Compact Workstation
C41025

FESTO

Operating manual
MPS® PA

Basic

With CD-Rom

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1 General requirements for operating the devices

General requirements for safe operation of the devices:

- National regulations for operating electrical systems and equipment must be observed in commercial facilities.
- The laboratory or classroom must be overseen by a supervisor.
  - A supervisor is a qualified electrician or a person who has been trained in electrical engineering, knows the respective safety requirements and safety regulations and whose training has been documented accordingly.
- Maximum permissible current loads for cables and devices must not be exceeded.
  - Always compare the current ratings of the device, the cable and the fuse.
  - If these are not the same, use a separate upstream fuse in order to provide appropriate overcurrent protection.
- Devices with an earth terminal must always be grounded.
  - If an earth connection (green-yellow laboratory socket) is available, it must always be connected to protective earth. Protective earth must always be connected first (before voltage), and must always be disconnected last (after voltage).

The laboratory or the classroom must be equipped with the following devices:

- An emergency-off device must be provided.
  - At least one emergency-off device must be located within, and one outside of the laboratory or the classroom.
- The laboratory or classroom must be secured so that operating voltage and compressed air supply cannot be activated by any unauthorized persons, for example with:
  - Key switches
  - Lockable shut-off valves
- The laboratory or classroom must be protected by residual current devices (RCDs).
  - Type B residual current circuit breakers with a residual current of ≤ 30 mA
- The laboratory or classroom must be protected by overcurrent protection devices.
  - Fuses or circuit breakers
- No damaged or defective devices may be used.
  - Damaged devices must be banned from further use and removed from the laboratory or classroom.
  - Damaged connecting cables, pneumatic tubing and hydraulic hoses represent a safety risk and must be removed from the laboratory or classroom.

2 Pictograms

This document and the hardware described include warnings concerning possible hazards which may arise if the system is used incorrectly. The following pictograms are used:

Warning
... means that non-observance may result in serious personal injury or damage to property.

3 Use for intended purpose

The stations of the Modular Production System for Process Automation (MPS®PA) may only be used:

- For their intended purpose in teaching and training applications
- When their safety functions are in flawless condition

The stations are designed in accordance with the latest technology as well as recognised safety rules. However, life and limb of the user and third parties may be endangered, and the components may be impaired if they are used incorrectly.

The learning system from Festo Didactic has been developed and produced exclusively for training and continuing vocational education in the field of automation technology. The training company and/or trainers must ensure that all trainees observe the safety precautions described in this workbook.

Festo Didactic hereby excludes any and all liability for damages suffered by trainees, the training company and/or any third parties, which occur during use of the equipment sets in situations which serve any purpose other than training and/or vocational education, unless such damages have been caused by Festo Didactic due to malicious intent or gross negligence.

4 For your safety

4.1 Important information

Fundamental prerequisites for safe use and trouble-free operation of the MPS®PA include knowledge of basic safety precautions and safety regulations. This manual includes the most important instructions for safe use of the MPS®PA.

In particular, the safety precautions must be adhered to by all persons who work with the MPS®PA. Beyond this, all pertinent accident prevention rules and regulations, which are applicable at the respective location of use, must be adhered to.

4.2 Obligations of the operating company

The operating company undertakes to allow only those persons to work with the MPS®PA who:

- Are familiar with the basic regulations regarding work safety and accident prevention and have been instructed in the use of the MPS®PA
- Have read and understood the chapter concerning safety and the warnings in this manual

Personnel should be tested at regular intervals for safety-conscious work habits.

4.3 Obligations of the trainees

All persons who have been entrusted to work with the MPS®PA undertake to complete the following steps before beginning work:

- Read the chapter concerning safety and the warnings in this manual
- Familiarise themselves with the basic regulations regarding work safety and accident prevention

4.4 Dangers associated with the modular production system

The MPS®PA is laid out in accordance with the latest technology, as well as recognised safety rules. Nevertheless, life and limb of the user and third parties may be endangered, and the machine or other property may be damaged during its use.

The MPS®PA may only be used:

- For its intended purpose
- When its safety functions are in flawless condition

Malfunctions which may impair safety must be eliminated immediately!

5 Work and safety instructions

General

- Trainees should only work with the circuits under the supervision of an instructor.
- Electrical devices (e.g. power packs, compressors and hydraulic units) may only be operated in training rooms that are equipped with residual current devices (RCDs).
- Observe the specifications included in the technical data for the individual components and in particular all safety instructions!
- Malfunctions which might impair safety must not be generated when the device is operated for training purposes.
- Wear personal safety equipment (safety glasses, safety shoes) when working on circuits.

Mechanical safety

- Switch off the power supply.
  - Switch off the working and control power before working on the circuit.
  - Only reach into the setup when it's at a complete standstill.
  - Be aware of potential overtravel times for the drives.
- Mount all of the components securely on the profile plate.
- Make sure that limit switches are not actuated from the front.
- Risk of injury during troubleshooting.
  Use a tool such as a screwdriver to actuate limit switches.
- Set all components up so that it's easy to activate the switches and interrupters.
- Follow the instructions about positioning the components.

Electrical safety

- Disconnect from all sources of electrical power.
  - Switch off the power supply before working on the circuit.
  - Please note that electrical energy may be stored in individual components.
    Further information on this issue is available in the data sheets and operating instructions included with the components.
- Use protective extra-low voltage only: max. 24 V DC.
- Establishing and disconnecting electrical connections
  - Electrical connections may only be established in the absence of voltage.
  - Electrical connections may only be disconnected in the absence of voltage.
- Maximum permissible current loads for cables and devices must not be exceeded.
  - Always compare the current ratings of the device, the cable and the fuse.
  - If these are not the same, use a separate upstream fuse in order to provide appropriate overcurrent protection.
- Use only connecting cables with safety plugs for electrical connections.
- When laying connecting cables, make sure they are not kinked or pinched.
- Do not lay cables over hot surfaces.
  - Hot surfaces are identified with a corresponding warning symbol.
- Make sure that connecting cables are not subjected to continuous tensile loads.
- Devices with an earth terminal must always be grounded.
  - If an earth connection (green-yellow laboratory socket) is available, it must always be connected to protective earth. Protective earth must always be connected first (before voltage), and must always be disconnected last (after voltage).
  - Some devices have high leakage current. These devices must be additionally grounded with a protective earth conductor.
- The device is not equipped with an integrated fuse unless specified otherwise in the technical data.
- Always pull on the plug when disconnecting connecting cables – never pull the cable.

Pneumatic safety

- Depressurize the system.
  - Switch off the compressed air supply before working on the circuit.
  - Check the system using pressure gauges to make sure that the entire circuit is fully depressurized.
  - Please note that energy may be stored in reservoirs.
    Further information on this issue is available in the data sheets and operating instructions included with the components.
- Do not exceed the maximum permissible pressure of 600 kPa (6 bar).
- Do not switch on the compressed air until all tubing connections have been established and secured.
- Do not disconnect tubing while under pressure.
- Do not attempt to connect tubing or push-in connectors with your hands or fingers.
- Risk of injury when switching compressed air on.
  Cylinders may advance and retract automatically.
- Risk of accident due to advancing cylinders.
  - Always position pneumatic cylinders so that the piston rod's working space is unobstructed over the entire stroke range.
  - Make sure that the piston rod cannot collide with any rigid components of the setup.
- Risk of accident due to tubing slipping off.
  - Use shortest possible tubing connections.

  - In the event that tubing slips off:
    Switch off the compressed air supply immediately.
- Pneumatic circuit setup:
  Connect the devices with plastic tubing with an outside diameter of 4 or 6 mm. Push the tubing into the push-in connector as far as it will go.
- Switch off the compressed air supply before dismantling the circuit.
- Dismantling the pneumatic circuit
  Press the blue release ring down so that the tubing can be pulled out.
- Noise due to escaping compressed air
  - Noise caused by escaping compressed air may damage your hearing. Reduce noise by using silencers, or wear hearing protection if noise cannot be avoided.
  - All of the exhaust ports for the components included in the equipment set are equipped with silencers. Do not remove these silencers.

Process engineering safety

- Before filling the tanks with water switch of power supply!
- Switch of power supply 24 VDC and 230 VAC (110 VAC)!
- The use of tap water in quality of drinking water (recommended), ensures a prolonged maintenance-free operation of the system (proportional valve and pump).
- The maximum operating temperature of the tanks must not exceed +65 °C.
- Do not operate the heating unit unless the heating element is fully immersed in fluid.
- Do not operate the piping system with a system pressure higher than 0,5 bar.
- Do not operate the pump without fluid, running dry or used for sea water or contaminated fluids.
- Please empty fluids from the system (tanks, piping, close valves) before you make changes at the piping system.
- It is possible to drain the fluids inside the MPS® PA Compact Workstation by opening hand valve V105
- Do not left the water inside the tanks for a longer time. It is possible, that bacteria as legionella grow up, which can cause diseases.

6 Technical data

Parameter		Wert
max. operating pressure piping system		50 kPa (0.5 bar)
power supply for station		24 V DC
profile plate		700 x 700 x 32 mm
dimensions		700 x 700 x 907 mm
weight		49 kg
(volumetric) flow rate of the pump		~ 5 l/min
tank volume		max. 10 l
flexible piping system		DN10 ($\varnothing_a$ 15mm)
digital inputs		7
digital outputs		5
analog inputs		4
analog outputs		2
amount of tanks		3
output range control element	pump (0...24 VDC)	voltage 0...10 V
	2/2W-proportional valve	voltage 0...10 V
	heating element, 230 VAC load supply	On/Off (control 24 VDC)
working range closed-loop system for level control		0...10 l
measuring range level sensor		0...9 l
signal range level sensor		current 4...20 mA
working range closed-loop system for flow rate control		0...10 l/min
measuring range flow sensor		0...10 l/min
signal range flow sensor		voltage 0...10 V
working range closed-loop system for pressure control		0...30 kPa (0...300 mbar)
measuring range pressure sensor		0...40 kPa (0...400 mbar) / 0...58 PSI
signal range pressure sensor		voltage 0...10 V
working range closed-loop system for temperature control		0...60° C / 32...140°F
measuring range temperature sensor		-50° C...+150° C / -58...302 °F
signal range temperature sensor		resistance PT100

7 Transport / Unpacking / Scope of delivery

Transport

The MPS® PA Compact Workstation is delivered in a container with a pallet base.
The container must be transported on a suitable fork lift truck at all times and must be secured against tipping or falling off.
The carrier and Festo Didactic are to be notified immediately of any damage caused during transport.

Unpacking

Carefully remove the padding material in the container box when unpacking the station. When unpacking the station, make sure that none of the station assemblies have been damaged.
Check the station for any possible damaged once unpacked. The carrier and Festo Didactic are to be notified immediately of any damage.

Scope of delivery

Check the scope of delivery against the delivery note and the order. Festo Didactic must be notified immediately of any discrepancies.

8 Design and function

The Festo Didactic Learning System for process automation and technology is designed to meet a number of different training and vocational requirements. The systems and stations of the MPS® PA Compact Workstation facilitate industry-orientated vocational and further training and the hardware consists of didactically suitable industrial components.
Moreover, training can be provided to instill team spirit, willingness to cooperate and organisational skills. Actual project phases can be taught by means of training projects, such as:

Planning,
Assembly,
Programming,
Commissioning,
Operation,
Maintenance and
Trouble shooting.

8.1 Training contents

Training contents covering the following subjects can be taught:

- Mechanics: Mechanical construction and piping of a station
- Process Engineering
  - Reading and drawing of function charts and dokumentation
  - Pneumatics in process automation
  - Piping connections of process control components
- Electrical technology
  - Correct wiring of electrical components
  - Sensors, design and function, correct use of sensors
  - Measuring of non-electrical, process and control variables
- PLC
  - Programming and use of a PLC
  - Programming of sequencial functions charts
  - Analogue value processing and closed-loop control functions
- Closed-loop control technology
  - basics of closed-loop control technology
  - Analyze and optimize a closed-loop system
  - P, I, D-control
  - Closed-loop controller
  - Configuration, assigning operation parameters and optimization of a closed-loop controller
- Commissioning
  - Commissioning of a closed-loop system
  - Commissioning of a process engineering system
- Fault finding
  - Systematic fault finding on a process engineering system
  - Examination and mantainence of a process engineering system
  - Operation and observation of a process
- Topics for project work
  - Selection of electrical components, e.g. level sensor
  - Savety check of a tank, how to use a float sensor

8.2 The Workstation

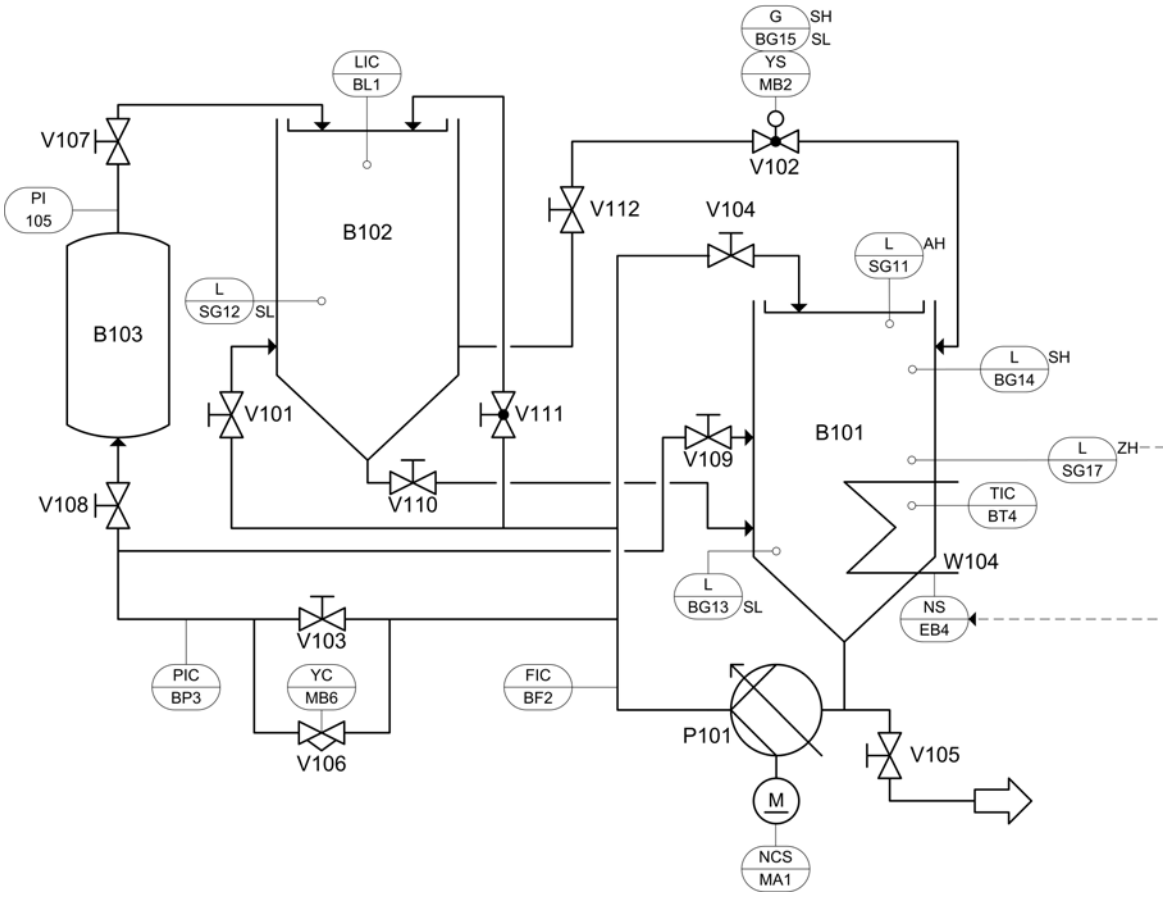
The MPS® PA Compact Workstation is available in different designs to suit indiviual training outcomes:

- Basic design
- Process instrumentation (PI)
- Energy
- or many other customized solutions...

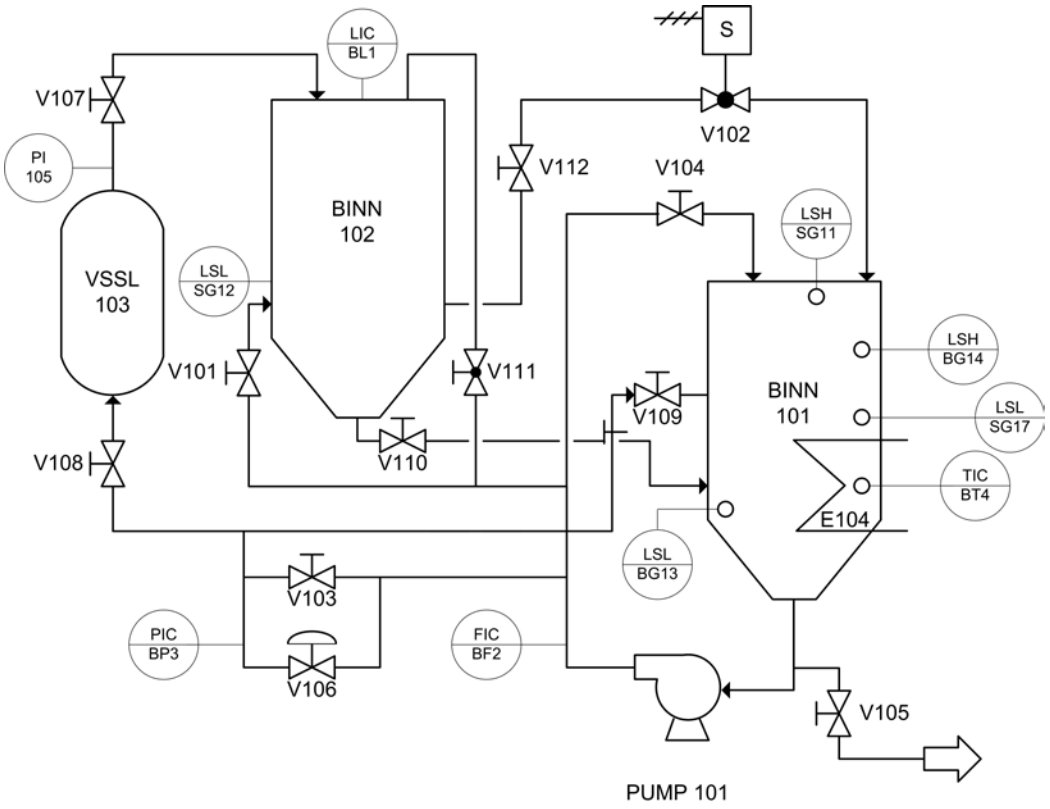
MPS® PA Compact Workstation – basic design

The MPS® PA Compact Workstation combines 4 closed-loops with digital and analog sensors and actuators. With a PLC or a controller it is possible to use them individually or cascaded:

- level controlled system
- flow rate controlled system
- pressure controlled system
- temperature controlled system



P&I diagram MPS® PA Compact Workstation in standards DIN EN 62424 and ISO 10628



PI diagram MPS® PA Compact Workstation in ISA 5.5 / ISA 5.1 Standard

It is possible to work with following functions by using the 4 closed-loop systems:

- two point control of a level control system with a analog standard signal
- continuous control of a level control system with a analog standard signal
- continuous control of a flow rate control system with a pump as controlled system and a impulse signal for frequence measuring
- continuous control of a flow rate control system with a proportional valve (controlled system) and a impulse signal for frequence measuring
- continuous control of a flow rate control system with a pump as controlled system and with a analog standard signal
- continuous control of a flow rate control system with a proportional valve as controlled system and with a analog standard signal
- continuous control of a pressure control system with a pump as controlled system and with a analog standard signal
- continuous control of a pressure control system with a proportional valve as controlled system and with a analog standard signal
- two point control of a temperature control system with a analog standard signal

Advanced control systems can be additionally used with in FluidLab-PA multi-loop:

- Cascade control of flow rate and level
- Override control of flow rate and pressure
- Feedforward of pressure and flow rate

The basic design components of the MPS® PA Compact Workstation are:

- Analog ultrasonic sensor
- Flow sensor, magnetic-inductive (0,1...25 l/min) with integrated measuring convertor and display
- Pressure sensor, piezoresistive with on-site display
- Pressure gauge for 0...1bar
- PT100 temperature sensor –50...+150 °C, with plug-in measuring convertor 0...100 °C with output 0-10V
- 2x Capacitive proximity switch for min/max level in lower tank
- Float switch for threshold function (electromechanical) in upper tank
- Float switch for overflow alarm monitoring in lower tank
- Float switch as a protection for the heating system
- Centrifugal pump
- Motor Controller for pump motor (DC)
- Proportional valve with electronic control module
- Heating system with integrated micro controller
- 2W ball valve with pneumatic rotary drive (COPAR) with 5/2way pilot valve and sensor box with position indicator and dual inductice position sensing
- I/O-board mit I/O terminal (Syslink) for binary signals and analogue terminal for analog signals
- Signal converter: current to voltage (rail mount), frequency to voltage (integrated in sensor), PT100 to voltage (plug-in)
- Piping system incl. 4 transparent segments
- Pressure tank (reactor), 2L, stainless steel
- 2x Water tanks, 10L, square
- Manual valves
- Service Unit
- cable ducts
- Aluminium profiles
- Profile plate
- 19'' mounting frame
- Mounting frame for ER units or A4 Edutrainers

Additional accessories should be used:

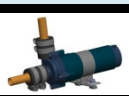
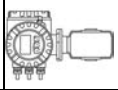
- 24 V DC power supply for 19" frame
- PLC or closed-loop controller, e.g. EasyPortUSB, EduTrainer Universal with PLC
- trolley
- basic control panel for 19" frame
- touchpanel (HMI)

The functions of each closed-loop system result in the specified combination of the (manual-) valves. Also they depend on the programming, configuration or parametrizing of the PLC/ controlling system.
For the usage of the station a control kit and a power supply for 24 V DC is required.

8.3 Overview of components

Following table shows all electric devices of the MPS®PA Compact Workstation in ever design, which are:

included or not included.

Description	Component	Basic design	Process Instrumentation (PI)	Energy
Pump				
Proportional valve				
Heating				
Ultrasonic sensor				
Flow rate sensor, electromagnetic				
Pressure sensor				
Temperature sensor				
Level probe, capacitive				
Magnetic- inductive flow meter				
Pressure sensor				
Temperature sensor				
Level switch, vibronic				
2way ball valve with pneumatic rotary drive				
DC-Wattmeter				
PAC3200 AC power meter				

Components and functions in this operating instruction are explained for the basic design.

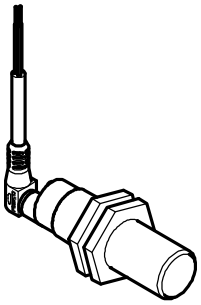
8.4 Level monitoring

Following technical examples for level monitoring are integrated into the MPS® PA Compact Workstation:

- proximity switches
- float switch for overflow savety
- float switch for threshold function

8.4.1 Proximity switches

Two capacitive proximity switches BG13 and BG14 are located on the side of the lower tank B101 and mounted on a profile. The proximity switches can be mechanically adjusted. The sensing distance through the tank wall can be adjusted with a screw. The binary 24 V input signals are connected to the I/O-terminal XD1.



Level monitoring with capacitive proximity switches BG13 and BG14

The minimum level of the tank B101 is indicated by the lower sensor BG13. At minimum level the heating element EB4 should be totally immersed into the liquid.
The maximum level of the tank B101 is indicated by the upper sensor BG14.
At reset position of the system both sensors have to be activated.

8.4.2 Overflow savety

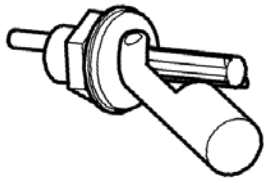
The overflow at tank B101 is monitored with float switch SG11. If the level in the tank exceeds the maximum level the transparent float cylinder is pushed upward. Inside the float cylinder are magnets which activate a reed contact.

Level monitoring with float switch for overflow savety SG11

The binary 24 V input signals (no) is connected to the I/O-terminal XD1. The signal of the overflow switch should activate an alarm function in the PLC-program and has effect on ball valve V102 and pump P101.
If changed electrically the overflow switch also can be used to turn off the pump or valve with a relay circuit or for signal indication to an emergency relay.

8.4.3 Threshold function

The increasing fluid level into the upper tank B102 is monitored at a certain minimum level by float switch SG12. If the mounting position is changed the switch can also indicate the decreasing level.

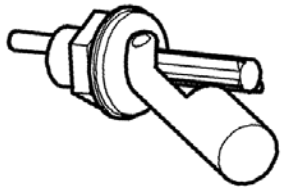


Level monitoring with float switch for threshold function SG12

The binary 24 V input signals (nc) is connected to the I/O-terminal XD1. The cable of the switch has a plug connection for easy connect/disconnect on changing the mounting position.

8.4.4 Switch-on protection for heating

The float switch SG17 is monitoring the decreasing filling level in tank. It avoids continuing heating if filling level undershoots the critical point. The heating must be sourrounded completely by the fluid.

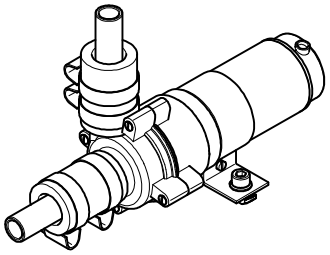


Float switch as switch-on protection for heating

The cable of the switch has a plug connection and is connected directly to the heating and to the connecting cable of the I/O- connecting board.

8.5 Pump

The centrifugal pump P101 is the controlling equipment used in all controlled systems. The pump is delivering fluid from a reservoir tank B101 through the piping system.



Controlling equipment - Pump P101

The pump must not be operated running dry. Before commissioning the reservoir tank or piping system to/from the pump should be filled with fluid.
The pump is driven by the motor controller QA1 and relay KF1. With a digital output
(Q2 at XD1) it is possible to switch from digital binary control to analog control variable from 0 to 24 V. At digital binary control (Q2 = 0) the pump is turn on/off with an additional output (Q3 at XD1). At analog control (Q2 = 1) the drive voltage from analog output signal channel 0 (UA1 at XD3) is setting the speed of the pump from 0 to 10 V.

Please also see the data sheet of the pump for further savety instructions!

8.6 Proportional valve

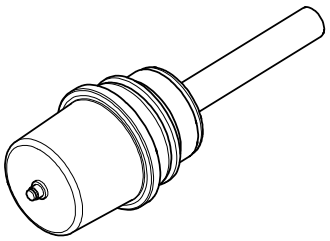
The proportional valve V106 is a directly actuated 2/2-way valve for flow control of fluids. It can be used as a adjustable remote element in open- or closed-loops. The valve piston is lifted of its seat as a function of the solenoid coil current and releases the flow through the valve.

Controlling element proportional valve V106

The control electronic of the proportional valve is activated with a binary output (Q4 at XD1). An analog signal from channel 1 (UA2 at XD3) is driving the signal input of the proportional valve with a standard analog signal from 0 to 10 V.
The standard analog signal is transformed into a pulse-width modulation (PWM) and the opening of the valve is infinitely adjustable. The frequence of the PWM can be adapted for different valve types.

8.7 Heating

The heating element is controlled by an internal micro controller, on activation of a binary ouput (Q1 at XD1).



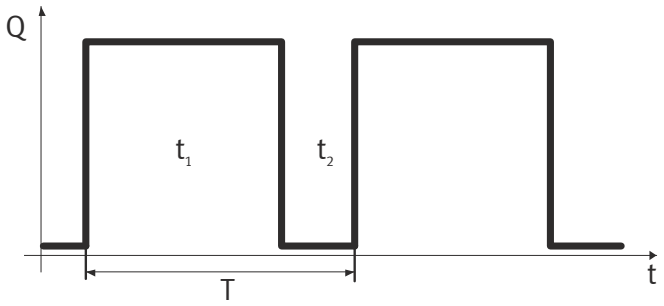
Heating

Notes on safety:

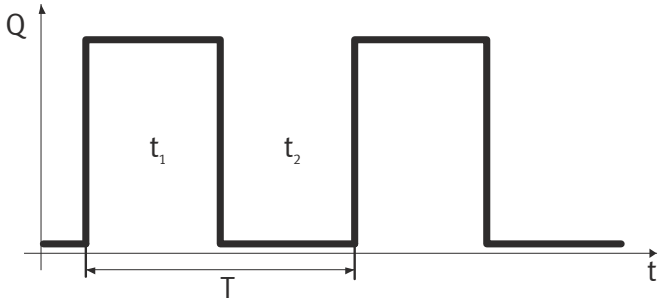
- The maximum operating temperature of the tanks must not exceed +65 °C.
- Do not operate the heating unit unless the heating element is fully immersed in fluid.
- Critical temperature at the heat element: at temperature around 50-60 °C the heating is internal automatically switched off. If the temperature value drops below 45 °C the heating is switched on again.
- Critical temperature at the micro controller of the heating: at a semiconductor temperature of around 90°C the heating is internal automatically switched off. If the temperature value drops below 85 °C the heating is switched on again.

Controlling the heat element

The heating can be controlled binary as well as analogue (continous). For the MPS®PA Compact Workstation the heating is controlled **binary only**. To use the heating as a continous output element a pulse-width-modulation (PWM) is used. The control is clocking the ON- and OFF- time of the heating. The time periode T is constant (e.g. 10s). By changing the ON-time t1 of the heating the thermal power Q is manipulated. If the ON-time is raised, also the thermal power is.



PWM with a puls-widht ration of 75%



PWM with a puls-widht ration of 50%

Key

t1	OFF-time
t2	ON-time
T	time periode
Q	thermal power

8.8 2W ball valve with pneumatic rotary drive

The 2-way ball valve V102 is opened and closed by a pneumatic rotary drive. The controlled equipment consists of a brass ball valve (1) with rotary drive type COPAR (4), using rack-pinion principle. A solenoid (2) 5/2 way valve (3) with port pattern to NAMUR and sensor box with inductive dual sensor (5) with position indicator (6) are flange mounted onto the rotary drive. The flow of the fluid from upper tank B102 into the lower tank B101 is controlled with the ball valve of the rotary drive.

2-way ball valve V102 with pneumatic rotary drive

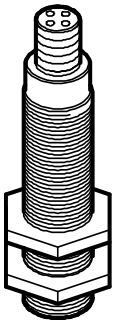
Key

1 brass ball valve
2 solenoid 24 V DC
3 5/2 way pilot valve with port pattern to NAMUR
4 quarter turn actuators, type rack-and-pinion principle
5 sensor box with inductive dual sensor
6 position indicator

The end position sensing attachment (5) consists of a contact-free inductive dual sensor. The two binary 24 VDC signals (BG15) are connected as inputs to the I/O-terminal XD1. There is also a visual indication of the drive position for the operator.

8.9 Level control function

The function of the level controlled system is to regulate the filling level of a fluid in a reservoir tank.
The controlled filling level system can be used as I- or PT1 controlled system.



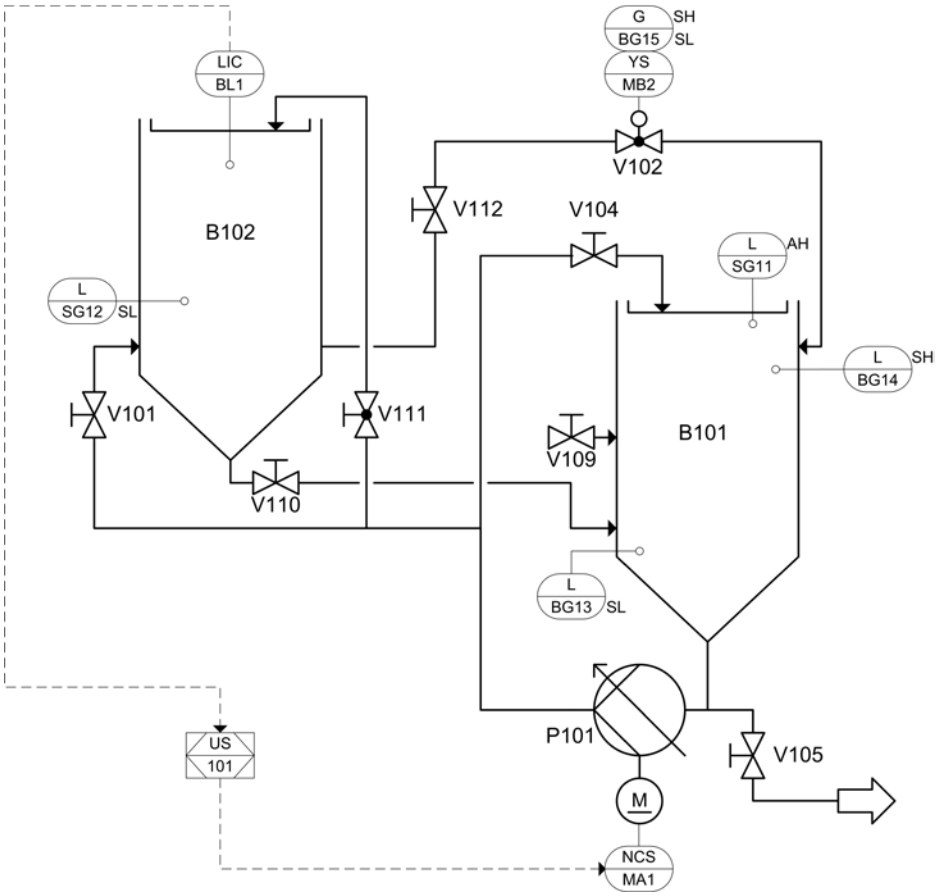
Controlled level system – ultrasonic sensor B101 (measuring point ‘LIC BL1’) for basic design

The pump P101 delivers a fluid from a storage tank B101 to a reservoir tank B102 via a piping system. The level of the fluid inside tank B102 is monitored with a analog sensor BL1 at measuring point ‘LIC BL1’ and read as actual value. The actual value should be kept on a certain level also if disturbances or set point changes occur.

In the basic design of the station an ultrasonic sensor BL1 (measuring point ‘LIC BL1’) is measuring the distance between sensor and water surface. The sensor has a fixed programmed measuring range.

The analog current signal (4...20 mA) of the ultrasonic sensor is connected to the measuring transducer TF1. The transducer changes the analog current signal into a standard voltage signal (0...10 V). The standard voltage signal is connected to the analog terminal XD3 (UE1).
For function and characteristic curve of the ultrasonic sensor please see data sheet.

The reservoir tank B102 can be filled from the bottom through manual valve V101 and from the top through ball-valve V111.



PI-diagram of the close loop level control system (EN62424/ISO10628)

The fluid quantity of the pump P101 can be a binary or manipulated value. For controlling system a two-position or a continuous element can be used
(see also EMCS block diagrams).
For disturbance is it possible to partly or totally open/close the ball valve V102 to drain the upper into the lower tank or open/close hand valve V104.

8.10 Flow rate control function

In a piping system or a filter unit the flow velocity of a fluid shall be regulated.
The system used is a controlled system with self-regulation (P-controlled system). It does not have a time delay. The control loop in combination with the pump (PT1 behaviour) creates an easily controllable system.

Controlled flow rate system – pump P101 with e.g. flow sensor BF2 (measuring point 'FIC BF2')

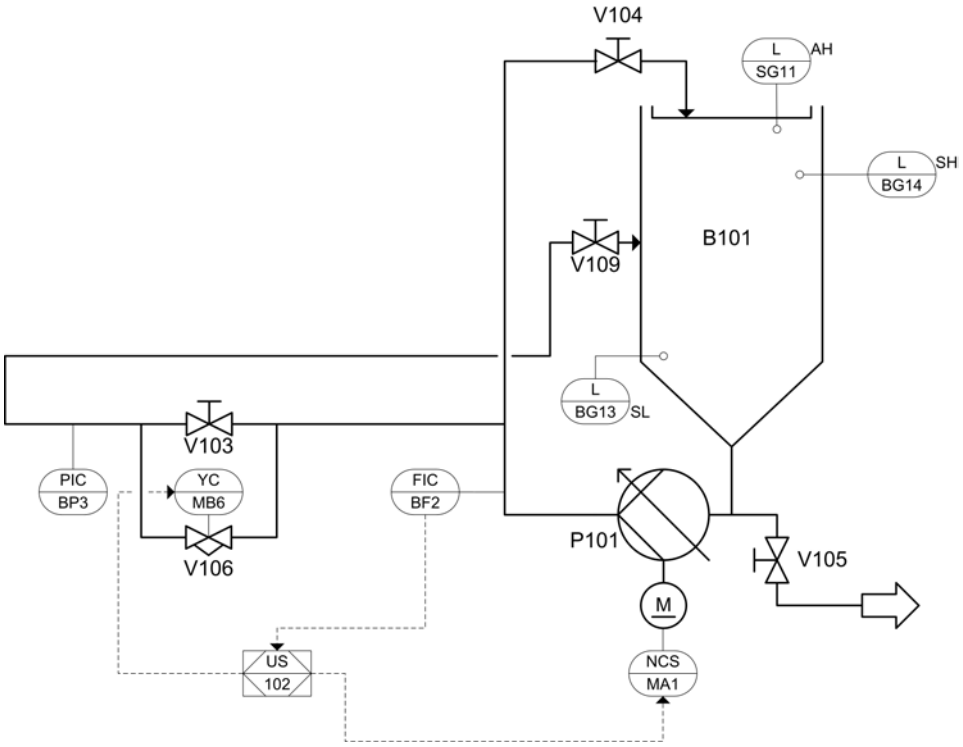
The pump delivers a fluid from the reservoir via a piping system. The actual value measured with a sensor should be kept on a certain flow rate also if disturbances or set point changes occur.

For controlling system a continuous element can be used. There are two operation modes:

- Flow rate control by the means of the pump P101 as controlled system. Manipulated value is the voltage of the pump, which sets the revolution speed.
- Flow rate control by the means of the proportional valve V106 as controlled system. Manipulated value is the voltage of the valve coil, which sets the stroke of the valve piston. The pump P101 is running with a constant revolution speed.

For disturbance is it possible to partly or totally open/close the hand valve V104 or V109.

The flow rate is detected by an electromagnetic flow sensor BF2 in the form of an actual value. The integrated measuring transducer converts the measured value into a standard signal voltage (0...10V). That signal is connected to the analog terminal XD3 (UE2).



PI-diagram of the close loop flow rate control system (EN62424/ISO10628)

8.11 Pressure control function

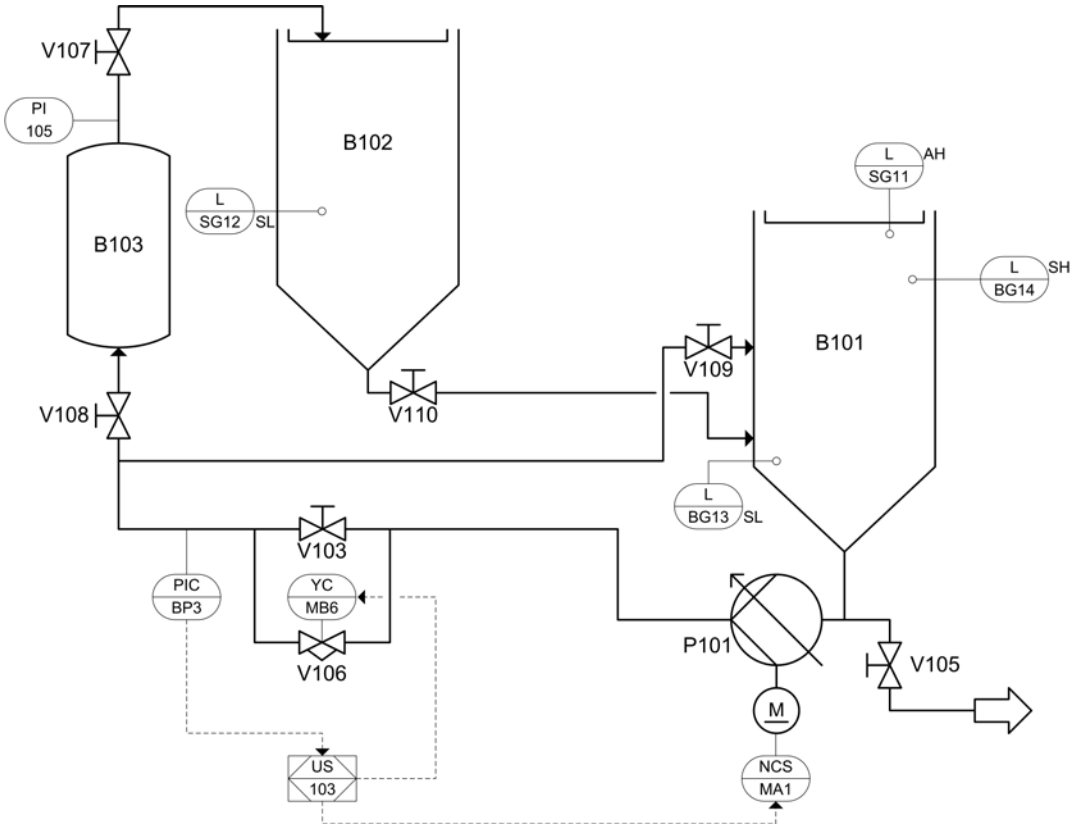
The process pressure of a fluid inside a pressure tank or a pipe system shall be regulated.
The controlled pressure system used is a controlled system with self-regulation (PT1-controlled system).
Because the pressure tank is partly filled with gas (air) it is an energy storage system.

Controlled pressure system – pressure tank B103 with pressure sensor BP3 (measuring point 'PIC BP3')

Via a piping system, the pump P101 delivers a fluid from a resevoir into a gas-prefilled pressure tank B103. The pressure of the gas (air) in the pressure tank is detected by means of a relative pressure sensor in the form of an actual value. The actual value should be kept on a certain pressure also if disturbances or set point changes occur.
The media pressure is detected by means of a relative piezoresistive sensor BP3 in the form of an actual value. The standard voltage signal of the pressure sensor is connected to the analog terminal XD3 (UE3). A measuring transformer is not necessary. The sensor can be easily unplugged from the pipe system. Please be aware that there could be a build up or locked-in pressure in the pipe.

Setup for controlling

As controlling system a continuous element can be used. During control a pressure is build up and controlled from liquid to gaseous medium in the pressure container B103. The amount of liquid inside of the pressure tank can be increased by opening/closing of the exhaust valve V107 if the pump P101 is running before using closed-loop control. It is recommended to setup the water level of the pressure tank at half level with V107 for an optimal work range during closed-loop control.



PI diagram of the close loop pressure control system (EN62424/ISO10628)

There are two operation modes:

- Pressure control by the means of the pump P101 as controlled system. Manipulated value is the voltage of the pump, which sets the revolution speed.
- Pressure control by the means of the proportional valve V106 as controlled system. Manipulated value is the voltage of the valve coil, which sets the stroke of the valve piston. The pump P101 is running with a constant revolution speed.

For disturbance is it possible to partly or totally open/close the hand valve V109.
To empty the pressure tank hand valves V 109, V 108 and V107 should be opened and pump P101 switched off. Please notice that the water level of the pressure container cannot drop below the level of the lower tank B101. Maybe it can be necessary to pump water from lower to upper tank B102.

Pressure gauge at PCE-task ‘PI 105’

Additionally the tank pressure can be read with a pressure gauge.

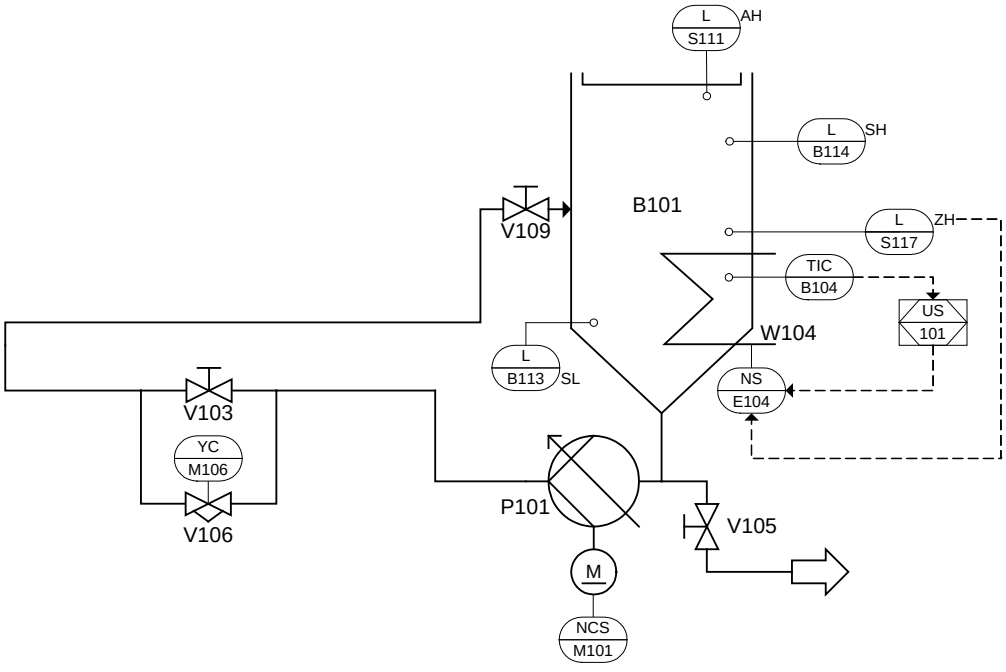
8.12 Temperature control system

The fluid process temperature of a heat exchanger shall be regulated.
The controlled temperature system used is a controlled system with self-regulation (PT1-controlled system). Because the conversion of energy happens slowly these comtrolled system has a big time constant (of time delay).

Controlled temperature system – reactor container B101 with temperatur sensor BT4 (measuring point 'TIC BT4')

The water in the reactor container B101 of the heat exchanger EB04 is heated by means of a heating element and is recirculated by means of the pump P101.
A PT100 sensor BT4 is used for measuring the system temperature at measuring point 'TIC BT4' in the form of an actual value. The actual value should be kept on a certain temperature also if disturbances or set point changes occur.

The media temperature is detected by means of a temperature resistive sensor BT4 in form of an actual value. The sensor is mounted into the lower tank. The resistance of the temperature sensor is connected to the measuring transformer TF4. The transformer changes the resistance into a standard voltage signal 0 to 10 V. The standard voltage signal is connected to the analog terminal XD3 (UE4).

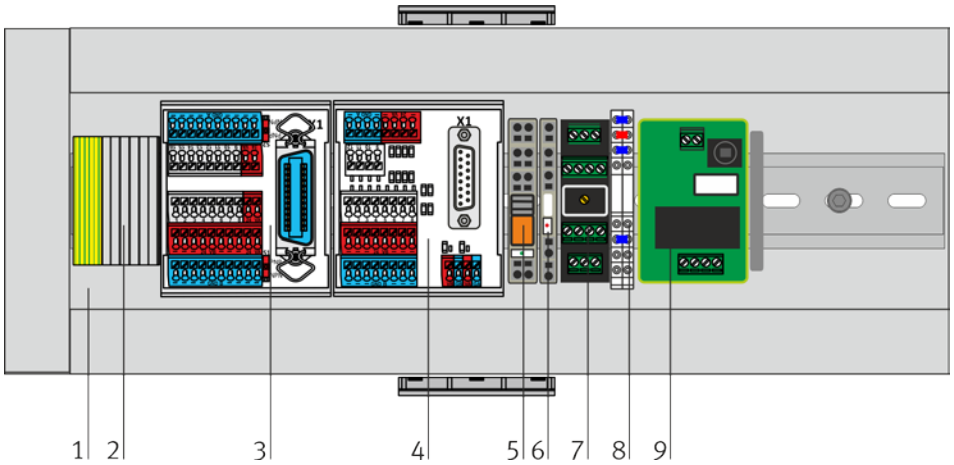


PI-diagram of the temperature control system

The on/off switching period of the heating element E104, which is the manipulated variable, determines the heat output of the heat exchanger. For controlling system a two-point element can be used. For disturbance is it possible to use cold fluid or (f.g. ice cubes) or mix with water from the upper tank.
The heating is controlled by an internal micro controller. With a binary ouput (Q1 at XD1) the heating can be switched on/off.

8.13 I/O-board

The connection board serves as an interface for analogue and digital input and output signals. All analogue signals are converted into 0 - 10 V and applied to the analogue terminal. Binary signals max. 8 inputs and 8 outputs per station are applied to the I/O terminal. This ensures compatibility with EasyPort, SimuBox, EduTrainern and PLC boards.



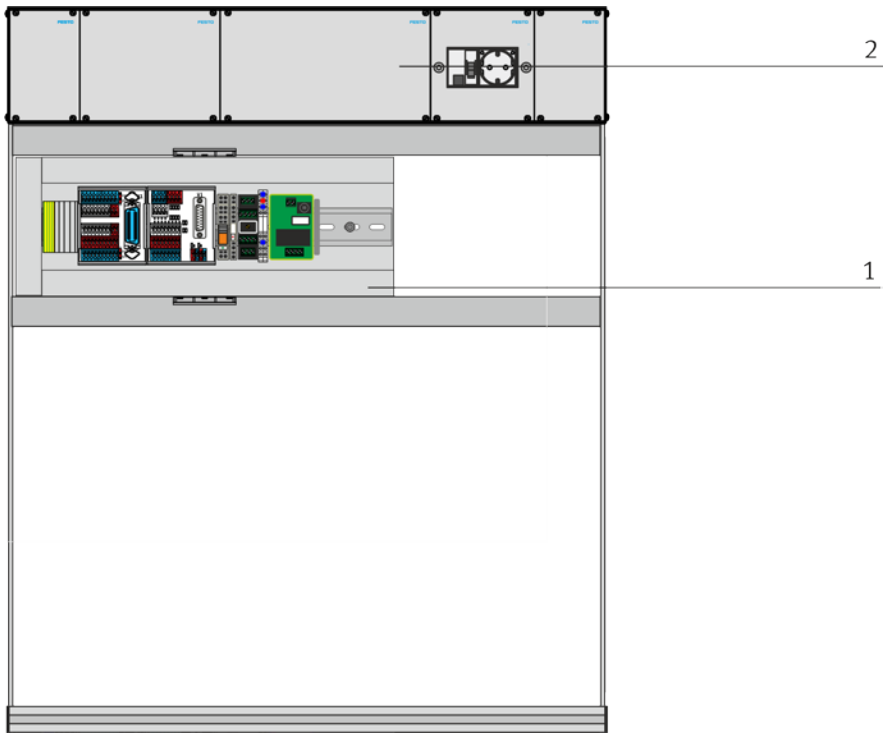
I/O-board of basic design

Key

1	Mounting plate
2	Terminal sockets for protective earth and power supply: 24VB/0VB for logic and sensors, 24VA/0VA for actuators
3	XD1 I/O terminal (SysLink station): Connection of inputs, e.g. capacitive proximity sensor and connection of outputs, e.g. pumps. Proportional valve, 2way-ball valve.
4	XD3 Analogue terminal: sensor signals of level, flow rate, pressure and temperature and manipulated variable y of pump and proportional valve.
5	Relay KF1: Control of the pump. If KF1 is active, the pump can be controlled with a continous manipulation voltage of 0-10V.
6	Power relay KF6: activating power electronic fort he proportional valve
7	QA1 Motor controller: binary and analogue control of the pump.
8	TF1 Measuring transducer I/U: converts 4-20 mA current signal of ultrasonic sensor for level measurement into 0-10 V standard voltage signal.
9	QA3 Starting current limiter: limits the maximum starting current of the motor controller to prevent voltage drops at the controller.

8.14 Mouting frame

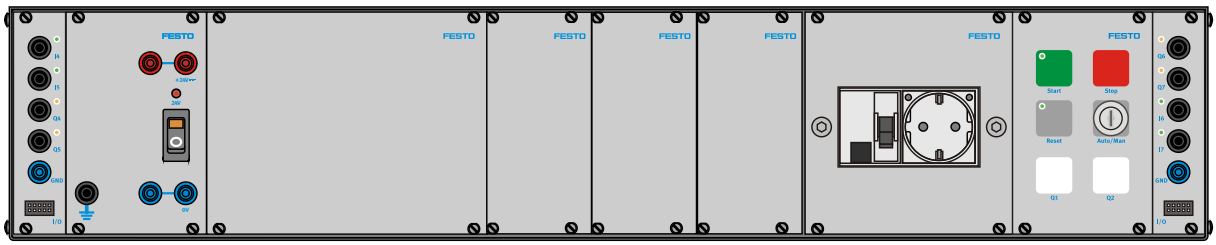
The mounting frame of the MPS® PA Compact Workstation consists of a two-row ER-frame for EduTrainers and a 19” base frame for 19” units.



Mounting frame

The 19" control panel is suitable for following operation or indication units:

- 19“ power supply 24 V DC/4,5A
- 19“ control panel with 3 push buttons, 1 key switch and 4 indicator
- 19“ Communication panels with 4 inputs and 4 outputs available at 4 mm safety sockets (only use with 19” control panel)
- 19“ EMERGENCY STOP panel



19“-frame –example assembly

8.15 Additional accessories

The common functions of the station can be extended and customized with modular components. Following components are not included to the delivery of the MPS-PA Compact Workstation basic design and should be ordered additionally.

8.15.1 Directly controlled 2-way solenoid valve, brass

Directly controller solenoid valves are used to automate manual valve functions of the MPS® PA Compact Workstation. The solenoid valves are integrated into the piping. The solenoid is switch on with a load relay.

Directly controlled 2way solenoid valve, brass

The 2-way solenoid valves are used for the following functions:

- Inlet feed tank B102 (supplement for V101)
- Tank-to-tank process with pump P101 (supplement for V101)
- Drain valve for tank B101

8.15.2 Directly controlled 2way solenoid valve, plastic

A 2-way solenoid valve in plastic design is used for the MPS® PA Compact Workstation to control the cooling cirulation, supplied together with the cooling unit with heat exchanger (C44001). The solenoid is switch on with a load relay.

Directly controlled 2way solenoid valve, plastic

8.15.3 Pilot-operated 2-way solenoid valve, brass

A 2-way solenoid valve is servo- or pilot-operated to open with less magnetic force at a minimum feed pressure of the media. It is assembled into the piping or at a T-connector. Because of it´s low power consumption the solenoid can be switched directly with a binary PLC output.

Pilot-operated 2-way solenoid valve

A pilot-operated solenoid valve is used to feed fresh water from the drinking water pipeline to the station tank B101.

Safety precautions:

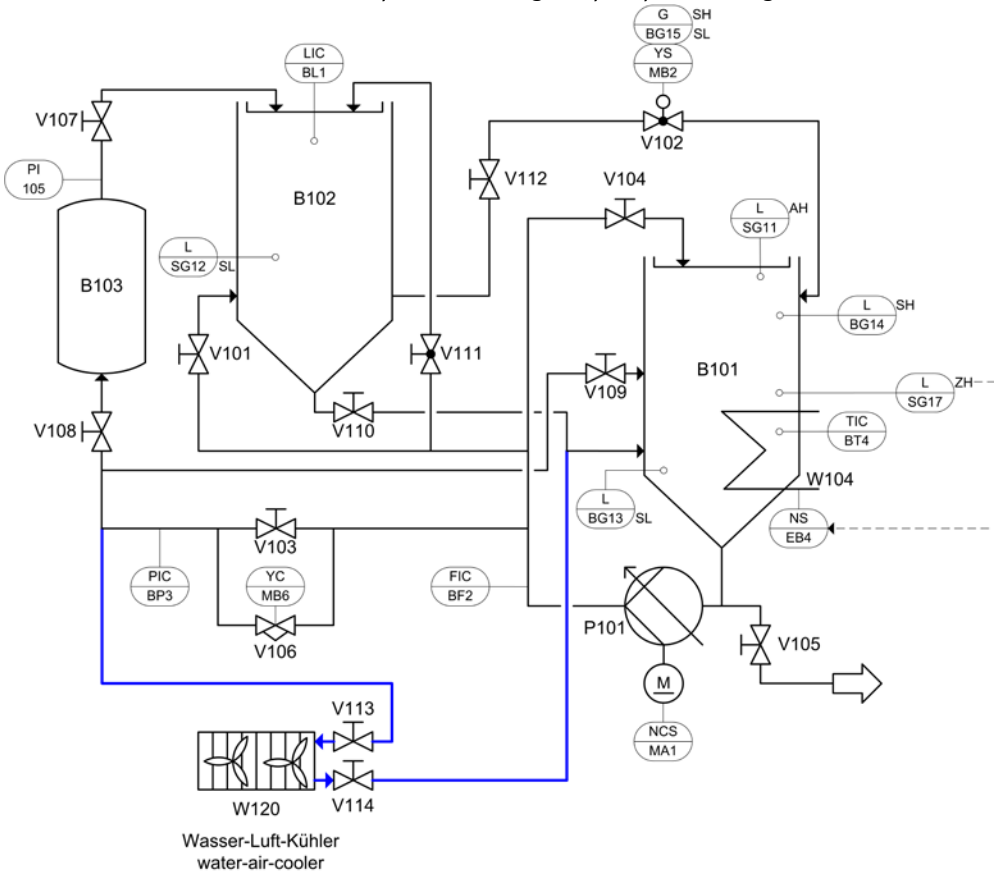
Refer to the data sheet for the 2/2-way solenoid valve, and the safety regulations as well!

8.15.4 Water-air cooler

The MPS® PA Compact Workstation is completed with the additonal functions for:

- cooling with a heat exchanger
- closed-loop speed control with variable-speed fans

The water-air cooler MA8 is installed with pluggable pipe connectors into the piping system. It cools down the media as low as the room temperature using the pump for through-feed method.



PI-diagram of the station with water-air cooler (EN62424/ISO10628)

The process media has to be pumped with P101 through the piping system. Set manual valves as described in chapter 6.9 for “Pressure control with pump” and also open manual valves V113 and V114. With manual valves V113 and V114 the cooling circuit can be closed.

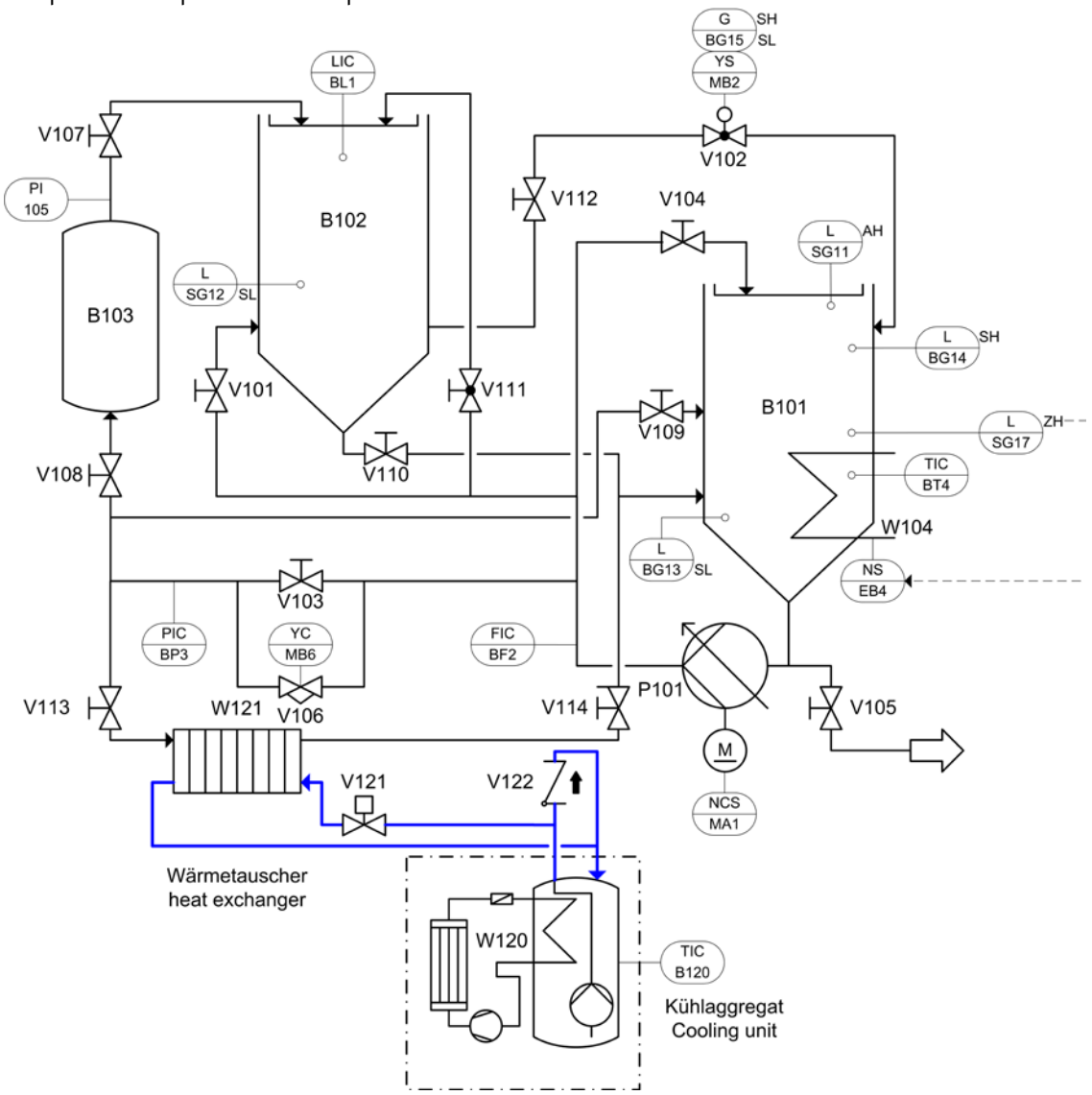
The water-air cooler is activated with relay KF5. Relay KF5 switches over:

- analoge output CH1 from proportional valve V106 to manipulated value for fan speed control
  0-10 V → 0-100 %.
- analoge input CH2 from pressure sensor B102 to measure value for fan speed feedback
  0-10 V → 0-6000 U/min

The speed control of the fan motors is driven continuous with a 0-10 V DC control voltage. An encoder provides a feedback signal from the motors – only one motor encoder is connected. The speed variable square wave signal is converted with a frequency transducer 0-200 Hz into a voltage signal 0-10 V. The water-air cooler is connected with a plug-in cable to the IO-board of the station.

8.15.5 Cooling unit with heat exchanger

The process temperature of the process media inside the tank should be reduced.



PI-diagram for heat exchanger for cooling circuit W121 with cooling unit W120

The liquid in tank B101 is pumped with P101 in a tank-to-tank circuit through a plate heat exchanger via valves V103 → V113 → V114. The system temperature of the tank is measured with the PT100 temperature sensor, PCE-task ‘TIC BT4‘ for process value.

The cooling circuit is activated with the cooling unit in a internal and external loop. Switch-on the cooling unit, set the cooling setpoint to “10°C” and start “Pump”. Using the internal loop the cooling unit pre-cools down the cooling liquid through one-way valve V122. It is recommended to use the supplied anti-freeze liquid. When the cooling solenoid valve V121 is opened the external cooling circuit via the plate heat exchanger is running to dissipate heat from the process media. The circulating cooler is using a microprocessor-based temperature controller for thermostatic temperature control with internal Pt100 resistive sensor.

Notes on safety:

- The minimum operating temperature of the process or cooling media must not fall below +5 °C to prevent freezing.
- Only activate the cooling unit after commissioning according to the specification.

8.15.6 Stirrer

The stirrer R107 consists of a drive unit (motor), a compensating coupling and a stirring rod. The stirrer is attached to a profile by means of a mounting plate.
The stirrer is mixing the process media in tank B101. Only activate the stirrer when submerged into the process media.

Stirrer module

Connection technology

The stirrer is controlled by means of a motor controller. The motor controller is activated with a digital output. In the case of manual control, the manipulated variable can be adjusted within a range of 0 to 10 V with the adjustement screw at the motor controller.

Motor controller

Notes on safety:

- Please also see the data sheet of the stirrer and motor controller for further savety instructions!

8.15.7 Centrifugal pump with 3-phase AC-motor

Instead of the standard pump in basic design, a centrifugal pump with 3-phase AC-motor can be installed.

Centrifugal pump with 3-phase AC-motor – for illustration only!

For continuous control of the pump speed a frequency convertor (FC) is assembled in a electrical cabinet.

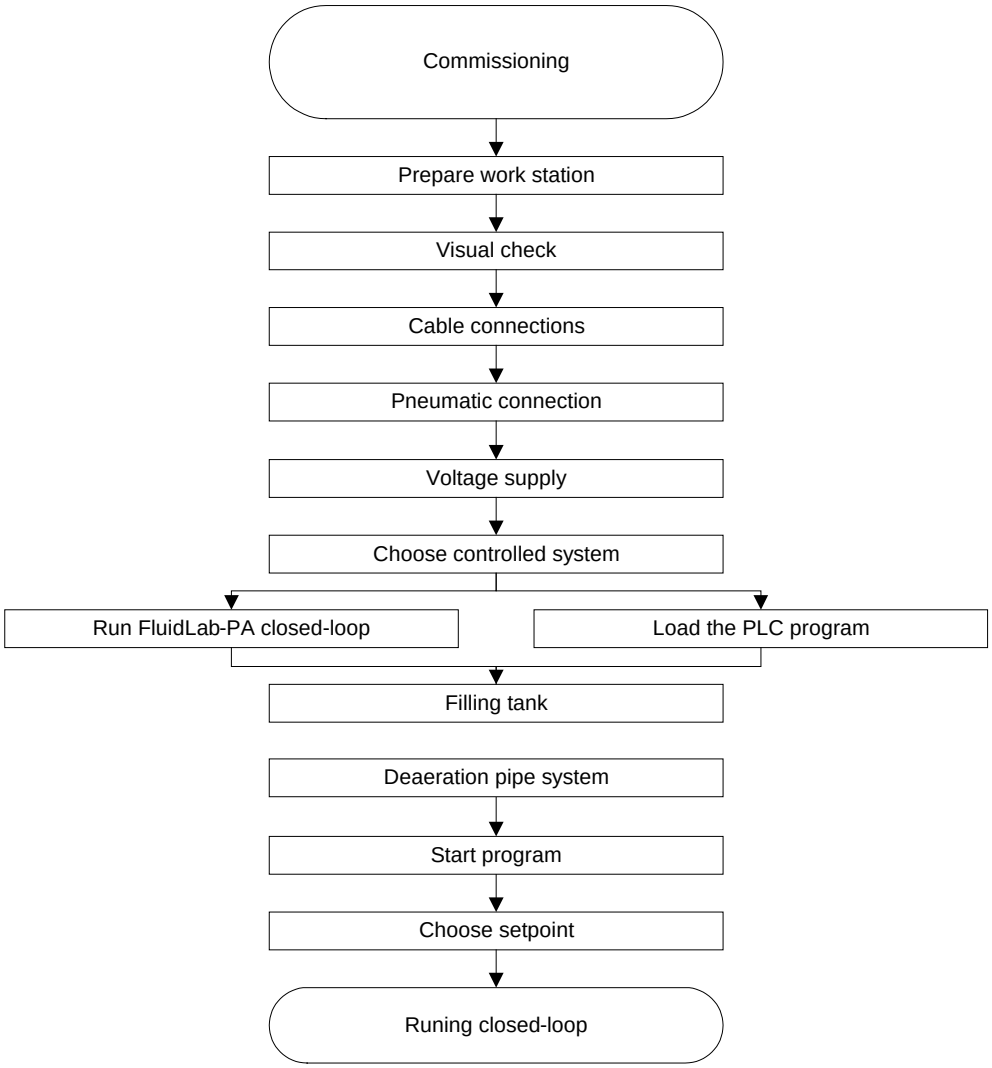
The pump is controlled by means of a frequency converter. The parameters of the frequency converter can be configured with the basic operator panel (BOP). Please observe the notes included in the operating instructions for the Micromaster M420 frequency converter. The adjustable parameters of the frequency converter for pump P101 are listed in the following section. Control of the pump with FC is similar to the standard pump. The FC is activated by a digital output (Q3 at XD1). Analog control is set with digital output and switch-over relay KF1 (Q2 at XD1). At analog control (Q2 = 1) the drive voltage from analog output signal channel 0 (UA1 at XD3) is setting the speed of the pump from 0 to 10 V.

Electrical cabinet with frequency convertor

A status signal additionally indicates a configurable operating state to the control system. The rotary speed or frequency is limited to “25 Hz” for safety reasons.
The pump may not be permitted to run dry. Before commissioning, the lower storage tank and the piping system to/from the pump must first be filled with the liquid to be pumped. Refer to the data sheets for the pump and the frequency converter, and the safety regulations as well!

9 Commissioning

For running the MPS® PA Compact Workstation all commissioning steps have to be obeyed according to the rules of operation:



Flow chart for commissioning the MPS® PA Compact Workstation

The MPS® PA Compact Workstation is generally delivered

- completely assembled,
- operationally adjusted,
- commissioned and
- tested.

The commissioning is normally limited to a visual check to ensure correct tubing connections / pipe connections / wiring and supply of operating voltage.
All components, tubing and wiring are clearly marked so that all connections can be easily reestablished.

9.1 Workstation

The following is required to commission MPS® PA Compact Workstation:

- The assembled and adjusted MPS® PA Compact Workstation
- A control console
- A Edutrainer with PLC, EasyPortUSB or industrial controller
- A power supply unit 24 V DC, 4.5 A
- A compressed air supply of 6 bar (600 kPA), approx. suction capacity of 50 l/min
- A PC with installed PLC programming or FluidLab-PA closed-loop software

9.2 Visual check

A visual check must be carried out before each commissioning!
Prior to starting up the station, you will need to check:

- The electrical connections
- The correct installation and condition of the pipes and pipe connections
- The correct installation and condition of the compressed air connections
- The mechanical components for visual defects (tears, loose connections etc.)

Eliminate any damage detected prior to starting up the station!

9.3 Cable connections

The MPS® PA Compact Workstation can be controlled in different ways. In the following chapters the different conroll variants will be described.

The overall cable connections are:

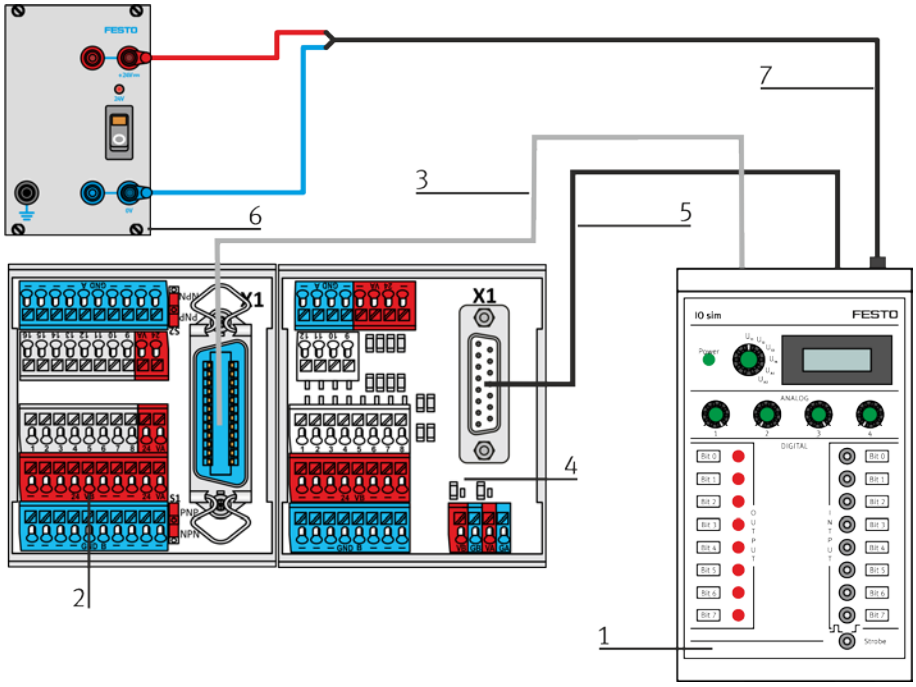
- Connect the pneumatic hose to the service unit of the station
- Connect an IEC power supply cable (C14, male) to the back side of the 19” frame of the station to the IEC connector (C13, female). The female connector also uses a fuse.

9.4 Simulation box digital/analog and MPS® PA Compact Workstation

All cable connections are described for a MPS® PA Compact Workstation with Simulationbox.

- Connect the Syslink plug of the simbox with the XD1 socket of the I/O terminal (2) of the station with a SysLink cable (3).
- Connect the analog plug of the simbox with the XD3 socket of the analog terminal (4) of the station with analog cable (5).
- Connect 4 mm safety plugs (red and blue) of the simbox and power supply unit with 4 mm safety plugs cable (red = + / blue = —).

> Notice:
> By using the crossover analoge cable with the simulation box
> only the first two analog cannels (0 = Level; 1 = Flow) can be displayed.



Cabel connections MPS® PA Compact Workstation – Simulationsbox, digital/analog

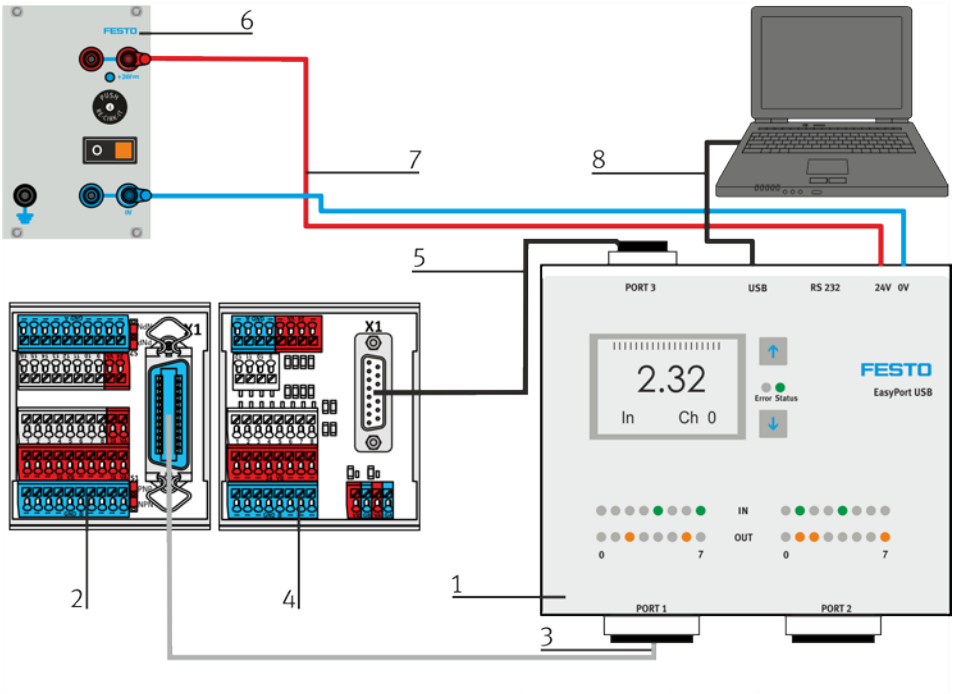
Key

1	SimBox digital / analog
2	I/O terminal SysLink (XD1) at I/O-Board of Station
3	SysLink-cable, I/O- data cable with SysLink, 20 pin (black endings, Order No. 167106)
4	Analog terminal (XD3) at I/O-Board of Station
5	Analog cable, 15-pin, cross over (red endings, Order No. 533039)
6	24 V DC power supply
7	Connector cable 24 V DC for simbox power supply

9.5 EasyPort USB and MPS® PA Compact Workstation

All cable connections are described as an example for a MPS® PA Compact Workstation with the EasyPort USB.

- Connect 4 mm safety plugs cable (7, red and blue) to the EasyPort USB screw terminals (24V/0V)
- Connect port 1 (Digital I/O) of the EasyPort USB with the XD1 socket of the I/O terminal (2) of the station with a SysLink cable (3).
- Connect port 3 (Analog I/O) of the EasyPort USB with the XD3 socket of the analog terminal (4) of the station with analog cable (5).
- Connect your PC to the EasyPort USB by means of a USB data cable (8).
- Connect EasyPort USB to 24 V DC power supply unit with 4 mm safety plugs cable (red = + / blue = —).



Cable connections MPS® PA Compact Workstation – EasyPort USB

Key

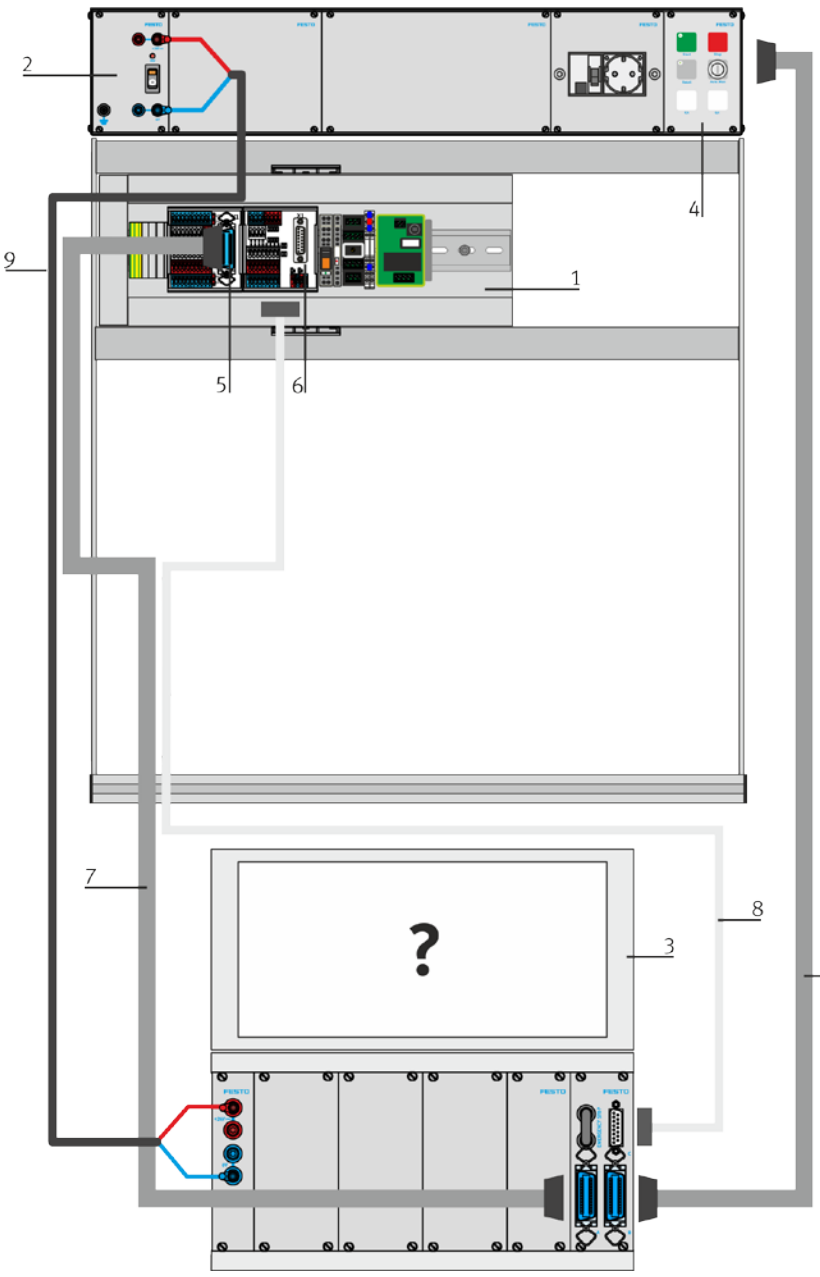
1	Easyport USB
2	I/O terminal SysLink
3	SysLink-cable, I/O- data cable with SysLink, 20 pol (grey endings, Order No. 034031)
4	Analog terminal
5	Analog cable, 15-polig, parallel (Order-No. 529141)
6	24 V DC power supply
7	universal cable set with 4 mm safety plugs (red/blue)
8	USB-cable

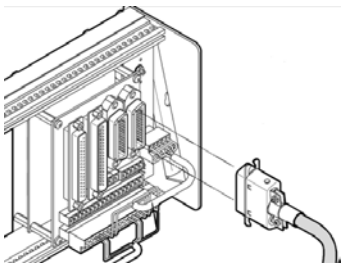
9.6 EduTrainer Universal with PLC

9.6.1 EduTrainer Universal without power supply

All cable connections are described as an example for a MPS® PA Compact Workstation with a PLC EduTrainer Universal **without power supply** inside the EduTrainer:

- Connect SysLink plug A of the Edutrainer (3) with the XD1 socket of the I/O terminal of the station with a SysLink cable (7).
- Connect the analog plug C (8) of the PLC /controller with the XD3 socket of the analog terminal (4) of the station with analog cable (5).
- Connect SysLink B (1/C) with the XMA plug of the control panel.
- Connect 4 mm safety plugs (red and blue) of the EduTrainer and power supply unit with 4 mm safety plugs cable (red = + / blue = —).
- Connect your PC to the PLC by means of a programming or network cable (no illustration).





Key

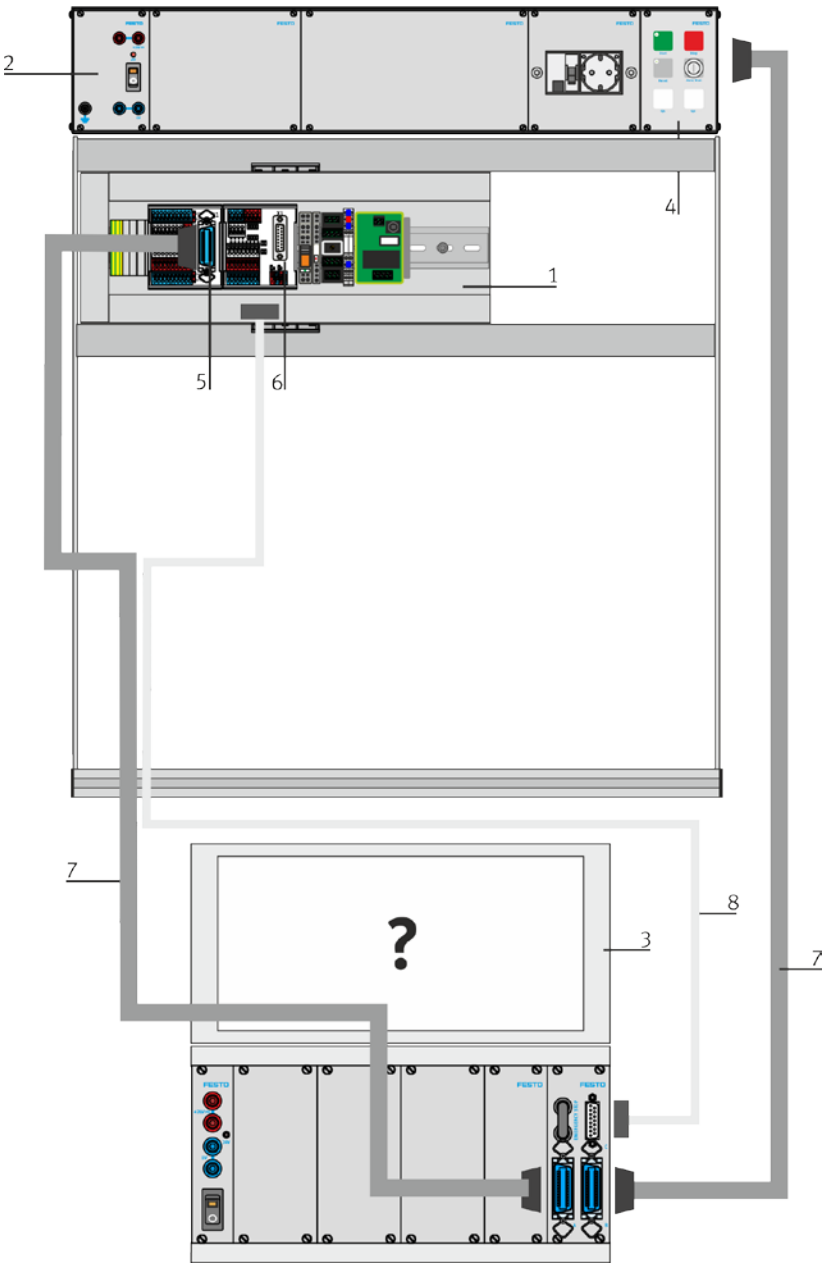
1	I/O-board MPS-PA Compact Workstation
2	Power supply 24 V DC, 4,5 A
3	Edutrainer Universal with PLC
4	19“ Control panel
5	I/O-terminal SysLink
6	Analog terminal
7	I/O data cable SysLink, parallel (034031)
8	Analog cable, 15-PIN, parallel (529141)
9	24 V connecting cable on 4 mm safety plugs

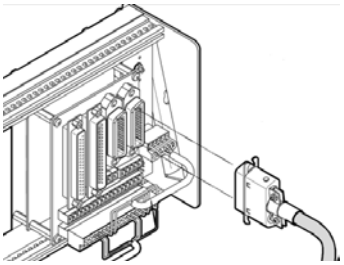
Cable connections MPS® PA Compact Workstation – EduTrainer Universal **without** power supply 24 V DC

9.6.2 EduTrainer Universal with power supply

All cable connections are described as an example for a MPS® PA Compact Workstation with a PLC EduTrainer Universal **with** power supply inside the EduTrainer:

- Connect SysLink plug A of the Edutrainer (3) with the XD1 socket of the I/O terminal of the station with a SysLink cable (7).
- Connect the analog plug C (8) of the PLC /controller with the XD3 socket of the analog terminal (4) of the station with analog cable (5).
- Connect SysLink B (1/C) with the XMA plug of the control panel.
- Connect your PC to the PLC by means of a programming or network cable (no illustration).





Key

1 I/O-board MPS-PA Compact Workstation
2 Power supply 24 V DC, 4,5 A
3 Edutrainer Universal with PLC
4 19“ Control panel
5 I/O-terminal SysLink
6 Analog terminal
7 I/O data cable SysLink, parallel (034031)
8 Analog cable, 15-PIN, parallel (529141)

Cable connections MPS® PA Compact Workstation – EduTrainer Universal **with** power supply 24 V DC

9.7 Visualization project for touch panel

Ther are several options to operate the MPS-PA Compact Workstation with a EduTrainer-Universal PLC (Control-Kit) through a touch panel (HMI = human machine interface). For the illustrated PLC types are example visualization projects available.

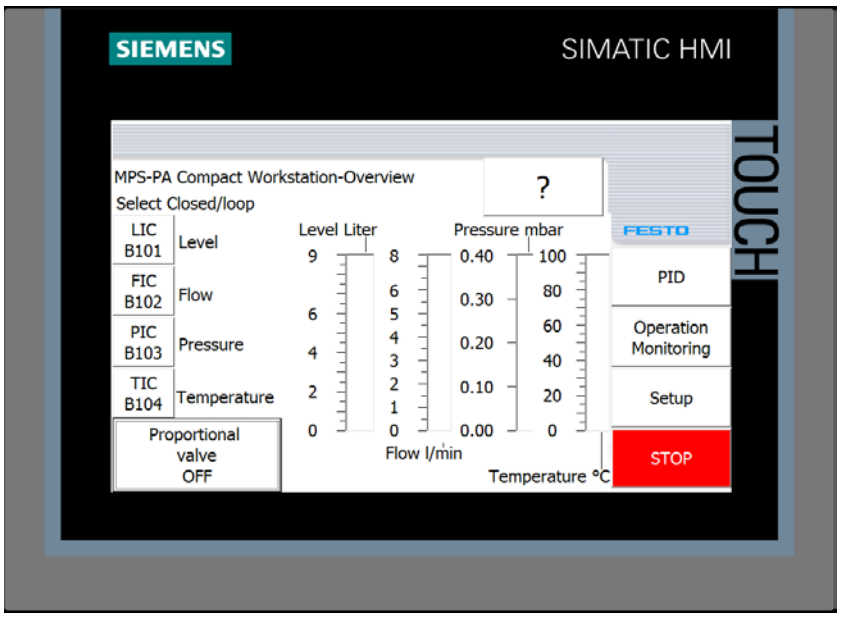
EduTrainer Universal with PLC	Touch panel (HMI)	Communication	Software for visualization project
Siemens S7-300 (PN) 	Siemens TP700 Comfort 	Industrial Ethernet/Profinet	Siemens Simatic Step7 Professional V14 WinCC Advanced V14
Siemens S7-1200 	Siemens KTP700 Basic 	Industrial Ethernet/Profinet	Siemens Simatic Step7 Professional V14 WinCC Basic V14
Siemens S7-1500 	Siemens TP700 Comfort 	Industrial Ethernet/Profinet	Siemens Simatic Step7 Professional V14 WinCC Advanced V14
Festo CDPX 7“ with integrated Codesys PLC 		Industrial Ethernet	Festo Designer Studio V1.90
AB CompactLogix 	AllenBradley PanelView +700 	EtherNet/IP	Rockwell Automation Factory Talk View V7.0 Machine Edition

In general the physical connection between PLC and touch panel is established with a network cable using RJ45 plugs.

EduTrainers with Siemens S7-300 CPUs without Ethernet-interface are connected via MPI-protocoll. Then the physical connection is done with a bus cable (RS485).

9.8 Visualization projcet

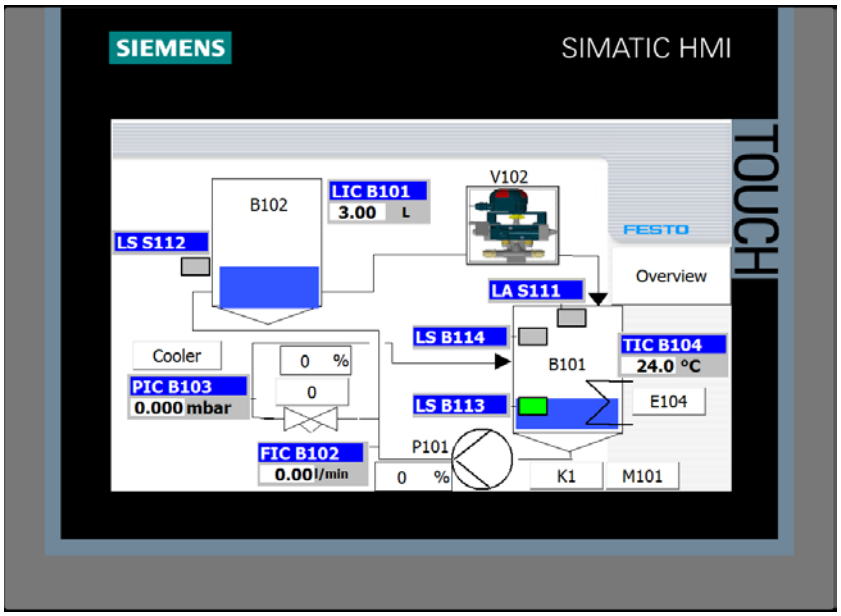
The touch panel visualization project starts with the main page. As an example the visualization project for a Siemens touch panel TP700 Comfort is illustrated.



Visualization project example TP700 Comfort – main page

Choose subordinate pages from the main page (starting picture) with functions for:

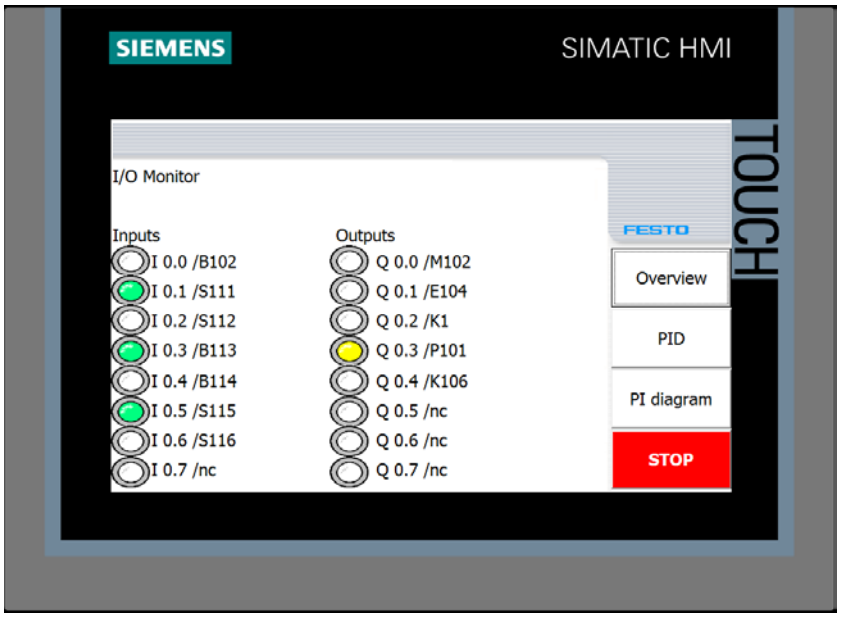
- Manual operation or after selection of the control-loop: PID controller
- Monitoring
- Setup – select language for DE, EN, ES, FR and parameter
- STOP: abbort all active functions
- Selection of the control-loop: Level-Flow-Pressure-Temperature
- Select proportional valve for control-loops flow or pressure
- Bargraph of analoge process values



Visualization project example TP700 Comfort – Manual operation

Functions:

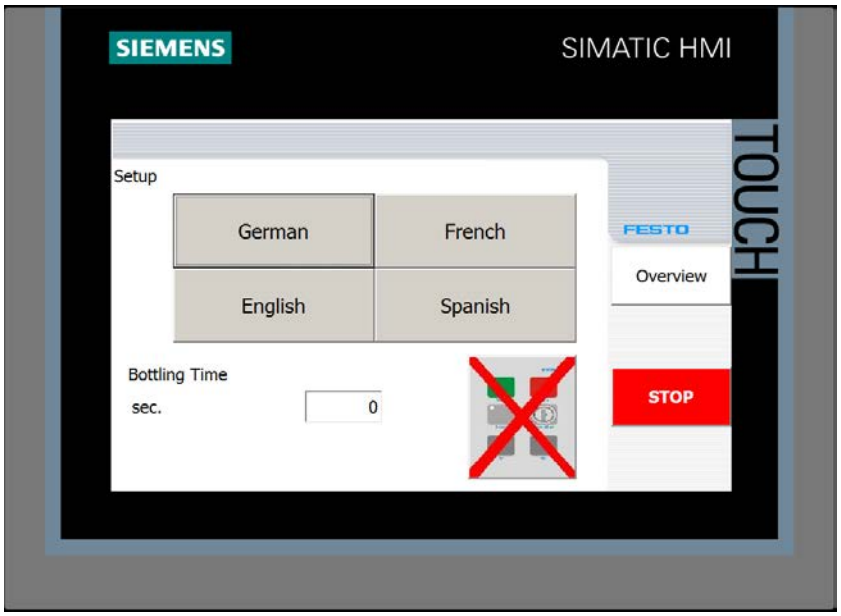
- Display sensor signals
- Operating actuators, switching and continuous
- Station overview of PCE-task and final control elements



Visualization project example TP700 Comfort – Monitoring

Functions:

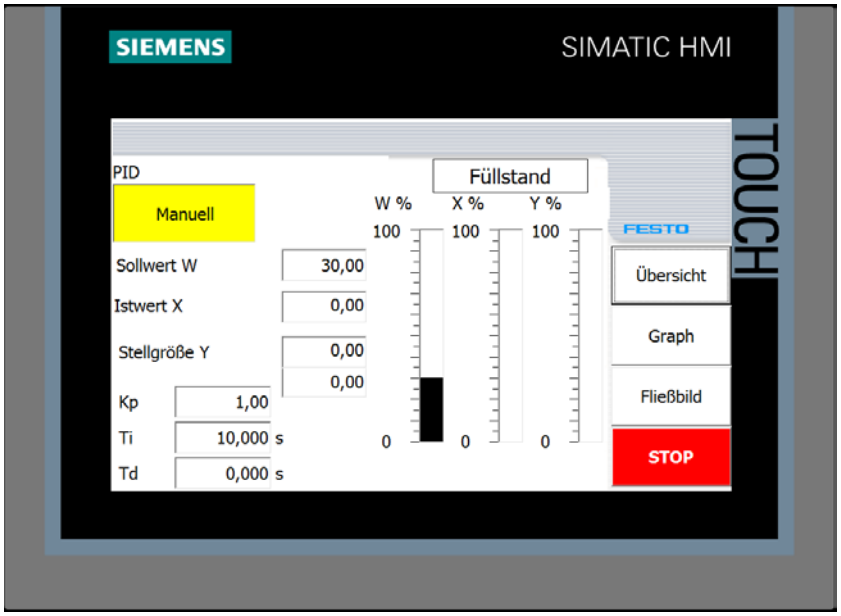
- Display signals of binary inputs and outputs.
- STOP: abbort all active functions



Visualization project example TP700 Comfort – Setup

Functions:

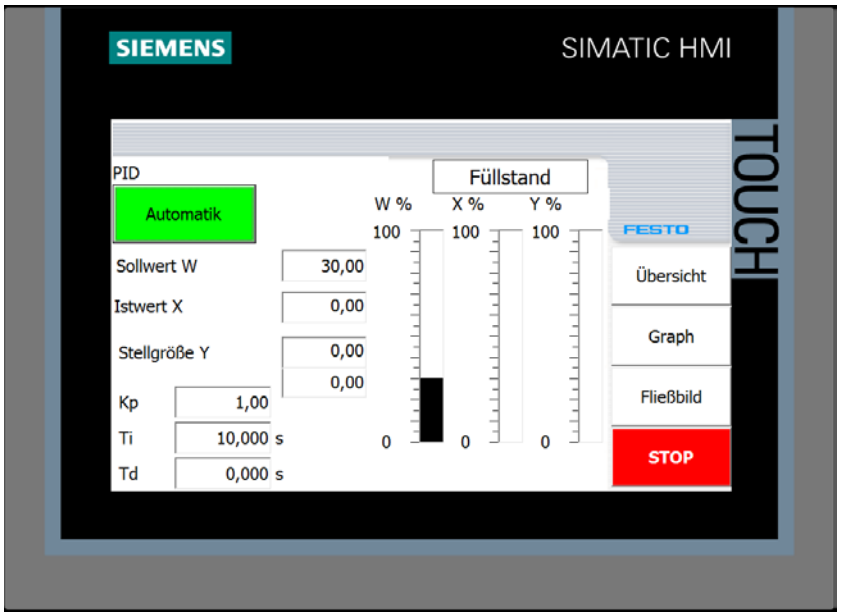
- select language for DE, EN, ES, FR
- setting parameters for bottling time, when bottling function is switched on for level control
- setting 19” control panel connected: activated/ deactivated (see illustration)
  Notice: if activated and the control panel is not truly connected than the STOP-input (normally closed) abborts all functions!



Visualization project example TP700 Comfort – PID controller in manual mode

Functions:

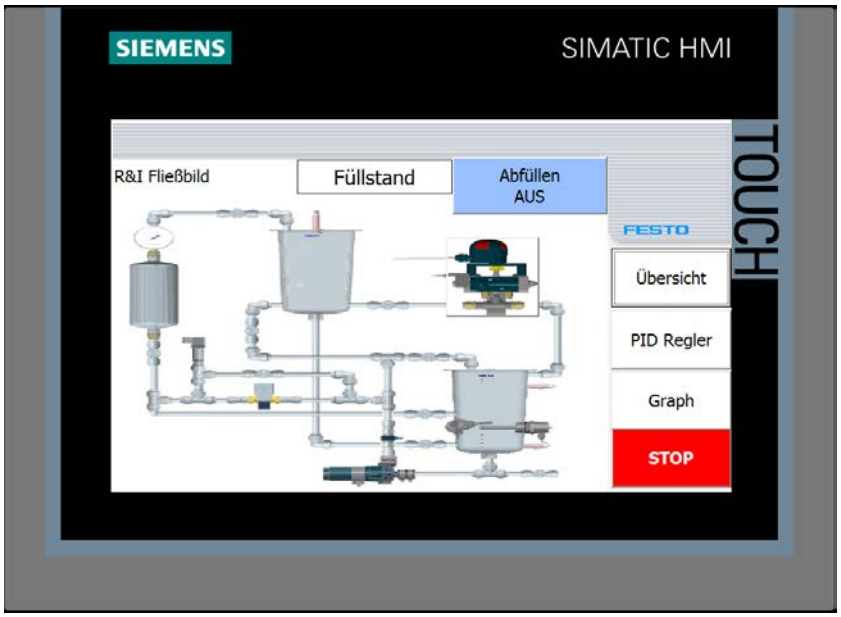
- Display and operation of controller values and parameters.
- Operation of Manual and Automatic Mode of the controller. If Manual is selected the manual manipulated value is activ.



Visualization project example TP700 Comfort – PID controller in automatic mode

Functions:

- Display and operation of controller values and parameters.
- Operation of Manual and Automatic Mode of the controller. If Automatic is selected the controller forms the manipulated value.
- STOP: abbort all active functions



Visualization project example TP700 Comfort – P&I diagram

Functions:

- Activate bottling process for level control
- STOP: abbort all active functions

9.9 Adjusting sensors

9.9.1 Capacitive proximity sensor BG13/BG14

The two capacitive proximity sensors are used to determine liquid level in the lower tank and are to be adjusted such as to enable the contactless sensing of the liquid in the container, but not the wall of the container. The liquid changes the capacity of a capacitor integrated into the proximity sensor.

> Notes
> The capacitive proximity sensors are used to sense the liquid level of both the lower and upper liquid levels of the tanks.

Prerequisites

- The tank and a profile for the attachment of the mounting bracket are assembled
- The electrical connection of the capacitive proximity sensor is established
- The power supply is switched on.

Procedure

1. Mount the proximity sensors onto the mounting bracket so that they do not touch the tank, each at a distance of 5 mm from the tank.
2. Fill the tank with liquid.
3. The proximity sensors are set at the following values:
   – 2 l (bottom); 6 l (top)
   – Move the switches up or down until the switching status display (LED) switches on at the respective volume level.

> Note
> The proximity sensors must be triggered by the liquid in the tank. If there is no liquid in the tank, there must be no signal available.
> Check the positioning and setting of the proximity sensor by repeatedly filling and emptying the tank.

9.9.2 Float switch SG12/SG17

The float switch is to be fitted into the tank wall. The float switch opens if the minimum level of liquid in the tank B102 (SG12) is exceeding and switches a binary signal at the SysLink terminal or is used as dry-run protection in tank B101 (SG17) to prevent activation of the heater.

Note:
The float switch can be used for raising water levels as well as for falling levels. Therefore turn the float switch mechanically 180°.

Prerequisites

- The tank is mounted
- Electrical connection of the float switch is established
- The power supply is switched on.

Note:
Make sure that the flow always moves freely and is not stuck due to dirt.

Procedure

- The float switch is to be fed from the inside of the tank through the opening in the tank wall and the screw tightened externally.
- Connect the float switch and operate by hand. The switch must emit a signal without any liquid.
- Fill the tank and establish whether the float switch activates the signal if the minimum liquid level is exceeded. The float must turn into a horitontal position upwards.
- Check the positioning and setting of the sensor by repeated emptying and filling.

9.9.3 Float switch SG11

The float switch is to be fitted into the tank cover. The float switch opens if the maximum level of liquid in the tank B101 (SG11) is exceeding and switches **off** a binary signal at the SysLink terminal.

> Note:
> The float switch can be used as normally closed or normally open contact. Therefore turn the float mechanically 180°.

Prerequisites

- The tank is mounted
- Electrical connection of the float switch is established
- The power supply is switched on.

> Note:
> Make sure that the flow always moves freely and is not stuck due to dirt.

Procedure

- The float switch is to be fed from the inside of the tank through the opening in the tank cover an.d the screw tightened externally.
- Connect the float switch and operate by hand. The switch must emit a signal without any liquid.
- Fill the tank and establish whether the float switch activates the signal if the minimum liquid level is exceeded. The float must move into a vertical position upwards.
- Check the positioning and setting of the sensor by repeated emptying and filling.

9.9.4 Ultrasonic sensor BL1

The ultrasonic sensor is fitted into the tank cover. It emits an inaudible ultrasonic signal, which bounces back to the receiver in the sensor housing after reflection on an object, e.g. the liquid. The ultrasonic sensor supplies an analogue signal (4 – 20 mA) in relation to the fill level.

Prerequisites

- The tank is assembled.
- The electrical connection of the ultrasonic sensor is established.
- The sensor is screwed into the tank cover such that the LED is not illuminated, if the container is empty.
- The power supply is switched on.

Procedure

The LED must be illuminated even if the level of liquid is minimal. The sensor must be re-adjusted via the securing nuts if this is not the case.

> Note
> Make sure that the emitter side of the sensor is always clean.

9.10 Choosing controlled system

For using a specific controlled system integrated in the MPS® PA Compact Workstation see to following table for setup of the manual valves and actuators. Programming, configuration or parameterizing of the PLC or closed-loop controller depends on the chosen controlled system and used signal type. E.g. at controlled level system the ultrasonic sensor is used with a signal range of 4 to 20 mA. This signal is converted into a standard voltage signal of 0 to 10 V. Therefore the signal input at the controlling system has to be configured. Configuration of the PLC or closed-loop controller is depening on the used device. For the Compact Workstation following control types can be used:

- PLC, e.g. Simatic S7-1500 CPU 1512C
- EasyPort USB with educational software Fluid Lab®-PA closed-loop
- Simulation box digital/analog

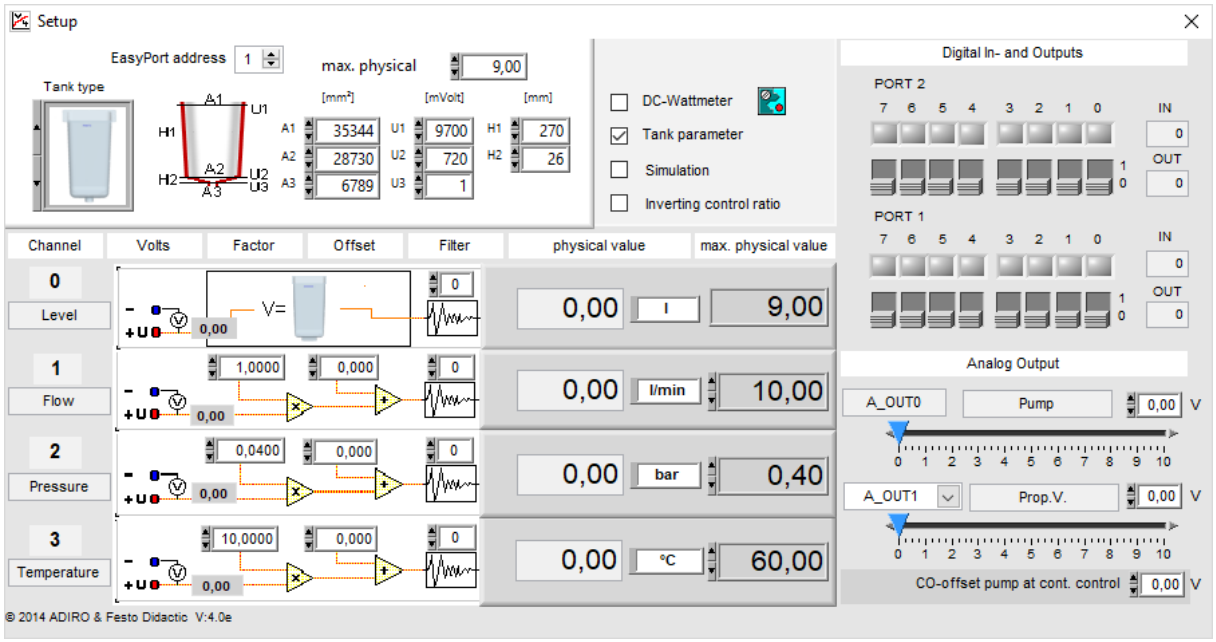
Component	Level controlled system fill from top	Level controlled system fill from bottom	Flow controlled system with actuator Pump P101	Flow controlled system with actuator Prop. Valve V106	Pressure controlled system with actuator Pump P101	Pressure controlled system with actuator Prop. Valve V106	Temperature controlled system
PCE task Sensor	LIC BL1		FIC BF2		PIC BP3		TIC BT4
Pump P101	controlling element		controlling element	binary On	controlling element	binary On	binary On
Prop. valve V106	Off	Off	Off	controlling element	Off	controlling element	Off
Heating element	Off	Off	Off	Off	Off	Off	controlling element
Hand valve V101	open	closed	closed	closed	closed	closed	closed
Ball valve V102	open/closed	open/closed	closed	closed	closed	closed	closed
Hand valve V103	closed	closed	closed	closed	open	closed	open
Hand valve V104	closed	closed	open	closed	closed	closed	closed
Drainage valve V105	closed	closed	closed	closed	closed	closed	closed
Hand valve V107	closed	closed	closed	closed	closed	closed	closed
Hand valve V108	closed	closed	closed	closed	open	open	closed
Hand valve V109	closed	closed	closed	open	open/closed	open/closed	open
Hand valve V110	closed	open	closed	closed	closed	closed	closed
Ball valve V111	closed	closed	closed	closed	closed	closed	closed
Hand valve V112	open/closed	closed	closed	closed	closed	closed	closed

Choosing the controlled system of MPS® PA Compact Workstation

9.11 Allocation list of inputs and outputs

Symbol	PIN assignment	EasyPort/ Simbox address	PLC address	Descritption
Binary inputs (XD1)				
-	1 (I 0)	I 0	%I0.0	Not used
SG11	2 (I 1)	I 1	%I0.1	Float switch tank B101 level high alarm
SG12	3 (I 2)	I 2	%I0.2	Float switch tank B102 level lower limit
BG13	4 (I 3)	I 3	%I0.3	Sensor, capacitive tank B101 level lower limit
BG14	5 (I 4)	I 4	%I0.4	Sensor, capacitive tank B101 level higher limit
BG15c	6 (I 5)	I 5	%I0.5	Position indicator 2way ball valve V102 position closed
BG15o	7 (I 6)	I 6	%I0.6	Position indicator 2way ball valve V102 position opened
-	8 (I 7)	I 7	%I0.7	Not used
Binary outputs (XD1)				
MB2	9 (Q 0)	Q 0	%Q0.0	Solenoid valve 2way ball-valve V102 open
EB4	10 (Q 1)	Q 1	%Q0.1	Heating ON, binary, in tank B101
KF1	11 (Q 2)	Q 2	%Q0.2	Relay, Preselction of pump P101 0=binary/1=analogue
MA1	12 (Q 3)	Q 3	%Q0.3	Motorcontroller Pump P101 binary ON
KF6	13 (Q 4)	Q 4	%Q0.4	Load relay for proportional valve V106 drive electronic KK6
(KF5)	14 (Q 5)	Q 5	%Q0.5	Optional: Switch-over relay K2 water-air cooler
-	15 (Q 6)	Q 6	%Q0.6	Not used
(M121)	16 (Q 7)	Q 7	%Q0.7	Optional: 2way solenoid valve V121 open cooling circuit
Analogue inputs (XD3)				
LIC BL1	1 (UE1)	AE 0	IW4	Process value PV, level in tank B102
FIC BF2	2 (UE2)	AE 1	IW6	Process value PV, flow rate in pipe system
PIC BP3	3 (UE3)	AE 2	IW8	Process value PV, pressure in pipe system optional: with waterair-cooler, rotation of fan motor
TIC BT4	4 (UE4)	AE 3	IW10	Process value PV, temperature in tank B101
Analogue outputs (XD3)				
MA1	9 (UA1)	AO 0	QW4	Manipulated output CO, pump P101
MB6	10 (UA2)	AO 1	(QW6	Manipulated output CO, proportional valve V106 optional: with waterair-cooler, speed of fan motor

9.12 FluidLab-PA closed-loop settings



Adapt tank parameters U1, U2 and U3 individually.

9.13 Loading the PLC program

9.13.1 Siemens S7-1500 CPU 1512C

Use f.g. an EduTrainer Universal with Siemens S7-1500 CPU1512C.
Programming software: Siemens STEP7 Version 14 (SP1) or higher

1. Connect PC and PLC using the network cable
2. Switch on the power supply unit
3. Switch on the compressed air supply
4. Release the EMERGENCY-STOP switch (if available)
5. Overall reset PLC memory
6. CPU switch in STOP position
7. Start the PLC programming software
8. Dearchive the file **CWS_Level_CPU1512C.zap14** from the directory …\Sources\PLC\S7-1500\ of the supplied CD-ROM.
9. Load the project to the PLC. Look for help at Getting Started

10. CPU switch in RUN position

9.13.2 Festo CDPX

Controller: Festo CDPX with integrated Codesys V3 controller
Programming software PLC: Codesys V3.5 pbF
Programming software HMI: Designer Studio V2.x

1. Connect the PC and controller using a network cable.
2. Switch on the power supply.
3. Switch on compressed air supply.
4. Release EMERGENCY-STOP pushbutton (if available).
5. Start the programming software.
6. Dearchive the file e.g. C41025_MPS-PA_CWS_PCKO0016_CDPX.zip in the directory …\Sources\PLC\CDPX\ of the CD-ROM provided
7. Compile the project.
8. Download the project to the controller with Codesys and to the HMI with Designer Studio.

9.14 Filling and deaeration

It is recommended to use FluidLab-PA closed-loop with EasyPort USB or Simulation box to control ouputs:

- 2-way ball valve V102,
- pump P101,
- proportional valve V106,

during commissioning. Also it is possible to dearate the system by using the PLC example program “Level”.

1. Before filling the system with water close drainage valve V105.
2. Before filling the system with water close all hand valves
3. Switch of power supply!
4. Turn off compressed air supply!
5. Fill container only if power supply is switched off!
   Water spray can cause short circuits.
6. Fill the lower tank B101 up to a water level of 10 l in quality of drinking water. Fill up lower tank B101 with water until the upper capacitive sensor BG14 is activated. Float switch SG11 for overflow safety function must not be activated!
7. Clear of water spray!
8. Switch on power supply 24 VDC.
9. Switch on pump P101 and pump water to the upper tank B102. Therefore open hand valve V101 (or RESET and START program).
10. Close hand valve V101 and open hand valve V103 and proportional valve V106.
11. Close hand valve V103 and proportional valve V106.
12. Switch of pump P101 (or STOP program)
13. There will be loss of water in the piping system visible in the lower tank after deaeration. Refill lower tank and compensate the water (as described in 5.).

9.15 Start sequence PLC example program “Level”

Please find on the CD which is enclosed to the technical documentation a PLC program for a closed loop level control. In following you find a description for starting the sequence.

1. Check voltage power supply and compressed air supply.
2. Choose controlled system and setup hand valves according to commissioning table (6.10).
3. Activate RESET sequence. The RESET sequence is prompted by the illuminated RESET pushbutton and executed when the pushbutton has been pressed. Normal position of the station is defined if water level in lower tank is filled and following digital sensors are activated:

Float switch SG11 for overflow savety	not activated
Upper limit switch BG14	activated
Lower limit switch BG13	activated
Float switch S112 for threshold (upper tank)	not activated

4. Start the sequence of the MPS® PA Compact Workstation. The start is prompted by the illuminated START pushbutton and executed when the push button has been actuated.
5. It program is started operation mode “logic control” is running and indicated with light Q1.
6. The pump P101 delivers process fluid from the lower storage tank B101 into the upper reservoir tank B102. As soon as the level rise up to the float switch SG12 is activated the PLC is changing operation mode from logic control to close-loop control. Light Q2 is indicating operation mode close-loop control. Filling level is monitored with the ultrasonic sensor B102 (actual value) and controlled up to the setpoint (fixed value at startup of PLC). If the water level has reached the setpoint and the steady-state of e.g. bottling pressure is reached ball valve V102 is opened time controlled. After bottling time t the ball valve V102 is closed and once again the water level controlled to setpoint. After setpoint is reached again another bottling process is started, etc.
7. The program is stopped automatically if the water level in the lower storage tank is lower than the limit switch B113 (deactivated).

By pressing STOP pushbutton the ball valve V102 is closed and the pump P101 switched off. The sequence program is stopped.

9.16 Notice

- By pressing STOP or Emergency pushbutton the sequence program is stopped.
- Warning: fluid is flowing from the upper tank into the lower tank through the deactivated pump if vlave V101 is open.
- Reset-sequence:
  If after STOP or start-up the system is not in normal position the reset sequence is prompted by the illuminated RESET pushbutton and executed when the pushbutton has been pressed. During RESET sequence fluid is drained from upper tank B102 to lower tank B101 therefore ball valve V102 is opened until normal position is reached.
- Setpoint and control parameters can be choosen at Step7 Online table "Closed-Loop Parameter“, at a touch panel or SCADA system. If the setpoint is choosen too high and the water level in the lower tank is dropped below limit switch BG13 the sequence is automatically stopped. Reset system and choose a smaller setpoint!

10 Maintenance and troubleshooting

The MPS® PA Compact Workstation is largely maintenance-free. The following should be cleaned at regular intervals using a soft fluff-free cloth or brush:

- The lenses of the optical sensors, the fibre-optics and reflectors
- The active surface of the proximity sensor
- The entire station: profile plate, trolley, frames, etc.

Do not use aggressive or abrasive cleaning agents.

Note:
Always use water in quality of drinking water. If the MPS® PA Compact Workstation is not used for a longer period of time all water should be drained from the system. It is recommended to clean of remaining water from the piping system and from tanks by using a vaccum cleaner for fluids. Also wipe dry with a soft fluff-free cloth.

Please notice savety information of data sheets!

10.1 Faults in piping system or tanks

The following table shows faults that can be simulated by using the hand valves or are caused by incorrect operation.

Location	Fault / disturbance / risk potential	Implication ?	How to manipulate?	How to determine or prevent?
Faults in piping system or tanks				
upper tank B102	leakage at upper tank	longer filling time or level is not raising	open valve V110 between upper and lower tank somewhat	observe level measuring in FluidLab PA
upper tank B102	apply load to the level system	longer filling time	open valve V102 with FluidLab PA or IO Sim	observe level measuring in FluidLab PA
manual valve V101	restrict inlet to upper tank	longer filling time or increase of pump pressure in piping	throttle manual valve V101	observe level, pressure or flow rate measuring in FluidLab PA
pressure tank B103	overflow of water to lower tank	not enough water in lower tank if upper tank is empty. If lower tank is refilled than high potential for overflow.	manual valves V104+V101 close, V103+V108+V107 open, pump until part of lower tank is in pressure tank B103, then close V107+V108, Pump off. Water now is “hidden” in tankB103	read levels in the tanks and at the inspection pipe at pressure tank.
lower tank B101	Pump draws air.	Noise at pump and air bubbles in the inspection riser pipe.	Store water in upper tank or limit return flow, so level in lower tank drops to minimum.	visual inspection and acoustic observation.
manual valve V108	raise pressure drop	pressure drop in pump piping	slightly closing manual valve V104, V101 close, V103 and V108 open,	observe level or flow measuring in FluidLab PA
heating W104	no heat emission	The heating rod electronic is not activated. No green LED displayed.	water level in tank B101 is too low or water was transported into tank B102 or B103, float switch is not mechanically operated	visual inspection
upper tank B102	Fluctuating signal of the level	Displayed values in software/touch panel are noisy or have signal fluctuations	Water splashes from above without downpipe in the tank	observe curve in FluidLab PA or at touch panel
fill upper tank B102 via manual valve V101	Water runs from above back into the bottom tank when filling	Level can not be kept constant	Pump voltage offset too low, no check valve installed	visual inspection or observe curve in FluidLab PA or at touch panel

10.2 Failure in pneumatic system

The following table shows faults that can be simulated by using the pneumatic componets or are caused by incorrect operation.

Location	Fault / disturbance / risk potential	Implication	How to manipulate?	How to determine
Failure in pneumatic system				
service unit or compressor	no pressurized air supply	2 way ball-valve not opening if a output signal of 24 VDC is applied	Compressor switched off, pressure supply hose not connected, manual valve at service unit switched off or pressure regulator at service unit set to a low pressure	Visual inspection at pressure gauge of service unit
supply hose compressor or pressure outlet to sevice unit; feed line to quarter-turn actuator	Pneumatic hose squeezed	2 way ball-valve not opening if a output signal of 24 VDC is applied	bend hose and secure with cable tie	disconnect air hose at solenoid valve, hold hose tight and switch on pressure, observe if pressurized air is blowing out
quarter-turn actuator of 2way ball-valve V102	solenoid valve blowing off uncontrollable	quarter-turn actuator not turning, ball-valve not opening	set pressure regulator at service unit to a low pressure □ 3 bar	Acoustic inspection of blow off noise.
quarter-turn actuator of 2way ball-valve V102	Slow or no movement	quarter-turn actuator not turning, ball-valve not open-/closing	turn adjustment screw of exhaust valve at solenoid to closing position	Visual inspection at quarter-turn actuator of 2way ball-valve V102

10.3 Electrical faults

The following table shows faults that can be simulated by using the electrical componets or are caused by incorrect operation.

Location	Fault / disturbance / risk potential	Implication	How to manipulate?	How to determine or prevent?
Electrical faults				
19“ frame power inlet plug, left/below	Power supply without function	no function	unplug CE connector or take out micro-fuse	visual inspection at power supply indicator light at power switch or measure voltage
I/O-terminal at I/O-board	No function at digital outputs	24 VDC outputs are not switching, no indication at LED	unplug SysLink-cable from I/O-terminal	visual inspection
heating W104, lower tank	Water is not heating up	no function at heating, LED is green	no load supply 230 V AC: power cable of heating disconnected or ground-fault circuit breaker switched off	Visual inspection, measure with volt meter
pump P101	low delivery rate	flow rate too low, filling time higher	at motor controller terminals 1 and 2 are switched	flow rate displayed/measured at appr. ~ 2 l/min
pump P101	low delivery rate	flow rate too low, filling time higher	at motor controller adjustement screw is turned counter clockwise with small screw driver	flow rate two low displayed/measured
SysLink i/o-terminal	signal conditions are not correct	signals are displayed wrong or not at all	Slide switch is to position NPN instead of PnP	visual inspection with datasheet, see drawing

10.4 Mechanical faults

The following table shows faults that can be mechanically simulated or are caused by incorrect operation.

Location	Fault / disturbance / risk potential	Implication	How to manipulate?	How to determine or prevent?
Mechanical faults				
quarter-turn actuator MM1 of 2way ball-valve V102	Quarter-turn actuator is not turning,	ball-valves is not closing	set mechanical blockade into ball-valve (special assembly!!!)	Inspection of function with electrical signals
Signal box of quarter-turn actuator, 2way ball-valve V102	Quarter-turn actuator indicates closed instead of opened	Signal box shows red instead of yellow at opened ball-valve	Open cap and disarrange indicator colours	Visual inspection
lower tank B101	Level indication too low/high	Digital input(s) not showing the correct/no signal	sensor mechanically disarranged or set to wrong position at profile	Visual inspection

10.5 Parameter faults

The following table shows faults that can be simulated or are caused by wrong setup of parameters or incorrect operation.

Location	Fault / disturbance / risk potential	Implication	How to manipulate?	How to determine or prevent?
Parameter faults				
pump P101	characteristic not linear	at level control a P-controller cannot eliminate the control error ER=0 of the I-system	system behaviour of the piping system, set offset at FluidLab-PA to zero!	setup offset of the manipulated value
flow sensor	flow measure is reacting too slow	contolled system is not controllable	signal damping dAP is set too high at sensor display or in software	Kennlinie aufzeichnen mit FluidLab-PA
upper tank B102	Level signal of tank and reading at software are not equal	measure error or inaccuracy	Adjust level sensor change parameters for tank geometry	Setup tank parameters in software FluidLab-PA or PLC-program
flow sensor	signal of flow sensor	sensor does not provide a measurement signal at the output	parameters of the sensor are deadjusted on the display	check parameter, see manual
Easyport	Bad communication	No connection to Easyport can be established	Change Easyport USB Address at Easyport manually	Visual inspection at the Easyport USB

11 Appendix

All documents are stored as pdf-files on the CD-ROM supplied.

11.1 Spare parts list

For MPS® PA Compact Workstation C40125 a spare part list is available upon request.

11.2 PI-diagrams

- MPS® PA Compact Workstation, basic design
- MPS® PA Compact Workstation, basic design, with water-air cooler
- MPS® PA Compact Workstation, basic design, with cooling unit

11.3 Electrical circuit diagrams

- MPS® PA Compact Workstation, basic design
- MPS® PA Compact Workstation, basic design, with water-air cooler
- MPS® PA Compact Workstation, basic design, with cooling unit
- Control panel

11.4 Pneumatic circuit diagrams

- MPS® PA Compact Workstation, basic design

11.5 Data sheets

Collection of data sheets for Learning System Process Automation