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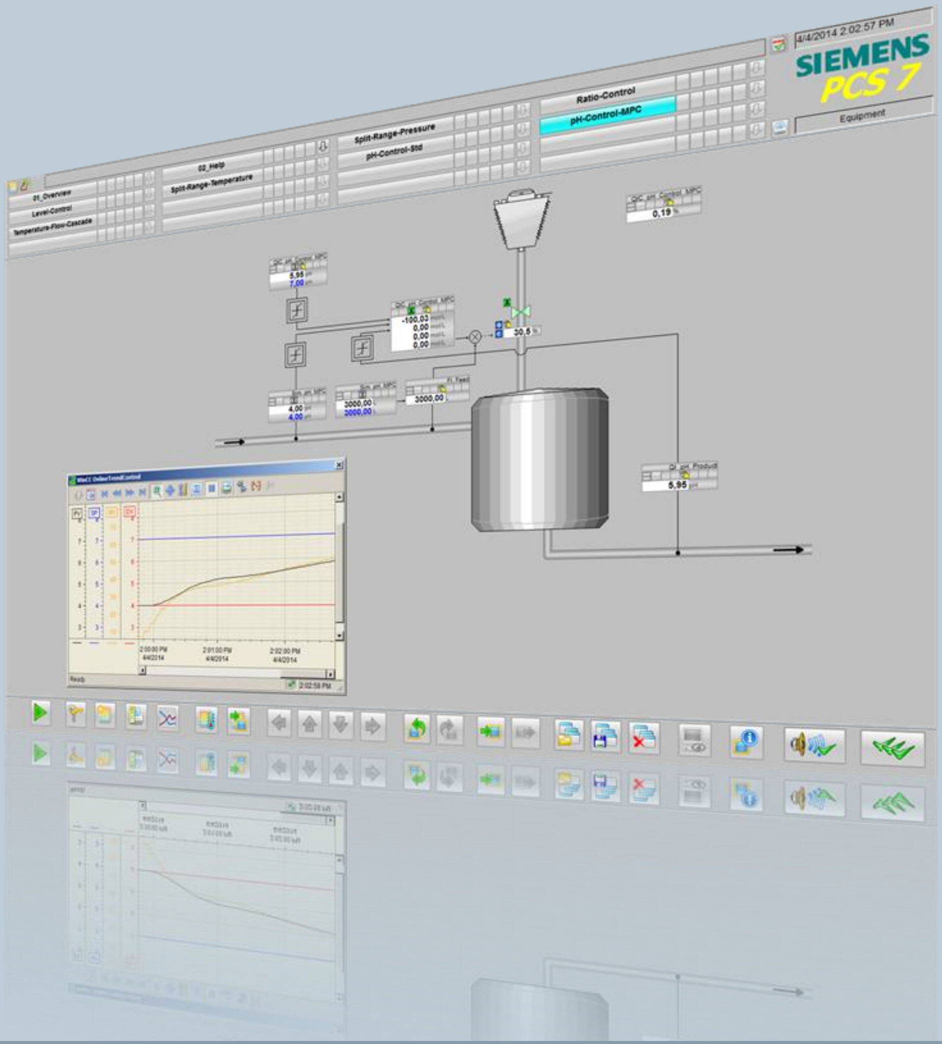

Application description • 04/2014

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

SIMATIC PCS 7

http://support.automation.siemens.com/WW/view/en/53843373

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1 Task Description and Solution

1.1 Task

The standardization of automation technology for process engineering plants, in the chemical industry for example, is a great challenge. Various processes and process steps, different devices and flexibility in the production process make this task very difficult.

One approach for standardization is structuring the user software into equipment modules.

In the DIN EN 61512 standard an equipment module is defined as device control within technical equipment. A technical equipment consists of the user program as well as of the physical equipment.

1.2 Solution

1.2.1 Equipment Modules

This application example contains standardized equipment modules in form of software typicals (process tag types), which are supplied in SIMATIC PCS 7 as a multiproject.

- Reducing the required know-how for application development
- Reducing the configuration workload
- Illustrating typical control strategies
- Unified structures
- Flexible structure of partial automation solutions

The equipment modules supply a template containing the typical components of a partial automation solution, its control, the required logic and the visualization.

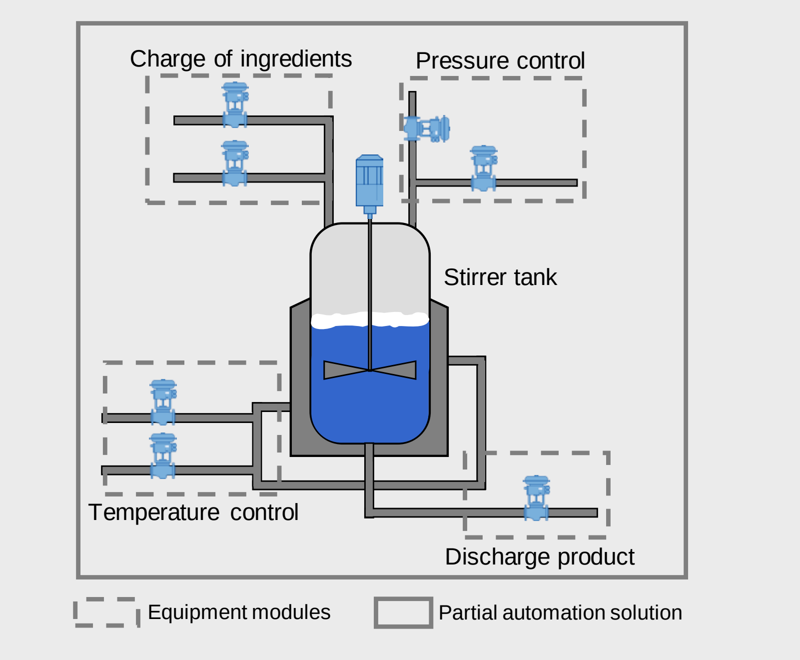
An equipment module is configured independently of the automation hardware and is part of a preconfigured PCS 7 project, including the process visualization. Due to the hardware-independent configuration and the modular structure, the equipment modules can be integrated and added to PCS 7 projects at will. The equipment modules are created on the basis of the function blocks and process tag types of the PCS 7 Advanced Process Library (APL) and Industry Library (IL).

1.2.2 Overview of the general solution

Schematic layout

The following figure shows an example of the equipment modules as part of the automation solution.

Figure 1-1



Description

The concept of equipment modules offers pre-programmed and unified components for creating an automation solution, such as dosing or tempering.

The equipment modules have been realized in the PCS 7 multiproject as follows:

- the Component view contains one project for the automation system (AS) and one project for the operator station (OS) respectively.
- the Plant hierarchy contains a hierarchy folder for each equipment module.

In the AS project all control functions have been realized in form of CFC charts (Continuous Function Chart). Furthermore, the AS-project contains a simulation which simulates a process, e.g. filling level change, within an equipment module.

The OS project contains the visualization with one process image each per equipment module and shows:

- the schematic layout of the equipment module
- a simulation
- the relevant characteristic values (KPI = Key Performance Indicator)
- a display of the control quality

Restriction

The industrial process is not simulated within the equipment module.

Required knowledge

Basic knowledge of the following subject areas is required:

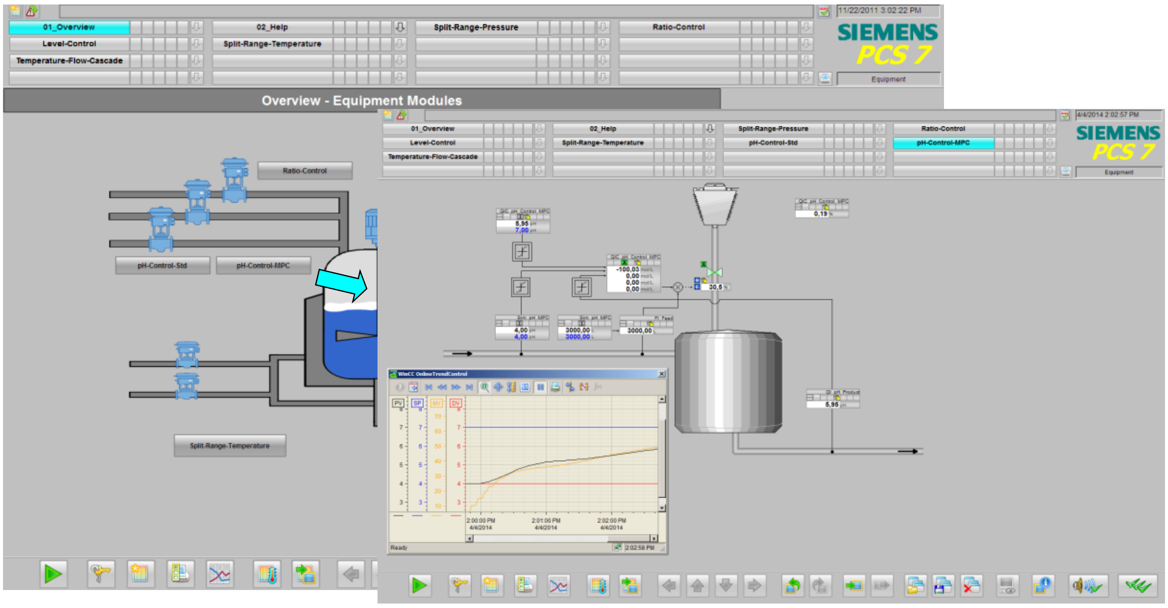
- Configuration with SIMATIC PCS 7 and APL
- Knowledge of control engineering
- Basic knowledge of process engineering

1.2.3 Core functionality

The overview screen and the structure of a process image of an equipment module are described below. A detailed description of the core functionality of an equipment module is available in chapter 5.

Visualization user interface

Figure 1-2



Overview Screen **Process Image**

The visualization user interface of the Equipment Modules consists of an overview screen and a process image for each equipment module.

Overview screen

The overview screen contains a schematic display, in form of a material flow chart of the industrial plant, which contains all equipment modules in the example project.

Via the button of an equipment module you go to the respective process image, which contains the functionality and the specific information of an equipment module. The process images depicted a respective section from the P&I diagram of a plant.

Process display

The process image of the equipment module consists of the following main components:

- Schematic layout of the equipment module
- Simulation
- Faceplates for controlling the individual components (aggregates)
- Trend display for visualizing the controller response

The process image gives the operator the overview of the respective equipment module so he/she can track the response during runtime via the respective equipment module by means of time intervals.

1.2.4 Used hardware and software components

The application document was created using the following components:

Hardware components

Table 1-1

Component	Note
SIMATIC PCS 7 ES/OS 547C BCE WXP	Used for the PCS 7 V7.1.3 sample project
SIMATIC PCS 7 ES/OS IPC547D W7	Used for the PCS 7 V8.0 and PCS 7 V8.0 SP1 sample projects

NOTE If the hardware differs, please observe the minimum installation requirements of the software components. The minimum requirements are available in the readme file of PCS 7.

Standard software components

Table 1-2

Component	Note
SIMATIC PCS 7 V7.1 SP 3	Component of SIMATIC PCS 7 ES/OS 547C BCE WXP
SIMATIC PCS 7 V8.0	Component of SIMATIC PCS 7 ES/OS IPC547D W7
SIMATIC PCS 7 V8.0 SP1	Component of SIMATIC PCS 7 ES/OS IPC547D W7
S7-PLCSIM	License is not part of SIMATIC PCS 7
APL Library V7.1 SP5 + Upd1	Component of SIMATIC PCS 7 V7.1 SP3
APL Library V8.0	Component of SIMATIC PCS 7 V8.0
APL Library V8.0 SP1	Component of SIMATIC PCS 7 V8.0 SP1

Example files and projects

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

Table 1-3

Component	Note
53843373_EquipmentModules_PCS7V713.zip	PCS 7 V7.1.3 sample project
53843373_EquipmentModules_PCS7V80.zip	PCS 7 V8.0 sample project
53843373_EquipmentModules_PCS7V801.zip	PCS 7 V8.0 SP1 sample project
53843373_EquipmentModules.pdf	This document

NOTE

The PCS 7 example project is based on the PCS 7 Industry Library (IL) and the PCS 7 Advanced Process Library (APL). Whereas the APL is covered by the SIMATIC PCS 7 Engineering license, you must obtain a separate Engineering license and Runtime licenses for IL.

The download contains the block "SimAn", which requires a license. The usage of this block in your configuration environment or in the process mode obligates you to purchase the PCS 7 Industry Library licenses.

Ordering information can found under the following Entry ID: 60982306.

NOTE

All procedures, descriptions and screenshots relevant for PCS 7 are based on the PCS 7 V7.1 SP3 and are applicable to the PCS 7 V8.0 and PCS 7 V8.0 SP1 without restrictions. The innovated faceplates of the APL V8.0 do not affect the way of operation of the equipment modules and are not described separately.

2 Basics

2.1 General

Automation systems

Industrial processes, e.g. in the chemical or pharmaceutical industry, are controlled using automation technology.

The degree of automation of the plants varies considerably and depends on the plant type and the process.

An automation solution normally comprises the following aspects:

- Measurement and control
- Controlling including higher-level control strategies, if necessary
- Transmission, processing and display of information
- Meeting defined steps and procedures
- Considering complex interactions
- Ensuring constant product quality

Process control

The primary task of the operator is the operative process management based on process and plant information regarding production process and its logistics and auxiliary processes.

Using process management guarantees the directed and reproducible adjustment of operating conditions and ensures meeting defined tolerance ranges. In the case of a failure, measures need to be taken in order to return the process to the desired state. Additionally, the process sequence shall be optimized continuously regarding costs, quality and safety.

2.2 Standardized plant components

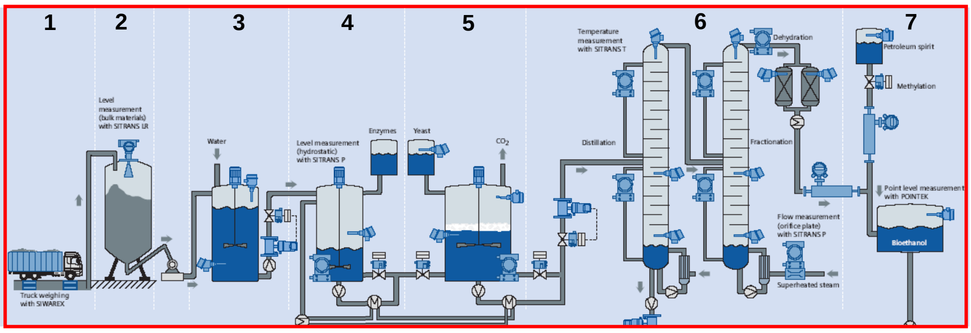
Partial automation solution

The figure below shows the components of a bioethanol production plant. The process is divided into several process steps, such as fermentation and distillation.

The individual process steps are divided into units, which in return consist of various equipment modules such as dosing or agitating.

This division is the basis for the structure of the partial automation solution.

Figure 2-1 Process steps of the bioethanol process



Automation solution

Unit

The term “unit” stands for a unit in industrial process plants (e.g. stirrer tank reactor, fermenter) including the device, sensors, actuators and automation software (hardware and software).

Structured units exist for continuous as well as discontinuous processes.

A unit variant is the so-called “package unit”. Examples for “package units” are refrigeration plants, vacuum systems and packaging machines. Here the manufacturer of the mechanical process engineering device provides an automation software specifically designed for this device, which is located on a separate hardware. The “package unit” is integrated as a whole into a higher-level process control system.

Equipment Module

An equipment module is a component of a unit and contains sensors, actuators and the automation hardware and software. Equipment modules are designed and configured to be used in specific applications, e.g. in process technology (doser, filling level or temperature control).

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

- Interconnected and configured process tags
- Simulation for illustrating the principle of operation

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

Control Module

The control module (aldo control unit) consists of actuators and sensors. In PCS 7, the control module is realized with software typicals (process tag types), e.g. for a valve, motor or a controller.

The realization in the CFC chart contains all relevant blocks, interconnections and basic parameters. A process tag type is generated from the CFC and is stored in the PCS 7 master data library. Any number of instances can be created with this process type, e.g. using the Import/Export wizard (IEA).

Each individual controller designation (process tag designation) is based on a uniform name convention. This means the designation states the function and task of the control module.

Unit Template

A unit template is composed of several equipment modules.

In a unit template, equipment modules are combined into a partial automation function. Additionally a unit template contains a CFC chart with economic or process engineering characteristic numbers (KPI characteristics), a CFC chart for monitoring the operating time and CFC charts for simulation.

A unit template is summarized in a hierarchy folder and can be easily integrated into and adjusted to existing projects.

As opposed to the “package units”, the Unit concept does not set up any local “insular control” with proprietary hardware, but creates prefabricated software solutions for frequently occurring units in a central process control system. Partial automation solutions for industrial plants are supplied in a standardized, prefabricated and user editable format. The templates only need to be adjusted to the existing process technology as well as the automation hardware. This clearly reduces the engineering expenses for further similar automation tasks.

Configuration via templates

The configuration using templates can be performed on unit level, on equipment module level or control module level.

On the control module level, a template for creating instances is generated via the process tag type in PCS 7. Configuration and interconnection of the process tag types can be automated using an import/export file.

Equipment modules or units are duplicated as a unit and adjusted to the respective process technology.

The equipment module and the unit template contain all functions required for the automation in form of:

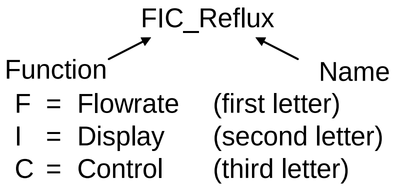
- CFC charts (instances of process tag types)
- SFC charts
- OS pictures

3 Design and Structure

3.1 Name convention of the CFC charts

A uniform name convention was used for the process tag designation, where the function is labeled according to the European EN 62424 standard. The following figure shows the composition of a process tag name:

Figure 3-1



The following table contains all letters used in the application and their meaning:

Table 3-1

First letter	Meaning
F	Flow rate (“Flow”)
L	Filling level (“Level”)
N	Motor
P	Pressure
Q	Quantity
S	Speed, frequency
T	Temperature
X	User’s choice (first letter)
Y	Control valve

Table 3-2

Subsequent letter	Meaning
C	Control
F	Ratio („Fraction“)
I	Indication
S	Binary control function or switching function (not safety-relevant)

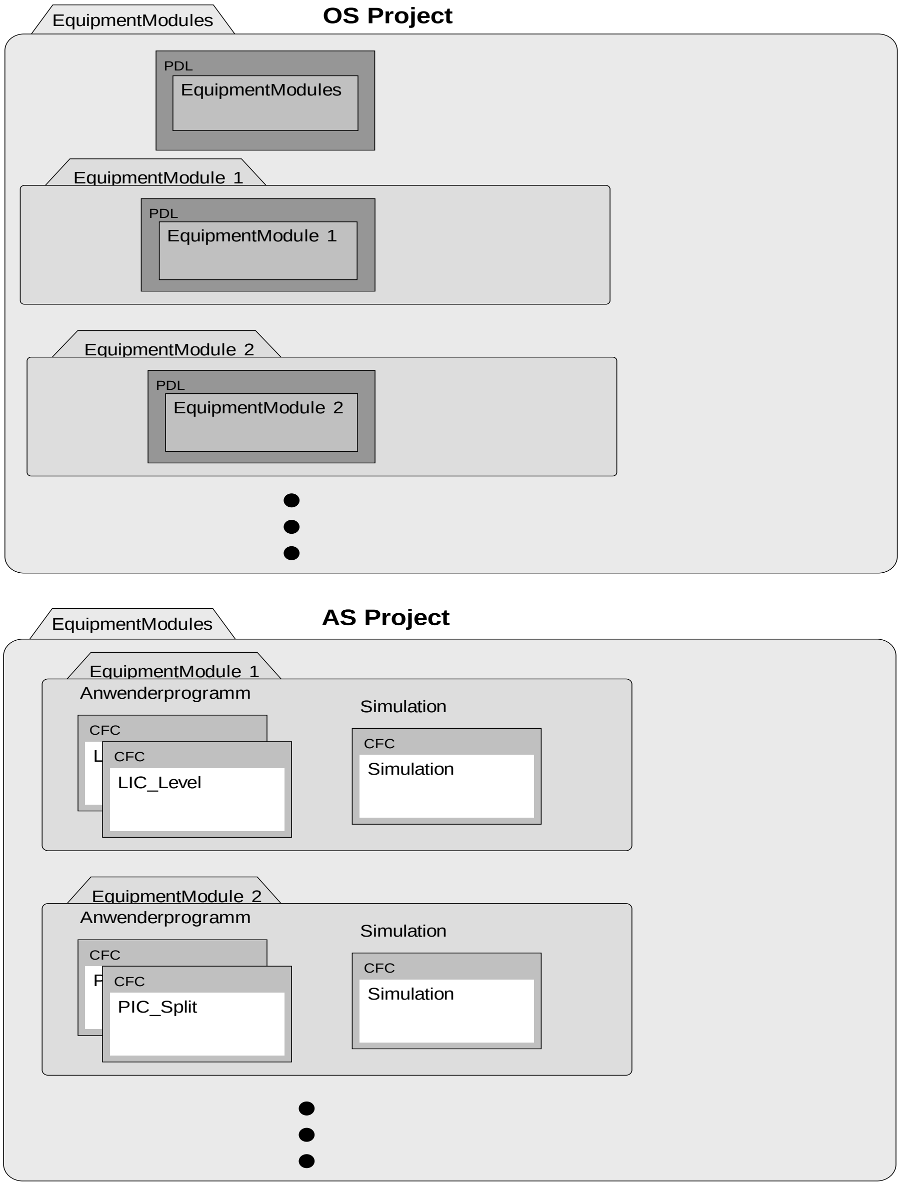
3.2 Plant view

The equipment modules are realized in two hierarchy layers in the Plant view.

In the AS project “EquipmentModules_AS_Prj” the first hierarchy layer is empty and the subordinate hierarchy layer contains a hierarchy folder for each equipment module with the required CPC charts in it.

The first hierarchy layer of OS project “EquipmentModules_OS_Prj” contains the overview screen of all “EquipmentModules.pdl” equipment modules. The subordinate hierarchy layer contains a hierarchy folder for each equipment module with a process image. The following figure shows a schematic representation of the folder structure, i.e. the names of the subfolders deviate from the folder names used in the PCS 7 projects.

Figure 3-2



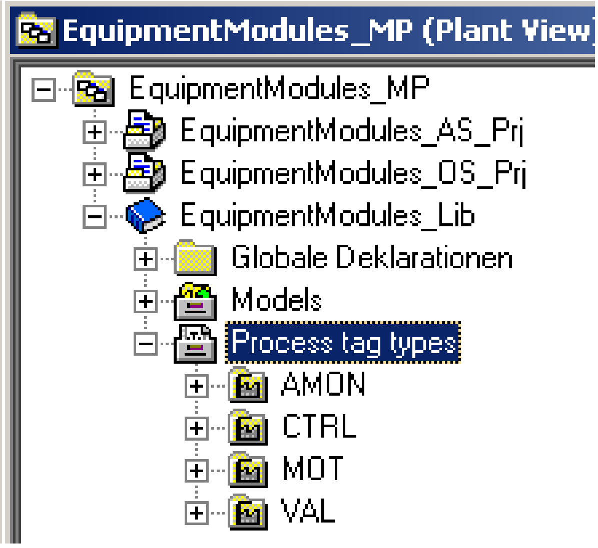
4 Control Module

4.1 Introduction

A control module is used for controlling individual devices such as motors, valves and controllers. The blocks required for this task, e.g. for controlling a valve are combined in a process tag. If the same process tag is used several times in the project, a process tag type is created from this process tag in PCS 7 and filed in the master data library. This process tag type can be used flexibly in the project as an instance.

This chapter gives you detailed information on the structure and functioning of the process tag type which form the basis of the process tags of the equipment modules. All process tag types are filed in the “EquipmentModules_Lib” master data library of the PCS 7 project.

Figure 4-1



The process tag types are divided as follows:

- Measured value display in the “AMON” folder
- Controller in the “CTRL” folder
- Motor in the “MOT” folder
- Valve in the “VAL” folder

The process tag types have a compact and structured design, i.e. all blocks relevant for a process tag are located at defined locations. Relevant channel blocks are located in subchart B of a CFC chart.

Detailed information on configuration and parameter settings is available in chapter 5 “Equipment Modules”.

4.2 “CTRL” controller

The controller process tag contains the control block, additional monitoring and locking functions (interlock functionality) and a connection to a sequential control.

The process tag types used as an instance in equipment modules are described below:

- “CTRL__Std” for standard PID controls
- “CTRL_Std4Valve” for standard PID controls with valve connector
- “CTRL_Std4MPC” for standard PID controls with MPC setpoint specification
- “CTRL_Splitrange” for controls with a manipulated variable and two actuators
- “CTRL_RatioMain” and “CTRL_RatioComp” for ratio control
- “CTRL_MPC4Valve” Multi-variable controller for one control variable
- “CTRL_MPC” Multi-variable controller for standard control operations

4.2.1 Standard controller

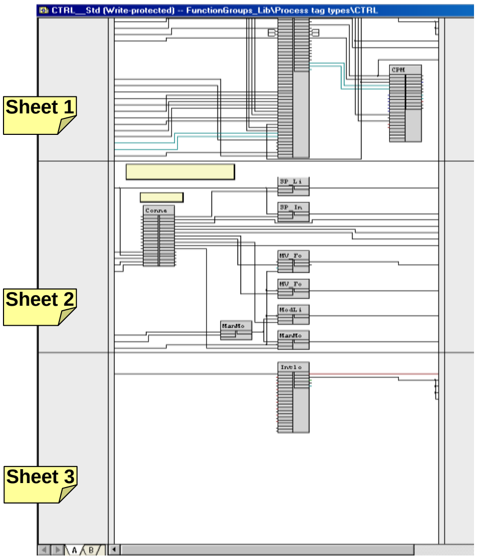
Process tag type “CTRL__Std” is used for fixed value and cascade control.

Examples for standard controls are:

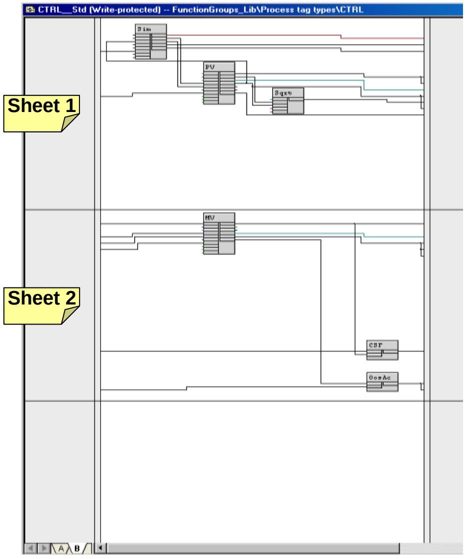
- Filling level control with inlet and outlet
- Temperature control

The figure below shows the structure of the controller process tag.

Subchart „A“



Subchart „B“



Subchart A

Sheet 1 contains the following blocks:

- C (“PIDConL”): PID controller
- CPM (“ConPerMon”): block for permanent monitoring of the control quality

The operating mode, setpoint, actual and manipulated value outputs of the controller are interconnected with the CPM block.

Sheet 2 contains the following blocks.

- Connector (“ConnPID”): block for SFC connection (no 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 value via interconnection
  - MV_Forced (“SelA02In”): forced manipulated value with selection (“In1” undefined, “In2” SFC connection)
  - MV_ForOn (“Or04“): activates forced manipulated value “In2” (MV_Forced) at the PID controller
  - ManModOpLi (“Or04”): formation of an OR output signal from field device in maintenance mode (channel blocks PV and MV) and invalid process value (channel block PV in subchart “B”, sheet 1).

With the SFC connection operation-relevant data are transferred to the PID controller via the logic blocks. Additionally, channel blocks and the interlock block (subchart “A”, sheet 3) influence the output signals of the logic blocks.

Sheet 3 contains the following block:

- Intlock (Intlk08): block for calculating a standardized interlock with optional display on the OS.

Interlock becomes active for invalid process value (MV channel block in subchart “B”, sheet 2). In the case of the active interlocking, the controller goes to manual mode and uses the forced manipulated value “In1” of the “MV_Forced” block.

Subchart B

Sheet 1 contains the following blocks:

- Sim (“SimAn”): simulation block (block description in the appendix)
- PV (“Pcs7AnIn”): channel block for signal processing of an analog input value
- Sqrt (“SwSqrt”): linearization block (block description in the appendix)

Simulation block “SimAn” is interconnected with “Pcs7AnIn” a channel block. The simulated process value is “0”. A linearization of the process value is not performed (Mode = 0 in the Sqrt block).

NOTE If no simulation is used, the real process value must be interconnected at input “PV_In” of channel block PV (“Pcs7AnIn”). The simulation is deactivated by entering the value “0” at simulation block “SimAn” at input “Sim1Act0p”.

Sheet 2 contains the following blocks.

- MV (“Pcs7AnOu”): channel block for signal processing of an analog output value
- CSF (“Or04”): formation of an OR output signal from output “Bad” (process value invalid) of channel blocks PV and MV
- OosAct (“Or04”): formation of an OR output signal from output “OosAct” (field device in maintenance mode) of channel blocks PV and MV

The “PV_In” input of the channel block is interconnected with output “MV” (manipulated value) of the PID controller. Additionally, the channel block is interconnected with simulation block “SimAn” (subchart “B”, sheet 1).

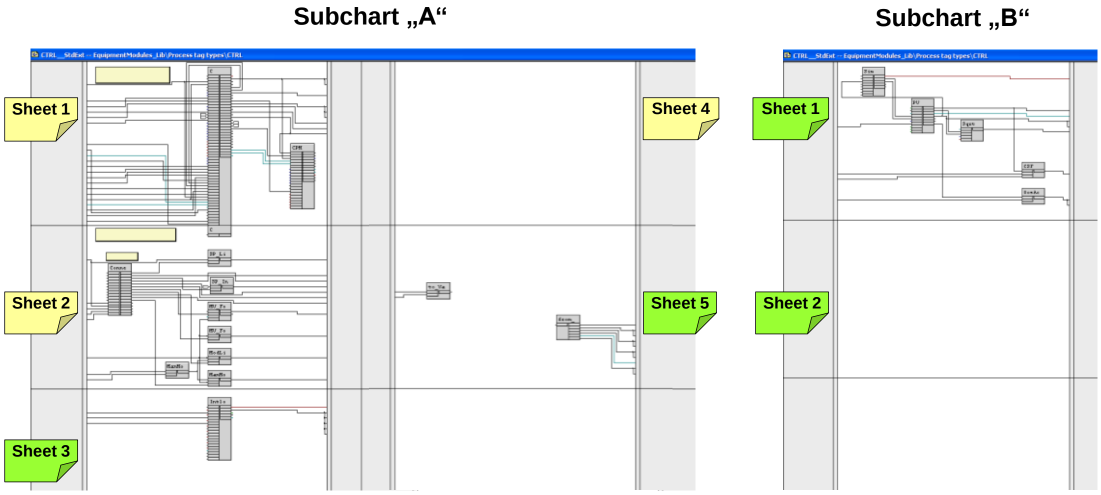
NOTE If no simulation is used, the real process value (e.g. positioner) must be interconnected at output “PV_Out” of channel block MV (“Pcs7AnOu”). The simulation is deactivated by entering the value “0” at simulation block “SimAn” at input “Sim2Act0p.

4.2.2 Standard controller with valve connection

Similar to "CTRL__Std", the process tag type "CTRL_Std4Valve" is used for fixed value and cascade control. In contrast to "CTRL__Std", however, the process tag does not include a channel block for the control valve (MV), but is interconnected with a valve process tag type ("Val_An").

The following section describes the changes as compared with the process tag type "CTRL_Std" and which are highlighted in green in the figure below.

Figure 4-3



Subchart A

Sheet 3 contains the interlock block which uses the following signals of the valve process tag for a standardized interlock with optional display in the OS:

- signaling of an invalid process value ("Bad" signal) at the MV and Rbk channel block
- signaling of field device maintenance (OosAct signal) at the MV and Rbk channel block

Sheet 5 contains the following interconnection blocks for quick engineering.

- to_Valve ("ComStruIn"): Transmits the manipulated variable (MV) and the interlock status to the valve process tag
- from_Valve ("ComStruOu"): Receives the feedback from the actuating signal (Rbk), messages indicating invalid process values and field device maintenance of the channel blocks MV and Rbk, the control unit (OutUnit) and scaling (ScaleOut) of the valve process tag.
- Subchart B
- In sheet 1, the messages from the channel blocks of the valve process tag are additionally identified at the blocks CSF and OosAct (shifted from sheet 2).
- Sheet 2 no longer contains a channel block for the signal processing of an analog output value, as it is already included in the valve process tag.

4.2.3 Standard controller with MPC setpoint specification

Similar to "CTRL_Std4Valve", the process tag type "CTRL_Std4MPC" is used for fixed value and cascade control. In contrast to "CTRL_Std4Valve", however, the "CTRL_Std4MPC" process tag includes an additional block for connection to the process tag of the multi-variable controller ("CTRL_MPC"). Control is effected via the manipulated variable of the MPC process tag.

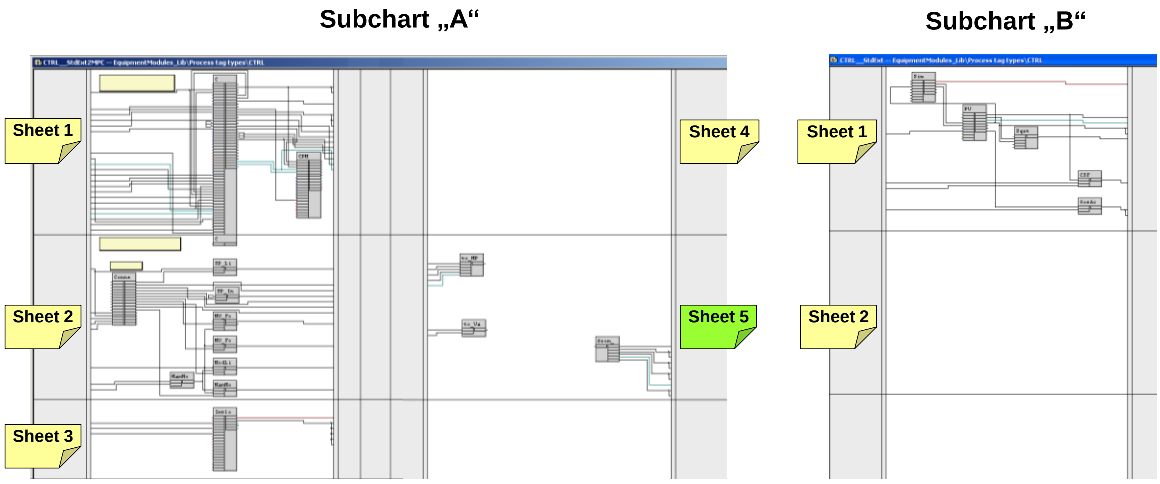
NOTE

The following two connections between the process tags "CTRL_Std4MPC" and "CTRL_MPC" are to be configured:

- the blocks "ComStruOu" of the MPC controller and "ComStruIn" of the PID controller
- the associated MV output parameter of the MPC controller and the SP_Ext input parameter of the block "ConnPID" of the PID controller

The following section describes the changes as compared with the process tag type "CTRL_Std4Valve" which are highlighted in green in the figure below.

Figure 4-4



Subchart „A“

Subchart „B“

Subchart A

Sheet 5 additionally contains the following block:

- to_MPC ("ComStruIn"): Transmits control commands from the PID controller ("SP_InHiOut", "SP_InLoOut", "PV_Out", "CascaCut", "PV_UnitOut") to the MPC controller.

4.2.4 Split range controller

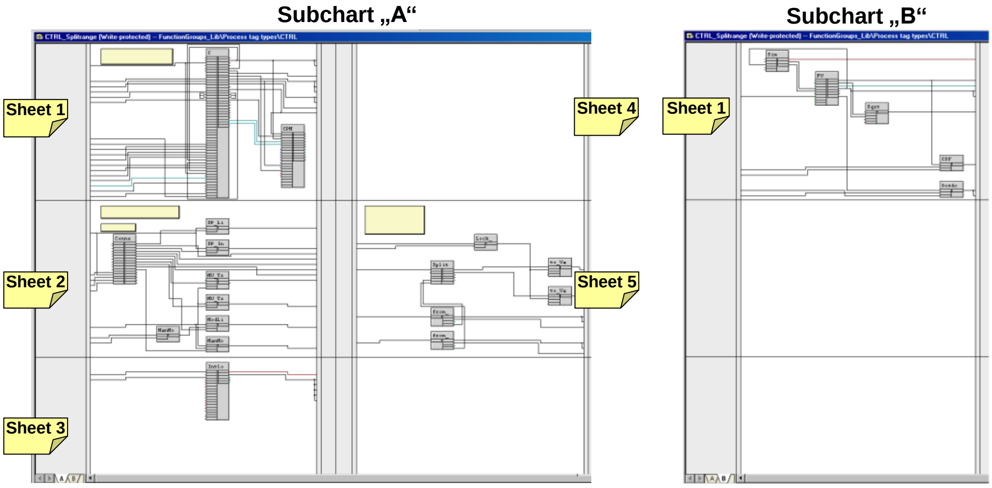
Process tag type “CTRL_Splitrange” is used for controlling several manipulated variables with one actuator (with restricted effective range and, possibly, opposed direction of control action).

Examples for split range controllers are:

- Temperature control with separate manipulated variables for heating and cooling
- Pressure control with separate valves for gas feed and for heating and venting

The figure below shows the structure of the controller process tag.

Figure 4-5



Subchart A

Sheet 1 contains the following blocks:

- C (“PIDConL”): PID controller with continuous output signal
- CPM (“ConPerMon”): block for permanent monitoring of the control quality

The outputs operating mode, setpoint, actual and manipulated value of the controller are interconnected with the CPM block.

Sheet 2 contains the following blocks.

- Connector (“ConnPID”): block for SFC connection (no 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 value via interconnection
- MV_Trk (“SelA02In”): forced manipulated value with selection (“In1” 50, “In2” SFC connection)
- MV_TrkOn (“Or04”): activates forced manipulated value “In2” (MV_Forced) at the PID controller
- ManModOpLi (“Or04”): formation of an OR output signal from field device in maintenance mode (channel block PV in subchart “B”, sheet 1 and channel blocks of the valve process tags) and invalid process value (channel block PV in subchart “B”, sheet 1).
- ModLiOp (“Or04”): operating mode selection between operator (value “0”) and interconnection or SFC (value “1”)
- ManModLi (“Or04”): manual mode via interconnection or SFC (controlled via ModLiOp = 1)

With the SFC connection operation-relevant data are transferred to the PID controller via the logic blocks. Additionally, channel blocks and the interlock block (subchart “A”, sheet 3) influence the output signals of the logic blocks.

Sheet 3 contains the following block:

- Intlock (Intlk08): block for calculating a standardized interlock with optional display on the OS.

The interlock becomes active for an invalid process value (channel blocks from valve process tags).

Sheet 5 contains the following blocks.

- Lock_Val_Ans (“Or04”): during active interlocking (value “0”) or automatic mode of the PID controller (AutAct = “1”) an interconnected valve block is operated in automatic mode with output value “Out1” / “Out2” of the “SplRange” block.
- Split range (“SplRange”) block for dividing the output signal of a PID controller
- Communication blocks for transfer and receiving of control commands (valve process tags)
- to_Val_An1/to_Val_An2 (“ComStruI”): the blocks transfer output values and operating modes to valve process tags.
- from_ValAn1/from_ValAn2 (“ComStruO”): the blocks receive output value, operating mode, unit and scaling of the process values from valve process tags.

The split range block divides the manipulated value of the PID controller between its outputs (Out1 and Out2). The limit values (Out1Scale and Out2Scale) are configured from the communication blocks (from_ValAn1 and from_ValAn2).

Additionally, the status information (invalid process value, field device in maintenance mode) of channel block Rbk of the valve process tags for interlocking (subchart “A”, sheet 3) and operating mode selection ModLiOp and ManModLi (subchart “A”, sheet 2).

Subchart B

Sheet 1 contains the following blocks:

- Sim (“SimAn”): simulation block (block description in the appendix)
- PV (“Pcs7AnIn”): channel block for signal processing of an analog input value
- Sqrt (“SwSqrt”): linearization block (block description in the appendix)
- CSF (“Or04”): formation of an OR output signal from output “Bad” (process value invalid) of channel blocks PV and the channel blocks of the valve process tags.
- OosAct (“Or04”): formation of an OR output signal from output “OosAct” (field device in maintenance mode) of channel block PV and the channel blocks of the valve process tags.

Simulation block “SimAn” is interconnected with “Pcs7AnIn” a channel block. The simulated process value is “0”. A linearization of the process value is not performed (Mode = 0 in the Sqrt block).

NOTE If no simulation is used, the real process value must be interconnected at input “PV_In” of channel block PV (“Pcs7AnIn”). The simulation is deactivated by entering the value “0” at simulation block “SimAn” at input “Sim1Act0p”.

4.2.5 Ratio controller

The ratio controller is composed of a flow rate controller for the main components and another flow rate controller for each added component.

Examples for ratio controllers are:

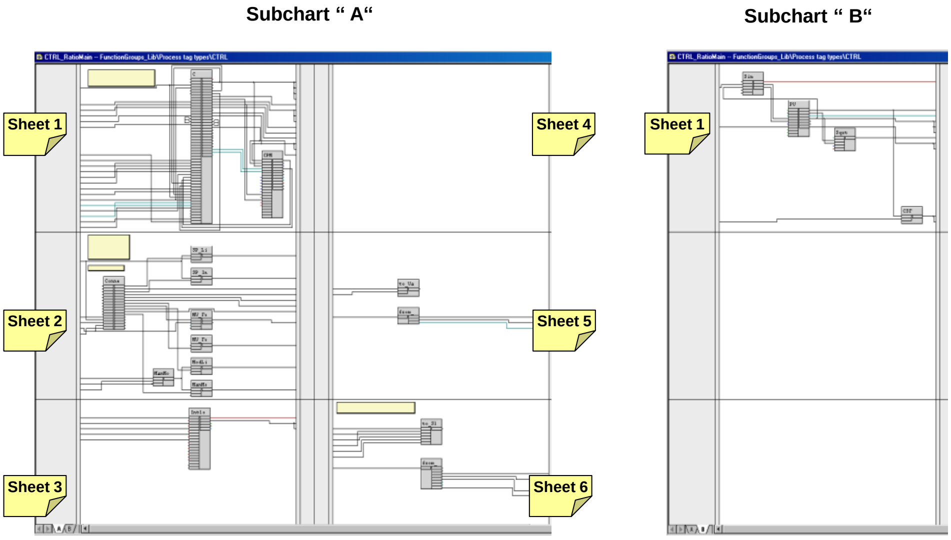
- Mixing control of liquids or gases with defined mixing ratios
- Fuel feed in a defined ratio with air supply for gas burners

Main component

Process tag type “CTRL_RatioMain” is used for the main component of ratio control, where the setpoint value is default. The flow rate for a further mixing component is automatically controlled with the controller process tag “CTRL_RatioComp” via a defined ratio.

The figure below shows the structure of the controller process tag.

Figure 4-6



Subchart A

Sheet 1 contains the following blocks:

- C (“PIDConL”): PID controller with continuous output signal
- CPM (“ConPerMon”): block for permanent monitoring of the control quality

The outputs operating mode, setpoint, actual and manipulated value of the controller are interconnected with the CPM block.

Sheet 2 contains the following blocks.

- Connector (“ConnPID”): block for SFC connection (no 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 value via interconnection

  - MV_Forced (“SelA02In”): forced manipulated value with selection (“In1” SFC connection, “In2” PID controller)
  - MV_ForOn (“Or04“): activates forced manipulated value “In2” (MV_Forced) at the PID controller
  - ManModOpLi (“Or04”): formation of an OR output signal from field device in maintenance mode and invalid process value from channel block PV (subchart “B”, sheet 1) and interlock block (controller process tag for further component, channel block of the valve process tag).
  - ModLiOp (“Or04”): operating mode selection between operator (value “0”) and interconnection or SFC (value “1”)
  - ManModLi (“Or04”): manual mode via interconnection or SFC (controlled via ModLiOp = 1)

With the SFC connection operation-relevant data are transferred to the PID controller via the logic blocks. Additionally, channel blocks and the interlock block (subchart “A”, sheet 3) influence the output signals of the logic blocks.

Sheet 3 contains the following block:

- Intlock (“Intlk08”): block for calculating a standardized interlock with optional display on the OS.

The interlock becomes active for an invalid process value (channel blocks from valve process tags).

Sheet 5 contains the following communication blocks for transfer and receiving of control commands (valve process tag for the main component):

- to_Valve (“ComStruIn”): the communication block forms a structure from the manipulated value (MV) of the PID controller and the interlock output (Out) for the transfer to a valve process tag.
- from_Valve (“ComStruOu”): the communication block contains the signals, relevant for the interlock (Intlock block), from the channel block (Rbk) of the valve process tag.

Sheet 6 contains the following communication blocks for transfer and receiving of control commands (controller process tag for the further components):

- to_Slave (“ComStruIn”): the communication block forms a structure from the outputs (setpoint value, manipulated value, message for cascade connection, process value) of the PID controller and the outputs (invalid process value, scaling of the process value) of the channel block (PV) for a transfer to the controller process tag for further components.
- from_Slave_1 (“ComStruOu”): the communication block contains the signals, relevant for the interlocking and scaling, of the PID controller and the channel block of the controller process tag for further components.

Subchart B

Sheet 1 contains the following blocks:

- Sim (“SimAn”): simulation block (block description in the appendix)
- PV (“Pcs7AnIn”): channel block for signal processing of an analog input value
- Sqrt (“SwSqrt”): linearization block (block description in the appendix)
- CSF (“Or04”): formation of an OR output signal from output “Bad” (process value invalid) of channel blocks PV (subchart “B”, sheet 1) and the channel blocks of the controller process tags for further components.

Simulation block “SimAn” is interconnected with “Pcs7AnIn” a channel block. The simulated process value is “0”. A linearization of the process value is not performed (Mode = 0 in the Sqrt block).

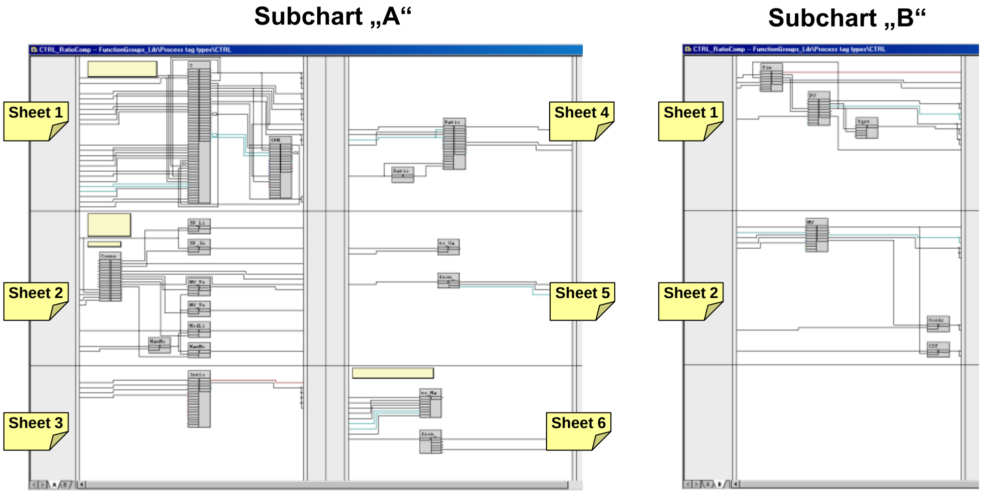
NOTE If no simulation is used, the real process value must be interconnected at input “PV_In” of channel block PV (“Pcs7AnIn”). The simulation is deactivated by entering the value “0” at simulation block “SimAn” at input “Sim1Act0p”.

Further mixing component “CTRL_RatioComp”

Process tag type “CTRL_RatioComp” is used for each further mixing component of the ratio control, where the setpoint value is derived from the main current via a defined ratio factor.

The figure below shows the structure of the controller process tag.

Figure 4-7



Subchart A

Sheet 1 contains the following blocks:

- C (“PIDConL”): PID controller with continuous output signal
- CPM (“ConPerMon”): block for permanent monitoring of the control quality

The outputs operating mode, setpoint, actual and manipulated value of the controller are interconnected with the CPM block.

Sheet 2 contains the following blocks.

- Connector (“ConnPID”): block for SFC connection (no 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 value via interconnection
  - MV_Trk (“SelA02In”): forced manipulated value with selection (“In1” not defined, “In2” SFC connection)

- MV_TrkOn (“Or04”): activates forced manipulated value “In2” (MV_Forced) at the PID controller
- ManModOpLi (“Or04”): formation of an OR output signal from field device in maintenance mode (channel blocks PV and MV) and invalid process value (channel block PV in subchart “B”, sheet 1).
- ModLiOp (“Or04”): operating mode selection between operator (value “0”) and interconnection or SFC (value “1”)
- ManModLi (“Or04”): manual mode via interconnection or SFC (controlled via ModLiOp = 1)

With the SFC connection operation-relevant data are transferred to the PID controller via the logic blocks. Additionally, channel blocks and the interlock block (subchart “A”, sheet 3) influence the output signals of the logic blocks.

Sheet 3 contains the following block:

- Intlock (“Intlk08”): block for calculating a standardized interlock with optional display on the OS.

The interlock becomes active for an invalid process value (channel blocks of the controller process tags (main component and further mixing components) and valve process tags).

Sheet 4 contains the following blocks.

- RatioSel (“Not01”): block for switching between internal and external ratio value in the ratio block
- Ratio (“Ratio”): block for creating a ratio value

To create the ratio, the Ratio block uses the setpoint value of the main component. Via parameter “RatLiOp” = 0 it is defined, that the ratio value is specified by the user and the internal value is used.

Sheet 5 contains the following communication blocks for transfer and receiving of control commands (valve process tag):

- to_Valve (“ComStruIn”): the communication block forms a structure from the manipulated value (MV) of the PID controller and the interlock output (Out) for the transfer to a valve process tag.
- from_Valve (“ComStruOu”): the communication block contains the signals, relevant for the interlock (Intlock block), from the channel block (Rbk) of the valve process tag.

Sheet 6 contains the following communication blocks for transfer and receiving of control commands (controller process tag of the main component):

- to_Master (“ComStruIn”): the communication block forms a structure from the outputs (setpoint value, block “Out of order” message , message for cascade connection, process value) of the PID controller, of the SCF block (invalid process value, scaling of the process value) of the channel block (PV) for the transfer to controller process tag for further components.
- from_Master (“ComStruOu”): from the controller process tag of the main component, the communication block contains the signals, relevant for the interlocking, of the CSF block as well as the setpoint value of the PID controller.

Subchart B

Sheet 1 contains the following blocks:

- Sim (“SimAn”): simulation block (block description in the appendix)
- PV (“Pcs7AnIn”): channel block for signal processing of an analog input value
- Sqrt (“SwSqrt”): linearization block (block description in the appendix)

Simulation block “SimAn” is interconnected with channel block “Pcs7AnIn”. The default process value is “0”. A linearization of the process value is not performed (Mode = 0 in the Sqrt block).

NOTE If no simulation is used, the real process value must be interconnected at input “PV_In” of channel block PV (“Pcs7AnIn”). The simulation is deactivated by entering the value “0” at simulation block “SimAn” at input “Sim1Act0p”.

Sheet 2 contains the following blocks.

- MV (“Pcs7AnOu”): channel block for signal processing of an analog output value
- OosAct (“Or04”): formation of an OR output signal from output “OosAct” (field device in maintenance mode) of channel blocks PV and MV
- CSF (“Or04”): formation of an OR output signal from output “Bad” (process value invalid) of channel blocks PV and MV

The “PV_In” input of the channel block is interconnected with output “MV” (manipulated value) of the PID controller. Additionally, the channel block is interconnected with simulation block “SimAn” (subchart “B”, sheet 1).

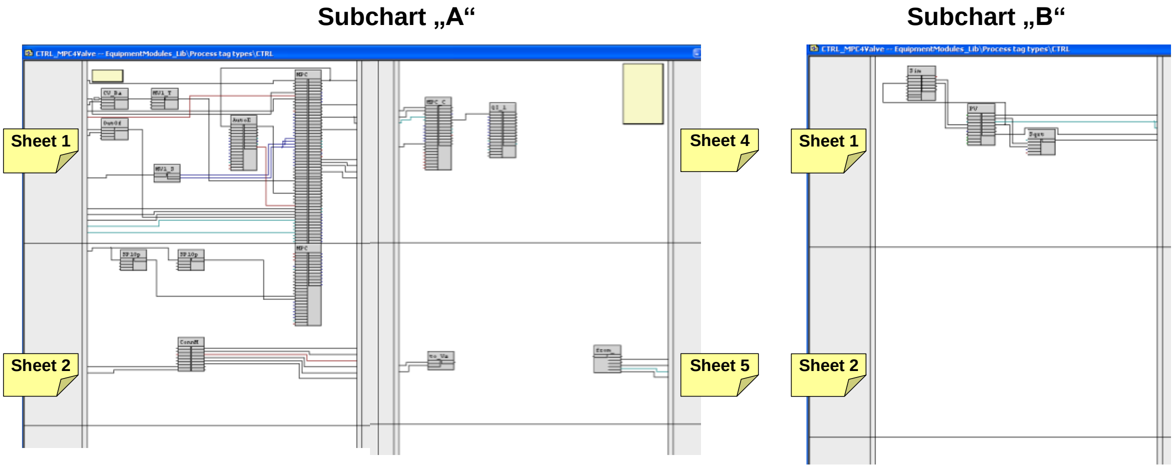
NOTE If no simulation is used, the real process value (e.g. positioner) must be interconnected at output “PV_Out” of channel block MV (“Pcs7AnOu”). The simulation is deactivated by entering the value “0” at simulation block “SimAn” at input “Sim2Act0p”.

4.2.6 Multi-variable controller for one control variable

The process tag type "CTRL_MPC4Valve" is used for fixed value control operations, whereby the controlled variable is influenced by one or several disturbance variables.

An example for multi-variable control with one control variable is the regulation of the pH value.

The figure below shows the structure of the controller process tag.



Subchart A

Sheet 1 contains the following blocks:

- MPC ("ModPreCon"): Model-based predictive controller (multi-variable controller)
- CV_Bad ("Or04"): Creates an OR output signal of the channel blocks’ hardware errors in the display and valve process tag at the MPC input.
- CV_Oos ("Or04"): Creates an OR output signal from the channel blocks' "OosAct" message (field device in maintenance mode) in the display and valve process tag at the MPC input.
- MV1_TrkOn ("Or04"): Forced manipulated variable (MV1) for the MPC controller after hardware error (CV_Bad).
- MV1_Scale ("StruScIn"): Allocates the manipulated variable scaling to MV1HiLim, MV1LoLim, MV1ManHiLim and MV1ManLoLim.
- AutoExcitation ("AutoExci"): Process excitation signals for the predictive MPC controller (only during commissioning of the controller).

Sheet 2 contains the following blocks:

- Blocks for static operating point optimization of control variables of the MPC controller
- SP1OptHiLim ("Add04"): Adjustment of the upper tolerance limit for SP1
- SP1OptLoLim ("Add04"): Adjustment of the lower tolerance limit for SP1
- Connector ("ConnMPC"): Block for the SFC connection (not included in the APL or standard library)

Sheet 4 contains the following blocks:

- MPC_CPM_1 ("ConPerMon"): Block for the permanent control quality monitoring (SP1Out, MV1 and CV1Out)
- QI_1 ("MonAnL"): Display and limit monitoring of the mean control deviation for the time window defined in "MPC_CPM_1" ("TimeWindow")

Sheet 5 includes the following connection blocks for quick engineering:

- to_Valve ("ComStruIn"): Transmits the manipulated value (MV) and out-of-service status ("OOsAct") to the valve process tag.
- from_Valve ("ComStruOu"): Receives the feedback from the actuating signal (Rbk), messages indicating invalid process values and field device maintenance of the channel blocks MV and Rbk, the control unit (OutUnit) and scaling (ScaleOut) of the valve process tag.

Subchart B

Sheet 1 contains the following blocks:

- Sim ("SimAn"): Simulation block (see block description in the appendix)
- PV ("Pcs7AnIn"): Channel block for signal processing of an analog input value
- Sqrt ("SwSqrt"): Linearization block (see block description in the appendix)

The simulation block "SimAn" is interconnected with a "Pcs7AnIn" channel block. Linearization of the process value is not performed (Mode = 0 in the Sqrt block).

Note If no simulation is used, the real process value must be interconnected at the input "PV_In" of the PV channel block ("Pcs7AnIn"). The simulation is deactivated by entering the value "0" at the input "Sim1Act0p" of the simulation block "SimAn".

4.2.7 Multi-variable controller for standard control operations

The process tag type "CTRL_MPC" is used, among others, for fixed value and cascade control. In contrast to "CTRL__Std", however, the multi-variable controller manages up to four interlinked manipulated and controlled variables. The process tag type in the example below is laid out for up to 3 control variables and, if required, one further measurable disturbance variable can be acquired.

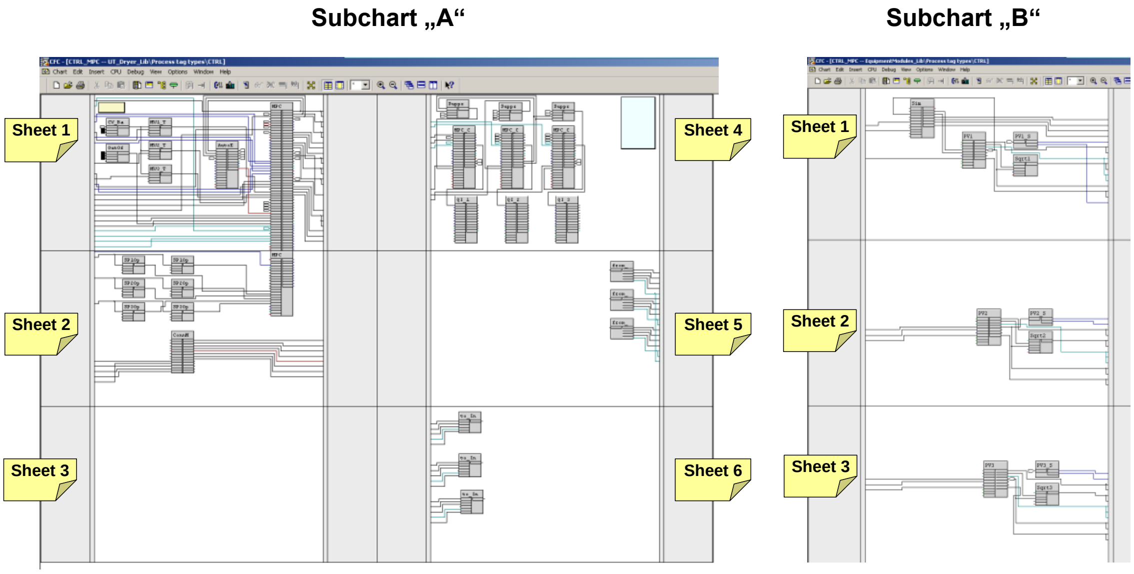
Note For further information and notes on the model-based predictive controller for more than one measurable disturbance variable, please refer to the document "SIMATIC Process Control System PCS 7 PCS 7 Advanced Process Library V8.0" under the entry ID: 57265842.

Due to the complexness of control operations (influenced by up to four control variables), the multi-variable controller is preferably used for slower control actions.

Examples of multi-variable control operations include:

- regulation of the pH value
- control of a distillation process (rectification)

The figure below shows the structure of a controller process tag.



Subchart A

Sheet 1 contains the following blocks:

- MPC ("ModPreCon"): Multi-variable controller
- CV_Bad ("Or04"): Creates an OR output signal of the channel blocks’ hardware errors in the display process tags "CV" at the MPC input.

- CV_Oos ("Or04"): Creates an OR output signal from the channel blocks'"OosAct" message (field device in maintenance mode) of the display process tags "CV" at the MPC input.
- MV1_TrkOn ("Or04"): Forced manipulated variable (MV1) for the MPC controller after hardware error (CV_Bad) or if the cascade connection between the MV1-PID controller and the slave controller has been interrupted.
- MV2_TrkOn ("Or04"): Forced manipulated variable (MV2) for the MPC controller after hardware error (CV_Bad) or if the cascade connection between the MV2-PID controller and the MV2 slave controller has been interrupted.
- MV3_TrkOn ("Or04"): Forced manipulated variable (MV3) for the MPC controller, after hardware error (CV_Bad) or if the cascade connection between the MV3-PID controller and the MV3 slave controller has been interrupted.
- AutoExcitation ("AutoExci"): Process excitation signals for the predictive MPC controller (only during commissioning of the controller).

Sheet 2 contains the following blocks:

- Blocks for static operating point optimization of control variables of the MPC controller
  - SP1OptHiLim ("Add04"): Adjustment of the upper tolerance limit for SP1
  - SP1OptLoLim ("Add04"): Adjustment of the lower tolerance limit for SP1
  - SP2OptHiLim ("Add04"): Adjustment of the upper tolerance limit for SP2
  - SP2OptLoLim ("Add04"): Adjustment of the lower tolerance limit for SP2
  - SP3OptHiLim ("Add04"): Adjustment of the upper tolerance limit for SP3
  - SP3OptLoLim ("Add04"): Adjustment of the lower tolerance limit for SP3

Note When applying the operating point optimization function, the control variable is not assigned to an exact setpoint (e. g. SP1) but to a tolerance range. The associated actual value (CV1) may vary within this tolerance. This definition of a tolerance range makes the controller more flexible and effective, since the process needs not be continuously adjusted to a fixed value.

- Connector ("ConnMPC"): Block for SFC connection (not included in the APL or standard library), disturbance variable detection "DV1" and transmission of the manipulated value to the controller process tags "MV1" to "MV3".

Sheet 4 contains the following blocks:

- Suppr_CPM_Calc_1 ("Or04"): Suppression of CPI calculation and message, if the message suppression was initiated at "MPC_CPM_2" and "MPC_CPM_3" (CPI_SuRoot = 1), or if a control performance warning is active (CPI_WL_Act = 1).
- Suppr_CPM_Calc_2 ("Or04"): Suppression of CPI calculation and message, if the message suppression was initiated at "MPC_CPM_1" and "MPC_CPM_3" (CPI_SuRoot = 1), or if a control performance warning is active(CPI_WL_Act = 1).
- Suppr_CPM_Calc_3 ("Or04"): Suppression of CPI calculation and message, if the message suppression was initiated at "MPC_CPM_1" and

"MPC_CPM_2" (CPI_SuRoot = 1), or if a control performance warning is active (CPI_WL_Act = 1).

- MPC_CPM_1 ("ConPerMon"): Block for permanent control performance monitoring (SP1Out, MV1 and CV1Out)
- MPC_CPM_2 ("ConPerMon"): Block for permanent control performance monitoring (SP2Out, MV2 and CV2Out)
- MPC_CPM_3 ("ConPerMon"): Block for permanent control performance monitoring (SP3Out, MV3 and CV3Out)
- QI_1 ("MonAnL"): Display and limit monitoring of the mean control deviation within the time window ("TimeWindow") defined in "MPC_CPM_1"
- QI_2 ("MonAnL"): Display and limit monitoring of the mean control deviation within the time window ("TimeWindow") defined in "MPC_CPM_2"
- QI_3 ("MonAnL"): Display and limit monitoring of the mean control deviation within the time window ("TimeWindow") defined in "MPC_CPM_3"

Sheet 5 contains the following blocks:

- from_CTRL_1 ("ComStruOu"): Receipt of control commands from the subordinate PID controller process tags for the MPC controller parameters ("MV1ManHiLim", "MV1ManLoLim" and "MV1Trk") and the block "MV1_TrkOn".
- from_CTRL_2 ("ComStruOu"): Receipt of control commands from the subordinate PID controller process tags for the MPC controller parameters ("MV2ManHiLim", "MV2ManLoLim" and "MV2Trk") and the block "MV2_TrkOn".
- from_CTRL_3 ("ComStruOu"): Receipt of control commands from the subordinate PID controller process tags for the MPC controller parameters ("MV3ManHiLim", "MV3ManLoLim" and "MV3Trk") and the block "MV3_TrkOn".

Note The "ComStruOu" blocks help to reduce the amount of configuration work to be carried out, i.e. only the following connections are to be configured for each PID controller:

- The "ComStruOu" block of the MPC controller with the "ComStruIn" block of the PID controller.
- The associated MV output parameter of the "ConnMPC" block with the SP_Ext input parameter of the "ConnPID" block of the PID controller.

Sheet 6 contains the following blocks:

- to_Indicate_1 (“ComStruIn“): Transfer of signals (analog measured value, unit, scale and messages) of the channel block PV1 to the measured value display process tag type
- to_Indicate_2 (”ComStruIn“”): Transfer of signals (analog measured value, unit, scale and messages) of the channel block PV2 to the measured value display process tag type to_Indicate_3 (“ComStruIn”): Transfer of signals (analog measured value, unit, scale and messages) of the channel block PV3 to the measured value display process tag type

Subchart B

Sheet 1 contains the following blocks:

- Sim ("SimAn"): Simulation block (see block description in the appendix)
- PV1 ("Pcs7AnIn"): Channel block for signal processing of an analog input value (CV1)
- PV1_Scale (“StruScIn“): Scale of the process value for scaling the MPC setpoint
- Sqrt1 ("SwSqrt"): Linearization block (see block description in the appendix)

The simulation block "SimAn" is interconnected with the "Pcs7AnIn" channel blocks PV1 to PV3. No linearization of the process value in the "SwSqrt" block (Mode = 0).

Note If no simulation is used, the real process value must be interconnected at the input "PV_In" of the relevant PV channel block ("Pcs7AnIn"). Simulation can be deactivated by entering the value "0" at the input "Sim1Act0p" of the simulation block "SimAn".

Sheet 2 contains the following blocks:

- PV2 ("Pcs7AnIn"): Channel block for signal processing of an analog input value (CV1)
- PV2_Scale (“StruScIn“): Scale of the process value for scaling the MPC setpoint
- Sqrt2 ("SwSqrt"): Linearization block (see block description in the appendix)
-
- Sheet 3 contains the following blocks:
- PV3 ("Pcs7AnIn"): Channel block for the signal processing of an analog input value (CV1)
- PV3_Scale (“StruScIn“): Scale of the process value for scaling the MPC setpoint
- Sqrt3 ("SwSqrt"): Linearization block (see block description in the appendix)

4.3 “AMON” measured value display

General

Operator control and monitoring of an analog measured value occurs in the process tag for measured value display.

In addition to monitoring, limit values with priorities can be defined.

Subsequently, the following process tag types are described, which are used as instance in equipment modules:

- “AMON__Std” for measured value display
- “AMON_Flow” for measured value display with measured value linearization
- “AMON_Connect” for measured value display for multi-variable control system

4.3.1 Standard measured value

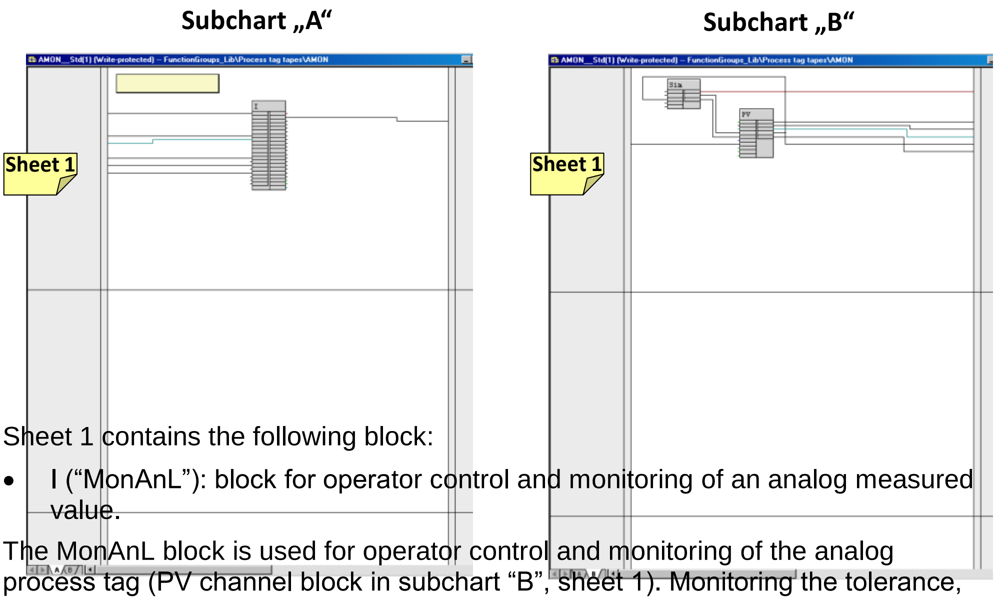
Process tag type “AMON__Std” is used for monitoring and measured value display of linear signals.

Examples for measured value display are:

- Display of a filling level
- Display of a pressure

The figure below shows the structure of the process tag for measured value display.

Figure 4-10



Subchart A

Sheet 1 contains the following block:

- I (“MonAnL”): block for operator control and monitoring of an analog measured value.

The MonAnL block is used for operator control and monitoring of the analog process tag (PV channel block in subchart “B”, sheet 1). Monitoring the tolerance, warning and alarm limits is switched visible in the properties of the block. The limit values are entered at the block inputs. In the case of limit violations, or if the inclination of the signal does not correspond to the requirements, messages are generated and output.

Subchart B

Sheet 1 contains the following blocks:

- Sim (“SimAn”): simulation block (block description in the appendix)
- PV (“Pcs7AnIn”): channel block for signal processing of an analog input value

Simulation block “SimAn” is interconnected with channel block “Pcs7AnIn”. The default process value is “0”.

NOTE If no simulation is used, the real process value must be interconnected at input “PV_In” of channel block PV (“Pcs7AnIn”). The simulation is deactivated by entering the value “0” at simulation block “SimAn” at input “Sim1Act0p”.

4.3.2 Linearized measured value

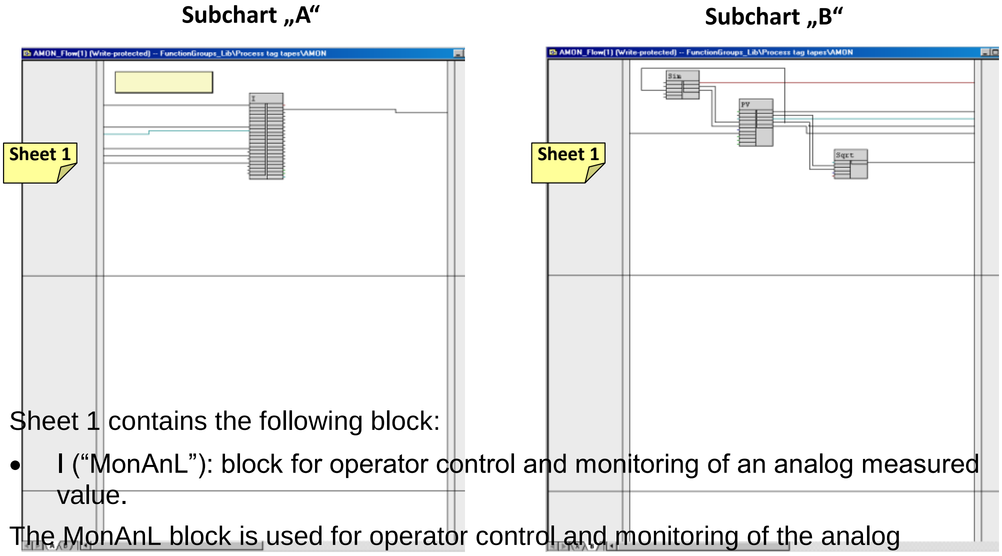
Process tag type “AMON__Flow” is used for monitoring and measured value display of signals, which require linearization, e.g. flow measurement (restrictor measurement). For non-linear signals, a square root correction can be performed.

Examples for measured value display are:

- Display of a flow rate

The figure below shows the structure of the process tag for measured value display.

Figure 4-11



Subchart A

Sheet 1 contains the following block:

- I (“MonAnL”): block for operator control and monitoring of an analog measured value.

The MonAnL block is used for operator control and monitoring of the analog process tag (PV channel block in subchart “B”, sheet 1). Monitoring the tolerance, warning and alarm limits is switched visible in the properties of the block. The limit values are entered at the block inputs. In the case of limit violations or if the inclination of the signal does not correspond to the requirements, messages are generated and output.

Subchart B

Sheet 1 contains the following blocks:

- Sim (“SimAn”): simulation block (block description in the appendix)
- PV (“Pcs7AnIn”): channel block for signal processing of an analog input value
- Sqrt (“SwSqrt”): linearization block (block description in the appendix)

Simulation block “SimAn” is interconnected with channel block “Pcs7AnIn”. The default process value is “0”. A linearization of the process value is not performed (Mode = 0 in the Sqrt block).

NOTE If no simulation is used, the real process value must be interconnected at input “PV_In” of channel block PV (“Pcs7AnIn”). The simulation is deactivated by entering the value “0” at simulation block “SimAn” at input “Sim1Act0p”.

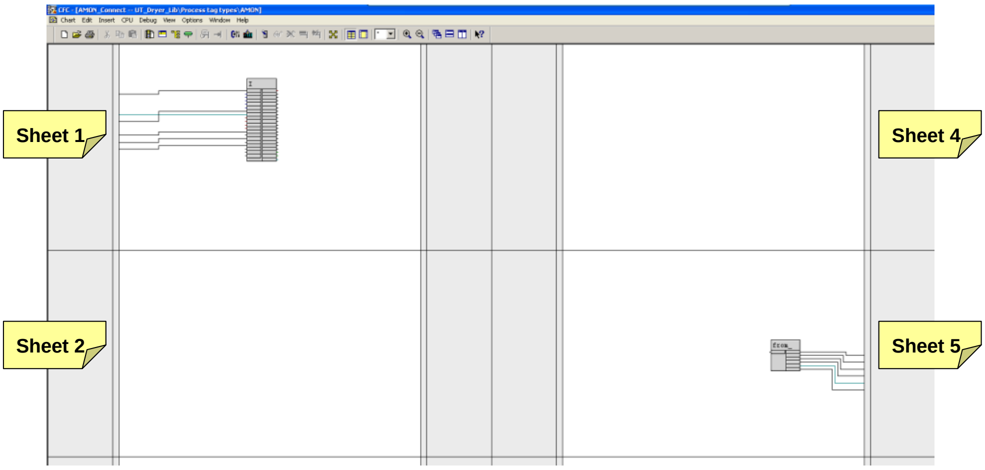
4.3.3 Standard measured value for MPC

Process tag type “AMON__Connect” is used for monitoring and measured value display of linear signals. The process tag contains no channel blocks and is used for measured value display of the multi-variable controller.

The figure below shows the structure of the process tag for measured value display.

Figure 4-12

Subchart „A“



Subchart A

Sheet 1 contains the following block:

- I (“MonAnL”): block for operator control and monitoring of an analog measured value.

Monitoring the tolerance, warning and alarm limits is switched visible in the properties of the block. The limit values are entered at the block inputs. In the case of limit violations or if the inclination of the signal does not correspond to the requirements, messages are generated and output.

Sheet 5 contains the following block:

- from_CTRL ("ComStruOu"): The communication block contains a structure, which transfer a process value, process value unit, scaling and error status (CSF and Oos) to the display.

NOTE For using the maintenance release, the output “MS_Release” of the display block must be interconnected additionally at input “MS_Release” of the channel block.

4.4 “Val_An” valve

General

The following process tag types are described below, which are used as instance in equipment modules:

- “Val_An_Afb1” for controlling an analog valve with feedback signal

4.4.1 Analog valve (continuously adjustable valves) with position feedback

The process tag type is used for controlling an analog valve with feedback signal. The control signal can be formed via a ramp function.

The block forms the manipulated value difference from the difference between the control signal and the recorded manipulated value feedback. In this way, it is able to monitor the compliance with an upper and lower limit value.

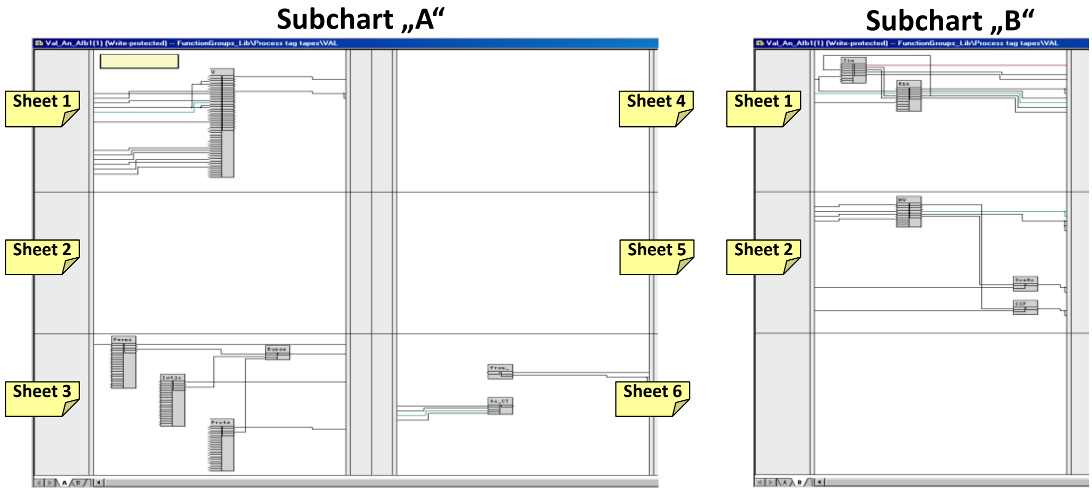
Examples for the valve process tag are:

- Controlling and monitoring a flow volume (solids, liquids and gases)
- Controlling and monitoring a flow volume with adjustable rest position

The figure below shows the structure of a valve process tag.

Figure 4-13

Figure 4-14



Subchart A

Sheet 1 contains the following block:

- V (“VlvAnL”): valve block for controlling an analog control valve and positioner

The valve block contains the external manipulated value from a controller process tag via a communication block (from_CTRL in subchart “A”, sheet 6) and controls the MV channel block (subchart “B”, sheet 2). The feedback from the control signal is given by channel block Rbk (subchart “B”, sheet 1).

NOTE The lower (MV_LoLim = “0”) and upper (MV_HiLim= “100”) limit value for limited output of the manipulated value is preconfigured. If a limited manipulated value is required, you interconnect the MV_ExtOut output.

Sheet 3 contains the following block:

- Permit (“Intlk08”): switch-on enable for the valve (“1” = enable for opening/closing the valve from rest position)

Intlock (“Intlk08”): block for calculating a standardized interlock with optional display on the OS.

- Protect (“Intlk08”): protective interlock, which after the active signal is going (“0”) requires a reset of the valve block
- BypassAct (“Or04”): forming an OR output signal of the BypAct outputs of the interlock blocks (Permit, Intlock and Protect). When bypass is active (“1”) the valve block outputs a configurable message (“bypass active”).

The interlock becomes active for an invalid process value of channel blocks Rbk and MV.

Sheet 6 contains the following communication blocks for receiving and transfer of control commands (controller process tag):

- from_CTRL (“ComStruOu”): the communication block contains a structure which transfers an external manipulated value and the operating mode (automatic mode with external manipulated value) to the valve block.
- to_CTRL (“ComStruIn”): the communication block forms a structure from outputs of the channel blocks (“Process value invalid” message, “Field device in maintenance mode”, unit and scaling of the process value and readback process value).

Subchart B

Sheet 1 contains the following blocks:

- Sim (“SimAn”): simulation block (block description in the appendix)
- Rbk (“Pcs7AnIn”): channel block for feedback of an analog input value

Simulation block “SimAn” is interconnected with channel block “Pcs7AnIn”. The default process value is “0”. The standard value (PV_Out) of the channel block is interconnected with the valve block for the manipulated value feedback.

NOTE If no simulation is used, the real process value must be interconnected at input “PV_In” of channel block PV (“Pcs7AnIn”). The simulation is deactivated by entering the value “0” at simulation block “SimAn” at input “Sim1Act0p”.

Sheet 2 contains the following blocks:

- MV (“Pcs7AnOu”): channel block for signal processing of an analog output value
- OosAct (“Or04”): formation of an OR output signal from output “OosAct” (field device in maintenance mode) of channel blocks Rbk and MV
- CSF (“Or04”): formation of an OR output signal from output “Bad” (process value invalid) of channel blocks Rbk and MV

The “PV_In” input of the channel block is interconnected with output “MV” (manipulated value) of the valve block. Additionally, the channel block is interconnected with simulation block “SimAn” (subchart “B”, sheet 1).

NOTE If no simulation is used, the real process value (e.g. positioner) must be interconnected at output “PV_Out” of channel block MV (“Pcs7AnOu”). The simulation is deactivated by entering the value “0” at simulation block “SimAn” at input “Sim2Act0p”.

4.5 “MOT” motor

General

In this process tag the motor is controlled at constant speed. A motor block monitors and controls the motor state via control signals. When using an analog value, monitoring for limit value violation is additionally possible.

Subsequently, the following process tag types are described, which are used as instance in equipment modules:

- “MOT_1sp_1fb_1cm__Std” for controlling a motor
- “MOT_spd_cl_FbDrive” for controlling drives

4.5.1 Motor with feedback

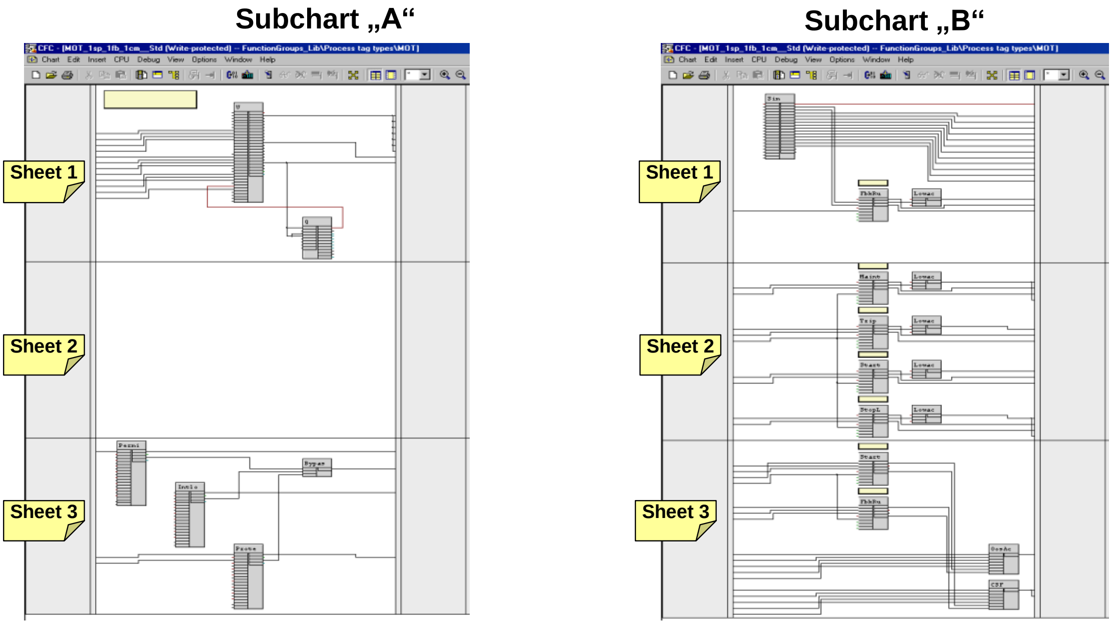
The process tag type is used for controlling a motor with feedback signals (motor on, maintenance, motor error, local starting and stopping).

Examples for the motor process tag are:

- Controlling an agitator
- Controlling a centrifugal pump with electric motor

The figure below shows the structure of a motor process tag.

Figure 4-15



Subchart „A“

Subchart „B“

Subchart A

Sheet 1 contains the following blocks:

- U (“MotL”): motor block for controlling a motor via control signals
- Q (“CountOh”): operating time of the motor since the last reset

The motor block is configured for different application options. An operating mode (local mode, automatic mode, manual mode and out of order) is selected via interconnections (CFC, SFC). For controlling the motor, the “Start” reconnection of the motor block is interconnected with the Start channel block (subchart “B”, sheet 3). The feedback for starting the motor is interconnected with the “CountOh” count block and the FbkRunOut channel block (subchart “B”, sheet 3).

Sheet 3 contains the following blocks:

- Permit (“Intlk08”): switch-on enable for the motor (“1” = enable for opening/closing the motor from rest position)
- Intlock (“Intlk08”): block for calculating a standardized interlock with optional display on the OS.
- Protect (“Intlk08”): protective interlock, which after the active signal is going (“0”) requires a reset of the motor block
- BypassAct (“Or04”): forming an OR output signal of the BypAct outputs of the interlock blocks (Permit, Intlock and Protect). When bypass is active (“1”) the motor block outputs a configurable message (“bypass active”).

The outputs of the interlock blocks are interconnected with the motor block in sheet 1. The permit interlock becomes active at an invalid process value of the channel block in subchart “B”. The protect interlock becomes active for messages of the Maint and StartLocal channelblocks (subchart “B”, sheet 2).

Subchart B

Sheet 1 contains the following blocks:

- Sim (“SimDi”): simulation block (block description in the appendix)
- FbkRun (“Pcs7DiIn”): channel block for recording a feedback signal during motor start
- LowacFbkRun (“SwLowact”): configurable inversion of the signal (block description in the appendix)

Simulation block “SimDi” is interconnected with all channel blocks in subchart “B”. The LowacFbkRun block is interconnected with motor block U. LowacFbkRun transfers the feedback for motor start from the FbkRun channel block.

For activating the simulation at the respective block inputs of the simulation block (e.g. “Sim1Act0” and “Sim1Value” for channel driver FbkRun) value “1” is default.

NOTE If no simulation is used, the real process value must be interconnected at input “PV_In” of channel block FbkRun (“Pcs7Diln”). The simulation is deactivated by entering the value “0” at simulation block “SimDi” at input “Sim1Act0p”.

Sheet 2 contains the following blocks:

- Maint (“Pcs7DiIn”): channel block for recording a maintenance request

- LowacMaint (“SwLowact”): configurable inversion of the signal (block description in the appendix)
- Trip (“Pcs7DiIn”): channel block for recording a motor failure?
- LowacTrip (“SwLowact”): configurable inversion of the signal (block description in the appendix)
- StartLocal (“Pcs7DiIn”): channel block for reporting during local operation (starting a motor)
- LowacStartLocal (“SwLowact”): configurable inversion of the signal (block description in the appendix)
- StopLocal (“Pcs7DiIn”): channel block for reporting for local operation (starting a motor)
- LowacStopLocal (“SwLowact”): configurable inversion of the signal (block description in the appendix)

The LowacMaint, LowacTrip, LowacStartLocal and LowacStopLocal blocks are interconnected with motor block U. Additionally, the LowacMaint and LowacStopLocal blocks are interconnected with the Protect interlock block.

For activating the simulation at the respective block inputs of the simulation block in sheet 1 (e.g. “Sim1Act0” and “Sim1Value” for channel driver FbkRun) the default value is “1”.

NOTE If no simulation is used, the real process values must be interconnected at the “PV_In” inputs of the “Pcs7DiIn” channel blocks. The simulation is deactivated by entering the value “0” at simulation block “SimDi” at the appropriate input, for example, “Sim1Act0p” (for channel block Maint).

Sheet 3 contains the following blocks:

- Start (“Pcs7nDiOu”): Channel block for starting/stopping the motor
- FbkRunOut (“Pcs7nDiOu”): channel block for the output of the feedback for the motor start
- OosAct (“Or08”): formation of an OR output signal from output “OosAct” (field device in maintenance mode) of all channel blocks and transfer of the status to motor block U (subchart “A”, sheet 1).
- CSF (“Or08”): formation of an OR output signal from output “Bad” (process value is invalid) of all channel blocks and transfer of the status to motor block U (subchart “A”, sheet 1). Additionally, the status is transferred to the Permit interlock block.

The “PV_In” input of the Start channel block is interconnected with output “Start” of the motor block (subchart “A”, sheet 1). Additionally, the “PV_In” input of the FbkRunOut channel block is interconnected with output “FbkRunOut” of the motor block (subchart “A”, sheet 1).

NOTE If no simulation is used, the “PV_Out” outputs must be interconnected with the real connections (e.g. motor starter) at the Start and FbkRunOut channel blocks. The simulation is deactivated by entering the value “0” at simulation block “SimDi” at inputs “Sim6Act0p” and “Sim7Act0p”.

4.5.2 Drive with standard telegram type support

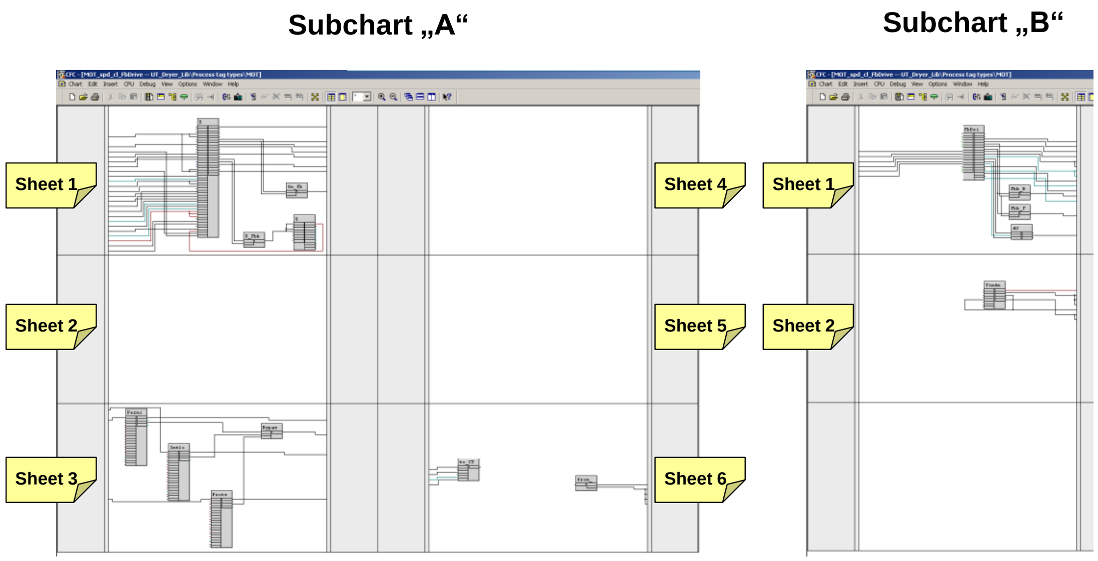
The process tag type is used for controlling a frequency-controlled drive which supports standard telegram types. The process tag type is based on the application example “Configuration of Frequency Converters with the APL Channel Block „FbDrive” under the following entry-ID: 64181993 and was expanded by additional blocks.

NOTE The expansion in comparison with the application example “Configuration of Frequency Converters with the APL Channel Block „FbDrive” is decribed below.

Examples for the motor process tag are:

- Controlling a rotary feeder
- Controlling a compressor

The figure below shows the structure of a drive process tag.



Subchart A

Sheet 1 contains the following blocks:

- S (“MotSpdCL”): controllable reversible drive
- On_Fbk (“Or04”): control of motor (forward/reverse)
- S_ Fbk (“Or04”): feedback of active operation
- Q (“CountOh”): operating time of the motor since the last reset

Sheet 3 contains the following blocks:

- Permit (“Intlk08”): switch-on enable for the drive (“1” = enable for opening/closing the drive from rest position)

- Intlock (“Intlk08”): block for calculating a standardized interlock with optional display on the OS.
- Protect (“Intlk08”): protective interlock, which after the active signal is going (“0”) requires a reset of the drive block
- BypassAct (“Or04”): forming an OR output signal of the BypAct outputs of the interlock blocks (Permit, Intlock and Protect). When bypass is active (“1”) the drive block outputs a configurable message (“bypass active”).

The outputs of the interlock blocks are interconnected with the drive block in sheet 1.

Sheet 1 contains the following blocks:

- FbDrive (“FbDrive”): channel block for compact drives
- Fbk_Rev (“And04”): feedback of reverse operation
- Fbk_Fwd (“And04”): feedback of forward operation
- AV (“AV”): additional analog value

Sheet 6 contains the following communication blocks for receiving and transfer of control commands (controller process tag):

- from_CTRL (“ComStruOu”): the communication block contains a structure which transfers an external manipulated value and the operating mode (automatic mode with external manipulated value) to the valve block.
- to_CTRL (“ComStruIn”): the communication block forms a structure from outputs of the channel blocks (“Process value invalid” message, “Field device in maintenance mode”, unit and scaling of the process value and readback process value).

Subchart B

Sheet 2 contains the following block:

- Sim (“SimDi”): simulation block (block description in the appendix)

Simulation block “SimDi” is interconnected with the technological block (drive block) in subchart “A”.

NOTE If no simulation is used, the “Sim1ActOp” input of the simulation block must be deactivated and the required inputs of the “FbDrive” channel block to be interconnected.

5 Equipment Modules

This chapter contains all relevant information on each equipment module including its specific properties. Structure and basic functionality of the used process tag types is described in chapter 4 “Control Module”.

The following equipment modules are described below:

- “Level-Control” filling level
- “Ratio-Control”
- “Split-Range-Pressure” control
- “Split-Range-Temperature” control
- Control of the pH value with a standard controller „pH-Control-Std“
- Control of the pH value with a multi-variable controller „pH-Control-MPC“
- “Temperature-Flow-Cascade”

5.1 “Level-Control” filling level

For filling level control, feedstock components are fed into a container via a feed pipe and the substance mixture is drained via a drain outlet. The controller reacts to deviations of the filling level (difference between inflow and discharge volume) and controls these either via reducing or increasing the inflow or drainage.

The example below solves the filling level control via the drainage (drain outlet).

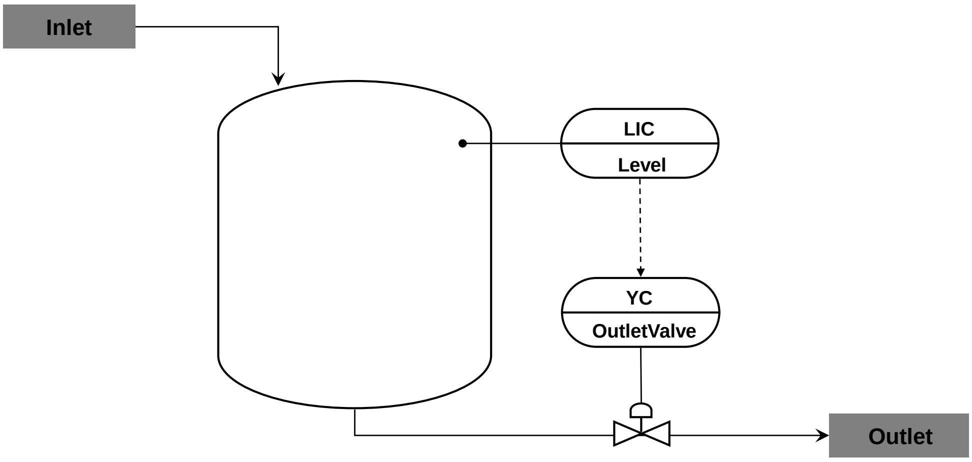
5.1.1 Overview

The structure is displayed in a P&I diagram below and all process tags and the simulation of the equipment module are described.

P&I diagram

The following P&I diagram represents all components relevant for the operation, such as aggregates, containers, etc. as symbols.

Figure 5-1



Process tags

The equipment module “Level-Control” consists of 3 interconnected process tags and one simulation chart. In the simulation chart the filling level of a container is simulated.

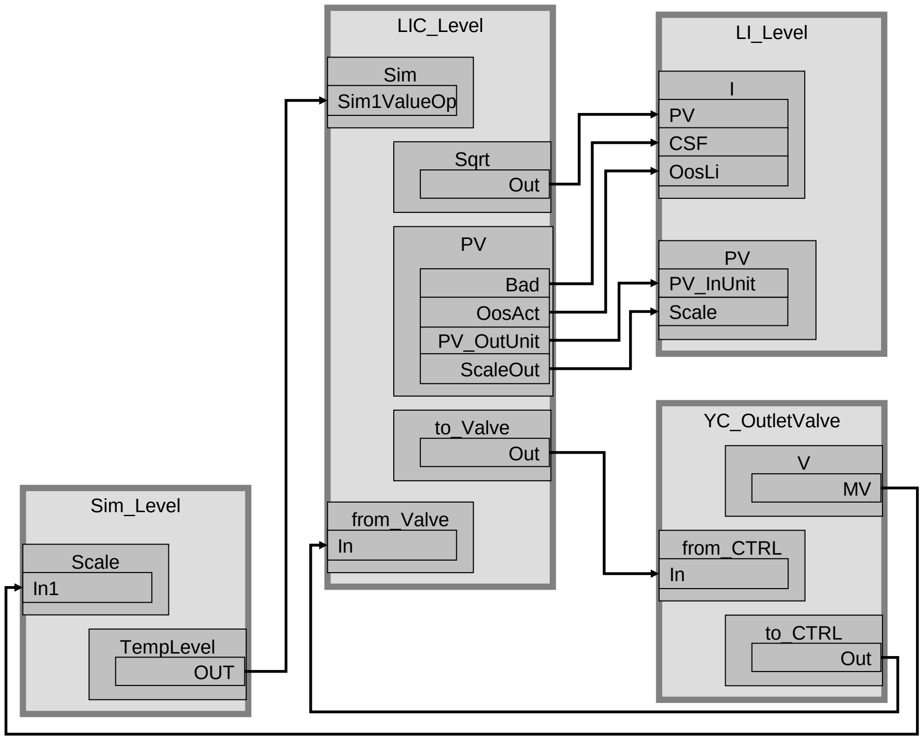
The following table provides an overview of the process tags of the equipment module including the respective process tag types.

Table 5-1

Process tag	Process tag type	Description
LIC_Level	“CTRL_Std”	Filling level control of a container
LI_Level	“AMON__Std“	Measured value display for the filling level of a container
YC_OutletValve	“Val_An_Afb1”	Control valve for the drain outlet

In the following figure the entire structure, including all interconnections across all CFC charts, are represented in a simplified format.

Figure 5-2



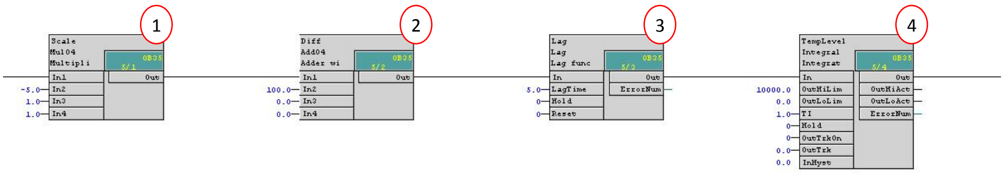
Controller process tag “LIC_Level” detects the filling level of the container (simulation chart “Sim_Level”) and controls it using the “YC_OutletValve” control valve. Process tag “LI_Level” shows the process value (filling level). Additionally, faults in the valve process tag set the controller process tag to manual mode and are displayed at both process tags.

5.1.2 Structure and configuration

Simulation “Sim_Level”

The filling level of the container is simulated in CFC chart “Sim_Level”. The graphic representation below shows the sequence of the simulation.

Figure 5-3



1. Calculating the flow rate (100 % opened valve corresponds to a drainage of 500 l/s from the container)
2. Permanent inflow into the container (100 l/s)
3. Delaying the flow rate change (PT1 behavior with 5 seconds delay)
4. Forming an integral value through integrating the flow rate change (each second)

LIC_Level

In the “LIC_Level” process tag the filling level of the container is recorded and transferred to the “LI_Level” process tag for measured value display. The setpoint is specified in this process tag. In order to control the filling level, control signals are transferred to the “YC_OutletValve” valve process tag via a communication block.

The “LIC_Level” controller process tag was created from the “CTRL__Std” process tag type and expanded by two communication blocks (“to_Valve” and “from_Valve”).

The following table shows the configuration of the instance from “CTRL__Std”.

Table 5-2

Block	Connection	Value	Usage
C	NegGain.Value	1	Activating the negative gain, since the control is used for the drain outlet
C	Gain.Value	2.0	Controller gain
C	TI.Value	300.0	Controller delay
C	SP_InHiLim	10000.0	Maximal value of the internal setpoint
Intlock	InvIn02	1	Inverting the hardware error signal of the valve process tag
Intlock	InvIn03	1	Inverting the “Out of service” signal of the valve process tag
ComStruIn			Inserted as “to_Valve”, for transfer of control signals to the valve process tag
to_Valve	Out		Interconnecting to the valve (control) (YC_OutletValve\from_CTRL.In)
to_Valve	ReStru1		Interconnecting the manipulated value to the valve

Block	Connection	Value	Usage
			(LIC_Level\C.MV)
to_Valve			Inserted as “from_Valve” to receive status information of the valve process tag
ComStruOut			Interconnecting to the valve (status)
from_Valve	In		(YC_OutletValve\to_CTRL.Out)
from_Valve	Int1		Interconnecting the unit of the manipulated value (LIC_Level\MV.PV_InUnit)
from_Valve	BoStru1		Interconnecting the hardware error from the valve to the interlock block
from_Valve	BoStru2		Interconnecting the “Out of service” signal from the valve to the interlock block (LIC_Level\Intlock.In02)
Sim	Sim1ActOp.Value	1	Activating the simulation of the container filling level
Sim	Sim1ValueOp		Interconnecting to the simulated filling level
Sim	Sim2ActOp.Value	1	(Sim_Level\TempLevel.Out)
Sim	Sim2ValueOp		Activating the simulation of the manipulated value
PV	Scale	10000.0	Maximum value of the process value
PV	PV_InUnit	1038	Unit of the process value (L)
PV	Bad		Interconnecting the hardware error from the channel block to the process tag for the process value display
PV	PV_OutUnit		(LI_Level\I.CSF)
PV	ScaleOut		Interconnecting the unit from the process value to the process tag for the process value display
PV	OosAct		(LI_Level\PV.PV_InUnit)
Sqrt	Out		Interconnecting the process value to the display block (LIC_Level\I.PV)

LI_Level

In the “LI_Level” process tag, the measured value of the channel block of the “LIC_Level” process tag is displayed. Limit values (alarm, warning) are not set in the operator control and monitoring block (MonAnL), since these are defined specifically for each process.

The following table shows the configuration of the instance from “AMON__Std”.

Table 5-3

Block	Connection	Value	Usage
I	PV		New interconnection to the process value of the controller process tag (LIC_Level\Sqrt.Out)
I	OosLi		New interconnection to the “Out of

Block	Connection	Value	Usage
			service” signal of the channel block of the controller process tag (LIC_Level\PV.OosAct)
I	CSF		New interconnection to the “Bad” signal of the channel block of the controller process tag (LIC_Level\PV.Bad)
PV	Scale		Interconnecting the scaling of the manipulated value (LIC_Level\PV.ScaleOut)
PV	PV_InUnit		Interconnecting the unit of the process value (LIC_Level\PV.PV_OutUnit)

YC_OutletValve

The “YC_OutletValve” process tag controls the flow volume (opens the drain outlet of the container). The process tag contains communication blocks for data exchange (control signals and control commands) with the controller process tag.

Valve block “V” receives an external manipulated value (via a communication block) from the controller process tag. Both channel blocks in subchart “B” (Rbk and MV) receive the same value in a simulation environment (manipulated value of the valve block (subchart “A”, sheet 1)) via the preceding simulation block.

The following table shows the configuration of the instance from “Val_An_Afb1”.

Table 5-4

Block	Connection	Value	Usage
V	MV		Interconnecting to the simulation (Sim_Level\Scale.In1)
V	ER_AH_En	0	Switching off the alarm message for maximal valve opening
V	(invisible)	0	Switching off the alarm message for minimal valve opening
from_CTRL	In		Interconnection to the controller (LIC_Level\to_Valve.Out)
to_CTRL	Out		Interconnection to the controller (LIC_Level\from_Valve.In)
Sim	Sim1ActOp.Value	1	Activating the simulation of the readback value
Sim	Sim1ValueOp		Interconnecting with the simulation of the readback value from the valve (YC_OutletValve\V.MV)
Sim	Sim2ActOp.Value	1	Activating the simulation of the manipulated value
Sim	Sim2ValueOp		Interconnecting with the simulation of the manipulated value from the valve (YC_OutletValve\V.MV)
Rbk	PV_OutUnit		Interconnecting the unit of the manipulated value of the valve (YC_OutletValve\to_CTRL.Int1)

5.1.3 Commissioning, operation and instance-specific adjustments

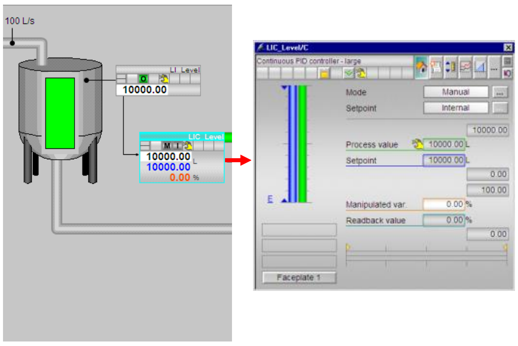
Commissioning and operation requires a downloaded user program in automation system (AS) or S7-PLCSIM, and an activated OS (WinCC Runtime). Instructions for downloading the user program and activating the OS are available in chapter 7 “Starting the Equipment Module”

Commissioning

Please wait 3 minutes after the start of the CPU (in the initial state) until the container reaches the maximum filling level.

For commissioning, please follow the instructions below:

Table 5-5

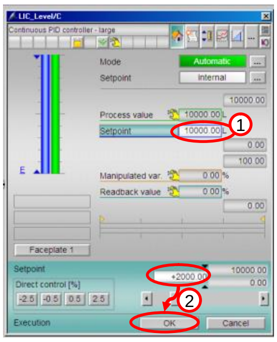
No.	Action
1.	Click on the block icon of the “LIC_Level” controller. The respective faceplate is opened.  LIC_Level/C Continuous PID controller - large Mode: Manual Setpoint: Internal 10000.00 Process value: 10000.00 L Setpoint: 10000.00 L 0.00 100.00 Manipulated var.: 0.00 % Readback value: 0.00 % 0.00 Faceplate 1
2.	Change the operating mode of the controller. In the faceplate you click on the “…” button next to the mode switch (“Mode”) and in the faceplate extension you click on the “Automatic” button and adopt the settings with “OK”.
3.	For changing the setpoint value you click on the “Setpoint” input field and enter the setpoint value in the faceplate expansion. Acknowledge the input with “ENTER” and adopt the new value with “OK”.

Operation

The following instruction describes the operation of the equipment module “Level Control”.

In the following scenario, the filling level is reduced from 10000 L auf 2000 L.

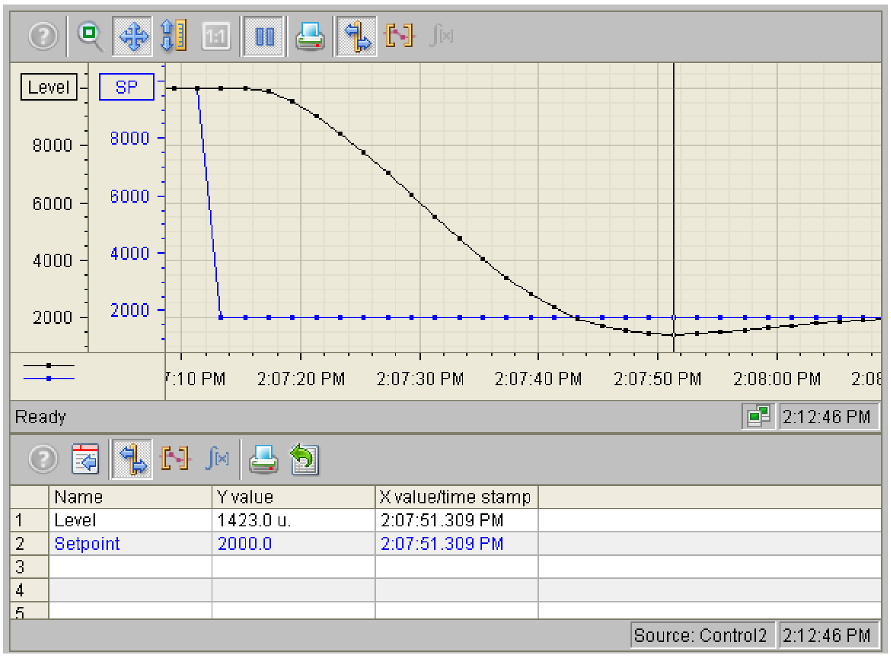
Table 5-6

No.	Action
1.	Click on the block icon of the “LIC_Level” controller and click into the “Setpoint” input field.
2.	In the faceplate expansion you enter the new setpoint of 2000. Then acknowledge the input with the “Enter” key and click on the “OK” button.  Mode: Automatic Setpoint: Internal Process value: 10000.00 L Setpoint: 10000.00 L Manipulated var.: 0.00 % Readback value: 0.00 % Setpoint: +2000.00 also set using an external setpoint value in this step.

Evaluation

In order to illustrate the principle of operation of the filling level control, the controller was configured so the setpoint value is reached quicker. Due to this configuration, the filling level slightly overshoots during controlling.

Figure 5-4



	Name	Y value	X value/time stamp
1	Level	1423.0 u.	2:07:51.309 PM
2	Setpoint	2000.0	2:07:51.309 PM
3			
4			
5			

Instance-specific adjustments

The following tables contain the relevant parameters which must either be set or interconnected. Chapter 6.2 “Process connection” describes the procedure for connecting process devices.

The following table contains the parameters to be set specifically for each process.

Table 5-7

Process tag	Block	Connection	Usage
LI_Level	I Subchart “A”	PV_AH_En	Alarm for exceeded limit value, if PV ≥ PV_AH_Lim
LI_Level	I Subchart “A”	PV_WH_En	Warning for exceeded limit value, if PV ≥ PV_WH_Lim
LI_Level	I Subchart “A”	PV_WL_En	Warning for falling below the limit value, if PV ≥ PV_WL_Lim
LI_Level	I Subchart “A”	PV_AL_En	Alarm for falling below the limit value, if PV ≥ PV_AL_Lim
LIC_Level	C Subchart “A”	Gain	Proportional gain
LIC_Level	C Subchart “A”	TD	Derivative time (rate time) in [s]
LIC_Level	C Subchart “A”	TI	Integral time (reset time) in [s]
LIC_Level	C Subchart “A”	SP_InHiLim	Limit value (high) of the internal
LIC_Level	C Subchart “A”	SP_InLoLim	Limit value (low) of the internal setpoint value
LIC_Level	C Subchart “A”	PV_AH_En	Alarm for exceeded limit value, if PV ≥ PV_AH_Lim
LIC_Level	C Subchart “A”	PV_WH_En	Warning for exceeded limit value, if PV ≥ PV_WH_Lim
LIC_Level	C Subchart “A”	PV_TH_En	Warning for falling below the limit value, if PV ≥ PV_TH_Lim
LIC_Level	C Subchart “A”	PV_TL_En	Tolerance for falling below the limit value, if PV ≤ PV_TL_Lim
LIC_Level	C Subchart “A”	PV_WL_En	Warning for falling below the limit value, if PV ≥ PV_WL_Lim
LIC_Level	C Subchart “A”	PV_AL_En	Alarm for falling below the limit value, if PV ≥ PV_AL_Lim
LIC_Level	C Subchart “A”	ER_AH_En (invisible)	Alarm for exceeded error signal, if ER ≥ ER_AH_Lim
LIC_Level	C Subchart “A”	ER_AL_En (invisible)	Alarm for fallen short of error signal, if ER ≥ ER_AL_Lim
LIC_Level	PV Subchart “A”	Scale	Scaling the measured value (e.g. container filling level of max. 10000)

Process tag	Block	Connection	Usage
LIC_Level	PV Subchart “A”	PV_InUnit	Unit of the scaled measured value (e.g. “1038” filling level in liters)
YC_OutletValve	V Subchart “A”	MV_HiLim MV_LoLim	Upper and lower limit of the manipulated value
YC_OutletValve	MV Subchart “A”	Scale	Scaling the manipulated variable (manipulated value from the valve block)
YC_OutletValve	Subchart “A”	PV_InUnit	Unit of the scaled manipulated variable

NOTE For commissioning the “LIC_Level” controller the “PID-Tuner” program is available. Chapter 6.3 “Configuration of the PID controllers” describes the procedure for optimizing the controller.

The following table contains an overview of parameters to be interconnected with process devices.

Table 5-8

Process Tag	Block	Connection	Usage
LIC_Level	PV Subchart “B”	PV_In	Recording the container filling level
YC_OutletValve	Rbk Subchart “B”	PV_In	Manipulated variable feedback
YC_OutletValve	MV Subchart “B”	PV_Out or PV_ChnST	Output of the manipulated variable or output of the manipulated variable including signal status of the output signal

NOTE In the object properties of the message-capable blocks you can configure instance-specific messages. An instruction for the procedure is available in the configuration manuals “Process Control System PCS 7 Operator Station (V7.1)” under the following entry ID: 36194551 and “SIMATIC Process Control System PCS 7 Operator Station (V8.0)” under the entry ID: 57270173.

5.1.4 Different requirements regarding the filling level control in industrial processes

Depending on the task to be fulfilled by a container or tank in an industrial process plant, the objectives of filling level control are of different natures:

1. The filling level shall be kept at a specified setpoint as exactly as possible, e.g. in a reactor or in the sump of a distillation column. This is required, if the filling level has an effect on chemical reactions or separation processes, i.e. it is significant for the process. Variations in the inflow (feed) are compensated via the outlet.
2. A container (e.g. a tank) is used as a buffer, so as to keep the inflow and drain as constant as possible. In this case, filling level control is not based on a fixed

setpoint, but shall remain within the permissible limits. This type of task is referred to as "buffered level control".

For the first type of task we recommend the use of a standard structure with a PID tuner, whereby most filling level control operations are integral action processes (using a manipulated value). In some cases a P-controller (without I-action) is sufficient, as it harmonizes better with the dynamics of the integrated process, although it shows persistent control deviations in case of feed disturbances. If the valve curve does not show a linear profile, we recommend the use of a cascade structure with a master controller for the filling level and a slave controller for the outlet (precondition: flow rate measurement at the outlet).

The second type of task (buffered level control) requires a different behavior which applies to the majority of applications in practice. In this case, variations in the inflow (feed) are compensated by means of the tank volume.

This can be realized in two different ways: Instead of continuously measuring the filling level and adjusting it to a defined setpoint, the minimum and maximum limits are monitored with the help of binary (e.g. capacitive) level switches. This solution is not based on a continuous control system, but uses an event-discrete control system, i.e. the inflow or outflow are shut-off via a binary signal from a level switch.

The second solution is based on a controller which is purposely set to a slower speed. In the course of configuration, the maximum admissible deviation Δh_{max} of the filling level from the setpoint (most often 50% of the tank height) and the maximum erratic inflow disturbances d_{max} to be expected are defined. With regard to persistent control errors, the gain of the P controller must be set to a value larger than $Gain=d_{max}/\Delta h_{max}$. A PI controller can also be configured, so that the maximum filling level adjustment in case of erratic disturbances is smaller than d_{max}. The Dachema seminar on "Process control systems – from the basics to advanced control applications" (see /2/ in section 8.1 “Further literature”) recommends to use the following formulas:

$GainEff=0.7358d_{max}/\Delta h_{max}$

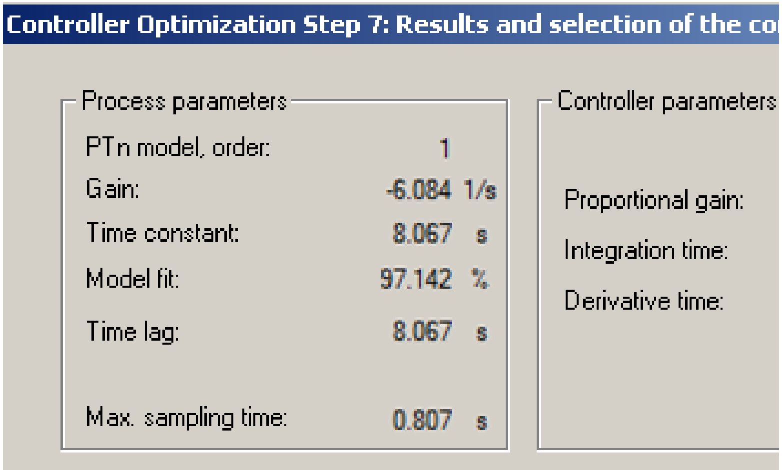
$Ti= 5.4366/K_i *\Delta h_{max}/ d_{max}$

Note The physical controller gain corresponds to [MV_Unit/PV_Unit]. In the case of normalization (NormPV ≠ NormMV), the gain must be recalculated according to the following formula:

Gain = GainEff * (NormPV.High - NormPV.Low)/(NormMV.High - NormMV.Low)

The integration constant K_i of the control loop in the unit [PV_Unit/s] can be determined with the PID tuner. The integration constant is available under "Gain" in the "Process parameter" area.

Figure 5-5: PID tuner for integral process



Controller Optimization Step 7: Results and selection of the co

Process parameters

PTn model, order:	1	
Gain:	-6.084	1/s
Time constant:	8.067	s
Model fit:	97.142	%
Time lag:	8.067	s
Max. sampling time:	0.807	s

Controller parameters

Proportional gain:

Integration time:

Derivative time:

5.2 Ratio-Control

With ratio control, feedstock components or various gases are fed into a container in a fixed mixing ratio via inlet pipes.

Ratio control consists of a controller for the main component (master controller) and one each controller for each further additional component (slave controller).

The example below describes the control for an inflow consisting of two components.

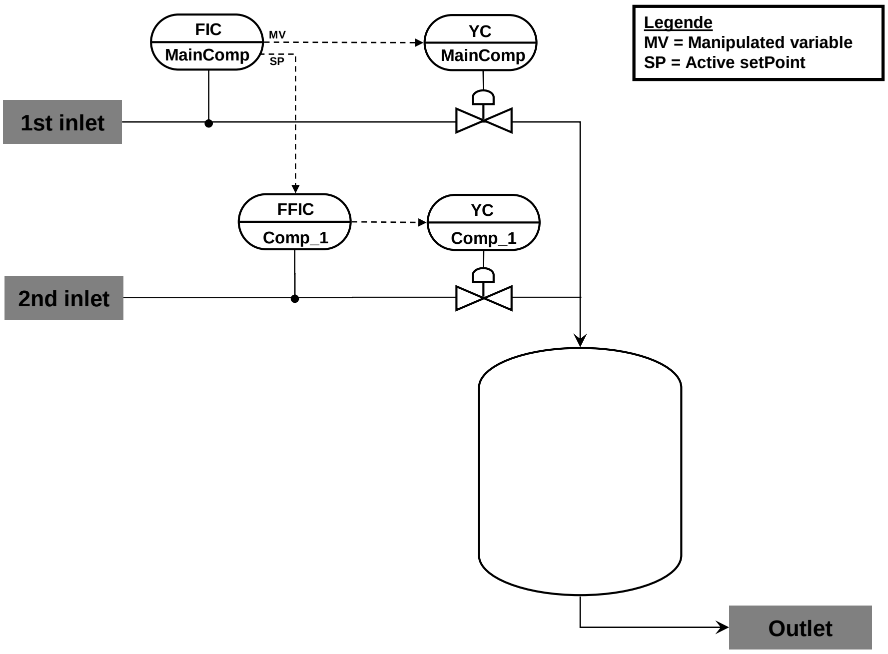
5.2.1 Overview

The structure is displayed in a P&I diagram below and all process tags and the simulation of the equipment module are described.

P&I diagram

The following P&I diagram represents all components relevant for the operation, such as aggregates, containers, etc. as symbols.

Figure 5-6



Process tags

The equipment module “Ratio-Control” consists of 6 interconnected process tags and one simulation chart. The inflow total (of the components) is formed and displayed in the simulation chart.

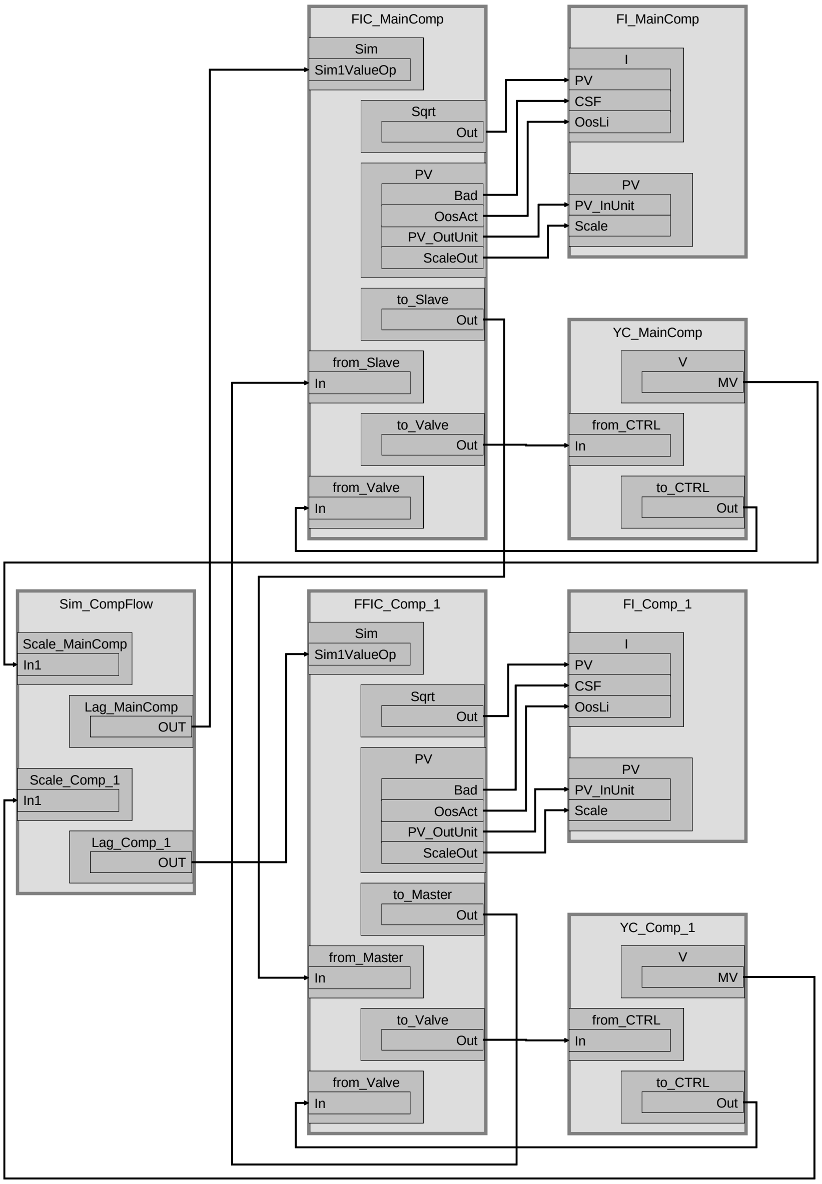
The following table provides an overview of the process tags of the equipment module including the respective process tag types.

Table 5-9

Process tag	Process tag type	Description
FIC_MainComp	“CTRL_RatioMain”	Flow control of the main component
FFIC_Comp_1	“CTRL_RatioComp”	Flow control of the main additional component
FI_MainComp	“AMON_Flow”	Flow rate display of the main component
FI_Comp_1	“AMON_Flow”	Flow rate display of the additional component
YC_MainComp	“Val_An_Afb”	Control valve for the main component
YC_Comp_1	“Val_An_Afb1”	Control valve for the additional component

In the following figure the entire structure, including all interconnections across all CFC charts, are represented in a simplified format.

Figure 5-7



Controller process tag “FIC_MainComp” detects the flow rate of the main component and controls it using the “YC_MainComp” control valve. The “FI_MainComp” process tag indicates the process value (flow rate) and the status values of the “FIC_MainComp” process tag.

Additionally, “FIC_MainComp” transfers the own setpoint value to process tag “FFIC_Comp_1”. “FIC_MainComp” is subsequently the master controller for “FFIC_Comp_1”.

Controller process tag “FFIC_Comp_1” detects the flow rate of the additional component and controls it using the “YC_Comp_1” control valve. The “FI_Comp_1” process tag uses the process value (flow rate) and the status values of the “FIC_Comp_1” process tag.

The setpoint value contains “FFIC_Comp_1” from the “FIC_MainComp” process tag, so “FFIC_Comp_1” is the slave controller.

Master controller “FIC_MainComp” receives information about hardware state and operating state (“Out of service”) from the respective process tag “YC_MainComp” and slave controller “FFIC_Comp_1”. Furthermore, the slave controller transfers additional information, whether the cascade was separated or whether the slave controller follows the master controller as intended. As soon as a hardware error or the operating state “Out of service” occurs, or the cascade was separated for other reasons, the “Interlock“ is triggered and master and slave controller go to tracking mode.

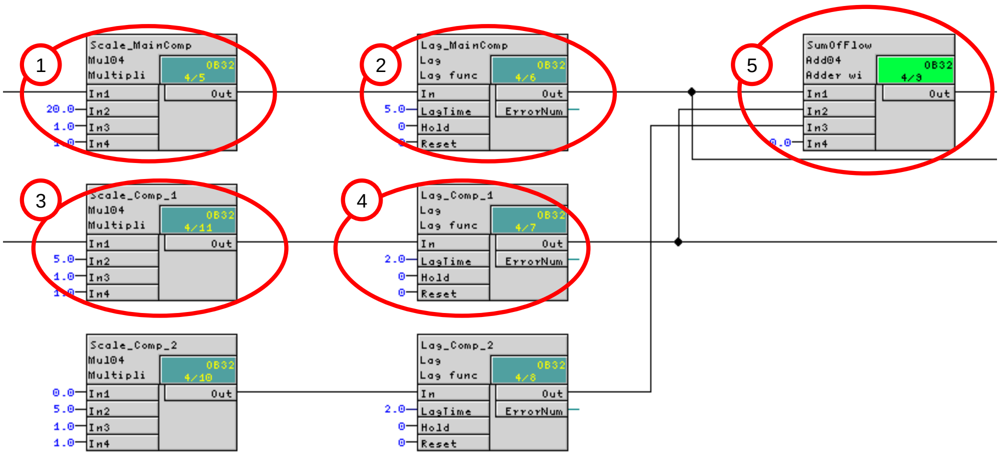
5.2.2 Structure and configuration

Simulation „Sim_CompFlow“

In CFC chart “Sim_CompFlow” the flow rate of the main component and the additional components are simulated and the entire flow volume is calculated. Additionally, the flow volume is indicated on the basis of process tag type “AMON_Flow”.

The graphic representation below shows the sequence of the simulation.

Figure 5-8



1. Calculating the flow rate for the main component (100 % opened valve corresponds to an inflow of 2000 l/h)
2. Delaying the flow rate change (PT1 behavior with 5 seconds delay)
3. Calculating the flow rate for the additional component (100 % opened valve corresponds to an inflow of 500 l/h)

4. Delaying the flow rate change (PT1 behavior with 2 seconds delay)
5. Determining the entire flow volume (addition)

Inputs “In1” of the selected blocks 1 and 3 receive their manipulated values from the “I” valve blocks of the “YC_MainComp” and “YC_Comp_1” process tags. Outputs “Out” of the selected blocks 2 and 4 are interconnected with the process tag for process value display and the controller process tags of the respective component.

FIC_MainComp

Process tag “FIC_MainComp” records the flow rate of the main component and transfers it to the “FI_MainComp” process tag for measured value display. In order to control the flow rate, control signals are transferred to the “YC_MainComp” process tag via a communication block.

The setpoint value is transferred to the controller process tag(s) of the additional component(s). Due to using the setpoint value instead of the manipulated value, the controller structure does **not** correspond to a typical cascade control.

NOTE In communication block “to_Slave” the process value and the manipulated value are transferred in addition to the setpoint value. The control result depends on the reaction times of the main component and the additional component. In the application example the reaction times of main component and additional component are very similar, therefore, the setpoint value is used.

The following table shows the configuration of the instance from “CTRL_RatioMain”.

Table 5-10

Block	Connection	Value	Usage
C	Gain.Value	5.0e-2	Controller gain (proportional gain)
C	TI.Value	4.1	Controller gain (integral time)
C	SP_InHiLim	2000.0	Maximal value of the internal setpoint
to_Valve	Out		Interconnection to the valve (controlling) (YC_MainComp\from_CTRL.In)
from_Valve	In		Interconnecting to the valve (status) (YC_MainComp\to_CTRL.Out)
to_Slave	Out		Interconnection to the slaves (controlling) (FFIC_Comp_1\from_Master.In)
from_Slave_1	In		Interconnection to the slaves (controlling) (FFIC_Comp_1\from_Master.In)
Sim	Sim1ValueOp		Interconnecting to the simulated process value (Sim_CompFlow\Lag_MainComp.Out)
PV	PV_OutUnit		Interconnecting the unit from the process value to the process tag for the process value display (FI_MainComp\PV.PV_InUnit)
PV	ScaleOut		Interconnecting the scaling from the process value to the process tag for the process value display (FI_MainComp\PV.Scale)

Block	Connection	Value	Usage
PV	OosAct		Interconnecting the “Out of service” signal from the process tag for the process value display (LI_MainComp\I.OosLi)
PV	Bad		Interconnecting the hardware error from the channel block to the display block (FI_MainComp\I.CSF)
Sqrt	Out		Interconnecting the process value to the display block (FI_MainComp\I.PV)

FFIC_Comp_1

Process tag “FIC_Comp_1” records the flow rate of the additional component and transfers it to the “FI_Comp_1” process tag for measured value display. In order to control the flow rate, control signals are transferred to the “YC_Comp_1” process tag via a communication block.

In automatic mode, the “FFIC_Comp_1” process tag uses the setpoint value from master controller “FIC_MainComp”, which is converted, i.e. multiplied with a defined ratio factor, to a setpoint value for the added component using a ratio block.

The following table shows the configuration of the instance from “CTRL_RatioComp”.

Table 5-11

Block	Connection	Value	Usage
C	Gain.Value	0.25	Controller gain
C	TI.Value	2.2	Controller delay
C	SP_InHiLim	500.0	Maximal value of the internal setpoint
to_Valve	Out		Interconnection to the valve (controlling) (YC_Comp_1\from_CTRL.In)
from_Valve	In		Interconnecting to the valve (status) (YC_Comp_1\to_CTRL.Out)
to_Master	Out		Interconnection to the master (FIC_MainComp\from_Slave_1.In)
from_Master	In		Interconnection to the master (controlling) (FIC_MainComp\to_Slave_1.Out)
Sim	Sim1ValueOp		Interconnecting to the simulated process value (Sim_CompFlow\Lag_Comp_1.Out)
PV	PV_OutUnit		Interconnecting the unit from the process value to the process tag for the process value display (FI_Comp_1\PV.PV_InUnit)
PV	ScaleOut		Interconnecting the scaling from the process value to the process tag for the process value display (FI_Comp_1\PV.Scale)
PV	OosAct		Interconnecting the “Out of service” signal from the process tag for the process value display (LI_Comp_1\I.OosLi)

Block	Connection	Value	Usage
PV	Bad		Interconnecting the hardware error from the channel block to the display block (FI_Comp_1\I.CSF)
Sqrt	Out		Interconnecting the process value to the display block (FI_ Comp_1\I.PV)

FI_MainComp

In the “LI_MainComp” process tag the measured value of the channel block of the “LIC_MainComp” process tag is displayed. Limit values (alarm, warning) are not set in the operator control and monitoring block (MonAnL), since these are defined specifically for each process.

The following table shows the configuration of the instance from “AMON__Flow”.

Table 5-12

Block	Connection	Value	Usage
I	PV		New interconnection to the process value of the controller process tag (FIC_MainComp\Sqrt.Out)
I	OosLi		New interconnection to the “Out of service” signal of the channel block of the controller process tag (FIC_MainComp \PV.OosAct)
I	CSF		New interconnection to the “Bad” signal of the channel block of the controller process tag (FIC_MainComp\PV.Bad)
PV	Scale		Interconnection to the scaling of the process value (FIC_MainComp\PV.ScaleOut)
PV	PV_InUnit		Interconnection to the unit of the process value (FIC_MainComp\PV.PV_OutUnit)

FI_Comp_1

In the “LI_Comp_1” process tag the measured value of the channel block of the “LIC_Comp_1” process tag is displayed. Limit values (alarm, warning) are not set in the operator control and monitoring block (MonAnL), since these are defined specifically for each process.

The following table shows the configuration of the instance from “AMON__Flow”.

Table 5-13

Block	Connection	Value	Usage
I	PV		New interconnection to the process value of the controller process tag (FFIC_Comp_1\Sqrt.Out)
I	OosLi		New interconnection to the “Out of service” signal of the channel block of the controller process tag (FFIC_Comp_1\PV.OosAct)
I	CSF		New interconnection to the “Bad” signal of the channel block of the controller process tag (FFIC_Comp_1\PV.Bad)
PV	Scale		Interconnection to the scaling of the process value

Block	Connection	Value	Usage
			(FFIC_Comp_1\PV.ScaleOut)
PV	PV_InUnit		Interconnection to the unit of the process value (FFIC_Comp_1\PV.PV_OutUnit)

YC_MainComp

Valve process tag “YC_MainComp” controls the flow rate of the main component. The process tag contains communication blocks for data exchange (control signals and control commands) with the controller process tag.

Valve block “V” receives an external manipulated value (via a communication block) from the controller process tag. Both channel blocks in subchart “B” (Rbk and MV) receive the same value as the process value (manipulated value of the valve block (subchart “A”, sheet 1)) via the preceding simulation block.

The following table shows the configuration of the instance from “Val_An_Afb1”.

Table 5-14

Block	Connection	Value	Usage
V	MV		Interconnecting to the simulation (Sim_CompFlow\Scale_MainComp.In1)
from_CTRL	In		Interconnection to the controller (controlling) (FIC_MainComp\to_Valve.Out)
to_CTRL	Int1		Interconnection deleted (YC_MainComp\Rbk.PV_OutUnit)
to_CTRL	Scale1		Interconnection deleted (YC_MainComp\Rbk.ScaleOut)
to_CTRL	Out		Interconnection to the controller (status) (FIC_MainComp\from_Valve.In)
Sim	Sim1ActOp.Value	1	Activating the simulation of the readback value
Sim	Sim1ValueOp		Interconnecting with the simulation of the readback value from the valve (YC_MainComp\V.MV)
Sim	Sim2ActOp.Value	1	Activating the simulation of the manipulated value
Sim	Sim2ValueOp		Interconnecting with the simulation of the manipulated value from the valve (YC_MainValve\V.MV)
MV	PV_OutUnit		Interconnecting the unit of the manipulated value of the valve (YC_MainComp\to_CTRL.Int1)

YC_Comp_1

Valve process tag “YC_Comp_1” controls the flow rate of the additional component. The process tag contains communication blocks for data exchange (control signals and control commands) with the controller process tag.

Valve block “V” receives an external manipulated value (via a communication block) from the controller process tag. Both channel blocks in subchart “B” (Rbk and MV) receive the same value (manipulated value of the valve block (subchart “A”, sheet 1)) via the preceding simulation block.

The following table shows the configuration of the instance from “Val_An_Afb1”.

Table 5-15

Block	Connection	Value	Usage
V	MV		Interconnecting to the simulation (Sim_CompFlow\Scale_Comp_1.In1)
from_CTRL	In		Interconnection to the controller (controlling)
to_CTRL	Int1		Interconnection deleted (YC_Comp_1\Rbk.PV_OutUnit)
to_CTRL	Scale1		Interconnection deleted (YC_Comp_1\Rbk.ScaleOut)
to_CTRL	Out		Interconnection to the controller (status) (FFIC_Comp_1\from_Valve.In)
Sim	Sim1ActOp.Value	1	Activating the simulation of the readback value
Sim	Sim1ValueOp		Interconnecting with the simulation of the readback value from the valve (YC_Comp_1\V.MV)
Sim	Sim2ActOp.Value	1	Activating the simulation of the manipulated value
Sim	Sim2ValueOp		Interconnecting with the simulation of the manipulated value from the valve (YC_Comp_1\V.MV)
MV	PV_OutUnit		Interconnecting the unit of the manipulated value of the valve (YC_Comp_1\to_CTRL.Int1)

5.2.3 Commissioning, operation and instance-specific adjustments

Commissioning and operation requires a downloaded user program in automation system (AS) or S7-PLCSIM, and an activated OS (WinCC Runtime). Instructions for downloading the user program and activating the OS are available in chapter 7 “Starting the Equipment Module”.

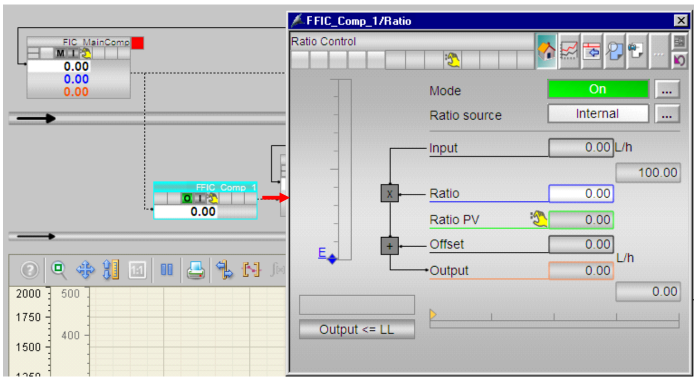
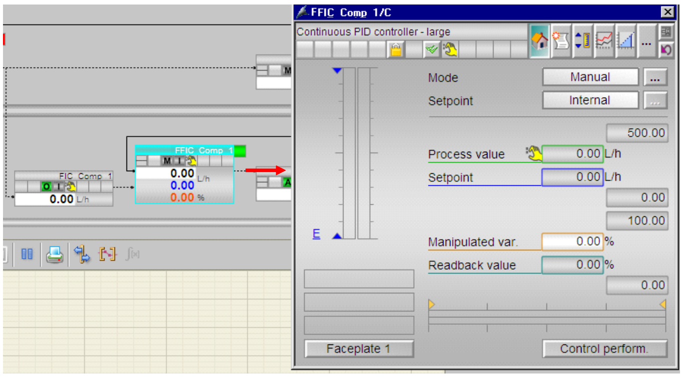
Commissioning

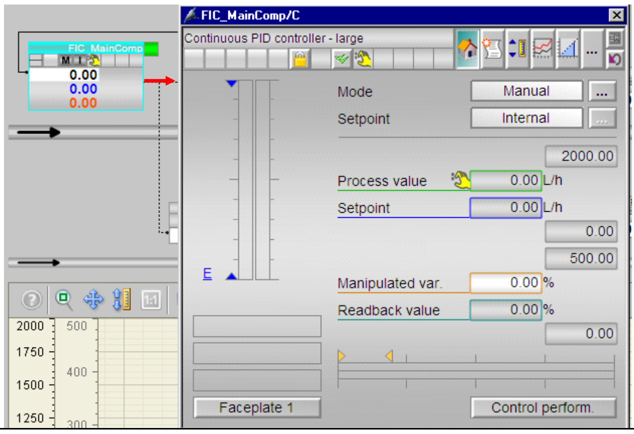
After starting the CPU (in the initial state) both controllers and the valve for the main component are in manual mode. The valve for the additional component is in automatic mode.

Due to the manual controller mode for additional component “FFIC_Comp_1” the controller for main component “FIC_MainComp” is locked (Interlock function). Therefore, the automatic mode of the main controller and the external setpoint value cannot be activated.

For commissioning, please follow the instructions below:

Table 5-16

No.	Action
1.	Click on the block icon for ratio block “FFIC_Comp_1/Ratio” to set the ratio between additional and main component.  FFIC_Comp_1/Ratio Ratio Control Mode: On Ratio source: Internal Input: 0.00 L/h 100.00 Ratio: 0.00 Ratio PV: 0.00 Offset: 0.00 L/h Output: 0.00 0.00 Output <= LL
2.	Click on the “Ratio” input field and enter the ratio 0.25 in the faceplate extension. Acknowledge the input with the “ENTER” key and click on the “OK” button.
3.	Click on the block icon of the “FFIC_Comp_1/C” controller. The respective faceplate is opened.  FFIC_Comp_1/C Continuous PID controller - large Mode: Manual Setpoint: Internal 500.00 Process value: 0.00 L/h Setpoint: 0.00 L/h 0.00 100.00 Manipulated var.: 0.00 % Readback value: 0.00 % 0.00 Faceplate 1 Control perform.

No.	Action
4.	Change the operating mode of the controller. In the faceplate you click on the “…” button next to the “Mode” switch, and in the faceplate extension you click on the “Automatic” button and adopt the settings with “OK”. The setpoint is automatically specified from external. **Note:** Fur further additional components repeat steps 1 4 for each component.
5.	Click on the block icon of the controller for main component “FIC_MainComp”.  FIC_MainComp/C Continuous PID controller - large Mode: Manual Setpoint: Internal Process value: 0.00 L/h Setpoint: 0.00 L/h Manipulated var.: 0.00 % Readback value: 0.00 %
6.	Change the operating mode of the controller. In the faceplate you click on the “…” button next to the mode switch (“Mode”) and in the faceplate extension you click on the “Automatic” button and adopt the settings with “OK”.
7.	For changing the setpoint value you click on the “Setpoint” input field and enter a setpoint value of 1000 l/h in the faceplate expansion. Acknowledge the input with the “ENTER” key and click on the “OK” button. **Note:** Instead of the internal setpoint you can also set using an external setpoint value in this step.

NOTE At the “Ratio” block the most current actual value of the ratio is displayed, which is used for controlling the slave controllers.

Operation

The following instruction describes the operation of the equipment module “Ratio Control”. After the startup and the adjustment of values, the flow rate of the main component is 1000 l/h and the additional component 250 l/h (the ratio between additional and main component is 0.25).

In the scenario below, the flow rate of the main component is increased from 1000 l/h to 1500 l/h.

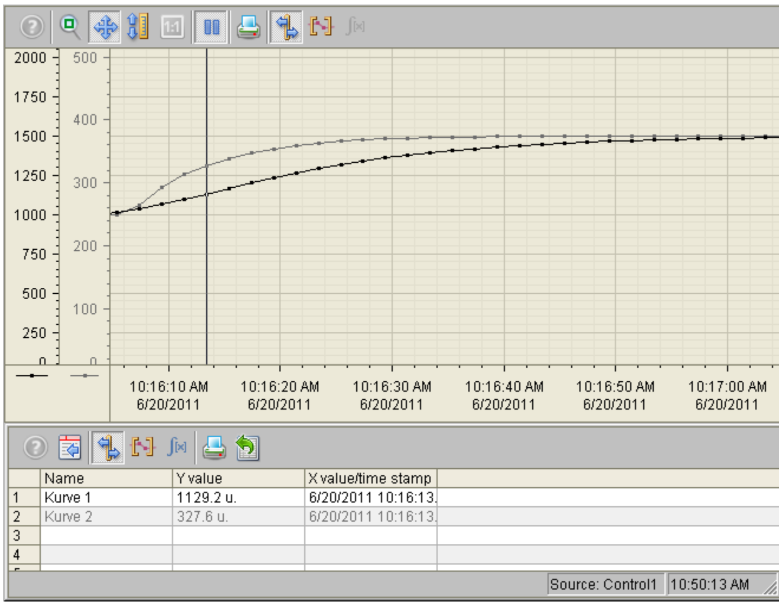
Table 5-17

No.	Action
1.	Click on the block icon of the “FIC_MainComp” controller and click into the “Setpoint” input field.
2.	In the faceplate expansion you enter the new setpoint of 1500 l/h. Then acknowledge the input with the “Enter” key and click on the “OK” button.
3.	Wait approximately 50 seconds and then click on the “Start/Stop” symbol of the OnlineTrendControl
4.	In the toolbar of the OnlineTrendControl you click on the “ruler” icon and reduce the ruler to the smallest value with the largest deviation, as displayed in the evaluation below.

Evaluation

The “OnlineTrendControl” embedded in the process image is set to maximum value range. After a ratio change the value range of the additional component automatically adjusts.

Figure 5-9



	Name	Y value	X value/time stamp
1	Kurve 1	1129.2 u.	6/20/2011 10:16:13.
2	Kurve 2	327.6 u.	6/20/2011 10:16:13.
3			
4			

Source: Control1 10:50:13 AM

Due to the different reaction times of the controller, the ratio is temporarily 29% (0.29). In comparison to the set ratio value of 25% (0.25) a short-term deviation of 4% occurs before the correct ratio is reached in the steady-state.

The controller design for slave controller “FFIC_Comp_1” can in this case not be improved by means of PID controller optimization, since the objective of the controller design is optimal tracking of the additional component.

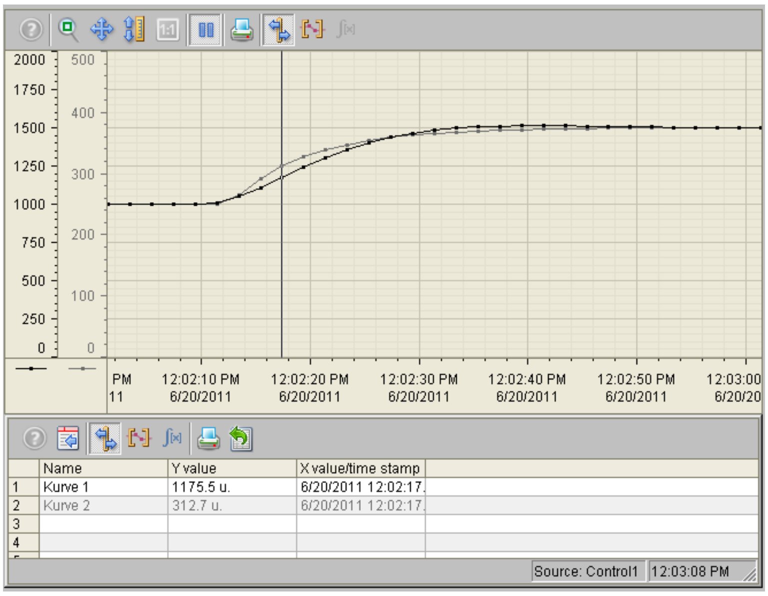
NOTE The online help offers further information and configuration notes on process tag type “RatioControl”. The process tag type is available in the “PCS 7 Advanced Process Library”.

The reaction time from OnlineTrendControl leads to the following considerations for the controller design, in order to adjust the transient response of master and slave control loop as much as possible:

- The relatively large deviation at the start of the control indicates an exceedingly high gain of the slave controller, i.e. the actual value of the slave controller increases faster than the actual value of the master controller.
- The relatively slow reaching of the final value of the setpoint step-change indicates an exceedingly large integral time of the master controller, i.e. the master controller settles slower than the slave controller.

A change in controller gain of slave controller “FFIC_Comp_1” from 0.25 to 0.1 and, at the same time, a change in the integral time of master controller “FIC_MainComp” from 4.1 to 2 yields the following result for the same setpoint step-change.

Figure 5-10



	Name	Y value	X value/time stamp	
1	Kurve 1	1175.5 u.	6/20/2011 12:02:17.	
2	Kurve 2	312.7 u.	6/20/2011 12:02:17.	
3				
4				

Source: Control1 12:03:08 PM

Due to the different reaction times of the controller, the ratio is 26.7% (0.29) after optimization. In comparison to the set ratio value of 25% (0.25) a short-term deviation of 1.7% occurs.

Process adjustment

The following tables contain the relevant parameters which must either be set or interconnected. Chapter 6.2 “Process connection” describes the procedure for connecting process devices.

The following table contains the parameters to be set specifically for each process.

Table 5-18

Process tag	Block	Connection	Usage
FI_MainComp / FI_Comp_1	I Subchart “A”	PV_AH_En	Alarm for exceeded limit value, if PV ≥ PV_AH_Lim
FI_MainComp / FI_Comp_1	I Subchart “A”	PV_WH_En	Warning for exceeded limit value, if PV ≥ PV_WH_Lim
FI_MainComp / FI_Comp_1	I Subchart “A”	PV_WL_En	Warning for falling below the limit value, if PV ≥ PV_WL_Lim
FI_MainComp / FI_Comp_1	I Subchart “A”	PV_AL_En	Alarm for falling below the limit value, if PV ≥ PV_AL_Lim
FIC_MainComp / FFIC_Comp_1	C Subchart “A”	Gain	Proportional gain
FIC_MainComp / FFIC_Comp_1	C Subchart “A”	TD	Derivative time (rate time) in [s]
FIC_MainComp / FFIC_Comp_1	C Subchart “A”	TI	Integral time (reset time) in [s]
FIC_MainComp / FFIC_Comp_1	C Subchart “A”	SP_InHiLim	Limit value (high) of the internal setpoint value
FIC_MainComp / FFIC_Comp_1	C Subchart “A”	SP_InLoLim	Limit value (low) of the internal setpoint value
FIC_MainComp / FFIC_Comp_1	C Subchart “A”	PV_AH_En	Alarm for exceeded limit value, if PV ≥ PV_AH_Lim
FIC_MainComp / FFIC_Comp_1	C Subchart “A”	PV_WH_En	Warning for exceeded limit value, if PV ≥ PV_WH_Lim
FIC_MainComp / FFIC_Comp_1	C Subchart “A”	PV_TH_En	Warning for falling below the limit value, if PV ≥ PV_TH_Lim
FIC_MainComp / FFIC_Comp_1	C Subchart “A”	PV_TL_En	Tolerance for falling below the limit value, if PV ≤ PV_TL_Lim
FIC_MainComp / FFIC_Comp_1	C Subchart “A”	PV_WL_En	Warning for falling below the limit value, if PV ≥ PV_WL_Lim
FIC_MainComp / FFIC_Comp_1	C Subchart	PV_AL_En	Alarm for falling below the limit value,

Process tag	Block	Connection	Usage
	"A"		if PV ≥ PV_AL_Lim
FIC_MainComp / FFIC_Comp_1	C Subchart "A"	ER_AH_En (invisible)	Alarm for exceeded error signal, if ER ≥ ER_AH_Lim
FIC_MainComp / FFIC_Comp_1	C Subchart "A"	ER_AL_En (invisible)	Alarm for fallen short of error signal, if ER ≥ ER_AL_Lim
FIC_MainComp / FFIC_Comp_1	PV Subchart "B"	Scale	Scaling the measured value (e.g. flow range of max. 500)
FIC_MainComp / FFIC_Comp_1	PV Subchart "B"	PV_InUnit	Unit of the scaled measured value (e.g. "1353" flow rate in L/h)
FFIC_Comp_1	Ratio Subchart "A"	OutHiLim	Upper limit value for the output value
FFIC_Comp_1	Ratio Subchart "A"	OutLoLim	Lower limit value for the output value
FFIC_Comp_1	Ratio Subchart "A"	RatHiLim	Upper ratio limit
FFIC_Comp_1	Ratio Subchart "A"	RatLoLim	Lower ratio limit
YC_MainComp / YC_Comp_1	V Subchart "A"	MV_HiLim	Upper and lower limit of the manipulated value
YC_MainComp / YC_Comp_1	MV Subchart "B"	MV_LoLim	Scaling the manipulated variable (manipulated value from the valve block)
YC_MainComp / YC_Comp_1	MV Subchart "B"	Scale	Unit of the scaled manipulated variable

NOTE

For commissioning the "LIC_Level" controller the "PID-Tuner" program is available. Chapter 6.3 "Configuration of the PID controllers" describes the procedure for optimizing the controller. If during optimization a considerably different transient response should occur, you may try to adjust and adapt the parameters of both control loops manually. The stability of the transient response of both control module loops has the highest priority. A short term deviation of the ratio for setpoint step-changes may result.

The following table contains an overview of parameters to be interconnected with process devices.

Table 5-19

Process tag	Block	Connection	Usage
FIC_MainComp	PV Subchart “B”	PV_In	Flow rate of the main component
FFIC_Comp_1	PV Subchart “B”	PV_In	Flow rate of the additional component
YC_MainComp	Rbk Subchart “B”	PV_In	Manipulated variable feedback
YC_MainComp	MV Subchart “B”	PV_Out or PV_ChnST	Output of the manipulated variable or output of the manipulated variable including signal status of the output signal
YC_Comp_1	Rbk Subchart “B”	PV_In	Manipulated variable feedback
YC_Comp_1	MV Subchart “B”	PV_Out or PV_ChnST	Output of the manipulated variable or output of the manipulated variable including signal status of the output signal

NOTE

In the object properties of the message-capable blocks you can configure instance-specific messages. An instruction for the procedure is available in the configuration manuals “Process Control System PCS 7 Operator Station (V7.1)” under the following entry ID: 36194551 and “SIMATIC Process Control System PCS 7 Operator Station (V8.0)” under the entry ID: 57270173.

5.2.4 Expanding by a further component

General information

The “Ratio-Control” equipment module is designed for usage of one main component and 2 additional components. The number of additional components is limited by the interlock block or its number of interlock inputs respectively.

NOTE You can expand the “Ratio-Control” equipment module by more than 2 additional substances using the following options.

1. Combine the signals of the communication blocks (from_Slave) with OR blocks. This interconnects 1 valve and 7 additional components with an interlock block.
   Disadvantage:
   inaccurate error display, i.e. no differentiation between errors in cascade control, “Out of service” signal of the controller block, and “Bad” status of the controller channel blocks.
2. Duplicate the existing interlock block and combine both outputs of the interlock blocks (“Out”) with an OR block. For interconnecting (“Out” output) the OR blockyou use the interconnection (“Out” output) of the existing interlock block. You can call up the faceplate of the first interlock block from the faceplate of the controller. The faceplate of the second interlock block is opened via its block symbol in the process image.
3. Replace the existing interlock block containing 8 input signals (“Intlk08”) by an interlock block containing 16 input signals (“Intlk16”). Adopt all interconnections of the previous interlock block.

Prerequisites

If various additional components are measured in different units, the conversion factor in the ratio block also handles the unit conversion.

NOTE For different units the further unit of measure must be configured at the additional component and the setpoint value converted, e.g. with a multiplier block.

Additionally, clear labeling is recommended for a joint display of the trend curve.

If different manipulated ranges are required for sub-control loops of a ratio control, the respective interconnections must be deleted and configured for the respective sub-control loop.

NOTE Instructions on configuration and parameter settings are available in the function manuals “SIMATIC Process Control System PCS 7, PCS 7 Advanced Process Library V7.1 SP5” at entry ID: 48034370 and “SIMATIC Process Control System PCS 7 PCS 7 Advanced Process Library V8.0” at entry ID: 57265842.

Description

To expand the equipment module by one further additional component, please proceed according to the following instruction:

1. Copy process tags “FI_Comp_1”, “FFIC_Comp_1” and “YC_Comp_1” all at the same time. Paste the copied process tags back into the same hierarchy folder. Rename the process tags accordingly (the process tags are referred to as “FI_Comp_2”, “FFIC_Comp_2” and “YC_Comp_2” below).

NOTE When copying the process tags at the same time (select process tag and then clock on “Edit > Copy” in the menu bar) the connections between the selected process tags remain.

2. Open the “FIC_MainProduct” process tag and duplicate the “from_Slave_1“ block in subchart “A” sheet 6.

NOTE The “to_Slave” block is not duplicated, since all slave controllers receive the same data from the master controller.

3. Open process tag “FFIC_Comp_2” and perform the following interconnections:

Table 5-20

Block	Connection	Usage
to_Master	Out	Interconnection to the master (FIC_MainComp\from_Slave_2.In)
from_Master	In	Interconnection to the master (controlling) (FIC_MainComp\to_Slave_1.Out)

4. Open process tag “FFIC_MainComp” and perform the following interconnections:

Table 5-21

Block	Connection	Usage
from_Slave_2	BoStruct1	Interconnection to the interlock block (Interlock.In06)
from_Slave_2	BoStruct2	Interconnection to the interlock block (Interlock.In07)
from_Slave_2	BoStruct3	Interconnection to the interlock block (Interlock.In08)

5. The simulation model is designed for two additional components. Please perform the following interconnections in order to connect the second additional component with the simulation. Open process tag “FFIC_Comp_2” and perform the following interconnections in subchart “B” sheet 1:

Table 5-22

Block	Connection	Usage
Sim	Sim1ValueOp	Interconnecting to the simulation chart (Sim_CompFlow/Lag_Comp_2.Out)

6. Open process tag “YC_Comp_2” and perform the following interconnections in subchart “A” sheet 1:

Table 5-23

Block	Connection	Usage
V	MV	Interconnecting to the simulation chart (Sim_CompFlow/Scale_Comp_2.In1)

NOTE Expanding the “Ratio-Control” equipment module by further additional components requires compilation and download of blocks and charts, as well as OS compilation.

5.3 “Split-Range-Pressure” control

Pressure control is typically a fast control. The container pressure is increased by feeding inert gas (e.g. nitrogen) via an inlet pipe. When opening the outlet valve, the gas mixture is released and the container pressure reduced. The controller reacts to a pressure change and controls it either by opening the inlet or the outlet valve.

The example below solves the container pressure control by adding pressure and venting.

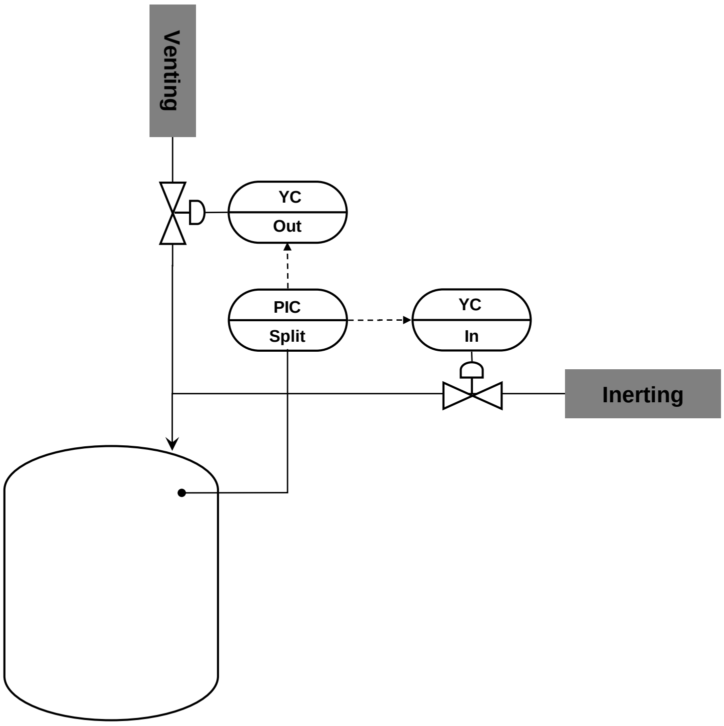
5.3.1 Overview

The structure is displayed in a P&I diagram below and all process tags and the simulation of the equipment module are described.

P&I diagram

The following P&I diagram represents all components relevant for the operation, such as aggregates, containers, etc. as symbols.

Figure 5-11



Process tags

The equipment module “Split-Range-Pressure” consists of 4 interconnected process tags and one simulation chart. In the simulation chart a container pressure and the impact of feeding inert gas as well as venting are simulated.

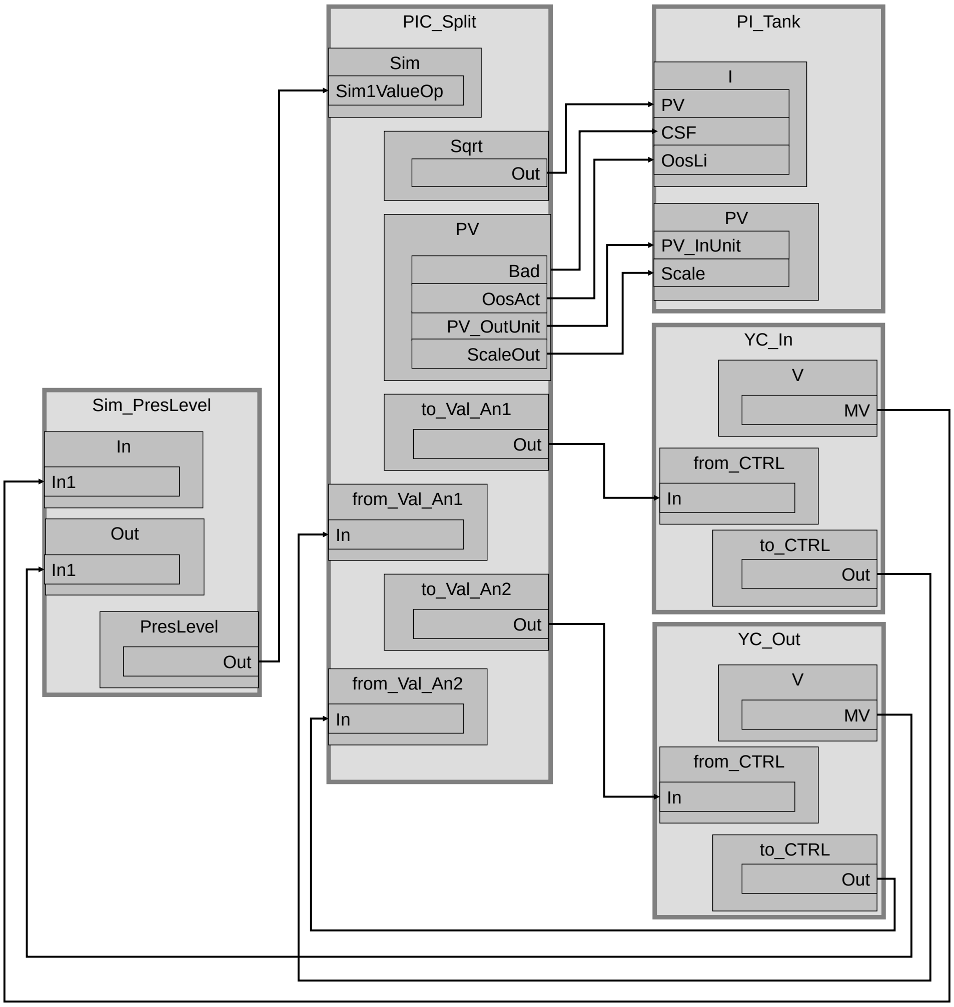
The following table provides an overview of the process tags of the equipment module including the respective process tag types.

Table 5-24

Process tag	Process tag type	Description
PIC_Split	“CTRL_Splitrange”	Controller for split-range control with a manipulated variable and two actuators
PI_Tank	“AMON__Std“	Measured value display of the container pressure
YC_In	“Val_An_Afb1”	Manipulated variable for feeding inert gasses
YC_Out	“Val_An_Afb1”	Control valve for venting

In the following figure the entire structure, including all interconnections across all CFC charts, are represented in a simplified format.

Figure 5-13



The “PIC_Split” process tag uses the simulated container pressure from simulation chart “Sim_PresLevel” and generates the setpoint specification for the split-range controller. The PID controller transfers the control commands via communication blocks “to_Val_An1” and “to_Val_An2” to the “YC_In” and “YC_Out” control valves. Additionally, the controller process tag receives status information from the channel drivers of the valve process tag via the “from_Val_An1” and “from_Val_An2” communication blocks.

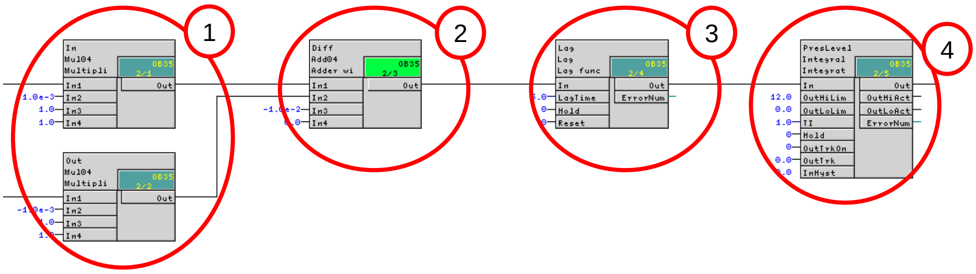
5.3.2 Structure and configuration

Simulation “Sim_PresLevel”

In CFC chart “Sim_PresLevel” the pressure change in the container is simulated by inerting or venting.

The graphic representation below shows the sequence of the simulation.

Figure 5-13



1. Calculating the pressure change based on the proportionality factor (100% valve opening corresponds to 0.1 bar pressure change)
2. Reducing the pressure by 0.01 bar, e.g. through pressure loss in the container
3. Delaying the pressure change
4. Forming an integral value through integrating the pressure change (each second)

PIC_Split

In the “PIC_Split” process tag the container pressure is recorded and transferred to the “PI_Tank” process tag for measured value display. The setpoint is specified in this process tag (“PIC_Split”). In order to control the container pressure, control signals are transferred to the “YC_In” and “YC_Out” control valves via communication blocks.

The following table shows the configuration of the instance from “CTRL_Splitrange”.

Table 5-25

Block	Connection	Value	Usage
C	NegGain.Value	1	Reversing the response behavior for the valve (valve 1 opens for negative instead of positive error signal)
C	Gain.Value	8.0	Controller gain
C	TI.Value	75.0	Controller delay
C	SP_InHiLim	10.0	Maximal value of the internal setpoint
C	ManLoLim	-100.0	Limit value (low) of the manual value
C	CPI_In		Interconnection for opening the

Block	Connection	Value	Usage
			ConPerMon faceplate from the controller faceplate (PIC_Split\CPM.CPI)
C	RefStdDevIn		Interconnection for opening the ConPerMon faceplate from the controller faceplate (PIC_Split\CPM.RefStdDev)
CPM	RefVariance	0.0	
Connector	SP_IntLi.Value	1	Using the internal setpoint value as start value
Connector	SP_Ext.Value	5.0	External setpoint
Connector	ModLiOp.Value	1	Activating the selection the operating mode via the block
Connector	AutModLi.Value	1	Activating the automatic mode
MV_Trk	In1.Value	0.0	Forced manipulated value for the controller
Intlock	InvIn02	1	Inverting the hardware error signal of channel block “PV”
Intlock	Inv02		Interconnection to channel block “PV” (PIC_Split\PV.Bad)
Intlock	InvIn03	1	Inverting the “Out of service” signal of channel block “PV”
Intlock	Inv03		Interconnection to channel block “PV” (PIC_Split\PV.OosAct)
from_Val_An1	In		Status of the valve for added pressure (YC_In\to_CTRL.Out)
from_Val_An2	In		Status of the valve for venting (YC_Out\to_CTRL.Out)
to_Val_An1	Out		Control commands of the valve for added pressure (YC_In\from_CTRL.In)
to_Val_An2	Out		Control commands of the valve for venting (YC_Out\from_CTRL.In)
Sim	Sim1ActOp.Value		Activating the simulation of the controlled variable
Sim	Sim1ValueOp		Interconnection to the simulated process value (Sim_PresLevel\PresLevel.Out)
PV	Bad		Interconnecting the hardware error from the channel block to the process tag for the process value display (PI_Tank\I.CSF)
PV	PV_OutUnit		Interconnecting the unit from the process value to the process tag for the process value display (PI_Tank\PV.PV_InUnit)
PV	ScaleOut		Interconnecting the scaling from the process value to the process tag for the process value display (PI_Tank\PV.Scale)
PV	OosAct		Interconnecting the “Out of service” signal from the process tag for the process value

Block	Connection	Value	Usage
			display (PI_Tank\I.OosLi)
Sqrt	Out		Interconnecting the process value to the display block (PI_Tank\I.PV)

PI_Tank

In the “PI_Tank” process tag the measured value of the channel block of the “PIC_Split” process tag is displayed. Limit values (alarm, warning) are not set in the operator control and monitoring block (MonAnL), since these are defined specifically for each process.

The following table shows the configuration of the instance from “AMON__Std”.

Table 5-26

Block	Connection	Value	Usage
I	PV		New interconnection to the process value of the controller process tag (PIC_Split\Sqrt.Out)
I	OosLi		New interconnection to the “Out of service” signal of the channel block of the controller process tag (PIC_Split\PV.OosAct)
I	CSF		New interconnection to the “Bad” signal of the channel block of the controller process tag (PIC_Split\PV.Bad)
PV	Scale		Interconnecting the scaling of the manipulated value (PIC_Split\PV.ScaleOut)
PV	PV_InUnit		Interconnecting the unit of the process value (PIC_Split\PV.PV_OutUnit)

YC_In and YC_Out

The valve process tags have been designed specifically for the application in a split-range control. Each valve process tag contains communication blocks for data exchange (control signals and control commands) with the controller process tag.

The “V” valve blocks receive one manipulated value each (via communication blocks) from the controller process tag. Both channel blocks in subchart “B” (Rbk and MV) receive the same value (manipulated value of the valve block (subchart “A”, sheet 1)) via the preceding simulation block.

The following table shows the configuration of the instance from “Val_An_Afb1”.

Table 5-27

Block	Connection	Value	Usage
V (YC_In) (YC_Out)	MV		Interconnection for the simulation (Sim_SplitLevel\In.In1) (Sim_SplitLevel\Out.In1)
V	NoFbkOpen	1	Feedback “Valve open” deactivated
V	NoFbkClose	1	Feedback “Valve closed” deactivated
from_CTRL (YC_In) (YC_Out)	In		Interconnection to the controller (PIC_Split\to_Val_An1.Out) (PIC_Split\to_Val_An2.Out)
to_CTRL (YC_In) (YC_Out)	Out		Interconnection to the controller (PIC_Split\from_Val_An1.In) (PIC_Split\from_Val_An2.In)
Sim	Sim1ActOp.Value	1	Activating the simulation of the readback value
Sim	Sim2ActOp.Value	1	Activating the simulation of the manipulated value
Sim	Sim1ValueOp		Simulation of the readback value from the valve
Sim	Sim2ValueOp		(Interconnected with V.MV)

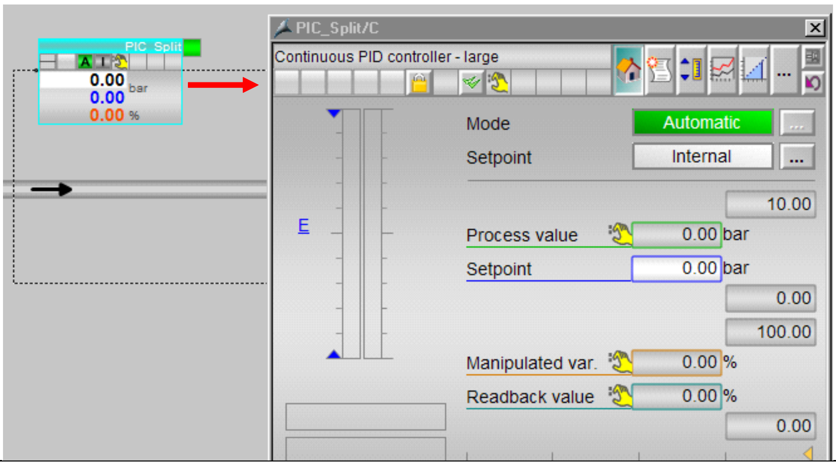
5.3.3 Commissioning, operation and instance-specific adjustments

Commissioning and operation requires a downloaded user program in automation system (AS) or S7-PLCSIM, and an activated OS (WinCC Runtime). Instructions for downloading the user program and activating the OS are available in chapter 7 “Starting the Equipment Module”.

Commissioning

For commissioning, please follow the instructions below:

Table 5-28

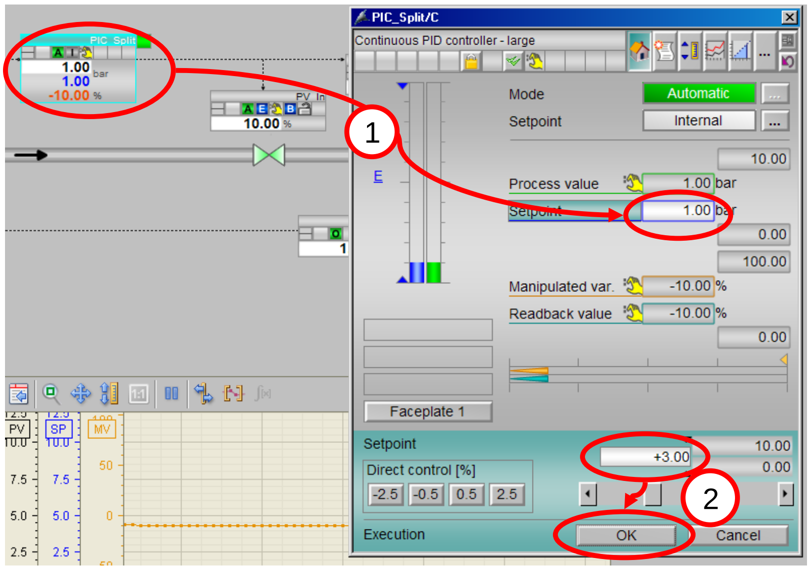
No.	Action
1.	Click on the block icon of the “PIC_Split” controller. The respective faceplate is opened. 
2.	Click on the “Setpoint” input field and enter value “1” into the input field of the faceplate expansion. Then acknowledge the input with the “Enter” key and click on the “OK” button. **Note:** Instead of the internal setpoint you can also set using an external setpoint value in this step.

Operation

The following instruction describes the operation of the equipment module “Split-Range-Pressure”. After startup the setpoint value is 1 bar. To balance the pressure loss of the container, the valve for venting must be 10 % open.

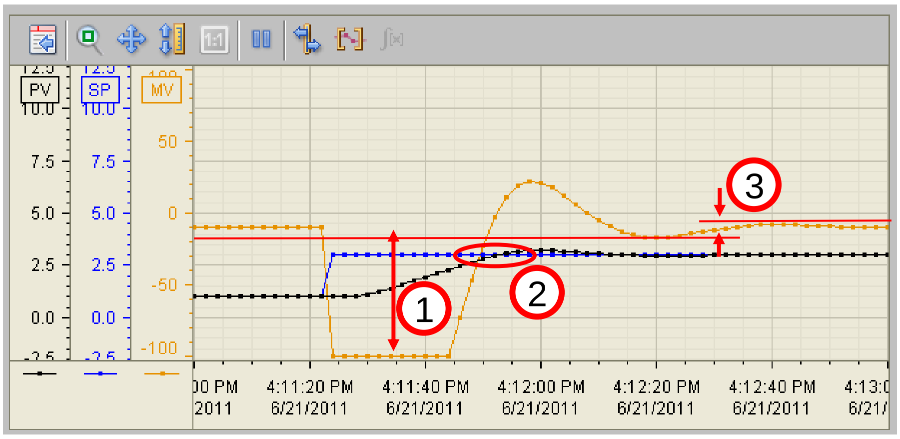
In the following scenario the setpoint value is increased from 1°bar to 3°bar.

Table 5-29

No.	Action
1.	Click on the block icon of the “PIC_Split” controller. The respective faceplate is opened.
2.	Click on the “Setpoint” input field and enter value “3” into the input field of the faceplate expansion. Then acknowledge the input with the “Enter” key and click on the “OK” button. 
3.	Then close the faceplate and observe the curve plotter for approx. 2 minutes, until the setpoint has been reached.

Evaluation

Figure 5-14



1. After the setpoint jump the manipulated value is set to 100 which opens the pressure feed valve
2. After the process value exceeds the setpoint, the pressure feed valve is closed and the venting valve is opened
3. After reaching the setpoint, the pressure feed valve is approx. 10% open, which compensates the pressure loss of the container

Instance-specific adjustments

The following tables contain the relevant parameters which must either be set or interconnected. Chapter 6.2 “Process connection” describes the procedure for connecting process devices.

The following table contains the parameters to be set specifically for each process.

Table 5-30

Process tag	Block	Connection	Usage
PI_Tank	I Subchart “A”	PV_AH_En	Alarm for exceeded limit value, if PV ≥ PV_AH_Lim
PI_Tank	I Subchart “A”	PV_WH_En	Warning for exceeded limit value, if PV ≥ PV_WH_Lim
PI_Tank	I Subchart “A”	PV_WL_En	Warning for falling below the limit value, if PV ≥ PV_WL_Lim
PI_Tank	I Subchart “A”	PV_AL_En	Alarm for falling below the limit value, if PV ≥ PV_AL_Lim
PIC_Split	C Subchart “A”	Gain	Proportional gain
PIC_Split	C Subchart “A”	TD	Derivative time (rate time) in [s]
PIC_Split	C Subchart “A”	TI	Integral time (reset time) in [s]
PIC_Split	C Subchart “A”	SP_InHiLim	Limit value (high) of the internal setpoint value
PIC_Split	C	SP_InLoLim	Limit value (low) of the internal

Process tag	Block	Connection	Usage
	Subchart “A”		setpoint value
PIC_Split	C Subchart “A”	PV_AH_En	Alarm for exceeded limit value, if PV ≥ PV_AH_Lim
PIC_Split	C Subchart “A”	PV_WH_En	Warning for exceeded limit value, if PV ≥ PV_WH_Lim
PIC_Split	C Subchart “A”	PV_TH_En (invisible)	Warning for falling below the limit value, if PV ≥ PV_TH_Lim
PIC_Split	C Subchart “A”	PV_TL_En (invisible)	Tolerance for falling below the limit value, if PV ≤ PV_TL_Lim
PIC_Split	C Subchart “A”	PV_WL_En	Warning for falling below the limit value, if PV ≥ PV_WL_Lim
PIC_Split	C Subchart “A”	PV_AL_En	Alarm for falling below the limit value, if PV ≥ PV_AL_Lim
PIC_Split	C Subchart “A”	ER_AH_En (invisible)	Alarm for exceeded error signal, if ER ≥ ER_AH_Lim
PIC_Split	C Subchart “A”	ER_AL_En (invisible)	Alarm for fallen short of error signal, if ER ≥ ER_AL_Lim
PIC_Split	Split-range Subchart “A”	InScale	Limit rage for the input signal (e.g. from -100 to +100)
PIC_Split	Split-range Subchart “A”	NeutPos	Neutral position
PIC_Split	Split-range Subchart “A”	DeadBand	Dead band range
PIC_Split	PV Subchart “B”	Scale	Scaling the measured value (e.g. pressure of max. 10)
PIC_Split	PV Subchart “B”	PV_InUnit	Unit of the scaled measured value (e.g. “1137” pressure in bar)
YC_In / YC_Out	V Subchart “A”	MV_HiLim MV_LoLim	Upper and lower limit of the manipulated value
YC_In / YC_Out	MV Subchart “B”	Scale	Scaling the manipulated variable (manipulated value from the valve block)
YC_In / YC_Out	MV Subchart “B”	PV_InUnit	Unit of the scaled manipulated variable

NOTE For commissioning the “PIC_Split” controller the “PID-Tuner” program is available. Chapter 6.3 “Configuration of the PID controllers” describes the procedure for optimizing the controller. The experiment for data recording for the “PID-Tuner” is initially performed in an operating range in which only positive manipulated variables occur. Afterwards, a comparable experiment is made in an operating range, where only negative manipulated variables occur.

If both partially controlled sections for venting and inerting yield clearly different values for the process gain, this must be compensated by a varied increase in both branches of the split-range characteristic curve.

The online help offers further information and configuration notes on process tag type “SplitrangeControl”. The process tag type is available in the “PCS 7 Advanced Process Library”.

The following table contains an overview of parameters to be interconnected with process devices.

Table 5-31

Process tag	Block	Connection	Usage
PIC_Split	PV Subchart “B”	PV_In	Inside container pressure
YC_In	Rbk Subchart “B”	PV_In	Manipulated variable feedback
YC_In	MV Subchart “B”	PV_Out or PV_ChnST	Output of the manipulated variable or output of the manipulated variable including signal status of the output signal
YC_Out	Rbk Subchart “B”	PV_In	Manipulated variable feedback
YC_Out	MV Subchart “B”	PV_Out or PV_ChnST	Output of the manipulated variable or output of the manipulated variable including signal status of the output signal

NOTE In the object properties of the message-capable blocks you can configure instance-specific messages. An instruction for the procedure is available in the configuration manuals “Process Control System PCS 7 Operator Station (V7.1)” under the following entry ID: 36194551 and “SIMATIC Process Control System PCS 7 Operator Station (V8.0)” under the entry ID: 57270173.

5.4 “Split-Range-Temperature” control

Temperature control is a slow speed control where the temperatures in the container change slowly. To reach a specified temperature inside the container, either heating steam or cooling water are fed into a heat exchanger or a vessel shell. Due to the separation with heat-permeable walls, both methods are referred to as indirect heat/cold transfer.

For the heat exchanger, the container contents are continuously fed back into the container through the heat exchanger via a pipe, until a predefined temperature is reached. The principle of operation for temperature control via the vessel shell is equal to that of the heat exchanger. For temperature control via the vessel shell the container contents are mixed using an agitator.

NOTE The “Split-Range-Temperature” equipment module can be employed for processes where temperature control is intended via the container vessel shell or via an external heat exchanger.

In the following example, the temperature control is solved by using a heat exchanger.

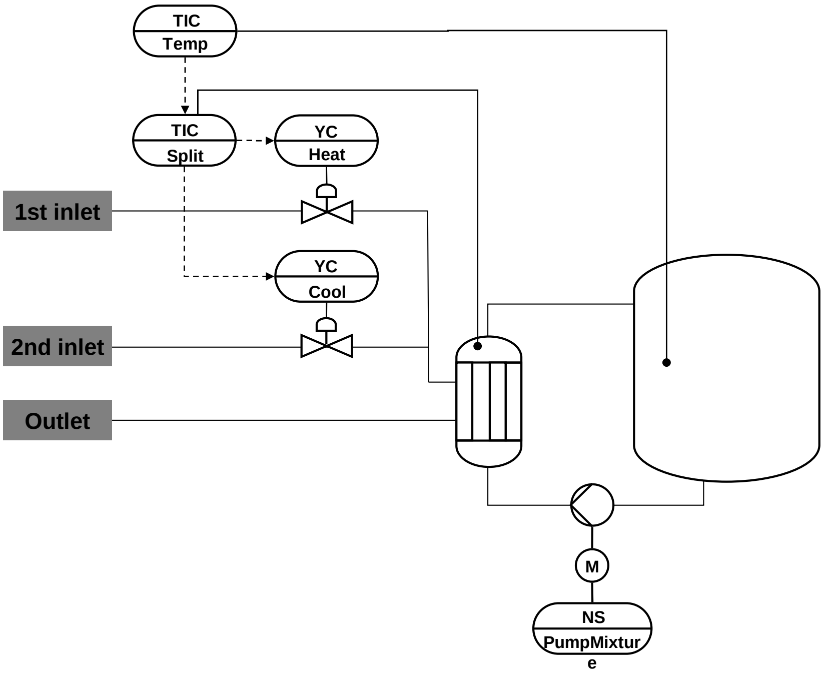
5.4.1 Overview

The structure is displayed in a P&I diagram below and all process tags and the simulation of the equipment module are described.

P&I diagram

The following P&I diagram represents all components relevant for the operation, such as aggregates, containers, etc. as symbols. This is a cascade control with split-range function at the slave controller.

Figure 5-15



Process tags

The equipment module “Split-Range-Temperature” consists of 7 interconnected process tags and one simulation chart. In the simulation chart an internal container temperature (component mixture), temperature of a heat exchanger and the impact through temperature changes (heating steam and cooling water) is simulated.

The following table provides an overview of the process tags of the equipment module including the respective process tag types.

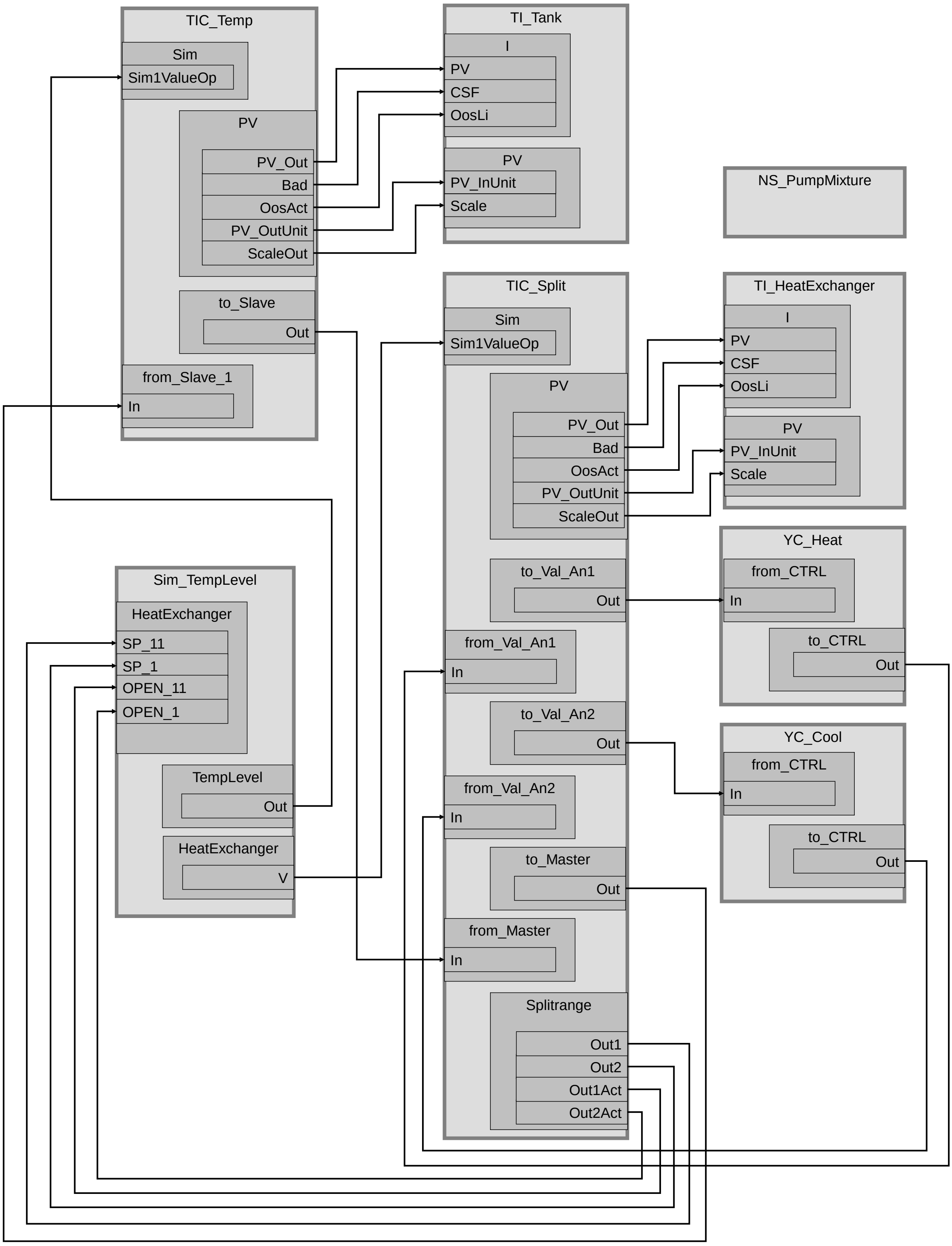
Table 5-32

Process tag	Process tag type	Description
TIC_Split	“CTRL_Splitrange”	Slave controller for split-range control with a manipulated variable and two actuators
TIC_Temp	“CTRL_Std”	Master controller for controlling the temperature
TI_Tank	“AMON__Std”	Measured value display of the internal container temperature (product)
TI_HeatExchanger	“AMON__Flow”	Measured value display of the temperature of the heat exchanger
YC_Heat	“Val_An_Afb1”	Control valve for the first manipulated variable
YC_Cool	“Val_An_Afb1”	Control valve for the second manipulated variable
NS_PumpMixture	“MOT_1sp_1fb_1cm__Std”	Pump (e.g. stream pump) for continuous circulation of the container content

NOTE The “NS_PumpMixture” process tag is interconnected in the SFC (“Sequential Functional Chart”). An interconnection with other process tags in the “Split-Range-Temperature” equipment module is not required.

In the following figure the entire structure, including all interconnections across all CFC charts, are represented in a simplified format.

Figure 5-16



The “TIC_Temp” process tag uses the simulated container temperature from simulation chart “Sim_TempLevel” and generates the setpoint specification for the split-range controller. This configures the desired temperature curve in the “TIC_Temp” process tag. The “TI_Tank” process tag indicates the process value and the status values of the “TIC_Temp” process tag.

The “TIC_Split” process tag receives the specified setpoint from the master controller and controls the simulated temperature of a heat exchanger, which transfers heat to the inside of the container. The “TI_HeatExchanger” process tag indicates the process value and the status values of the “TIC_Split” process tag.

The split-range control is handled via the “TIC_Split” controller process tag. The PID controller transfers the control commands via communication blocks “to_Val_An1” and “to_Val_An2” to the “YC_Heat” and “YC_Cool” control valves. Additionally, the controller process tag receives status information from the channel drivers of the valve process tag via the “from_Val_An1” and “from_Val_An2” communication blocks.

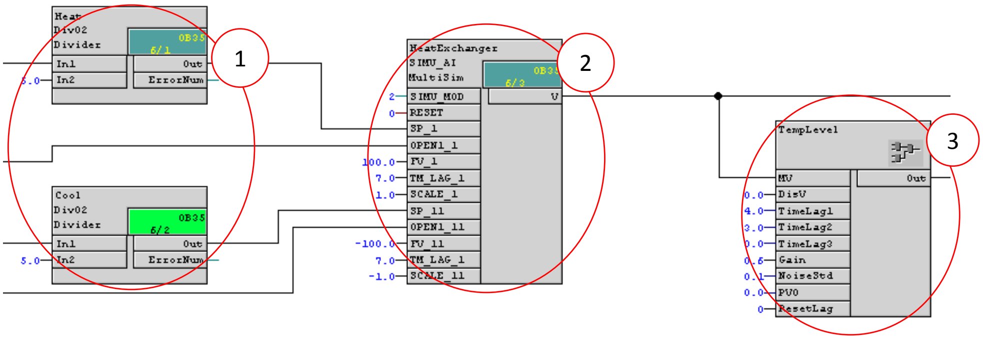
5.4.2 Structure and configuration

“Sim_TempLevel” simulation

A temperature change through heating steam or cooling water on the heat exchanger as well as the inside container temperature are simulated in the “Sim_TempLevel” CFC chart.

The graphic representation below shows the sequence of the simulation.

Figure 5-17



1. Reducing the manipulated variable for the simulation, which enables an amplified valve opening representation for heating valves and cooling valves in the trend plotter.
2. Calculating the temperature of a heat exchanger. The temperature change depends on the valve opening for both valves (bipolar signal is distributed between the heating steam and the cooling water valve) and is processed after running a delay block.
3. Inside container temperature changing in relation to the heat exchanger. The temperature inside the container is 40% lower than in the heat exchanger (factor 0.6) and is calculated after running two delay elements. The output signal (container temperature) comes with a slight signal noise.

NOTE The simulation behavior does not correspond to a real process and is used for displaying the functionality and principle of operation of the equipment module “Split Range Temperature”. The “SIMU_AI” shows integrated behavior with an equally strong heating and cooling effect. For real heat exchangers a temperature loss and different behavior during heating (e.g. steam) and cooling (e.g. river water) must be expected.

TIC_Temp

In the “TIC_Temp” process tag the inside container pressure (product temperature) is recorded and transferred to the “TI_Temp” process tag for measured value display. The setpoint is specified in the “TIC_Temp” process tag, which transfers the setpoint value to the slave controller (“TIC_Split” process tag) as external setpoint value. This makes the “TIC_Temp” process tag the master controller of the cascade control.

The “TIC_Temp” process tag is an instance of process tag type “CTRL__Std” and contains two additional communication blocks (“to_Slave” and “from_Slave_1”).

The following table shows the configuration of the instance from “CTRL__Std”.

Table 5-33

Block	Connection	Value	Usage
C	Gain.Value	1.5	Controller gain
C	TI.Value	7.054	Controller delay
C	TD.Value	1.855	Controller derivative time
Intlock	InvIn02	1	
Intlock	InvIn03	1	
Intlock	InvIn04	1	
ComStruIn			Inserted as “to_Slave”, for controlling the slave controller
to_Slave	ReStru1		Interconnecting the manipulated value as external setpoint to the slave controller (TIC_Temp\C.MV)
to_Slave	BoStru2		Interconnecting the “Bad” signal of the channel blocks of “TIC_Temp” to the slave controller (TIC_Temp\CSF.Out)
to_Slave	Int1 (switch to visible)		Interconnecting the “PV_OutUnit” to the slave controller (TIC_Temp\MV.PV_OutUnit)
to_Slave	Int2 (switch to visible)		Interconnecting the “PV_OutUnit” to the slave controller (TIC_Temp\PV.PV_OutUnit)
to_Slave	Scale1 (switch to visible)		Interconnecting the “PV_OutUnit” to the slave controller (TIC_Temp\PV.ScaleOut)
to_Slave	Out		Interconnection to the slave controller (TIC_Split\from_Master.In)
ComStruOut			Inserted as “from_Slave_1” for receiving the slave controller status
from_Slave_1	In		Interconnection to the slave controller

Block	Connection	Value	Usage
			(TIC_Split\to_Master.Out)
from_Slave_1	BoStru1		Interconnecting the cascade interruption from the slave controller (TIC_Temp\Intlock.In02)
from_Slave_1	BoStru2		Interconnecting the hardware error from the slave controller (TIC_Temp\Intlock.In03)
from_Slave_1	BoStru3		Interconnecting the “Out of service” signal from the slave controller (TIC_Temp\Intlock.In04)
from_Slave_1	Int1		Interconnecting the unit of measure of the setpoint value from the slave controller (TIC_Temp\MV.PV_InUnit)
from_Slave_1	Scale1		Interconnecting the scaling of the setpoint value from the slave controller (TIC_Temp\MV.Scale)
Sim	Sim1ValueOp		Interconnecting to the simulation chart (Sim_TempLevel\TempLevel.Out)
Sim	Sim1ActOp.Value	1	
Sim	Sim2ActOp.Value	1	
PV	PV_Out		Interconnecting the process value to the measured value display (PI_Tank\I.PV)
PV	ScaleOut		Interconnecting the process value scaling to the measured value display (TI_Tank\PV.Scale)
PV	Bad		Interconnecting the “Bad” status for the measured value display (TI_Tank\I.CSF)
PV	OosAct		Interconnection from the “Out of service” signal to the process value display (TI_Tank\I.OosLi)
PV	PV_InUnit	1001	Unit of the process value in degree Centigrade

TIC_Split

In the “TIC_Split” process tag the temperature of the heat exchanger is recorded and transferred to the “TI_HeatExchanger” process tag for measured value display. The “TIC_Split” process tag controls both control values “YC_Heat” and “YC_Cool” via communication blocks. The setpoint specification receives the “TIC_Split” process tag from the “TIC_Temp” process tag. “TIC_Split” is the slave controller of the cascade control. The manipulated value is transferred by the “TIC_Temp” process tag as external setpoint value and is used as simulation value.

“TIC_Split” is an instance from process tag type “CTRL__Splitrange” and contains two additional communication blocks (“to_Master” and “from_Master”). In order for the controller and the valves to use the same manipulated valuable unit (%), the interconnection from_Master.Int1 and C.MV_Unit was deleted.

The following table shows the configuration of the instance from CTRL_Splitrange”.

Table 5-34

Block	Connection	Value	Usage
C	Gain.Value	3.5	Controller gain
C	NormMV.High NormMV.Low	100 -100	Manipulated value area
C	DeadBand	0.2	Width of the dead band
C	ManLoLim (invisible)	-100.0	Lower limit for manual operation
C	CPI_In		Interconnection for opening the ConPerMon faceplate from the faceplate (TIC_Split\CPM.CPI)
C	RefStdDevIn		Interconnection for opening the ConPerMon faceplate from the faceplate
C	MV_OpScale.High MV_OpScale.Low	100 -100	(TIC_Split\CPM.RefStdDev)
CPM	RefVariance	0.0	
Connector	SP_LiOp.Value	1	Setpoint value via interconnection as start value
Connector	SP_ExtLi.Value	1	Using the external setpoint as start value
Connector	SP_Ext.Value		(TIC_Split\from_Master.ReStru1)
Connector	AutModLi.Value	1	Activating the automatic mode
Splitrange	Out1		Interconnection for the cooling simulation (Sim_TempLevel\ HeatExchanger.SP_11)
Splitrange	Out2		Interconnection for the heating simulation (Sim_TempLevel\ HeatExchanger.SP_1)
Splitrange	Out1Act		Interconnection for the cooling simulation (Sim_TempLevel\ HeatExchanger.OPEN_11)
Splitrange	Out2Act		Interconnection for the heating simulation (Sim_TempLevel\ HeatExchanger.OPEN_1)
from_Val_An1	In		Status of the valve for heating steam (YC_Heat\to_CTRL.Out)
from_Val_An2	In		Status of the valve for cooling water (YC_Cool\to_CTRL.Out)
to_Val_An1	Out		Control commands of the valve for heating steam (YC_Heat\from_CTRL.In)
to_Val_An2	Out		Control commands of the valve for cooling water (YC_Cool\from_CTRL.In)
ComStruIn			Reinserted as “to_Master”, for transferring control signals
to_Master	BoStru1		(TIC_Split\C.CascaCut)

Block	Connection	Value	Usage
to_Master	BoStru2		(TIC_Split\CSF.Out)
to_Master	BoStru3		(TIC_Split\OosAct.Out)
to_Master	Int1		(TIC_Split\PV.PV_OutUnit)
to_Master	Scale1		(TIC_Split\PV.ScaleOut)
to_Master	Out		(TIC_Temp\from_Slave_1.In)
ComStruOut			Reinserted as “from_Master”, for receiving control commands
from_Master	In		(TIC_Temp\to_Slave.Out)
from_Master	ReStru1		(TIC_Split\Connector.SP_Ext)
from_Master	BoStru2		(TIC_Split\Intlock.In03)
from_Master	Int2 (switch to visible)		Interconnecting the “PV_OutUnit” from the channel block of the master controller
from_Master	Scale1 (switch to visible)		(TIC_Split\PV.PV_InUnit)
Sim	Sim1ActOp.Value	1	Activating the simulation of the controlled variable
Sim	Sim1ValueOp		(Sim_TempLevel\HeatExchanger.V)
PV	PV_Out		Interconnection from the process value to the measured value display (TI_HeatExchanger\I.PV)
PV	PV_OutUnit		Interconnecting the process value unit to the measured value display (TI_HeatExchanger\PV.PV_InUnit)
PV	ScaleOut		Interconnecting the process value scaling to the measured value display (TI_HeatExchanger\PV.Scale)
PV	Bad		Interconnecting the “Bad” status for the measured value display (TI_HeatExchanger\I.CSF)
PV	OosAct		Interconnection from the “Out of service” signal to the process value display (TI_HeatExchanger\I.OosLi)
PV	Scale		Measured value scaling

TI_Tank

In the “TI_Tank” process tag the measured value of the channel block of the “TIC_Temp” process tag is displayed. Limit values (alarm, warning) are not set in the operator control and monitoring block (MonAnL), since these are defined specifically for each process.

The following table shows the configuration of the instance from “AMON__Std”.

Table 5-35

Block	Connection	Value	Usage
I	PV		New interconnection to the channel block of the controller process tag (TIC_Temp\PV.PV_Out)
I	OosLi		New interconnection to the “Out of service” signal of the channel block of the controller process tag

Block	Connection	Value	Usage
			(TIC_Temp\PV.OosAct)
I	CSF		New interconnection to the “Bad” signal of the channel block of the controller process tag (TIC_Temp\PV.Bad)
PV	Scale		Interconnection to the scaling of the process value (TIC_Temp\PV.ScaleOut)
PV	PV_InUnit		Interconnection to the unit of the process value (TIC_Temp\PV.PV_OutUnit)

TI_HeatExchanger

In the “TI_HeatExchanger” process tag the measured value of the channel block of the “TIC_Split” process tag is displayed. Limit values (alarm, warning) are not set in the operator control and monitoring block (MonAnL), since these are defined specifically for each process.

The following table shows the configuration of the instance from “AMON__Flow”.

Table 5-36

Block	Connection	Value	Usage
I	PV		New interconnection to the channel block of the controller process tag (TIC_Split\PV.PV_Out)
I	OosLi		New interconnection to the “Out of service” signal of the channel block of the controller process tag (TIC_ Split\PV.OosAct)
I	CSF		New interconnection to the “Bad” signal of the channel block of the controller process tag (TIC_Split\PV.Bad)
PV	Scale		Interconnection to the scaling of the process value (TIC_ Split\PV.ScaleOut)
PV	PV_InUnit		Interconnecting the unit of the process value (TIC_ Split\PV.PV_OutUnit)

YC_Heat and YC_Cool

The valve process tags have been designed specifically for the application in a split-range control. Each process tag contains communication blocks for data exchange (control signals and control commands) with the controller process tag.

Valve block “V” receives an external manipulated value (via a communication block) from the controller process tag. Both channel blocks in subchart “B” (Rbk and MV) receive the same value as the process value (manipulated value of the valve block (subchart “A”, sheet 1)) via the preceding simulation block.

The following table shows the configuration of the instance from “Val_An_Afb1”.

Table 5-37

Block	Connection	Value	Usage
V	NoFbkOpen	1	Feedback “Valve open” deactivated

Block	Connection	Value	Usage
V	NoFbkClose	1	Feedback “Valve closed” deactivated
from_CTRL (YC_Heat) (YC_Cool)	In		Interconnection to the controller (TIC_Split\to_Val_An1.Out) (TIC_Split\to_Val_An2.Out)
to_CTRL (YC_Heat) (YC_Cool)	Out		Interconnection to the controller (TIC_Split\from_Val_An1.In) (TIC_Split\from_Val_An2.In)
Sim	Sim1ActOp.Value	1	Activating the simulation of the readback value
Sim	Sim2ActOp.Value	1	Activating the simulation of the manipulated value
Sim	Sim1ValueOp		Simulation of the readback value from the valve (Interconnected with V.MV)
Sim	Sim2ValueOp		Simulation of the manipulated value from the valve (Interconnected with V.MV)

NS_PumpMixture

The Motor process tag has been designed for universal application and is controlled via an SFC interconnection or by an operator. In the equipment module the operator starts the pump during startup.

The following table shows the configuration of the instance from “MOT_1sp_1fb_1cm__Std”.

Table 5-38

Sim	Sim1ValueOp		Interconnection to motor block (U\Start.Out)
Sim	Sim6ValueOp		Interconnection to motor block (U\Start.Out)
Sim	Sim7ActOp	1	Simulation of the feedback for starting the motor (local message)

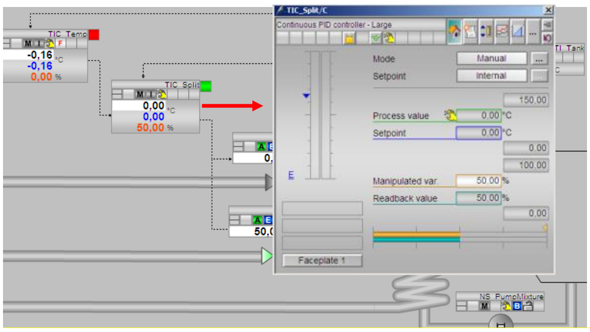
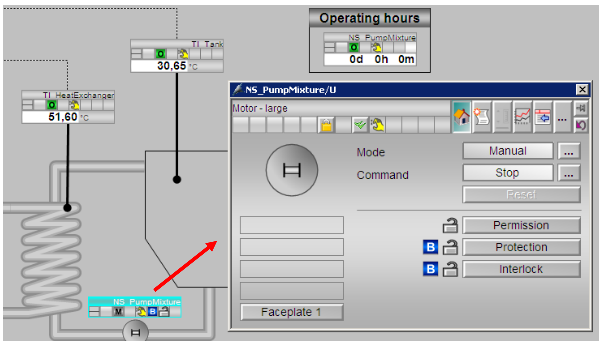
5.4.3 Commissioning, operation and instance-specific adjustments

Commissioning and operation requires a downloaded user program in automation system (AS) or S7-PLCSIM, and an activated OS (WinCC Runtime). Instructions for downloading the user program and activating the OS are available in chapter 7 “Starting the Equipment Module”.

Commissioning

For commissioning, please follow the instructions below:

Table 5-39

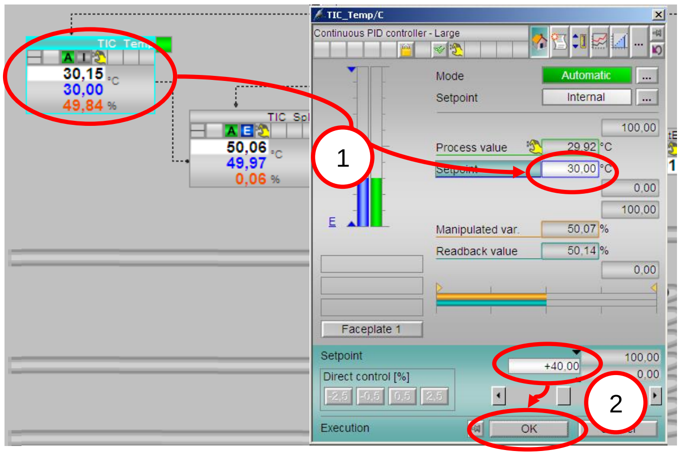
No.	Action
1.	Click on the block icon of the “TIC_Split” controller. The respective faceplate is opened.  TIC_Split/C Continuous PID controller - Large Mode: Manual Setpoint: Internal Process value: 0.00 °C Setpoint: 0.00 °C Manipulated var.: 50.00 % Readback value: 50.00 % Faceplate 1
2.	Change the operating mode of the controller. In the faceplate you click on the “…” button next to the mode switch (“Mode”) and in the faceplate extension you click on the “Automatic” button and adopt the settings with “OK”. **Note**: The interlock of master controller “TIC_Temp” is cancelled.
3.	Perform steps 1 to 2 for master controller “TIC_Temp”.
4.	For changing the setpoint value you click on the “Setpoint” input field and enter the setpoint value “30” in the faceplate expansion. Acknowledge the input with “ENTER” and adopt the new value with “OK”. **Note**: The input of a setpoint value is only performed in the faceplate of the “TIC_Temp” controller.
5.	Click on the block icon of the “NS_PumpMixture” pump. The respective faceplate is opened.  Operating hours NS_PumpMixture: 0d 0h 0m NS_PumpMixture/U Motor - large Mode: Manual Command: Stop Reset Permission Protection Interlock Faceplate 1
6.	For starting the motor in the faceplate you click on the “…” button next to Command and in the faceplate extension you click on the “Start” button and adopt the settings with “OK”.

Operation

The following instruction describes the operation of the equipment module “Split-Range-Temperature”. After the CPU start (in the initial state) and commissioning the setpoint value is 30°C and the temperature remains on 30°C with little fluctuations.

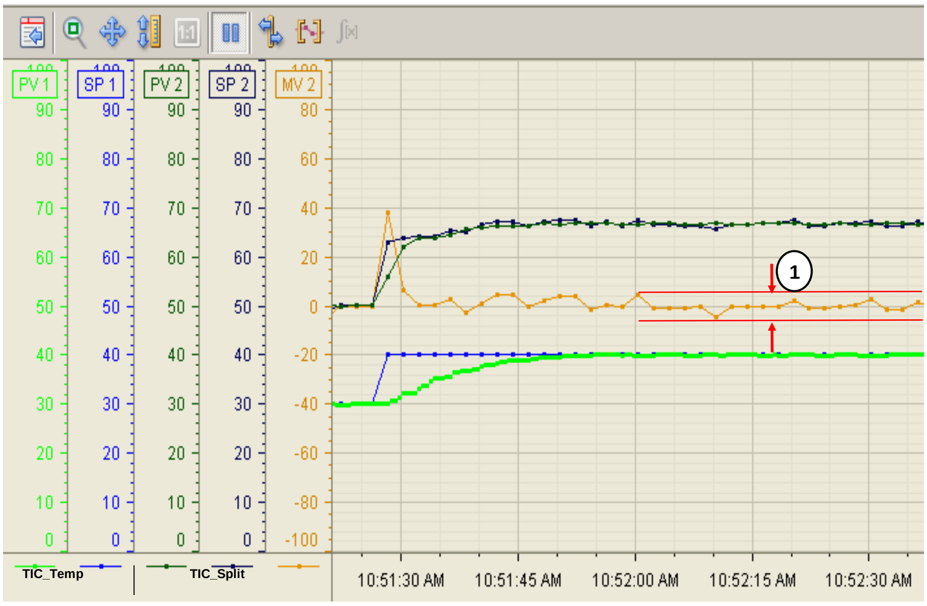
In the following scenario the setpoint value is increased from 30°C to 3°C.

Table 5-40

No.	Action
1.	Click on the block icon of the “TIC_Temp” controller. The respective faceplate is opened.
2.	Click on the “Setpoint” input field and enter value “40” into the input field of the faceplate expansion. Then acknowledge the input with the “Enter” key and click on the “OK” button. 
3.	Close the faceplate and observe the curve plotter for approx. 1 minute, until the setpoint has been reached.

Evaluation

Figure 5-18



After setpoint value change SP 1 the master controller calculates a manipulated variable MV 1 and forwards it to the slave controller in the cascade. This manipulated variable is represented as setpoint SP 2 for the slave controller in the trend diagram.

The slave controller calculates the manipulated variable MV 2 from the setpoint value trend SP 2. MV 2 affects the heating and cooling valves and yields the temperature trend PV 2 of the heat exchanger.

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

Legend	
①	The setpoint value (SP 1) causes noise in the MV 2 manipulated variable. The oscillation of the MV 2 manipulated variable around the neutral position is due to the simulation. At the real process this alternating behavior of heating and cooling needs to be avoided.

Instance-specific adjustments

The following tables contain the relevant parameters which must either be set or interconnected. Chapter 6.2 “Process connection” describes the procedure for connecting process devices.

The following table contains the parameters to be set specifically for each process.

Table 5-41

Process tag	Block	Connection	Usage
TI_Tank / TI_HeatExchanger	I Subchart “A”	PV_AH_En	Alarm for exceeded limit value, if PV ≥ PV_AH_Lim
TI_Tank/ TI_HeatExchanger	I Subchart “A”	PV_WH_En	Warning for exceeded limit value, if PV ≥ PV_WH_Lim
TI_Tank/ TI_HeatExchanger	I Subchart “A”	PV_WL_En	Warning for falling below the limit value, if PV ≥ PV_AL_Lim
TI_Tank/ TI_HeatExchanger	I Subchart “A”	PV_AL_En	Alarm for falling below the limit value, if PV ≥ PV_AL_Lim
TIC_Temp /’ TIC_Split	C Subchart “A”	Gain	Proportional gain
TIC_Temp / TIC_Split	C Subchart “A”	TD	Derivative time (rate time) in [s]
TIC_Temp / TIC_Split	C Subchart “A”	TI	Integral time (reset time) in [s]
TIC_Temp / TIC_Split	C Subchart “A”	SP_InHiLim	Limit value (high) of the internal setpoint value
TIC_Temp / TIC_Split	C Subchart “A”	SP_InLoLim	Limit value (low) of the internal setpoint value
TIC_Temp / TIC_Split	C Subchart “A”	PV_WH_En	Alarm for exceeded limit value, if PV ≥ PV_AH_Lim
TIC_Temp / TIC_Split	C Subchart “A”	PV_TH_En	Warning for exceeded limit value, if PV ≥ PV_WH_Lim
TIC_Temp / TIC_Split	C Subchart “A”	PV_TL_En	Warning for falling below the limit value, if PV ≥ PV_TH_Lim
TIC_Temp / TIC_Split	C Subchart “A”	PV_TL_En	Tolerance for falling below the limit value, if PV ≤ PV_TL_Lim
TIC_Temp / TIC_Split	C Subchart “A”	PV_WL_En	Warning for falling below the limit value, if PV ≥ PV_WL_Lim
TIC_Temp / TIC_Split	C Subchart “A”	PV_AL_En	Alarm for falling below the limit value, if PV ≥ PV_AL_Lim
TIC_Temp / TIC_Split	C Subchart “A”	ER_AH_En (invisible)	Alarm for exceeded error signal, if ER ≥ ER_AH_Lim
TIC_Temp / TIC_Split	C Subchart “A”	ER_AL_En (invisible)	Alarm for fallen short of error signal, if ER ≥ ER_AL_Lim
TIC_Temp	PV	Scale	Scaling the measured value (e.g.

Process tag	Block	Connection	Usage
	Subchart “B”		temperature of max. 100)
TIC_Temp	PV Subchart “B”	PV_InUnit	Unit of the scaled measured value (e.g. “1001” for degree Centigrade)
TIC_Temp	MV Subchart “B”	PV_InUnit	Unit of the scaled measured value (e.g. “1342” for percent)
TIC_Split	C Subchart “A”	NormMV	Manipulated value range (MV) for normalization of the proportional gain (GAIN)
TIC_Split	Splitrange Subchart “A”	InScale	Limit rage for the input signal (e.g. from -100 to +100)
TIC_Split	Splitrange Subchart “A”	NeutPos	Neutral position
TIC_Split	Splitrange Subchart “A”	DeadBand	Dead band range
YC_Heat / YC_Cool	V Subchart “A”	MV_HiLim MV_LoLim	Upper and lower limit of the manipulated value
YC_Heat / YC_Cool	MV Subchart “B”	Scale	Scaling the manipulated variable (manipulated value from the valve block)
YC_Heat / YC_Cool	MV Subchart “B”	PV_InUnit	Unit of the scaled manipulated variable

NOTE

For commissioning the “TIC_Split” controller the “PID-Tuner” program is available to you. Chapter 6.3 “Configuration of the PID controllers” describes the procedure for optimizing the controller. The experiment for data recording for the “PID-Tuner” is initially performed in an operating range in which only positive manipulated variables occur. Afterwards, a comparable experiment is made in an operating range, where only negative manipulated variables occur.

If both partially controlled sections for heating and cooling yield clearly different values for the process gain, this must be compensated by a varied increase in both branches of the split-range characteristic curve.

After the slave controller, including the split-range, has been fully started up and tested, the “TIC_Temp” master controller is adjusted using the “PID Tuner” program.

The online help offers further information and configuration notes on process tag type “CascadeControl”. The process tag type is available in the “PCS 7 Advanced Process Library”.

The following table contains an overview of parameters to be interconnected with process devices.

Table 5-42

Process tag	Block	Connection	Value
TIC_Temp	PV Subchart “B”	PV_In	Inside container temperature (component mixture)

Process tag	Block	Connection	Value
TIC_Split	PV Subchart “B”	PV_In	Temperature in the heat exchanger
YC_Heat	Rbk Subchart “B”	PV_In	Manipulated variable feedback
YC_Heat	MV Subchart “B”	PV_Out or PV_ChnST	Output of the manipulated variable or output of the manipulated variable including signal status of the output signal
YC_Cool	Rbk Subchart “B”	PV_In	Manipulated variable feedback
YC_Cool	MV Subchart “B”	PV_Out or PV_ChnST	Output of the manipulated variable or output of the manipulated variable including signal status of the output signal
NS_PumpMixture	FbkRun Subchart “B”	PV_In	Feedback signal when starting a motor
NS_PumpMixture	Maint Subchart “B”	PV_In	Motor maintenance request
NS_PumpMixture	Trip Subchart “B”	PV_In	Motor error message
NS_PumpMixture	StartLocal Subchart “B”	PV_In	Local operation (starting a motor)
NS_PumpMixture	StopLocal Subchart “B”“	PV_In	Local operation (stopping a motor)
NS_PumpMixture	Start Subchart “B”	PV_Out	Starting / stopping a motor
NS_PumpMixture	FbkRunOut Subchart “B”	PV_Out	Feedback for starting the motor

NOTE In the object properties of the message-capable blocks you can configure instance-specific messages. An instruction for the procedure is available in the configuration manuals “Process Control System PCS 7 Operator Station (V7.1)” under the following entry ID: 36194551 and “SIMATIC Process Control System PCS 7 Operator Station (V8.0)” under the entry ID: 57270173

5.5 Control of the pH value with a standard controller

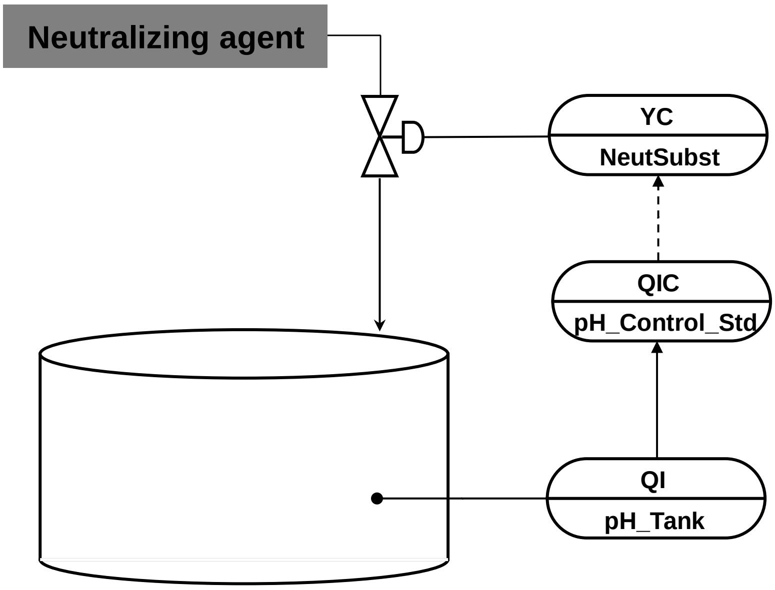
The equipment module "pH-Control-Std" is used to regulate the pH value of a product. This is effected by adding a neutralizing agent to the product during the continuous plant process until the desired pH value is reached.

Due to the highly nonlinear titration curve this means that, depending on the operating point, the control loop gain may be subject to extreme variations. Only in applications in which the pH value shall be kept constant within a very narrow range, and if the disturbing influences are limited, the pH value can be regulated with a preconfigured PID controller. The specialty of the equipment module presented here is the transformation of the pH setpoint and the pH process value into concentration differences, so as to achieve a linearization of the control loop characteristic. This transformation is based on a titration curve which describes the behavior of the chemical reaction of the given process at least by approximation.

In the case of complex applications with long dead times (because of the measuring dead time of the pH probe, the time required for mixing and the reaction time of the neutralizer) and the requirement of dynamic disturbance compensation based on the pH value in the inflow (feed), we recommend to compensate these influences with the help of a multi-variable controller.

5.5.1 Overview

The following section describes the structure in the P&I scheme including all process tags and simulation of the equipment module.



Process tags

The equipment module "pH-Control-Std" consists of 3 interconnected process tags and a simulation chart. The simulation chart is used to calculate the pH setpoint on the basis of the concentration difference between component and neutralizer.

The setpoint (pH value) is defined in an OpAnL block. The controller receives the converted pH values (setpoint and actual value) in the form of a concentration difference for regulation.

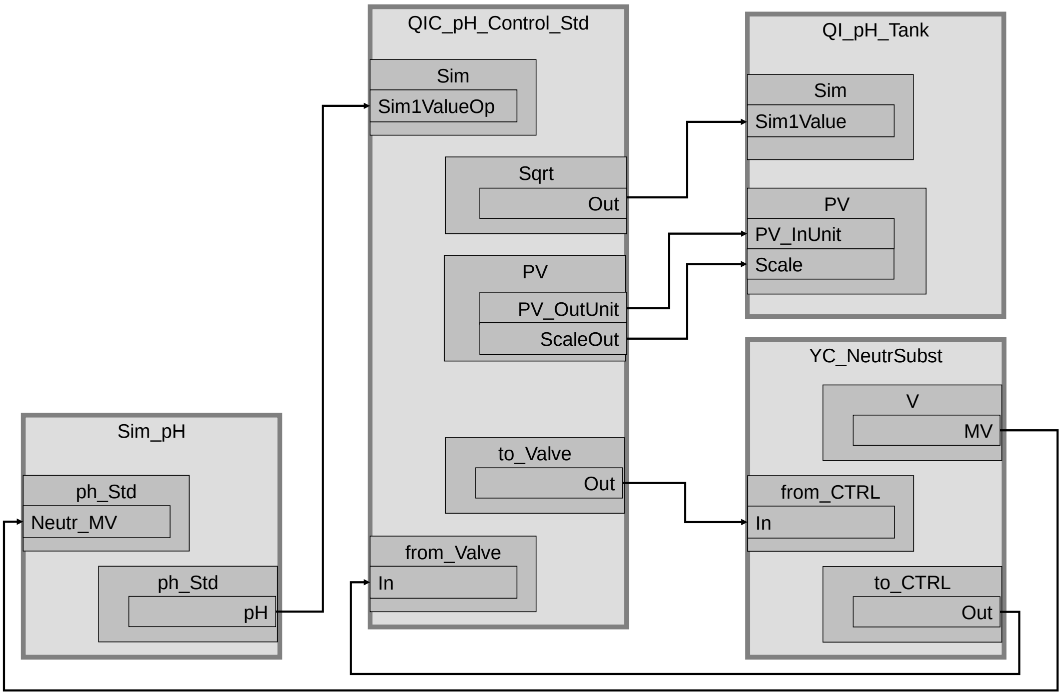
The table below provides an overview of the process tags for the equipment module including the associated process tag types.

Table 5-43

Process tag	Process tag type	Description
QIC_pH_Control_Std	"CTRL_Std4Valve"	Standard PID controller with one manipulated variable
QI_pH_Tank	"AMON__Std"	Display of the measured pH value of the product
YC_NeutrSubst	"Val_An_Afb1"	Control valve for the neutralizer

In the following figure the entire structure, including all interconnections across all CFC charts, are represented in a simplified format.

Figure 5-20



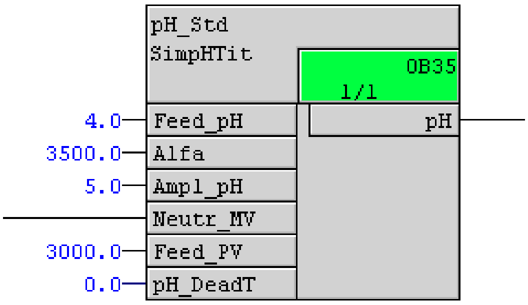
The controller process tag "QIC_pH_Control_Std" captures the pH value in the tank (product) and – depending on the concentration differences between pH setpoint and actual pH value – it adds the required amount of neutralizer via the control valve "YC_NeutrSubst". Since the controller process tag is used to display the concentration difference, the pH value is displayed with the help of a display process tag. If the valve process tag shows an error, the controller process tag will change over to manual mode and display will be realized in both process tags.

5.5.2 Structure and configuration

Simulation "Sim_pH"

The CFC chart "pH_Std" is used for calculation of the pH value. The figure below shows how the simulation block is configured.

Figure 5-21



The block inputs include notional parameters for the buffer parameter "Alfa" and the amplitude range "Ampl_pH" to be covered. In addition, fixed values for the pH value and the feed rate are defined.

There is no dead time defined for the pH simulation value (simulation process).

Note For further information please refer to the block description in chapter 10.6 "Block description "SimpHTitr.

QIC_pH_Control_Std

This process tag is used to pick up the product’s pH value in the tank during a continuous production process and to transfer this value to the process tag "QI_pH_Tank" in the measured value display. In this process tag, the setpoint is defined in an OpAnl block. Setpoint and actual value are converted into concentration differences and then transmitted to the controller.

Note The titration curve for a specific chemical process must be configured with the help of the PID tuner before the PID controller is set. For further information on how to convert the pH value into a concentration difference please refer to the block description in chapter 10.5 "Block description "pHTitrBlock.

The pH value is regulated by transmitting control signals to the valve process tag "YC_NeutrSubst".

Note If the component feed rate is expected to be subject to large differences, we recommend to realize disturbance compensation through linear conversion of the manipulated value using the block "pHTitrBlock". This block is described in chapter 10.5 "Block description "pHTitrBlock.

The controller process tag "QIC_pH_Control_Std" is an instance of the process tag type "CTRL_Std4Valve".

The table below shows how the instance of "CTRL_Std4Valve" is configured.

Table 5-44

Block	Connection	Value	Usage
C	NegGain.Value	0	Positive controller gain, since the control operation is used to increase the pH value
C	Gain.Value	6	Controller gain
C	NormPV	10000 -10000	Minimum and maximum value of the concentration difference.
C	TI.Value	2	Controller delay
C	SP_InHiLim	10000	Maximum value of the internal setpoint
C	SP_InLoLim	-10000	Minimum value of the internal setpoint
C	SP_Ext		Previous interconnection deleted. New interconnection to the conversion block (pHTitrConvert.SP_Out)
C	PV		Previous interconnection deleted. New interconnection to the conversion block (pHTitrConvert.CV_Out)
C	PV_OpScale	10000 -10000	Previous interconnection to the channel block deleted. Minimum and maximum value of the concentration difference.
C	PV_Unit	1399	Previous interconnection to the channel block deleted. Unit of the concentration difference in mol/L
pHTitrBlock			Newly added as "pHTitrConvert" for the conversion of pH values
pHTitrConvert	Alfa	35000	Buffer parameter
pHTitrConvert	Ampl_pH	5.0	Amplitude range to be processed
pHTitrConvert	CV_Out		Interconnection to the controller block (C.PV)
pHTitrConvert	SP_Out		Interconnection to the controller block (C.SP_Ext)
Connector	SP_LiOp	1	1 = Setpoint specification via CFC/SFC
Connector	SP_ExtLi	1	1 = External setpoint specification via CFC/SFC
Connector	SP_ExtOut		Previous interconnection deleted. New interconnection to the conversion block (pHTitrConvert.SP)
OpAnL			Newly added as "pH_SP" for setpoint entry by the operator
pH_SP	SP_IntLi	1	1 = Internal setpoint via specification CFC/SFC
pH_SP	SP_Int	7	Internal setpoint
pH_SP	SP_HiLim	7.5	Maximum setpoint
pH_SP	SP_LoLim	6.5	Minimum setpoint
pH_SP	SP_Unit	1422	Setpoint unit as pH value

Block	Connection	Value	Usage
pH_SP	SP_Out		Interconnection to the connector block (Connector.SP_Ext)
Intlock	InvIn02	1	Inversion of the hardware error signal from the valve process tag
to_Valve	Out		Interconnection to the valve process tag (YC_NeutrSubst\from_CTRL.In)
from_Valve	In		Interconnection from the valve process tag (YC_NeutrSubst\to_CTRL.Out)
Sim	Sim1ActOp.Value	1	Simulation value of the pH value if set to "1" active
Sim	Sim1ValueOp		Interconnection to the pH value in the simulation chart (Sim_pH\pH_Std.pH)
PV	Scale.High Scale.Low	12.0 2.0	Maximum and minimum process value
PV	PV_InUnit	1422	Unit of the process value (pH)
PV	Bad		Interconnection to the interlock block (Intlock.In01)
PV	PV_OutUnit		Interconnection to the display process tag (QI_pH_Tank \PV.PV_InUnit)
PV	ScaleOut		Interconnection to the display process tag (QI_pH_Tank \PV.Scale)
Sqrt	Out		Interconnection to the display process tag (QI_pH_Tank \Sim.Sim1ValueOp) and the conversion block (pHTitrConvert.CV)

QI_pH_Tank

The "QI_pH_Tank"process tag is used to display the channel block measuring value of the controller process tag "QIC_pH_Control_Std". No limit values (alarm, warning) are set in the operator control and monitoring block, since these are defined specifically for each process.

The table below shows the configuration of the instance of "AMON__Std".

Table 5-45

Block	Connection	Value	Usage
Sim	Sim1ActOp	1	Active simulation value
Sim	Sim1ValueOp		New interconnection to the process value of the controller process tag (QIC_pH_Control_Std\Sqrt.Out)
PV	Scale		Interconnection to the scaling of the process value (QIC_pH_Control_Std \PV.ScaleOut)
PV	PV_InUnit		Interconnection to the unit of the process value (QIC_pH_Control_Std \PV.PV_OutUnit)

Note The messages for hardware error and device in maintenance mode (CSF) (OosLi) of the controller process tag are not displayed separately. If these messages are required, interconnect them additionally with the interlock block of the controller process tag.

YC_NeutrSubst

The valve process tag "YC_NeutrSubst" is used to control the flow rate of the neutralizing agent. This process tag contains the communication blocks for data exchange (control signals and control commands) with the controller process tag.

The valve block "V" receives an external manipulated value from the controller process tag (via a communication block). In a simulation environment, both channel blocks in subchart "B" (Rbk and MV) receive the same value (manipulated value of the valve block (subchart "A", sheet 1)) via the preceding simulation block.

The table below shows the configuration of the instance from "Val_An_Afb1".

Table 5-46

Block	Connection	Value	Usage
V	MV		Interconnection to the simulation (Sim_pH\phSimu.FV_IN_2)
V	ER_AH_En (hidden)	0	Deactivation of the alarm message for maximum valve opening
V	ER_AL_En (hidden)	0	Deactivation of the alarm message for minimum valve opening
from_CTRL	In		Interconnection to the controller (QIC_pH_Control_Std\to_Valve.Out)
to_CTRL	Out		Interconnection to the controller (QIC_pH_Control_Std\from_Valve.In)
Sim	Sim1ActOp.Value	1	Activates simulation of the readback value
Sim	Sim1ValueOp		Interconnected with the simulation of the readback value from the valve (YC_NeutrSubst\V.MV)
Sim	Sim2ActOp.Value	1	Activates simulation of the manipulated value
Sim	Sim2ValueOp		Interconnection with the simulation of the manipulated value from the valve (YC_NeutrSubst \V.MV)

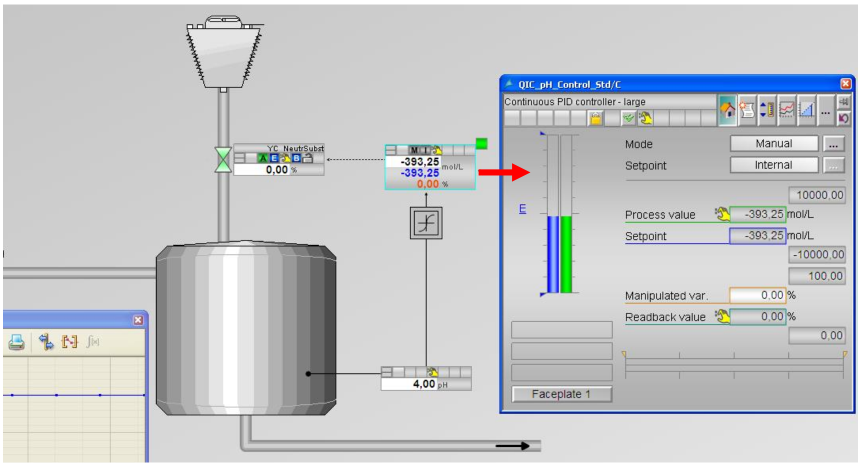
5.5.3 Commissioning, operation and instance-specific adjustments

Commissioning and operation requires a downloaded user program in automation system (AS) or S7-PLCSIM, and an activated OS (WinCC Runtime). Instructions for downloading the user program and activating the OS are available in chapter 7 “Starting the Equipment Module”.

Commissioning

For commissioning, proceed as follows:

Table 5-47

No.	Action
1.	Click the block icon of the controller "QIC_pH_Control_Std" to open the associated faceplate.  Mode: Manual Setpoint: Internal 10000,00 Process value -393,25 mol/L Setpoint -393,25 mol/L -10000,00 100,00 Manipulated var. 0,00 % Readback value 0,00 % 0,00
2.	Change the operating mode of the controller. In the faceplate, click the "…" button next to the "Mode" switch and in the expanded faceplate, click the "Automatic" button. Then confirm your settings with "OK".
3.	The controller uses the pH value predefined in the OpAnL block icon as external setpoint. The default value of this setpoint (neutral zone) is set to "7" pH which is taken as a basis for the quantity of neutralizer to be added (for regulation).

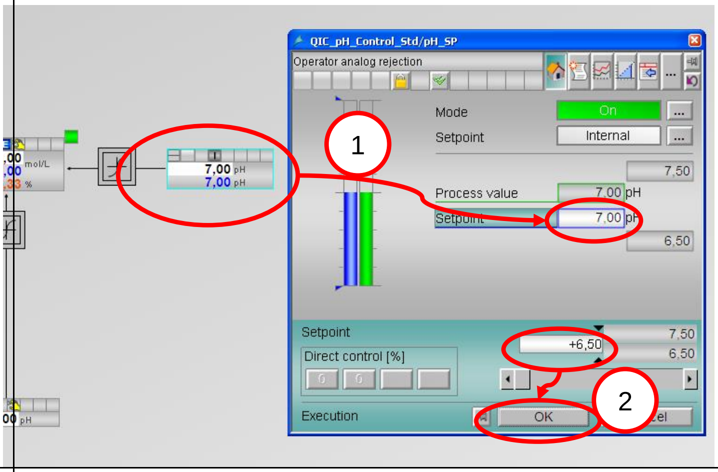
Operation

The following instruction describes how the equipment module "pH-Control-Std" is operated. After start-up of the CPU (in initial status) and commissioning, the setpoint is set to 7 pH.

In the following scenario, the pH value (setpoint) shall be reduced from 7 pH to 6.5 pH.

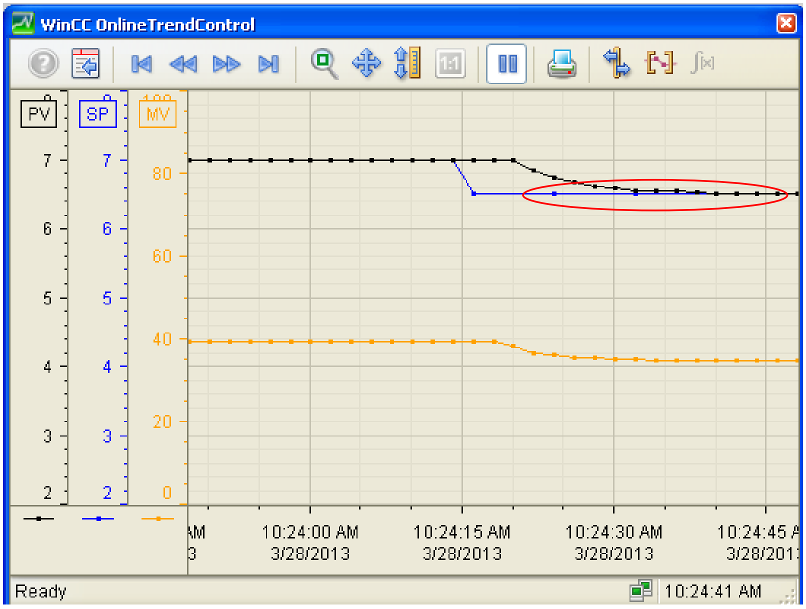
Table 5-48

No.	Action
1.	Click the block icon of the OpAnL block (right to the controller block) to open the associated faceplate.

No.	Action
2.	Click the input field "Setpoint" and enter the value "6.5" in the input field of the expanded faceplate. Then press the "ENTER" key to confirm settings and click 
3.	Close the faceplate and watch the curve plotter for approx. 1 minute until the setpoint is reached.

Evaluation

Figure 5-22



The controller has been optimized so as to reach the setpoint without overshoots. After the setpoint change, the controller adds the neutralizer with a slight delay.

Note The controller is set to an operating point of ± 0.5 pH around the neutral zone of 7 pH. If the operating point deviates from this value, the controller may need to be optimized anew.

Instance-specific adjustments

The following tables contain the relevant parameters which must either be set or interconnected. Chapter 6.2 “Process connection” describes the procedure for connecting process devices.

The table below lists all parameters to be set specifically for the relevant process.

Table 5-49

Process tag	Block	Connection	Usage
QI_pH_Tank	I Subchart "A"	PV_AH_En	Upper limit violation alarm, if PV ≥ PV_AH_Lim
QI_pH_Tank	I Subchart "A"	PV_WH_En	Upper limit violation warning, if PV ≥ PV_WH_Lim
QI_pH_Tank	I Subchart "A"	PV_WL_En	Lower limit violation warning, if PV ≤ PV_WL_Lim
QI_pH_Tank	I Subchart "A"	PV_AL_En	Lower limit violation alarm, if PV ≤ PV_AL_Lim
QIC_pH_Control_Std	C Subchart "A"	Gain	Proportional gain
QIC_pH_Control_Std	C Subchart "A"	TD	Derivative action time in [s]
QIC_pH_Control_Std	C Subchart "A"	TI	Integral action time in [s]
QIC_pH_Control_Std	C Subchart "A"	SP_InHiLim	Limit value (high) of the internal setpoint
QIC_pH_Control_Std	C Subchart "A"	SP_InLoLim	Limit value (low) of the internal setpoint
QIC_pH_Control_Std	C Subchart "A"	PV_AH_En	Upper limit violation alarm, if PV ≥ PV_AH_Lim
QIC_pH_Control_Std	C Subchart "A"	PV_WH_En	Upper limit violation warning, if PV ≥ PV_WH_Lim
QIC_pH_Control_Std	C Subchart "A"	PV_TH_En	Tolerance for upper limit exceedance, if PV ≥ PV_TH_Lim
QIC_pH_Control_Std	C Subchart "A"	PV_TL_En	Tolerance for lower limit exceedance, if PV ≤ PV_TL_Lim
QIC_pH_Control_Std	C Subchart "A"	PV_WL_En	Warning of lower limit exceedance, if PV ≤ PV_WL_Lim
QIC_pH_Control_Std	C Subchart "A"	PV_AL_En	Alarm for lower limit exceedance, if PV ≤ PV_AL_Lim
QIC_pH_Control_Std	C Subchart "A"	ER_AH_En (hidden)	Alarm for upper control deviation exceedance, if ER ≥ ER_AH_Lim
QIC_pH_Control_Std	C Subchart "A"	ER_AL_En (hidden)	Alarm for lower control deviation exceedance, if ER ≤ ER_AL_Lim
QIC_pH_Control_Std	C Subchart "A"	ER_AH_Lim	Limit for upper control deviation exceedance
QIC_pH_Control_Std	C Subchart "A"	ER_AL_Lim	Limit for lower control deviation exceedance

Process tag	Block	Connection	Usage
QIC_pH_Control_Std	C Subchart "A"	PV_OpScale	Scaling of the process value within the display range (operator)
QIC_pH_Control_Std	pHTitrConvert Subchart "A"	Alfa	Buffer parameter
QIC_pH_Control_Std	pHTitrConvert Subchart "A"	Ampl_pH	Amplitude range to be processed
QIC_pH_Control_Std	PV Subchart "B"	Scale	Scaling of the measuring value (e. g. temperature of max. 100)
QIC_pH_Control_Std	PV Subchart "B"	PV_InUnit	Unit of the scaled measuring value (e. g. "1001" for degrees Celsius)
YC_NeutrSubst	V Subchart "A"	MV_HiLim MV_LoLim	Upper and lower limit of the manipulated value
YC_NeutrSubst	MV Subchart "B"	Scale	Scaling of the manipulated variable (manipulated value from the valve block)
YC_NeutrSubst	MV Subchart "B"	PV_InUnit	Unit of the scaled manipulated variable

Note For the commissioning of the "QIC_pH_Control_Std" controller, a "PID tuner" program is available. The procedure for controller optimization is described in chapter 6.3 “Configuration of the PID controllers”. The data recording experiment for the "PID tuner" is initially performed in an operating range where only positive manipulated variables occur. Optimization of the pH value controller was performed due to concentration differences with different manipulated values (MV) at a constant infeed amount (component).

The table below provides an overview of all parameters to be interconnected with process devices.

Table 5-50

Process tag	Block	Connection	Usage
QIC_pH_Control_Std	PV Subchart "B"	PV_In	pH value in the tank
YC_NeutrSubst	Rbk Subchart "B"	PV_In	Manipulated variable feedback
YC_NeutrSubst	MV Subchart "B"	PV_Out or PV_ChnST	Output of the manipulated value with or without signal status

Note In the object properties of the message-capable blocks you can configure instance-specific messages. Instructions on how to proceed are available in the configuration manuals "Process Control System PCS 7 Operator Station (V7.1)" under the entry ID: 36194551 and "SIMATIC Process Control System PCS 7 Operator Station (V8.0)" under the entry ID: 57270173.

5.6 Control of the pH value with a multi-variable controller

Control of the pH value with the help of the multi-variable controller "pH-Control-MPC" is used for the same control task but fulfills some special requirements regarding the highly nonlinear titration curve, whereby the pH value is regulated with a standard controller, supplemented by the targeted compensation of dead times in the control loop (because of the measured dead time of the pH probe, the time required for mixing and the reaction time of the neutralizer), as well as a model-based compensation of measurable disturbances resulting from variations in the pH value of the infeed material.

In the following example, regulation of a product's pH value by adding a neutralizing agent is supplemented by considering not only the pH value of the product, but also the process value and inflow volume (feed) of the component.

This example is intended for a continuous process in which the pH value and the inflow volume (feed) of the component can be modified.

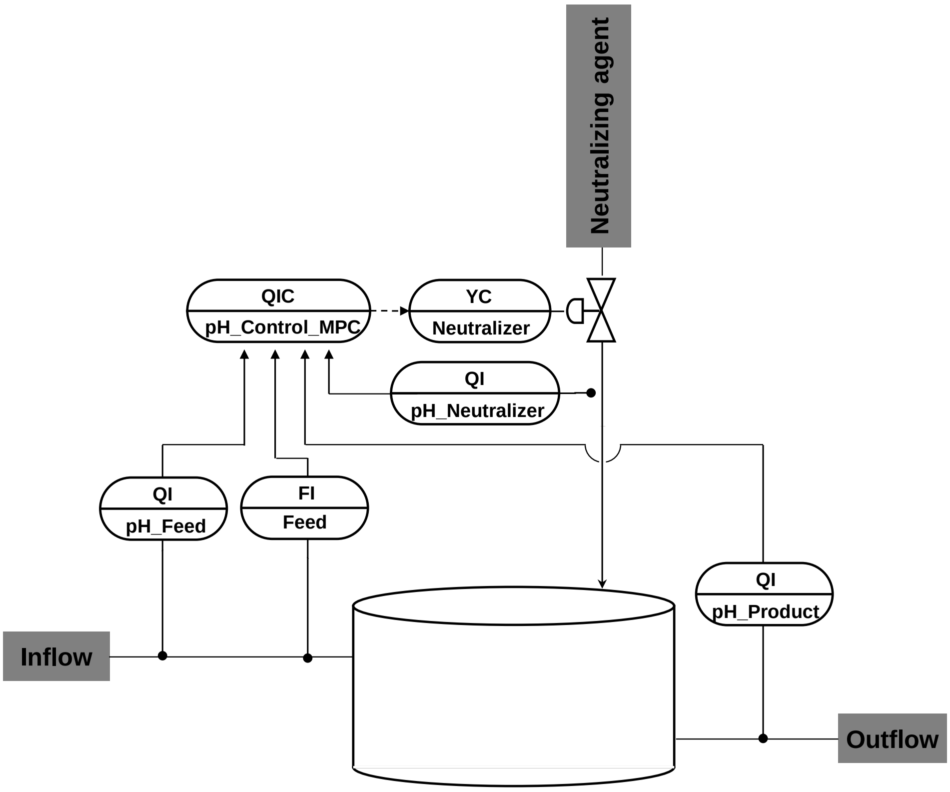
5.6.1 Overview

The P&I diagram below shows the structure and describes all process tags and the simulation of equipment modules.

P&I diagram

The following P&I diagram includes symbols for all components relevant to operation, such as aggregates, tanks, etc., using a multi-variable control system.

Figure 5-23



Process tags

The equipment module "pH-Control-MPC" consists of 4 interconnected process tags and one simulation chart. In the simulation chart, the pH value and the inflow volume of component and neutralizer (manipulated value of the valve) are used to determine the product's pH value.

The pH values of the component and the pH setpoint, as well as the inflow volume (feed) can be adjusted by the operator in the OS with the help of the OpAnL blocks added to the simulation chart and the controller process tag.

The controller uses pH values (setpoint and actual value of the product and actual value of the component) which have been converted into concentration differences. Furthermore, the feed rate of component influences the amount of neutralizer to be added, since the maximum manipulated value changes in relation to the factor of actual and maximum inflow volume of the component.

Note For further information on the calculation of manipulated values and scaling, please refer to the description of blocks in chapter 10.5 "Block description "pHTitrBlock.

The following values are specified in the OpAnL blocks and can be adjusted in the visualization display:

- pH setpoint (product)
- pH value of the component
- inflow volume (feed) of the component

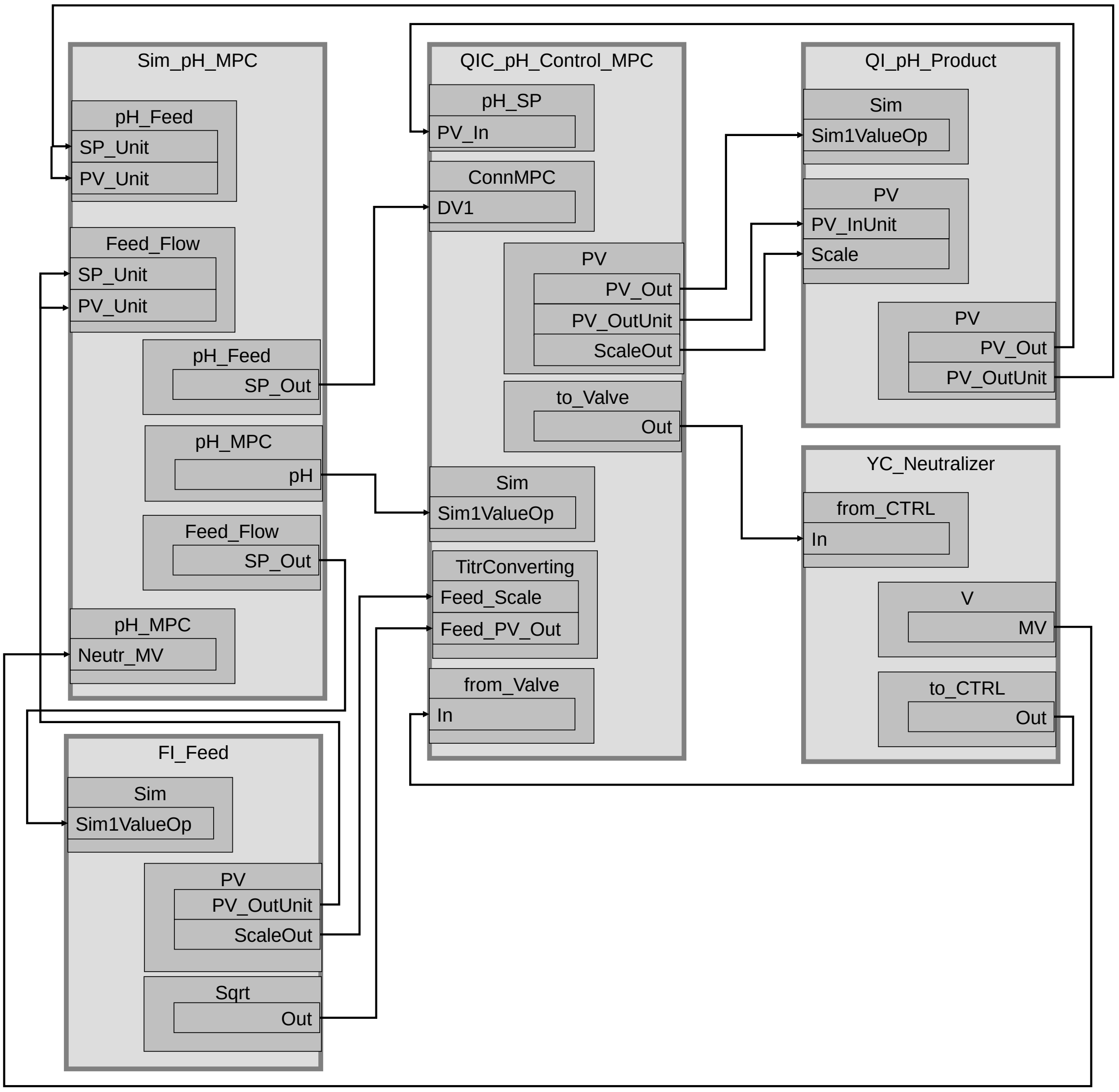
For easier handling, not all specified values have been allocated to a display process tag.

The table below provides an overview of the process tags and equipment modules including the associated process tag types.

Table 5-51

Process tag	Process tag type	Description
QIC_pH_Control_MPC	"CTRL_MPC4Valve"	Multi-variable controller with one manipulated value and acquisition of the pH value of the product
QI_pH_Product	"AMON__Std"	Measured value display of the product's pH value
FI_Feed	"AMON_Flow"	Display of the component's flow rate
YC_Neutralizer	"Val_An_Afb1"	Control valve for the neutralizer

The following P&I diagram represents all components relevant for the operation, such as aggregates, containers, etc. as symbols.



The controller process tag "QIC_pH_Control_MPC" records the pH value of the component and the pH value of the outflowing product in the form of concentration differences. Depending on the pH difference (setpoint and actual value of the product), the required amount of neutralizing agent will be added to the tank via the control valve "YC_Neutralizer". If an error occurs in the valve process tag, the controller process tag changes over to manual mode and the error will be displayed at both process tags.

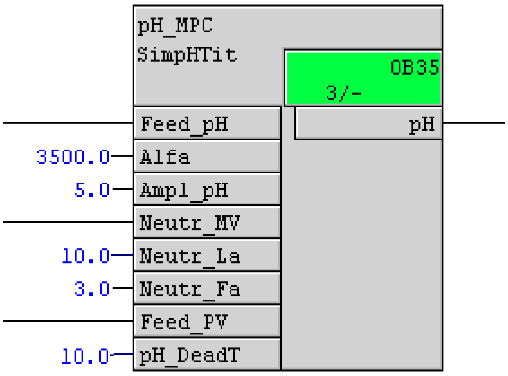
5.6.2 Structure and configuration

Simulation "Sim_pH_MPC"

The CFC chart "Sim_pH_MPC" is used to calculate the pH value. Sheet "1" additionally includes OpAnL blocks to specify the feed rate and the pH value of the component which are interconnected with the simulation block.

The figure below shows the parameter configuration of the simulation block.

Figure 5-25



The block inputs include notional parameters for the buffer parameter "Alfa" and the amplitude range "Ampl_pH" to be passed. In addition, fixed values for the pH value and the feed rate of the component as used in the OpAnL blocks are used for calculation.

For the pH simulation value (simulation process) a dead time of 10 seconds, a neutralizer infeed delay of 10 seconds and a gain factor of 3 are set by default.

Note For further information please refer to the block description in chapter 10.6 "Block description "SimpHTitr.

QIC_pH_Control_MPC

This process tag is used to pick up the product’s pH value in the tank during a continuous production process and to transfer this value to the process tag "QI_pH_Product" in the measured value display. In this process tag, the setpoint is defined in an OpAnl block. Setpoint and actual value are converted into concentration differences and then transmitted to the controller.

Note The titration curve for a specific chemical process must be configured before setting the MPC with the help of the MPC configurator.

For further information on the conversion of the pH value into a concentration difference, please refer to the block description in chapter 10.5 "Block description "pHTitrBlock.

The multi-variable controller (MPC) transmits control signals to the valve process tags "YC_Neutralizer".

The table below shows how the instance of "CTRL_MPC4Valve" is configured.

Table 5-52

Block	Connection	Value	Usage
MPC	PreFilt1	0.0	Time constant [s] of the setpoint filter for the setpoint SP1 (settling time of CV channel).
MPC	CV1		Previous interconnection deleted. New interconnection to the conversion block (TitrConverting.CV_Out)
MPC	DV1		Previous interconnection deleted. New interconnection to the conversion block (TitrConverting.DV_Out)
MPC	SP1		Previous interconnection deleted. New interconnection to the conversion block (TitrConverting.SP_Out)
MPC	SP1HiLim (hidden)	500	Upper limit for the setpoint of the concentration difference
MPC	SP1LoLim (hidden)	-500	Lower limit for the setpoint of the concentration difference
MPC	MV1HiLim		New interconnection to the conversion block (TitrConverting.MVHiLim)
MPC	CV1_Unit	1399	Unit of control variable 1 (process value)
MPC	DB_No	53	Data block with controller data
MPC	MV1		Previous interconnection deleted. New interconnection to the conversion block (TitrConverting.MV)
pH_SP	PV_In		Interconnection to the channel block of the pH value display process tag (QI_pH_Product\PV.PV_Out)
pHTitrBlock			Newly added as "TitrConverting" for the conversion of pH values
TitrConverting	CV		New interconnection to the channel block (PV.PV_Out)
TitrConverting	DV		New interconnection to the ConnMPC block (ConnMPC.DV1Out)
TitrConverting	SP		New interconnection to the ConnMPC block (ConnMPC.SP1Out)
TitrConverting	Alfa	35000	Buffer parameter
TitrConverting	Ampl_pH	5.0	Amplitude range to be processed
TitrConverting	MV		New interconnection of the controller block (MPC.MV1)
TitrConverting	Feed_PV_Out		New interconnection of the linearized measuring value of the display process tag (FI_Feed\Sqrt.Out)
TitrConverting	Feed_Scale		New interconnection of the channel block of the display process tag (FI_Feed\PV.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

Block	Connection	Value	Usage
			(MPC.MV1HiLim)
TitrConverting	MV_Valve		Interconnection to the communication block (to_Valve.ReStru1)
ConnMPC	SP1		Interconnection to the OpAnL block for setpoint specification (pH_SP.SP_Out)
ConnMPC	DV1		Interconnection of the OpAnL block to the pH value specification of the component (Sim_pH_MPC\pH_Feed.SP_Out)
ConnMPC	DV_On	1	1 = Activation of disturbance variable compensation
to_Valve	Out		Interconnection to the valve process tag (YC_Neutralizer\from_CTRL.In)
from_Valve	In		Interconnection to the valve process tag (YC_Neutralizer\to_CTRL.Out)
Sim	Sim1Act0p	1	Simulation value (pH value of the product) active at "1"
Sim	Sim1ValueOp		Interconnection to the pH simulation value (Sim_pH_MPC\pH_MPC.pH)
PV	Scale.High Scale.Low	12 2	Scaling of the process value
PV	PV_InUnit	1422	Unit of the process value in pH
PV	PV_Out		Interconnection of the measured value with the display process tag (QI_pH_Product\Sim.Sim1ValueOp)
PV	PV_OutUnit		Interconnection of the unit with the display process tag (QI_pH_Product\PV.PV_InUnit)
PV	ScaleOut		Interconnection of the scaling with the display process tag (QI_pH_Product\PV.Scale)

NOTE

With the help of the MPC configurator, the multi-variable controller was optimized for an operating point between 7.5 and 6.5 pH and saved in the data block DB 53. The relevant influencing variables were a component feed rate of 3000 L/s with pH4 and the neutralizer with pH12.

For trend recording, the manipulated value was excited by using the block "AutoExci" and, additionally, a disturbance variable change (±10%) was performed.

FI_Feed

The process tag "FI_Feed" is used to pick up and display the flow rate of the component and to monitor its limit values. The channel block of the display process tag receives its measured value from the OpAnL block of the simulation chart.

The table below shows how the instance of "AMON_Flow" is configured.

Table 5-53

Block	Connection	Value	Usage
Sim	Sim1Act0p	1	Simulation of the process value
Sim	Sim1ValueOp		Interconnection to the pH simulation value (Sim_pH_MPC\Feed_Flow.SP_Out)
PV	Scale	5000.0 0.0	Scaling of the process value
PV	PV_InUnit	1038	Unit of the process value in liters
PV	PV_OutUnit		Interconnection to the simulation chart (Sim_pH_MPC\Feed_Flow.SP_Unit) (Sim_pH_MPC\Feed_Flow.PV_Unit)
PV	ScaleOut		Interconnection to the controller process tag (QIC_pH_Control_MPC\TitrConverting.Feed_Scale)
Sqrt	Out		Interconnection to the controller process tag (QIC_pH_Control_MPC\TitrConverting.Feed_PV_Out)

QI_pH_Product

The process tag "QI_pH_Product" is used to display the pH value of the product. The pH value is picked up in the controller process tag but displayed in the form of a concentration difference in this process tag. The channel block of the display process tag includes the process value, the unit of the measured value and the scaling of the channel block of the multi-variable controller.

The table below shows how the instance of "AMON__Std" is configured.

Table 5-54

Block	Connection	Value	Usage
Sim	Sim1Act0p	1	Simulation of the process value
Sim	Sim1ValueOp		Interconnection to the pH value in the controller process tag (QIC_pH_Control_MPC\PV.PV_Out)
PV	PV_OutUnit		Interconnection to the simulation chart (Sim_pH_MPC\pH_Feed.SP_Unit) (Sim_pH_MPC\pH_Feed.PV_Unit)

YC_Neutralizer

The process tag "YC_Neutralizer" is used to pick up and to determine the flow rate of the neutralizing agent (readback). The manipulated value is transmitted from the multi-variable process tag via communication blocks.

The table below shows how the instance of "Val_An_Afb1" is configured.

Table 5-55

Block	Connection	Value	Usage
V	MV		Interconnection to the pH simulation (Sim_pH_MPC\pH_MPC.Neutr_MV)
V	ER_AH_En (hidden)	0	Deactivation of the alarm message for maximum valve opening
V	ER_AL_En (hidden)	0	Deactivation of the alarm message for minimum valve opening

Block	Connection	Value	Usage
Sim	Sim1Act0p	1	Simulation of the process value
Sim	Sim1ValueOp		Interconnection to the manipulated value (YC_Neutralizer\V.MV)
Sim	Sim2Act0p	1	Simulation of the process value
Sim	Sim2ValueOp		Interconnection to the manipulated value (YC_Neutralizer\V.MV)
from_CTRL	In		Interconnection to the multi-variable controller (QIC_pH_Control_MPC\to_Valve.Out)
to_CTRL	Out		Control signals from the multi-variable controller (QIC_pH_Control_MPC\from_Valve.In)

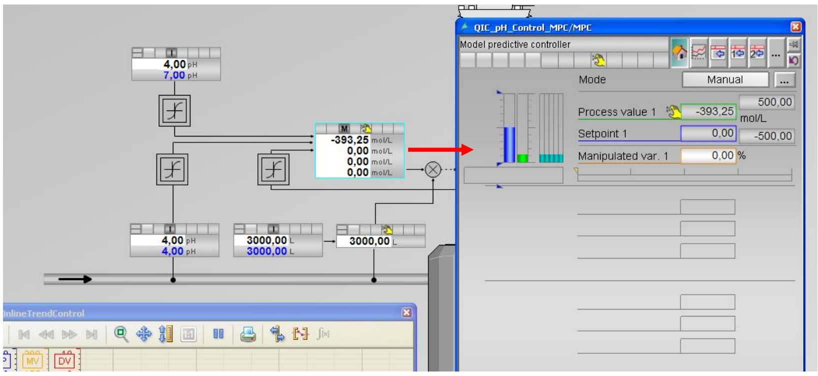
5.6.3 Commissioning, operation and instance-specific adjustments

Commissioning and operation requires a downloaded user program in automation system (AS) or S7-PLCSIM, and an activated OS (WinCC Runtime). Instructions for downloading the user program and activating the OS are available in chapter 7 “Starting the Equipment Module”.

Commissioning

For commissioning, proceed as follows:

Table 5-56

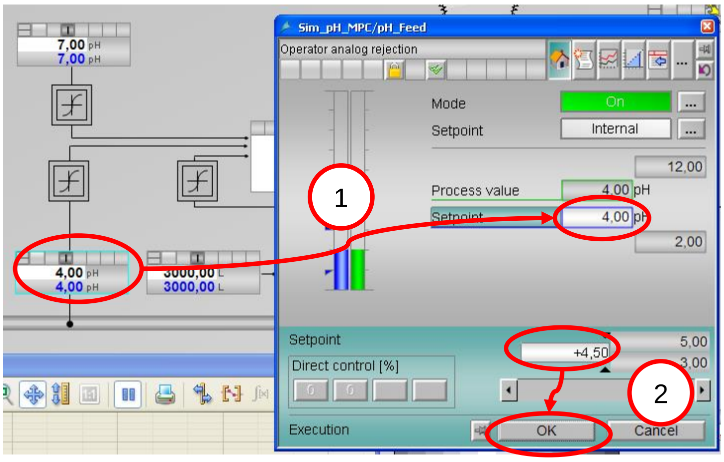
No.	Action
1.	Click the block icon of the controller "QIC_pH_Control_MPC" to open the associated faceplate.  QIC_pH_Control_MPC/MPC Model predictive controller Mode: Manual Process value 1: -393,25 mol/L Setpoint 1: 0,00 Manipulated var. 1: 0,00 %
2.	Change the operating mode of the first controller. In the faceplate, click the "…" button next to the mode switch ("Mode"), click the "Automatic" button in the expanded faceplate and then confirm your settings with "OK".
3.	The controller uses the predefined pH value of the OpAnL block icon as an external setpoint. The default value of this setpoint (neutral zone) is set to "7" pH which is the basis for the quantity of neutralizing agent to be added (for regulation).

Operation

The following instruction describes the operation of the equipment module "pH-Control-MPC". After start-up of the CPU (in initial status) and commissioning, the actual value shows pH7. The whole adjustment process takes approx. 14 minutes.

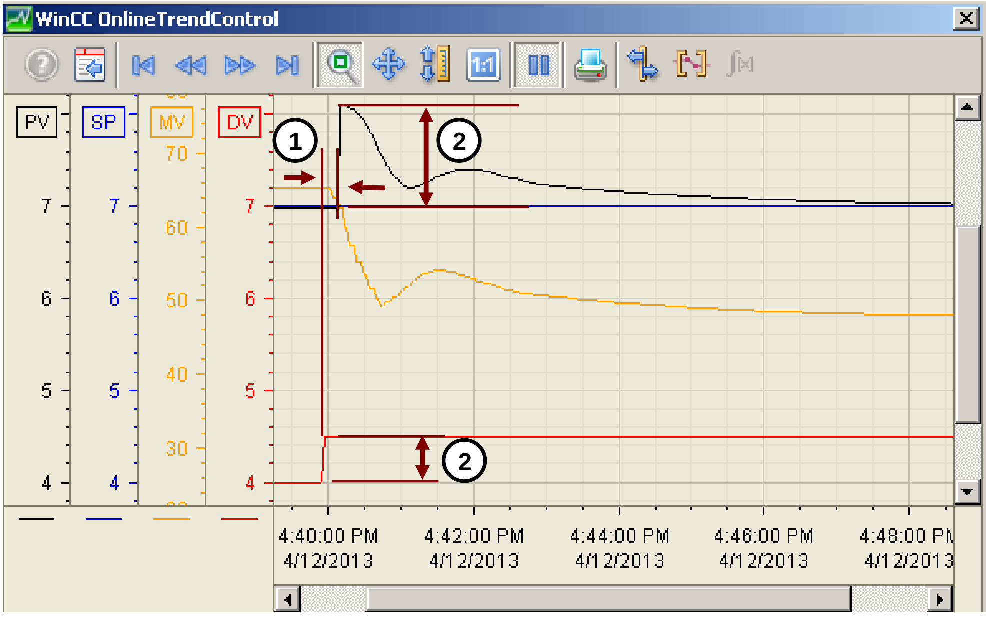
In the following scenario, the disturbance variable shall be changed. The pH value of the component shall be increased from pH 4 to pH 4.5.

Table 5-57

No.	Action
1.	Click the block icon for the operator control block "pH_Feed"to open the associated faceplate.
2.	Click the "Setpoint" input field and enter the value "5.2" in the input field of the s and click 
3.	Close the faceplate and watch the curve plotter for approx. 10 minutes until the setpoint is reached.

Evaluation

Figure 5-26



1. The controller has been optimized so that the setpoint will slowly and precisely be reached. The controller recognizes the change in the disturbance variable and changes the manipulated value accordingly before the process reacts to the disturbing influence (specified dead time in the simulation block). The

disturbance variable takes effect on the actual value without delay (time delay elements).

4. In this example, the pH value of the component was changed by pH 0.5 with an effect on the product of approx. pH 1.

Despite the early recognition of the disturbance variable, the controller takes approx. 8 minutes for compensation and control. This period will also be required for regulation, if the pH value of the component changes more significantly.

Instance-specific adjustments

The following tables contain the relevant parameters which must either be set or interconnected. Chapter 6.2 “Process connection” describes the procedure for connecting process devices.

The table below lists all parameters to be set specifically for the relevant process.

Table 5-58

Process tag	Block	Connection	Usage
QI_pH_Product	I Subchart "A"	PV_AH_En	Upper limit violation alarm, if PV ≥ PV_AH_Lim
QI_pH_Product	I Subchart "A"	PV_WH_En	Upper limit violation warning, if PV ≥ PV_WH_Lim
QI_pH_Product	I Subchart "A"	PV_WL_En	Lower limit violation warning, if PV ≤ PV_WL_Lim
QI_pH_Product	I Subchart "A"	PV_AL_En	Lower limit violation alarm, if PV ≤ PV_AL_Lim
QIC_pH_Control_MPC	ConnMPC Subchart "A"	SP1	Setpoint specification to be interconnected with the SFC
QIC_pH_Control_MPC	ConnMPC Subchart "A"	DV1	Disturbance variable to be interconnected with the component channel driver (pH value)
QIC_pH_Control_MPC	ConnMPC Subchart "A"	DV1	Activate disturbance variable usage "1"
QIC_pH_Control_MPC	ConnMPC Subchart "A"	ModLiOp AutModLi ManModLi	Operating mode of the controller to be interconnected with the SFC
QIC_pH_Control_MPC	SP10ptHiLim Subchart "A"	In2	Upper limit for setpoint optimization (pos. value)
QIC_pH_Control_MPC	SP10ptLoLim Subchart "A"	In2	Lower limit for setpoint optimization (neg. value)
QIC_pH_Control_Std	PV Subchart "B"	Scale	Scaling of measured value (e.g. max. 15, min 2)
QIC_pH_Control_Std	PV Subchart "B"	PV_InUnit	Unit of the scaled measured value (e.g. "1422" for pH)
YC_Neutralizer	V Subchart "A"	MV_HiLim MV_LoLim	Upper and lower limit of the manipulated variable
YC_Neutralizer	MV Subchart "B"	Scale	Scaling of the manipulated variable (manipulated value of the valve block)
YC_Neutralizer	MV Subchart "B"	PV_InUnit	Unit of the scaled manipulated value

Process tag	Block	Connection	Usage
FI_Feed	I Subchart "A"	PV_AH_En	Upper limit violation alarm, if PV ≥ PV_AH_Lim
FI_Feed	I Subchart "A"	PV_WH_En	Upper limit violation warning, if PV ≥ PV_WH_Lim
FI_Feed	I Subchart "A"	PV_WL_En	Lower limit violation warning, if PV ≤ PV_WL_Lim
FI_Feed	I Subchart "A"	PV_AL_En	Lower limit violation alarm, if PV ≤ PV_AL_Lim

Note Commissioning of the "QIC_pH_Control_MPC" controller can be performed using the program "MPC-Configurator". A description on how to proceed is available in the Simatic Manager online help.

The table below includes an overview of all parameters to be interconnected with process devices, including the associated process tags.

Table 5-59

Process tag	Block	Connection	Usage
QIC_pH_Control_Std	PV Subchart "B"	PV_In	pH value of the product
YC_Neutralizer	Rbk Subchart "B"	PV_In	Manipulated variable feedback
YC_Neutralizer	MV Subchart "B"	PV_Out or PV_ChnST	Output of the manipulated value with or without signal status
FI_Feed	PV Subchart "B"	PV_In	Inflow volume (feed) of the product

Note In the object properties of the message-capable blocks you can configure instance-specific messages. Instructions on how to proceed are available in the configuration manuals "Process Control System PCS 7 Operator Station (V7.1)" under the entry ID: 36194551 and "SIMATIC Process Control System PCS 7 Operator Station (V8.0)" under the entry ID: 57270173.

5.7 Temperature-Flow-Cascade

Temperature control with a cascade on a flow controller for a service medium (e. g. heating steam, cooling water or fuel) is used for applications where variations within the auxiliary control loop (of the flow controller) have to be balanced, or other inconvenient features of the manipulated variable (e. g. non-linear valve curve) of the slave controller have to be compensated and therefore do not become visible to the master controller. Temperature-Flow-Cascade controls are used e.g. for heat excahngers, reactors, or burners.

For the heat exchanger, the container contents or a component are continuously pumped through the exchange heater via a pipe. In the process, the component is heated or cooled to a defined temperature by the heat transfer of the service medium.

The same regulative concept is applied for the bruner, i.e. the tempertaure is controlled via the flow volume of the fuel.

Note The technical function „Temperature-Flow-Cascade“ can be employed for all industrial applications where a flow is used to control the temperature.

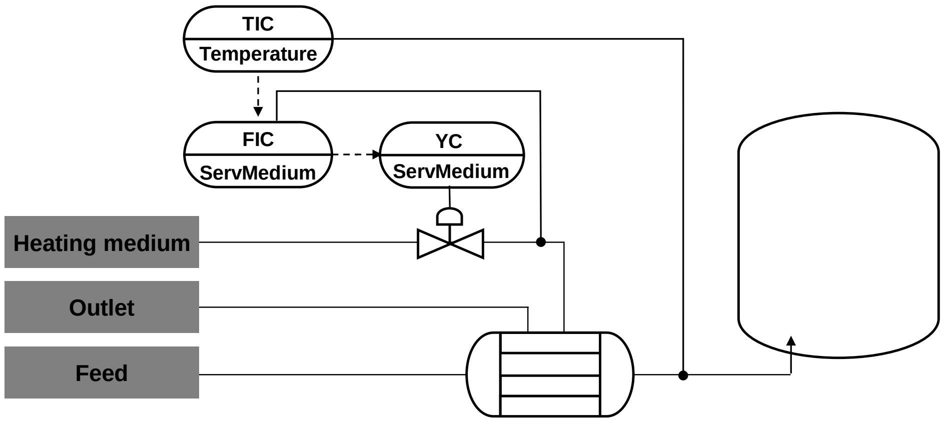
In the following example, the temperature control of a heat exchanger which is heated by a heating medium is observed. Heat exchangers can also be used to cool a substance flow. The flow of a cooling medium is then controlled instead of a heating medium. The generic name for heating or cooling medium is service medium. Wether the intented purpose is heating or cooling does not affect the control structure for heat exchangers. Merely the sign of the controlled section of the master controller is altered.

5.7.1 Overview

The P&I diagram below shows the structure and describes all process tags and the simulation of equipment modules.

P&I diagramm

The following P&I diagram includes symbols for all components relevant to operation, such as aggregates, tanks, etc., using a multi-variable control system



Process tag

The equipment module "Temperature-Flow-Cascade" consists of 3 interconnected process tags and one simulation chart. In the simulation chart the feed temperature is simulated.

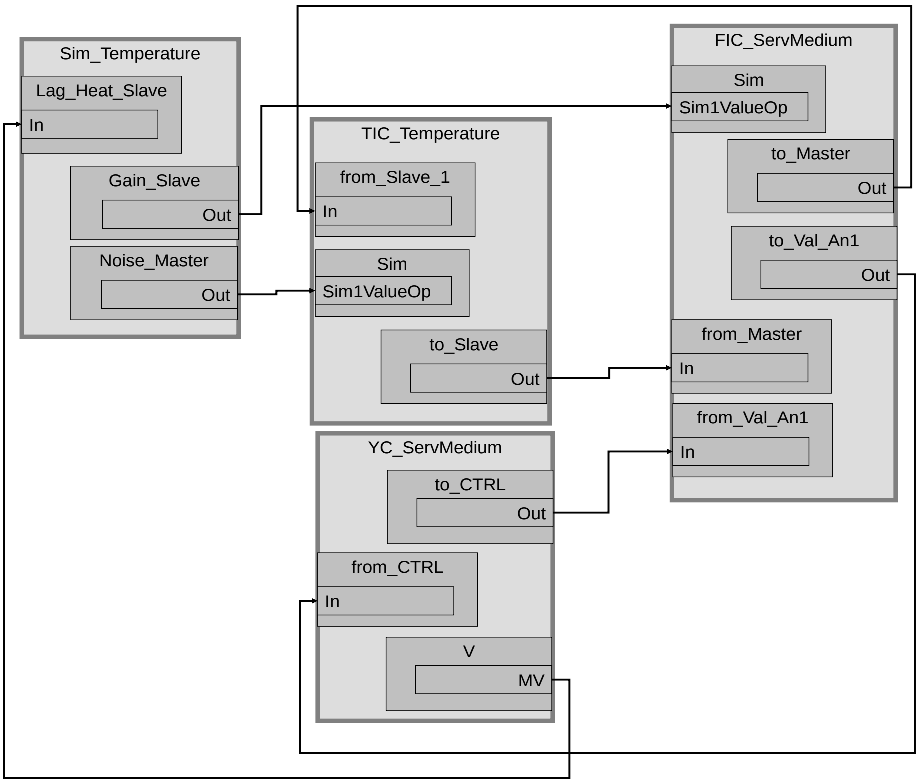
The table below provides an overview of the process tags and equipment modules including the associated process tag types.

Table 5-60

Process tag	Process tag type	Description
TIC_Temperature	„CTRL_Std4Valve“	Master controller for controlling the temperature
FIC_ServMedium	„CTRL_Std4Valve“	Slave controller for controlling the flow
YC_ServMedium	„Val_An_Afb1“	Control valve for the heating medium

The following P&I diagram represents all components relevant for the operation as symbols.

Figure 5-28



The “TIC_Temperature” process tag uses the simulated feed temperature from simulation chart “Sim_Temperature” and generates the setpoint specification for the slave controller. This configures the desired temperature curve in the “TIC_Temperature” process tag.

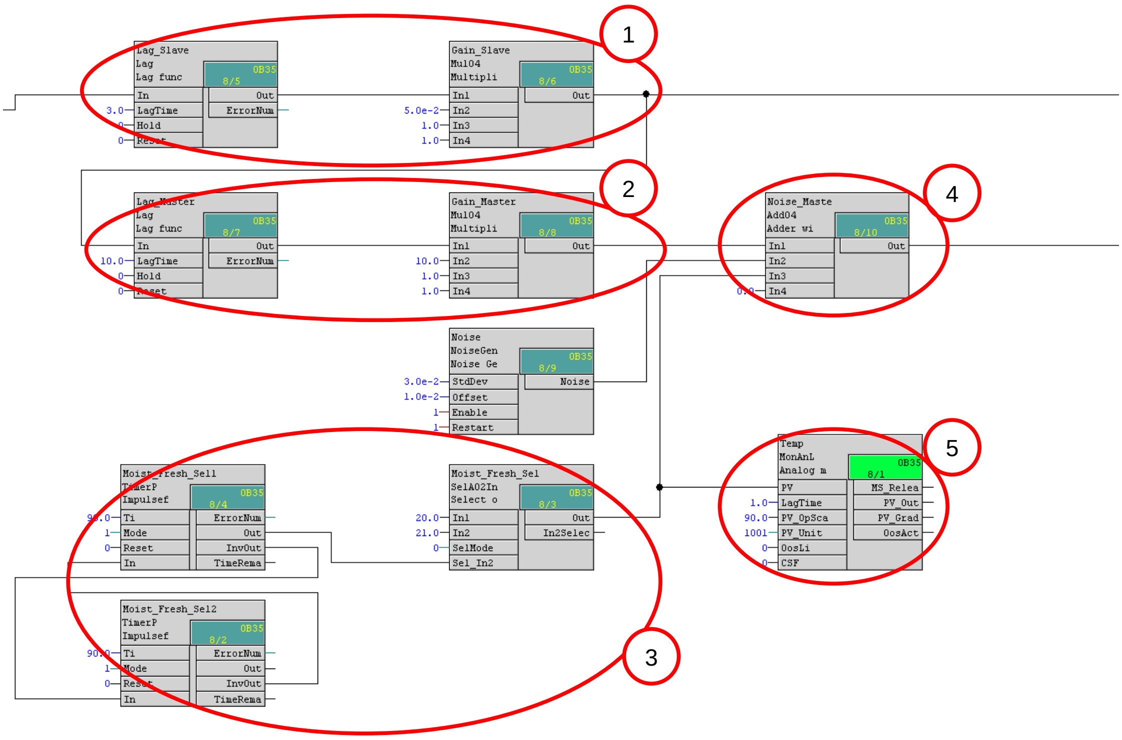
The “FIC_ServMedium” process tag receives the specified setpoint from the master controller and controls the flow volume to the heat exchanger. The PID controller transfers the control commands via communication blocks “to_Val_An1” to the “YC_ServMedium” control valve. Additionally, the controller process tag receives status information from the channel drivers of the valve process tag via the “from_Val_An1” communication blocks.

5.7.2 Structure and configuration

Simulation "Sim_Temperature"

A temperature change through heating steam on the heat exchanger is simulated in the “Sim_Temperature” CFC chart.

The figure below shows the parameter configuration of the simulation block.



1. If the valve is opened 100%, 5 t/h (factor 0.05) are output to the slave controller as actual flow value with a delay of 3 seconds.
2. With a delay of 10 seconds (to simulate the heating of the heating capacity of the heat exchanger) a value 10 times as high as the value of the heating steam flow is transferred to the reference junction as actual value of the hot air temperature.
3. Changing feed temperature which alteres between 20 °C and 21 °C every 90 seconds to simulate a disturbance.
4. Feed temperature for the master controller which alters depending on the heat exchanger. The output signal can be complemented with a slight signal noise.
5. Substance temperature before being heated by the heat exchanger.

Note

The simulation behavior does not correspond to a real process and is used for displaying the functionality and principle of operation of the equipment module “Temperature-Flow-Cascade“.

TIC_Temperature

In the “TIC-Temperature” process tag the feed temperature is recorded. The setpoint is specified in this process tag. The "TIC_Temperature" measurement point transfers the control variable as an external setpoint to the "FIC_ServMedium" slave controller. Thus, the "TIC_Temperature" measurement point is the master controller for cascading control. The "TIC_Temperature" measurement point is an instance from the measurement point type "CTRL_Std4Valve" and contains two additional communications modules ("to_Slave" and "from_Slave").The valve connection blocks were deleted.

Table 5-61

Block	Connection	Value	Usage
C	Gain.Value	1.0	Controller gain
C	TI.Value	7.3	Controller lag
ComStruIn			Inserted as “to_Slave”, for transfer of control signals to the slave controller
to_Slave	Out		Interconnecting to the slave controller (FIC_ServMedium \from_Master.In)
to_Slave	ReStru1		Interconnecting of the actual setpoint value (TIC_Temperature\C.SP)
to_Slave	ReStru2		Interconnecting of the process value (TIC_Temperature\C.PV_Out)
to _Slave	ReStru3		Interconnecting of the manipulated value as external setpoint value for the slave controller (TIC_Temperature\C.MV)
to_Slave	BoStru1		Interconnecting from CascaCut to the slave controller (TIC_Temperature\C.CascaCut)
to_Slave	BoStru2		Interconnecting the „Bad“-Signals of the channel blocks to the slave controller (TIC_Temperature\CSF.Out)
ComStruOut			Inserted as “from_Slave” to receive status information of the slave controller
from_Slave	In		Interconeccting to the slave controller (Status) (FIC_ServMedium\to_Master.Out)
from_Slave	Int1		Interconnecting the unit of the manipulated value (TIC_Temperature\C.MV_Unit)
from_Slave	BoStru1		Interconnecting from CascaCut to the slave controller (TIC_Temperature\Intlock.In02)
from_Slave	BoStru2		Interconnecting the „Bad“-Signals from the slave controller (TIC_Temperature\Intlock.In03)
from_Slave	BoStru3		Interconnecting the „Out of Service“signal from the slave controller (TIC_Temperature\Intlock.In04)
from_Slave	Scale1		Maximum value of the manipulated value (TIC_Temperature\C.MV_OpScale) (TIC_Temperature\C.NormMV)
Sim	Sim1ActOp. Value	1	Activating the simulation
Sim	Sim1Value Op		Interconnecting tot he simulated process value (Sim_Temperature\Noise_Maste.Out)

Block	Connection	Value	Usage
PV	Scale	200.0	Maximum value of the process value
PV	PV_InUnit	1001	Scalling oft he process value in degree Celcius

FIC_ServMedium

The flow rate of the heating steam is recorded at the "FIC_ServMedium" measurement point. The setpoint value specification for the flow rate is implemented through the master controller. The "FIC_ServMedium" measurement point transfers the control variable to the valve measurement point "YC_ServMedium". "FIC_ServMedium" is the slave controller for the cascading control. "FIC_ServMedium" is an instance of the measurement point type “CTRL_Std4Valve” and contains two communications modules ("to_Master" and "from_Master").

Table 5-62

Block	Connection	Value	Usage
C	Gain.Value	2.8	Controller gain
C	TI.Value	1.7	Controller lag
Intlock	InvIn03	1	
Intlock	Invln05	1	
Intlock	Invln06	1	
ComStruIn			Entered as "to_Master" for transmitting control signals to the master controller
to_Master	Out		Interconnecting tot he master controller (TIC_Temperature\from_Slave.In)
to_Master	ReStru1		Interconnecting oft he actual setpoint value (FIC_ServMedium\C.SP)
to_Master	ReStru2		Interconnecting oft he process value (FIC_ServMedium\C.PV_Out)
to_Master	BoStru1		Intervonnecting from CascaCut oft he slave controller (FIC_ServMedium\Intlock.In02)
to_Master	BoStru2		Interconnecting the „Bad“-Signals des channel blocks of „FIC_Inflow” for the master controller (FIC_ServMedium\CSF.Out)
to_Master	BoStru3		Interconnecting the „Out of Service“-Signals to the master controller (FIC_ServMedium\C.OosAct)
to_Master	Int1		Scalling the manipulated value (FIC_ServMedium\PV.PV_OutUnit)
to_Master	Int2		Scalling the process value (FIC_ServMedium\C.MVUnitOut)
to_Master	Scale1		Maximum vavuel oft he process value (FIC_ServMedium\PV.ScaleOut)
ComStruOut			Entered as "from_Master" to receive status information of the master controller
from_Master	In		Interconnecting tot he master controller (Status) (TIC_Temperature\to_Slave.Out)
from_Master	ReStru3		Interconnecting from CascaCut of the slave

Block	Connection	Value	Usage
			controller (FIC_ServMedium\Connector.SP_Ext)
from_Master	BoStru2		Interconnecting the „Bad“-Signals oft he channel block from „TIC_Temperature” from the master controller (FIC_ServMedium\Intlock.In05)
to_Valve	Out		Interconnecting to valve (YC_ServMedium\from_CTRL.In)
from_Valve	In		Interconnecting to valve (Status) (YC_ServMedium\to_CTRL.Out)
Sim	Sim1ActOp.Value	1	Activating the simulation
Sim	Sim1ValueOp		Interconnecting tot he simulated process value (Sim_Temperature\Gain_Slave.Out)
PV	Scale	10.0	Maximum value oft he process value
PV	PV_InUnit	1328	Scalling the process value (t/h)

YC_ServMedium

The valve measurement point "YC_ServMedium" controls the flow volume (opening of the feed input) of the heating steam to the heat exchanger. The measurement point contains communications modules for data exchange (control signals and control commands) with the controller measurement point.

The valve module "V" contains an external control variable (through a communications module) from the controller measurement point. In a simulation environment, both channel modules in chart partition "B" (Rbk and MV) receive the same value (control variable of the valve module (chart partition "A", sheet 1)) through the primary simulation module, i.e. a lag between valve actuation and valve movement is not simulated.

The following table shows the configuration of the instance from "Val_An_Afb1".

Table 5-63

Block	Connection	Value	Usage
V	MV		Interconnecting to the simulation (Sim_Temperature\Lag_Heat_Slave.In)
V	ER_AH_En (unsichtbar)	0	Switching off the alarm message for maximal valve opening
V	ER_AL_En (unsichtbar)	0	Switching off the alarm message for minimal valve opening
from_CTRL	In		Interconnection to the controller (FIC_ServMedium\to_Valve.Out)
to_CTRL	Out		Interconnection to the controller (FIC_ServMedium\from_Valve.In)
Sim	Sim1ActOp.Value	1	Activating the simulation of the readback value
Sim	Sim1ValueOp		Interconnecting with the simulation of the readback value from the valve (YC_ServMedium\V.MV)
Sim	Sim2ActOp.Value	1	Activating the simulation of the manipulated
Sim	Sim2ValueOp		Interconnecting with the simulation of the

Block	Connection	Value	Usage
			manipulated value from the valve (YC_ServMedium\V.MV)

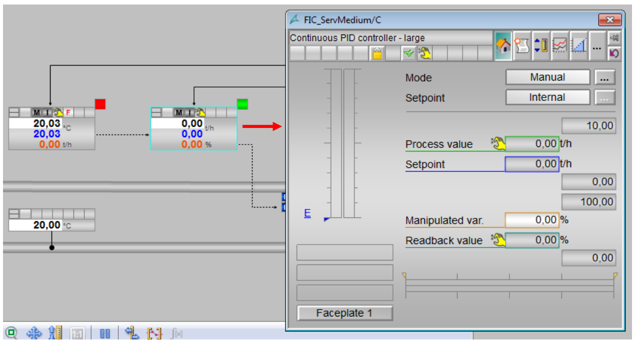
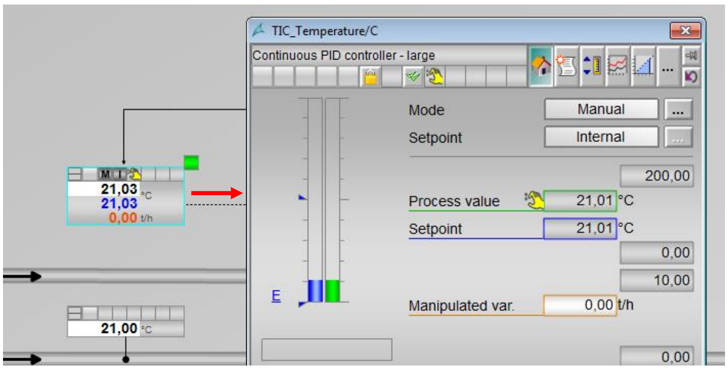
5.7.3 Commissioning, operation and instance-specific adjustments

Commissioning and operation requires a downloaded user program in automation system (AS) or S7-PLCSIM, and an activated OS (WinCC Runtime). Instructions for downloading the user program and activating the OS are available in chapter 7 “Starting the Equipment Module”.

Commissioning

For commissioning, proceed as follows:

Table 5-64

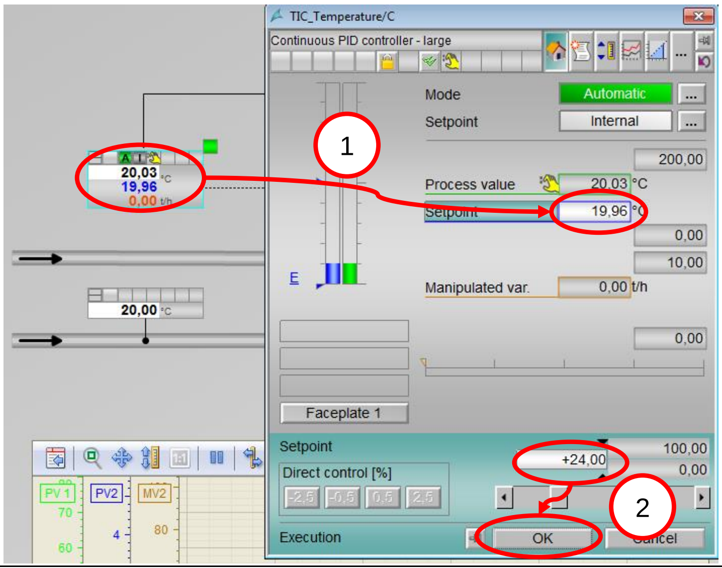
No.	Action
1.	Click the block icon of the controller "FIC_ServMedium/C" to open the associated faceplate.  FIC_ServMedium/C Continuous PID controller - large Mode: Manual Setpoint: Internal Process value: 0,00 t/h Setpoint: 0,00 t/h Manipulated var.: 0,00 % Readback value: 0,00 %
2.	Change the operating mode of the first controller. In the faceplate, click the "…" button next to the mode switch ("Mode"), click the "Automatic" button in the expanded faceplate and then confirm your settings with "OK". The setpoint is automatically specified from external. **Note:** The interlock of master controller is cancelled.
3.	Click the block icon of the master controller "FIC_ServMedium/C" to open the associated faceplate.  TIC_Temperature/C Continuous PID controller - large Mode: Manual Setpoint: Internal Process value: 21,01 °C Setpoint: 21,01 °C Manipulated var.: 0,00 t/h
4.	In the faceplate you click on the “…” button next to the mode switch (“Mode”) and in the faceplate extension you click on the “Automatic” button and adopt the settings with “OK”.

Operation

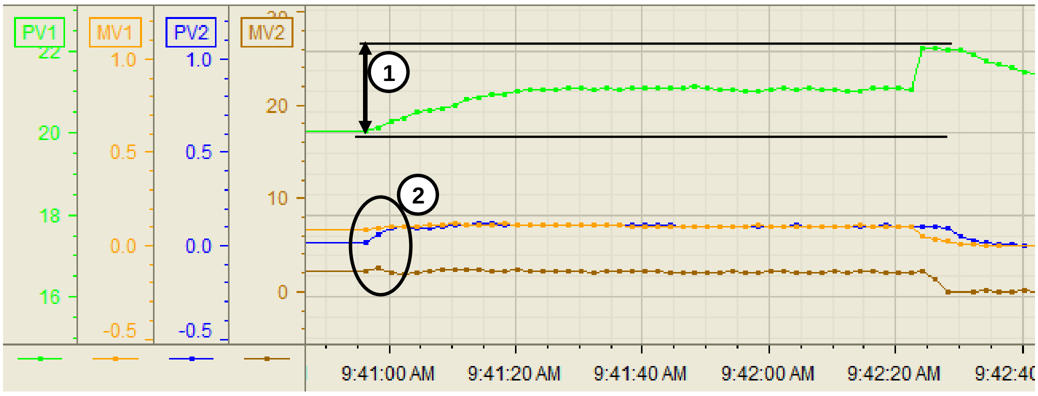
The following instruction describes the operation of the equipment module "Temperature-Flow-Cascade“. After start-up of the CPU (in initial status) and commissioning, the feed temperature stays unchanged.

In the following scenario, the temperature will be raised about 4°C.

Table 5-65

No.	Action
1.	Click the block icon for the operator control block " TIC_Temperature "to open the associated faceplate.
2.	Click the "Setpoint" input field and enter the value "24" in the input field of the expanded faceplate. Then press the "ENTER" key to confirm settings and click the "OK" button.  TIC_Temperature/C Continuous PID controller - large Mode: Automatic Setpoint: Internal Process value 20,03 °C Setpoint 19,96 °C Manipulated var. 0,00 t/h Setpoint +24,00
3.	Close the faceplate and watch the curve plotter for approx. 2 minutes until the setpoint is reached.

Evaluatio



1. The temperature of the added medium changes every 90 seconds causing the master controller to react to this change continually and regulate the temperature to its setpoint value of 21°C.

2. After recognizing the temperature change, the master controller transmits a new setpoint value to the slave controller. The slave controller reacts directly to this change by setting a new manipulated value (brown trend graph) and adjusting the process value (blue trend graph) to the setpoint value (orange trend graph).

The slave controller (flow of the heating medium in t/h) has been configurated so as to regulate exactly without overshoots.

Instance-specific adjustments

The following tables contain the relevant parameters which must either be set or interconnected. Chapter 6.2 “Process connection” describes the procedure for connecting process devices.

The table below lists all parameters to be set specifically for the relevant process.

Table 5-66

Process tag	Block	Connection	Usage
TIC_Temperature / FIC_ServMedium	C Subchart „A“	Gain	Proportional gain
TIC_Temperature / FIC_ServMedium	C Subchart „A“	TD	Derivative time (rate time) in [s]
TIC_Temperature / FIC_ServMedium	C Subchart „A“	TI	Integral time (reset time) in [s]
TIC_Temperature /	C Subchart „A“	SP_InHiLim	Limit value (high) of the internal
TIC_Temperature /	C Subchart „A“	SP_InLoLim	Limit value (low) of the internal setpoint value
TIC_Temperature / FIC_ServMedium	C Subchart „A“	PV_AH_En	Alarm for exceeded limit value, if PV ≥ PV_AH_Lim
TIC_Temperature / FIC_ServMedium	C Subchart „A“	PV_WH_En	Warning for exceeded limit value, if PV ≥ PV_WH_Lim
TIC_Temperature / FIC_ServMedium	C Subchart „A“	PV_TH_En	Tolerance for falling below the limit value, if PV ≤ PV_TL_Lim
TIC_Temperature / FIC_ServMedium	C Subchart „A“	PV_TL_En	Tolerance for falling below the limit value, if PV ≤ PV_TL_Lim
TIC_Temperature / FIC_ServMedium	C Subchart „A“	PV_WL_En	Warning for falling below the limit value, if PV ≥ PV_WL_Lim
TIC_Temperature / FIC_ServMedium	C Subchart „A“	PV_AL_En	Alarm for falling below the limit value, if PV ≥ PV_AL_Lim
TIC_Temperature / FIC_ServMedium	C Subchart „A“	ER_AH_En (invisible)	Alarm for exceeded error signal, if ER ≥ ER_AH_Lim
TIC_Temperature / FIC_ServMedium	C Subchart „A“	ER_AL_En (invisible)	Alarm for fallen short of error signal, if ER ≥ ER_AL_Lim
TIC_Temperature /	PV Subchart „B“	Scale	Scaling the measured value (e.g.. the feed temperature till 150°C)
TIC_Temperature /	PV	PV_InUnit	Unit of the scaled manipulated

Process tag	Block	Connection	Usage
FIC_ServMedium	Subchart „B“		variable (e.g. „1001“ for degree celcius)
YC_ServMedium	V Subchart „A“	MV_HiLim MV_LoLim	Upper and lower limit of the manipulated value
YC_ServMedium	MV Subchart „B“	Scale	Scaling the manipulated variable (manipulated value from the valve block)
YC_ServMedium	MV Subchart „B“	PV_InUnit	Unit of the scaled manipulated variable

Note

Commissioning of the controller can be performed using the program " PID-Tuner ". A description on how to proceed is available in chapter 6.3 “Configuration of the PID controllers. Please observe the sequence of the optimization, first the flow controller and second the temperature controller.

The table below includes an overview of all parameters to be interconnected with process devices, including the associated process tags.

Table 5-67

Process tag	Block	Connection	Usage
TIC_Temperature / FIC_ServMedium	PV Subchart „B“	PV_In	pH value of the product
YC_ServMedium	Rbk Subchart „B“	PV_In	Manipulated variable feedback
YC_ServMedium	MV Subchart „B“	PV_Out oder PV_ChnST	Output of the manipulated value with or without signal status

Note

In the object properties of the message-capable blocks you can configure instance-specific messages. Instructions on how to proceed are available in the configuration manuals "Process Control System PCS 7 Operator Station (V7.1)" under the entry ID: 36194551 and "SIMATIC Process Control System PCS 7 Operator Station (V8.0)" under the entry ID: 57270173.

6 Configuration and Settings

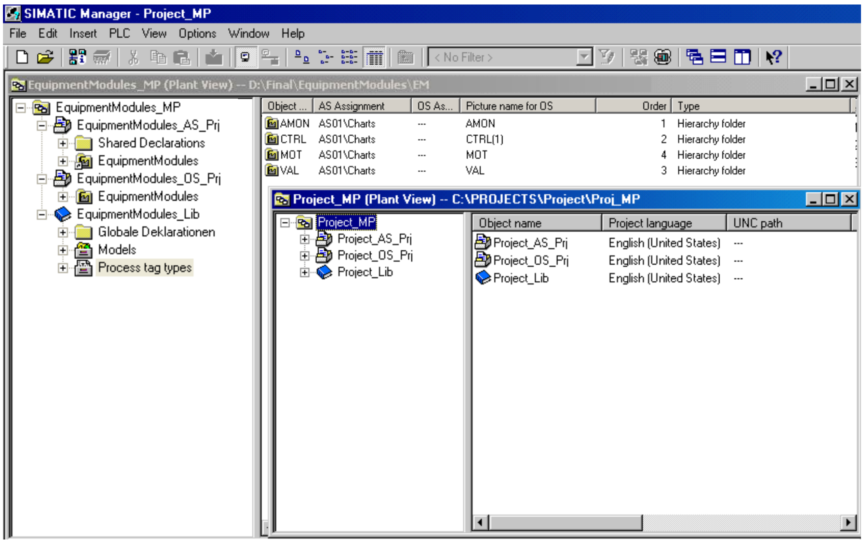
6.1 Integration of equipment modules

Preparation

The following instructions contain the integration of an equipment module into a PCS 7 project in which the following steps have been completed:

- Adjusting HW Config
- Configuring the communication between AS and OS (NetPro)
- Settings at the hierarchy folders
- Using a standardized master data library

Table 6-1

No.	Action
1.	Copy the “53843373_EquipmentModules_PCS7V713.zip” file onto the configuration computer and then open the SIMATIC Manager.
2.	Click “File > Retrieve” in the menu bar and select the “53843373_EquipmentModules_PCS7V713.zip” file. Then confirm by clicking “Open”.
3.	Select the folder in which the project is saved and acknowledge with “OK”. The project is extracted.
4.	In the “Retrieve” dialog you click the “OK” button and then click “Yes” in the dialog to open the project.
5.	Go to “Plant View”.
6.	Parallel you open the project in which the template is to be integrated. 

Object ...	AS Assignment	OS As...	Picture name for OS	Order	Type
AMON	AS01\Charts	---	AMON	1	Hierarchy folder
CTRL	AS01\Charts	---	CTRL(1)	2	Hierarchy folder
MOT	AS01\Charts	---	MOT	4	Hierarchy folder
VAL	AS01\Charts	---	VAL	3	Hierarchy folder

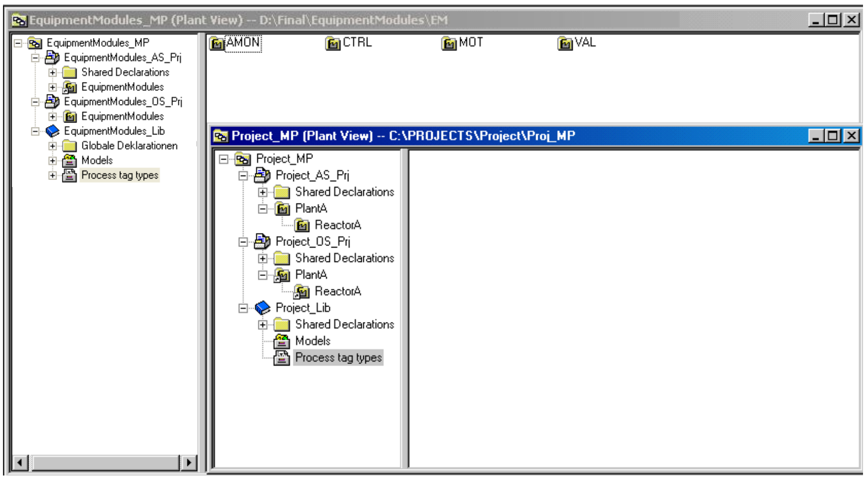
Object name	Project language	UNC path
Project_AS_Prj	English (United States)	---
Project_OS_Prj	English (United States)	---
Project_Lib	English (United States)	---

Integration of an equipment module

The following instruction describes how you can integrate the “Level-Control” equipment module, including the required process tag types, into your project. The interconnection of each individual signal and the settings of each individual parameter are not described here. It is illustrated how you can integrate the simulation into your project and how you can effectively interconnect the copied equipment module to your process.

The opened equipment module and the opened target project in the Plant view are a prerequisite.

Table 6-2

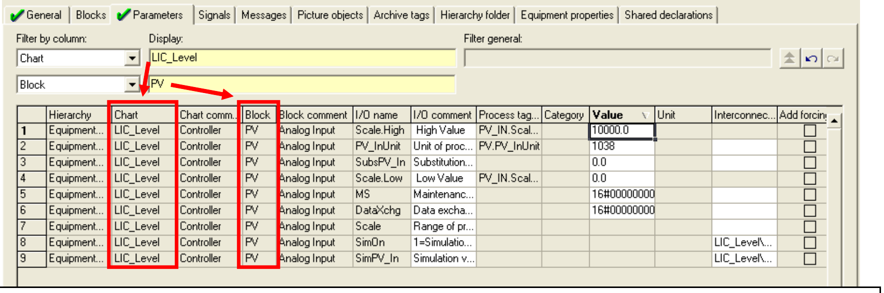
No.	Action
1.	In the Plant view of the equipment modules in the master data library you select all folders in “Process tag types” and click on “Edit > Copy”.
2.	Go to the target project. In the Plant view of the master data library you select the folder for “Process tag types” and then click on “Edit > Paste” in the menu bar.  **Note**: All charts of the equipment module and the simulation are copied.
3.	In the Plant view of the equipment module in the AS project you select the hierarchy folder “EquipmentModules > Level-Control” and click on “Edit> Copy”.
4.	Go to the target project. In the AS project you select the hierarchy folder to which the equipment module is added and then click “Edit > Paste” in the menu bar. **Note**: All charts of the equipment module and the simulation are copied.
5.	In the target project you select the AS project and in the menu bar you click on “Options > Plant View > Update in the Multiproject”. The dialog for exporting the Plant hierarchy appears.
6.	Acknowledge the dialog with “OK” and also confirm the following dialog with “OK”. The plant hierarchy is adjusted in the OS project of the target project.
7.	Compile and download the AS project and then compile the OS project.

Adjusting the parameters of an equipment module

The following instruction describes the steps for adjusting the parameters of an equipment module. For the operability of the simulation no settings need to be made.

The opened target project is a prerequisite.

Table 6-3

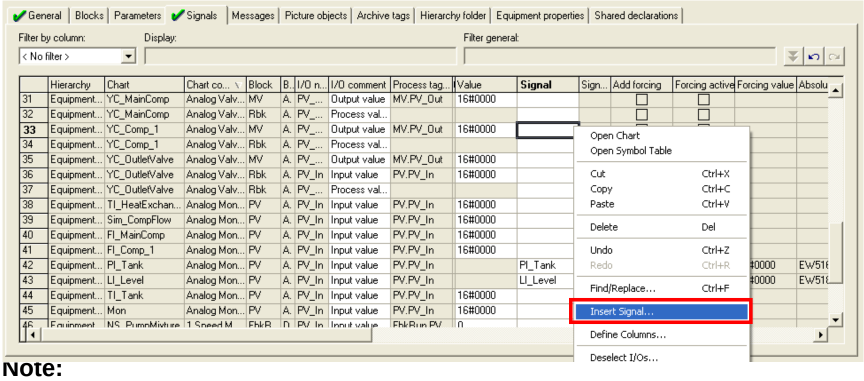
<table>
<tr><th>No.</th><th>Action</th></tr>
<tr><td>1.</td><td>Go to the process object view and click on the “Parameters” tab.</td></tr>
<tr><td>2.</td><td>In the dropdown menu you select the “Filter by column” entry and enter the chart name, for example LIC_Level, into the “Display” input field.
Note:
The button with the double arrow pointing down, next to the deactivated input field “Filter general” opens a second filter. With this filter you can, for example, filter for a “Block” named “PV” in the column and make adjustments.


Filter by column: Chart
Display: LIC_Level
Block
PV
<table>
<tr><th></th><th>Hierarchy</th><th>Chart</th><th>Chart comm...</th><th>Block</th><th>Block comment</th><th>I/O name</th><th>I/O comment</th><th>Process tag...</th><th>Category</th><th>Value</th><th>Unit</th><th>Interconnec...</th><th>Add forcin</th></tr>
<tr><td>1</td><td>Equipment...</td><td>LIC_Level</td><td>Controller</td><td>PV</td><td>Analog Input</td><td>Scale.High</td><td>High Value</td><td>PV_IN.Scal...</td><td></td><td>10000.0</td><td></td><td></td><td>☐</td></tr>
<tr><td>2</td><td>Equipment...</td><td>LIC_Level</td><td>Controller</td><td>PV</td><td>Analog Input</td><td>PV_InUnit</td><td>Unit of proc...</td><td>PV.PV_InUnit</td><td></td><td>1038</td><td></td><td></td><td>☐</td></tr>
<tr><td>3</td><td>Equipment...</td><td>LIC_Level</td><td>Controller</td><td>PV</td><td>Analog Input</td><td>SubsPV_In</td><td>Substitution...</td><td></td><td></td><td>0.0</td><td></td><td></td><td>☐</td></tr>
<tr><td>4</td><td>Equipment...</td><td>LIC_Level</td><td>Controller</td><td>PV</td><td>Analog Input</td><td>Scale.Low</td><td>Low Value</td><td>PV_IN.Scal...</td><td></td><td>0.0</td><td></td><td></td><td>☐</td></tr>
<tr><td>5</td><td>Equipment...</td><td>LIC_Level</td><td>Controller</td><td>PV</td><td>Analog Input</td><td>MS</td><td>Maintenanc...</td><td></td><td></td><td>16#00000000</td><td></td><td></td><td>☐</td></tr>
<tr><td>6</td><td>Equipment...</td><td>LIC_Level</td><td>Controller</td><td>PV</td><td>Analog Input</td><td>DataXchg</td><td>Data excha...</td><td></td><td></td><td>16#00000000</td><td></td><td></td><td>☐</td></tr>
<tr><td>7</td><td>Equipment...</td><td>LIC_Level</td><td>Controller</td><td>PV</td><td>Analog Input</td><td>Scale</td><td>Range of pr...</td><td></td><td></td><td></td><td></td><td></td><td>☐</td></tr>
<tr><td>8</td><td>Equipment...</td><td>LIC_Level</td><td>Controller</td><td>PV</td><td>Analog Input</td><td>SimOn</td><td>1=Simulatio...</td><td></td><td></td><td></td><td></td><td>LIC_Level\...</td><td>☐</td></tr>
<tr><td>9</td><td>Equipment...</td><td>LIC_Level</td><td>Controller</td><td>PV</td><td>Analog Input</td><td>SimPV_In</td><td>Simulation v...</td><td></td><td></td><td></td><td></td><td>LIC_Level\...</td><td>☐</td></tr>
</table>
</td></tr>
<tr><td>3.</td><td>Click into the “Value” column of the block connection you wish to change, and enter the new value. Acknowledge the entry with “ENTER”.</td></tr>
</table>

Interconnecting an equipment module

The opened target project is a prerequisite.

Table 6-4

<table>
<tr><th>No.</th><th>Action</th></tr>
<tr><td>1.</td><td>Open the “Signals” tab in the process object view.</td></tr>
<tr><td>2.</td><td>Right-click the “Signal” column of the signal you wish to interconnect, and select the “Insert signal” command.


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Filter general:
<table>
<tr><th></th><th>Hierarchy</th><th>Chart</th><th>Chart co...</th><th>Block</th><th>B..</th><th>I/O n...</th><th>I/O comment</th><th>Process tag...</th><th>Value</th><th>Signal</th><th>Sign...</th><th>Add forcing</th><th>Forcing active</th><th>Forcing value</th><th>Absolu</th></tr>
<tr><td>31</td><td>Equipment...</td><td>YC_MainComp</td><td>Analog Valv...</td><td>MV</td><td>A.</td><td>PV_...</td><td>Output value</td><td>MV.PV_Out</td><td>16#0000</td><td></td><td></td><td>☐</td><td>☐</td><td></td><td></td></tr>
<tr><td>32</td><td>Equipment...</td><td>YC_MainComp</td><td>Analog Valv...</td><td>Rbk</td><td>A.</td><td>PV_...</td><td>Process val...</td><td></td><td></td><td></td><td></td><td>☐</td><td>☐</td><td></td><td></td></tr>
<tr><td>33</td><td>Equipment...</td><td>YC_Comp_1</td><td>Analog Valv...</td><td>MV</td><td>A.</td><td>PV_...</td><td>Output value</td><td>MV.PV_Out</td><td>16#0000</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>34</td><td>Equipment...</td><td>YC_Comp_1</td><td>Analog Valv...</td><td>Rbk</td><td>A.</td><td>PV_...</td><td>Process val...</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>35</td><td>Equipment...</td><td>YC_OutletValve</td><td>Analog Valv...</td><td>MV</td><td>A.</td><td>PV_...</td><td>Output value</td><td>MV.PV_Out</td><td>16#0000</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>36</td><td>Equipment...</td><td>YC_OutletValve</td><td>Analog Valv...</td><td>Rbk</td><td>A.</td><td>PV_In</td><td>Input value</td><td>PV.PV_In</td><td>16#0000</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>37</td><td>Equipment...</td><td>YC_OutletValve</td><td>Analog Valv...</td><td>Rbk</td><td>A.</td><td>PV_...</td><td>Process val...</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>38</td><td>Equipment...</td><td>TI_HeatExchan...</td><td>Analog Mon...</td><td>PV</td><td>A.</td><td>PV_In</td><td>Input value</td><td>PV.PV_In</td><td>16#0000</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>39</td><td>Equipment...</td><td>Sim_CompFlow</td><td>Analog Mon...</td><td>PV</td><td>A.</td><td>PV_In</td><td>Input value</td><td>PV.PV_In</td><td>16#0000</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>40</td><td>Equipment...</td><td>FI_MainComp</td><td>Analog Mon...</td><td>PV</td><td>A.</td><td>PV_In</td><td>Input value</td><td>PV.PV_In</td><td>16#0000</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>41</td><td>Equipment...</td><td>FI_Comp_1</td><td>Analog Mon...</td><td>PV</td><td>A.</td><td>PV_In</td><td>Input value</td><td>PV.PV_In</td><td>16#0000</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>42</td><td>Equipment...</td><td>PI_Tank</td><td>Analog Mon...</td><td>PV</td><td>A.</td><td>PV_In</td><td>Input value</td><td>PV.PV_In</td><td></td><td>PI_Tank</td><td></td><td></td><td></td><td>#0000</td><td>EW51</td></tr>
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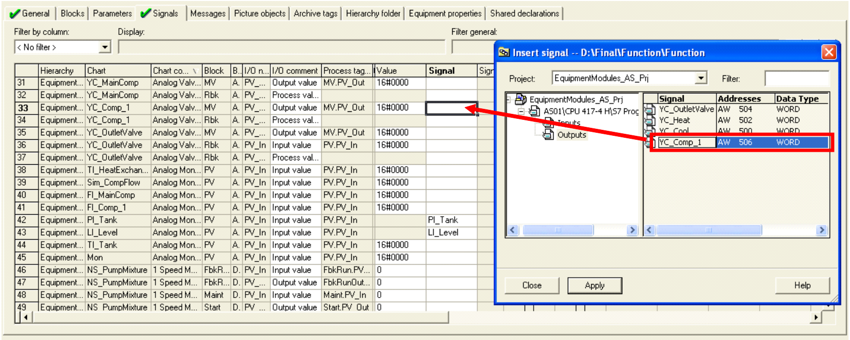
<tr><td>44</td><td>Equipment...</td><td>TI_Tank</td><td>Analog Mon...</td><td>PV</td><td>A.</td><td>PV_In</td><td>Input value</td><td>PV.PV_In</td><td>16#0000</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>45</td><td>Equipment...</td><td>Mon</td><td>Analog Mon...</td><td>PV</td><td>A.</td><td>PV_In</td><td>Input value</td><td>PV.PV_In</td><td>16#0000</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
Note:
The interconnected signals can be viewed in this column.</td></tr>
<tr><td>3.</td><td>In the dialog you open the folder structure and subsequently click on “Inputs” or “Outputs”.</td></tr>
<tr><td>4.</td><td>In the Details view you select the signal you wish to interconnect and click on the “Apply” button.


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<tr><td>33</td><td>Equipment...</td><td>YC_Comp_1</td><td>Analog Valv...</td><td>MV</td><td>A.</td><td>PV_...</td><td>Output value</td><td>MV.PV_Out</td><td>16#0000</td><td></td></tr>
<tr><td>34</td><td>Equipment...</td><td>YC_Comp_1</td><td>Analog Valv...</td><td>Rbk</td><td>A.</td><td>PV_...</td><td>Process val...</td><td></td><td></td><td></td></tr>
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<tr><td>38</td><td>Equipment...</td><td>TI_HeatExchan...</td><td>Analog Mon...</td><td>PV</td><td>A.</td><td>PV_In</td><td>Input value</td><td>PV.PV_In</td><td>16#0000</td><td></td></tr>
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<tr><td>45</td><td>Equipment...</td><td>Mon</td><td>Analog Mon...</td><td>PV</td><td>A.</td><td>PV_In</td><td>Input value</td><td>PV.PV_In</td><td>16#0000</td><td></td></tr>
<tr><td>46</td><td>Equipment...</td><td>NS_PumpMixture</td><td>1 Speed M...</td><td>FbkR...</td><td>D.</td><td>PV_In</td><td>Input value</td><td>FbkRun.PV...</td><td>0</td><td></td></tr>
<tr><td>47</td><td>Equipment...</td><td>NS_PumpMixture</td><td>1 Speed M...</td><td>FbkR...</td><td>D.</td><td>PV_...</td><td>Output value</td><td>FbkRunOut...</td><td>0</td><td></td></tr>
<tr><td>48</td><td>Equipment...</td><td>NS_PumpMixture</td><td>1 Speed M...</td><td>Maint</td><td>D.</td><td>PV_In</td><td>Input value</td><td>Maint.PV_In</td><td>0</td><td></td></tr>
<tr><td>49</td><td>Equipment...</td><td>NS_PumpMixture</td><td>1 Speed M...</td><td>Start</td><td>D.</td><td>PV_...</td><td>Output value</td><td>Start.PV_Out</td><td>0</td><td></td></tr>
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<tr><td>YC_Heat</td><td>AW 502</td><td>WORD</td></tr>
<tr><td>YC_Cool</td><td>AW 500</td><td>WORD</td></tr>
<tr><td>YC_Comp_1</td><td>AW 506</td><td>WORD</td></tr>
</table>
Note:
If you wish to interconnect several signals, then click on a further signal in the process object view and repeat step 2 to 4.</td></tr>
<tr><td>5.</td><td>Click on the “Close” button to close the dialog.</td></tr>
</table>

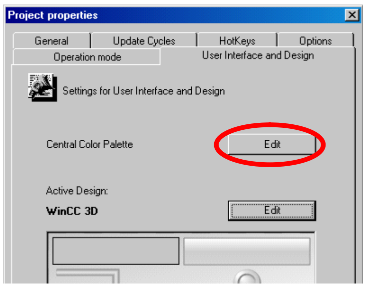
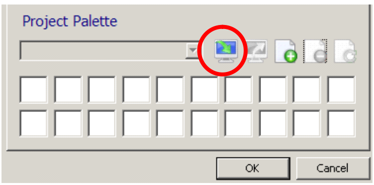
Integrating a color palette into the OS

The process images of the equipment modules use colors from the global color palette. In the target project the colors of the palette must also exist, otherwise the colors of the color palette are represented as black.

The colors for cooling water (blue, position 10), steam (red, position 11), medium (violet, position 12), added pressure/venting (bright-blue, position 13), text frame (gray, position 15) and frame font: (gray, position 16) are defined in the project palette.

The target project needs to be opened.

Table 6-5

No.	Action
1.	Go to the component view and open the tree view of the OS project.
2.	Open the OS project.
3.	Click the OS name with the right mouse button and select “Properties” from the context menu.
4.	In the “Properties” you select the “User Interface and Design” tab and then click the “Edit” button in the “Central Color Palette” area. 
5.	In the Color selection dialog you click on the “Import palette” icon. 
6.	In the file selection dialog you select “UnitTemplates.xml” from the <Projektpfad>\ChColumn\ChColu_2\wincproj\OS\GraCS \DistillColumn.xml> path and acknowledge with “Open”. **Note**: The equipment module uses colors 10 to 16 of the project palette in the process images. If you are already using these positions, cancel the import of the color palette and change the colors in the process image.
7.	In the message you click “Yes”, in order to overwrite the existing color palette and then close the color selection dialog and the project properties dialog with “OK”.

6.2 Process connection

The following instruction describes an option for interconnecting the process devices using the example of “Level-Control” and shows which of the configuration of the blocks is required.

NOTE

Commissioning requires a Loop check including written proof. Loop checks are used to check the trends for controller or control signals.

One option of Loop checks is:

A signal is specified on the hardware side and the signal value is checked on the software side (channel driver in the ES or faceplate in the OS). Checking and documentation verifies the interconnection in the software and the wiring up to the process device.

Interconnecting the process device

In order to interconnect a process device with the process tags requires parallel operation of simulation and real process. The target project needs to be open.

Table 6-6

No.	Action
1.	Open the CFC chart “LIC_Level” In subchart “B” you make the following changes: In channel block “PV” at input parameter “PV_In” you perform an interconnection with a process device (e.g. filling level measuring transmitter). **Note**: Channel block “MV” in the second sheet is not interconnected, since the control of the manipulated variable occurs through the valve process tag. Deactivation of the simulation causes an error at the “Bad” output of channel block “MV” and subsequently the interlocking of the controller.
2.	Open the CFC chart “LIC_Level”. In subchart “B” you make the following changes: In channel block “PV” at input parameter “PV_In” you perform an interconnection with a process device (e.g. filling level measuring transmitter). **Note**: The additional interconnection is used for comparing the process value (filling level measuring transmitter) with the simulation value.
3.	Open the CFC chart “YC_OutletValve”. In subchart “B” you make the following changes: In channel block “Rbk” at input parameter “PV_In” you perform an interconnection with a process device (e.g. feedback signal from manipulated variable).
4.	Compile and download the blocks and charts.

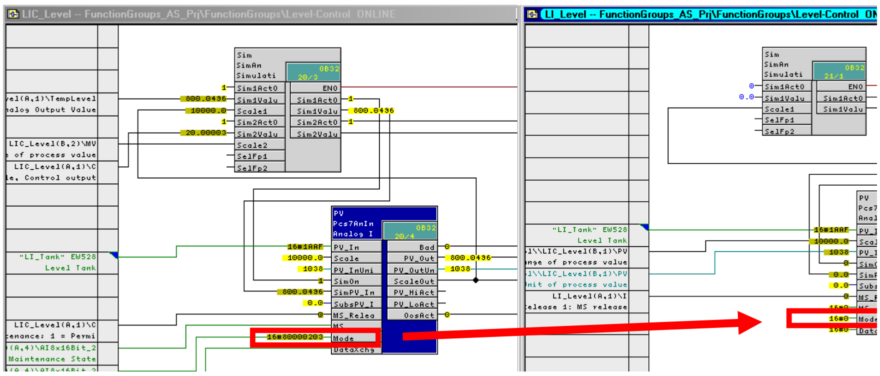
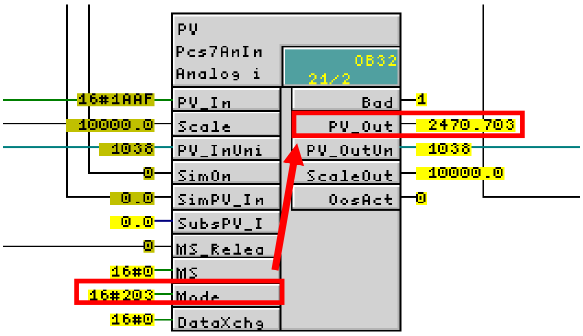
NOTE

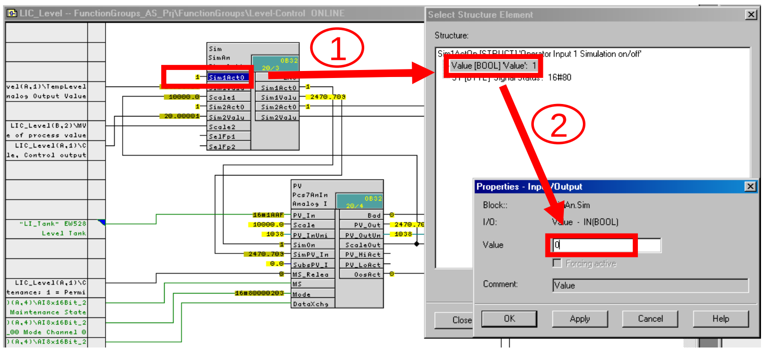
At channel blocks “Pcs7AnIn” and “Pcs7AnOu” it is specified via the “Mode” input parameter in which form the process value (raw value) is present and to be processed.

The following procedure illustrates an option for the startup process. Compare the local process behavior with the process behavior of the equipment module and adjust, if necessary, the simulation and the configuration of the equipment module.

CAUTION	**Move the simulation into a process-oriented and stable state in order to prevent unexpected process jumps when changing from simulation to the real process connection. Typically, all controllers should be in manual mode when switching from simulation to real measured values. Due to the adjustment of the setpoint to the actual value during manual mode a subsequent bumpless switchover from manual to automatic mode can be performed.**

Table 6-7

No.	Action
1.	Open CFC chart "LIC_Level" and "LI_Level". Activate the test mode for the "PV" channel blocks (subchart "B", sheet 1) so the connections become visible. 
2.	Adopt the configuration of the "Mode" input parameter from the "PV" channel driver of the "LIC_Level" controller process tag to channel driver "PV" of the "LI_Level" measured value display for the process tag.  **Note**: The process value of the process device is output correctly at the channel driver output (equal mode for processing the process value (raw value), as configured in the controller process tag).
3.	Adjust the simulation value to the process value by specifying a new setpoint value in the OS. Wait until the specified setpoint value has been reached.

No.	Action
4.	Deactivate the simulation by specifying the value “0” at simulation block “Sim” at input “Sim1Act0p”.  Sim1ActOp [STRUCT] 'Operator Input 1 Simulation on/off' Value [BOOL] 'Value': 1 ST [BYTE] 'Signal Status': 16#80 Block:: …An.Sim I/O: Value - IN(BOOL) Value 0 ☐ Forcing active Comment: Value **Note**: If the simulation value deviates from the process value, the controller tries to compensate, which leads to an undesired change of the manipulated value.
5.	Open the CFC chart “YC_OutletValve” and activate the test mode.
6.	Deactivate the simulation by specifying the value “0” at simulation block “Sim” (subchart “B”, sheet 1) at input “Sim1Act0p”. **Note**: Using an operator control block in the controller process tag and interconnecting with the simulation blocks of controller process tag and valve process tag enables deactivating the simulation in one step.

NOTE The universal tool SIMATIC PDM (Process Device Manager) for configuration, settings, commissioning, diagnosis and maintenance can be used for monitoring the process value of a process device.

6.3 Configuration of the PID controllers

For the configuration of the PID controllers the program “PID Tuner” is available. This program determines the optimal PID parameters for the connected controlled section. The following instruction describes the general procedure at the example of the PID controller in the CFC chart “LIC_Level”.

NOTE A practical example for the operation is shown in the document “PID Control with Gain Scheduling and PID Tuning”

Requirements

- The controller is connected to the process or the simulation.
- The automation program is compiled and downloaded.

NOTICE **An intervention in the plant process occurs through optimization. You have to be aware of the consequences this might have.**

Continuously monitor the process at the trend plotter during optimization.

Selecting the amplitude of the trigger

- Choose the jump height large enough to prompt a process response which clearly stands out from the measurement noise of the signals.
- Choose the jump height small enough to ensure, that the process is not endangered and the product quality is not affected more than necessary.
- For non-linear processes you perform the trigger at the operating point at which the controller shall work. Choose the jump height small enough to record the approximate linear response in the surroundings of this operating point.

NOTE Coordinate all planned attempts (controller optimization) with the member of staff responsible for operation.

Settings at the block

The “PID Tuner” program is always executed on the Engineering Station (ES). Since the operator control and monitoring station (OS) and the ES normally do not run on the same computer, a coordination of the users is offered by the PCS 7 system. The enable is given in the operator screen of the controller (View > Parameter). This enable gives the engineering system (PID Tuner) the right to actively interfere with the process. During optimization the respective operating options on the OS are blocked.

To be able to use the “PID-Tuner” program, value “1” must be pending at the “OptimEn” input of the “PIDConL” block. If you wish to set this input in ES, execute steps 1 to 5. If an enable on the OS was granted, start with step 1 of subchapter “Performing the controller optimization”.

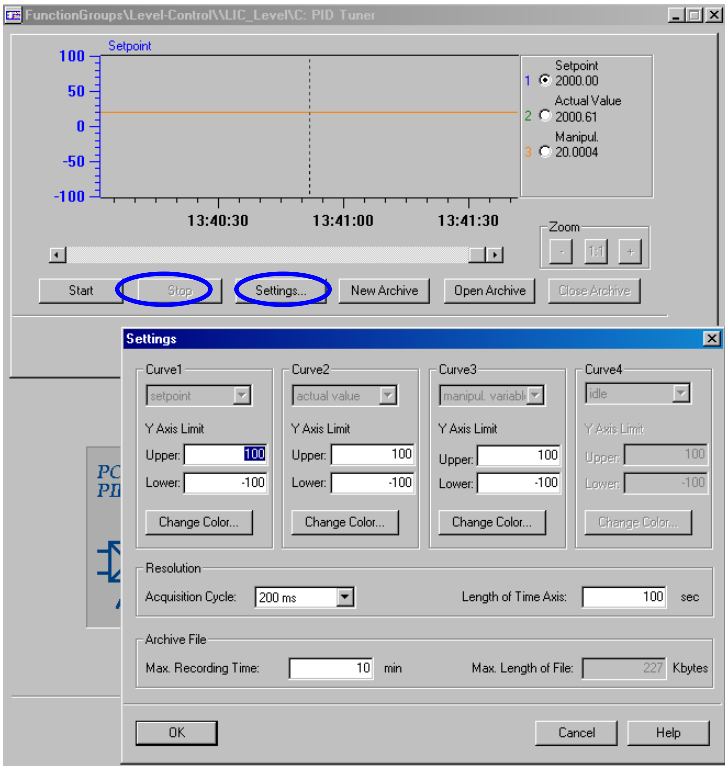
Table 6-8

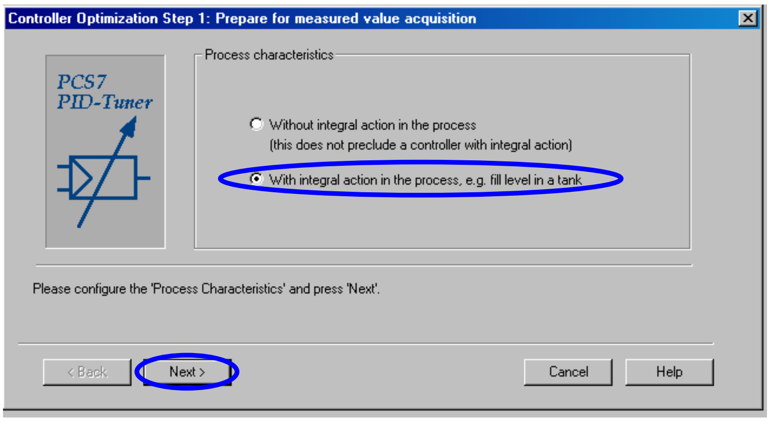
No.	Action
1.	Open the PCS 7 project in the Plant View.
2.	Open the hierarchy folder of the AS project “EquipmentModules > Level-Control” and double-click on the “LIC_Level” chart. The CFC editor is opened
3.	In the menu bar of the CFC Editors click “Debug > Test Mode” and acknowledge the “Register CPU for testing” dialog with “Yes”.
4.	Double-click block “C” (subchart “A”, sheet 1) and click on the “Connections” tab.
5.	Change the value of the “OptimEn” connection to value “1” and acknowledge with “OK”. Then close the block.

Performing controller optimization

The following instruction describes a controller optimization for a controlled section for filling level with integrating behavior.

Table 6-9

No.	Action
1.	In the menu bar of the CFC editors you click on “Edit > Optimize PID controller…”. The PID tuner opens.
2.	In the curve plotter you click “Stop” to stop the recording and then clock the “Settings” button.  FunctionGroups\Level-Control\\LIC_Level\C: PID Tuner Setpoint 1 ● 2000.00 Actual Value 2 ○ 2000.61 Manipul. 3 ○ 20.0004 Settings Curve1: setpoint; Y Axis Limit Upper: 100; Lower: -100 Curve2: actual value; Y Axis Limit Upper: 100; Lower: -100 Curve3: manipul. variabl; Y Axis Limit Upper: 100; Lower: -100 Curve4: idle; Y Axis Limit Upper: 100; Lower: -100 Resolution Acquisition Cycle: 200 ms Length of Time Axis: 100 sec Archive File Max. Recording Time: 10 min Max. Length of File: 227 Kbytes

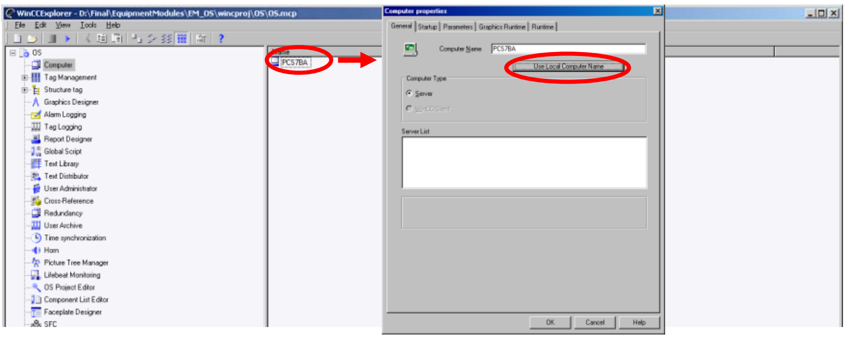
No.	Action
3.	For the 3 curves (setpoint, actual value, manipulated value) you specify suitable limits for the Y axis.
4.	Adjust the “Recording cycle” and the “Length of the time axis” to the expected process behavior and acknowledge the input with “OK”. **Note**: The online help offers detailed information on controller optimization. In the bottom part of the PID tuner you click the “Help” button to open the online help.
5.	In the bottom part of the PID tuner you click the “Start Controller Optimization”.
6.	In step 1 for a filling level control you click the radio button “With integral action in the process” and then click on “Next”. For controlled sections for temperature please select "Without integral action in the process".  Controller Optimization Step 1: Prepare for measured value acquisition Process characteristics ○ Without integral action in the process (this does not preclude a controller with integral action) ● With integral action in the process, e.g. fill level in a tank Please configure the 'Process Characteristics' and press 'Next'.
7.	In the “Operating mode” group you select the “Automatic” checkbox if you already have an approximately stable controller. As a start point you enter the typical operating point of the controlled variable. Please note the warning in the bottom part of the dialog and then click on “Next”.
8.	As “Step trigger, new setpoint:” you specify a setpoint value clearly above the typical operating point. Please note the warning in the bottom part of the dialog and then click on “Next”. The controller optimization is now started.
9.	After completing the optimization in the “Process trigger” group you select the checkbox “Reset”. Please note the warning in the bottom part of the dialog and then click on “Next”.
10.	In the “Controller design for” group you select the “Optimal control response” box and click “Next”. An additional window with the result of the identification is opened.
11.	In the “Controller parameter” group you select the checkbox of the PI controller and click on “Next”.
12.	In step 8 you click: “Simulate a control loop with the optimized parameters” and on “Next”.
13.	Click the “New” button to accept the determined values. Please note the warning in the bottom part of the dialog and then click on “Finish” to complete the optimization.

7 Starting the Equipment Modules

7.1 Preparation

The following instruction describes the commissioning of the equipment module, in which the controller is simulated with the “S7-PLCSIM” program. If a real controller is used you must adjust the hardware settings in HW Config beforehand.

Table 7-1

No.	Action
1.	Copy the “53843373_EquipmentModules_PCS7V713.zip” file to any folder on the configuration computer and then open the SIMATIC Manager.
2.	Click “File > Retrieve” in the menu bar and select the “53843373_EquipmentModules_PCS7V713.zip” file. Then confirm by clicking “Open”.
3.	Select the folder in which the project is saved and acknowledge with “OK”. The project is retrieved.
4.	Acknowledge the “Retrieve” dialog with “OK” and then click “Yes” in the dialog to open the project.
5.	Right-click on “EquipmentModules_OS_Prj > ES01VM01 > WinCC Appl. > OS” and click on the menu command “Open object”.
6.	Acknowledge the “The configured server is not available” dialog with “OK”.
7.	In WinCC Explorer you open the properties of your computer and click the “Use Local Computer Name”. Acknowledge the “Change computer name” message with “OK”.  WinCCExplorer - D:\Final\EquipmentModules\EM_OS\wincproj\OS\OS.mcp Computer properties Computer Name: PCS7BA Computer Type: ● Server
8.	In the WinCC Explorer you click on “File > Exit” and in the following dialog you select “Close project and exit WinCC Explorer”. Acknowledge with "OK".
9.	Open the WinCC Explorer again as described in step 5.
10.	In the WinCC Explorer you right-click on “OS > Tag Management > SIMATIC S7 PRO… > Industrial Ethernet” and select the menu command “System parameter”. Note: The dialog can be opened in the background and must then be clicked in the Windows toolbar.
11.	In the “Unit” tab you check the set “Logical device name”. When using the “S7-PLCSIM” the device name PLCSIM (ISO) is selected. Changing the device name requires a restart of the program. Open the WinCC Explorer again as described in step 5.

7.2 Commissioning

The following instruction describes how the equipment module is set to initialization mode.

Commissioning requires that the SIMATIC Manager has already been opened and the equipment module is selected in the components view.

Start simulation (S7-PLCSIM)

To start the simulation, proceed according to the instruction:

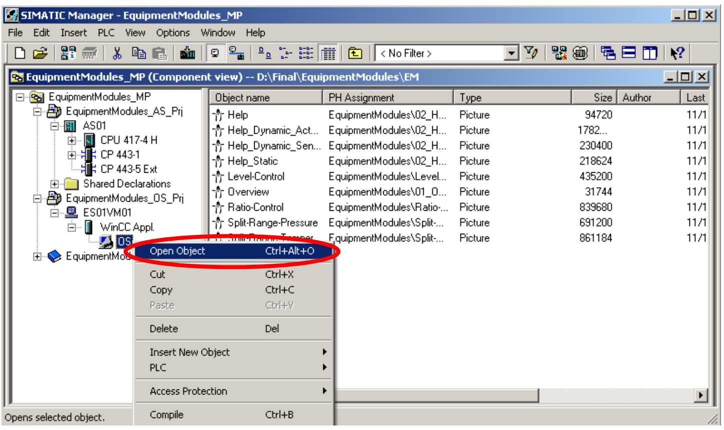
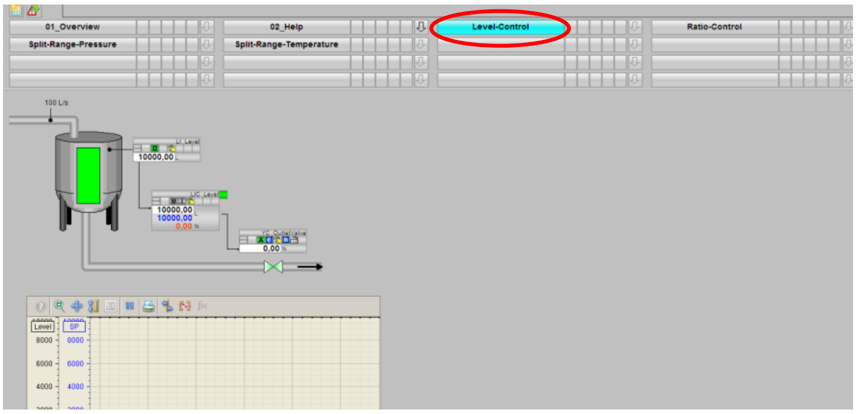
Table 7-2

No.	Action
1.	Select “Options > Simulate Modules” from the menu. The dialog window of “S7-PLCSIM” opens.
2.	In the “Open project” dialog you select the “Open project from a file” option.
3.	Select the “EquipmentModules.plc” file from the path <project path>\EquipmentModules\EM_AS\EquipmentModules.plc>.
4.	Select “Execute > Key position switch > RUN-P” from the menu.
5.	Go to the components view of the SIMATIC Manager and select “EquipmentModules_AS_Prj > AS01”.
6.	In the menu bar you click on “PLC > Download” and acknowledge the “Download” with “Yes”. Acknowledge the “Stop Target Module” dialog with “OK” and subsequently the “Download” dialog with “Yes”.

Activating OS (WinCC Runtime)

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

Table 7-3

No.	Action
1.	Make a right mouse click on the OS and select the “Open Object” menu. 
2.	To activate the OS (WinCC Runtime), select “File > Activate” in the WinCC Explorer menu.
3.	In the “System Login” dialog you log in with the user “Equipment” and the password “Modules” and acknowledge with “OK”.
4.	In the picture section you select an equipment module (e.g. “Level-Control”), whose principle of operation you wish to know about. 

8 Links & Literature

8.1 Further literature

The following list is by no means complete and only provides a selection of appropriate sources.

Table 8-1

	Topic	Title
/1/	Practice book for controlling with SIMATIC S7 and SIMATIC PCS7 for process automation	Regeln mit SIMATC (Controlling with SIMATIC) Müller, Jürgen / Pfeiffer, Bernd-Markus / Wieser, Roland Publicis Kommunikationsag ISBN 978-3895783401
/2/	Design of standard controller	Krämer, S. Auslegung von Standreglern in der verfahrenstechnischen Praxis. (Design of standard controller in process practice.) Dechema- Seminar „Prozessregelungen – von den Grundlagen zu Advanced Control“ (The Dachema seminar on "Process control systems – from the basics to advanced control applications") Sep. 2008

8.2 Internet links

The following list is by no means complete and only provides a selection of appropriate sources.

Table 8-2

	Topic	Title / Link
\1\	Siemens Industry Online Support	http://support.automation.siemens.com
\2\	Download page of this entry	http://support.automation.siemens.com/WW/view/en/53843373
\3\	SIMATIC PCS 7 Overview – Landing Page	http://support.automation.siemens.com/WW/view/en/63481413
\4\	Controller optimization with PID tuner	http://support.automation.siemens.com/WW/view/en/8031495
\5\	Application for model-based predicative control	http://support.automation.siemens.com/WW/view/en/42200753
\6\	Configuring a cascade control	http://support.automation.siemens.com/WW/view/en/43033319
\7\	PCS 7 Unit Template "Stirred Tank Reactor" using the example of the Chemical Industry	http://support.automation.siemens.com/WW/view/en/60546560
\8\	PCS 7 Unit Template "Fermenter" using the example of the Chemical	http://support.automation.siemens.com/WW/view/en/68098270

	Topic	Title / Link
	Industry	
\9\	PCS 7 Unit Template " Distillation Column" using the example of the Chemical Industry	http://support.automation.siemens.com/WW/view/en/48418663
\10\	PCS 7 Unit Template "Dryer" using the example of the Chemical Industry	http://support.automation.siemens.com/WW/view/en/74747848
\11\	PCS 7 Unit Template "Polymerization Reactor" using the example of the Chemical Industry	http://support.automation.siemens.com/WW/view/en/84061788
\12\	SIMATIC Process Control System PCS 7, PCS 7 Advanced Process Library V7.1 SP5	http://support.automation.siemens.com/WW/view/en/48034370
\13\	How do you procure documentation for PCS 7 V8.0 (including the PCS 7 V8.0 Manual Collection)?	http://support.automation.siemens.com/WW/view/en/59538371

9 History

Table 9-1

Version	Date	Changes
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 multi-variable controls and drives integrated. Additional links added
V2.2	17.04.2014	New equipment module “Temperature-Flow-Cascade” added

10 Appendix

10.1 Block description “SwSqrt”

Function description

The square root function does not correct the non-linear signal band of a squared signal. The block has one operating mode without (mode 1) and one with low value suppression (mode 2). Simulation and substitution values are performed without change.

The square root function is activated by changing the MODE input to 1 or 2. For 2 the signals are suppressed under the LSUPLEVL (=LRANGE).

Operating modes

During the simulation (SimMode = 1) the status of the input signal is ignored.

Table 10-1

	MODUS	Scale	IN	QUALITY	OUT
	<1 >2	all	all	all	OUT = IN
	all	all	all	16#48 16#60	OUT = IN
	1 or 2	Scale.Low < Scale.High	all	all	OUT = IN
	1	Scale.Low < Scale.High	IN <= Scale.Low Oder IN < 0	<> 16#48 <> 16#60	OUT = SQRT*1
	1	Scale.Low < Scale.High	IN > 0	<> 16#48 <> 16#60	OUT = SQRT*2
	2	Scale.Low < Scale.High	IN < 0 or SUP*	<> 16#48 <> 16#60	OUT =0
	2	Scale.Low < Scale.High	IN > LoSupLv	<> 16#48 <> 16#60	OUT = SQRT*2

$$SUP* = \sqrt{IN \bullet (Scale.High - Scale.Low)} < LoSupLvl \bullet \frac{Scale.High - Scale.Low}{100}$$

$$SQRT *^{1} = (-1) \bullet \sqrt{(-1) \bullet IN \bullet Scale.High}$$

$$SQRT *^{2} = \sqrt{IN \bullet (Scale.High - Scale.Low)} + Scale.Low$$

Inputs

Table 10-2

Input	Data type	Default value	Description
Mode	BOOL	0	MODE selection
IN ->Value ->ST	STRUCT ->INT ->Byte	 0 16#0	Input value
Scale ->High ->Low	STRUCT ->REAL ->REAL	 100.0 0.0	Measuring range of "IN"
LoSupLvl	REAL	0.0	Degree of suppression for low values
SimMode	Bool	0	1=Ignore Sim/Subs, 0=Pass IN value through, Value if IN.ST=48 or 60

Outputs

Table 10-3

Output	Data type	Default value	Description
OUT ->Value ->ST	STRUCT ->INT ->Byte	 0 16#0	Output value

10.2 Block description “SwLowact”

Function description

If the low active mode is activated then the input signals can be inverted on the output of the block “SwLowact”.

Simulation and substitution values are performed without change.

Operating modes

During the simulation (SimMode = 1) the status of the input signal is ignored. Set the MODE-Input to 1 for using this option.

Table 10-4

Mode Input	IN	Default value	OUT
0	any	any	OUT=IN
1	any	16#48	OUT=IN
1	any	16#60	OUT=IN
1	any	Not 16#48, not 16#48	OUT=not(IN)

Input and Output parameters

Table 10-5

Parameter	Parameter type	Description	Data type	Default values
Mode	IN	MODE selection	BOOL	0
In	IN	Input value	STRUCT	0
SimMode	IN	1=Ignore Sim/Subs, 0=Input value is output value, if In.ST=48 or 60	BOOL	0
Out	OUT	Output value	BOOL	0

10.3 Block description “SimAn”

Function description

The block represents the interface between an analog channel driver block of the Advanced Process Library (APL) and the operator station (OS). In the run sequence, the block is installed before the driver block. A maximum of 8 analog values are simulated with a block.

Inputs

Table 10-6

Input (**X** = 1 … 8=)	**Data type**	**Default value**	**Description** (**X** = 1 … 8=)
Sim**X**ActOp->Value ->ST	STRUCT ->BOOL ->Byte	 0 16#0	Simulation ON/OFF for simulation value **X**
Sim**X**ValueOp ->Value ->ST	STRUCT ->REAL ->Byte	 0.0 16#0	Simulation value **X**
Scale**X** ->High ->Low	STRUCT ->REAL ->REAL	 100.0 0.0	Measuring range of simulation value **X**
OpEnSiOff	BOOL	1	1=operator can switch off the simulation.
OpEnSiOn	BOOL	1	1=operator can switch on the simulation.
OpEnSiValue	BOOL	1	1=operator can enter the simulation value.
BatchEn	BOOL	0	1=Batch enable
BatchID	DWORD	16#0	Batch ID number
BatchName	STRING[32]		Batch name
StepNo	DWORD	16#0	Batch step number
Occupied	BOOL	0	1=occupied by a batch.
SelFp1	ANY		Calling a batch as additional faceplate in the standard view
SelFp2	ANY		Calling a batch as additional faceplate in the standard view
Feature	STRUCT		Connection for further functions

Outputs

Table 10-7

Output (**X** = 1 … 8=)	**Data type**	**Default value**	**Description** (**X** = 1…8)
Sim**X**ActOut->Value ->ST	STRUCT ->BOOL ->Byte	 0 16#0	Simulation ON/OFF for simulation value **X**
Sim**X**ValueOut ->Value ->ST	STRUCT ->REAL ->Byte	 0.0 16#0	Simulation value **X**

10.4 Block description “SimDi”

Function description

The block represents the interface between an analog channel driver block of the Advanced Process Library (APL) and the operator station (OS). In the run sequence, the block is installed before the driver block. A maximum of 8 digital values can be simulated with one block.

Inputs

Table 10-8

Input (**X** = 1…8)	**Data type**	**Default value**	**Descritpion** (**X** = 1…8)
Sim**X**ActOp->Value ->ST	STRUCT ->BOOL ->Byte	 0 16#0	Simulation ON/OFF for simulation value **X**
Sim**X**ValueOp ->Value ->ST	STRUCT ->BOOL ->Byte	 0.0 16#0	Simulation value **X**
OpEnSiOff	BOOL	1	1=operator can switch off the simulation.
OpEnSiOn	BOOL	1	1=operator can switch on the simulation.
OpEnSiValue	BOOL	1	1=operator can enter the simulation value.
BatchEn	BOOL	0	1=Batch enable
BatchID	DWORD	16#0	Batch ID number
BatchName	STRING[32]		Batch name
StepNo	DWORD	16#0	Batch step number
Occupied	BOOL	0	1=occupied by a batch.
SelFp1	ANY		Calling a batch as additional faceplate in the standard view
SelFp2	ANY		Calling a batch as additional faceplate in the standard view
Feature	STRUCT		Connection to further functions

Outputs

Table 10-9

Output **(X = 1 …8)**	**Data type**	**Default value**	**Description** **(X = 1 …8)**
Sim**X**ActOut->Value ->ST	STRUCT ->BOOL ->Byte	 0 16#0	Simulation ON/OFF for simulation value **X**
Sim**X**ValueOut ->Value ->ST	STRUCT ->REAL ->Byte	 0.0 16#0	Simulation value **X**

10.5 Block description "pHTitrBlock"

Function description

This block is used for the conversion of pH values into concentration differences. This is effected by entering some 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 correlation between the pH value and the concentration difference between H^+ (or H_3O^+) ions (acid) and OH^- ions (lye) in the solution. For a given combination of chemicals, it can be determined experimentally by adding an acid or caustic solution (neutralizer) in small steps. After each small dose the solution is mixed and after a while, when the neutralization reaction has become effective, the new pH value is noted down.

For the equipment modules for pH value regulation, the following trigonometric function is used as an approximation of the titration profile:

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

The pH values are then converted into concentration differences by inverting this characteristic profile:

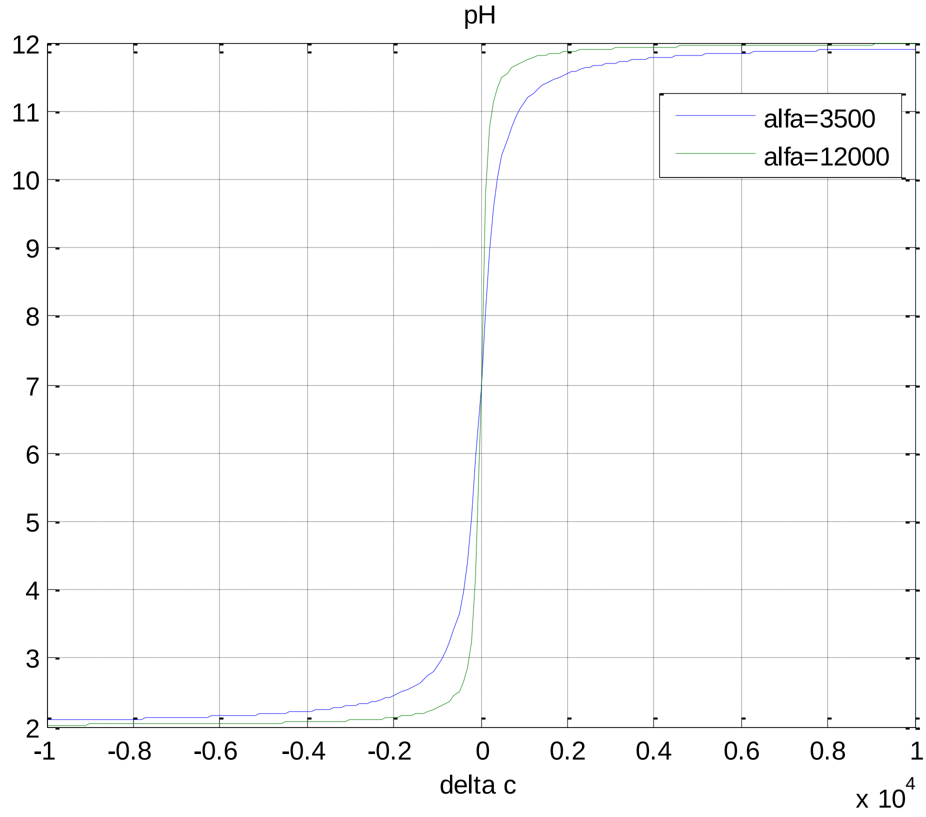
$$\Delta c = \frac{1}{\alpha}\tan\left(\frac{\pi}{2pH_{ampl}}(pH-7)\right)10^6$$

Note

Conversion is performed in the following two blocks which are part of "pHTitrBlock" included in the master data library:

- FB1025 "Titr_pH" for conversion from concentration difference → pH value
- FB1026 "TitrDeltaC" for conversion from pH value → concentration difference

Figure 10-1 – Titration curves for differently buffered solutions, pH_{ampl}=5



In this titration curve diagram, the neutral zone is given at pH 7 with a maximum deflection (amplitude) of 5. The slope of the characteristic curve in the neutral point (parameter α) shows typical values between 3500 and 12000.

NOTICE	**Precondition for use in a productive process environment is the knowledge of the titration curve parameters which must be entered in the block. These parameters include:** • **the amplitude range to be processed *pH_{ampl}* on the pH value scale** • **the buffer parameter α (alfa) as a measure for the slope of the curve in the neutral point**

Inputs

Table 10-10

Input	Data type	Description
CV	STRUCT ->Real ->Byte	actual pH value

Input	Data type	Description
DV	STRUCT ->Real ->Byte	pH value of the disturbance variable
SP	STRUCT ->Real ->Byte	pH setpoint (e.g. defined by the OpAnL operator control block or SFC)
Alfa	STRUCT ->Real ->Byte	Measure for the slope of the characteristic curve in the neutral point
Ampl_pH	STRUCT ->Real ->Byte	The amplitude range to be covered
MV	STRUCT ->Real ->Byte	Controller setpoint
Feed_PV_Out	STRUCT ->Real ->Byte	Inflow (feed) of the component (disturbance variable)
Feed_Scale	STRUCT ->Real ->Real	Feed scaling (ScaleOut)

The inputs "CV", "DV" and "SP" are converted into concentration differences by means of the parameters "Alfa" and "Ampl_pH".

Outputs

Table 10-11

Output	Data type	Description
CV_Out	STRUCT ->Real ->Byte	Concentration difference of the actual pH 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 of the manipulated value MV in dependence of the component’s feed rate (MVHiLim =100/Feed_PV_Out/Feed_Scale.Max)
MV_Valve	STRUCT ->Real ->Byte	Variable manipulated value (to the valve process tag) in dependence of the component’s feed rate (MV_Valve = Feed_PV_Out/Feed_Scale.Max * MV)

Interconnection of the manipulated/disturbance variables’ inputs and outputs ("MV", "Feed_PV_Out", "Feed_Scale", "MVHiLim", "MV_Valve") is performed when the feed quantity shall be compensated by means of a disturbance variable.

NOTE The output variable of the controller (conceptually a "concentration") is multiplied with the (normalized) inflow quantity of the wastewater (component) in order to calculate a unit for the required amount of neutralizer. If the setpoint limitation in the controller were constant, the control range of the dosing valve would be fully utilized only at maximum wastewater throughput. This problem is solved by a dynamic interconnection of MV1HiLim in dependence of the inflow quantity (feed).

10.6 Block description "SimpHTitr"

Function description

This block is used to calculate a ph value on the basis of process-specific characteristics such as the titration curve of the process, inflow volumes (feed) and the pH value of the component and neutralizer. The titration curve describes the connection between the pH value and the concentration difference of the neutralizer added.

Inputs

Table 10-12

Input	Data type	Description
Feed_pH	STRUCT ->Real ->Byte	pH value of the component
Alfa	STRUCT ->Real ->Byte	Measure for the slope of the characteristic curve in the neutral point
Ampl_pH	STRUCT ->Real ->Byte	The amplitude range to be processed
Neutr_MV	STRUCT ->Real ->Byte	Manipulated value of the controller for the neutralizer
Neutr_Lag	Real	Delay of the manipulated value (neutralizer)
Neutr_Factor	Real	Factor value for neutralizer inflow
Feed_PV	STRUCT ->Real ->Byte	Component inflow volume (feed)
pH_DeadTime	Real	Delayed signal output in seconds (dead time)

NOTICE **When using the dead time function (pH_DeadTime > 0), a multi-variable controller (ModPreCon block) for dead time compensation and disturbance variable compensation must be used.**

Outputs

Table 10-13

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

Calculation of the pH value is performed in the following steps:

1. Determine the products (multiplication) from the concentration differences, the component inflow volumes and the neutralizing agent
2. Determine the total feed volume
3. Calculate the factor (relative concentration difference) from the products and the total feed volume
4. Convert the concentration difference into the actual pH value

Simulation offers to adjust both the process-specific characteristic values of the titration curve, as well as the effect of the values for disturbance variable compensation (by changing the pH value of the components by ± 1) and the variable feed rates (changing the feed volume by ±500 mol/L).

10.7 Units of measure

The units of measure are listed in the following table (in accordance with IEC 61158).

Table 10-14

Value	Display	Description	Value	Display	Description
1000	K	Kelvin	1100	g/cm3	Grams per cubic centimeter
1001	°C	Degrees Celsius	1105	g/L	Grams per liter
1002	°F	Degrees Fahrenheit	1120	N	Newton
1005	°	Degrees	1123	mN	Millinewton
1006	'	Minute	1130	Pa	Pascal
1007	"	Second	1133	kPa	Kilopascal
1010	m	Meter	1137	bar	Bar
1013	mm	Millimeter	1138	mbar	Millibar
1018	ft	Foot	1149	mmH2O	Millimeters of water
1023	m2	Square meter	1175	W·h	Watt hour
1038	L	Liter	1179	kW·h	Kilowatt hour
1041	hl	Hectoliter	1181	kcalth	Kilocalorie
1054	s	Second	1190	kW	Kilowatt
1058	min	Minute	1209	A	Ampere
1059	h	Hour	1211	mA	Milliampere
1060	d	Day	1221	A·h	Ampere hour
1061	m/s	Meters per second	1240	V	Volt
1077	Hz	Hertz	1342	%	Percent
1081	kHz	Kilohertz	1349	m3/h	Cubic meters per
1082	1/s	Per second	1353	L/h	Liters per hour
1083	1/min	Per minute	1399	Mol/L	Mole per liter
1088	kg	Kilogramm	1422	pH	pH value
1092	t	Metric ton			

NOTE An overview of the units of measure you will find in the manuals „SIMATIC Process Control System PCS7 PCS 7 Advanced Process Library V7.1 SP5“ and “SIMATIC Process Control System PCS 7 PCS 7 Advanced Process Library V8.0”.