feedback on and feedback off).

Optional functions for all variants:

- BypassAct: Message with activated bypass
- Intlock: Interlocking without resetting
- Permit: Activation enable
- Protect: Protective interlock with reset
- Q: Operating hours counter
- Trip: Motor protection active
- Maint: Maintenance status
- Local: Local mode
- Start: Motor started signal
- Stop: Motor stopped signal

The figure below contains the available options.

Figure 4-18: Variants of Mot

Mot (CMT Master Data Library)	BypassAct	Intlock	Permit	Protect	Q	Opt_1Fbk	Opt_2Fbk	Trip	Maint	Local	Start	Stop	
Variants	Function					Channel block							Description
Mot_StdFbk	o	o	o	o	o	x		o	o	o	o	o	Operating of the motor with simple control
Mot_AdvFbk	o	o	o	o	o		x	o	o	o	o	o	Operating of the motor with control of operation (operation/stopp)

x = Selecting a variant o = Selectable functions

Application examples include:

- Stirrer for mixing materials in a container
- Pumps for pumping solid, liquid, and gaseous substances

Structure

Figure 4-19: Structure of the Mot control module type

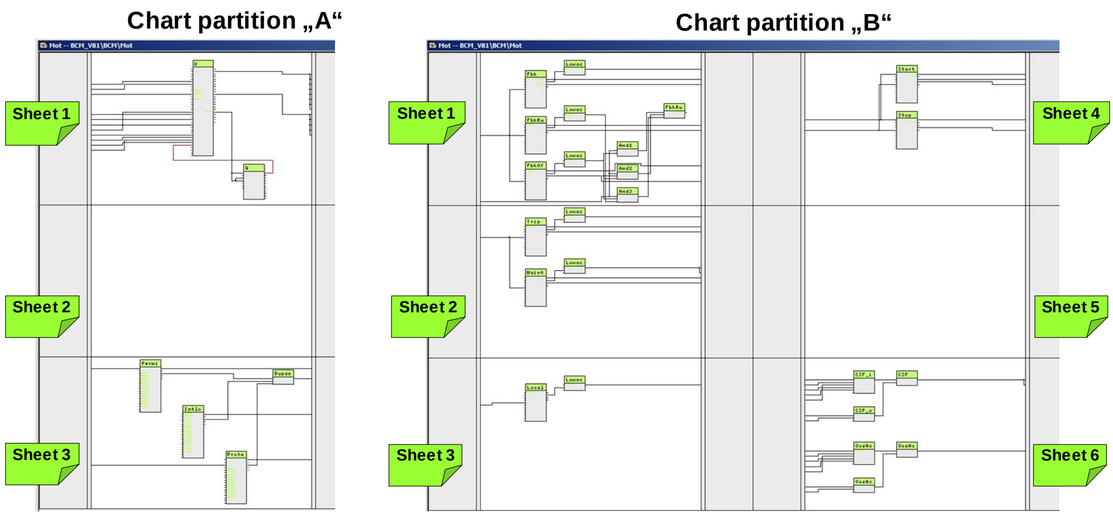


Chart partition A

The following blocks are located on sheet 1:

- U ("MotL"): Motor block for controlling a fixed-speed motor via control signals
- Q ("CountOh"): Operating time of the motor since it was last reset

The motor block is parameterized for different application options. Using interconnections (CFC, SFC), an operating mode is selected (local mode, automatic mode, manual mode and out of service). To control the motor, the "Start" connection of the motor block is interconnected with the Start channel block (chart partition "B", sheet 4). The feedback for a started motor comes from the Fbk or FbkRun channel block.

The following blocks are located on sheet 3:

- Permit ("Intlk08"): Activation enable for the motor ("1" = Enable for opening/closing of the motor from the neutral position)

- Intlock ("Intlk08"): Block for calculating a standardized locking with the option of display on the OS.
- Protect ("Intlk08"): Protective interlock that requires resetting of the motor block after the active signal ("0") has gone.
- BypassAct ("Or04"): Formation of an OR output signal of the interlock block BypAct outputs (Permit, Intlock, and Protect). With Bypass active ("1"), the motor block outputs a configurable message ("Bypass active").

The outputs of the interlocking block are interconnected with the motor block on sheet 1. Permit locking is activated in the case of an invalid process value of the channel blocks. Protect locking is activated in the case of maintenance messages from the channel blocks.

Chart partition B

The following blocks are located on sheet 1:

- Fbk ("Pcs7DiIn"): Channel block for signal processing of the "Motor running" motor feedback signal. This block can also be used for the inverse status. In this case, the system inverts the signal at the LowactFbk block at the Mode input.
- LowactFbk "SwLowact": Parameterizable signal inversion (block description in the Appendix).
- FbkRun ("Pcs7DiIn"): Channel block for signal processing of the "motor running" motor checkback signal.
- LowactFbkRun "SwLowact": Parameterizable signal inversion (block description in the Appendix).
- FbkOff ("Pcs7DiIn"): Channel block for signal processing of the "motor inactive" motor checkback signal.
- LowactFbkOff "SwLowact": Parameterizable signal inversion (block description in the Appendix).
- And1 ("And04"): Comparison of whether the motor is not running (motor block) and the motor is not at a standstill (FbkOff channel block).
- And2 ("And04"): Comparison of whether the motor is not running (motor block), the motor is not at a standstill (FbkOff channel block), and the motor is running (FbkRun channel block).
- And3 ("And04"): Comparison of whether the motor is not running (motor block), the motor is at a standstill (FbkOff channel block), and the motor is running (FbkRun channel block).
- FbkRun_In ("Or04"): Formation of an OR output to feed back that the motor is running if one of the AND comparisons returns a positive signal.

Note Two block combinations (Opt_1Fbk and Opt2_Fbk) can be used to feed back whether the motor is running. With the first option, one checkback signal is available. With the second option, the checkback signal that the motor is at a standstill is used in addition.

The following blocks are located on sheet 2:

- Trip ("Pcs7DiIn"): Channel block for signal processing of a motor fault
- LowactTrip ("SwLowact"): Parameterizable signal inversion (block description in the Appendix)

- Maint ("Pcs7DiIn"): Channel block for signal processing of a maintenance procedure (by activation of the locking at the Protect block and triggering of an "ExtMassage1" message at the motor block).
- LowactMaint ("SwLowact"): Parameterizable signal inversion (block description in the Appendix)

The following blocks are located on sheet 3:

- Local ("Pcs7DiIn"): Channel block for signal processing with local mode.
- LowactLocal ("SwLowact"): Parameterizable signal inversion (block description in the Appendix)

The following blocks are located on sheet 4:

- Start ("Pcs7DiOu"): Channel block for signal processing for starting the motor
- Stop ("Pcs7DiOu"): Channel block for signal processing for stopping the motor

The following blocks are located on sheet 6:

- CSF_in ("Or04"): Formation of an OR output signal from the "Bad" output (process value not valid) of the input channel blocks.
- CSF_out ("Or04"): Formation of an OR output signal from the "Bad" output (process value not valid) of the output channel blocks.
- CSF ("Or04"): Grouping of the "Bad" signals (process value not valid) and reporting to the motor block and the Permit group block.
- OosAct_in ("Or04"): Formation of an OR output signal from the "OosAct" output (device is being maintained) of the input channel blocks.
- OosAct_out ("Or04"): Formation of an OR output signal from the "OosAct" output (device is being maintained) of the output channel blocks.
- OosAct ("Or04"): Grouping of the "OosAct" signals (device being maintained) and reporting to the motor block.

4.6.2 "MotVsd" motor with variable speed

The "MotVsd" CMT is used to monitor motors with variable speed. Typically, control is carried out by means of controllers, SFC, or local mode.

Variant 1:

Variant 1 is used if the setpoint is specified locally at the frequency converter and not by the instrumentation and control technology.

Variant 2:

Variant 2 is activated by selecting functions "SP_Out" and "Rbk" on the instance. With this variant, the instrumentation and control technology controls and acquires the speed of the motor.

Optional functions for all variants:

The following options are available for selection for the variants:

- BypassAct: Message with activated bypass
- Intlock: Interlocking without resetting
- Permit: Activation enable
- Protect: Protective interlock with reset
- Q: Operating hours counter
- Opt_IF_Ctrl: Speed specification if a controller is used
- Trip: Motor protection active
- Maint: Maintenance status
- Local: Local mode
- Rbk: Speed feedback
- SP_Out: Motor speed (setpoint)

The figure below contains the available options.

Figure 4-20: Variants of MotVsd

MotVsd (CMT Master Data Library)	BypassAct	Intlock	Permit	Protect	Q	Opt_IF_Ctrl	FbkFwd	Fwd	Trip	Maint	Local	SP_Out	Rbk	
Variants	**Function**						**Channel block**							**Description**
MotVsd_Std	o	o	o	o	o	o	o	x	o	o	o	o	o	Start and stop of the motor with fixed speed
MotVsd_StdRbk	o	o	o	o	o	o	o	o	o	o	o	x	x	Start and stop of the motor with speed specification and feedback

x = Selecting a variant o = Selectable functions

Application examples include:

- Driving a rotary valve
- Driving a pump

Structure

Figure 4-21: Structure of the MotVsd control module type

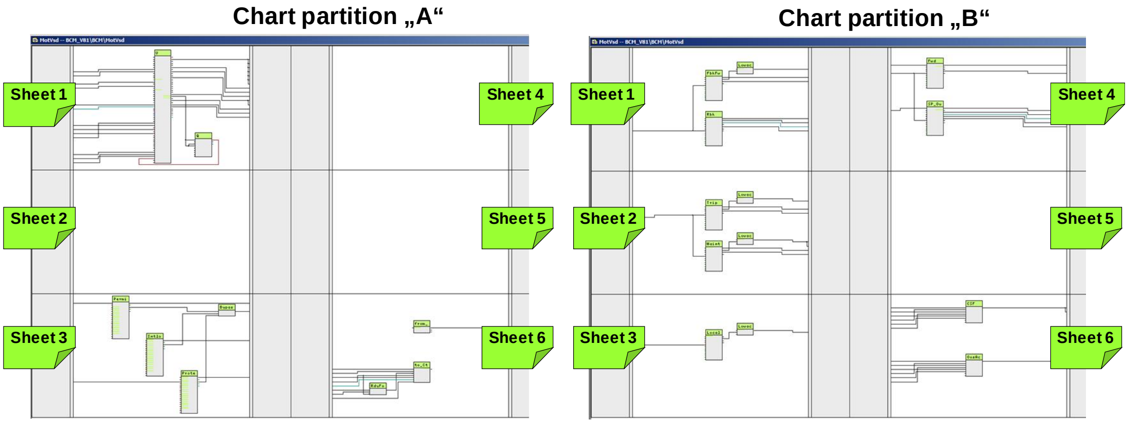


Chart partition A

The following blocks are located on sheet 1:

- U ("MotSpdCL"): Controllable motor with variable speed
- Q ("CountOh"): Operating time of the motor since it was last reset

The motor block is parameterized for different application options. Using interconnections (CFC, SFC), an operating mode is selected (local mode, automatic mode, manual mode and out of service). The motor block receives the external manipulated variable from the controller via a communication block (from_Ctrl in chart partition "A", sheet 6) that is transferred to channel block SP_Out (chart partition "B", sheet 4) control. The feedback for a started motor comes from the Rbk or FbkFwd channel block.

The following blocks are located on sheet 3:

- Permit ("Intlk08"): Activation enable for the motor ("1" = Enable for opening/closing of the motor from the neutral position)
- Intlock ("Intlk08"): Block for calculating a standardized locking with the option of display on the OS.
- Protect (“Intlk08"): Protective interlock that requires resetting of the motor block after the active signal ("0") has gone
- BypassAct ("Or04"): Formation of an OR output signal of the interlock block BypAct outputs (Permit, Intlock, and Protect). With Bypass active ("1"), the motor block outputs a configurable message ("Bypass active").

The outputs of the interlocking block are interconnected with the motor block on sheet 1. Permit locking is activated in the case of an invalid process value of the channel blocks. Protect locking is activated in the case of maintenance messages from the channel blocks.

The link blocks below, used for rapid engineering, are located on sheet 6.

- from_Ctrl ("ComStruOu"): Reception of the manipulated variable (MV) or motor speed from the control.
- to_Ctrl ("ComStruIn"): Transfer of the manipulated variable (Rbk) with the unit and the travel range, cascade interruption, active locking (LockAct), and the messages in the case of invalid process values and field device maintenance of channel blocks MV, Fbk, and Rbk.

Chart partition B

The following blocks are located on sheet 1:

- FbkFwd ("Pcs7DiIn"): Channel block for signal processing of the "Direction of rotation forwards" motor checkback signal.
- LowactFbkFwd "SwLowact": Parameterizable signal inversion (block description in the Appendix)
- Rbk ("Pcs7AnIn"): Channel block for signal processing for motor speed acquisition.

The following blocks are located on sheet 2:

- Trip ("Pcs7DiIn"): Channel block for signal processing of a motor fault
- LowactTrip ("SwLowact"): Parameterizable signal inversion (block description in the Appendix)
- Maint ("Pcs7DiIn"): Channel block for signal processing of a maintenance procedure (by activation of the locking at the Protect block and triggering of an "ExtMassage1" message at the motor block).
- LowactMaint ("SwLowact"): Parameterizable signal inversion (block description in the Appendix)

The following blocks are located on sheet 3:

- Local ("Pcs7DiIn"): Channel block for signal processing with local mode.
- LowactLocal ("SwLowact"): Parameterizable signal inversion (block description in the Appendix)

The following blocks are located on sheet 4:

- Fwd ("Pcs7DiOu"): Channel block for signal processing for starting the motor in the "Forwards" direction of rotation
- SP_Out ("Pcs7AnOu"): Channel block for signal processing of the motor speed

The following blocks are located on sheet 6:

- CSF ("Or04"): Formation of an OR output signal from the "Bad" output (process value not valid) of the channel blocks and reporting to the motor block and the Permit group block.
- OosAct ("Or04"): Formation of an OR output signal from the "OosAct" output (device is being maintained) of the channel blocks and reporting to the motor block.

5 Equipment Modules

In this chapter, you will find all the relevant information for each equipment module including specific properties. The structure and basic functionality of the control module types that are used are described in chapter 4 “Control Module“.

The following equipment modules are described below:

- **"**Split-Range-Pressure**"** control
- “Ratio-Control”
- “Level-Control”
- “Split-Range-Temperature” control
- pH value control using the "pH-Control-Std" standard controller
- pH value control using the "pH-Control-MPC" multivariable controller
- Temperature control using the "Temperature-Flow-Cascade"

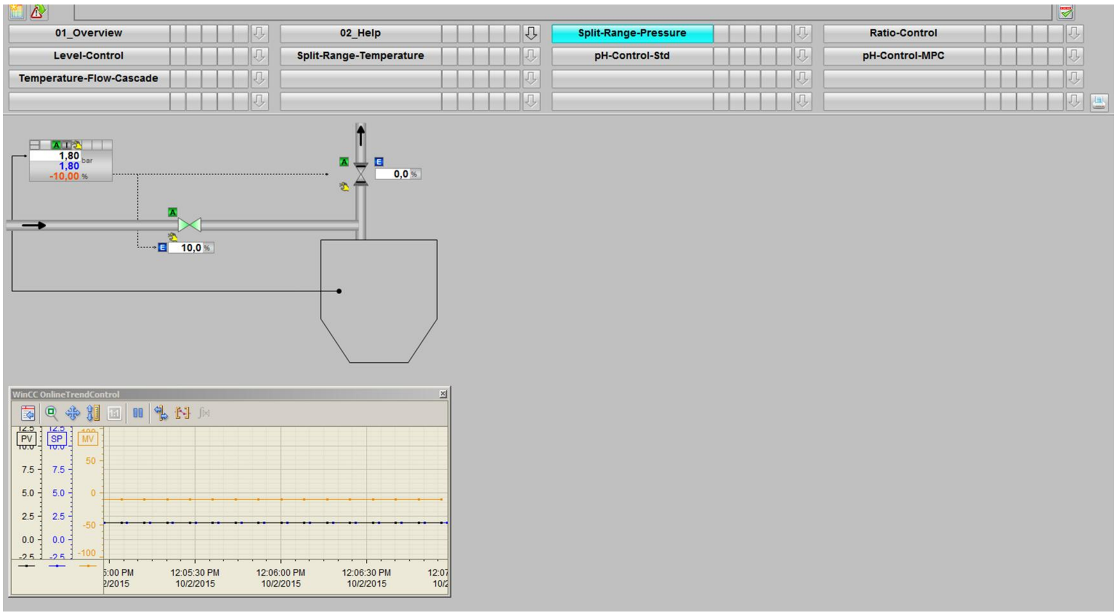
Note Below, we will use the designations CM for control module and CMT for control module type.

5.1 "Split-Range-Pressure" control

Pressure control is usually carried out using a fast controller. The container pressure is increased by feeding an inert gas (e.g. nitrogen) via a supply line. Opening the outlet valve allows the gas mixture to escape and the container pressure diminishes. The controller responds to a change in pressure and regulates it by opening the supply line or the outlet valve.

In the following example, control of the container pressure is triggered by supplying pressure and venting it.

Figure 5-1: Split-Range-Pressure equipment module

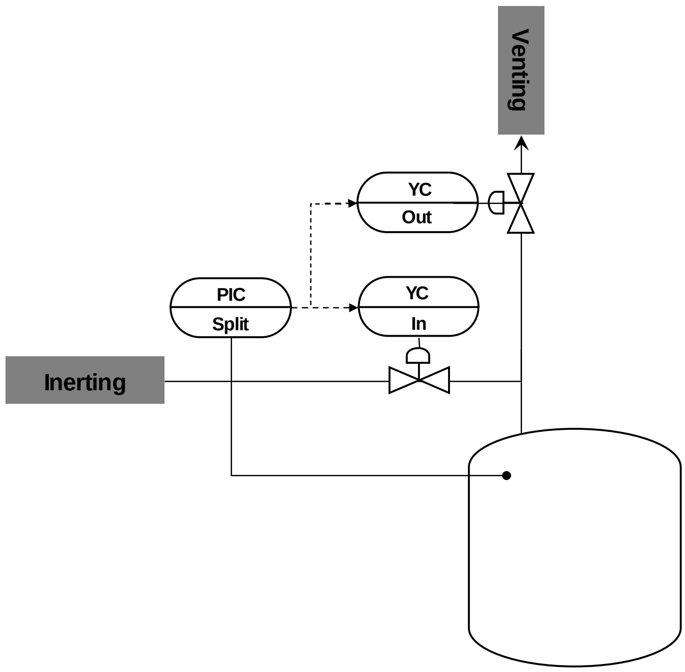


Overview

P&ID

The P&I diagram below represents symbolically all of the components, such as units and containers, etc. relevant to operation.

Figure 5-2



CM and variants

The "Split-Range-Pressure" equipment module consists of three interconnected CMs and one simulation chart. In the simulation chart, a container pressure and the effects due to feeding and venting inert gas are simulated.

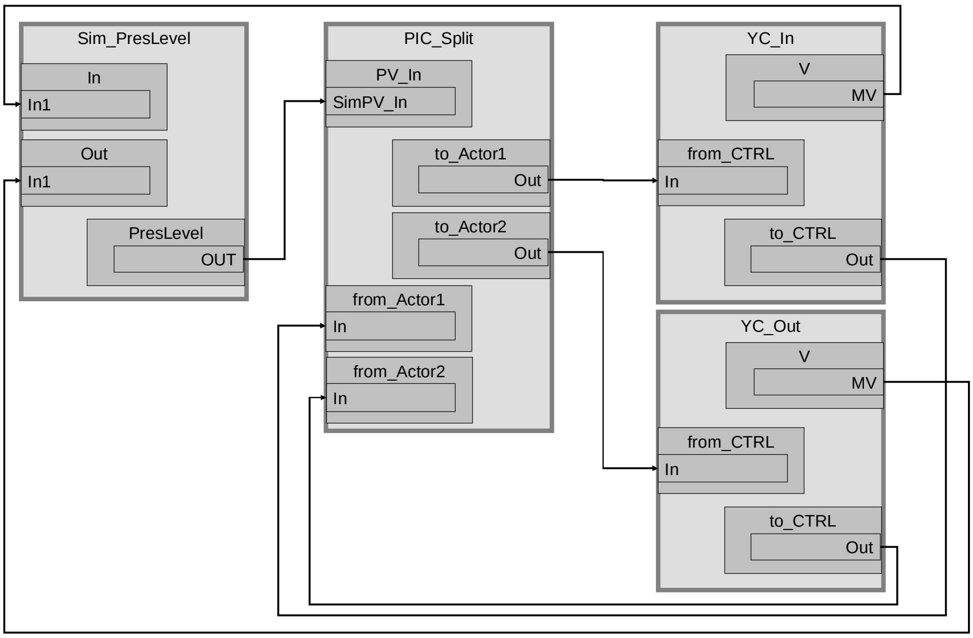
The following table provides an overview of the CMs of the equipment module including the associated CMTs.

Table 5-1

CM	CMT	Variant	Description
PIC_Split	"CtrlSplitRange"	CtrlSplitRange_Std	Pressure control with one manipulated variable and two actuators
YC_In	"ValAn"	ValAn_Std	Control valve for supplying inert substances
YC_Out	"ValAn"	ValAn_Std	Control valve for ventilation

In the figure below, the structure with the cross-chart interconnections is shown in simplified form.

Figure 5-3



"PIC_Split" acquires the container pressure ("Sim_PresLevel" simulation chart), and regulates it with the help of the two control valves "YC_In" and "YC_Out".

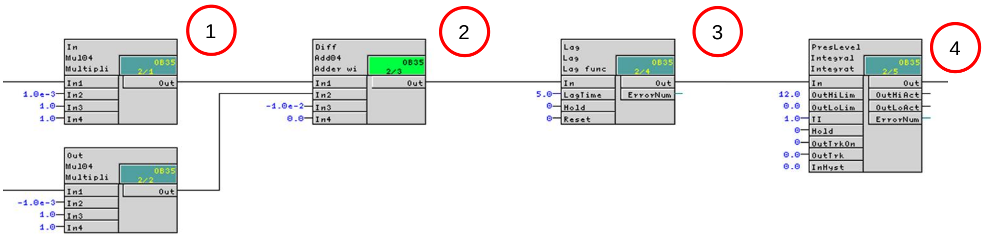
Structure and parameterization

"Sim_PresLevel" simulation

The pressure change in the container due to inerting or venting is simulated in the "Sim_PresLevel" CFC.

The figure below shows the sequence of the simulation.

Figure 5-4



1. Calculation of the pressure change starting from the proportionality factor (valve opened by 100% corresponds to a change in pressure of 0.1 bar)
2. Reduction in the pressure by 0.01 bar, e.g. due to container pressure loss
3. Time lag of the change in pressure
4. Formation of an integral value by integrating the change in pressure (every second)

PIC_Split

The instance has the following parameterization.

Table 5-2

Block	Connection	Value	Use
PV_Scale	HiScale	10.0	Scaling of the process value upper limit
PV_Unit	In	1137	Process value unit in bar
C	NegGain.Value	1	Reversal of the response characteristic for the valve (valve 1 opens in the case of a negative control difference instead of a positive one)
C	Gain.Value	8.0	Controller gain
C	TI.Value	75.0	Controller lag
C	SP_InHiLim	10.0	Maximum value of the internal setpoint
C	ManLoLim (hidden)	-100.0	Lower limit for the manipulated variable in manual mode
SplitRange	InScale.High InScale.Low	100.0 -100.0	Marginal range for the input signal
SplitRange	NeutPos	0.0	Neutral position
to_Actor1	Out		Interconnection to the valve (YC_In\from_Ctrl.In)
to_Actor2	Out		Interconnection to the valve (YC_Out\from_Ctrl.In)
from_Actor1	In		Interconnection to the valve (YC_In\to_Ctrl.Out)
from_Actor2	In		Interconnection to the valve (YC_Out\to_Ctrl.Out)
PV	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)
PV	SimPV_In		Interconnection for the simulated process value (Sim_PresLevel\PresLevel.Out)

Note The program "PID Tuner" is available for commissioning the "PIC_Split" controller. The system first records data for the "PID-Tuner" in an operating range in which only positive manipulated variables occur. After this, a comparable experiment is made in an operating range in which only negative manipulated variables occur.

If both parts of the partial controlled system for venting and inerting demonstrate significantly different values for process intensification, this must be compensated by a different rise in both branches of the split range characteristic curve.

Additional information and configuration guidelines can be found in the Online Help for the "SplitrangeControl" process tag type.

YC_In and YC_Out

The instances have the following parameterization.

Table 5-3

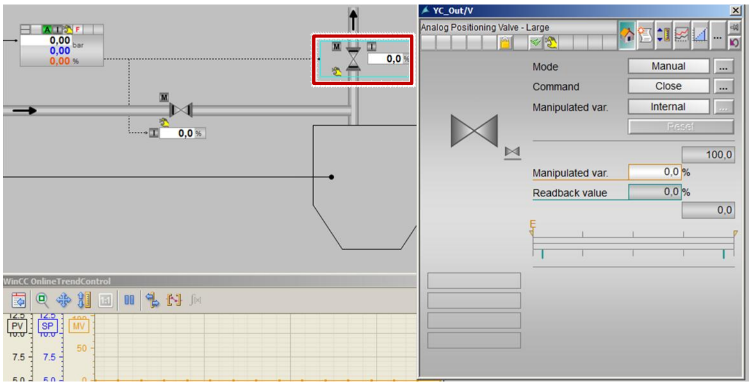
Block	Connection	Value	Use
V (YC_In) (YC_Out)	MV		Interconnection for the simulation (Sim_PresLevel\In.In1) (Sim_PresLevel\Out.In1)
from_Ctrl (YC_In) (YC_Out)	In		Interconnection for the controller (PIC_Split\to_Actror1.Out) (PIC_Split\to_Actor2.Out)
to_Ctrl (YC_In) (YC_Out)	Out		Interconnection to the controller (PIC_Split\from_Actror1.In) (PIC_Split\from_Actror2.In)
MV_Out (YC_In) (YC_Out)	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)

Commissioning and operation

For commissioning and operation, it is assumed that the user program has been loaded in the automation system (AS) or the S7-PLCSIM and that the OS (WinCC Runtime) has been activated. You can find a guide for loading the user program and activating the OS in chapter 6 "Starting the equipment modules".

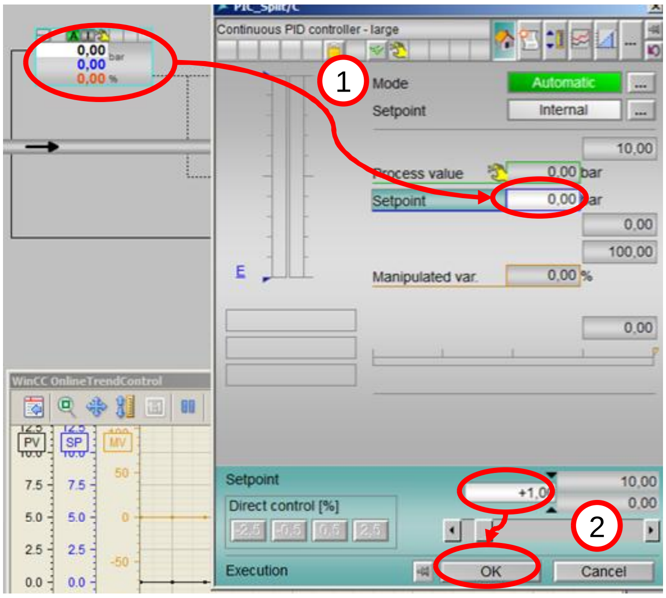
Proceed as follows:

1. Click on the symbol display of valve "YC_Out".
   The system opens the corresponding faceplate.



2. In the faceplate, change the operating mode to "Automatic".
3. Switch to valve "YC_In" and change the operating mode to "Automatic".
4. Switch to controller "PIC_Split" and change the operating mode of the controller to "Automatic".

5. Enter “1 bar” as setpoint.

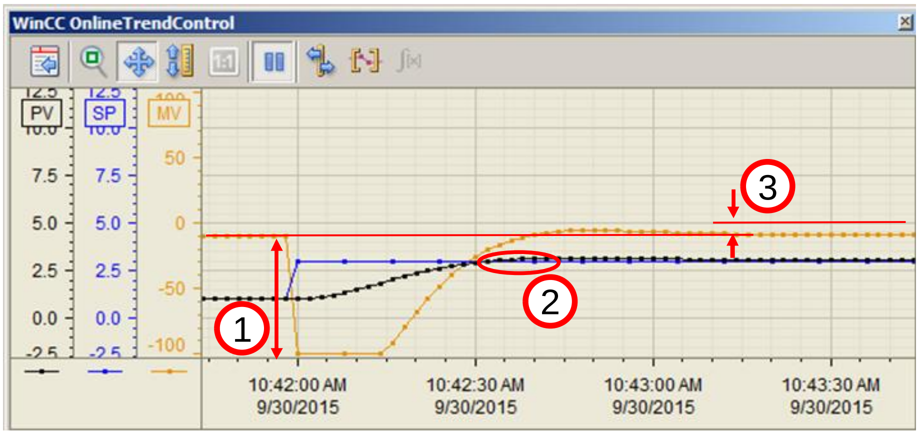


The new setpoint will have been reached after about two minutes. To compensate the pressure loss of the container, the valve is opened to about 10% for venting.

6. Specify “3 bar” as new setpoint for the controller.
7. Close the faceplate and observe the plotter for about two minutes until the new setpoint has been reached.

Evaluation

Figure 5-5



1. After the setpoint step-change, the manipulated variable is set to 100 and with this, the pressure feed valve is opened.
2. The process value slightly exceeds the setpoint; the pressure feed valve is closed evenly.
3. After reaching the setpoint, the pressure feed valve has been opened by about 10%; this means that the pressure loss of the container has been compensated.

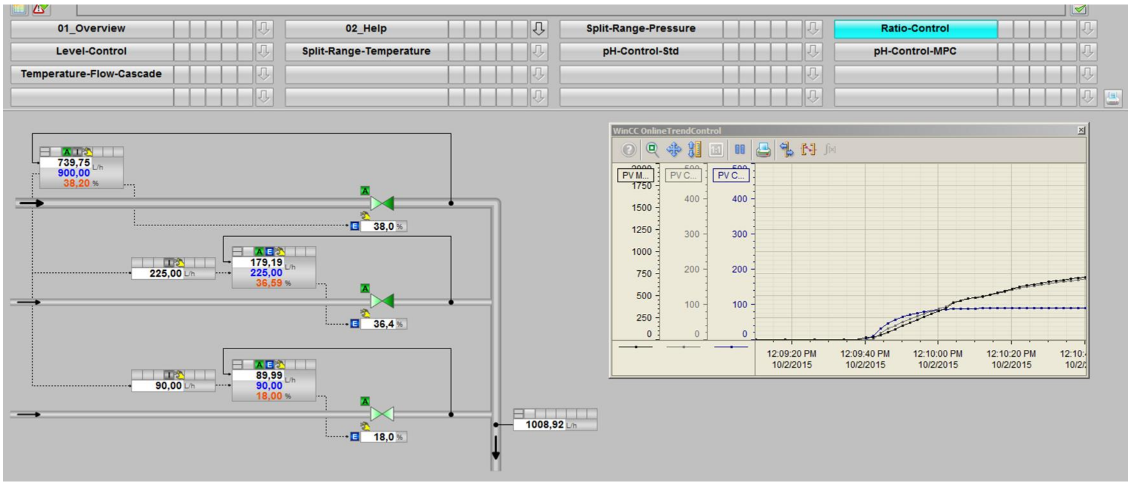
5.2 “Ratio-Control”

In the case of ratio control, fixed mixing ratios of input materials or different gases are fed into a container via inlet lines.

The ratio controller consists of a control for the main input material (master control) and one control for each additional input material (slave control).

The example below describes feed control with two input substances to which another input material is added.

Figure 5-6: Ratio-Control equipment module



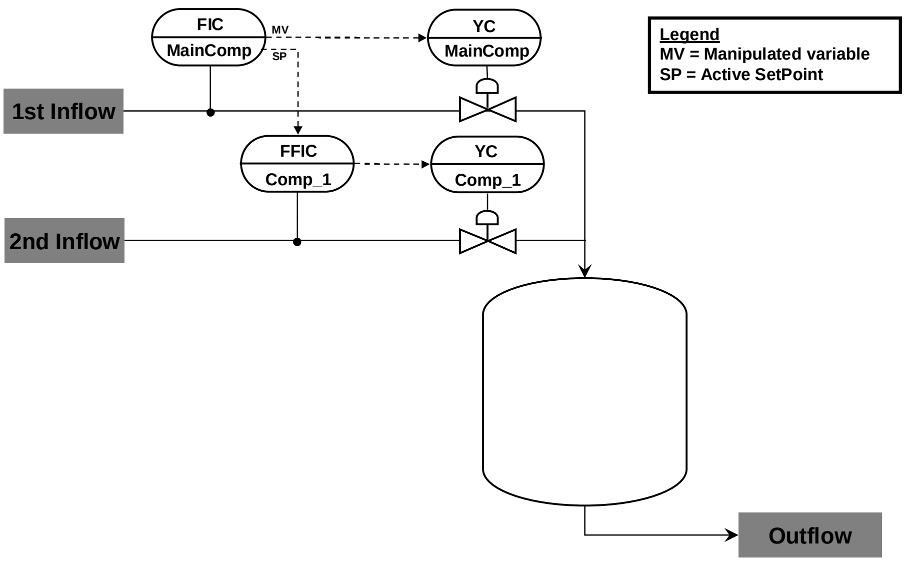
Overview

Below, you can see the structure in the P&I diagram; all the process tags and the simulation of the equipment module are described.

P&ID

The P&I diagram below represents symbolically all of the components, such as units and containers, etc. relevant to operation.

Figure 5-7



CM and variants

The "Ratio-Control" equipment module consists of four interconnected CMs and one simulation chart. On the simulation chart, the system forms the total of all the inflows (input substances) and displays them.

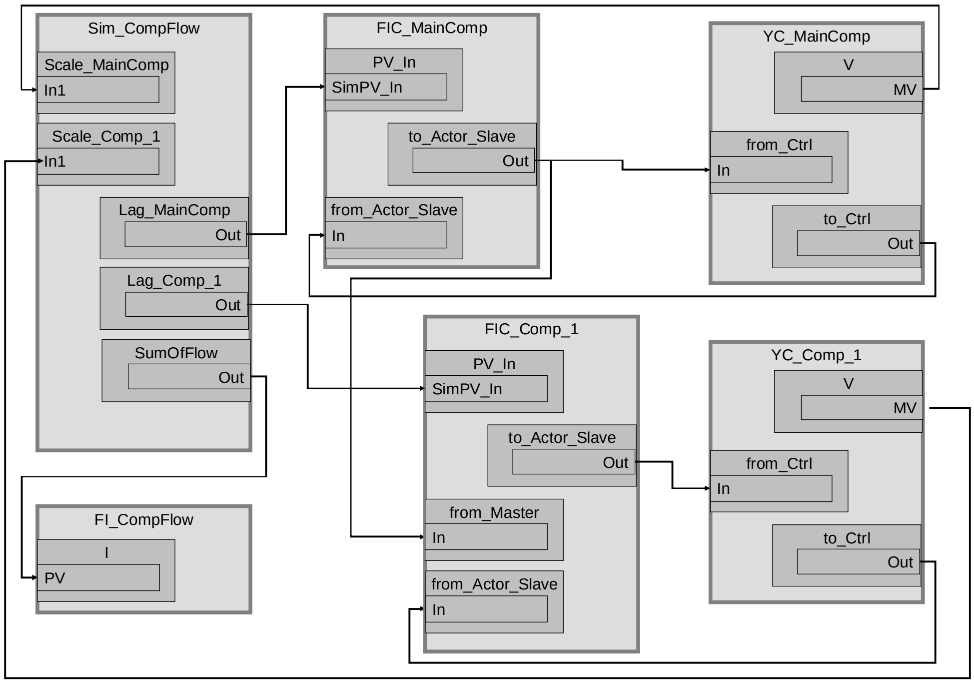
The following table provides an overview of the CMs of the equipment module including the associated CMTs.

Table 5-4

CM	CMT	Variant	Description
FIC_MainComp	"Ctrl"	Ctrl_Std	Flow control of the main input material
FFIC_Comp_1	"CtrlRatio"	CtrlRatio_Std	Flow control of the additional input material
YC_MainComp	"ValAn"	ValAn_Std	Control valve for the main input material
YC_Comp_1	"ValAn"	ValAn_Std	Control valve for the additional input material
FI_CompFlow	"AMon"	AMon Activated option "Opt_PV_Scale"	Display of the calculated overall inflow

In the figure below, the structure with the cross-chart interconnections is shown in simplified form.

Figure 5-8



Control "FIC_MainComp" acquires the flow of the main input material and regulates it using control valve "YC_MainComp". In addition, "FIC_MainComp" transfers its own setpoint to process tag "FFIC_Comp_1". This means that "FIC_MainComp" is the master controller for "FFIC_Comp_1".

Control "FFIC_Comp_1" acquires the flow of the additional input material and regulates it using control valve "YC_Comp_1". "FFIC_Comp_1" receives the setpoint from control "FIC_MainComp"; this means that „FFIC_Comp_1“ is the slave controller.

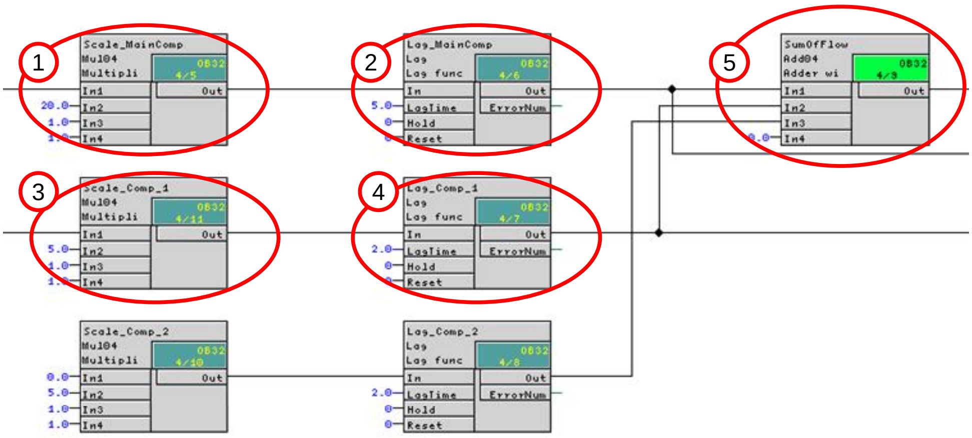
Structure and parameterization

"Sim_CompFlow" simulation

The flow of the main input material and the additional input material are simulated in the "Sim_CompFlow" CFC and the overall flow rate is calculated too. Apart from this, the system displays the flow rate based on process tag type "AMON_Flow".

The figure below shows the sequence of the simulation.

Figure 5-9



1. Calculation of the flow for the main input material (valve opened by 100% corresponds to inflow of 2000 l/h)
2. Delay in change of flow (PT1 response with 5-second delay)
3. Calculation of the flow for the additional input material (valve opened by 100% corresponds to inflow of 500 l/h)
4. Delay in change of flow (PT1 response with 2-second delay)
5. Determination of the complete flow quantity (addition)

Inputs "In1" of highlighted blocks 1 and 3 get their manipulated variables from valve blocks "I" of process tags "YC_MainComp" and "YC_Comp_1". The "Out" outputs of highlighted blocks 2 and 4 are interconnected with the channel blocks of the controls.

FIC_MainComp

The instance has the following parameterization.

Table 5-5

Block	Connection	Value	Use
PV_Scale	HiScale	2000.0	Scaling of the process value upper limit
PV_Unit	In	1353	Unit of the process value l/h (liters per hour)
C	Gain.Value	0.05	Controller gain
C	TI.Value	2.2	Controller lag
C	SP_InHiLim	2000.0	Maximum value of the internal setpoint
to_Actor_Slave	Out		Interconnection to the valve and slave controller (YC_MainComp\from_Ctrl.In) (FFIC_Comp_1\from_Master.In)

Block	Connection	Value	Use
from_Actor_Slave	In		Interconnection to the valve (YC_MainComp\to_Ctrl.Out)
PV	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)
PV	SimPV_In		Interconnection for the simulated process value (Sim_CompFlow\Lag_MainComp.Out)

Note In the current configuration, the master controller can carry out control regardless of the status of the slave controller. If you do not want this behavior, you can, for example, interconnect the "CascaCut" output of the slave controller to the "Interlock" input or block (can be selected optionally).
If you want to use other signals of the slave controller such as "LockAct" (locking active) or "OosAct" (out of service) for locking, you can add another "ComStruOut" communication block to the slave controller and interconnect block outputs BoStru1 thru BoStru3 to the locking block.

Note The setpoint is transferred to the controller process tag(s) of the additional input material(s). Using the setpoint instead of the manipulated variable means that the controller structure **does not** correspond to a typical cascade controller.

The "PID Tuner" program is available for commissioning of the controller. If there is a considerably difference in transient response at optimization, you can try adapting and compensating the parameters of both control loops manually. The highest priority is the stability of the transient response of both individual control circuits. In this connection, there can be a brief deviation in the relationships in the case of setpoint step-changes.

FFIC_Comp_1

The instance has the following parameterization.

Table 5-6

Block	Connection	Value	Use
PV_Scale	HiScale	500.0	Scaling of the process value upper limit
PV_Unit	In	1353	Unit of the process value l/h (liters per hour)
C	Gain.Value	0.25	Controller gain
C	TI.Value	4.1	Controller lag
C	SP_InHiLim	500.0	Maximum value of the internal setpoint
to_Actor_Slave	Out		Interconnection to the valve (YC_Comp_1\from_Ctrl.In)
from_Actor_Slave	In		Interconnection to the valve (YC_Comp_1\to_Ctrl.Out)
from_Master	In		Interconnection to the master controller (FIC_MainComp\to_Actor_Slave.Out)
Ratio	RatHiLim	1	Upper limit (ratio)
Ratio	RatLoLim	0	Lower limit (ratio)

Block	Connection	Value	Use
Ratio	RatLiOp	0	Ratio specification by user
PV	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)
PV	SimPV_In		Interconnection for the simulated process value (Sim_CompFlow\Lag_Comp_1.Out)

YC_MainComp and YC_Comp_1

The instances have the following parameterization.

Table 5-7

Block	Connection	Value	Use
V (YC_MainComp) (YC_Comp_1)	MV		Interconnection for the simulation (Sim_CompFlow\In.In1) (Sim_CompFlowl\Out.In1)
from_Ctrl (YC_MainComp) (YC_Comp_1)	In		Interconnection to the controller (FIC_MainComp\to_Actor_Slave.Out) (FFIC_Comp_1\to_Actor_Slave.Out)
to_Ctrl (YC_MainComp) (YC_Comp_1)	Out		Interconnection to the controller (FIC_MainComp\to_Actor_Slave.In) (FFIC_Comp_1\to_Actor_Slave.In)
MV_Out (YC_MainComp) (YC_Comp_1)	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)

FI_CompFlow

The instance has the following parameterization.

Table 5-8

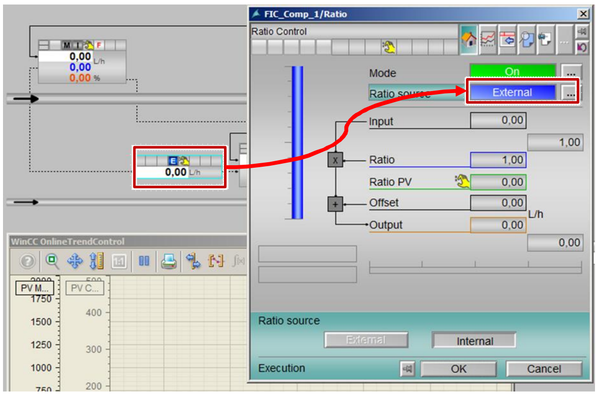
Block	Connection	Value	Use
PV_Scale	HiScale	3000.0	Scaling of the process value upper limit
PV_Unit	In	1353	Unit of the process value l/h (liters per hour)
I	PV		Interconnection for the simulation: (Sim_CompFlow/SumOfFlow.Out)

Commissioning and operation

For commissioning and operation, it is assumed that the user program has been loaded in the automation system (AS) or the S7-PLCSIM and that the OS (WinCC Runtime) has been activated. You can find a guide for loading the user program and activating the OS in chapter 6 "Starting the equipment modules".

Proceed as follows:

1. Click on the symbol display of ratio block "FFIC_Comp_1/Ratio" and change the ratio source to "Internal".



2. Enter the new ratio of "0.25".
   The ratio corresponds to the factor of the flow setpoint at which the additional input material has to flow to the main input material.
3. Switch to valve "YC_Comp_1" and change the operating mode to "Automatic".
4. Switch to slave controller "FFIC_Comp_1" and change the operating mode to "Automatic" and the setpoint specification to "External".

Note While master controller "FIC_MainComp" is not working in automatic mode, it does not return a setpoint (proportionally) to the slave controller either.

5. Switch to valve "YC_MainComp" and change the operating mode to "Automatic".
6. Switch to master controller "FIC_MainComp" and change the operating mode to "Automatic".
7. Enter the setpoint "1000 l/h" in the master controller.

Note The system displays the current setpoint of the ratio on the "Ratio" block, which is used for controlling for the slave controller.

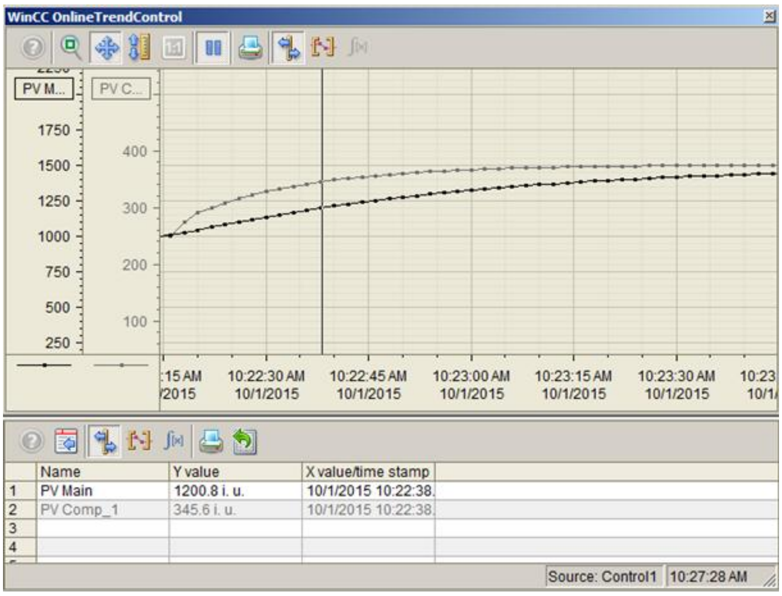
Both controller setpoints will have been reached after about 1 minute.

8. Enter a new setpoint of "1500 l/h" in master controller "FIC_MainComp".
9. Wait for about 90 seconds and then click on the "Start/Stop" icon on the toolbar of the OnlineTrendControl.
10. On the toolbar of the OnlineTrendControl, click on the "Ruler" icon and move the ruler to the lowest value with the greatest deviation, as show in the evaluation below.

Evaluation

The "OnlineTrendControl" that is embedded in the process picture is set to the maximum value ranges. If the ratio changes, the value range of the additional input material adapts automatically.

Figure 5-10



Due to the different response times of the controllers, the ratio is temporarily 29% (0.29). Compared to the set ratio of 25% (0.25), a deviation of 4% results briefly before the correct ratio is reached in the steady state.

In this case, it is not possible to improve the controller design for slave controller "FFIC_Comp_1" by means of PID controller optimization, since the aim of the controller design is optimum tracking of the additional input material.

Note

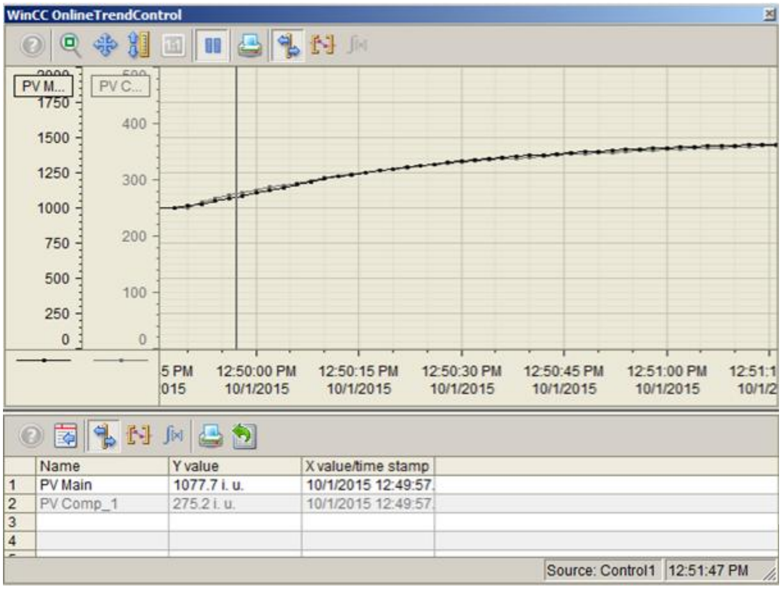
For further information and configuration guidelines, refer to the Online Help for the "RatioControl" process tag type. You can find the process tag type in “PCS 7 – Advanced Process Library”.

The response time from the OnlineTrendControl leads to the considerations below for the controller design to match the transient responses of the master and slave circuits as closely as possible to one another:

- The relatively large deviation at the start of controlling indicates that the gain of the slave controller is too high, i.e. the slave controller setpoint rises faster than the actual value of the master controller.
- The relatively slow speed with which the final value of the setpoint step-change is reached, indicates an integration time of the master controller that is too high, i.e. the master controller enters the steady state slower than the slave controller.

A change in the gain of slave controller "FFIC_Comp_1" from 0.25 to 0.1 with a simultaneous change in the integral-action time of master controller "FIC_MainComp" from 2.2 to 2 generates the result below with the same setpoint step-change.

Figure 5-11



Due to the different response times of the controllers, the ratio after optimization is temporarily 25.6% (0.256). Compared to the set ratio of 25% (0.25), a deviation of 0.6% results briefly.

Adding another input material

Using the "Ratio-Control" equipment module, you can set up a large number of ratio controllers. The number of additional input materials is limited by the interlock block or the number of interlock inputs that it has.

Note

If the number of locking signals of the slave controller has to be acquired in the master controller, the options below are available for adapting the Ctrl type (CMT):

1. Group the signals of the communication blocks (from_Actor_Slave) using OR blocks. As a result, one valve and seven additional input materials are interconnected by means of one interlock block.
   Disadvantage:
   Inaccurate error display, i.e. the system does not differentiate between errors in the cascade controller, an “out of service” signal of the controller block, and a “Bad” status of the controller channel blocks.
2. Duplicate the existing interlock block and group the two (Out) outputs of the interlock blocks using an OR block. For interconnection (Out output) of the OR block, use the (Out output) interconnections of the existing interlock block.
   You can call up the faceplate of the first interlock block from the controller's faceplate. The faceplate of the second interlock block is opened by means of its block display symbol in the process picture.
3. Replace the existing (Intlk08) locking block with 8 input signals with an (Intlk16) locking block with 16 input signals. Apply all the interconnections of the previous locking block.

Requirements

If different additional input materials are measured in different measurement units, the conversion factor in the ratio block also includes conversion of the units.

Note

In the case of different units, you must parameterize the other measurement unit for the additional input material and convert the setpoint using a multiplier block, for example.

Additionally, when displaying the trend curves on a common basis, it is advisable to label clearly.

If different travel ranges are needed in the case of the partial control loops of a ratio controller, you must delete the corresponding interconnections and parameterize them for the respective partial control loop.

Description

To add another additional input material to the equipment module, proceed as follows:

1. Copy CMs "FFIC_Comp_1" and "YC_Comp_1" at the same time. Paste the copied CMs back into the same hierarchy folder. Rename the process tags appropriately (below, the CMs will be referred to as "FFIC_Comp_2" and "YC_Comp_2").

Note When you copy the process tags at the same time (highlight the process tags and then click on Edit > Copy on the menu bar), the connections between the highlighted process tags are retained.

2. Open process tag "FFIC_Comp_2" and make the following interconnections:

Table 5-9

Block	Connection	Use
from_Master	In	Interconnection to the master controller (FIC_MainComp\to_Actor_Slave.Out)

3. The simulation model is designed for two additional input materials. Make the interconnections below in CFC "FFIC_Comp_2" to connect the second additional input material to the simulation.

Table 5-10

Block	Connection	Use
PV	SimOn	Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)
PV	SimPV_In	Interconnection for the simulated process value (Sim_CompFlow\Lag_Comp_1.Out)

4. Open process tag "YC_Comp_2" and make the interconnections below in chart partition "A" sheet 1:

Table 5-11

Block	Connection	Use
V	MV	Interconnection for the simulation (Sim_Level\Scale.In1)
MV_Out	SimOn	Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)

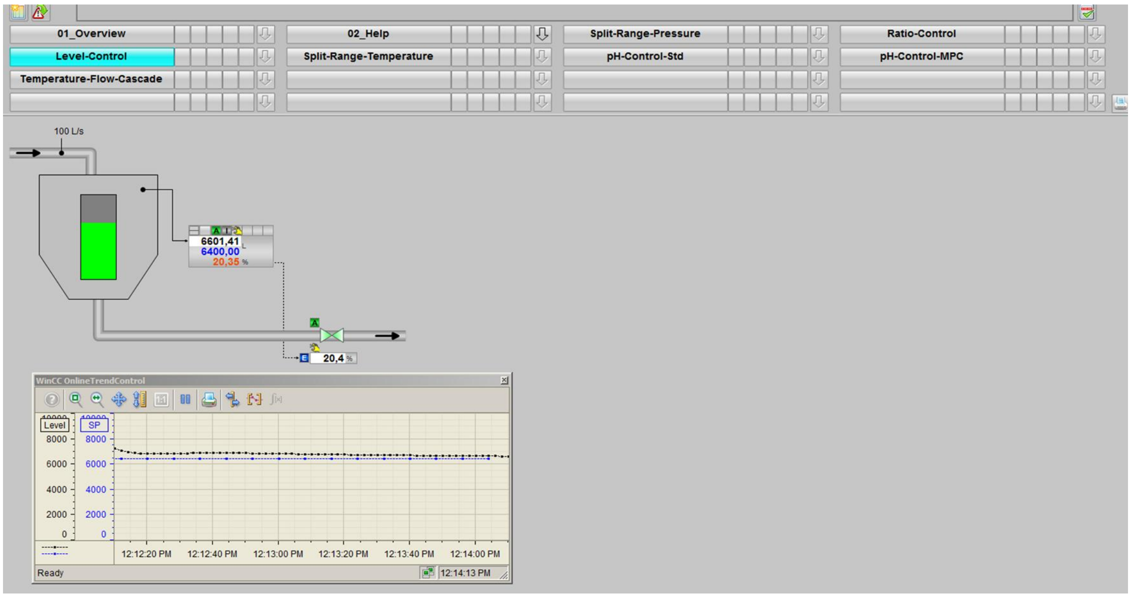
Note When additional input materials are added to the “Ratio-Control” equipment module, you must compile and load the blocks and charts and compile the OS.

5.3 "Level-Control"

In the case of the level control, input materials are fed via inlet lines to a container and the mixture is removed via an outlet. The controller responds to deviations in the fill level (the difference between the amount flowing in and out) and regulates it by either lowering or raising the inflow or outflow.

In the example below, control of the fill level is by means of the outflow.

Figure 5-12: "Level-Control" equipment module



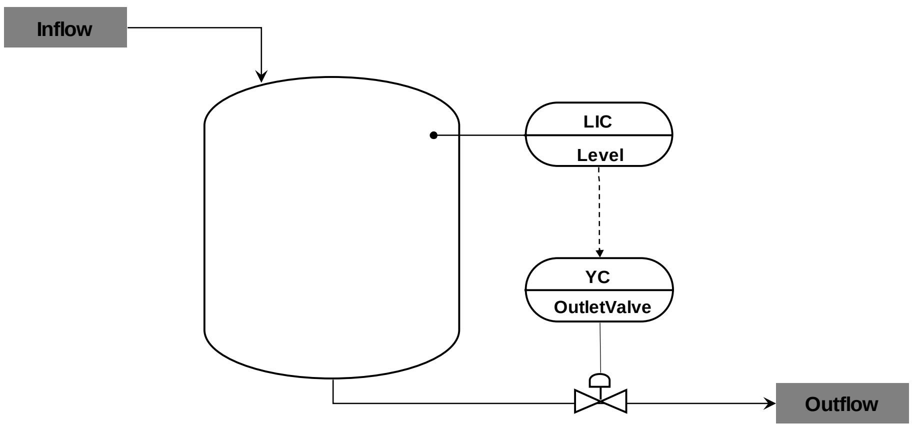
Overview

Below, the structure in the P&I diagram is shown and all of the CMs and the simulation of the equipment module are described.

P&ID

The P&I diagram below represents symbolically all of the components, such as units and containers, etc. relevant to operation.

Figure 5-13



CM and variants

The "Level-Control" equipment module consists of two interconnected CMs and one simulation chart. The fill level of a container is simulated in the simulation chart.

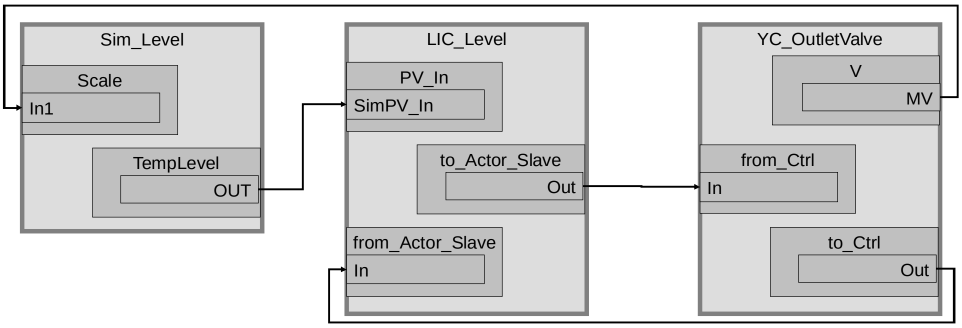
The following table provides an overview of the CMs of the equipment module including the associated CMTs.

Table 5-12

CM	CMT	Variant	Description
LIC_Level	"Ctrl"	Ctrl_Std	Level control of a container
YC_OutletValve	"ValAn"	ValAn_Std	Control valve for discharge

In the figure below, the structure with the cross-chart interconnections is shown in simplified form.

Figure 5-14



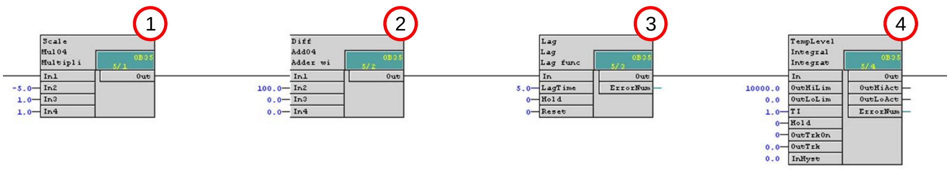
Control "LIC_Level" acquires the fill level of the container (Sim_Level simulation chart) and regulates it using "YC_OutletValve" control valve.

Structure and parameterization

"Sim_Level" simulation

The fill level of the container is simulated in CFC "Sim_Level". The figure below shows the sequence of the simulation.

Figure 5-15



1. Calculation of the flow (valve opened by 100% corresponds to outflow from the container of 500 l/h)
2. Permanent inflow of the container (100 l/s)
3. Delay in change of flow (PT1 response with 5-second delay)
4. Formation of an integral value by integrating the change in flow (every second)

LIC_Level

The instance has the following parameterization.

Table 5-13

Block	Connection	Value	Use
PV_Scale	HiScale	10000.0	Scaling of the process value upper limit
PV_Unit	In	1038	Process value unit in L (liters)
C	NegGain	1	Activation of negative gain, since the controller is used for the outflow
C	Gain	2.0	Controller gain
C	TI	120.0	Controller lag
C	SP_InHiLim	10000.0	Maximum value of the internal setpoint
to_Actor_Slave	Out		Interconnection to the valve (YC_OutletValve\from_Ctrl.In)
from_Actor_Slave	In		Interconnection to the valve (YC_OutletValve\to_Ctrl.Out)
PV	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)
PV	SimPV_In		Interconnection for the simulated process value (Sim_Level\TempLevel.Out)

YC_OutletValve

The instance has the following parameterization.

Table 5-14

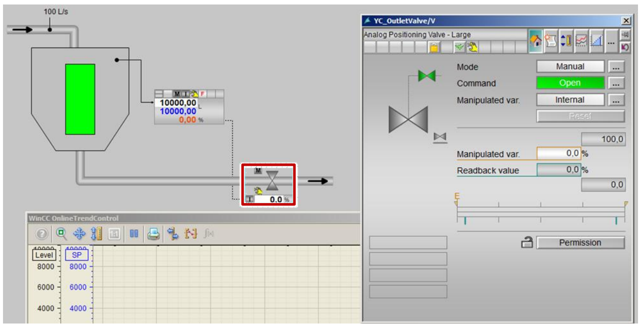
Block	Connection	Value	Use
V	MV		Interconnection to the simulation (Sim_Level\Scale.In1)
from_Ctrl	In		Interconnection to the controller (LIC_Level\to_Actor_Slave.Out)
to_Ctrl	Out		Interconnection to the controller (LIC_Level\from_Actor_Slave.In)
MV_Out	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)

Commissioning and operation

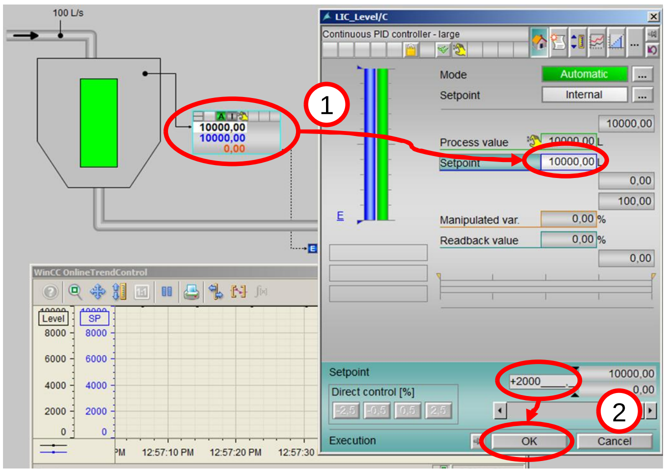
For commissioning and operation, it is assumed that the user program has been loaded in the automation system (AS) or the S7-PLCSIM and that the OS (WinCC Runtime) has been activated. You can find a guide for loading the user program and activating the OS in chapter 6 "Starting the equipment modules".

Wait for two minutes after starting up the CPU (in the initial status) until the container has reached the maximum fill level, and then proceed as follows:

1. Click on the symbol display of the "YC_OutletValve".
   The system opens the corresponding faceplate.

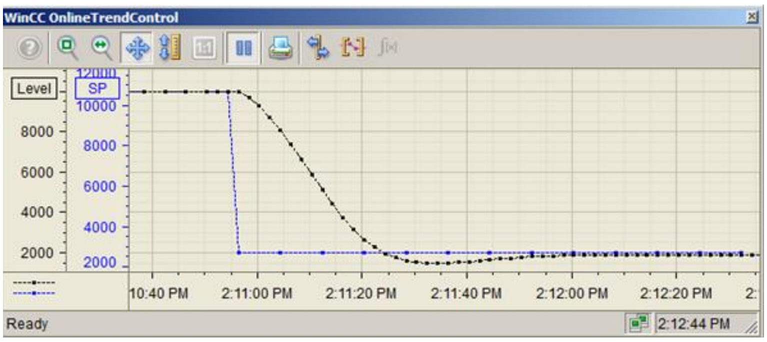


2. In the faceplate, change the operating mode to "Automatic".
3. Switch to controller "LIC_Level" and change the operating mode of the controller to "Automatic".
4. Enter a setpoint of “2000”.



Evaluation

To demonstrate the fill level controller's way of working, the controller has been configured to reach the setpoint quickly. Due to this configuration, the fill level overshoots slightly when controlling.



Different demands that are placed on fill level control in process engineering processes

Depending on the jobs that a container has to do in a process engineering plant, there are different objectives for a fill level controller:

1. The objective is to keep a fill level as close as possible to a specified setpoint, e.g. in a reactor or the sump of a column. This is necessary if the fill level affects chemical reactions or separation processes, i.e. it is significant to the process. Fluctuations in the inflow are compensated via the outflow.
2. Use a container (e.g. a tank) as a buffer to implement an inflow or outflow amount that is as uniform as possible. In this connection, the system does not maintain a fixed fill level value (setpoint); rather, the setpoint is within permissible limits. This task is referred to as a "buffering controller".

For the first task, a standard design with a PID tuner makes sense; in this connection, you should be aware that most fill level controllers have integrating behavior (outflow as a manipulated variable). In many cases, a P controller (with no integral component) is adequate, which harmonizes dynamically with the integrating controlled system more easily but displays permanent control deviations if there are disturbances in the inflow. If the valve characteristic curve is non-linear, it is recommended in practice using a cascade structure with a master controller for the fill level and a slave controller for the outflow (flow measurement at the outflow is essential for this).

With the second (buffering control) task, a different behavior is required, which accounts for the majority of practical applications. In this connection, the container volume is used selectively to compensate for inflow fluctuations.

Two options are available when doing this:

This fill level is not measured continuously; rather, the minimum and maximum limits are monitored by binary (e.g. capacitive) fill level switches. Continuous control is not used for this solution; rather, discrete-event control is used, i.e. a binary signal is used to close the inflow or outflow.

The second option is to use an open-loop control and selectively set slower. Within the scope of the specification, you define the maximum permissible deviation Δh_{max} of the setpoint from the fill level (the setpoint is mostly 50% of the height of the container) and the stepped disturbances d_{max} of the inflow that can be expected. With regard to permanent control deviations, you must set the gain of a P controller greater than Gain= $d_{max} / \Delta h_{max.}$ You can also set up a PI controller such that the maximum excursions of the fill level with a stepped disturbance is less than d_{max}. In the Dechema Seminar entitled "Process Controls – From the Basics to Advanced Control“ (www.dechema.de), the formulas below are recommended:

GainEff=0.7358 d_{max} / Δh_{max}

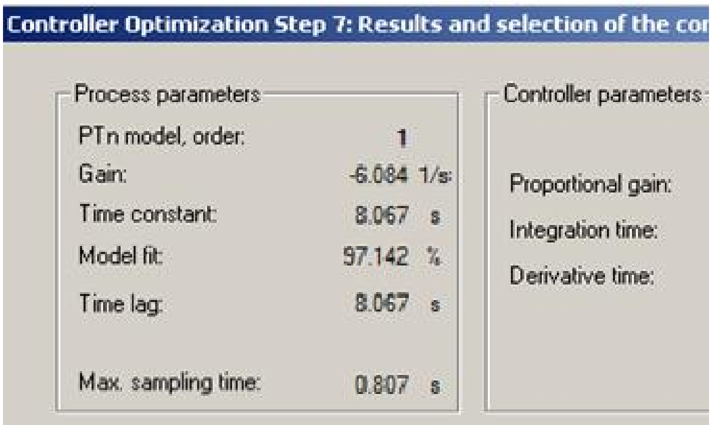
Ti= 5.4366/K_i * Δh_{max} / d_{max}

Note

> The physical controller gain is [MV_Unit/PV_Unit]. In the case of normalization (NormPV ≠ NormMV), the gain must be converted according to the following formula:
>
> Gain = GainEff * (NormPV.High - NormPV.Low)/(NormMV.High - NormMV.Low)

It is possible to determine the integration constant K_i of the controlled system in the unit [PV_Unit/s] using the PID tuner. You can find the integration constants in point "Gain" in the "Process-parameter" area.

Figure 5-16: PID tuning for the integrating controlled system



5.4 "Split-Range-Temperature" control

Temperature control is a slow speed control with which the temperatures in the container change slowly. To achieve a specified temperature inside the container, the system feeds either hot steam or cooling water via supply lines into a heat exchanger/container jacket. Due to separation by means of heat-permeable walls, both these procedures are indirect cold/heat transfers.

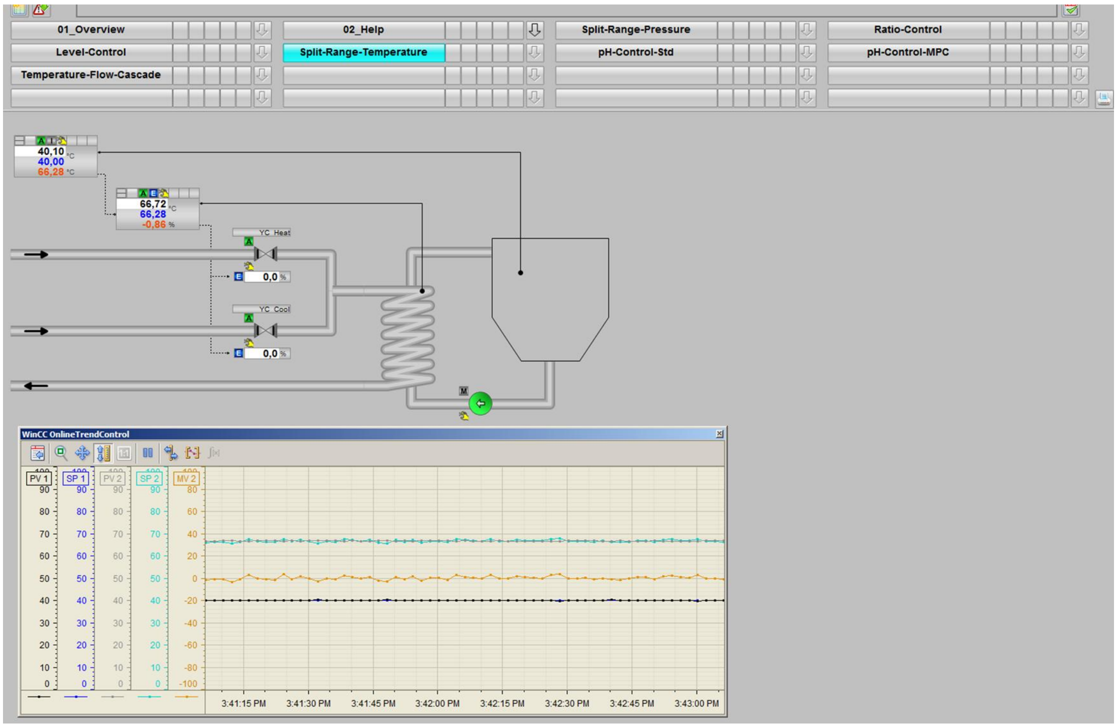
In the heat exchanger, the system continuously pumps the contents of the container through the heat exchanger via piping back to the container until a pre-defined temperature is reached. The way in which the temperature controller works via the container jacket is the same as a heat exchanger. In the case of temperature control via the container jacket, the contents of the container are mixed by means of an agitator.

Note

> The "Split-Range-Temperature" equipment module can be used for processes in which temperature control is provided via the container jacket or an external heat exchanger.

In the following example, temperature control is carried out using a heat exchanger.

Figure 5-17: "Split-Range-Temperature" equipment module



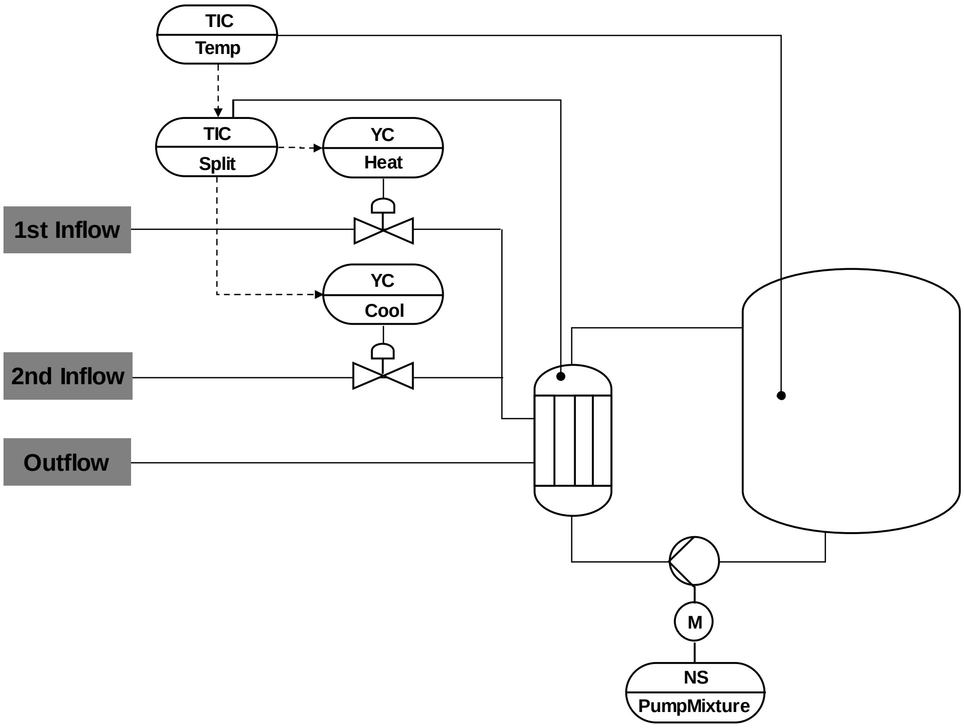
Overview

Below, the structure in the P&I diagram is shown and all of the CMs and the simulation of the equipment module are described.

P&ID

The P&I diagram below represents symbolically all of the components, such as units and containers, etc. relevant to operation.

Figure 5-18



CM and variants

The "Split-Range-Temperature" equipment module consists of four interconnected CMs, one CM for pump control, and one simulation chart. The simulation chart simulates the internal temperature of a container (input material mixture), the temperature of a heat exchanger, and the effect of changes in temperature (heating steam and cooling water).

The following table provides an overview of the CMs of the equipment module including the associated CMTs.

Table 5-15

CM	CMT	Variant	Description
TIC_Temp	"Ctrl"	Ctrl_Std	Master controller for temperature control
TIC_Split	CtrlSplitRange"	CtrlSplitRange_Std activated option "Opt_IF_Master"	Slave controller for split-range control with one manipulated variable and two actuators
YC_Heat	"ValAn"	ValAn_Std	Control valve for the first manipulated variable
YC_Cool	"ValAn"	ValAn_Std	Control valve for the second manipulated variable
NS_PumpMixture			A pump (e.g. a flow pump) for continuous pumped circulation of the contents of the

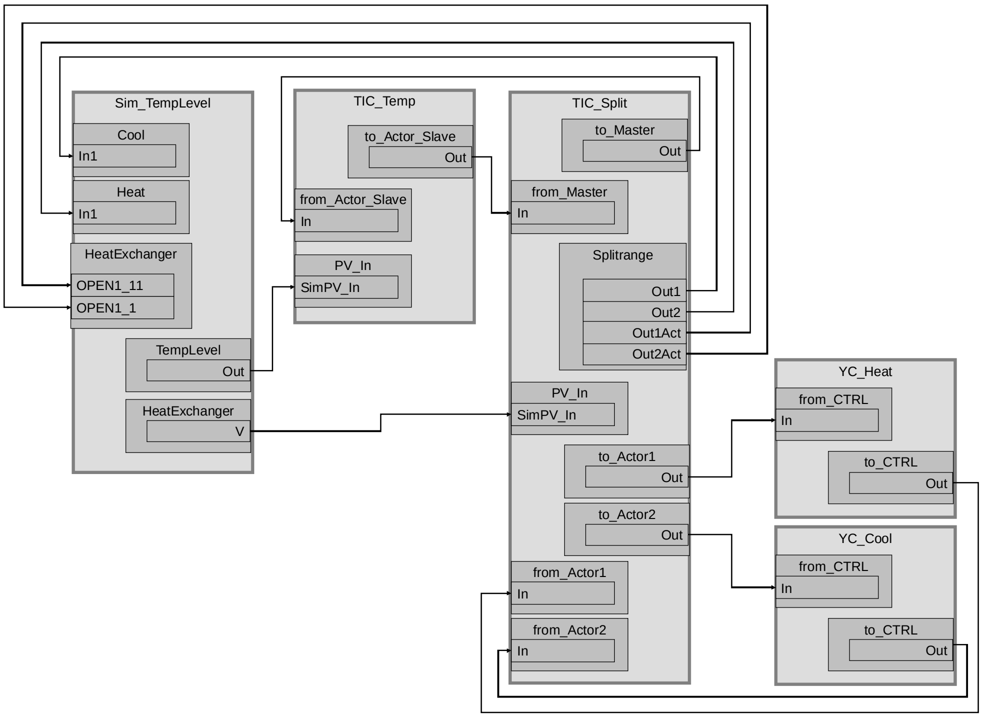
CM	CMT	Variant	Description
			container

Note The “NS_PumpMixture” CM is interconnected in the SFC (Sequential Function Chart) It is not necessary to interconnect with other process tags in the Split-Range-Temperature equipment module.

To ensure that the system does not generate an error message due to a missing feedback signal, the "Start" output signal is interconnected with the "FbkRun" input signal of motor block "U".

In the figure below, the structure with the cross-chart interconnections is shown in simplified form.

Figure 5-19



Controller "TIC_Temp" uses the simulated internal container temperature from simulation chart "Sim_TempLevel" and generates the setpoint specification for the split range control. The desired temperature progression is thus configured in process tag "TIC_Temp".

Controller "TIC_Split" receives the setpoint specification from the master controller and regulates the simulated temperature of a heat exchanger that transfers heat to the inside of the container.

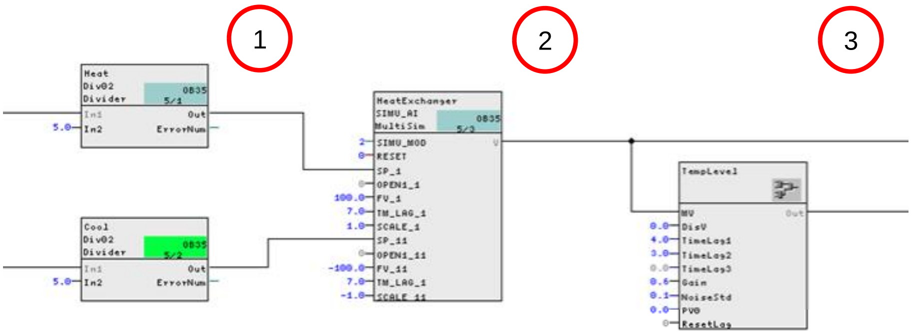
Structure and parameterization

"Sim_TempLevel" simulation

In CFC "Sim_TempLevel", the system simulates a temperature change due to hot steam or cooling water onto the heat exchanger and simulates the internal temperature of the container.

The figure below shows the sequence of the simulation.

Figure 5-20



1. Reduction in the manipulated variable for simulation. This makes it possible to represent the valve openings of the heating and cooling valves with more emphasis in the plotter.
2. Calculation of the temperature of a heat exchanger. The change in temperature depends on the openings of both valves (a bipolar signal is distributed to the heating steam and cooling water valve) and it is processed after passing through a time-delay block.
3. Internal container temperature that changes in dependence on the heat exchanger.
   The temperature in the inside of the container is 40% lower than in the heat exchanger (a factor of 0.6) and it is calculated after passing through two delay elements.
   The output signal (internal container temperature) has slight signal noise.

Note

Simulation behavior does not correspond to a real process and it is used to demonstrate the functionality and mode of operation of the "Split range temperature" equipment module. Block "SIMU_AI" demonstrates integrating behavior whereby heating and cooling act with the same intensity. With real heat exchangers, heat losses and different behavior when heating (e.g. steam) and cooling (e.g. flowing water) are to be expected.

TIC_Temp

The instance has the following parameterization.

Table 5-16

Block	Connection	Value	Use
PV_Scale	HiScale	100.0	Scaling of the process value upper limit
PV_Unit	In	1001	Unit of the process value in degrees Celsius
C	Gain	1.5	Controller gain

Block	Connection	Value	Use
C	TI	7.054	Controller lag
C	TD	1.855	Controller differential time
C	SP_InHiLim	100.0	Maximum value of the internal setpoint
to_Actor_Slave	Out		Interconnection to the slave controller (TIC_Split\from_Ctrl.In)
from_Actor_Slave	In		Interconnection to the slave controller (TIC_Split\to_Ctrl.Out)
PV	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)
PV	SimPV_In		Interconnection for the simulated process value (Sim_TempLevel\TempLevel.Out)

TIC_Split

The instance has the following parameterization.

Table 5-17

Block	Connection	Value	Use
PV_Unit	In	1001	Unit of the process value in degrees Celsius
C	Gain	3.5	Controller gain
C	DeadBand	0.2	Width of dead band
C	SP_InHiLim	100.0	Maximum value of the internal setpoint
C	ManLoLim (hidden)	-100.0	Lower limit for the manipulated variable in manual mode
SplitRange	InScale.High InScale.Low	100.0 -100.0	Marginal range for the input signal
SplitRange	NeutPos	0.0	Neutral position
SplitRange	Out1		Interconnection to the simulation (Sim_TempLevel\Cool.In1)
SplitRange	Out2		Interconnection to the simulation (Sim_TempLevel\Heat.In1)
SplitRange	Out1Act		Interconnection to the simulation (Sim_TempLevel\HeatExchanger.OPEN1_11)
SplitRange	Out2Act		Interconnection to the simulation (Sim_TempLevel\HeatExchanger.OPEN1_1)
to_Actor1	Out		Interconnection to the valve (YC_Heat\from_Ctrl.In)
to_Actor2	Out		Interconnection to the valve (YC_Cool\from_Ctrl.In)
from_Actor1	In		Interconnection to the valve (YC_Heat\to_Ctrl.Out)
from_Actor2	In		Interconnection to the valve (YC_Cool\to_Ctrl.Out)
PV	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)

Block	Connection	Value	Use
PV	SimPV_In		Interconnection for the simulated process value (Sim_TempLevel\HeatExchanger.V)

Note The "PID Tuner" program is available for commissioning the "TIC_Split" controller. The system first records data for the "PID-Tuner" in an operating range in which only positive manipulated variables occur. After this, a comparable experiment is made in an operating range in which only negative manipulated variables occur. If both parts of the partial controlled system for heating and cooling demonstrate significantly different values for process intensification, this must be compensated by a different rise in both branches of the split range characteristic curve. After the slave controller including the split range has been completely commissioned and tested, the master controller "TIC_Temp" is set using the "PID Tuner" program.

For further information and configuration guidelines, refer to the Online Help for the "CascadeControl" process tag type of the PCS 7 Advanced Process Library.

YC_Heat and YC_Cool

The instances have the following parameterization.

Table 5-18

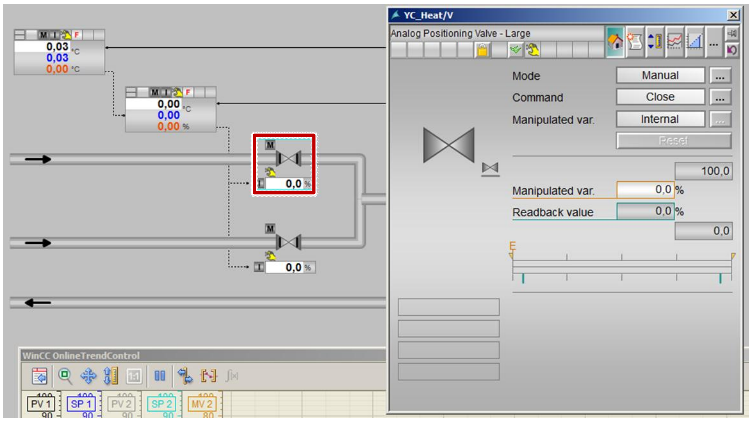
Block	Connection	Value	Use
from_Ctrl (YC_In) (YC_Out)	In		Interconnection to the controller (TIC_Split\to_Actror1.Out) (TIC_Split\to_Actor2.Out)
to_Ctrl (YC_In) (YC_Out)	Out		Interconnection to the controller (TIC_Split\from_Actror1.In) (TIC_Split\from_Actror2.In)
MV_Out (YC_In) (YC_Out)	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)

Commissioning and operation

For commissioning and operation, it is assumed that the user program has been loaded in the automation system (AS) or the S7-PLCSIM and that the OS (WinCC Runtime) has been activated. You can find a guide for loading the user program and activating the OS in chapter 6 "Starting the equipment modules".

Proceed as follows:

1. Click on the symbol display of the "YC_Heat".
   The system opens the corresponding faceplate.



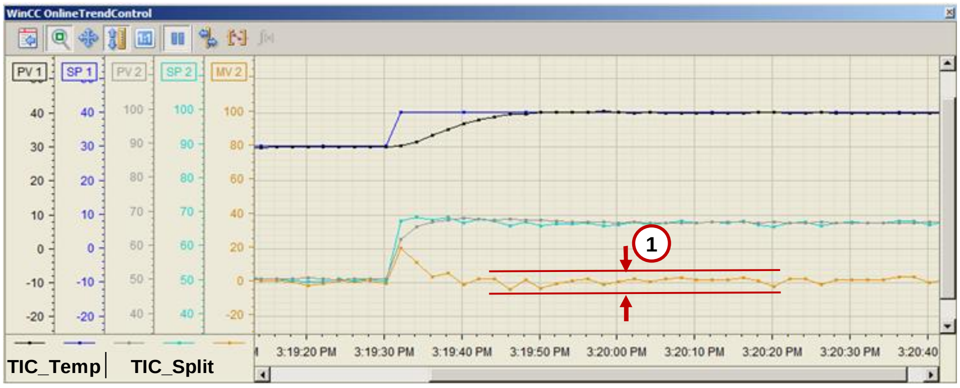
2. In the faceplate, change the operating mode to "Automatic".
3. Switch to valve "YC_Cool" and change the operating mode to "Automatic".
4. Switch to slave controller "TIC_Split" and change its operating mode to "Automatic" and the setpoint specification to "External".
5. Switch to master controller "TIC_Temp" and change the operating mode of the controller to "Automatic".
6. In master controller "TIC_Temp", enter a setpoint of "30" °C for the operating range.
7. Wait for about one minute and enter a new setpoint of "40” °C.
8. Observe the plotter for about one minute until the new setpoint has been reached.
9. Then click on the "Start/Stop" icon on the toolbar of the OnlineTrendControl.

Note

You can start the motor using the "Start" command on the faceplate.
In process mode, the motor is controlled via an SFC, e.g. at start up of the plant.

Evaluation

Figure 5-21



After setpoint change SP 1, the master controller calculates a manipulated variable MV 1 and transfers it in the cascade to the slave controller. This manipulated variable is represented as setpoint SP 2 for the slave controller in the curve chart.

The slave controller calculates manipulated variable MV 2 from setpoint curve SP 2. MV 2 acts on the heating and cooling valves and yields temperature curve PV 2 of the heat exchanger.

Temperature PV 1 in the container follows the temperature of heat exchanger PV 2 with a delay.

Legend

Legend	
1	The noise of process variable PV1 leads to noise of manipulated variable MV 1 and consequently of setpoint SP2. The oscillation of manipulated variable MV 2 around the neutral position is due to the simulation. In the real process, you should avoid this alternating behavior of heating and cooling, e.g. by defining dead bands.

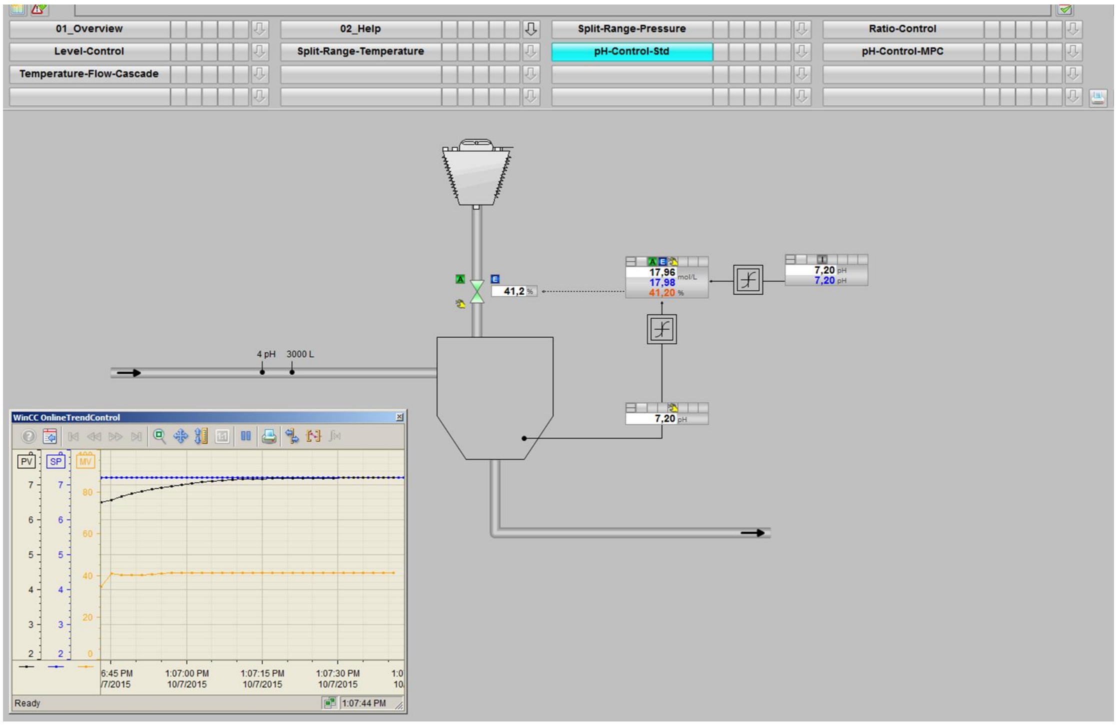
5.5 pH value control using a standard controller

The pH of the product is set in pH value control "pH-Control-Std". For this, a neutralizer is added to the product in continuous operation to reach the desired pH value.

Due to the highly non-linear titration curve, this means that the gain of the controlled system may fluctuate severely, depending on the operating point. It is only possible to carry out pH value control using a PID controller with fixed parameterization in the case of applications in which the pH value is to be kept constant in a very tight range and the interferences are limited. The special feature of the equipment module presented here is the fact that the pH setpoint and the pH process value are converted to concentration differences to achieve linearization of the controlled system characteristic. Conversion is carried out on the basis of a titration curve that describes the chemical reaction of the process in question at least approximately.

In difficult applications with long dead times (due to the measurement dead time of the pH probe, the time needed for mixing, and the response time of the neutralization reaction) and the need for dynamic feedforward control based on the pH value in the inflow, we recommend using a multivariable controller to compensate the influences.

Figure 5-22: "pH-Control-Std" equipment module



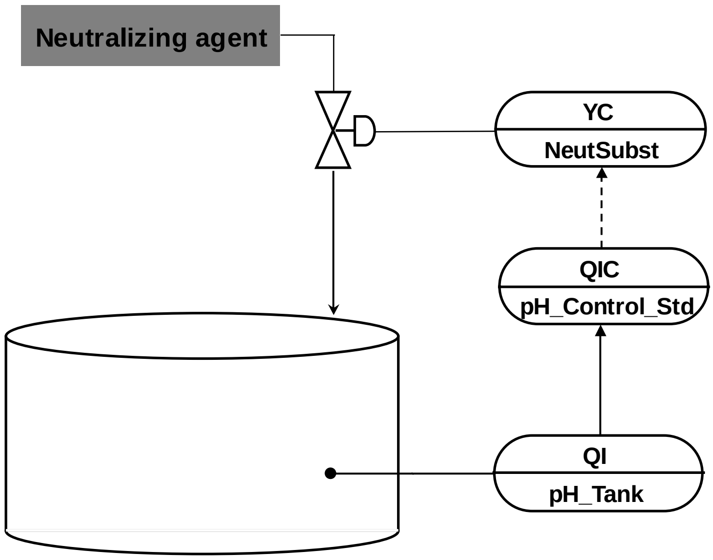
Overview

Below, the structure in the P&I diagram is shown and all of the CMs and the simulation of the equipment module are described.

P&ID

The P&I diagram below represents symbolically all of the components, such as units and containers, etc. relevant to operation.

Figure 5-23



CM and variants

The “pH-Control-h" equipment module consists of three interconnected CMs and one simulation chart. In the simulation chart, the system carries out pH setpoint specification (OpAnL block) and calculates the pH setpoint based on the difference in concentration from the input substance and the neutralizing agent.

The controller gets the converted pH values (setpoint and actual values) as differences in concentration to control.

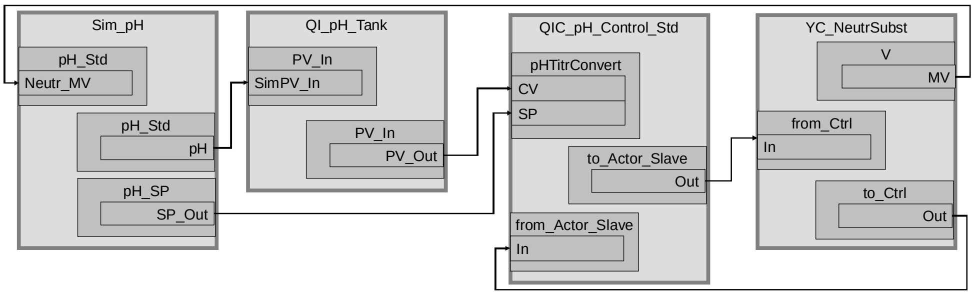
The following table provides an overview of the CMs of the equipment module including the associated CMTs.

Table 5-19

CM	CMT	Variant	Description
QI_pH_Tank	"AMon"	AMon_Std	Display of the product pH value-
QIC_pH_Control_Std	"Ctrl"	Ctrl_SW Activated "Opt_PV_Scale" option	Standard PID controller without channel blocks for controlling the difference in concentration
YC_NeutrSubst	"ValAn"	ValAn_Std	Control valve for the neutralizing agent

In the figure below, the structure with the cross-chart interconnections is shown in simplified form.

Figure 5-24

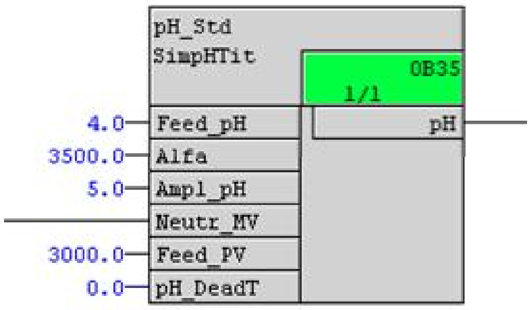


Structure and parameterization

"Sim_pH" simulation

In CFC "pH_Std" the system calculates the pH value. On sheet 2, there is an OpAnL block to specify the pH setpoint.
The following figure shows parameterization of the simulation block.

Figure 5-25



In the block inputs, fictional parameters are entered for buffer parameter "Alfa" and the "Ampl_pH" amplitude range that is to be crossed. In addition, fixed values are specified for the pH value and flow amount of input material. No deadtime is set for the pH simulation value (simulation process).

Note

You can find additional information in chapter 9.3 "Block description of "SimpHTitr".

QI_pH_Tank

The pH value of the product in the tank is acquired and displayed in the instance. The instance has the following parameterization.

Table 5-20

Block	Connection	Value	Use
PV_Scale	HiScale	15.0	Scaling of the pH process value upper limit
PV_Unit	In	1422	Unit of the process value as a pH value
PV	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)
PV	SimPV_In		Interconnection for the simulated process value (Sim_pH\pH_Std.pH)
PV	SimPV_Out		Interconnection to the controller (QIC_pH_Control_Std\pHTitrConvert.CV)

QIC_pH_Control_Std

In the instance, the system converts the pH value provided by display "QI_pH_Tank" to a concentration difference using block "pHTitrBlock". The concentration difference is used for control. The instance has the following parameterization.

Table 5-21

Block	Connection	Value	Use
PV_Scale	HiScale LoScale	10000.0 -10000.0	Scaling of the concentration difference process value limits
PV_Unit	In	1399	Unit of the process value in mol/L (concentration difference)
C	Gain	40.0	Controller gain
C	TI	8.0	Controller lag
C	SP_InHiLim	10000.0	Maximum value of the internal setpoint
C	SP_InLoLim	-10000.0	Minimum value of the internal setpoint
pHTitrBlock			Newly inserted as "pHTitrConvert" to convert pH values to concentration differences
pHTitrConvert	CV		Interconnection to pH measured value display (QI_pH_Tank\PV_In.PV_Out)
pHTitrConvert	SP		Interconnection to the OpAnL setpoint specification in the simulation chart (Sim_pH\pH_SP.SP_Out)
pHTitrConvert	Alfa	35000	Buffer parameter
pHTitrConvert	Ampl_pH	5.0	Amplitude range that is to be crossed
pHTitrConvert	CV_Out		Interconnection to the controller block (C.PV)
pHTitrConvert	SP_Out		Interconnection to the SFC block (IF_SFC.SP_Ext)
to_Actor_Slave	Out		Interconnection to the valve (YC_NeutrSubst\from_Ctrl.In)
from_Actor_Slave	In		Interconnection to the valve

Block	Connection	Value	Use
			(YC_NeutrSubst\to_Ctrl.Out)

Note You must carry out parameterization of the titration curve for a concrete chemical process before setting the PID controller using the PID tuner. If large variations in the inflow amount of the input materials are to be expected, it is recommended to compensate the disturbance by means of linear manipulated variable conversion using the "pHTitrBlock" block. You can find additional information about converting the pH value into a concentration difference in the block description in chapter 10.

Note The "PID Tuner" program is available for commissioning controller "QIC_pH_Control_Std". The system first records data for the "PID-Tuner" in an operating range in which only positive manipulated variables occur. After this, a comparable experiment is made in an operating range in which only negative manipulated variables occur. Optimization of the pH value-control was carried out based on the concentration difference using different manipulated variables (MV) with a constant (input material) inflow amount.

Note The following messages of the measurement "QI_pH_Tank" are not displayed in the controller:

- for hardware fault (CSF)
- device being maintained (OosLi

If they are needed, interconnect them additionally with blocks "CSF" and "OosAct" in chart partition "B" sheet 3.

As an alternative, you can activate the "to_Indicate" option in the display process tag and add an appropriate "from_Indicate" link block to the Ctrl CMT and interconnect it appropriately. As an example, you can use the "CtrlMPC" CMT as a guide.

YC_NeutrSubst

The instance has the following parameterization.

Table 5-22

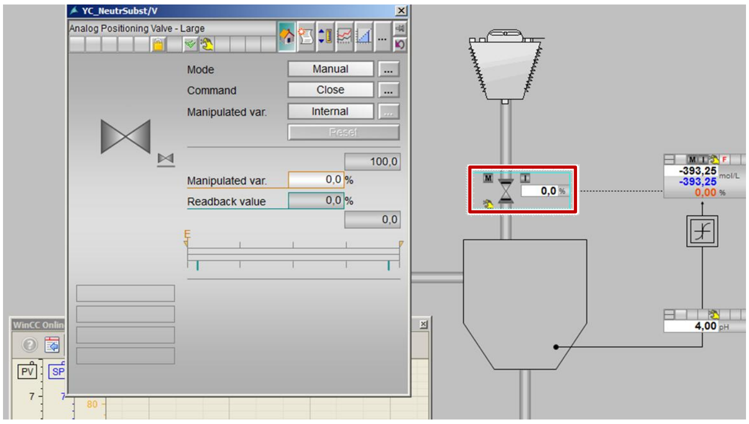
Block	Connection	Value	Use
V	MV		Interconnection to the simulation (Sim_pH\pH_Std.Neutr_MV)
from_Ctrl	In		Interconnection to the controller (QIC_pH_Control_Std\to_Actor_Slave.Out)
to_Ctrl	Out		Interconnection to the controller (QIC_pH_Control_Std\from_Actor_Slave.In)
MV_Out	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)

Commissioning and operation

For commissioning and operation, it is assumed that the user program has been loaded in the automation system (AS) or the S7-PLCSIM and that the OS (WinCC Runtime) has been activated. You can find a guide for loading the user program and activating the OS in chapter 6 "Starting the equipment modules".

Proceed as follows:

1. Click on the symbol display of the "YC_NeutrSubst" valve.
   The system opens the corresponding faceplate.



2. In the faceplate, change the operating mode to "Automatic".
3. Switch to controller "QIC_pH_Control_Std" and change the operating mode of the controller to "Automatic" and the setpoint specification to "External".

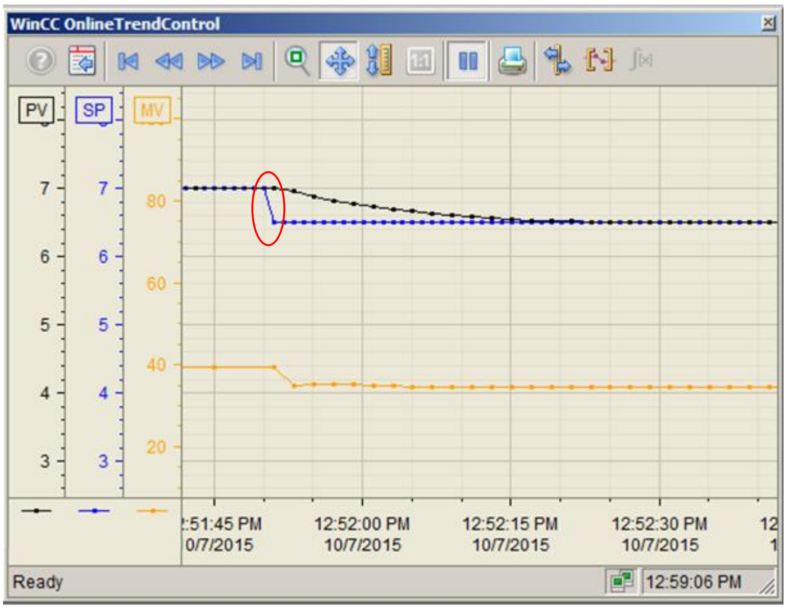
Note

> The controller uses the preset pH value of the OpAnL symbol display as the setpoint. In this symbol display, 7 pH is set as the setpoint (neutral zone) on the basis of which the amount of neutralizing agent is fed (regulated).

4. Wait for about 2 minute until the process value reaches its specified operating range.
5. Switch to operator control block "pH_SP" and specify a new setpoint of 6.5 pH.
6. Close the faceplate and observe the plotter for about one minute until the new setpoint has been reached.

Evaluation

Figure 5-26



The controller is optimized without overshooting to reach the setpoint. After changing the setpoint, the controller regulates the addition of neutralizer with a slight delay.

Note The controller is set for an operating point of ± 0.5 pH around the neutral zone 7 pH. Under some circumstances, different operating points may make it necessary to optimize the controller again.

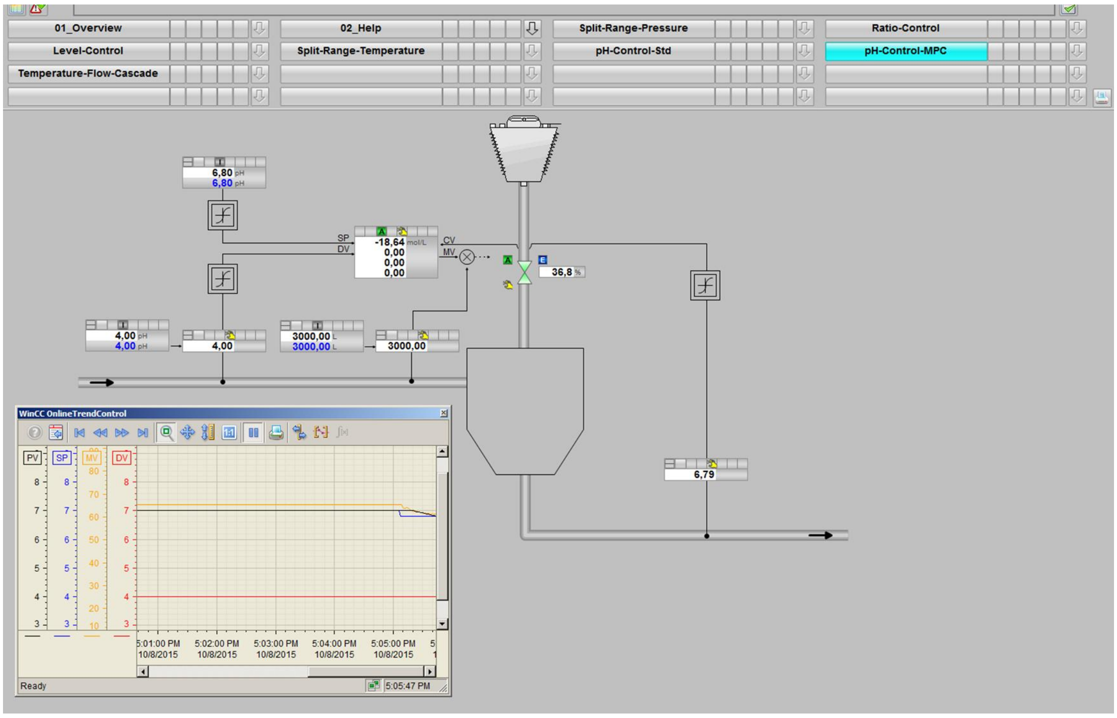
5.6 pH value control using a multivariable controller controller

pH value regulation using a "pH-Control-MPC" multivariable controller is used for the same tasks with their special features due to the highly non-linear titration characteristic curve. In addition to pH value control using a standard controller, it makes possible selective compensation of dead times of the controlled system (due to the measurement dead time for mixing, and the reaction time of the neutralization reaction) as well as model-based compensation of measurable disturbances due to fluctuations in the pH value in the inflow.

In the following example of pH value control by the addition of a neutralizing agent, we will consider the pH value and feed amount of the input material in addition to regulating the pH value by adding a neutralizer.

The example is designed for continuous operation and it is possible to change the pH value and the inflow amount of the input material.

Figure 5-27: "pH-Control-MPC" equipment module



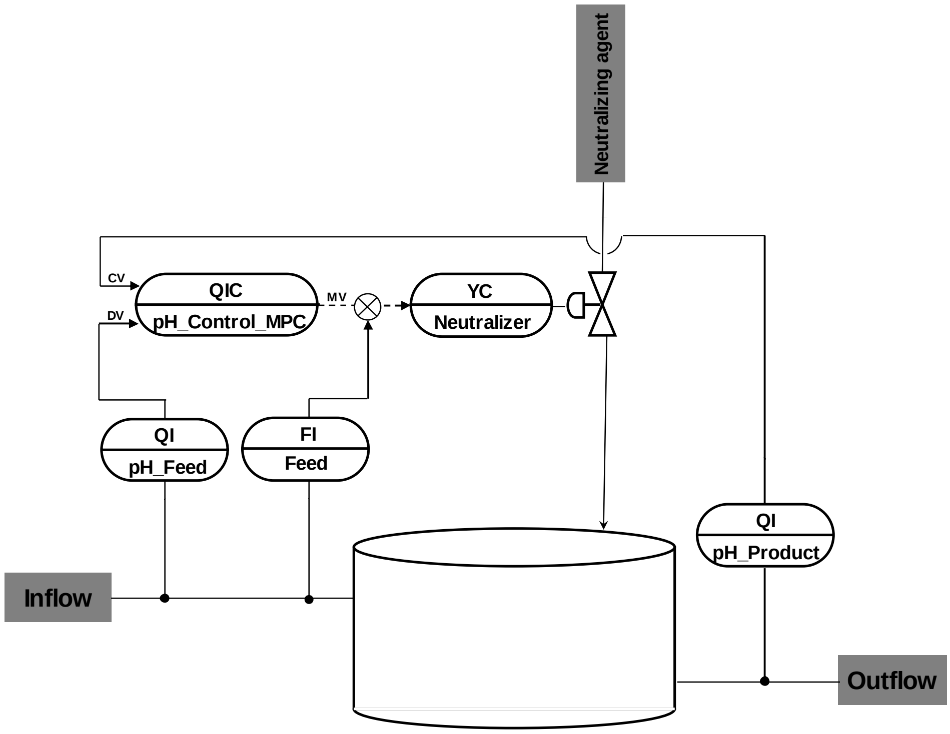
Overview

Below, the structure in the P&I diagram is shown and all of the CMs and the simulation of the equipment module are described.

P&ID

The P&I diagram below represents symbolically all of the components, such as units and containers, etc. relevant to operation.

Figure 5-28



CM and variants

The "pH-Control-MPC" equipment module consists of five interconnected CMs and one simulation chart. In the simulation chart, the pH value of the product is determined from the pH value and the inflow amount of the input material and of the neutralizer (manipulated variable of the valve).

Operators can adapt in the OS the pH value for the input material and the pH setpoint as well as the inflow amount. For this, OpAnL blocks have been inserted in the simulation chart and the controller process tag.

For regulation, the controller uses the converted pH values (setpoint and actual values of the product and actual value of the input material) as concentration differences. In addition, the inflow amount of the input material affects the inflow amount of the neutralizer, since the maximum manipulated variable changes proportionally to the factor from the actual inflow amount and the maximum inflow amount of the input material.

Note You can find additional information about calculating the manipulated variable or scaling in the block description in chapter 10.

You specify the values below in the OpAnL blocks and can adjust them in visualization:

- pH setpoint (product)
- pH value of the input material
- inflow amount of the input material

To simplify things, an additional display process tag was not used for every value specification.

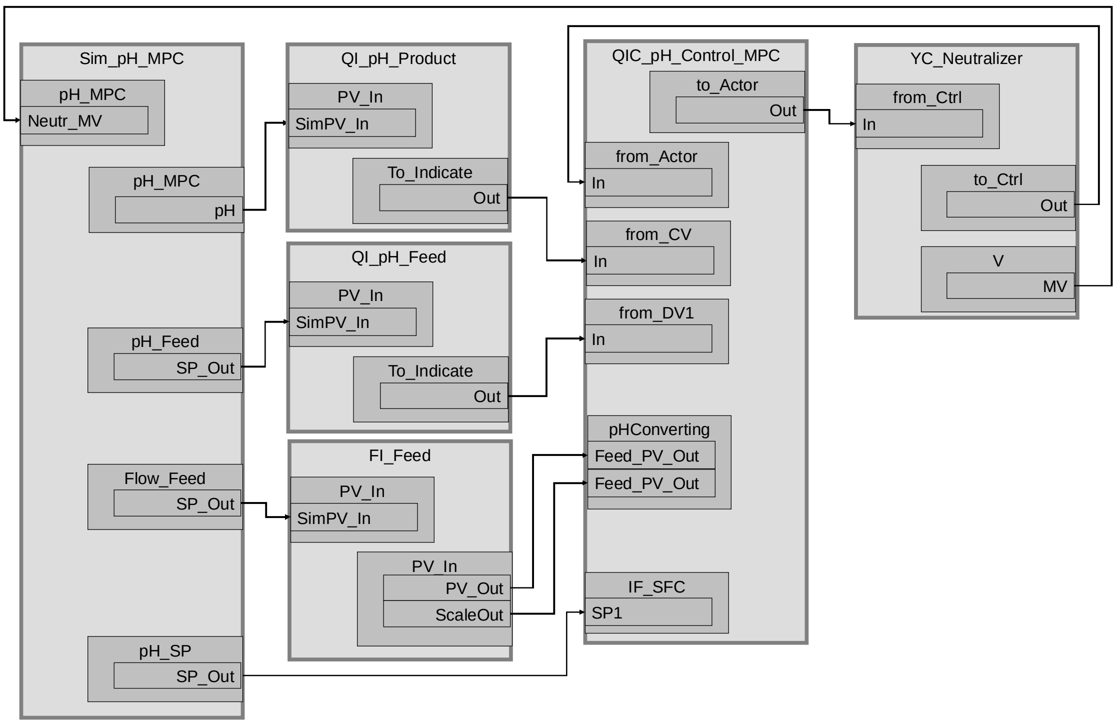
The following table provides an overview of the CMs of the equipment module including the associated CMTs.

Table 5-23

CM	CMT	Variant	Description
QIC_pH_Control_MPC	"CtrlMPC4Valve "	CtrlMPC4Valve_ Std	Multivariable controller for regulating the pH value of the product
QI_pH_Product	"AMon"	AMon_Std Activated "to_Indicate" option	Display of the pH value of the product
QI_pH_Feed	"AMon"	AMon_Std Activated "to_Indicate" option	Display of the pH value of the input material
FI_Feed	"AMon"	AMon_Std	Throughflow display of the input material
YC_Neutralizer	"ValAn"	ValAn_Std	Control valve for the neutralizing agent

In the figure below, the structure with the cross-chart interconnections is shown in simplified form.

Figure 5-29



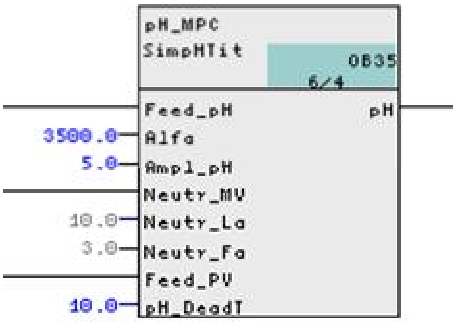
Multivariable controller "QIC_pH_Control_MPC" acquires the pH value of the input material, the pH value of the draining product, and the pH setpoint specification as concentration differences. Depending on the pH difference (setpoint and actual value of the product), the system feeds the necessary amount of neutralizer to the tank via control valve "YC_Neutralizer".

Structure and parameterization

"Sim_pH_MPC" simulation

In CFC "Sim_pH_MPC" the system calculates the pH value. On sheet 2, there is an OpAnL block to specify the pH setpoint, the pH value, and the inflow amount of the input material.
The following figure shows parameterization of the simulation block.

Figure 5-30



In the block inputs, fictional parameters are entered for buffer parameter "Alfa" and the "Ampl_pH" amplitude range that is to be crossed. In addition, the manipulated variable of control valve "YC_Neutralizer" and the inflow amount of the input material (OpAnL block on sheet 2) are used for the calculation.

A deadtime of 10 seconds, a neutralizer inflow delay of 10 seconds, and a gain factor of 3 are set for the pH simulation value (simulation process).

Note You can find additional information in the block description in chapter 10.

QI_pH_Product

The pH value of the product is acquired and displayed in the instance. The instance has the following parameterization.

Table 5-24

Block	Connection	Value	Use
PV_Scale	HiScale	15.0	Scaling of the pH process value upper limit
PV_Unit	In	1422	Unit of the process value as a pH value
to_Indicate	Out		Interconnection to the multivariable controller (QIC_pH_Control_MPC\from_CV.In)
PV	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)
PV	SimPV_In		Interconnection for the simulated process value (Sim_pH_MPC\pH_MPC.pH)

QI_pH_Feed

The pH value of the input material is acquired and displayed in the instance. The instance has the following parameterization.

Table 5-25

Block	Connection	Value	Use
PV_Scale	HiScale	15.0	Scaling of the pH process value upper limit
PV_Unit	In	1422	Unit of the process value as a pH value
to_Indicate	Out		Interconnection to the multivariable controller (QIC_pH_Control_MPC\from_DV1.In)
PV	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)
PV	SimPV_In		Interconnection for the simulated process value (Sim_pH_MPC\pH_Feed.SP_Out)

FI_Feed

The amount of the input material is acquired and displayed in the instance. The instance has the following parameterization.

Table 5-26

Block	Connection	Value	Use
PV_Scale	HiScale	5000.0	Scaling of the amount
PV_Unit	In	1038	Process value unit in L (liters)
PV	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)
PV	SimPV_In		Interconnection for the simulated process value (Sim_pH_MPC\Flow_Feed.SP_Out)
PV	PV_Out		Interconnection to the multivariable controller (QIC_pH_Control_MPC\pHConverting.Feed_PV_Out)
PV	Scale_Out		Interconnection to the multivariable controller (QIC_pH_Control_MPC\pHConverting.Feed_Scale)

QIC_pH_Control_MPC

In the multivariable controller, the system converts the pH value provided by display "QI_pH_Product" to a concentration difference using block "pHTitrBlock". The concentration difference is used for control. In the same way, the system converts the setpoint specification as well as the pH value of the input material disturbance variable to a concentration difference.

The instance has the following changes and parameterization.

Table 5-27

Block	Connection	Value	Use
MPC	CV1		Existing interconnection deleted. New interconnection to the conversion block (pHConverting.CV_Out)
MPC	DV1		Existing interconnection deleted. New

Block	Connection	Value	Use
			interconnection to the conversion block (pHConverting.DV_Out)
MPC	SP1		Existing interconnection deleted. New interconnection to the conversion block (pHConverting.SP_Out)
MPC	SP1HiLim	500	Upper setpoint limit for the concentration difference
MPC	SP1LoLim	-500	Lower setpoint limit for the concentration difference
MPC	MV1HiLim		Existing interconnection deleted. New interconnection to the conversion block (pHConverting.MVHiLim)
MPC	CV1_Unit	1399	Existing interconnection deleted. Unit of measurement for the controlled variable in mol/L (process value)
MPC	DB_No	50	Data block with controller data
MPC	MV1		Existing interconnection deleted. New interconnection to the conversion block (pHConverting.MV)
pHTitrBlock			Newly inserted as "pHConverting" to convert pH values
pHConverting	CV		New interconnection to the link block (from_CV.ReStru1)
pHConverting	DV		New interconnection to the link block (from_DV1.ReStru1)
pHConverting	SP		New interconnection to the IF_SFC block (IF_SFC.SP1Out)
pHConverting	MV		New interconnection from controller block (MPC.MV1)
pHConverting	Feed_PV_Out		New interconnection from throughflow display of the input material (FI_Feed\PV_In.PV_Out)
pHConverting	Feed_Scale		New interconnection from throughflow display of the input material (FI_Feed\PV_In.ScaleOut)
TitrConverting	CV_Out		Interconnection to the controller block (MPC.CV1)
TitrConverting	DV_Out		Interconnection to the controller block (MPC.DV1)
TitrConverting	SP_Out		Interconnection to the controller block (MPC.SP1)
TitrConverting	MVHiLim		Interconnection to the controller block (MPC.MV1HiLim)
TitrConverting	MV_Valve		Interconnection to the communication block (to_Valve.ReStru1)
IF_SFC	SP1		Interconnection of OpAnL block for setpoint specification (Sim_pH_MPC\pH_SP.SP_Out)
to_Actor	Out		Interconnection to the valve (YC_Neutralizer\from_Ctrl.In)
from_Actor	In		Interconnection to the valve (YC_Neutralizer\from_Ctrl.Out)

Note The multivariable controller was optimized using the MPC configurator for an an operating range from 7.5 to 6.5 pH and stored in DB 50. The relevant influencing variables were an inflow amount of the input material of 3000 L/s with pH 4 and a neutralizing agent with a pH of 12.

For trend recording, the manipulated variable was excited using the "AutoExci" block and the disturbance variable was changed (±10%).

YC_Neutralizer

The instance has the following parameterization.

Table 5-28

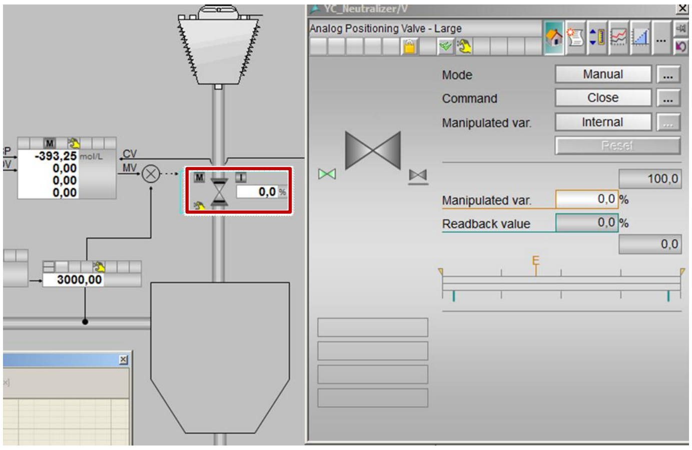
Block	Connection	Value	Use
V	MV		Interconnection to the simulation (Sim_pH_MPC\pH_MPC.Neutr_MV)
from_Ctrl	In		Interconnection to the controller (QIC_pH_Control_MPC\to_Actor.Out)
to_Ctrl	Out		Interconnection to the controller (QIC_pH_Control_MPC\from_Actor.In)
MV_Out	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)

Commissioning and operation

For commissioning and operation, it is assumed that the user program has been loaded in the automation system (AS) or the S7-PLCSIM and that the OS (WinCC Runtime) has been activated. You can find a guide for loading the user program and activating the OS in chapter 6 "Starting the equipment modules".

Proceed as follows:

1. Click on the symbol display of the "YC_Neutralizer" valve.
   The system opens the corresponding faceplate.

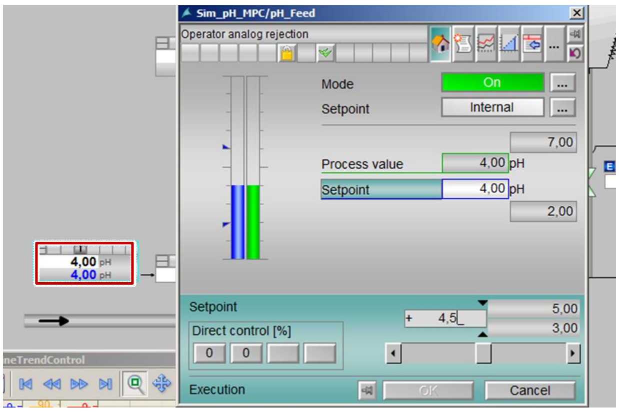


2. In the faceplate, change the operating mode to "Automatic".
3. Switch to controller "QIC_pH_Control_MPC" and change the controller's operating mode to "Automatic".

Note

> The controller uses the preset pH value of the OpAnL symbol display as the setpoint. In this symbol display, 7 pH is set as the setpoint (neutral zone) on the basis of which the amount of neutralizing agent is fed (regulated).

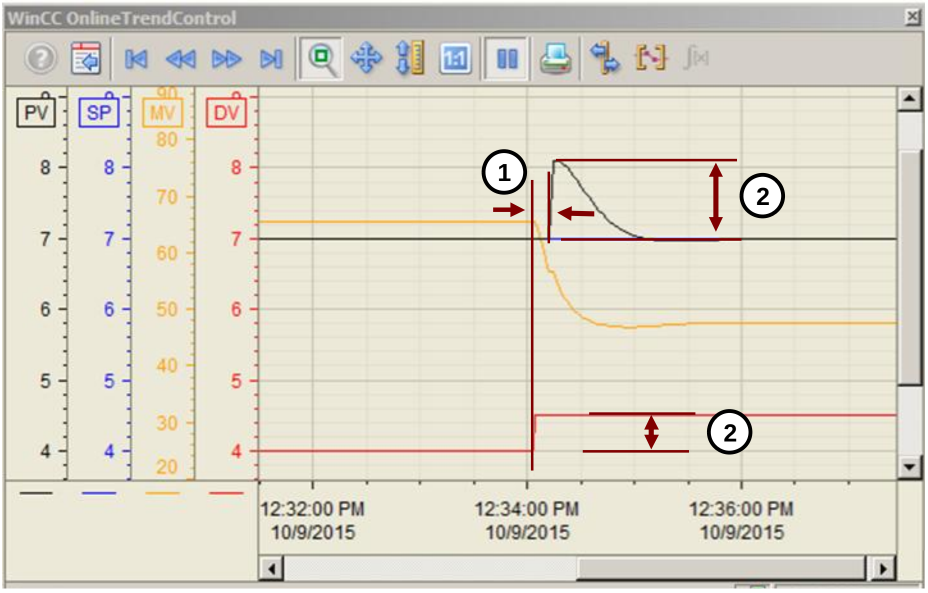
4. Wait for about 1 minute until the process value reaches its specified operating range.
5. Switch to operator control block "pH_Feed" and specify a new setpoint of 4.5 pH.



6. Close the faceplate and observe the plotter for about one minute until the new setpoint has been reached.

Evaluation

Figure 5-31



1. The controller is optimized to reach the setpoint exactly and consequently, slowly. The controller detects the change in the disturbance variable and it modifies the manipulated variable before the process responds to influencing of the disturbance variable (set deadtime in the simulation block). The disturbance variable acts on the actual value without delay (time delay elements).
2. In the example, the pH value of the input material was increased by 0.5 pH; however, it had an effect of about 1 pH on the product.

Despite detecting the disturbance variable in good time, the controller needs about 90 seconds for compensation and regulation. This time is also needed for regulation with bigger changes in the pH value of the input material.

5.7 "Temperature-Flow-Cascade"

Temperature regulation to a flow controller for a service medium (e.g. heating steam, cooling water, or fuel) using a cascade is used for applications in which fluctuations within the auxiliary control loop (of the flow controller) have to be compensated or the slave controller has to compensate other unpleasant properties of the actuator (e.g. a non-linear valve characteristic curve) and which are therefore invisible for the master controller. The equipment module "Temperature-Flow-Cascade" is used for heat exchangers, reactors, or burners, for example.

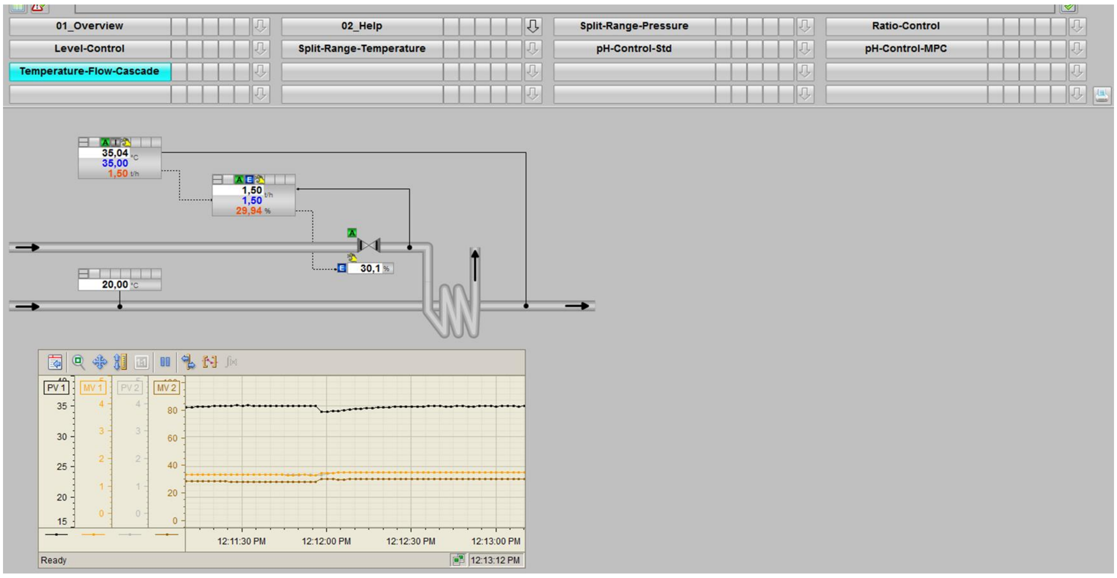
In the heat exchanger, the system continuously pumps the contents of the container through the heat exchanger via piping. This heats up or cools the input material to a defined temperature by means of thermal transfer by the service medium.

The same control concept is used with a burner, i.e. the amount of fuel flow regulates the temperature.

Note The "Temperature-Flow-Cascade" equipment module can be used for any process engineering applications in which temperature regulation is carried out via a throughflow.

In the following example, we will consider temperature regulation on a heat exchanger that is heated by means of a heating medium. It is also possible to use heat exchangers to cool a material flow. In this case, the throughflow of a cooling medium is regulated instead of a heating medium. The general generic term for a heating or cooling medium is a service medium. The controller structure of heat exchangers does not depend on whether they are used for heating or cooling. The only thing that changes is the sign of the master controller's controlled system.

Figure 5-32: Temperature-Flow-Cascade equipment module



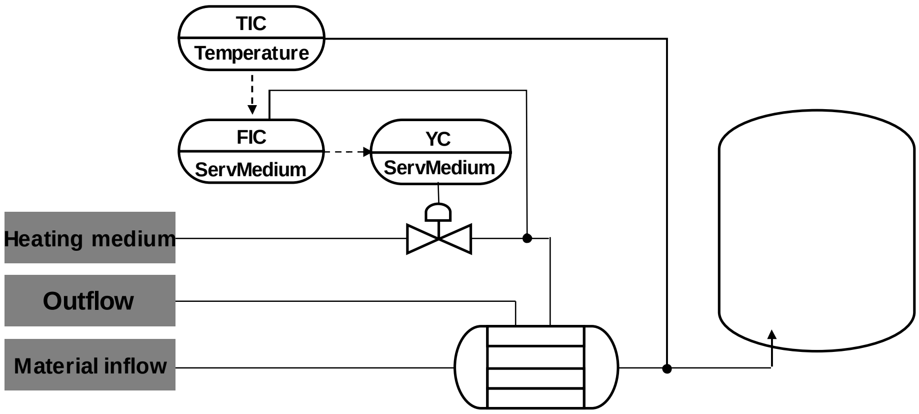
Overview

Below, the structure in the P&I diagram is shown and all of the CMs and the simulation of the equipment module are described.

P&ID

The P&I diagram below represents symbolically all of the components, such as units and containers, etc. relevant to operation.

Figure 5-33



CM and variants

The "Temperature-Flow-Cascade" equipment module consists of three interconnected CMs and one simulation chart. The simulation chart simulates the effect of the heat exchanger on the input material temperature.

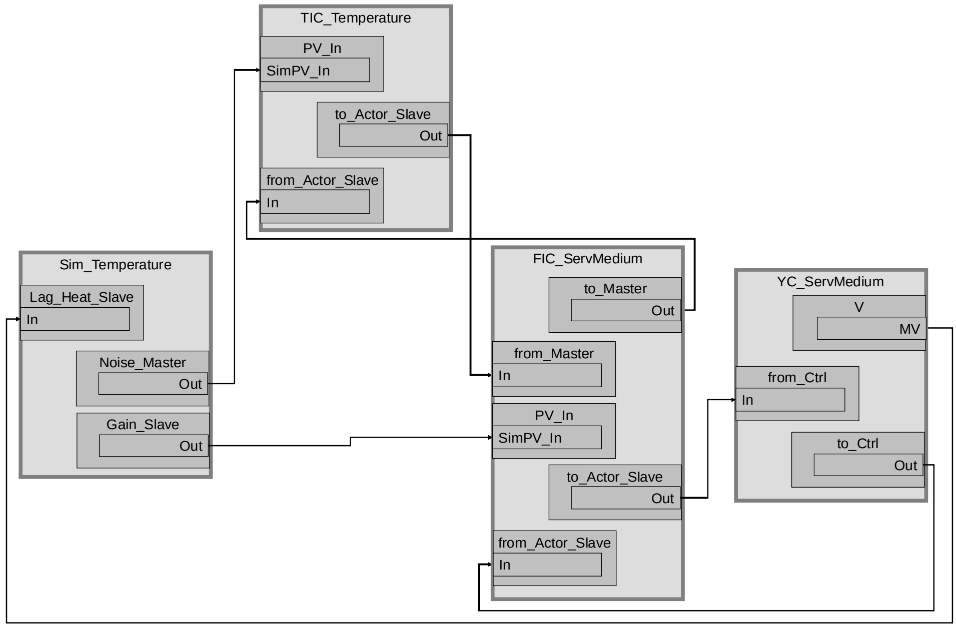
The following table provides an overview of the CMs of the equipment module including the associated CMTs.

Table 5-29

CM	CMT	Variant	Description
TIC_Temperature	"Ctrl"	Ctrl_Std	Master controller for temperature control
FIC_ServMedium	"Ctrl"	Ctrl_Std Activated option "Opt_IF_Master"	Slave controller for the flow control
YC_ServMedium	"ValAn"	ValAn_Std	Control valve for the heating medium

In the figure below, the structure with the cross-chart interconnections is shown in simplified form.

Figure 5-34



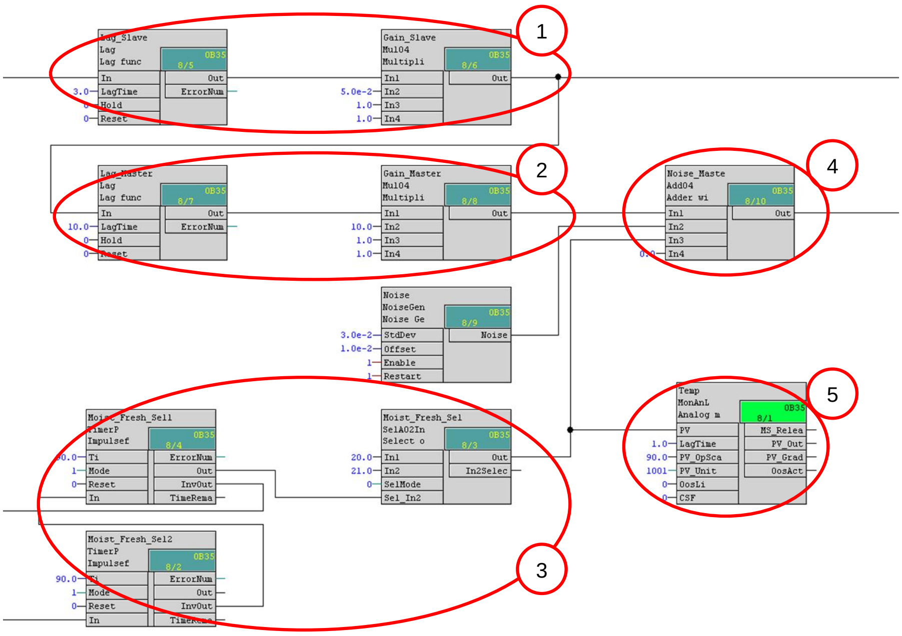
Controller "TIC_Temperature" uses the temperature of a material to be regulated from the "Sim_Temperature" simulation chart and generates the setpoint specification for the slave controller. This means that the desired temperature progression is configured in process tag "TIC_Temperature". Slave controller "FIC_ServMedium" regulates the flow rate of the heating medium by means of control valve "YC_ServMedium" based on the setpoint specification of the master controller.

Structure and parameterization

"Sim_Temperature" simulation

In CFC "Sim_Temperature", the system simulates a temperature change of a material by a heat exchanger. The figure below shows the sequence of the simulation.

Figure 5-35



1. If a valve is 100% open, with a 3-second delay, 5 t/h (factor 0.05) is sent to the slave controller as the flow rate actual value.
2. With a 10-second delay (as a simulation for heating up of the thermal capacity of the heat exchanger), ten times the value of the heating steam flow rate is sent to the reference junction as the actual value of the hot air temperature.
3. Alternating input material temperature that changes every 90 seconds between 20 °C and 21 °C to simulate a disturbance.
4. Input material temperature for the master controller that changes in dependence on the heat exchanger. The output signal can be given slight signal noise.
5. Material temperature before being heated by the heat exchanger.

Note

Simulation behavior does not correspond to a real process and it is used to demonstrate the functionality and mode of operation of the "Temperature-Flow-Cascade" equipment module.

TIC_Temperature

The instance has the following parameterization.

Table 5-30

Block	Connection	Value	Use
PV_Scale	HiScale	200.0	Scaling of the process value upper limit
PV_Unit	In	1001	Unit of the process value in degrees Celsius
C	TI	7.3	Controller lag
C	SP_InHiLim	200.0	Maximum value of the internal setpoint
to_Actor_Slave	Out		Interconnection to the slave controller (FIC_ServMedium\from_Ctrl.In)
from_Actor_Slave	In		Interconnection to the slave controller (FIC_ServMedium\to_Ctrl.Out)
PV	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)
PV	SimPV_In		Interconnection for the simulated process value (Sim_Temperature\Noise_Master.Out)

FIC_ServMedium

The instance has the following parameterization.

Table 5-31

Block	Connection	Value	Use
PV_Scale	HiScale	10.0	Scaling of the process value upper limit
PV_Unit	In	1328	Unit of the process value in t/h (tons per hour)
C	Gain.Value	2.8	Controller gain
C	TI	1.7	Controller lag
C	SP_InHiLim	10.0	Maximum value of the internal setpoint
to_Actor_Slave	Out		Interconnection to the control valve (YC_ServMedium\from_Ctrl.In)
from_Actor_Slave	In		Interconnection to the control valve (YC_ServMedium\to_Ctrl.Out)
to_Master	Out		Interconnection to the master controller (TIC_Temperature\from_Actor_Slave.In)
from_Slave	In		Interconnection to the master controller (TIC_Temperature\to_Actor_Slave.Out)
PV	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)
PV	SimPV_In		Interconnection for the simulated process value (Sim_Temperature\Gain_Slave.Out)

Note The "PID Tuner" program is available for commissioning of the controller. The important thing for controller optimization is that you optimize the slave controller (heating steam throughflow) first and then the master controller for temperature regulation.

YC_ServMedium

The instance has the following parameterization.

Table 5-32

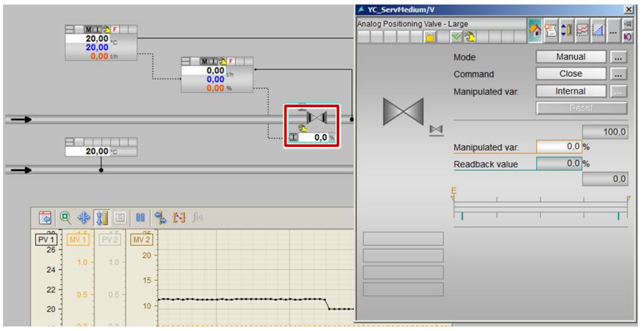
Block	Connection	Value	Use
V	MV		Interconnection to the simulation (Sim_Temperature\Lag_Slave.In)
from_Ctrl	In		Interconnection to the controller (FIC_ServMedium\to_Actor_Slave.Out)
to_Ctrl	Out		Interconnection to the controller (FIC_ServMedium\from_Actor_Slave.In)
MV_Out	SimOn		Activation of simulation on the channel block (Equipment_Modules\\ Activate_Simulation\Sim_Act.Out)

Commissioning and operation

For commissioning and operation, it is assumed that the user program has been loaded in the automation system (AS) or the S7-PLCSIM and that the OS (WinCC Runtime) has been activated. You can find a guide for loading the user program and activating the OS in chapter 6 "Starting the equipment modules".

For commissioning, proceed as follows:

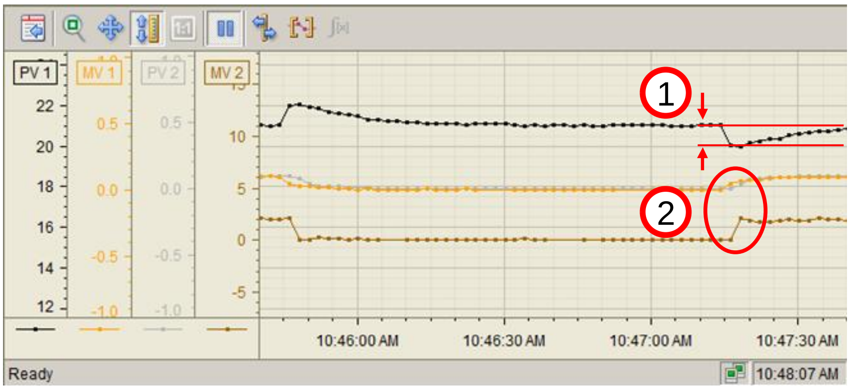
1. Click on the symbol display of the "YC_ServMedium" valve.
   The system opens the corresponding faceplate.



2. In the faceplate, change the operating mode to "Automatic".
3. Switch to slave controller "FIC_ServMedium" and change its operating mode to "Automatic" and the setpoint specification to "External".
4. Switch to master controller "TIC_Temperature" and change the operating mode of the controller to "Automatic".
5. Enter a new setpoint of 21°C in master controller "TIC_Temperature".
6. Wait for about 2 minutes and then click on the "Start/Stop" icon on the toolbar of the OnlineTrendControl.

Evaluation

Figure 5-36



1. The temperature of the supplied medium changes every 90 seconds, which means that the master controller responds continuously to this change and regulates to the temperature setpoint of 21°C.
2. On detecting a temperature change, the master controller transfers a new setpoint to the slave controller. The slave controller responds directly to this change with a new setpoint (brown trend display) and tracks the process value (gray trend display) to the setpoint (orange trend display).

The slave controller (throughflow of the heating medium in t/h) is configured for exact regulation without overshooting.

5.8 Instance-specific adaptations

Note No alarm, warning and tolerance limits are pre-parameterized in the equipment modules. If you parameterize a limit value, you must also activate the corresponding notification.

For example, parameter "PV_AH_En" for upper alarm limit "PV_AH_Lim".

Note Interconnection of the process variables depends on the selected variant of a CM. In the configuration below, the control, process, and manipulated variables are acquired via the "Pcs7AnIn" and "Pcs7AnOu" analog channel blocks.

The tables below contain the relevant parameters that you must either set or interconnect.

Controller

Table 5-33

Block	Connection	Use
C	Gain	Proportional gain
C	TD	Differential action time in [s]
C	TI	Integral action time in [s]
C	SP_InHiLim	(Upper) limit value of the internal setpoint
C	SP_InLoLim	(Lower) limit value of the internal setpoint
C	PV_AH_En	Alarm in case of upper limit value violation if PV ≥ PV_AH_Lim
C	PV_WH_En	Alarm in case of upper limit value violation if PV ≥ PV_WH_Lim
C	PV_TH_En	Tolerance in case of upper limit value violation if PV ≥ PV_TH_Lim
C	PV_TL_En	Tolerance in case of lower limit value violation if PV ≤ PV_TL_Lim
C	PV_WL_En	Alarm in case of lower limit value violation if PV ≤ PV_WL_Lim
C	PV_AL_En	Alarm in case of lower limit value violation if PV ≤ PV_AL_Lim
C	ER_AH_En (hidden)	Alarm in case of upper control difference violation if ER ≥ ER_AH_Lim
C	ER_AL_En (hidden)	Alarm in case of lower control difference violation if ER ≤ ER_AL_Lim
PV_Scale	HiScale LoScale	Scaling of the measured value (e.g. maximum container fill level of 10000)
PV_Unit	IN	Unit of the scaled measured value (e.g. 1038 fill level in liters)
PV	PV_In	Acquisition of the controlled variable, e.g. fill level

Display

Table 5-34

Block	Connection	Use
I	PV_AH_En	Alarm in case of upper limit value violation if PV ≥ PV_AH_Lim
I	PV_WH_En	Alarm in case of upper limit value violation if PV ≥ PV_WH_Lim
I	PV_TH_En	Tolerance in case of upper limit value violation if PV ≥ PV_TH_Lim
I	PV_TL_En	Tolerance in case of lower limit value violation if PV ≤ PV_TL_Lim
I	PV_WL_En	Alarm in case of lower limit value violation if PV ≤ PV_WL_Lim
I	PV_AL_En	Alarm in case of lower limit value violation if PV ≤ PV_AL_Lim
PV_Scale	HiScale LoScale	Scaling of the measured value (e.g. maximum container fill level of 10000)
PV_Unit	IN	Unit of the scaled measured value (e.g. 1038 fill level in liters)
PV	PV_In	Acquisition of the process variable, e.g. fill level

Valve

Table 5-35

Block	Connection	Use
V	MV_HiLim MV_LoLim	Upper and lower limit of the manipulated variable
MV_Scale	HiScale LoScale	Scaling of the manipulated variable (manipulated value of the valve block)
MV_Unit	IN	Unit of the scaled manipulated variable
MV_Out	PV_Out or PV_ChnST	Channel blocks for linking a control valve Output of the manipulated variable or Output of the manipulated variable including the signal status

Note

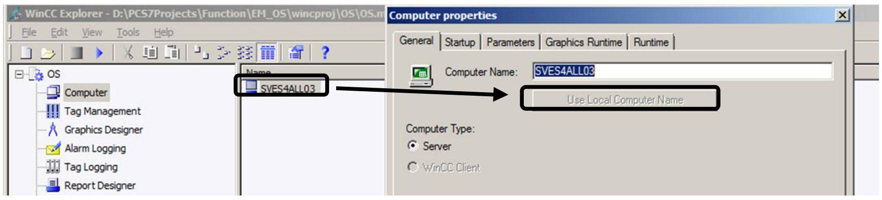
In the object properties of the message-type blocks, you can configure instance-specific messages. You can find a guide to the procedure in the "SIMATIC Process Control System PCS 7 Operator Station (V8.2)" configuration manual under: https://support.industry.siemens.com/cs/ww/en/view/109485970.

6 Starting the equipment modules

6.1 Preparation

The following instructions describe commissioning of the equipment modules by simulating the controller using the "S7-PLCSIM" program. If you are using a real controller, you must configure existing hardware components in the hardware settings.

1. Copy the file "53843373_EquipmentModules_PROJ_PCS7V82.zip" to any folder on the configuration PC and then open SIMATIC Manager.
2. Click on "File > Retrieve" on the menu bar and select file "53843373_EquipmentModules_PROJ_PCS7V82.zip". Then click on "Open" to confirm.
3. Choose the folder where you want to save the project and click on "OK" to confirm.
   The project is retrieved.
4. Confirm the "Retrieve" dialog by clicking on the "OK" pushbutton and then click on "Yes" in the dialog to open the project.
5. Right-click on "EquipmentModules_OS > VMES015 > WinCC Appl. > OS" and then click on the "Open object" menu command.
6. Click on "OK" to confirm the "Configured server not available" dialog.
7. In the WinCC Explorer, open the characteristics of your computer and, in the opened Characteristics dialog, click on the "Use local computer name" button.



8. Confirm the "Change computer name" message with "OK".
9. In the WinCC Explorer, click on "File > Exit" and in the subsequent dialog select "Terminate WinCC Explorer and close project".
10. Then confirm with OK.
11. Reopen the WinCC Explorer as described in step 5.
12. Open by double-clicking on "Variables library".
13. In the "WinCC Configuration Studio", open "Variables library > SIMATIC S7 Protocol Suite > TCP/IP" and select the menu command "System parameters".
14. In the "Unit" tab, check the "Logical device names" setting. If the "S7 PLCSIM" program is used, the device name "PLCSIM.TCPIP.12" is selected.
    A restart is required after a device name change.

Note

If the OS cannot establish a connection with the AS (grayed out block icons), select the logical device name "CP_H1_1" and restart the OS runtime.

6.2 Commissioning

You can commission the equipment modules after starting the simulation. You can find a detailed description in chapter 5.

Starting the simulation (S7 PLCSIM)

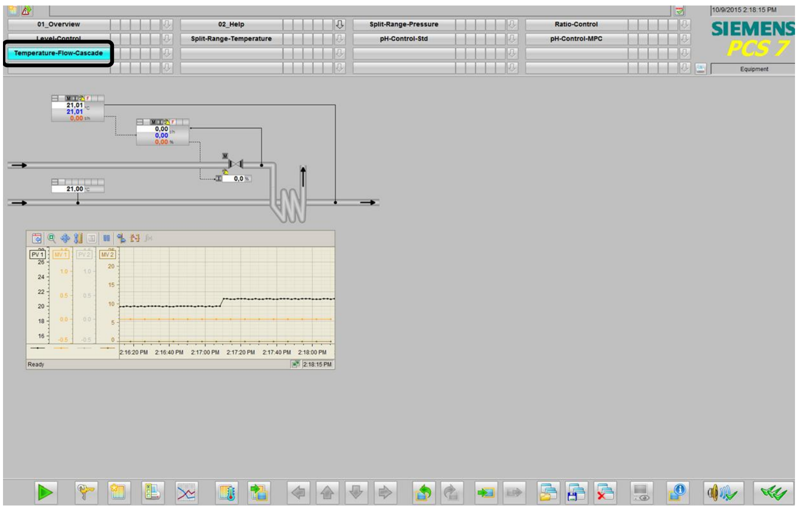
To start the simulation, proceed according to the following instructions:

1. Select "Extras > Simulate Modules" from the menu.
   The "S7-PLCSIM" dialog window opens.
2. In the "Open project" dialog, select "Open project from file".
3. Select file "EquipmentModules.plc" from path <project path>\Function\EM\EquipmentModules.plc>.
4. In the menu, select "Execute > key switch position > RUN-P".
5. Switch to component view of SIMATIC Manager and select "EquipmentModules_AS > AS01".
6. On the menu bar, click on "Target system > Load" and confirm the "Load" dialog with "Yes".
7. Confirm the "Stop target group" dialog with "OK" and the subsequent "Load" dialog with "Yes".

Activate OS (WinCC runtime)

To activate the OS, proceed according to the following instructions:

1. Right-click on the OS and select the menu "Open object".
2. To activate the OS (WinCC Runtime), select the menu command "File > Activate" in WinCC Explorer.
3. In the "System Login" dialog, enter user name "Equipment" as the "Login" and "Modules" as the password and then click on "OK" to confirm.
4. In the picture area, select an equipment module; in this example, it is "Temperature-Flow-Cascade".



7 Related literature

Table 7-1

	Topic	Title
\1\	Siemens Industry Online Support	http://support.industry.siemens.com
\2\	Download page for this entry	https://support.industry.siemens.com/cs/ww/en/view/53843373
\3\	SIMATIC PCS 7 overview (collection of links for FAQ, manuals, compendium, forum, application examples and multimedia)	https://support.industry.siemens.com/cs/ww/en/view/63481413
\4\	Controller optimization with the PID Tuner	https://support.industry.siemens.com/cs/ww/en/view/8031495
\5\	Model Predictive Control including integral transfer functions	https://support.industry.siemens.com/cs/ww/en/view/42200753
\6\	Configuration of Cascade Control	https://support.industry.siemens.com/cs/ww/en/view/43033319
\7\	PCS 7 Unit Template "Stirred Tank Reactor" using the example of the Chemical Industry	https://support.industry.siemens.com/cs/ww/en/view/60546560
\8\	PCS 7 Unit Template "Fermenter" using the example of the Chemical Industry	https://support.industry.siemens.com/cs/ww/en/view/68098270
\9\	PCS 7 Unit Template "Distillation Column" using the example of the Chemical Industry	https://support.industry.siemens.com/cs/ww/en/view/48418663
\10\	PCS 7 Unit Template "Dryer" using the example of the Chemical Industry	https://support.industry.siemens.com/cs/ww/en/view/74747848
\11\	PCS 7 Unit Template "Polymerization Reactor" using the example of the Chemical Industry	https://support.industry.siemens.com/cs/ww/en/view/84061788
\12\	How do you procure documentation for PCS 7 (including the PCS 7 Manual Collection)?	https://support.industry.siemens.com/cs/ww/en/view/59538371

8 History

Table 8-1

Version	Date	Change
V1.0	07.12.2011	First issue
V1.1	22.04.2012	Valid for PCS 7 V7.1.3 and PCS 7 V8.0
V1.2	04.06.2012	Corrections and notes in response to suggestions
V2.0	12.06.2013	Expansion of the Val process tag type, new CTRL process tag types, additional equipment modules for pH value regulation.
V2.1	25.10.2013	New process tag types (CTRL,AMON and MOT) for multivariable controls and drives integrated. Additional links added
V2.2	17.04.2014	New equipment module “Temperature-Flow-Cascade” added
V3.0	28.09.2016	Updated for PCS 7 V8.2

9 Appendix

9.1 Controllers and control response

The aim of this chapter is to give you an understanding of controller response and the principle of operation in the case of faults or maintenance. To do this, we describe tracking of the manipulated variable in picture form and display the messages or displays on the faceplates in the case of faults.

Tracking standard and cascade controllers

Tracking of the manipulated variable is explained using the Temperature-Flow-Cascade as an example by changing the (internal/external) setpoint specification from the control valve to the master controller and the (manual/automatic) operating mode.

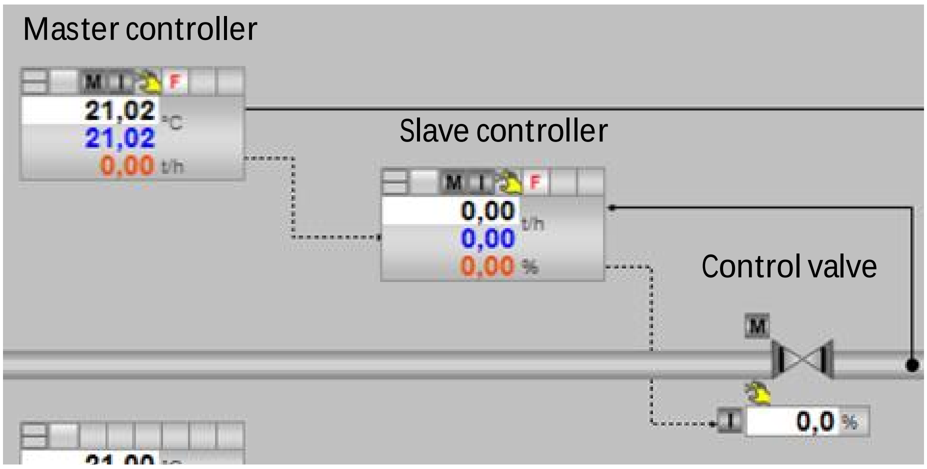


Table 9-1: Tracking values

No.	Master controller	Slave controller	Control valve	Comment
1.	Manual/Internal (Forcing active)	Manual/Internal (Forcing active)	Manual/Internal	
2.	Manual/Internal (Forcing active) **Manipulated value 1t/h**	Manual/Internal (Forcing active) **Manipulated value 20%**	Manual/Internal **Manipulated value 20%**	Manipulated value specification 20% in control valve The manipulated values are tracked automatically
3.	Manual/Internal (Forcing active) Manipulated value 1t/h	Manual/Internal **(Forcing canceled)** Manipulated value 20%	**Automatic**/External Manipulated value 20%	Operating mode changed in control valve. The control valve applies the tracked (external) manipulated variable on a bumpless basis from the slave controller
4.	Manual/Internal (Forcing active) Manipulated value 1t/h	**Automatic**/Internal Manipulated value 20%	Automatic/External Manipulated value 20%	Operating mode changed in slave controller. No change in behavior.

No.	Master controller	Slave controller	Control valve	Comment
5.	Manual/Internal **(Forcing canceled)** Manipulated value 1t/h	Automatic/**External** Manipulated value 20%	Automatic/External Manipulated value 20%	Setpoint specification changed in slave controller. The slave controller applies the tracked (external) manipulated variable on a bumpless basis from the master controller

Tracking "Ratio-Control"

Tracking of the manipulated variable is explained using the "Ratio-Control" equipment module as an example by changing the (internal/external) setpoint specification from the control valve to the master controller and the (manual/automatic) operating mode.

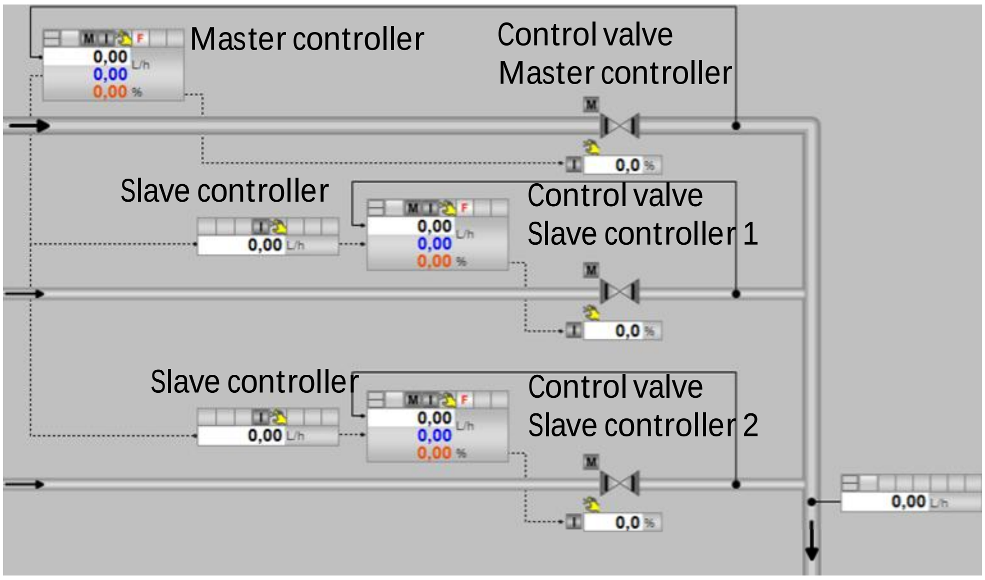


Table 9-2: Tracking values

No.	Master controller	Slave controller	Control valve master controller	Control valve slave controller	Comment
1.	Manual/Internal (Forcing active)	Manual/Internal (Forcing active)	Manual/Internal	Manual/Internal	
2.	Manual/Internal (Forcing active) Manipulated value 0.00 L/h	Manual/Internal (Forcing active) **Manipulated value 100 L/h**	Manual/Internal Manipulated value 0%	Manual/Internal **Manipulated value 20%**	Manipulated value specification 20% in control valve2 The manipulated variable is tracked automatically
3.	Manual/Internal (Forcing active) **Manipulated value 600 L/h**	Manual/Internal (Forcing canceled) Manipulated value 100 L/h	Manual/ Internal **Manipulated value 30%**	Manual/ Internal Manipulated value 20%	Manipulated value specification 30% in control valve1 The manipulated variable is tracked automatically

No.	Master controller	Slave controller	Control valve master controller	Control valve slave controller	Comment
4.	Manual/Internal (Forcing active) Manipulated value 600 L/h	Manual/Internal **(Forcing canceled)** Manipulated value 100 L/h	Manual/ External Manipulated value 30%	**Automatic**/ External Manipulated value 20%	Operating mode changed in control valve2.
5.	Manual/Internal **(Forcing canceled)** Manipulated value 600 L/h	Manual/Internal (Forcing canceled) Manipulated value 100 L/h	**Automatic**/ External Manipulated value 30%	Automatic/ External Manipulated value 20%	Operating mode changed in control valve1.
6.	Manual/Internal (Forcing canceled) Manipulated value 600 L/h	**Automatic**/ **External** (forcing canceled) **Manipulated value 150 L/h**	Automatic/ External Manipulated value 30%	Automatic/ External **Manipulated value 30%**	Operating mode changed in slave controller. The manipulated variable is tracked automatically

Tracking "Split-Range-Temperature"

Tracking of the manipulated variable is explained using the "Split-Range-Temperature" equipment module as an example by changing the (internal/external) setpoint specification from the control valve to the master controller and the (manual/automatic) operating mode.

Figure 9-1

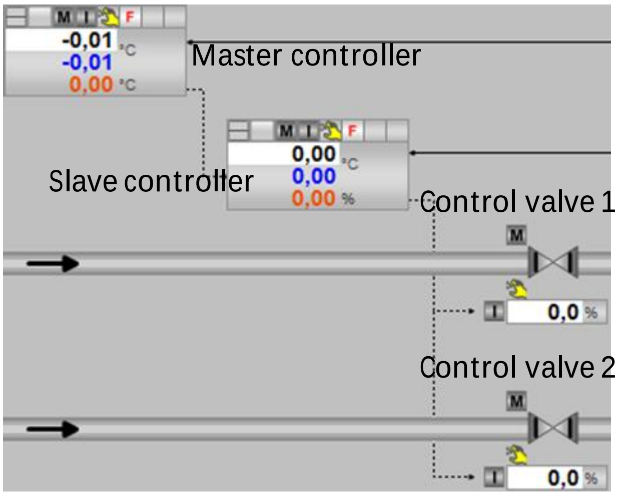


Table 9-3 Tracking values

No.	Master controller	Slave controller	Control valve1	Control valve2	Comment
1.	Manual/Internal (Forcing active)	Manual/Internal (Forcing active)	Manual/ Internal	Manual/ Internal	
2.	Manual/Internal (Forcing active)	Manual/Internal **(Forcing canceled)**	**Automatic/ External**	**Automatic/ External**	Operating mode changed with control valves. No change in behavior.

No.	Master controller	Slave controller	Control valve1	Control valve2	Comment
3.	Manual/Internal **(Forcing canceled)**	**Automatic/ External** (Forcing canceled)	Automatic/ External	Automatic/ External	Operating mode changed with slave controller. No change in behavior.
4.	**Automatic**/ Internal (Forcing canceled) **Manipulated variable 30°C**	Automatic/ External	Automatic/ External	Automatic/ External	Operating mode changed with master controller. Manipulated variable specification 30 °C in master controller. The slave controller applies the tracked (external) manipulated variable on a bumpless basis from the master controller.
5.	Manual/Internal (Forcing canceled) Manipulated variable 30°C	Automatic/ External **Manipulated variable 50°C**	Automatic/ External **Manipulated variable >=0%**	Automatic/ External **Manipulated variable >=0%**	Setpoint specification changed in slave controller. The slave controller applies the tracked (external) manipulated variable on a bumpless basis from the master controller.

Faults and maintenance for “Temperature-FlowCascade”

The tables below describe the way of functioning and generated messages of the individual process tags using the “Temperature-Flow-Cascade” in case of errors as an example.

The error on the channel block (the Bad output is active) occurs if there is a short-circuit or a wire break on the device, for example.

Maintenance status OoSAct occurs if maintenance is being carried out on the device.

Figure 9-2: Faulty slave controller

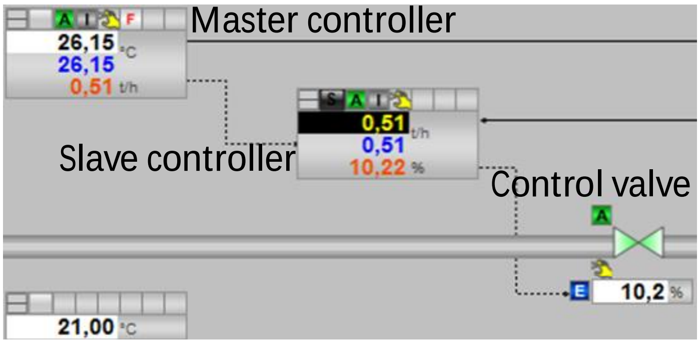


Table 9-4: Faulty slave controller

Master controller	Slave controller	Control valve
Control or manipulated variable specification is not possible since the CSF with the slave controller is forced	**CSF puts the controller into disturbance status (external error). Controller switches to manual mode. The manipulated variable for the control valve can be changed**	No change in operating mode. The manipulated variable of the slave controller still matches the manipulated variable, MV.

Note As soon as the CSF on the slave controller is no longer active, it can be switched back to the original operating status (automatic/external).

Figure 9-3: Faulty master controller

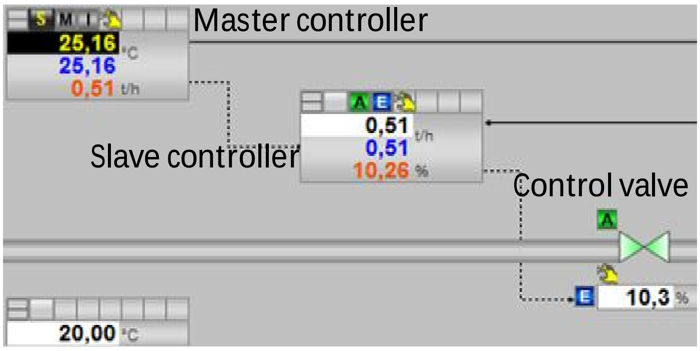


Table 9-5: Faulty master controller

Master controller	Slave controller	Control valve
CSF puts the controller into disturbance status (external error). The manipulated variable (MV) can be changed.	The slave controller continues to receive the MV from the master controller	The control valve continues to receive the MV from the slave controller

Note As soon as the CSF on the master controller is no longer active, it can be switched back to the original operating status (automatic/external).

Figure 9-4: Faulty control valve

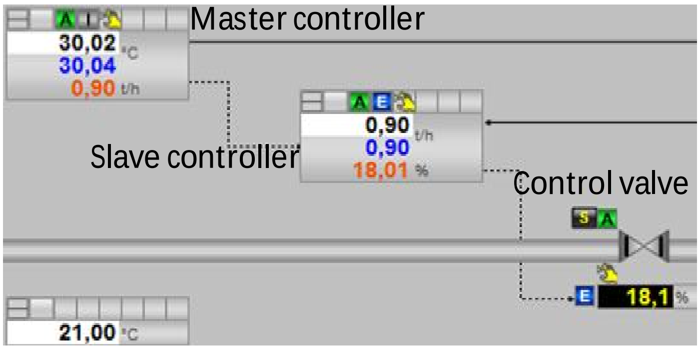


Table 9-6: Faulty control valve

Master controller	Slave controller	Control valve
The controller receives the MV in the case of a manual change on the control valve	The controller receives the MV in the case of a manual change on the control valve	**CSF puts the valve into disturbance status (external error)** **The manipulated variable (MV) can be changed (manual)**

Note As soon as the CSF on the control valve is no longer active, it can be switched back to the original operating status (automatic/external).

Figure 9-5: Maintenance status on slave controller

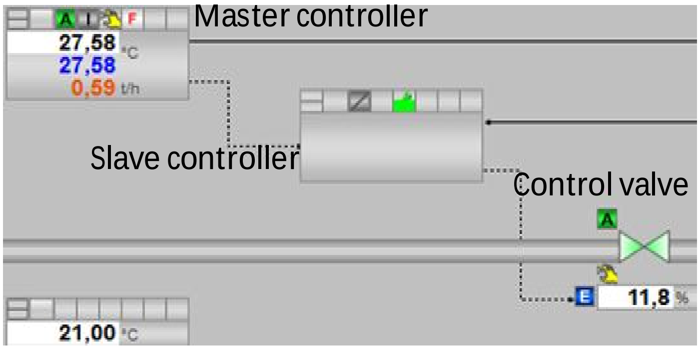


Table 9-7: Maintenance status on slave controller

Master controller	Slave controller	Control valve
The controller maintains the old MV until normal operation is re-established or the operator specifies a different MV on the slave controller manually.	**The controller cannot be operated due to maintenance.** **The user can switch to manual mode and specify the MV for the control valve.**	The control valve retains the old value while there is no new MV from the slave controller

Note As soon as the maintenance status is no longer active, the slave controller can be switched back to the original operating status (automatic/external).

Figure 9-6: Maintenance status on master controller

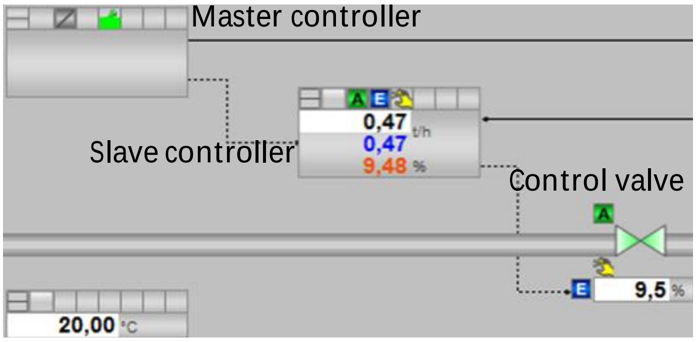


Table 9-8: Maintenance status on master controller

Master controller	Slave controller	Control valve
The controller cannot be operated due to maintenance. The user can switch to manual mode and specify the MV for the slave controller.	The controller retains the old value while there is no new MV from the master controller.	The control valve retains the old value while there is no new MV from the slave controller.

Note As soon as the maintenance status is no longer active, the master controller can be switched back to the original operating status (automatic/external).

Figure 9-7: Maintenance status on control valve

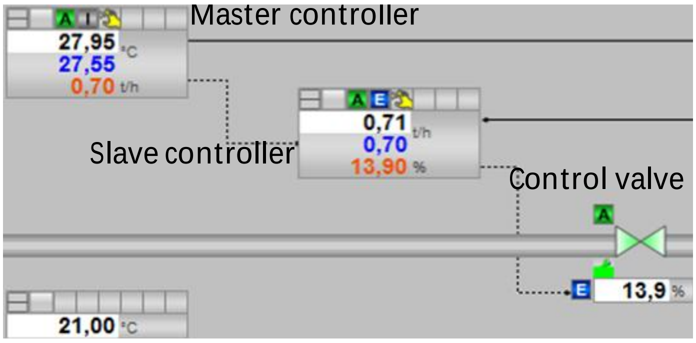


Table 9-9: Maintenance status on control valve

Master controller	Slave controller	Control valve
Normal operation is possible	Normal operation is possible	**Normal operation is still possible. The maintenance status is displayed.**

Faults and maintenance for “Ratio-Control”

The tables below describe the way of functioning and generated messages of the individual process tags using the “Ratio-Control” equipment module in case of errors as an example.

The error on the channel block (the Bad output is active) occurs if there is a short-circuit or a wire break on the device, for example.

Maintenance status OoSAct occurs if maintenance is being carried out on the device.

Note In the chapter below, we will not consider the second slave controller with control valve, since the behavior matches that of the first slave controller with control valve.

Figure 9-8: Faulty slave controller

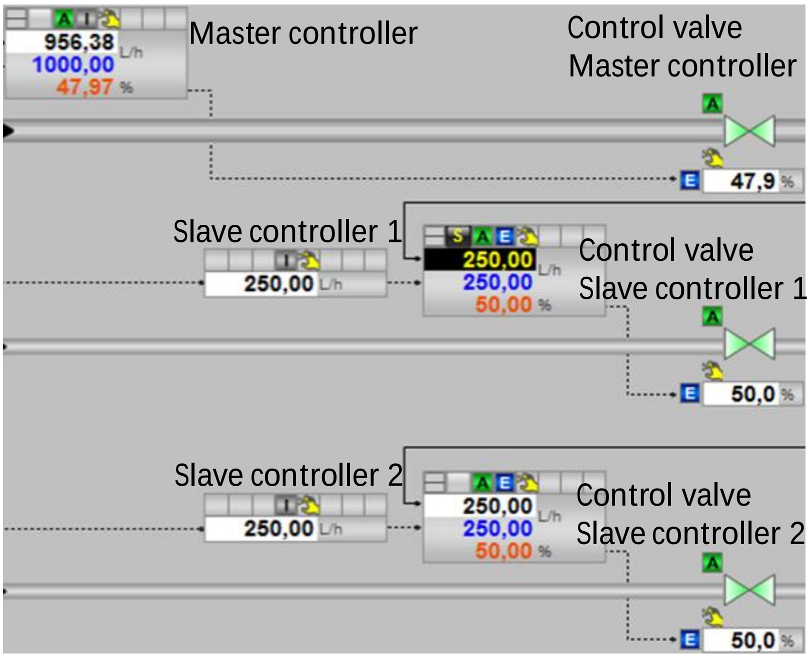


Table 9-10: Faulty slave controller

Master controller	Control valve master controller	Slave controller 1	Control valve slave controller 1
The controller functions without limitations.	The control valve functions without limitations.	**CSF puts the controller into malfunction status.** **The MV can be changed.**	The control valve retains the old MV until the slave controller specifies a new value.

Note As soon as the CSF on the slave controller is no longer active, it can be switched back to the original operating status (automatic/external).

Figure 9-9: Faulty master controller

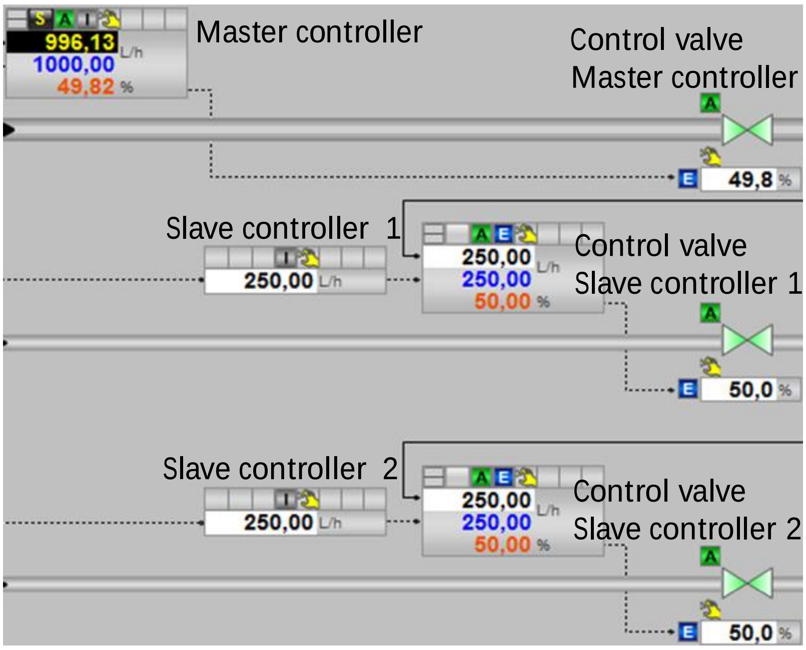


Table 9-11: Faulty master controller

Master controller	Control valve master controller	Slave controller 1	Control valve slave controller 1
CSF puts the controller into malfunction status. The manipulated variable can be changed.	The control valve functions without limitations.	The controller functions without limitations.	The control valve functions without limitations.

Note As soon as the CSF on the master controller is no longer active, it is back in Automatic mode.

Figure 9-10: Faulty control valve of master controller

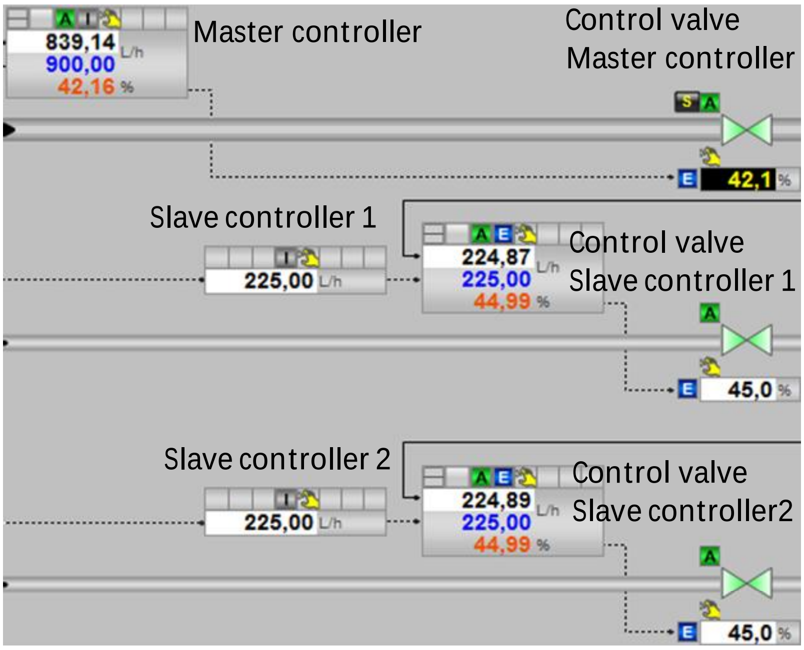


Table 9-12: Faulty control valve of master controller

Master controller	Control valve master controller	Slave controller	Control valve slave controller
The controller functions without limitations.	**CSF puts the control valve of the master controller into malfunction status. The valve functions without limitations.**	The controller functions without limitations.	The valve functions without limitations.

Note As soon as the CSF on the master controller's control valve is no longer active, it is back in Automatic/External mode.

Figure 9-11: Faulty control valve of slave controller

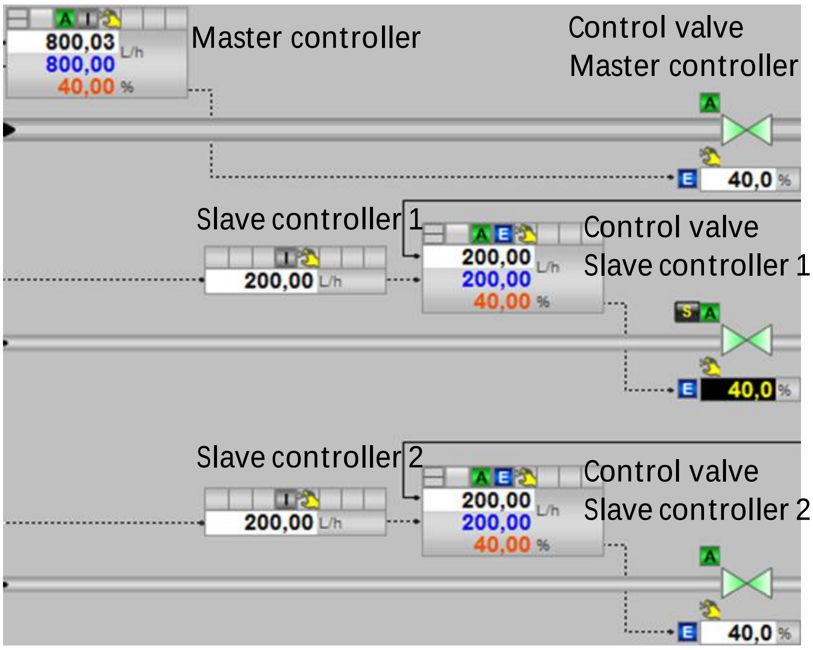


Table 9-13: Faulty control valve of slave controller

Master controller	Control valve master controller	Slave controller	Control valve slave controller
The controller functions without limitations.	The valve functions without limitations.	The controller functions without limitations.	**CSF puts the control valve of the master controller into malfunction status. The valve functions without limitations.**

Note

As soon as the CSF on the slave controller's control valve is no longer active, it is back in Automatic/External mode.

Figure 9-12: Maintenance status on slave controller

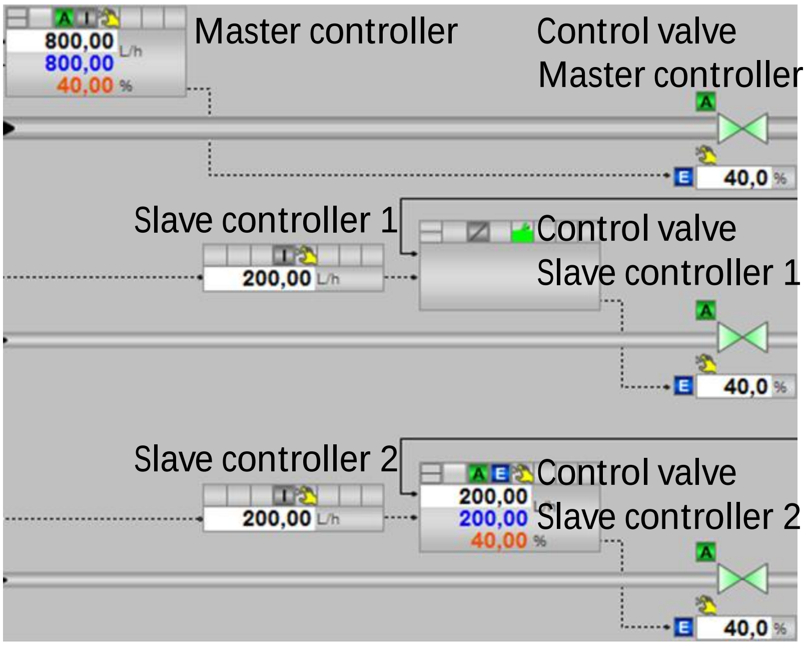


Table 9-14: Maintenance status on slave controller

Master controller	Control valve master controller	Slave controller	Control valve slave controller
The controller functions without limitations.	The valve functions without limitations.	**The controller cannot be operated due to maintenance. The user can switch to manual mode and change the MV.**	The control valve retains the old value until the slave controller specifies a new MV.

Note As soon as the maintenance status is no longer active, the slave controller can be switched back to the original operating status (automatic/external).

Figure 9-13: Maintenance status on master controller

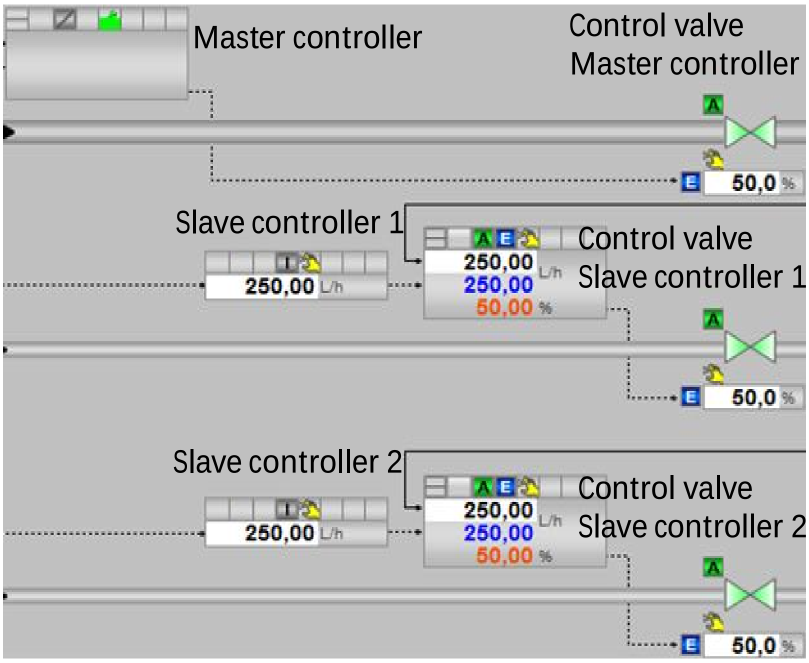


Table 9-15: Maintenance status on master controller

Master controller	Control valve master controller	Slave controller	Control valve slave controller
The controller cannot be operated due to maintenance. The user can switch to manual mode and change the MV.	The control valve retains the old value until the slave controller specifies a new MV.	The controller functions without limitations.	The valve functions without limitations.

Note As soon as the maintenance status is no longer active, the master controller can be switched back to the original operating status (automatic).

Figure 9-14: Maintenance status on control valve of master controller

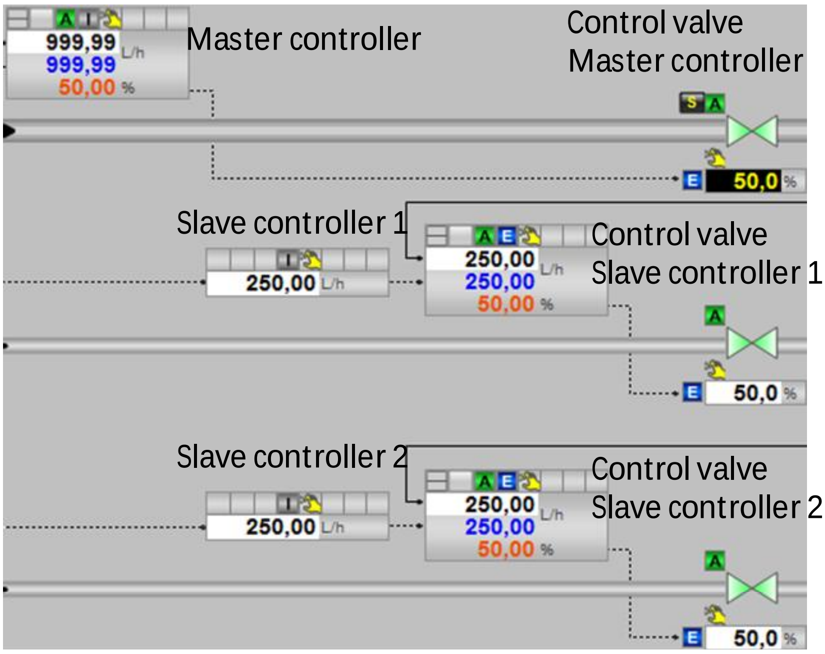


Table 9-16: Maintenance status on control valve of master controller

Master controller	Control valve master controller	Slave controller	Control valve slave controller
The controller functions without limitations.	**The valve displays the maintenance status and functions without limitations.**	The controller functions without limitations.	The valve functions without limitations.

Figure 9-15: Maintenance status on control valve of slave controller

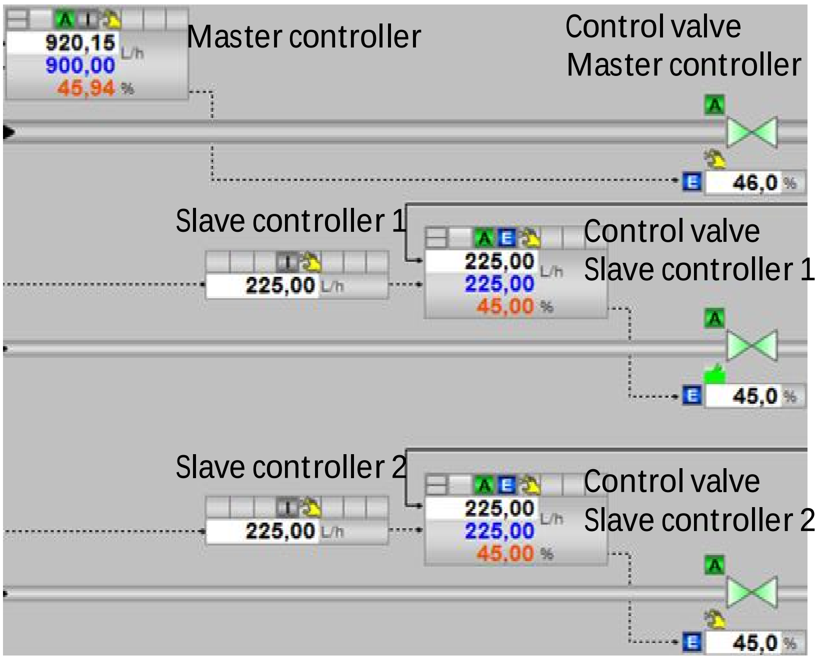


Table 9-17: Maintenance status on control valve of slave controller

Master controller	Control valve master controller	Slave controller	Control valve slave controller
The controller functions without limitations.	The valve functions without limitations.	The controller functions without limitations.	**The valve displays the maintenance status and functions without limitations.**

Faults and maintenance of "Split-Range-Temperature"

The tables below describe the way of functioning and generated messages of the individual process tags using the "Split-Range-Temperature" controller in case of errors as an example.

The error on the channel block (the Bad output is active) occurs if a short-circuit or a wire break occurs on the device, for example.

Maintenance status OoSAct occurs if maintenance is being carried out on the device.

Figure 9-16: Faulty slave controller

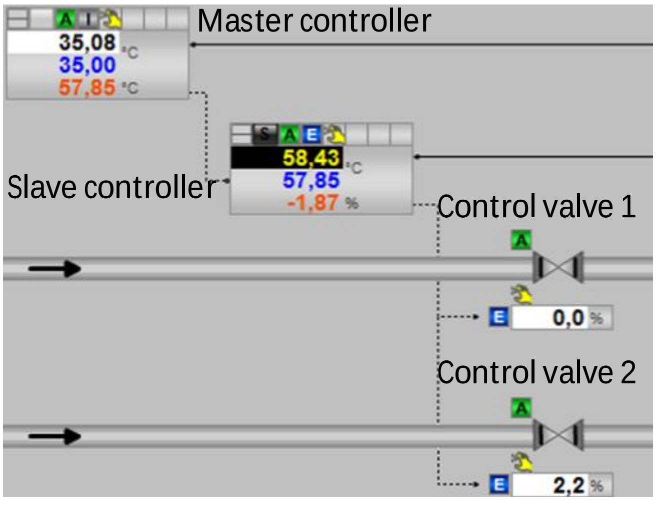


Table 9-18: Faulty slave controller

Master controller	Slave controller	Control valve1	Control valve2
The controller functions without limitations.	**CSF puts the controller into malfunction status.** **The MV can be changed.**	The valve functions without limitations.	The valve functions without limitations.

Note As soon as the CSF on the slave controller is no longer active, it can be switched back to the original operating status (automatic/external).

Figure 9-17: Faulty master controller

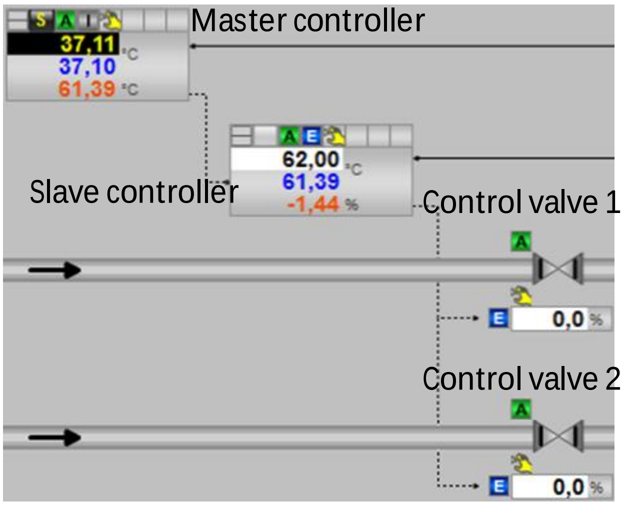


Table 9-19: Faulty master controller

Master controller	Slave controller	Control valve1	Control valve2
CSF puts the controller into malfunction status. **The MV can be changed.**	The controller retains the last manipulated variable that was present until the master controller specifies a new value.	The valve functions without limitations.	The valve functions without limitations.

Note

As soon as the CSF on the master controller is no longer active, it can be switched back to the original operating status (automatic).

Figure 9-18: Faulty control valve 1

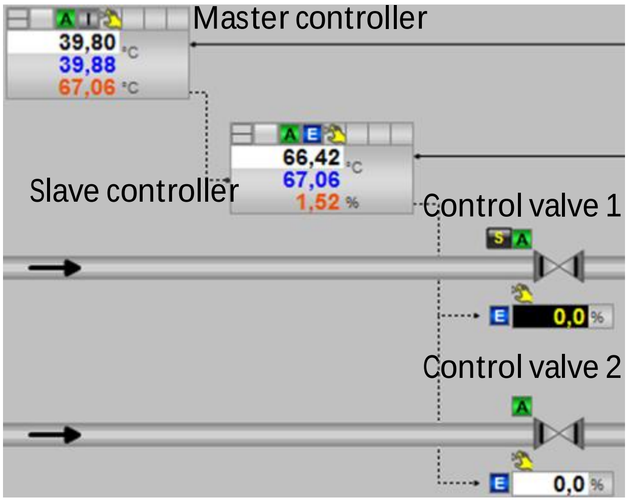


Table 9-20: Faulty control valve 1

Master controller	Slave controller	Control valve1	Control valve2
The controller functions without limitations.	The controller functions without limitations.	**CSF puts the valve into malfunction status. Operation and the MV can be changed.**	The valve functions without limitations.

Figure 9-19: Faulty control valve 2

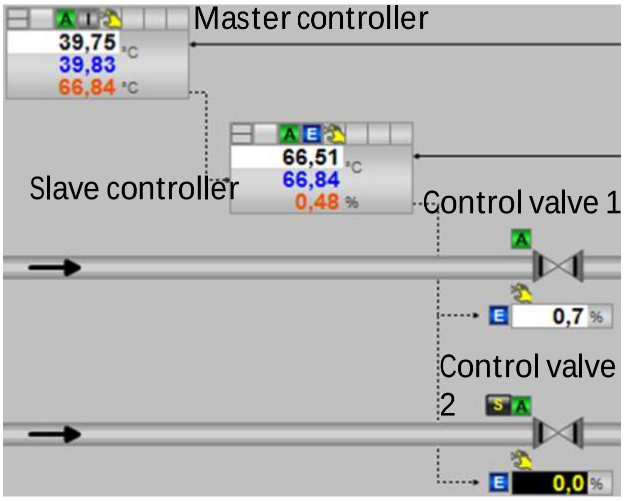


Table 9-21: Faulty control valve 2

Master controller	Slave controller	Control valve1	Control valve2
The controller functions without limitations.	The controller functions without limitations.	The valve functions without limitations.	**CSF puts the valve into malfunction status. The operating mode and the MV can be changed.**

Figure 9-20: Maintenance status on slave controller

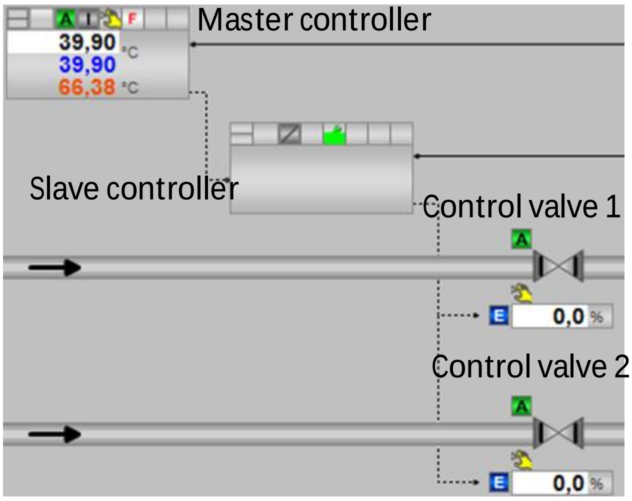


Table 9-22: Maintenance status on slave controller

Master controller	Slave controller	Control valve1	Control valve2
The controller cannot affect the process while the slave controller is being maintained.	**The controller cannot be operated due to maintenance. The user can switch to manual mode and specify the MV for the control valve.**	The valve functions without limitations.	The valve functions without limitations.

Note As soon as the maintenance status is no longer active, the slave controller can be switched back to the original operating status (automatic/external).

Abbildung 9-21: Maintenance on master controller

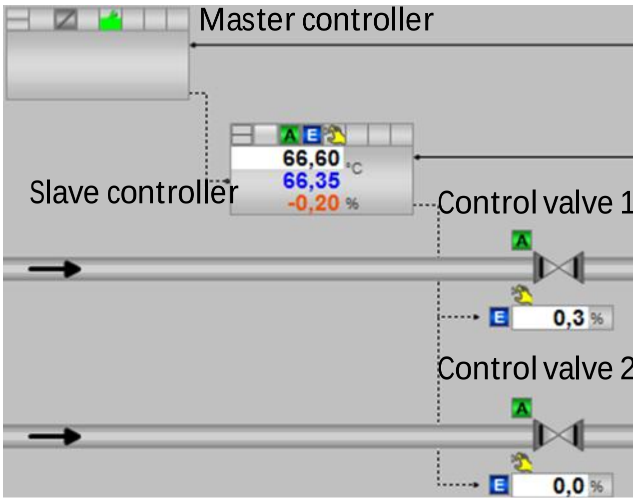


Table 9-23: Maintenance on master controller

Master controller	Slave controller	Control valve1	Control valve2
The controller cannot be operated due to maintenance. The user can switch to manual mode and specify the MV.	The controller retains the old value while there is no new MV from the master controller.	The valve functions without limitations.	The valve functions without limitations.

Note As soon as the maintenance status is no longer active, the master controller can be switched back to the original operating status (automatic).

Figure 9-22: Maintenance on control valve 1

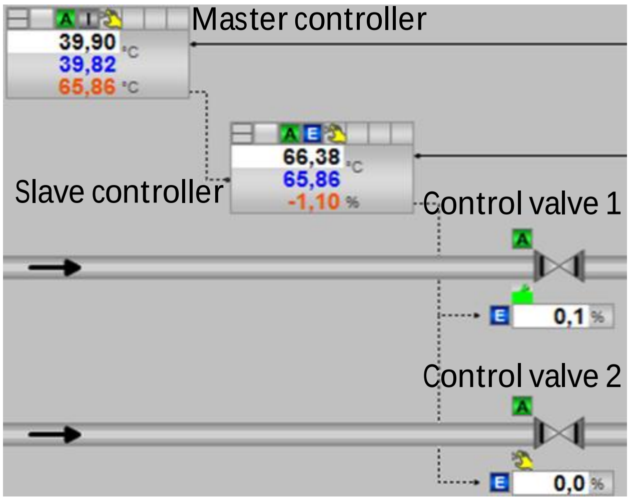


Table 9-24: Maintenance on control valve 1

Master controller	Slave controller	Control valve1	Control valve2
The controller functions without limitations.	The controller functions without limitations.	**The valve displays the maintenance status and functions without limitations.**	The valve functions without limitations.

Figure 9-23: Maintenance on control valve 2

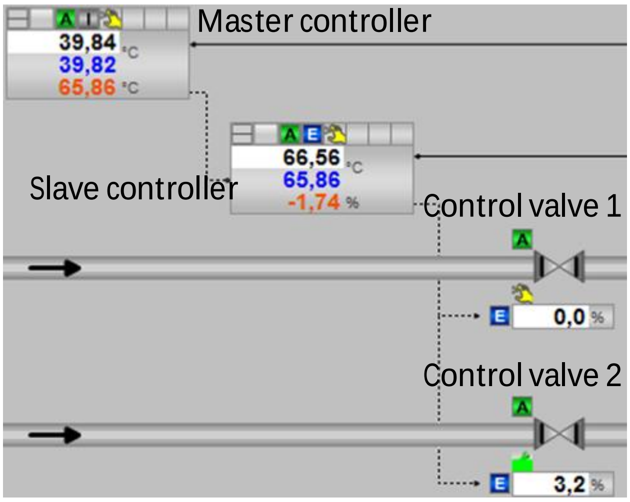


Table 9-25: Maintenance on control valve 2

Master controller	Slave controller	Control valve1	Control valve2
The controller functions without limitations.	The controller functions without limitations.	The valve functions without limitations.	**The valve displays the maintenance status and functions without limitations.**

9.2 Block description of "pHTitrBlock"

Function description

The block is used to to convert pH values to concentration differences. To do this, you must enter process-specific characteristics of the titration curve in the form of parameters for the pH amplitude and buffer effect (α). The titration curve describes the relationship between the pH value and the concentration difference between H^+ (or H_3O^+) ions (acidic) and OH^- ions (alkaline) in the solution. For a given combination of chemicals, you can determine them in an experiment by adding an acid or an alkali (neutralizer) in small steps. After each small dose, you mix the solution well, wait for the neutralization reaction, and make a note of the new pH value.

For the equipment modules for pH value control, you use the trigonometric function below as an approximation of the titration curve for conversion:

$$pH = 7 + \frac{2\,pH_{ampl}}{\pi} \arctan\left(\alpha \frac{\Delta c}{10^6} \right)$$

This characteristic curve is inverted to convert pH values to concentration differences.

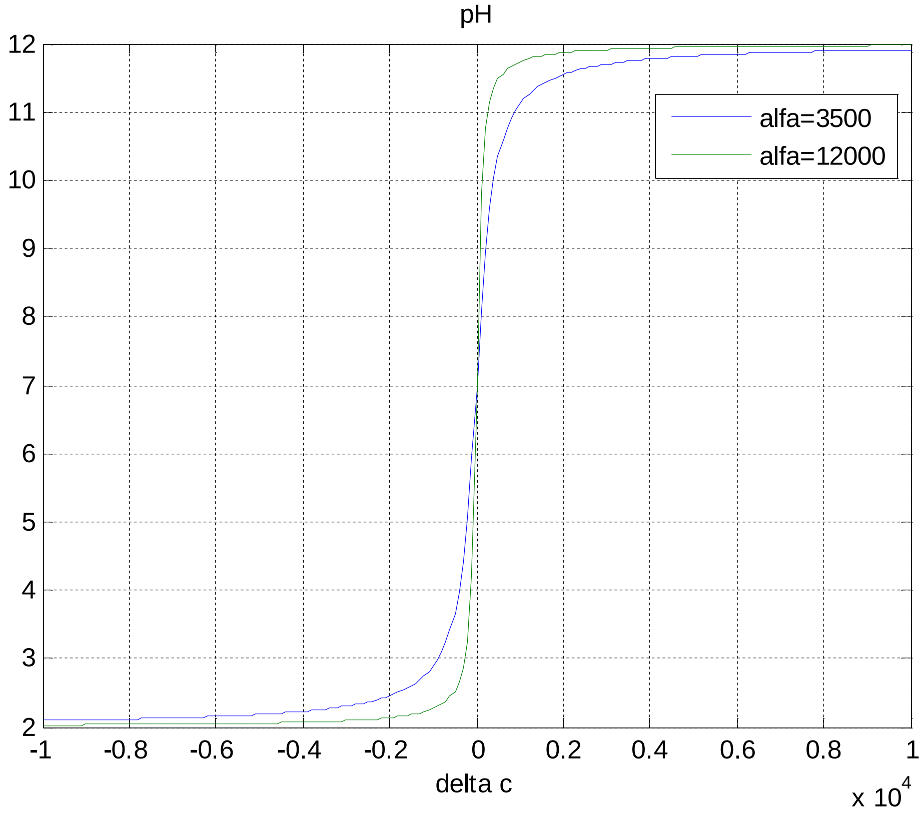
$$\Delta c = \frac{1}{\alpha} \tan\left(\frac{\pi}{2\,pH_{ampl}} \left(pH - 7\right) \right) 10^6$$

Note

Conversion is carried out in the two blocks below that are a component of the "pHTitrBlock" and are included in the master data library:

- FB1025 "Titr_pH" for converting the concentration difference to the →pH value
- FB1026 "TitrDeltaC" for converting the pH value to the →concentration difference

Figure 9-24 - Titration curve for various highly buffered solutions; pH_{ampl}=5



In the titration curve illustration, the neutral zone is at 7 pH with the maximum excursion (amplitude) of 5. Typical values of between 3500 and 12000 are present for the steepness of the characteristic curve in the neutral point (parameter α).

NOTICE	**Use in a productive environment is conditional upon knowing the titration curve that must be entered in the block. The parameters include:** • **the amplitude area** ***pH_{ampl}*** **to be passed through on the pH value scale** • **the buffer parameter α (alpha) as a measure of the steepness of the characteristic curve in the neutral point**

Inputs

Table 9-26

Input	Data type	Description
CV	STRUCT ->Real ->Byte	pH actual value
DV	STRUCT ->Real ->Byte	pH value of the disturbance variable

Input	Data type	Description
SP	STRUCT ->Real ->Byte	pH setpoint (specified by OpAnL operator control block oper SFC, for example)
Alfa	STRUCT ->Real ->Byte	Measure of the steepness of the characteristic curve in the neutral point
Ampl_pH	STRUCT ->Real ->Byte	The amplitude range that is to be crossed
MV	STRUCT ->Real ->Byte	Manipulated variable of the controller
Feed_PV_Out	STRUCT ->Real ->Byte	Inflow of the input material (disturbance variable)
Feed_Scale	STRUCT ->Real ->Real	Scaling of the inflow (ScaleOut)

Conversion of the concentration differences for inputs "CV", "DV", and "SP" is carried out based on parameters "Alfa" and "Ampl_pH".

Outputs

Table 9-27

Output	Data type	Description
CV_Out	STRUCT ->Real ->Byte	Concentration difference of the pH actual value
DV	STRUCT ->Real ->Byte	Concentration difference of the pH value of the disturbance variable
SP	STRUCT ->Real ->Byte	Concentration difference of the pH setpoint
MVHiLim	STRUCT ->Real ->Byte	Variable upper limit value of manipulated variable MV depending on the feed amount of input material (MVHiLim = 100/Feed_PV_Out/Feed_Scale.Max)
MV_Valve	STRUCT ->Real ->Byte	Variable manipulated variable (to the valve process tag) depending on the feed amount of input material (MV_Valve = Feed_PV_Out/Feed_Scale.Max * MV)

Interconnection of the inputs and outputs of the manipulated variables/disturbance variables ("MV", "Feed_PV_Out", "Feed_Scale", "MVHiLim", "MV_Valve") is compensated if it is intended to compensate the feed amount as a disturbance variable.

Note The output variable of the controller (what you can think of as a "concentration") is multiplied by the (standardized) feed amount of the waste water (input material) to calculate a measure of the required amount of neutralizer. If manipulated variable limitation in the controller itself were to be constant, this would result in it only being possible to use the dosing valve for complete control at maximum waste water flow through. One remedy is to to interconnect MV1HiLim dynamically in dependence on the feed amount.

9.3 Block description of "SimpHTitr"

Function description

The block is used to calculate a pH value based on process-specific characteristics like the titration curve of the process, the inflow amounts, and the pH values of the input material and the neutralizer, for example. The titration curve describes the relationship between the pH value and the concentration difference of the supplied neutralizer.

Inputs

Table 9-28

Input	Data type	Description
Feed_pH	STRUCT ->Real ->Byte	pH value of the input material
Alfa	STRUCT ->Real ->Byte	Measure of the steepness of the characteristic curve in the neutral point
Ampl_pH	STRUCT ->Real ->Byte	The amplitude range that is to be crossed
Neutr_MV	STRUCT ->Real ->Byte	Manipulated variable of the controller for the neutralizer
Neutr_Lag	Real	Delay of the manipulated variable (neutralizer)
Neutr_Factor	Real	Factor value for inflow of the neutralizer
Feed_pH	STRUCT ->Real ->Byte	inflow amount of the input material
pH_DeadTime	Real	Time-delayed signal output in seconds (deadtime)

NOTICE	**When using the deadtime (pH_DeadTime > 0), you must use a multivariable controller (ModPreCon block) for compensation and feedforward injection of disturbance variable.**

Outputs

Table 9-29

Output	Data type	Description
pH	STRUCT ->Real ->Byte	pH simulation value

To calculate the pH value, you carry out the following calculation steps:

1. Determine the products (multiplication) from the concentration differences and inflow amounts of the input material and the neutralizer
2. Determine the overall inflow amount
3. Calculate the factor (proportional concentration difference) from the products and the overall inflow amount
4. Convert the concentration difference to the pH actual value

In the simulation, you can adapt both the process-specific characteristics of the titration curve and the effect of the values of feedforward injection of disturbance variable (change the pH values of the input material by ± 1) and the variable throughflow amounts (change the inflow amount by ±500 mol/L).

9.4 Block description of "ComStruIn" and "ComStruOut"

Function description

The blocks are used for standardized interconnection of process tags (controllers with a valve process tag) or for setting up cascade controllers.

At which inputs of the

Inputs „ComStruIn“

Eingang	Datentyp	Beschreibung
ReStru1 bis ReStru6	STRUCT ->Real ->Byte	e.g. transfer of PV, SP or limit values
BoStru1 bis BoStru6	STRUCT ->Bool ->Byte	e.g. SP, Out of Service and Interlock
Int1 und Int2	INT	e.g. PV unit
Scale1 und Scale2	STRUCT ->Real ->Real	e.g. PV scale

Outputs „ComStruIn“

Ausgang	Datentyp	Beschreibung
Out. BoStru1-6 Int1-2 ReStru1-6 Scale1-2	STRUCT ->Real ->INT ->Real ->Real	Structure for connection to the control block

Inputs „ComStruOut“

Eingang	Datentyp	Beschreibung
In. BoStru1-6 Int1-2 ReStru1-6 Scale1-2	STRUCT ->Real ->INT ->Real ->Real	Structure for connection to the control block

Outputs „ComStruOut“

Ausgang	Datentyp	Beschreibung
ReStru1 bis ReStru6	STRUCT ->Real ->Byte	e.g. transfer of PV, SP or limit values
BoStru1 bis BoStru6	STRUCT ->Bool ->Byte	Channel state of the MV output driver
Int1 und Int2	INT	e.g. PV unit
Scale1 und Scale2	STRUCT ->Real ->Real	e.g. PV scale