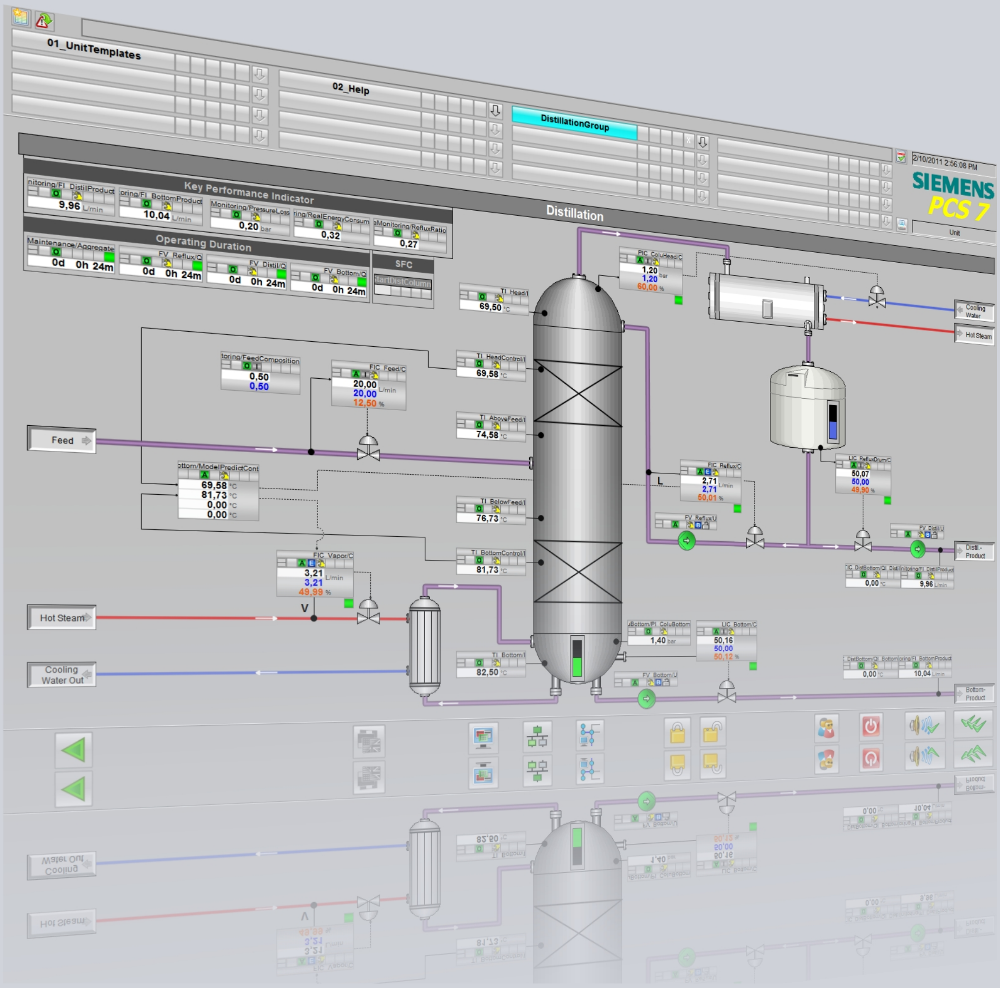
PCS 7 Unit Template “Distillation Column” using the example of the Chemical Industry

SIMATIC PCS 7

Application description • June 2013



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SIMATIC PCS 7

Distillation column

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1 Automation Task

1.1 Introduction

Looking at a chemical plant and its engineering processes it becomes apparent that certain process steps, procedures and devices repeat in identical or similar form. The concept of unit templates offers you pre-engineered, standardized partial automation solutions (templates) for plant engineering processes.

A unit template is configured independent of the automation hardware and contains a preconfigured user program including the process visualization.

Integrating the unit template into an existing PCS 7 project requires interconnecting the user program with the automation hardware and configuring the controllers.

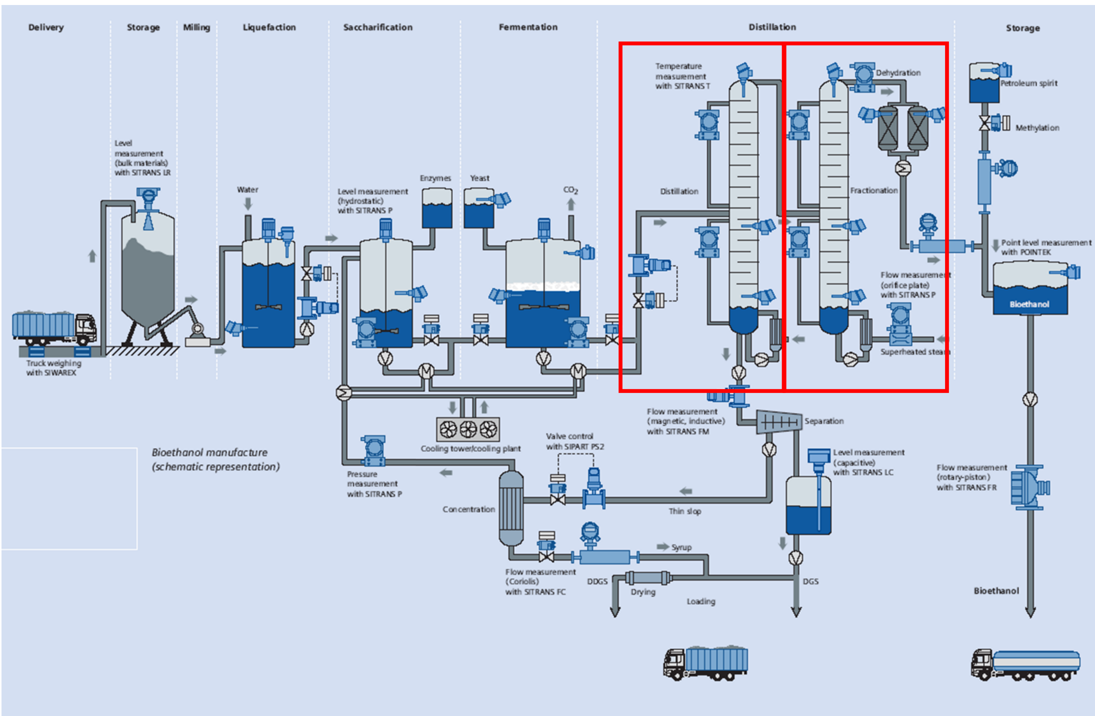
The objective for the application of unit templates is:

- Reducing the required know-how for application development
- Reducing the configuration workload
- Illustrating typical control strategies
- Unified program structures

1.2 Description

The “Distillation column” unit template is a template which contains all typical components of a distillation column, its control, the required logic and the visualization.

Figure 1-1 Distillation column as an integral part of the bio-ethanol process



The structure of the enclosed example project enables directly adopting predefined elements into an existing PCS 7 project.

For the user program, the Advanced Process Library (APL) is employed with a multi-variable controller concept. The multi-variable controller enables a distillation column control which keeps the demanded product quality constant and also enables optimization.

As a unit, a distillation column consists of a number of individual process engineering components, such as the column, the actuators and the sensors. The controller is the link between all components of a distillation column, hence an important part of an automation process.

During the configuration a number of conditions must be considered (e.g. interlocking, controller structures) which require a high level of detailed knowledge about the process plant and a high level of detailed knowledge and experience with PCS 7.

2 Automation Solution

2.1 Overview of the overall solution

Description

The quality of a substrate separation is measured by the purity of the separation products, i.e. the concentration of light ends and heavy ends in the head and bottom extraction. Measuring these concentrations by means of online analyzers is extensive, so it is not performed in most of the plants. On the individual trays of the column there are thermo-dynamic correlations in the phase equilibrium (between vapor and liquid) and hence there is also a correlation between the concentrations and the temperatures. The easily measurable temperatures are used as substitutional controlled variables. The advantage is that the correlation between the temperatures and the control operations can be linearized more easily than the correlation between the concentrations.

The “Distillation column” unit template is realized as PCS 7 multiproject and consists of an AS project (user program) as well as an OS project (visualization with process pictures). In the AS project all control functions have already been realized in form of CFC (Continuous Function Chart). Furthermore, the AS project contains a simulation which simulates a distillation column (packed or packed bed columns) for distilling isopropanol (light end) and butanol (heavy end).

The AS (Automation System) project was created using the APL (Advanced Process Library), which also contains a model predictive multi-variable controller. The multi-variable controller is the core component of the control strategy; it takes on the control of head and bottom temperature in the distillation column. Further controls are subordinate to the multi-variable controller.

The process pictures contain an overview of the most important characteristics (KPI: Key Performance Indicators) of the distillation column, as well as all detailed information on the individual components of the distillation column.

Restriction

The following exceptional cases are not covered by the “Distillation column” unit template:

- Multi-substance distillation, i.e. columns with additional lateral extractions
- Columns with gaseous head products, which require a different structure for the pressure control
- Vacuum columns with a special pressure control structure
- Stripper, i.e. columns without reinforcement part
- Columns with no representative temperature as controlled variable

Required knowledge

Basic knowledge of the following subject areas is required:

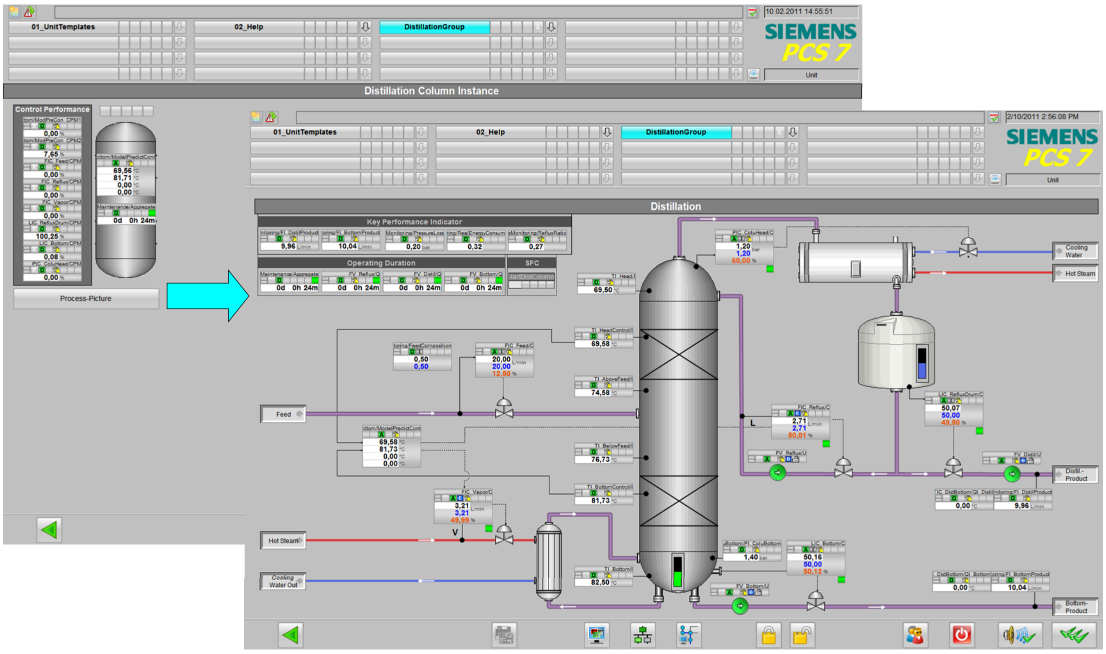
- Configuration with SIMATIC PCS 7 and the APL
- Knowledge of control engineering
- Basic knowledge of process engineering

2.2 Core functionality

The individual components of a distillation column are described below. The introduction is provided via the process picture of the visualization user interface.

2.2.1 Visualization

Figure 2-1



The visualization of the “Distillation column” unit template consists of an overview picture and a process picture.

Overview picture

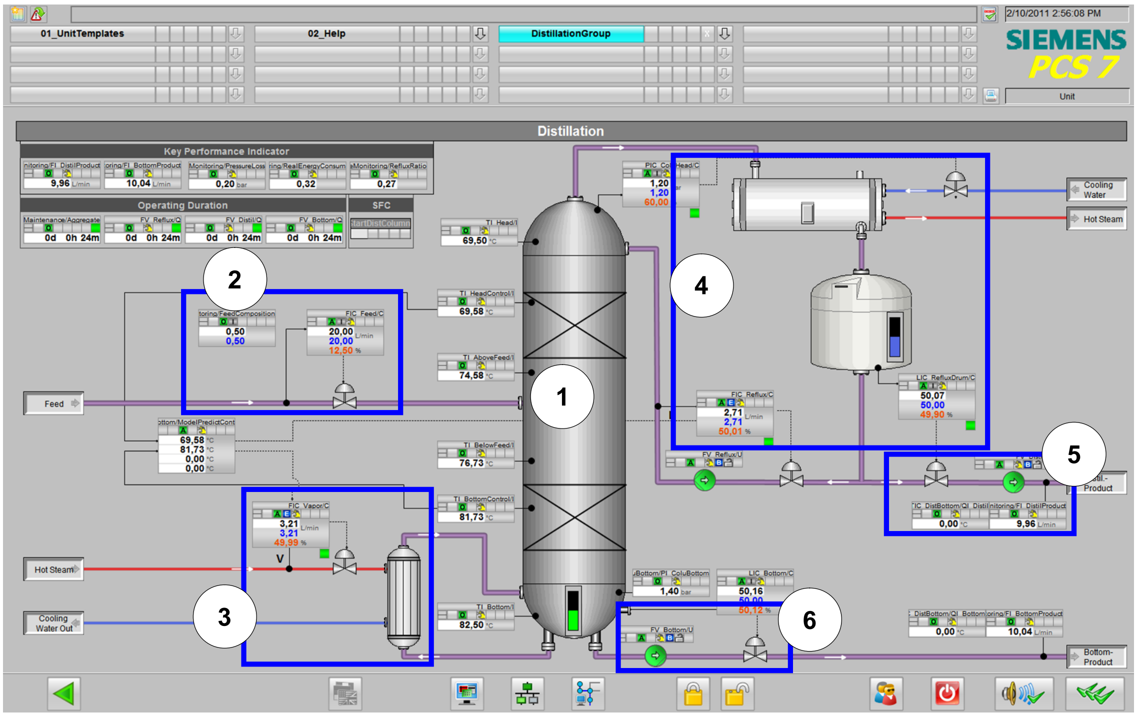
The overview picture shows the most important process values and the control performance of each control loop. For each displayed value you can receive further information via the respective faceplate and make changes. Evaluating the curve display of a control performance enables detecting gradual deterioration over a longer period of time (e.g. signs of wear).

Process display

The process display shows a schematic representation of the distillation column and the faceplates for controlling the individual components. Additionally, the process display contains an overview of relevant characteristics (Key Performance Indicator) and operating time displays. The process display gives the operator an overview of the entire plant and enables the operator to make necessary control operations.

2.2.2 Description of individual functions

Figure 2-2



The process display of the distillation column consists of the following main components:

1. Distillation column
2. Feed
3. Vaporizer ("Vapor")
4. Condenser with reflux ("Reflux")
5. Extraction of the head product ("Light end")
6. Extraction of the bottom product ("Heavy end")

1. Distillation column

The distillation column is controlled by means of a multi-variable controller. The head and bottom temperature (controlled variables) is detected and controlled via the vapor volume or the condensate reflux (manipulated variables). Both controlled variables are used as setpoint specifications for the underlying PID controllers.

2. Feed

The substance mixture is fed to the distillation column via the feed.

A PID controller controls the flow rate of the feed (controlled variable) via a valve (manipulated variable) until the setpoint specification has been reached. The process value of the PID controller is integrated into the higher-level multi-variable controller as a measurable disturbance variable.

In a column with predefined feed (preceding unit) the measured value of the feed (flow rate) is used for disturbance variable compensation. In this case there is no PID controller for controlling the flow rate.

3. Vaporizer ("Vapor")

The vaporizer removes the liquid substance mixture from the bottom of the column and heats it until the components vaporize. The gaseous substance mixture is then fed back to the distillation column.

The hot vapor flow rate (controlled variable) for heating the vaporizer is controlled via a valve (manipulated variable) using a PID controller which contains the setpoint specified by the multi-variable controller.

4. Condenser with reflux ("Reflux")

The condenser extracts the gaseous substance mixture at the head of the column and cools it down until both substances (light end and heavy end) start condensing. The liquid substance mixture is then fed back into the distillation column. The condenser also contains a tank where the liquid substance mixture is intermediately stored to enable regulating the reflux volume.

The pressure in the head of the distillation column (controlled variable) is controlled via the cooling water flow rate (manipulated variable) using a PID controller. The operator specifies the setpoint.

The reflux flow rate (controlled variable) is controlled via valve (manipulated variable) using a PID controller. The setpoint is specified by the multi-variable controller of the distillation column.

5. Extraction of the head product ("Light end")

The volume of drained head product depends on the filling level of the condenser and cannot be specified. For a stable operating point in the entire distillation column the volume of the head product to be extracted results from the following components:

- The concentration of the light end in the fed substance mixture
- The feed volume of the distillation column

The filling level in the condensate container (controlled variable) is controlled via a valve (manipulated variable) using a PID controller. The operator specifies the setpoint.

6. Extraction of the bottom product ("Heavy end")

The volume of the bottom product to be extracted depends on the filling level of the bottom and cannot be specified. For a stable operating point of the entire distillation column the volume of the bottom product to be extracted results from the following components:

- The concentration of the heavy end in the fed substance mixture
- The feed volume of the distillation column

The filling level in the bottom of the column (controlled variable) and hence indirectly the flow rate of the heavy end are controlled via a valve (manipulated variable) using a PID controller. The operator specifies the setpoint.

Further functions

Temperature and pressure display

The distillation column contains 6 temperature displays and 2 pressure displays:

- Temperature at the head of the distillation column
- Pressure at the head of the distillation column
- Temperature for regulating the head temperature
- Temperature above the feed
- Temperature below the feed
- Temperature for regulating bottom temperature
- Temperature at the bottom of the distillation column
- Pressure at the bottom of the distillation column

Specified concentration

For the feed the concentration of the light end can be specified in relation to the heavy end. This concentration ratio is an undetected disturbance variable for the process.

Operating point

An SFC (step chain) brings the distillation column to the operating point after the controller has been started.

Characteristic values (KPI = Key Performance Indicator)

The following characteristic values are measured or calculated:

- Production volume of the head product
- Production volume of the bottom product
- Pressure loss = Pressure at column bottom– Pressure at column head
- Relative power consumption = Vapor volume / Production volume of head product
- Reflux ratio: Reflux / Extraction of head product

Operating time display

The following operating displays are contained in the process picture:

- Distillation column
- Reflux motor
- Head product motor
- Bottom product motor

2.2.3 Control concept

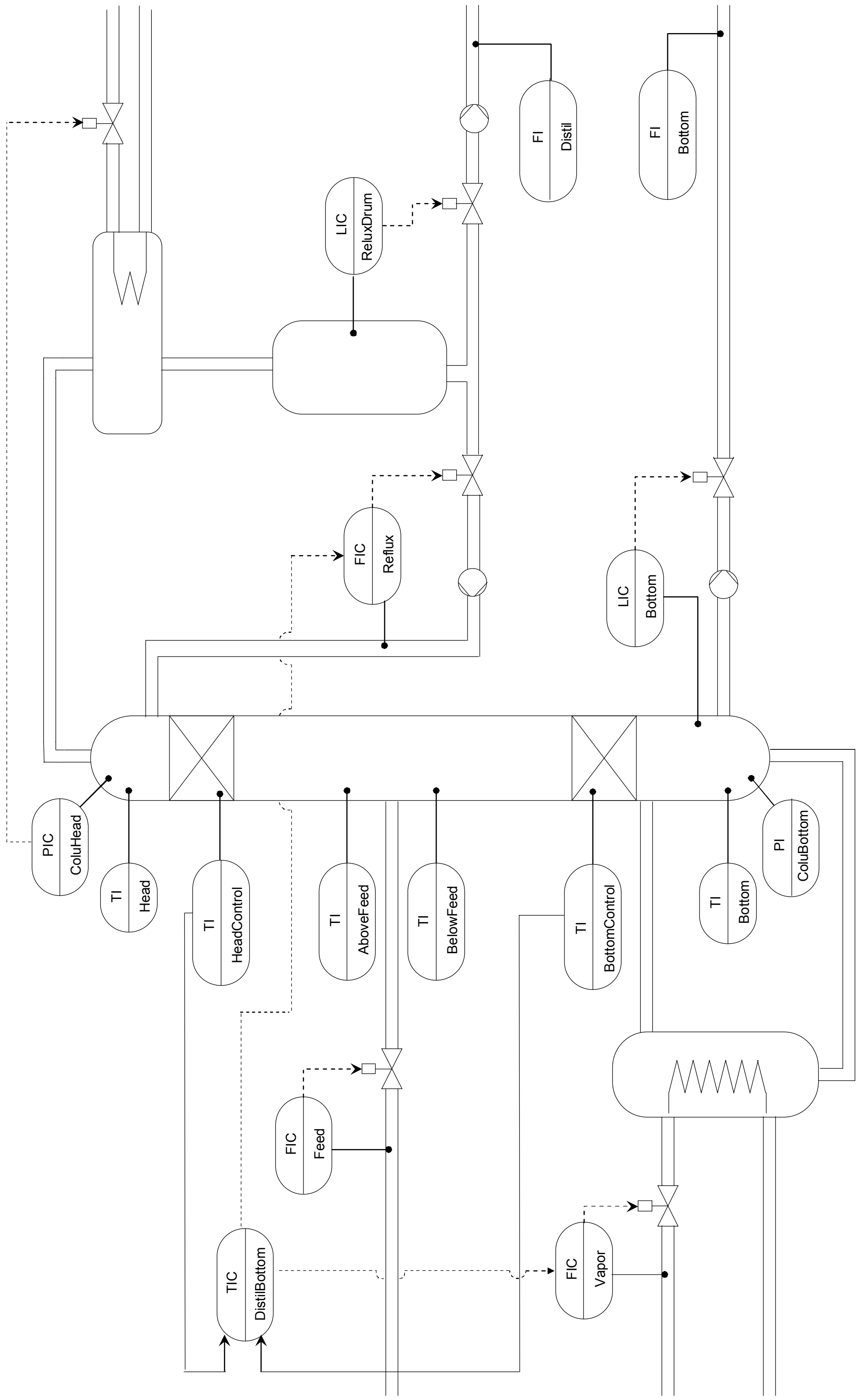
For controlling the distillation process an MPC multi-variable controller is used which controls the head and bottom temperature (see also chapter Temperature). These control variables are detected by the temperature process tags for head and bottom temperature. The controlled variables of the multi-variable controller are used as setpoint specifications for the underlying PID controllers.

Both level controls of the distillation column are fitted with standard PID controllers and work automatically.

2.2.4 Piping and instrumentation diagram

The figure below shows the individual components of a distillation column in the P&I (piping and instrumentation) diagram.

Figure 2-3



2.3 Used hardware and software components

The application is runnable as of SIMATIC PCS 7 V7.1 SP1. The following components are used for generating the application.

Hardware components

Table 2-1

Component	Note
SIMATIC PCS 7 ES/OS 547C BCE WXP	Used for the PCS 7 V7.1 SP1 sample project
SIMATIC PCS 7 ES/OS IPC547D W7	Used for the PCS 7 V8.0 SP1 sample project

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 2-2

Component	Note
SIMATIC PCS 7 V7.1 SP1	Component of SIMATIC PCS 7 ES/OS 547C BCE WXP
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 ES/OS 547C BCE WXP
PCS 7 Advanced Process Library V7.1 SP3	Component of SIMATIC PCS 7 V7.1 SP1
PCS 7 Advanced Process Library V8.0 SP1	Component of SIMATIC PCS 7 V8.0 SP1

Example files and projects

The following table contains all files and projects of this application document.

Table 2-3

Component	Note
48418663_DistillColumn _PCS7V711.zip	PCS 7 V7.1 SP1 sample project
48418663_DistillColumn _PCS7V7801.zip	PCS 7 V8.0 SP1 sample project
48418663_DistillColumn_en.pdf	This document

Note All procedures, descriptions and screenshots relevant for PCS 7 are based on the PCS 7 V7.1 SP1 and are applicable to the 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.

2.4 Performance data

The following performance data are relevant for selecting the controller and for operating the process visualization on the OS.

Application software

The performance data was determined in ProTime by entering all used blocks. Additionally, the cycle times of the flow charts were taken into account.

The following table shows the relevant basic performance data without basic CPU load and for selecting a CPU 416-3 PN/DP (6ES7416-3ER05-0AB0).

Table 2-4

Criterion	Program	Program + basic CPU load
Reaction time (t/ms)	CPU dependent	83
Buffer size (Mem/KB)	203	577
Programmable block communication (PBK)	64	89
Data block (DB)	113	113
Process objects (AS RT PO)	39	39

Note The listed basic performance data do not contain any CPU reserves and were calculated on the PCS 7 V7.1 SP1 project.

Visualization

The 55 process objects (OS RT PO) required for visualization were determined in ProTime.

Note The number of process objects is an average value valid for using the standard library of PCS 7. When using a different library (e.g. your own libraries) the required process objects and variables must be determined by yourself.

3 Basics

3.1 Process engineering

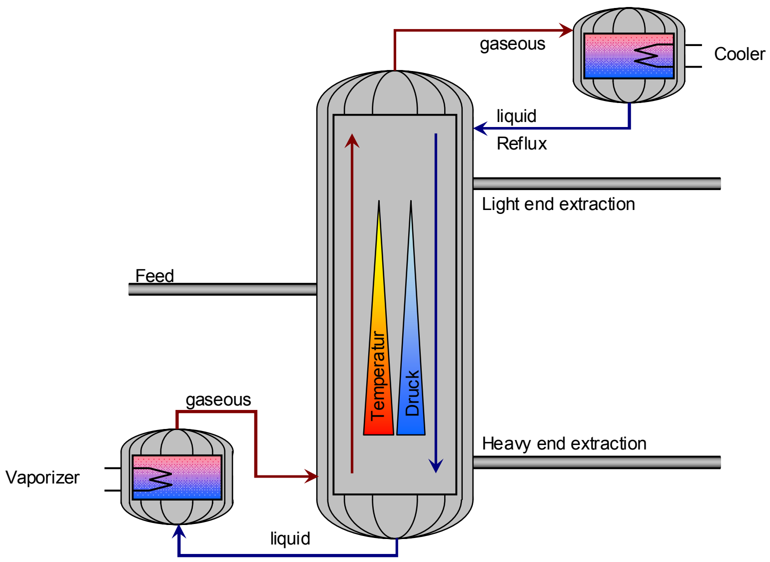
3.1.1 Distillation column (rectification column)

For distillation a multi-component mixture is divided into at least two streams using the different boiling temperatures of the components. The substance mixture (liquid) is fed into the column via a feed and vaporized at the bottom of the column.

The gas mixture rises up inside the column where the substance mixture slightly cools down and starts condensing. At the bottom of the column (bottom) the component with a higher boiling temperature (heavy end) accumulates and can be removed. At the head of the column the component with a lower temperature (light end) accumulates and can be removed there. The balance between the heavy end and light end fractions shifts across the entire column.

During rectification the gas mixture is fed back into the column via a reflux using a cooler. Opposing the ascending vapor, the reflux drips down over a number of trays where it is vaporized again. Rectification hence represents an expansion of the distillation process, or respectively a series connection of several distillation steps.

Figure 3-1



3.1.2 Temperature profile

The quality of a substrate separation is measured by the purity of the separation products, i.e. the concentration of light ends and heavy ends in the head and bottom extraction. Measuring these concentrations by means of online analyzers is extensive, so it is not performed in most of the plants. On the individual trays of the column there are thermo-dynamic correlations in the phase equilibrium (between vapor and liquid) and hence there is also a correlation between the concentrations and the temperatures.

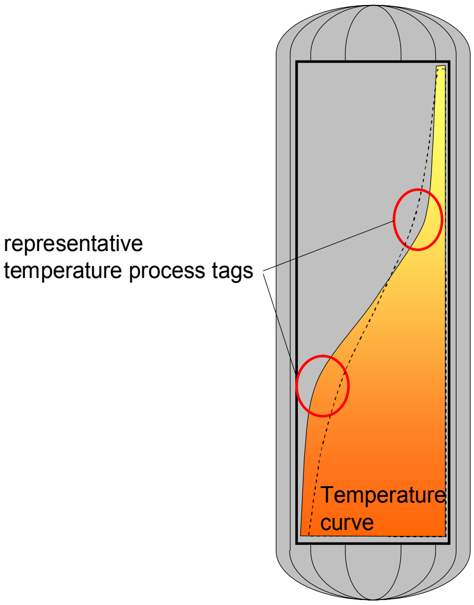
The easily measurable temperatures are used as substitutional controlled variables. The advantage is that the correlation between these temperatures and the control operations can be linearized more easily than the correlation between the concentrations.

In the process design for the column an “s”-type, a vertical temperature profile is established within the column, which leads to the desired concentration profile, hence to the desired purity of the products. Two temperature process tags representative for the control are placed in the reinforcement and output part of the column. The following points should be taken into account:

- The process tags should be located in those parts of the “s”-type profile with a significant temperature difference from tray to tray, so the process tags show a sensitive reaction to changes within the column (e.g. due to changes of the feed volume or the composition of the feed).
- The dead times for temperature control increase with the distance of the process tag to head and bottom.

The following figure shows the “s”-type temperature curve of a distillation column for two different temperature distributions.

Figure 3-2



3.2 Automation technology

3.2.1 The unit concept

The term “unit” stands for a unit in process plants (plant component, device, machines) including sensors, actuators and respective automation software, which in this composition of the components is often required. The unit as a “type” is used as a template for creating many, differently configured instances.

In process technology the so-called “package units” exist. 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 special hardware. The “package unit” is integrated as a whole into a process control system. The configuration of the control system does not require detailed knowledge of the automation of the “package unit”.

As opposed to the “package units” the automation solutions for process plants are unified in the unit concept, prefabricated and generated in form of templates which do not or only partially require a special hardware. The templates only need to be adjusted to the existing hardware and the special requirements. This clearly reduces the engineering expenses for several similar automation tasks.

Unit template

In a unit template, process tags are combined into an automation function. All blocks relevant for a process tag are interconnected in a CFC chart. For naming the process tag a uniform name convention was used.

Additionally, a unit template contains a CFC chart with economic and process engineering characteristics (Key Perdormance Indicators), a CFC chart for monitoring the operating time and CFC charts for simulation.

The unit template is summarized in a hierarchy folder and can be integrated into existing projects.

3.2.2 PLS engineering with templates

A process tag type (template) in a process control system is a unified template for creating signal flow charts which occur several times during plant automation. The signal flow charts (CFC: Continuous Function Chart) for many process tags of a similar type are created by forming instances of a process tag type and must then be configured and connected with the concrete measured and manipulated values. Configuration and interconnection of the process tag types can be automated using an import/export file.

A Unit Template in SIMATIC PCS 7 comprises all functions required for automating a unit:

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

All functions are summarized in a hierarchy folder of the technology view of the SIMATIC Manager.

3.2.3 KPI characteristics

KPI characteristics (Key Performance Indicator) are economic or process engineering parameters which describe the course of production, the degree of performance for certain requirements or the quality of a plant.

3.2.4 PID controller

The PID controller is an industrial standard controller used for a linear, continuous control (e.g. filling level control). A typical application is regulating a controlled variable (e.g. filling level of a vessel) by means of a manipulated variable (e.g. feed). The filling level (controlled variable) is here regulated to a predetermined setpoint value (manipulated variable) via the feed, while various volumes can also drain off through several outlets.

The series connection of PID controllers (cascading) enables improving the control results if apart from the main control variable a further intermediate variable can be measured. A master controller manipulates the main controlled variable, by defining setpoints for the subordinate slave controller which directly accesses the manipulated variable.

3.2.5 MPC controller

The MPC controller is a model predictive multi-variable controller (Model Predictive Control) for controlling complex, linear systems.

If there are several manipulated and controlled variables in a unit, which interfere with each other, a multi-variable controller clearly yields better control results. The aim of the control is to direct each controlled variable to the individual setpoint, independent of the other controlled variables. This is even more difficult since interfering with a manipulated variable does not only effect one controlled variable but also has an impact on other controlled variables.

A model predictive multi-variable controller additionally uses a complete mathematical description of the controlled system. This description enables the controller to calculate the process behavior over a defined period of time ("prediction horizon") without controller operation. An optimization algorithm is applied to find the most efficient manipulated variable strategy and the planned optimal trajectory is calculated. There are several options for formulating the optimization problem. Future control deviation, CV constraints and future MV moves are included in the performance index as well as economic targets.

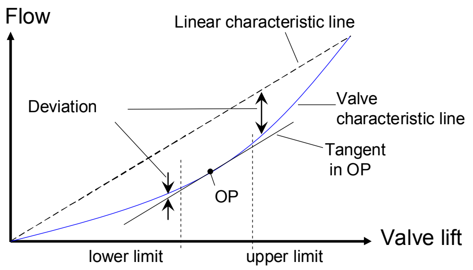
3.2.6 Linearization

Many components in industrial plants do not have linear characteristic curves. When 50% of the valves are controlled the characteristic curve of many valves does not yield a flow rate of 50% of the maximum value. The larger the deviation of the flow rate from the linear characteristic curve, the worse the control result of a linear controller. Since the design of a non-linear controller is more difficult than that of a linear controller, the characteristic curves are normally linearized.

Linearization in the operating point

For linearization in the operating point (OP) not the entire characteristic curve is viewed but only the part of the curve which lies in the vicinity of the defined operating point and which is required during normal operation. A tangent is placed in the operating point of the characteristic curve and the deviation of the tangent from the characteristic curve is viewed.

Figure 3-3



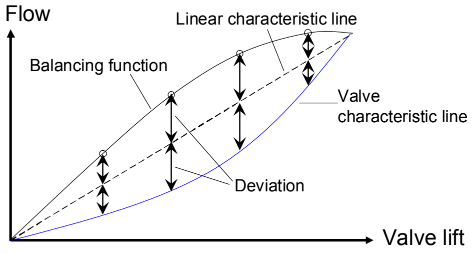
Using the tangent in the operating point the deviations between the actual non-linear characteristic curve and the assumed tangent are reduced to the extend that in most cases the control parameters need not be adjusted.

If a controller is designed for the operating range between lower and upper limit (operating range), the controller is then also only valid for this range. If several operating points of a characteristic curve are required, a controller can be designed for each operating point and, depending on the process value, the control parameters can be adjusted to the respective operating point.

Linearization with smoothing function

The linearization with a smoothing function is normally used if the operating range covers the largest part of the characteristic curve. For this linearization a polynomial is created which multiplied with the characteristic valve curve yields a linear function. The following graph shows how the smoothing function is determined mathematically or graphically.

Figure 3-4



4 Structure and Principle

4.1 Overview

4.1.1 Name convention of the CFC charts

A standard name convention was used for naming the process tags, with the function named after the European standard EN 62424. The following figure shows the composition of a process tag name.

Figure 4-1

FIC_Reflux

Function — Name

F = flow rate (first letter)
I = indicate (subsequent letter)
C = control (subsequent)

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

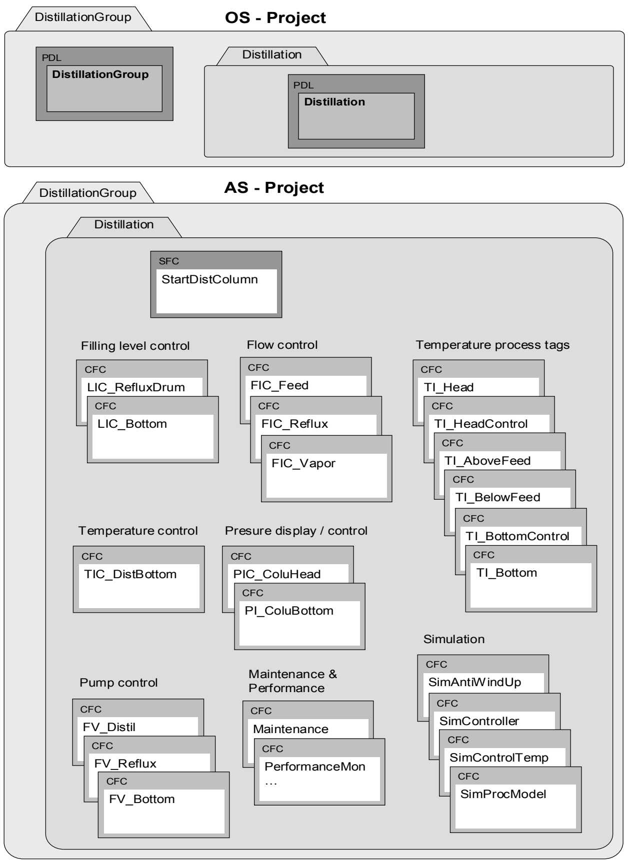
Table 4-1

First letter	
Letter	**Meaning**
F	Flow
L	Level
P	Pressure
T	Temperature
Subsequent letter	
I	Indication
C	Control
V	Valve (Regulator function)

4.1.2 Plant view

Unit template “Distillation column” is realized in the plant view in two hierarchy folders.
The first hierarchy folder of the OS project contains the overview picture “DistillationGroup.pdl” of the distillation column and a further hierarchy folder. The subordinate hierarchy folder contains the process picture. In the AS project the first hierarchy folder is empty and the subordinate hierarchy folder contains a sequential control (SFC chart) for starting the column as well as all of the required CFC charts.

Figure 4-2



4.2 Structure of process tag charts

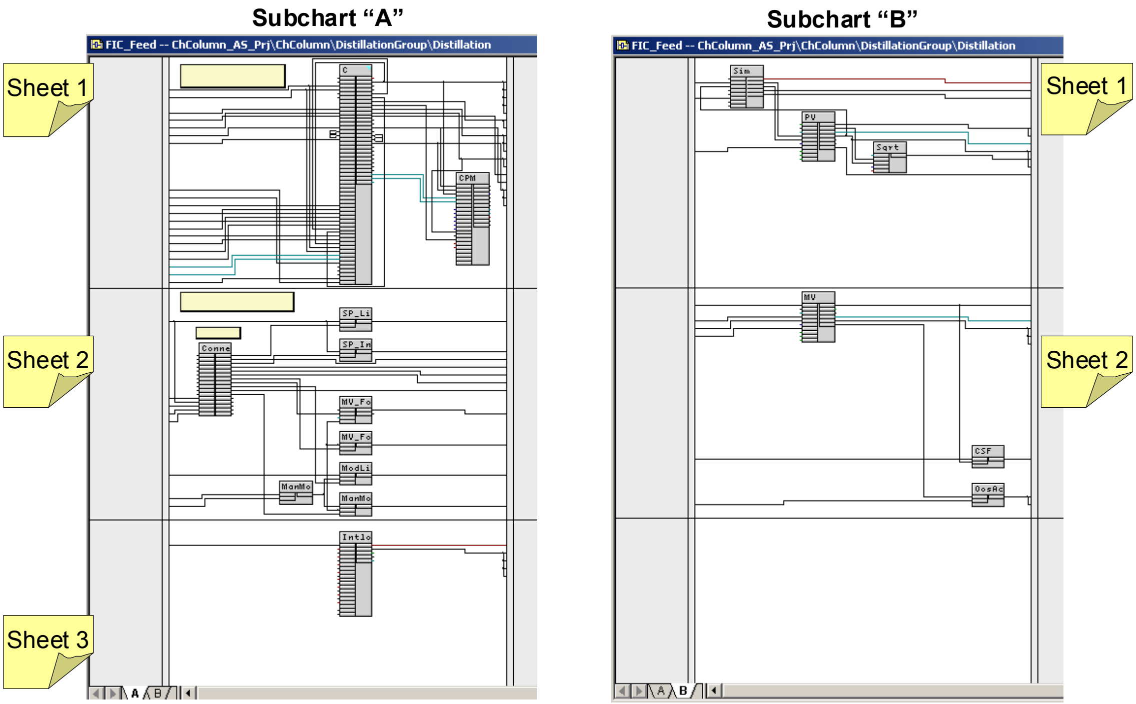
4.2.1 Charts “FIC_xxx”, “TIC_xxx”, “LIC_xxx”, “PIC_xxx”

The following process tags are structured according to the same principle:

- FIC_Feed
- FIC_Reflux
- FIC_Vapor
- LIC_Bottom
- LIC_RefluxDrum
- PIC_ColuHead

The following figure shows the CFC chart “FIC_Feed”:

Figure 4-3



Subchart A

In sheet 1 the PID controller “PIDConL” block (left block) is interconnected with the “ConPerMon” block (right block) used for permanent monitoring of the control performance.

Sheet 2 contains a block which is not contained in the APL or the standard library. This block provides an interface with SFC “StartDistColumn”, which simplifies the SFC connection. The logic blocks control the operating mode of the PID controller.

Sheet 3 contains the interlock block.

Subchart B

Sheet 1 contains the following blocks:

- PV ("Pcs7AnIn"): driver block for signal processing of an analog input value
- Sim ("SimAn"): simulation block
- Sqrt ("SwSqrt"): linearization block

At the "PV_In" input of the driver block the real process value must be interconnected. For more information, please refer to Table 5-3.

Sheet 2 contains the following blocks.

- Pcs7AnOu: driver block for signal processing of an analog output value
- Or04 block for the field device status and the process value validity

At the "PV_In" input of the driver block the real process value must be interconnected. For more information, please refer to Table 5-3.

4.2.2 "TI_xxx" charts

In subchart "A" the following CFC charts contain a "MonAnL" block for monitoring an analog process tag, and in subchart "B" the "Pcs7AnIn" block with a simulation block:

- TI_Head
- TI_HeadControl
- TI_AboveFeed
- TI_BelowFeed
- TI_BottomControl
- TI_Bottom

4.2.3 "FV_x" charts

The following CFC charts are structured according to the same principle:

- FV_Bottom
- FV_Distil
- FV_Reflux

Subchart A

Sheet 1 contains a motor block for controlling a pump motor and an operating hours counter.

Sheet 2 contains interlock and logic blocks for external modules of the pump (e.g. motor protection switch).

Subchart B

Sheet 1 contains a simulation block for external modules, a driver block for the "Feedback" input of the pump as well as the respective logic block.

Sheets 2 and 3 contain driver and logic blocks for external modules.

4.2.4 “TIC_DistBottom” chart

Sheet 1 contains the multi-variable controller and four logic blocks, which generate the logic for the status (quality code and service) of the controlled variable driver blocks.

Sheet 4 contains a block for each controlled variable for monitoring the control quality and a block for displaying the temperature deviation of the controlled variable from the setpoint.

Sheet 5 contains a logic block which, if necessary, suppresses the calculation of the control performance for the filling level control at the bottom.

4.3 “StartDistColumn” SFC chart

This SFC chart is necessary since all controls for the non-linear processes are linearized in the operating point and so they are not suitable for starting the plant. The following actions are configured in the SFC chart:

- Resetting the simulation
- Initialization of the controllers
- Initialization of the SFC connection
- Operating mode of the pumps to automatic mode
- Initialization of the “ConPerMon” block for monitoring the control performance
- Suppression of messages (MsgLock = 1) during the startup of the plant (only available in the PCS 7 V8.0 SP1 project)

After reaching the operating point of the distillation column, the “ConPerMon” blocks of the subsequent process tags are initialized after approx. 5 minutes with the SFC chart:

- FIC_Feed
- LIC_RefluxDrum
- LIC_Bottom
- PIC_ColuHead

Note

> The “ConPerMon” blocks of process tags “FIC_Reflux” and “FIC_Vapor” are not initialized due to the cascaded control.

4.4 Setup of the simulation

The simulation of the process runs in a time OB whose cycle time is 5 times slower than the cycle time of the template. Furthermore, the simulation model of the sample distillation column is adjusted so the time sequence is shortened in comparison to a real plant to receive a faster reaction to a manipulated value change (“fast motion”).

The simulation contained in the template consists of the following parts:

- Simulation in process tags “FIC_xxx”, “TI_xxx” and “PI_ColuBottom”
- Calculating the temperature values (CFC chart “SimControlTemp”)
- Integrations restriction (CFC chart “SimAntiWindUp”)
- Simulation of the process (CFC chart “SimProcModel”)
- Simulation of the transmission functions (CFC chart “SimController”)

Simulation in process tags “FIC_xxx”, “TI_xxx” and “PI_ColuBottom”

Process tags “FIC_xxx”, “TI_xxx” and “PI_ColuBottom” contain maximal two simulation blocks. The “Sim” block receives the simulated process value and also offers the possibility of scaling the process value. Scaling is not part of this template.

The “Sqrt” block calculates the square root from the process value and can be used as balancing function for squared process values. In this template the block is deactivated.

Calculating the temperature values (CFC chart “SimControlTemp”)

In CFC chart “SimControlTemp” the standardized temperatures of “TI_HeadControl” and “TI_BottomControl”, used in the simulation model are converted into degrees Celsius, so the values can be displayed in the process tags.

Integrations restriction (CFC chart “SimAntiWindUp”)

CFC chart “SimAntiWindUp” serves as integration restriction for integral transmission functions of the process model. This CFC chart is employed in CFC chart “SimProcModel” (chart in chart technology).

Simulation of the transmission function (CFC chart “SimController”)

CFC chart "SimController" simulates the transmission functions which prompt the PID controller to compensate. The transmission function consists of the following components:

- "Mul04" block to reinforce the transmission function
- "Lag" block to smooth the input variable after a delay time

Both blocks yield a PT1 transmission function. For simulating the pressure in the column head "PIC_ColuHead" an additional "NoiseGen" block was interconnected. This block creates a signal noise.

Simulation of the process (CFC "SimProcModel")

The process model is a 6x4 multi-variable system which simulates all mutually interfering input-output combinations in individual partial transmission functions. The simulation is designed for the operating point of the process.

The figure below shows the process model with the respective names.

Figure 4-4

General Model

		Inputs					
		u1	**u2**	**u3**	**u4**	**u5**	**u6**
Outputs	**y1**	$G_{1,1}$	$G_{1,2}$	$G_{1,3}$	$G_{1,4}$	$G_{1,5}$	$G_{1,6}$
	y2	$G_{2,1}$	$G_{2,2}$	$G_{2,3}$	$G_{2,4}$	$G_{2,5}$	$G_{2,6}$
	y3	$G_{3,1}$	$G_{3,2}$	$G_{3,3}$	$G_{3,4}$	$G_{3,5}$	$G_{3,6}$
	y4	$G_{4,1}$	$G_{4,2}$	$G_{4,3}$	$G_{4,4}$	$G_{4,5}$	$G_{4,6}$

Process Model (with name in the CFC chart)

		Reflux	Vapor	Distill. Flow	Bottom Flow	Flow Inlet	Concentr. Inlet
		L	**V**	**D**	**B**	**F**	**zF**
Concentr.Distillation	**xD**	y1u1	y1u2	y1u3	y1u4	y1u5	y1u6
Concentr.Bottom	**xB**	y2u1	y2u2	y2u3	y2u4	y2u5	y2u6
Level Distillation	**mD**	y3u1	y3u2	y3u3	---	---	---
Level Bottom	**mB**	y4u1	y4u2	---	y4u4	y4u5	---

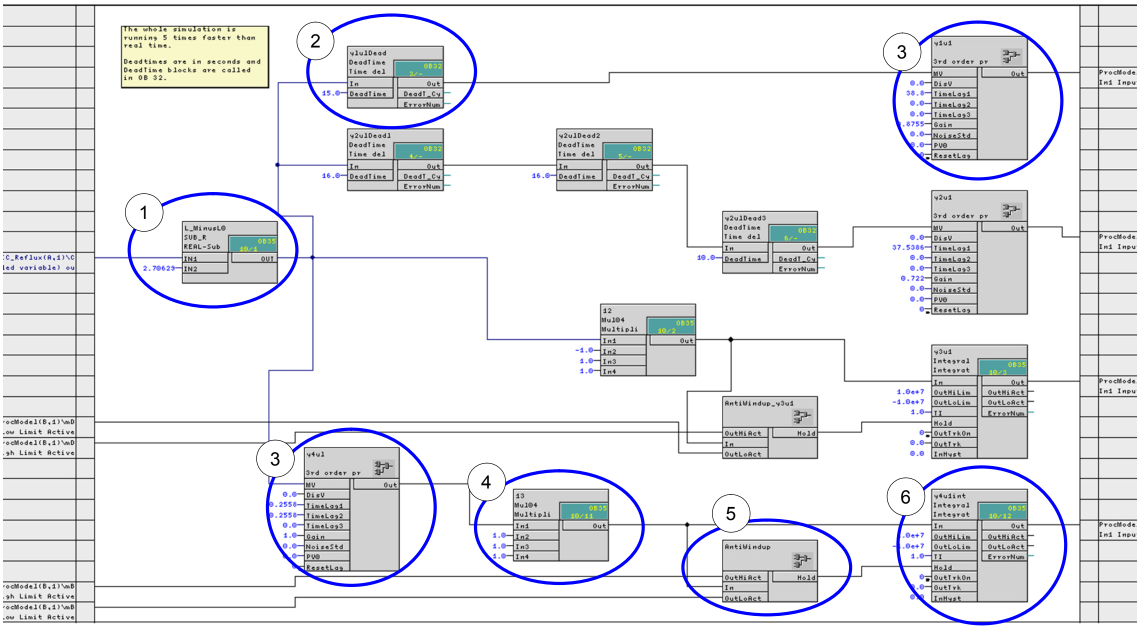
The process model is in CFC chart "SimProcModel" divided into two subcharts.

Subchart A

Subchart "A" contains partial transmission functions of an input signal which influence defined output signals (Figure 4-4). All partial transmission functions are structured according to the same principle where unnecessary function components do not exist.

The following figure shows sheet 1, which contains the influences of the input signal "Reflux" (L) on all output signals.

Figure 4-5



A partial transmission function may contain up to six components which are illustrated in a partial transmission function with PT behavior “y1u1” (components 1, 2, 3) and a partial transmission function with IT behavior “y4u1” (components 1, 3, 4, 5, 6).

The following components can be contained in a partial transmission function:

1. **Deviation from the operating point**
   At this block the operating point of the input is specified and the difference to it is calculated. Some input values are standardized beforehand in order to facilitate the calculation with various physical variables.
2. **Dead time**
   Specifies the dead time of the partial transmission function.
3. **PT transmission function** (chart in chart)
   Three delay elements and one reinforcement element are connected in succession. Additionally a noise can be added to the output signal.
4. **Sign**
   Determines the sign of the integrator.
5. **Delimiting the integration (“SimAntiWindUp” as chart in chart)**
   The input signal for the integrator is previously checked for exceeding or falling short of the limits and, if necessary, the integration of the output value is stopped (output signal).
6. **Integrator**
   The integrators are used for filling level simulations.

Subchart B

In subchart “B” the output signals are calculated from all intermediate values of the individual inputs. First all influences of the inputs are added up to one output. The output can be limited depending on the defined ranges. Subsequently, the standardization of the outputs (only for filling levels) is cancelled.

5 Configuration and Settings

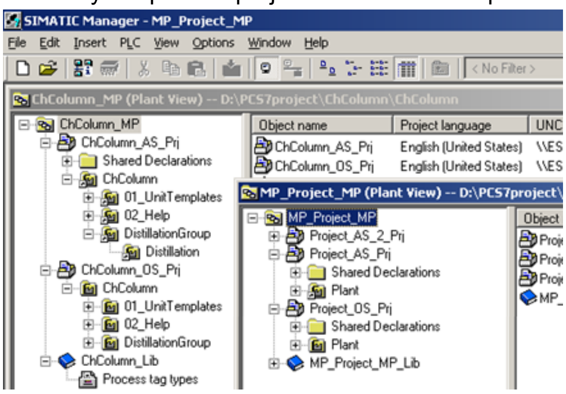
5.1 Using the sample solution

Preparation

The following instructions contain the integration of the unit template into a PCS 7 project in which the following steps are completed:

- Adjusting HW Config
- Configuring the communication between AS and OS (NetPro)
- Settings at the hierarchy folders

Table 5-1

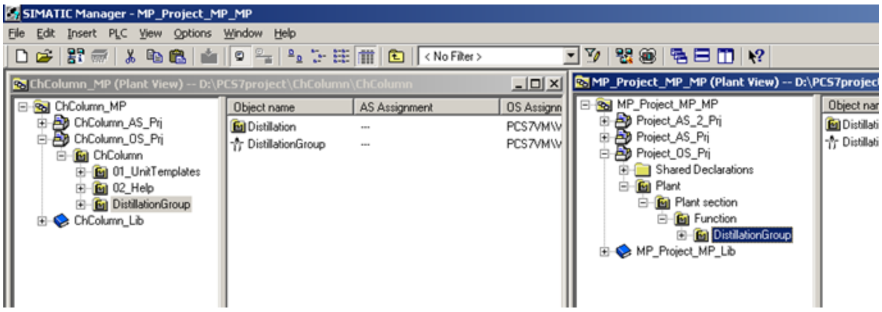
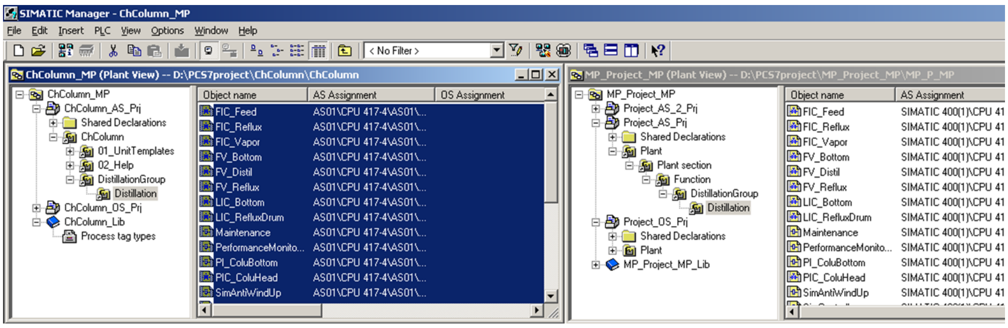
No.	
1.	Copying the “48418663_DistillColumn _PCS7V711.zip” file to the configuration computer and subsequently opening the SIMATIC Manager.
2.	Click “File > Retrieve” and select the “48418663_DistillColumn _PCS7V711.zip” file. Then confirm by clicking “Open”.
3.	Select the folder in which the project 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 the Plant View
6.	Parallel you open the project in which the template is to be integrated. 

Integration of the unit template

The following instruction describes how you can integrate the unit template 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 unit template to your process.

The opened unit template and the opened target project in the Plant view are required.

Table 5-2

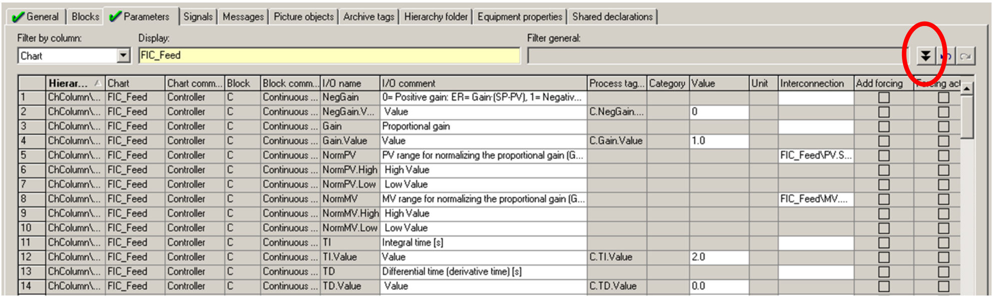
No.	Action
1.	In the plant view of the unit template in the OS project you select the hierarchy folder “ChColumn > DistillationGroup” and click on “Edit> Copy”.
2.	Go to the target project. In the OS project you select the hierarchy folder to which the distillation column is added and then click “Edit > Paste” in the menu bar. The hierarchy structure with the overview picture and the process picture is copied. 
3.	In the target project you select the OS project and in the menu bar you click on “Options > Plant View > Update in the Multiproject”. The dialog for exporting the Plant Hierarchy appears.
4.	Acknowledge the dialog with “OK” and also confirm the following dialog with “OK”. The plant hierarchy is adjusted in all AS projects of the target project.
5.	Go to the unit template and click the hierarchy folder “ChColumn > DistillationGroup > Distillation” in the AS project of the tree view.
6.	In the menu bar you click “Edit > Select all” and then click on “Edit > Copy”.
7.	Go to the target project. In the tree view of the AS project you select the hierarchy folder “DistillationGroup > Distillation” and in the menu bar you click “Edit > Paste”.  **Note:** All charts of the unit template and the simulation are copied.
8.	Compile the AS project and then the OS project.

Adjust the parameters of the unit template

The following instruction shows how to configure the entire unit template. For the operability of the simulation no settings need to be made.

The opened target project is a prerequisite.

Table 5-3

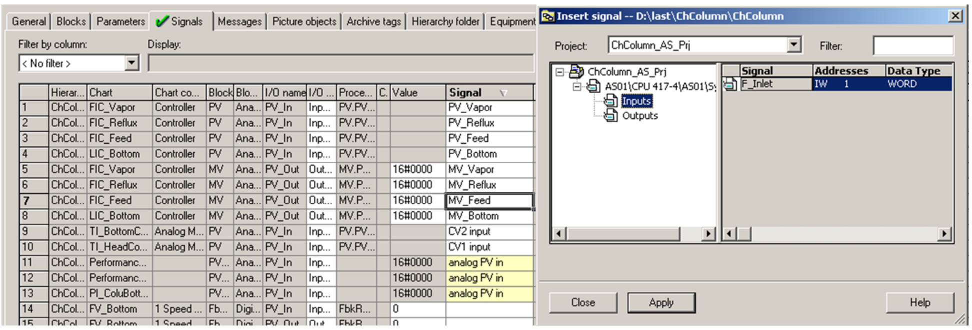
No.	Action
1.	Go to the process object view and click on the “Parameter” tab.
2.	In the dropdown menu you select the “Filter by column” entry and enter the chart name (e.g. FIC_Feed) into the “Display” input field. **Note:** The button with the double arrow pointing down, next to the deactivated input field “Filter general” opens a second filter. With this filter you can, for example, filter for all connections in the “I/O name” column containing “PV” which have an impact on the process value. 
3.	Click into the “Value” column of the block connection you wish to change and enter the new value. Acknowledge the input with the input button.

Interconnect the unit template

The opened target project is a prerequisite.

Table 5-4

No.	Action
1.	Open the "Signals" tab in the process object view.
2.	Right-click the "Signal" column of the signal you wish to interconnect and select the "Insert signal" command. **Note:** This column already contains the most important signals.
3.	In the dialog you open the folder structure and subsequently click on “Inputs” or “Outputs”.

No.	Action
4.	In the Details view you select the signal you wish to interconnect and click on the “Apply” button.  **Note:** If you wish to interconnect several signals, then click on a further signal in the process object view and repeat this step.
5.	Click on the “Close” button to close the dialog.

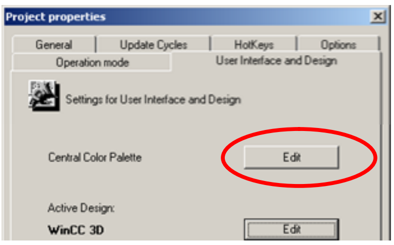
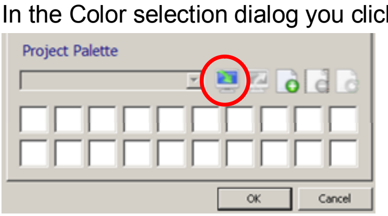
Integrating the central color palette of the unit template into the OS

The process picture of the unit template uses colors from the central project 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), vapor (red, position 11), medium (violet, position 12), text frame (gray, position 15) and frame font: (gray, position 16) are defined in the project palette.

The opened target project is a prerequisite.

Table 5-5

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. 

No.	Action
6.	In the file selection dialog you select “DistillColumn.xml” from the <Projektpfad>\ChColumn\ChColu_2\wincproj\OS\GraCS \DistillColumn.xml> path and acknowledge with “Open”. **Note:** The unit template uses colors 10 to 16 of the project palette in the process picture. If you are already using these positions, cancel the import of the color palette and change the colors of the pipes in the process picture.
7.	In the message you click “Yes”, in order to overwrite the existing color palette and then close the Color selection and the Project properties dialog with “OK”.

5.2 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 system. The following instruction describes the general procedure at the example of the PID controller in the CFC chart “FIC_Feed”.

Note

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

Prerequisites

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

ATTENTION

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

To receive an optimal result, perform the controller optimization between the minimal and maximal manipulated values of the respective parameters (for FIC_Feed: 15-25).

Continuously monitor the process at the curve plotter during optimization.

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 picture 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 the steps 1 to 5. If an enable on the OS was granted, start with step 1 of Table 5-7.

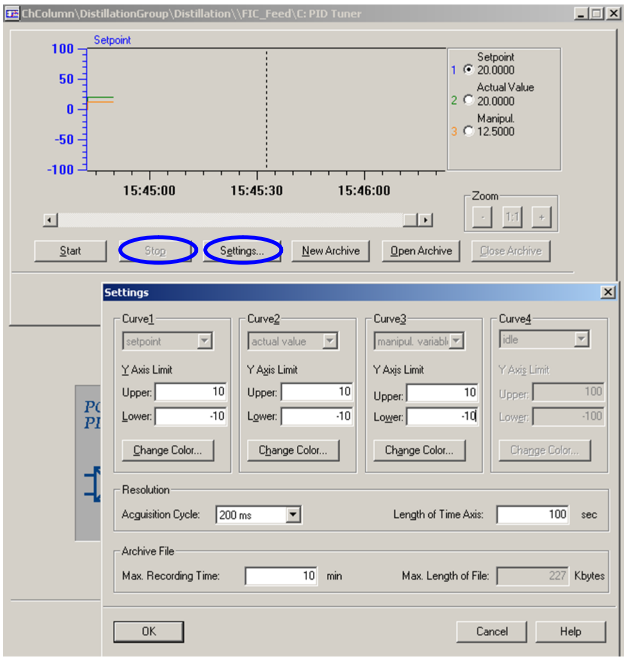
Table 5-6

No.	Action
1.	Open the PCS 7 project in the Plant View.
2.	Open the hierarchy folder “ChColumn > DistillationGroup > Distillation” and double-click on the “FIC_Feed” 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” in sheet 1 of the CFC chart 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 system with PT behavior.

Table 5-7

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 click the “Settings” button. 
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 you click the radio button “without integral action in the process” and then click on “Next”.
7.	In the “Operating mode” group you select the checkbox “Automatic”. 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.

No.	Action
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.

5.3 Configuration of the MPC controller

Preparations

The basis for the controller design are step responses recorded in manual controller mode and displayed in trend curves. These trend curves show all excited manipulated variables and all controlled variables. The excitement of the controlled variables starts in the operating point and contains a step to the upper limit value and to the lower limit value (linearization in the operating point) of the typical manipulated range for the plant operation. Each change of the manipulated variable is only performed after the system has reached a steady state. The same procedure can be used for measurable disturbance variables. These can be taken into account in the controller design.

Additionally trend curves for verifying the controller design can also be evaluated.

The required tend curves can be created in the CFC trend display and be exported.

Further information is available in the Help of the MPC configurator in “The individual design steps in detail > Recording the measurement series”.

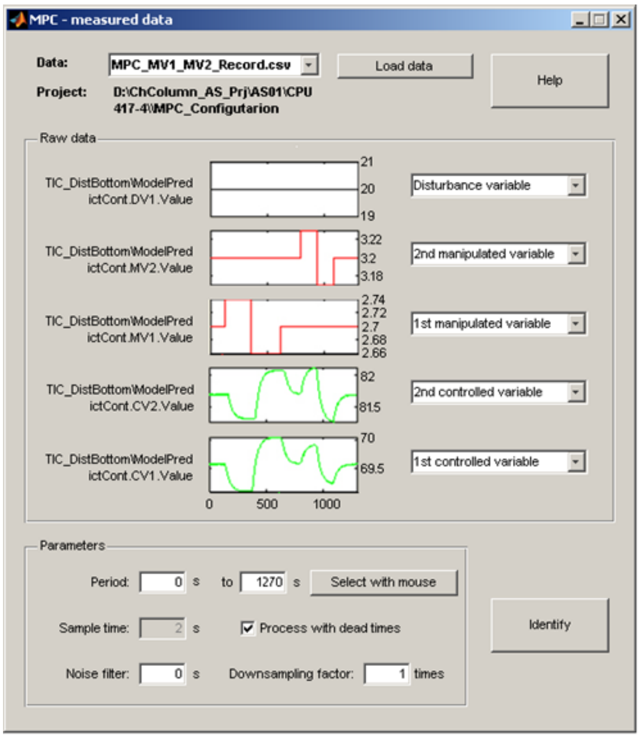
Note A detailed description is available in the application example “Model Predictive Control including integral transfer functions”.

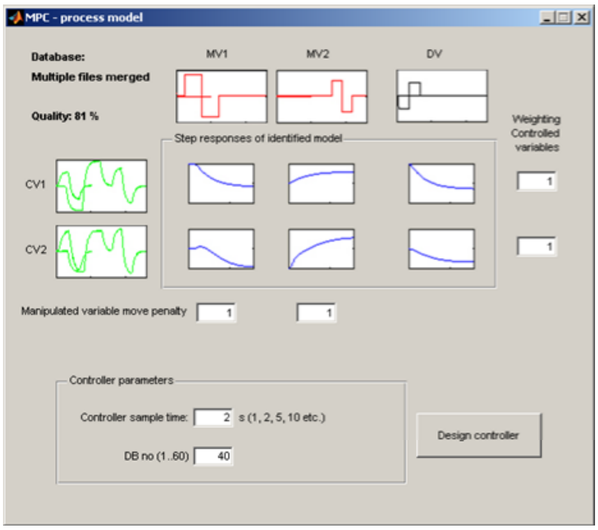
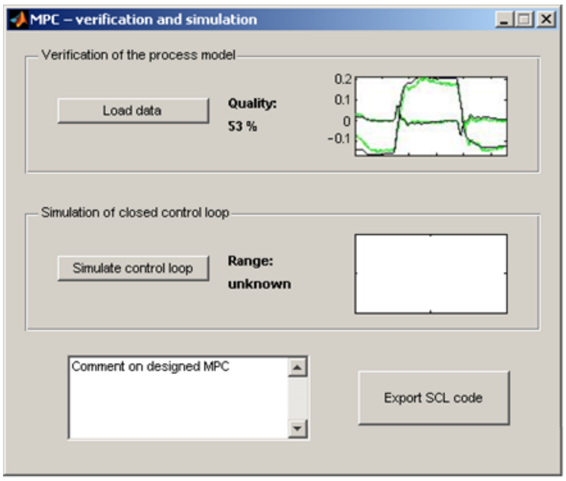
ATTENTION **Coordinating the MPC controller requires intervention into the process!**

Before the process intervention, please check the effects this intervention might have and inform the respective staff.

System identification

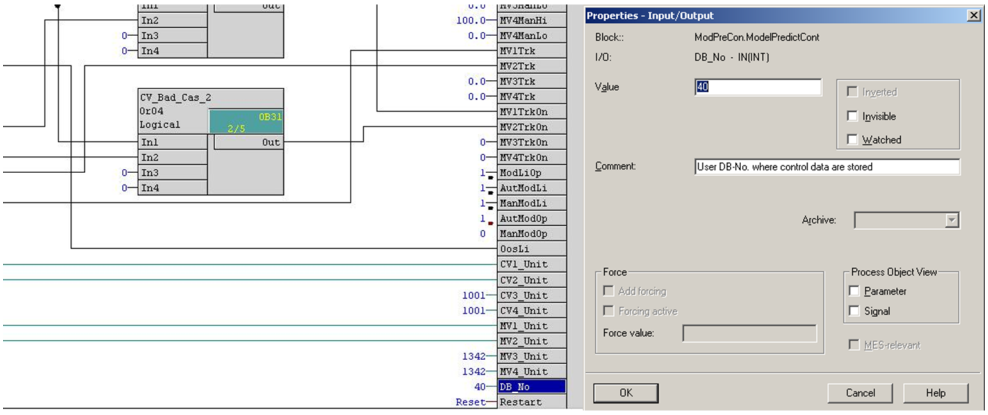
Table 5-8

No.	Action
1.	Open the PCS 7 project in the Plant View.
2.	Open the hierarchy folder “ChColumn > DistillationGroup > Distillation” and double-click on the “TIC_DistBottom” chart. The CFC editor is opened.
3.	Select the “ModelPredictCont” block and click on “Edit > Configure MPC” in the menu bar. The MCP configurator opens.
4.	Click the “Load data” button and select the file with the exported trend curves. Confirm your selection with “OK”. The selected trend curves are loaded to the “Raw data” group. **Note:** Click on the “Help” button to receive detailed information on the functioning of the MPC configurator.
5.	In the drop-down list on the right next to the trend display you select the represented signal and activate the “Process with dead times” checkbox.  Then click on the “Identify” button. The “MPC process model” dialog box opens. **Note:** In the “Parameters” group a period of time can be defined.
6.	Repeat steps 4 and 5 for the trend curve of the disturbance variable.

No.	Action
7.	In the “Parameters” group you enter the sample time (the OB cycle time, in which the controller is called up) and the DB number for the process model.  Then click on the “Design controller” button. The “MPC – verification and simulation” dialog box opens. **Note:** In the top left corner of the “MPC – process model” dialog the quality of the trend curve is displayed. The quality for a controller design should be larger than 50%.
8.	In the “Verification of the process model” group you click on the “Load data” button and select the file with the verification data in the opened file selection dialog. The verification is started and the quality of the process model is displayed. 
9.	Click the “Simulate control loop” button to check the value range. Subsequently, the result between button and trend display is evaluated and can also be viewed by clicking the trend display.
10.	Click on the “Export SCL code” button and select the folder for saving the SCL source in the subsequent file selection dialog. Enter a name for the file and click “Save”.
11.	Confirm the message with “OK” and close all dialogs of the MPC configurator and the CFC chart.
12.	Save the Session memory of the MPC configurator by right-clicking on the background of the operator user interface.

Process model introduced to the block

Table 5-9

No.	Action
1.	Go to the components view of the project.
2.	Right-click on “ChColumn_AS_Prj > AS01 > CPU 417-4 > AS01 > Sources” and select “Insert New Object > External Source…”.
3.	Select the previously created SCL source and click “Open”. The SCL source is imported.
4.	Double-click the SCL source and click on “File > Compile” in the menu bar of the opened SCL editor. Then close the SCL editor. **Note:** In the first line of the source code you see the DB number of the created block. **Attention:** If a data block with DB number exists, you receive a message whether you wish to overwrite the data block. Only overwrite data blocks whose function you know exactly. If in doubt cancel the compilation process and change the DB number of the first line into a not yet assigned DB number. The MPC function block must be called in the suitable watchdog interrupt OB. The cycle time of the OB and the specified time “OB-Timing” in the header of the SCL source must be identical.
5.	Right-click on “ChColumn_AS_Prj > AS01 > CPU 417-4 > AS01 >Charts” and double-click on the “TIC_DistBottom” chart which contains the MPC controller.
6.	Double-click on the “DB_No” input and change the value in the connection properties to the number of the previously created data block. 

Note

The process model is updated at the next compilation and download of the controller.

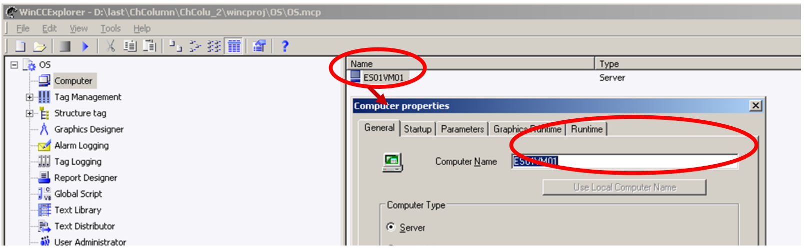
If the control program has already been downloaded, the DB number can also be changed online. The DB must be loaded to the controller and the “Restart” input be set to “Reset” online. After restarting the controller jumps of the manipulated variable may occur.

6 Starting the Unit Template

6.1 Preparation

The following instruction describes the commissioning of the unit template 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 6-1

No.	Action
1.	Copy the “48418663_DistillColumn _PCS7V711.zip” file to any folder on the configuration computer and subsequently opening the SIMATIC Manager.
2.	Click “File > Retrieve” and select the “48418663_DistillColumn _PCS7V711.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 “ChColumn_OS_Prj > PCS7VM > 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 “Use Local Computer Name”. Acknowledge the “Change computer name” message with “OK”. 
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 for PCS 7 V8:** Please double-click on the "Tag Management". Please right-click in the “WinCC Configuration Studio” on “SIMATIC S7 Protocol Suite > Industrial Ethernet” and select the menu command “System Parameter”.
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. **Note for PCS 7 V8:** If a connection between the OS and AS can't be established (gray block icons), please select the "Logical device name" "CP_H1_1" and restart the OS.

6.2 Commissioning

The following instruction shows how the unit template is set to initialization mode. The project contains a SFC chart where all the important settings are configured so the plant reaches the operating point.

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

Start simulation (S7-PLCSIM)

To start the simulation, proceed according to the instruction:

Table 6-2

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 “ChColumn.plc” file from the path <project path>\ChColumn\ChCo_Prj\ ChColumn.plc>
4.	Select “Execute > Key position switch > RUN-P” from the menu.
5.	Go to the components view of the SIMATIC Manager and select “ChColumn_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”.

Note

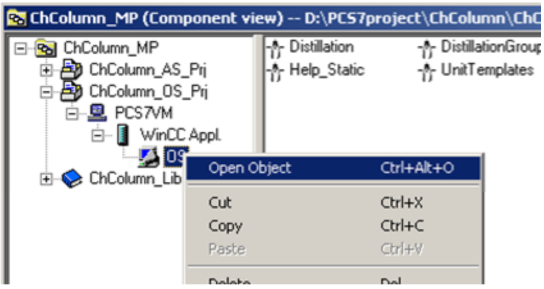
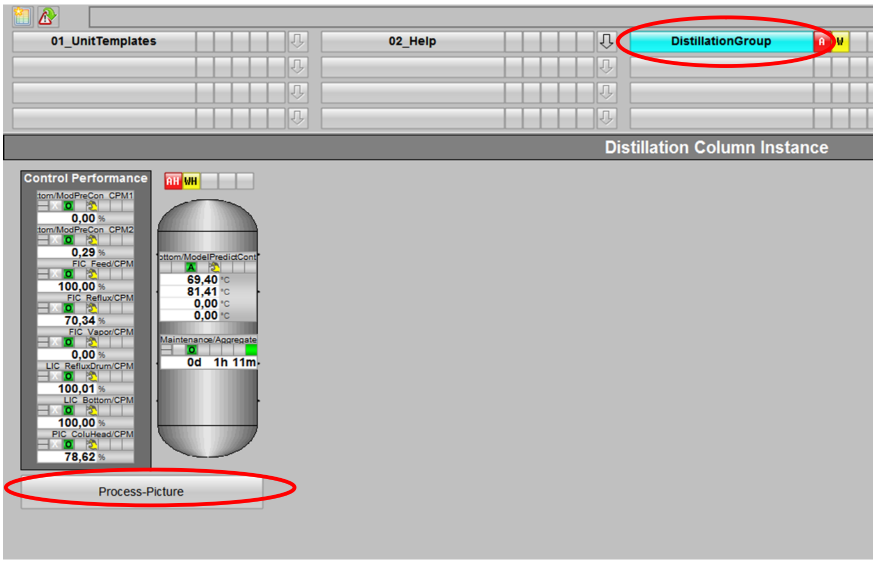
During the startup behavior of the distillation column simulation the focus was not on a correct startup of the column with regards to process engineering since this is very plant-specific. The startup control in the unit template is therefore not suitable for starting up a real plant.

The startup of the column simulation takes approx. 6 minutes until the plant has reached the operating point.

Activating OS (WinCC Runtime)

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

Table 6-3

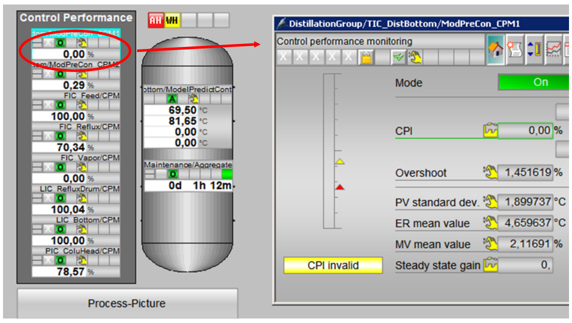
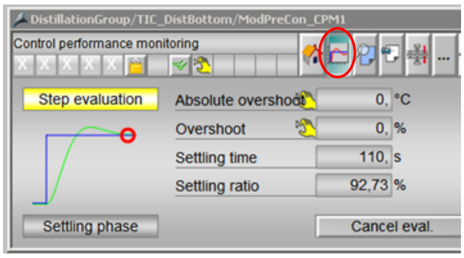
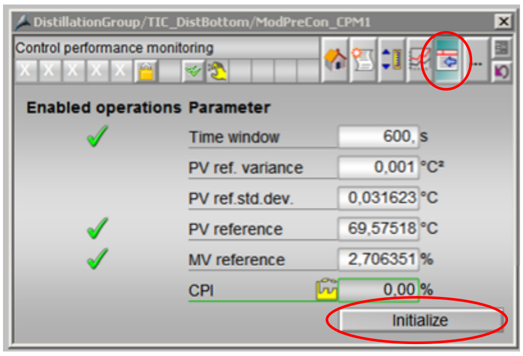
No.	Action
1.	Make a right mouse click on the OS and select the “Open Object” menu. 
2.	To activate the OS (WinCC Runtime), select “File > Activate” in the WinCC Explorer menu.
3.	In the “System Login” dialog you enter the user “Unit” as a “Login” and the password “Template” and acknowledge with “OK”.
4.	In the picture section you click on the entry “DistillationGroup” and then click on the “Process-Picture” button. 

Initialization of the control performance monitoring

The initialization of the control performance monitoring ("ConPerMon" blocks) of the multi-variable controller is possible approx. 15 minutes after starting the CPU.

For initialization of the control performance monitoring you proceed according to the following instruction:

Table 6-4

No.	Action
1.	In the picture section of the OS you click the entry "DistillationGroup". The overview picture is displayed.
2.	In the overview picture you click on block icon "ModPreCon_CPM1". The respective block is opened.  **Note:** In the faceplate the operator receives the information "CPI invalid".
3.	Go to the setpoint menu and wait until the evaluation has been completed.  **Note:** The initialization process can only be started after a completed evaluation.
4.	Go to the parameter menu and press the "Initialize" button. 
5.	Repeat steps 2 to 4 for block icon "ModPreCon_CPM2".

7 Operation of the Application

7.1 Overview

Via the process picture all components of the distillation column can be operated and monitored. The following two scenarios are restricted to the two parameters which are mainly relevant for operating a distillation column and the operation of the multi-variable controller for compensating disturbing influences.

- Scenario A: changing the feed volume
- Scenario B: changing the feed concentration

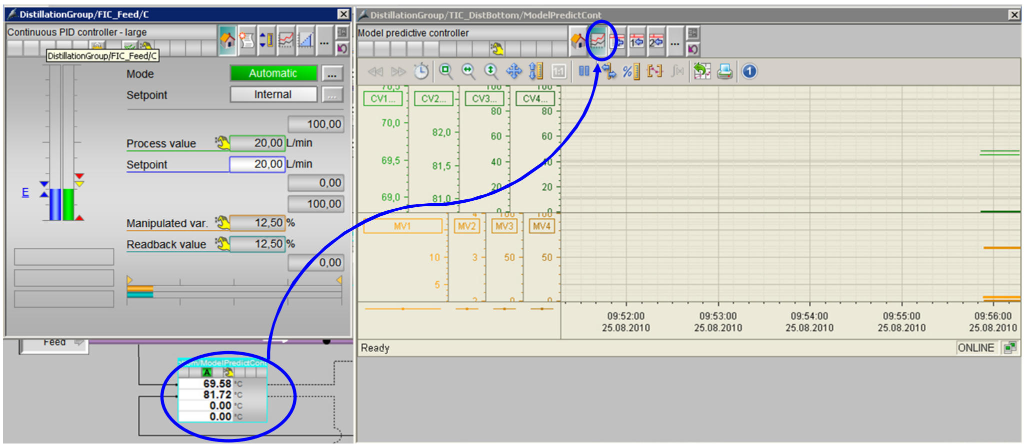
In both scenarios one respective parameter is changed which works as disturbance variable for the controller.

7.2 Scenario A: changing the feed volume

Description

In a stable state the distillation column the feed volume and the feed concentration determine the extracted volume of the head or bottom product. In this scenario the concentration of the light end in the fed substance mixture is constant and the feed volume is increased from 20 L/min to 23 L/min (+15%). The feed volume is detected as disturbance variable by the controller (DV1 input) and the effect of the disturbance variable is known in the process model.

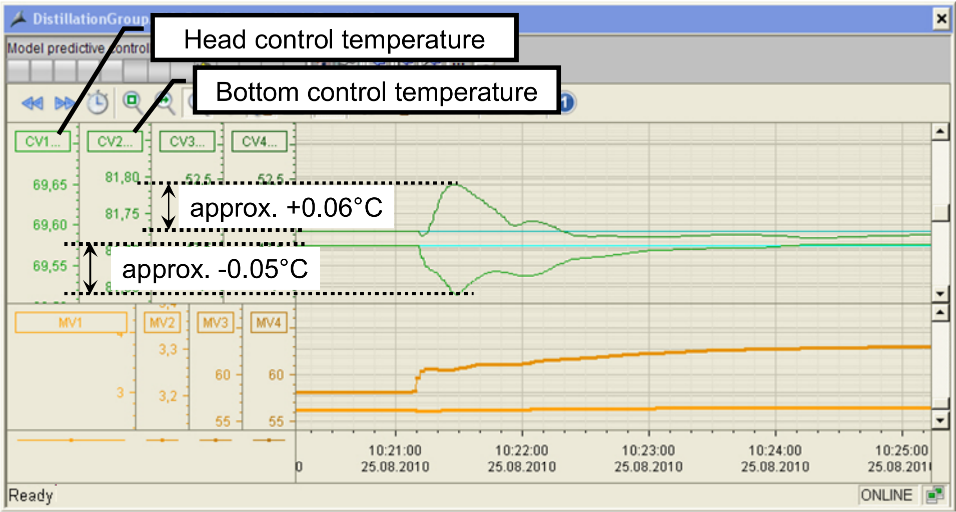
Table 7-1

No.	Action
1.	Click on the block icon of the “ModelPredictCont” block and click on the trend icon in the menu bar of the faceplate.
2.	Click on the block icon of “FIC_Feed” also in order to open its faceplate. Align the windows for a clear overview. 
3.	Click on the input field “Setpoint” in the “FIC_Feed” block and enter value“23” in the input field of the expansion. Acknowledge the input with the Enter key and click on the “OK” button. The setpoint value for the feed is adopted and the multi-variable controller starts controlling the detected disturbance variable.
4.	Wait approx. 4 minutes and click on the “Start/Stop” icon to evaluate the control result.

Evaluation

The figure below shows the trend curve of the multi-variable controller.

Figure 7-1



The low deviation of approx. 0.06°C shows a good control result, which is explained by the detected disturbance value and the known influence of the disturbance value to the controller. The controller can immediately react to the changed disturbance variable with the required operations and needs not wait for changes of the controlled variable.

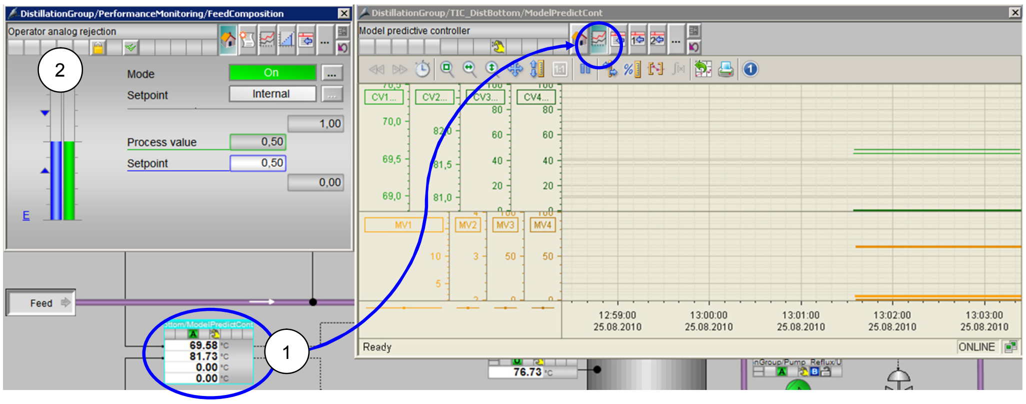
7.3 Scenario B: changing the feed concentration

Description

In a stable state of the distillation column the feed volume and the feed concentration determine the extracted volume of the head or bottom product. In this scenario the feed volume is constant and the concentration of the light end in the fed substance mixture is reduced from 0.5 to 0.4 (-20%).

The concentration of the light end in the fed substance mixture is an unknown disturbance variable for the controller which is not detected in the model.

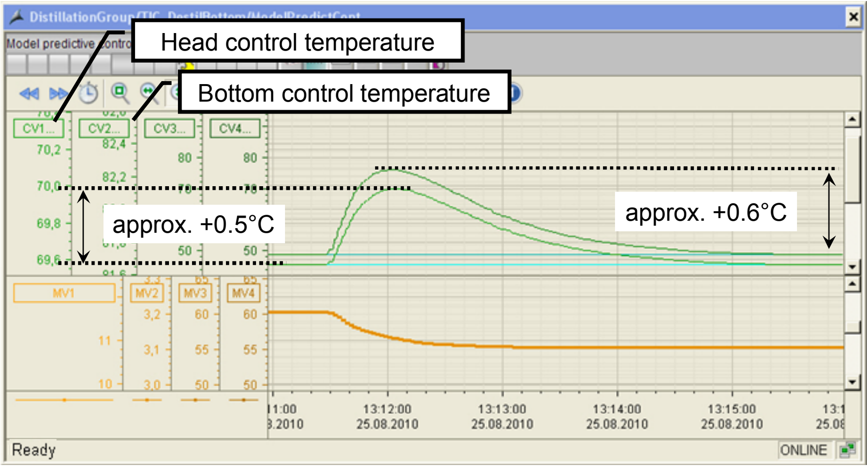
Table 7-2

No.	Action
1.	Click on the block icon of “ModelPredictCont” and click on the trend icon in the menu bar of the faceplate.
2.	Click on the block icon of “FeedComposition” also in order to open its faceplate. Align the windows for a clear overview. 
3.	Click on the input field “Setpoint” in the faceplate of “FeedComposition” and enter value “0.4” in the input field of the expansion. Then acknowledge the input with the “Enter” key and click on the “OK” button. The setpoint for the concentration of the light end in the fed substance mixture is adopted and the multi-variable controller starts compensating the disturbance variable.
4.	Wait approx. 4 minutes and click on the “Start/Stop” icon to evaluate the control result.

Evaluation

The figure below shows the trend curve of the multi-variable controller.

Figure 7-2



The low deviation of 0.6°C shows a good control result since the size and effect of the disturbance variable is not known to the controller and the controller can only react to changes of the controlled variables.

8 Links & Literature

Literature

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

Table 8-1

	Topic	Title
/1/	STEP7	Automating with STEP7 in STL and SCL Hans Berger Wiley-VCH ISBN 3895782955

Internet links

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

Table 8-2

	Topic	Title
\1\	Reference to this entry	http://support.automation.siemens.com/WW/view/en/48418663
\2\	Siemens Industry Online Support	http://support.automation.siemens.com
\3\	SIMATIC PCS 7 Overview – Landing Page	http://support.automation.siemens.com/WW/view/en/63481413
\4\	PCS 7 V8.0 SP 1 Manual Collection	http://support.automation.siemens.com/WW/view/en/71178283
\5\	Application for model-based predicative control	http://support.automation.siemens.com/WW/view/en/42200753
\6\	Controller optimization with PID tuner	http://support.automation.siemens.com/WW/view/en/8031495
\7\	SIMATIC Process Control System PCS 7 Compendium Part A – Configuration Guidelines	http://support.automation.siemens.com/WW/view/en/63187279
\8\	SIMATIC Process control system PCS 7 Compendium Part C – Technical functions with SFC types	http://support.automation.siemens.com/WW/view/en/63187297
\9\	ProTime PCS 7 – the configuration tool for SIMATIC PCS 7	https://www.automation.siemens.com/mcms/process-control-systems/en/distributed-control-system-simatic-pcs-7/supply-tool/Pages/protime.aspx
\10\	SIMATIC Process Control System PCS 7 Advanced Process Library (V8.0 SP1)	http://support.automation.siemens.com/WW/view/en/68154793

9 History

Table 9-1

Version	Date	Changes
V1.0	11.02.2011	First issue
V1.1	04.06.2013	Valid for PCS V7.1 SP1 and PCS 7 V8.0 SP1, new links added, minor changes in the description

Appendix

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.

No.	MODUS	Scale	IN	QUALITY	OUT
1.	<1 >2	all	all	all	OUT = IN
2.	all	all	all	16#48 16#60	OUT = IN
3.	1 or 2	Scale.Low < Scale.High	all	all	OUT = IN
4.	1	Scale.Low < Scale.High	IN <= Scale.Low Oder IN < 0	<> 16#48 <> 16#60	OUT = *SQRT*^{*1}*
5.	1	Scale.Low < Scale.High	IN > 0	<> 16#48 <> 16#60	OUT = *SQRT*^{*2}*
6.	2	Scale.Low < Scale.High	IN < 0 or *SUP**	<> 16#48 <> 16#60	OUT =0
7.	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

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

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

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

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.

Input (**X** = 1…8)	**Data type**	**Default value**	**Description** (**X** = 1…8)
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

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**

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

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 ->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 for further functions

Outputs

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**