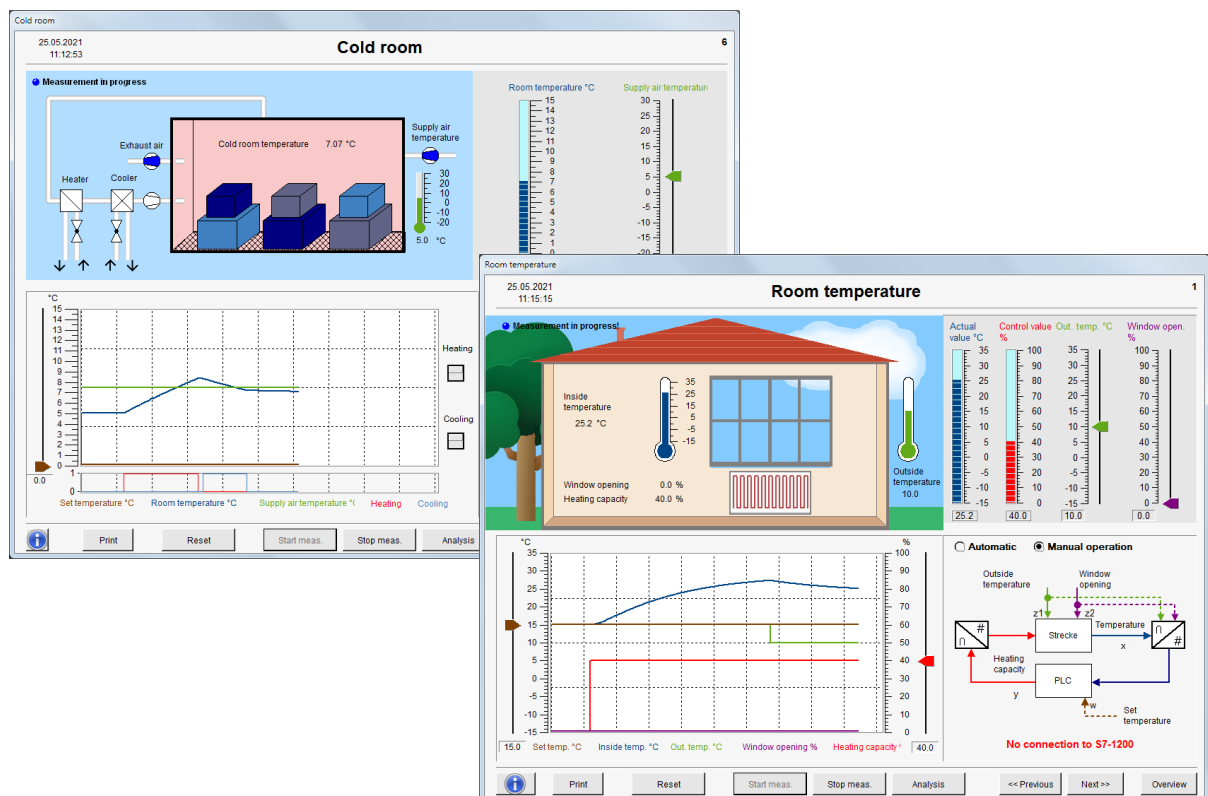
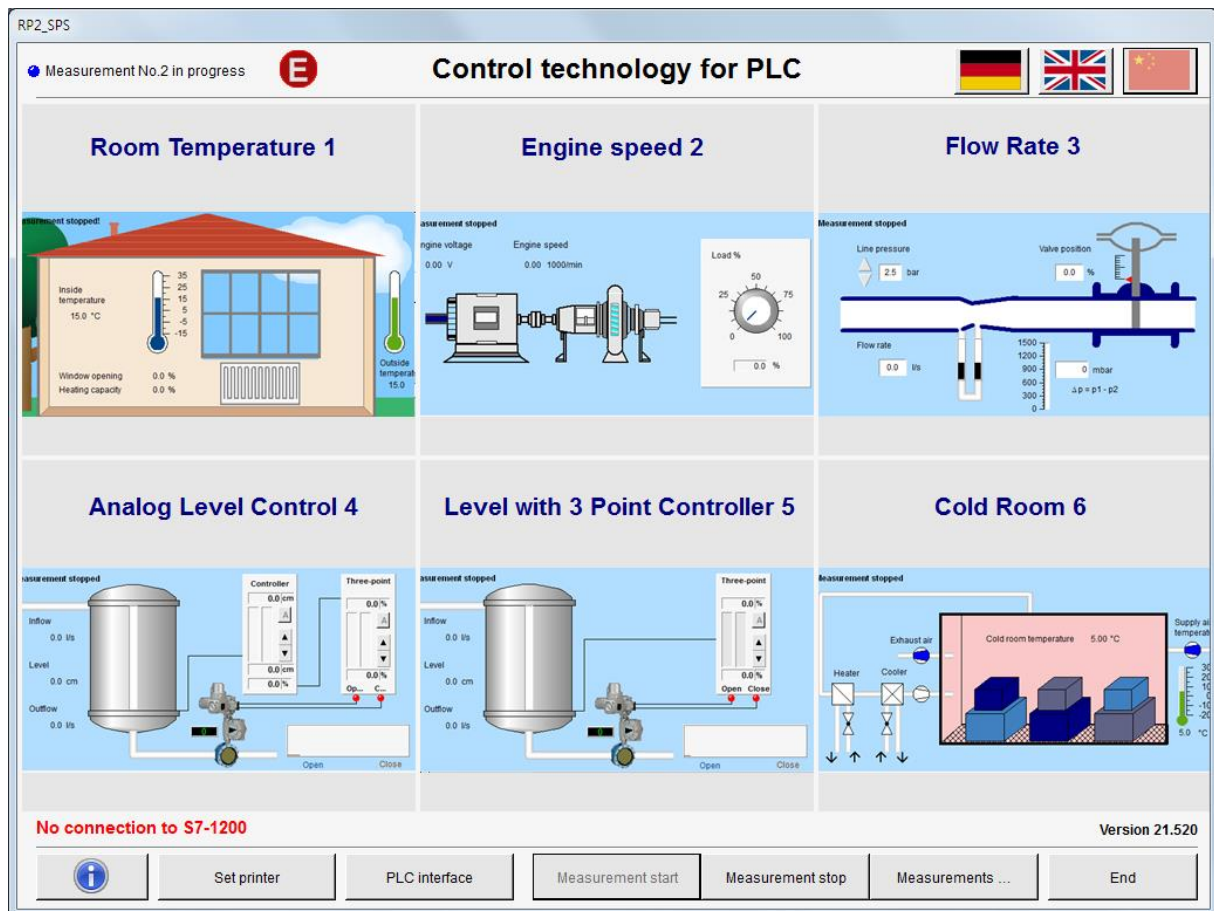


Control Technology for PLC



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Overview

The Control Training for PLC provides process simulations (control systems) which can be connected to a PLC (LOGO, S7-1200, S7-1500, S7-300).

There're 6 control systems: *Room temperature, engine speed, flow rate, liquid level, liquid level with 3 point controller, cooling room with 3 point controller.*

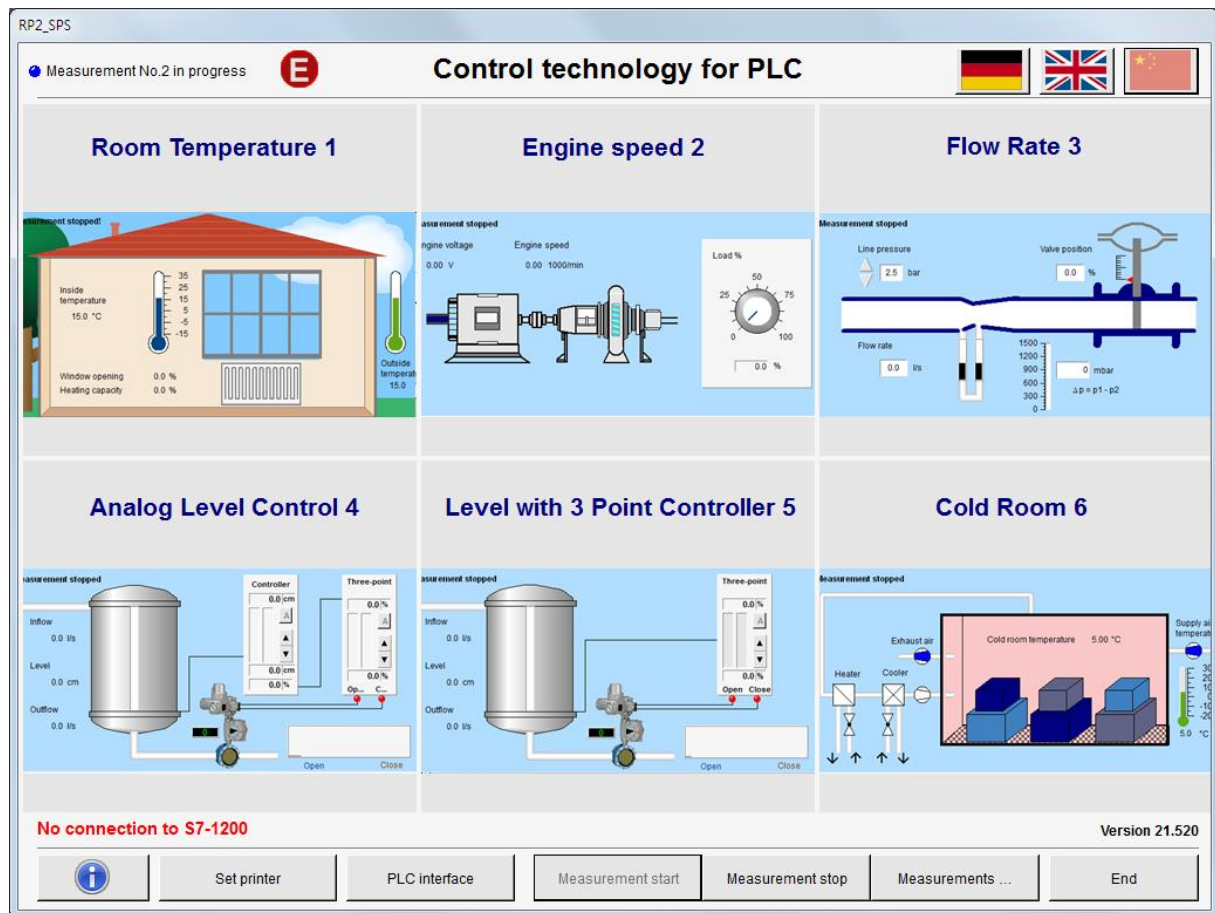
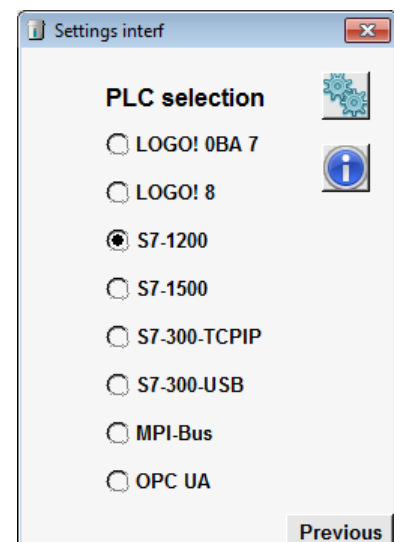


Figure 1: Start page of control training for PLC

All processes are displayed on the overview page. A click on a display opens the according page.

To choose a PLC use the button „PLC interface“. Following figure shows the possible selection.

All PLCs have a default IP address 192.168.0.1 (MPI-Bus excluded). The signals are assigned to flag-words and flags. Following table displays signal assignment.



The following table displays default assignment.

Notes to change the assignment can be found in a pdf file the program group.

Table 1: Signal Assignment in PLC

Configuration of driver for the connection with Control Training for PLC

Assignment binary signals:

Signal name	Description	Range	Type	for S7	Flag	Type	Address driver
K_Heater	Switches on heater of cold room		binary	Out	100	Bit	M100.0
K_Cooler	Switches on cooler of cold room		binary	Out	100	Bit	M100.1
F-VentilAuf	Valve control direction open		binary	Out	100	Bit	M100.2
F_VentilZu	Valve control direction close		binary	Out	100	Bit	M100.3
T_Hand	Manual control room temperature		binary	In	101	Bit	M101.2
M_Hand	Manual control engine		binary	In	101	Bit	M101.3
D_Hand	Manual control flow rate		binary	In	101	Bit	M101.4
F_Hand	Manual control level		binary	In	101	Bit	M101.5
K_Hand	Manual control cold room		binary	In	101	Bit	M101.6

Assignment analogue signals:

Signal name	Description	Range	Type	for S7	Flag	Type	Address driver
T_Ist	Room temperature	-35 - 35	analogue	In	20	DWord	MD20.IEEE
T_Aussen	Outside temperature	-35 - 35	analogue	In	24	DWord	MD24.IEEE
T_Fenster	Window opening	0 - 100	analogue	In	28	DWord	MD28.IEEE
M_Ist	Actual rotational speed	0 - 6	analogue	In	32	DWord	MD32.IEEE
M_Last	Total load engine/generator	0 - 100	analogue	In	36	DWord	MD36.IEEE
D_Ist	Actual flow	0 - 10	analogue	In	40	DWord	MD40.IEEE
D_LDruk	pipeline pressure	1 - 4	analogue	In	44	DWord	MD44.IEEE
F_Ist	Actual level	0 - 250	analogue	In	48	DWord	MD48.IEEE
F_Zulauf	inflow	0 - 100	analogue	In	52	DWord	MD52.IEEE
K_Ist	actual temperature cold room	0 - 15	analogue	In	56	DWord	MD56.IEEE
K_Zuluft	Supply air temperature cold room	-30 - 30	analogue	In	60	DWord	MD60.IEEE
T_Soll	Setpoint temperature	-35 - 35	analogue	In	64	DWord	MD64.IEEE
M_Soll	Setpoint rotational speed	0 - 6	analogue	In	68	DWord	MD68.IEEE
D_Soll	Setpoint flow rate	0 - 10	analogue	In	72	DWord	MD72.IEEE
F_Soll	Setpoint level	0 - 250	analogue	In	76	DWord	MD76.IEEE
K_Soll	Setpoint cold room temperature	0 - 15	analogue	In	80	DWord	MD80.IEEE
T_Y	Actuator heater	0 - 100	analogue	Out	84	DWord	MD84.IEEE
M_Y	Actuator engine	0 - 10	analogue	Out	88	DWord	MD88.IEEE
D_Y	Actuator flow rate	0 - 100	analogue	Out	92	DWord	MD92.IEEE
F_Y	Actuator level	0 - 100	analogue	Out	96	DWord	MD96.IEEE

If you'd like to change IP address or signal assignment have a look at the pdf file in the program group in the windows start menu.

The storage of measurements is started with the "Start meas." button and stopped with the "Stop meas." button.

„Measurements..." in the overview leads to a the measurements page where all measurements and trends can be viewed and managed.

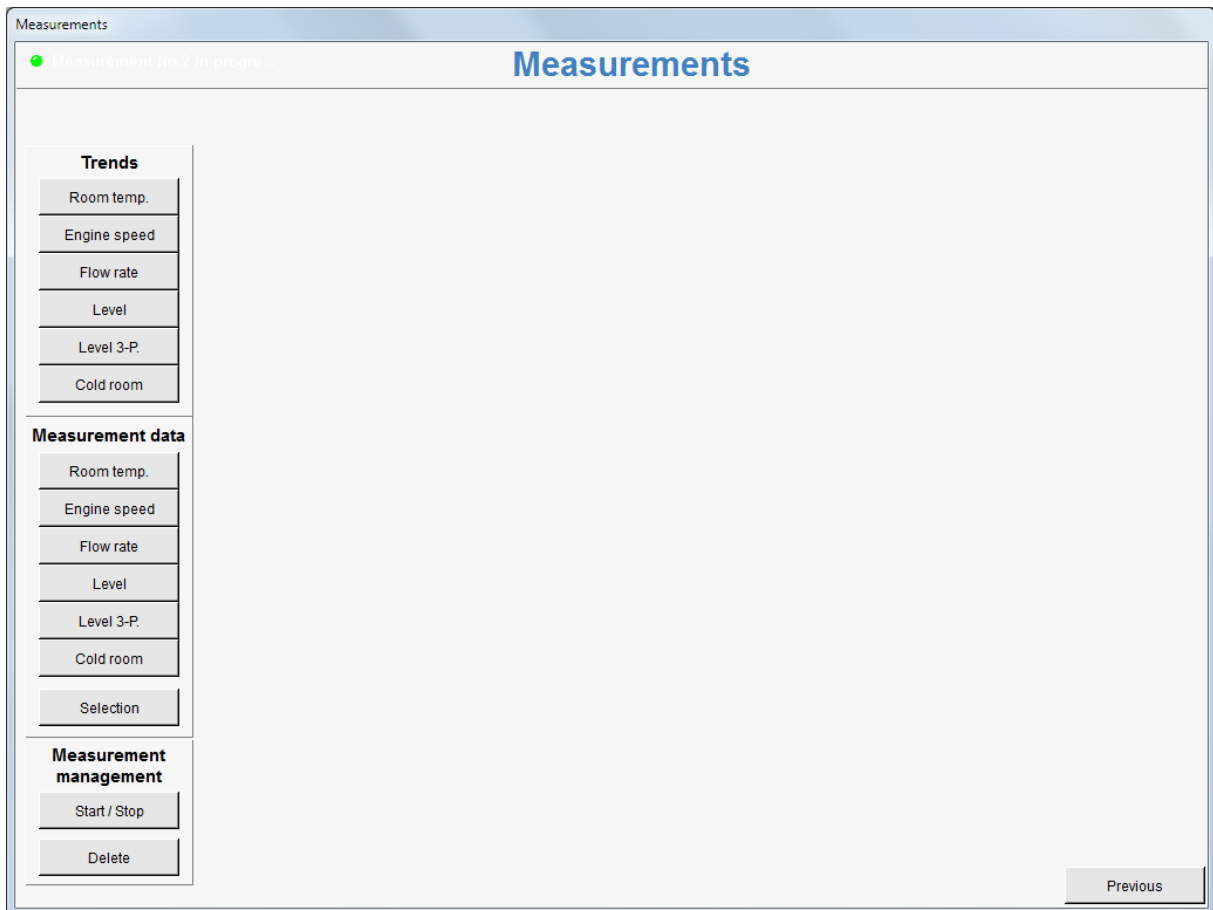


Figure 2: Measurements window with system selection

You can choose the displayed signal group by clicking the according button in the left column.

If you for example choose Room temp. A window with stored signals of the latest measurement will sign in, where you can see the stored signal path. The upper control bar allows following functions:

- Change time range numerically,
- Select time and display range by drag and drop,
- Restore original range,
- Search time frames with search criteria or specific measurement frame from batches, series and trials,
- Statistical analysis of displayed data,
- Statistical evaluation of data,
- Export displayed data to text file,

- Print measurement on selected printer. The signal graphic has up to 4 scales of analogue signals.
- Open help

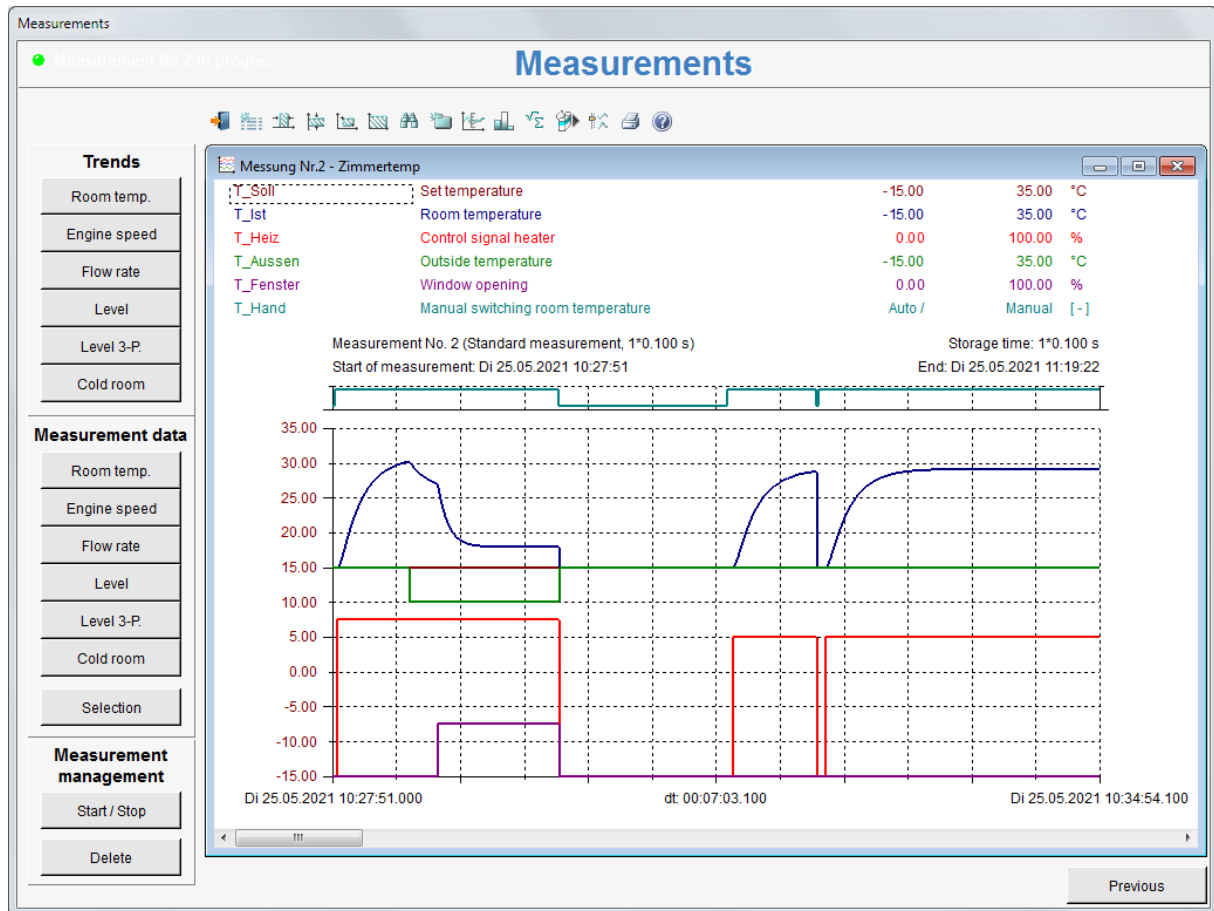


Figure 3: Measurement view of running measurement

With “Selection” you can choose from all measurements.

With “End” you can quit the program.

Control Systems

Room Temperature

This process consists a room, which is heated with an electrical heater. The exercise regarding control engineering is to control the temperature of the room by changing the heating power, so that it corresponds to a certain setpoint value. The heating power is the input variable, the inside temperature of the room is the output variable of the system. Outside temperature changes and window opening are disturbances (Figure 1).

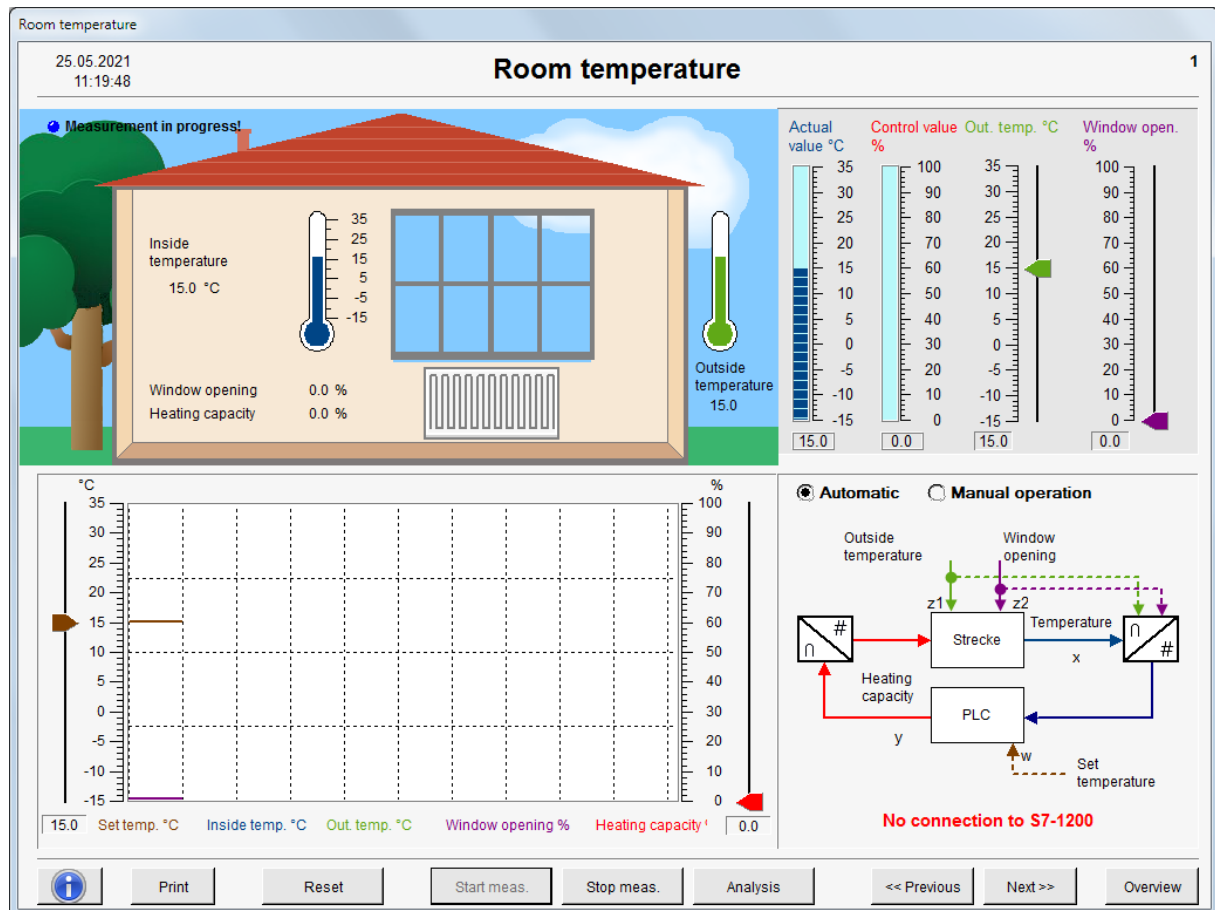


Figure 4: Process view of room temperature system

Following signals can be monitored:

- Temperature setpoint (command variable), range: -35 – 35 °C, Name: T_{Soll}
- Actual temperature (control variable), range: -35 – 35 °C, Name: T_{Ist}
- Heating power (actuator), range: 0 – 100 %, Name: T_Y
- Outside temperature (disturbance), range: -35 – 35 °C, Name: T_{Aussen}
- Window opening (disturbance), range: 0 – 100 %, Name: $T_{Fenster}$
- Manual operation, Name: T_{Hand}

The signals are assigned to following data words:

Table 1: Assignment of signals for room temperature system

Name	Description	Range	Type	for S7	Flag	Type	Address in driver
T_Hand	Manual control room temperature	0	binary	In	101	Bit	M101.2
T_Ist	Room temperature	-35 - 35	analogue	In	20	DWord	MD20.IEEE
T_Aussen	Outside temperature	-35 - 35	analogue	In	24	DWord	MD24.IEEE
T_Fenster	Window opening	0 - 100	analogue	In	28	DWord	MD28.IEEE
T_Soll	Setpoint temperature	-35 - 35	analogue	In	64	DWord	MD64.IEEE
T_Y	Actuator heater	0 - 100	analogue	Out	84	DWord	MD84.IEEE

All signals can be transferred into real values (float) and vice versa using range and format of “address in driver”.

The set point is adjusted with slide control or numerically in the window below slide control. The set point is an input signal for the PLC.

All disturbance variables are adjusted likewise, using slide control or numerically in the window below slide control. The disturbance variables are inputs for the PLC.

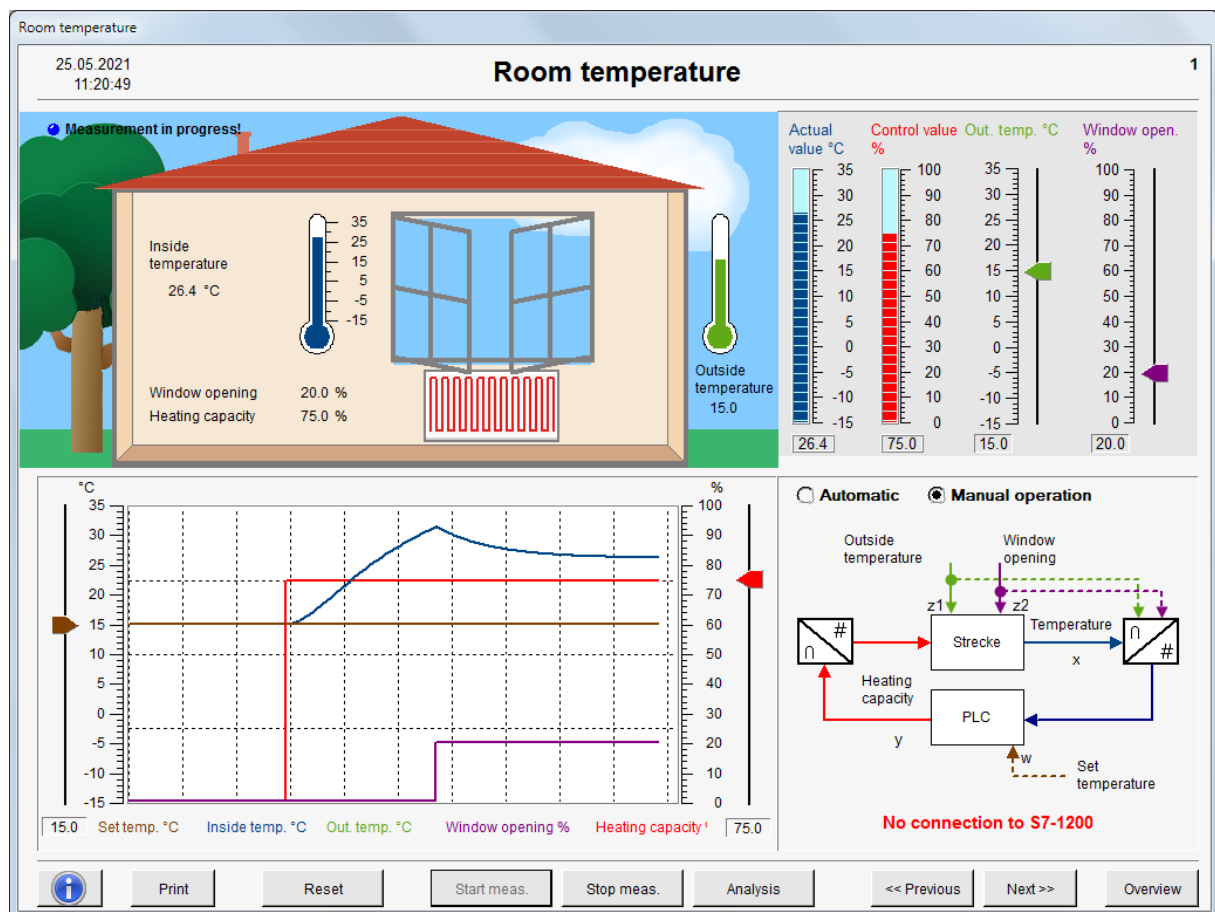


Figure 5: Adjusting the control variable in manual operation

The corrective signal (heating power) is an output of the PLC. In manual operation the corrective signal is adjusted via slide control or numerically in the window below slide control. Thereby you have the opportunity to analyse the system without using the PLC.

In automatic operation the corrective signal is calculated in the PLC and displayed in the process view. It effects the control system and influences the room temperature.

The signal T_Hand provides the PLC with the information if manual operation is on or off.

In the displayed process (Figure 5) window manual control is switched on an heating power is increased.

With "Start meas." And "Stop meas." Buttons a measurement is started or stopped.

The button analysis is only active with running measurement. When clicking analysis a sub window is opened, displaying all data of running measurement in a time diagram. The scale is adjusted when clicking on the corresponding signal. When clicking on signal curves the value of the active signal is displayed. With click and drag you see value and time differences and the gradient. In the bottom line is a menu bar with analysis tools zoom, change time range, change value range, ruler, export signals to text file and statistical evaluation (Figure 6).

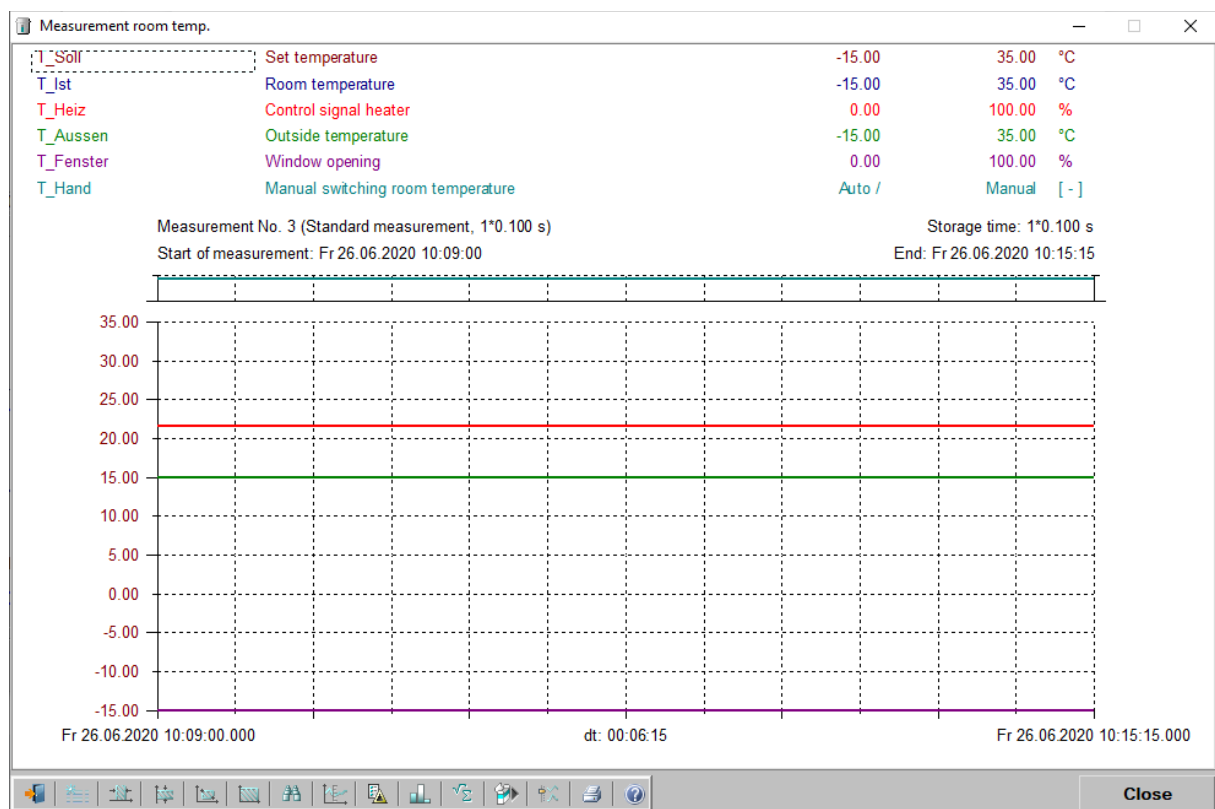


Figure 6: Measured values of room temperature

A detailed description of analysis tools opens when clicking the question mark.

The button „reset“ resets the simulation to it's initial values.

With „<< previous“ and „next >>“ you switch to according process views.

Engine Speed System

To evaluate the engine speed system the process view in Figure 7 is given.

This process is an engine, which's rotational speed shall be adjusted using the voltage. Therefore, the voltage constitutes the input variable, and the rotational speed the output variable of the system. The load acts as disturbance.

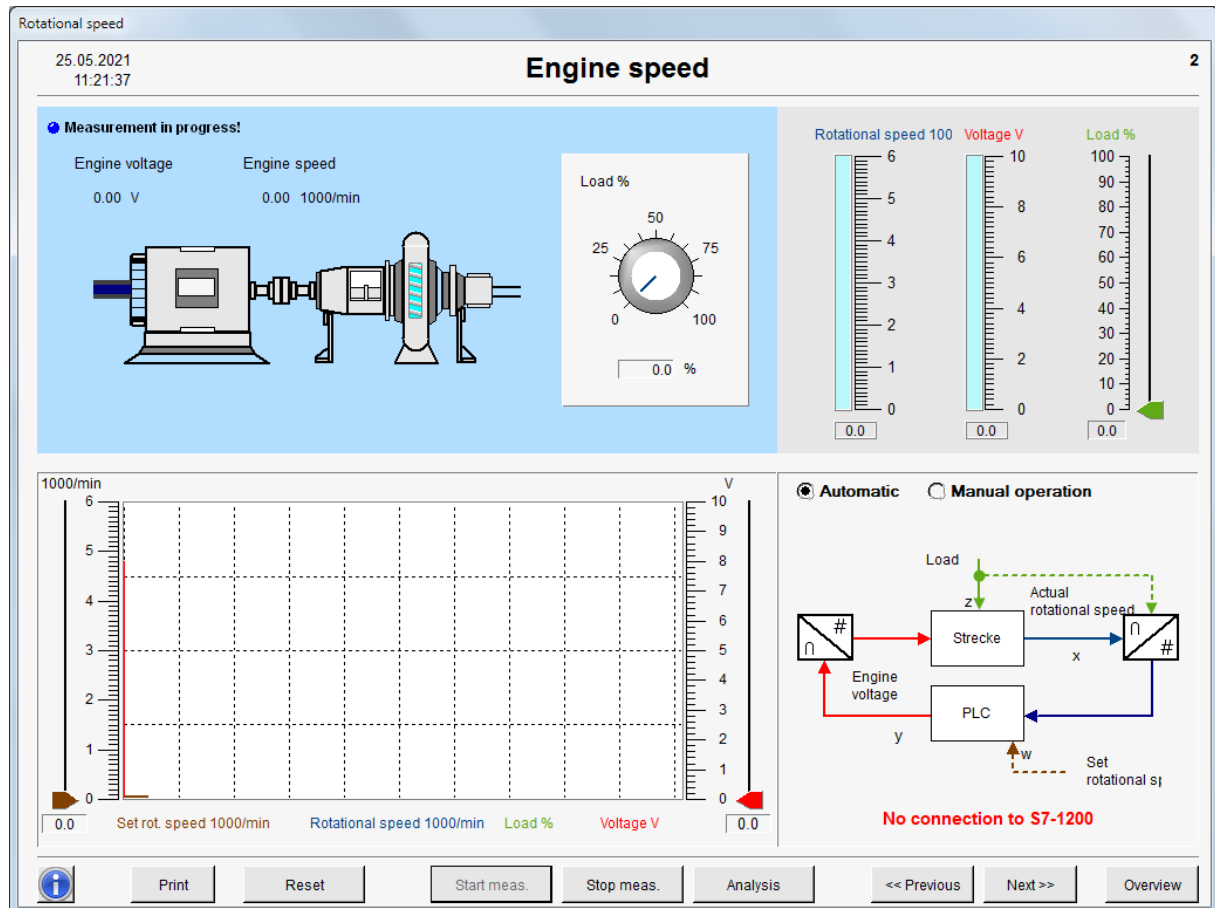


Figure 7: Process view of engine speed system

Following signals can be monitored:

- Set point rotational speed (command variable), range: 0 – 6 1000/min, Name: *M_Soll*
- Actual rotational speed (control variable), range: 0 – 6 1000/min, Name: *T_Ist*
- Corrective signal engine (actuator), range: 0 – 10 V, Name: *M_Y*
- Load taker generator (disturbance), range: 0 – 100 %, Name: *M_Last*
- Manual operation, Name: *M_Hand*

The signals are assigned to following data words:

Table 2: Assignment of signals for engine speed system

Signal name	Description	Range	Type	for S7	Flag	Type	Address in driver
M_Hand	Manual control engine	0	binary	In	101	Bit	M101.3
M_Ist	Actual rotational speed	0 - 6	analogue	In	32	DWord	MD32.IEEE
M_Last	Total load engine/generator	0 - 100	analogue	In	36	DWord	MD36.IEEE
M_Soll	Setpoint rotational speed	0 - 6	analogue	In	68	DWord	MD40.IEEE
M_Y	Actuator engine	0 - 10	analogue	Out	88	DWord	MD44.IEEE

All signals can be transferred into real values (float) and vice versa using range and format of “address in driver”.

The set point is adjusted with slide control or numerically in the window below slide control. The set point is an input signal for the PLC.

All disturbance variables are adjusted likewise, using slide control or numerically in the window below slide control. The disturbance variables are inputs for the PLC.

The corrective signal is an output of the PLC. In manual operation the corrective signal is adjusted via slide control or numerically in the window below slide control. Thereby you have the opportunity to analyse the system without using the PLC.

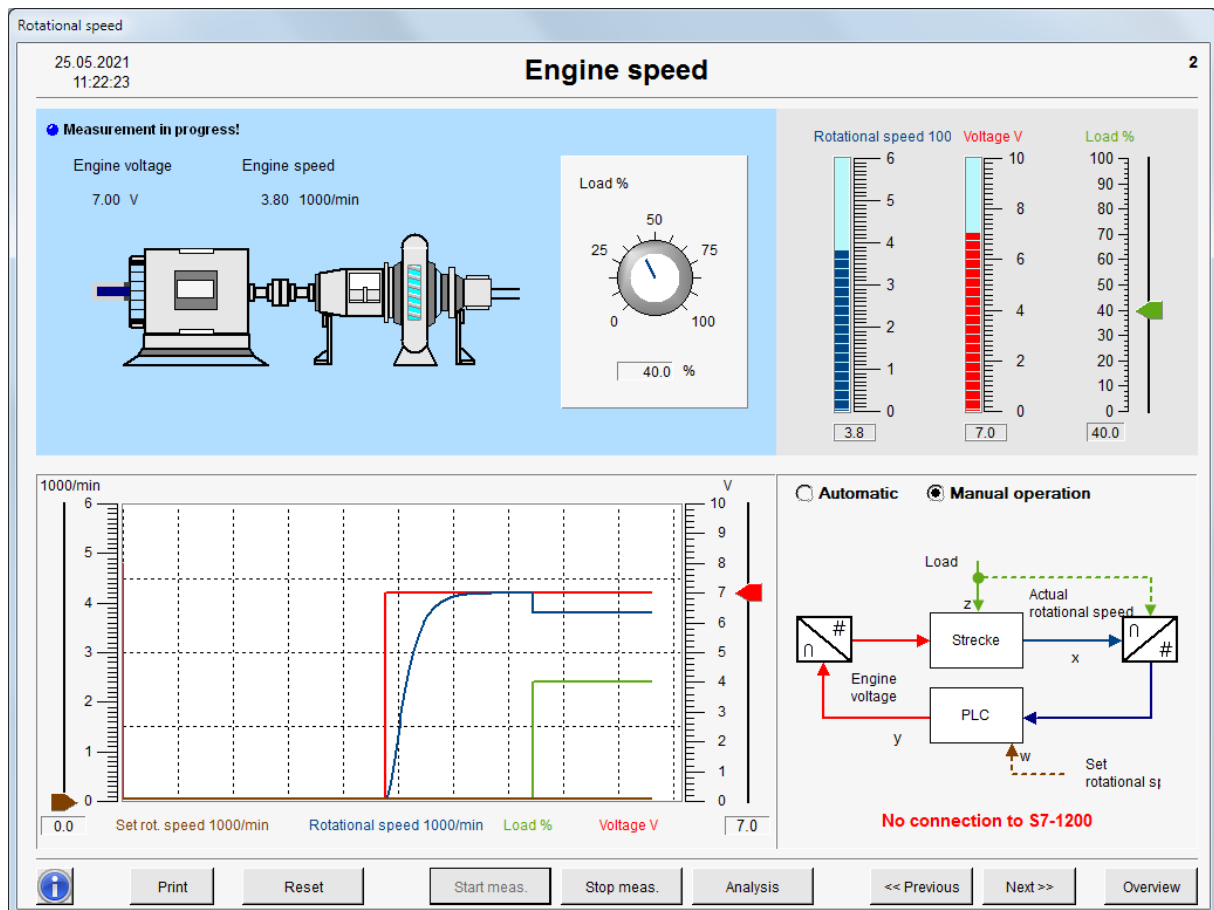


Figure 8: Manual setting of corrective signal

In automatic operation the corrective signal is calculated in the PLC and displayed in the process view. It effects the control system and influences the room temperature.

The signal M_Hand provides the PLC with the information if manual operation is on or off.

In the displayed process (Figure 8) window manual control is switched on and heating power is increased.

With "Start meas." And "Stop meas." Buttons a measurement is started or stopped.

The button analysis is only active with running measurement. When clicking analysis a sub window is opened, displaying all data of running measurement in a time diagram. The scale is adjusted when clicking on the corresponding signal. When clicking on signal curves the value of the active signal is displayed. With click and drag you see value and time differences and the gradient. In the bottom line is a menu bar with analysis tools zoom, change time range, change value range, ruler, export signals to text file and statistical evaluation (Figure 9).

A detailed description of analysis tools opens when clicking the question mark.

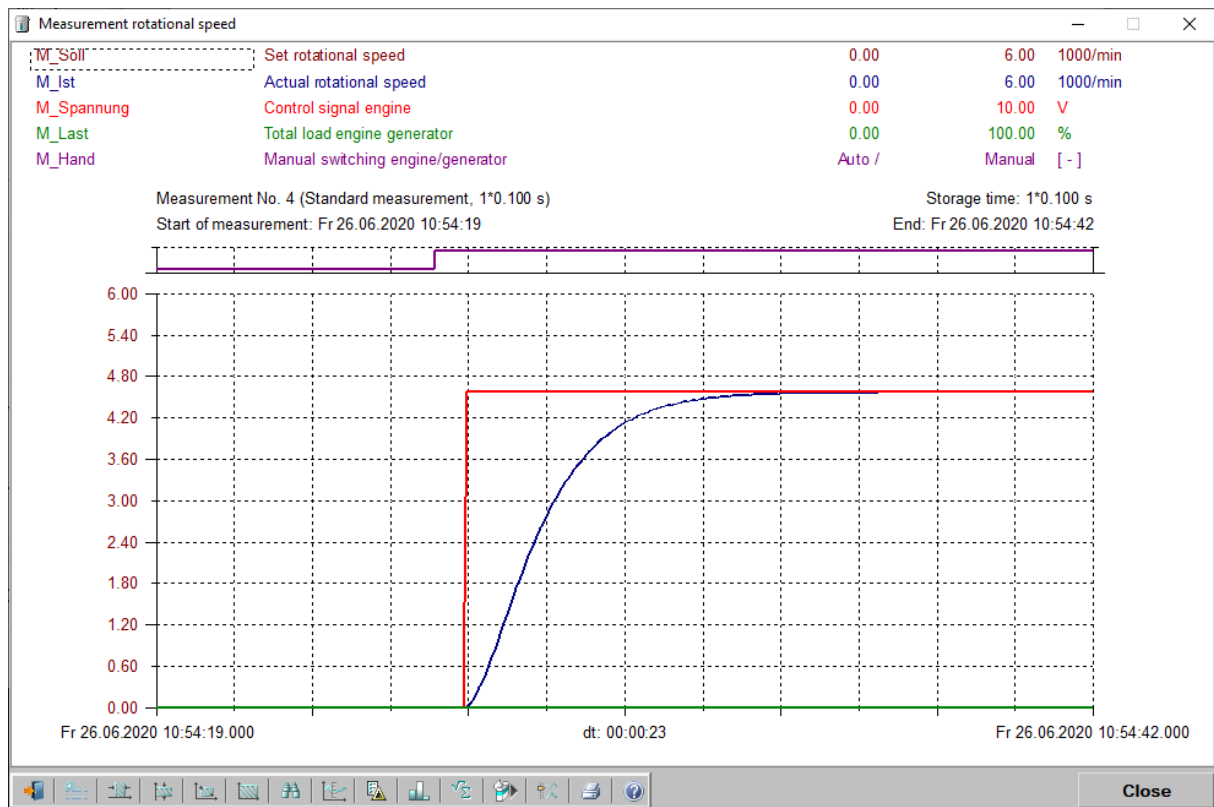


Figure 9: Measured signals in engine speed system

The button „reset“ resets the simulation to it's initial values.

With „<< previous“ and „next >>“ you switch to according process views.

Flow Rate Control

Figure 10 displays the flow rate system.

This process is a pipeline with a valve. Water is flowing through the pipeline with an adjusted pressure. The exercise regarding control engineering is to control the flow rate water by changing the valve position, so that it corresponds to a certain setpoint value. The valve position is the input variable, the flow rate is the output variable of the system. Pressure changes are a disturbance.

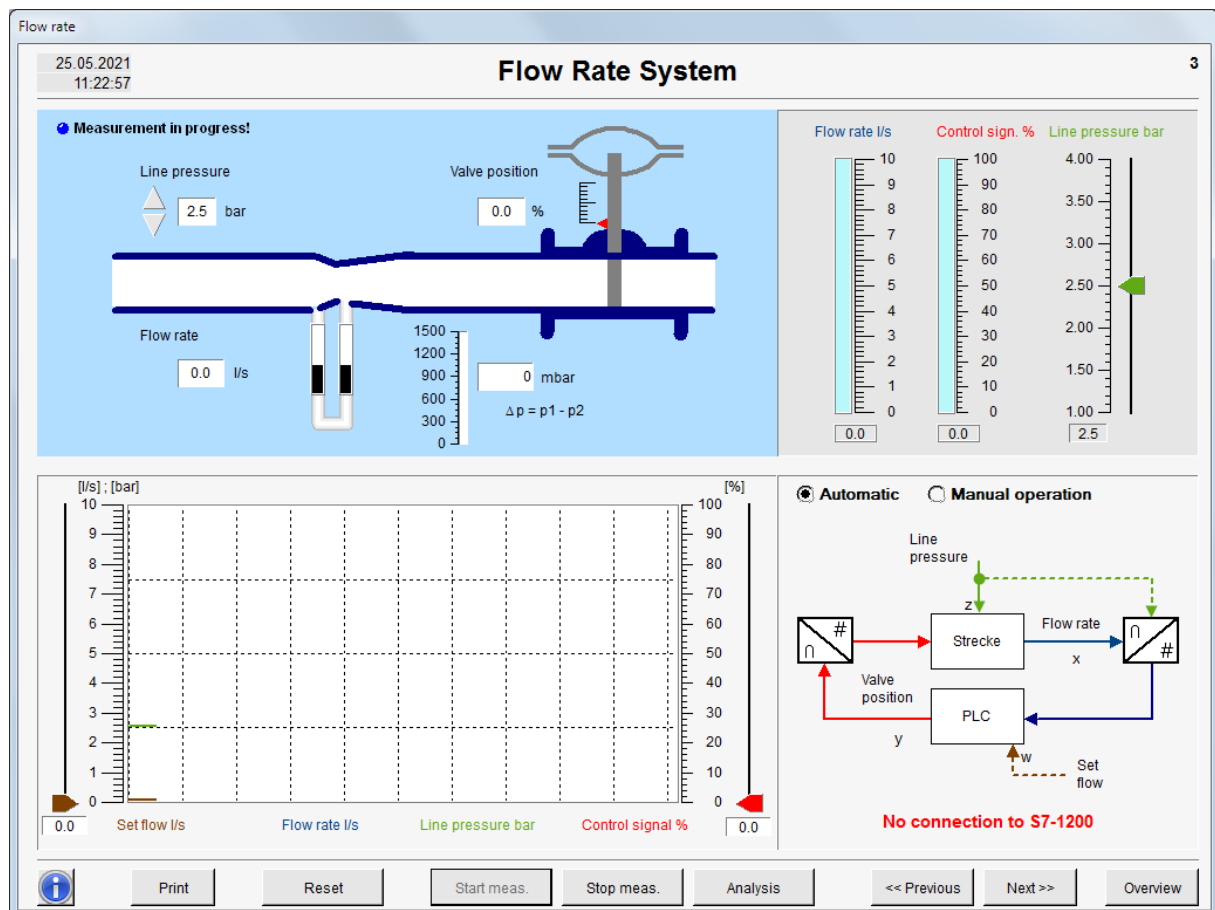


Figure 10: Process view of flow rate system

Following signals can be monitored:

- Set point flow rate (command variable), range: 0 – 10 l/s, Name: D_Soll
- Actual flow rate (control variable), range: 0 – 10 l/s, Name: D_Ist
- Corrective signal valve (actuator), range: 0 – 100 %, Name: D_Y
- Pipeline pressure (disturbance), range: 1 – 4 bar, Name: D_LDruck
- Manual operation, Name: D_Hand

The signals are assigned to following data words:

Table 3: Signal assignment for flow rate system

Signal name	Description	Range	Type	for S7	Flag	Type	Address in driver
D_Hand	Manual control flow rate	0	binary	In	101	Bit	M101.4
D_Ist	Actual flow	0 - 10	analogue	In	40	DWord	MD40.IEEE
D_LDruck	pipeline pressure	1 - 4	analogue	In	44	DWord	MD44.IEEE
D_Soll	Setpoint flow rate	0 - 10	analogue	In	72	DWord	MD72.IEEE
D_Y	Actuator flow rate	0 - 100	analogue	Out	92	DWord	MD92.IEEE

All signals can be transferred into real values (float) and vice versa using range and format of “address in driver”.

The set point is adjusted with slide control or numerically in the window below slide control. The set point is an input signal for the PLC.

All disturbance variable (pipeline pressure) are adjusted likewise, using slide control or numerically in the window below slide control. The disturbance variables are inputs for the PLC.

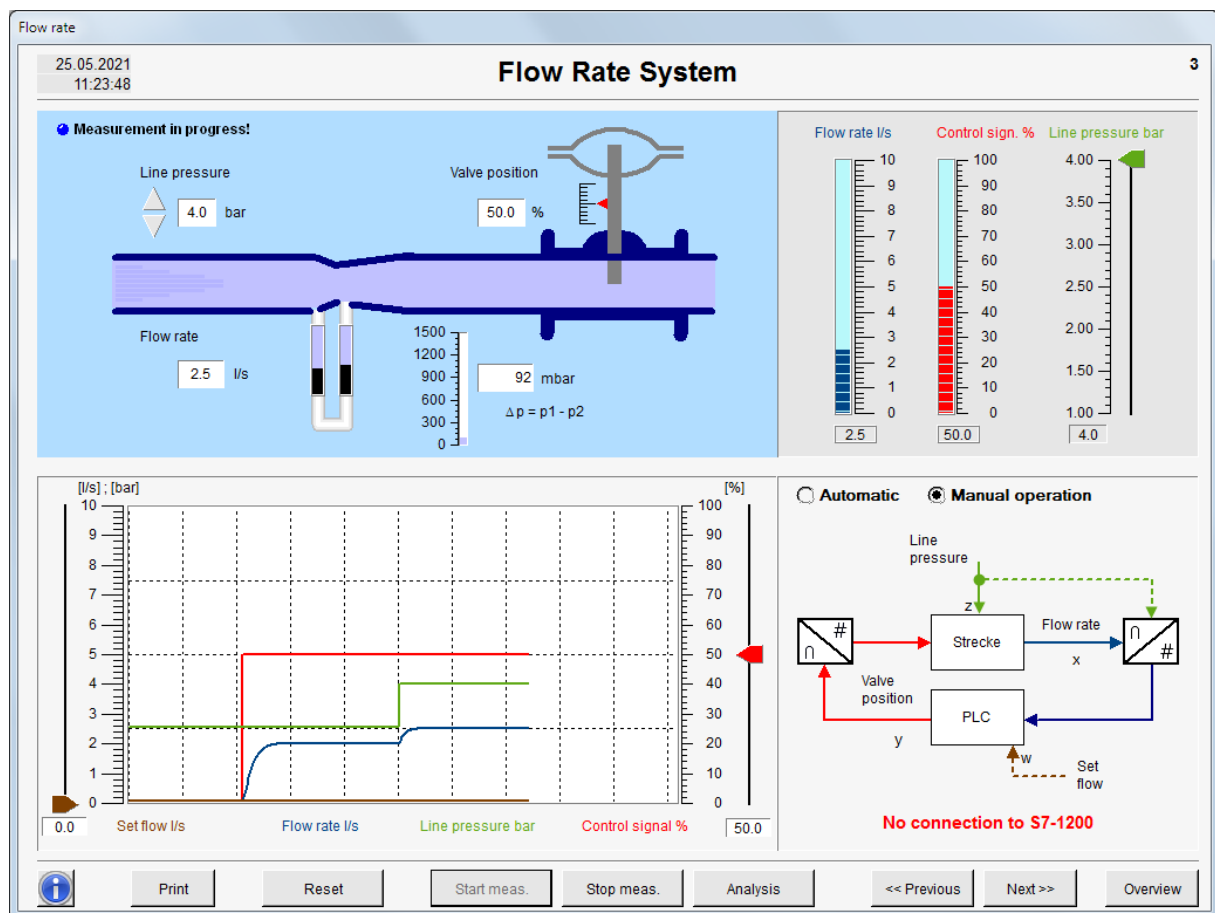


Figure 11: Manual setting of control signal (valve position)

The corrective signal (valve position) is an output of the PLC. In manual operation the corrective signal is adjusted via slide control or numerically in the window below slide control. Thereby you have the opportunity to analyse the system without using the PLC.

In automatic operation the corrective signal is calculated in the PLC and displayed in the process view. It effects the control system and influences the room temperature.

The signal D_Hand provides the PLC with the information if manual operation is on or off.

In the displayed process (Figure 11) window manual control is switched on and the corrective signal is increased.

With "Start meas." And "Stop meas." Buttons a measurement is started or stopped.

The button analysis is only active with running measurement. When clicking analysis a sub window is opened, displaying all data of running measurement in a time diagram. The scale is adjusted when clicking on the corresponding signal. When clicking on signal curves the value of the active signal is displayed. With click and drag you see value and time differences and the gradient. In the bottom line is a menu bar with analysis tools zoom, change time range, change value range, ruler, export signals to text file and statistical evaluation (Figure 12/Figure 9).

A detailed description of analysis tools opens when clicking the question mark.

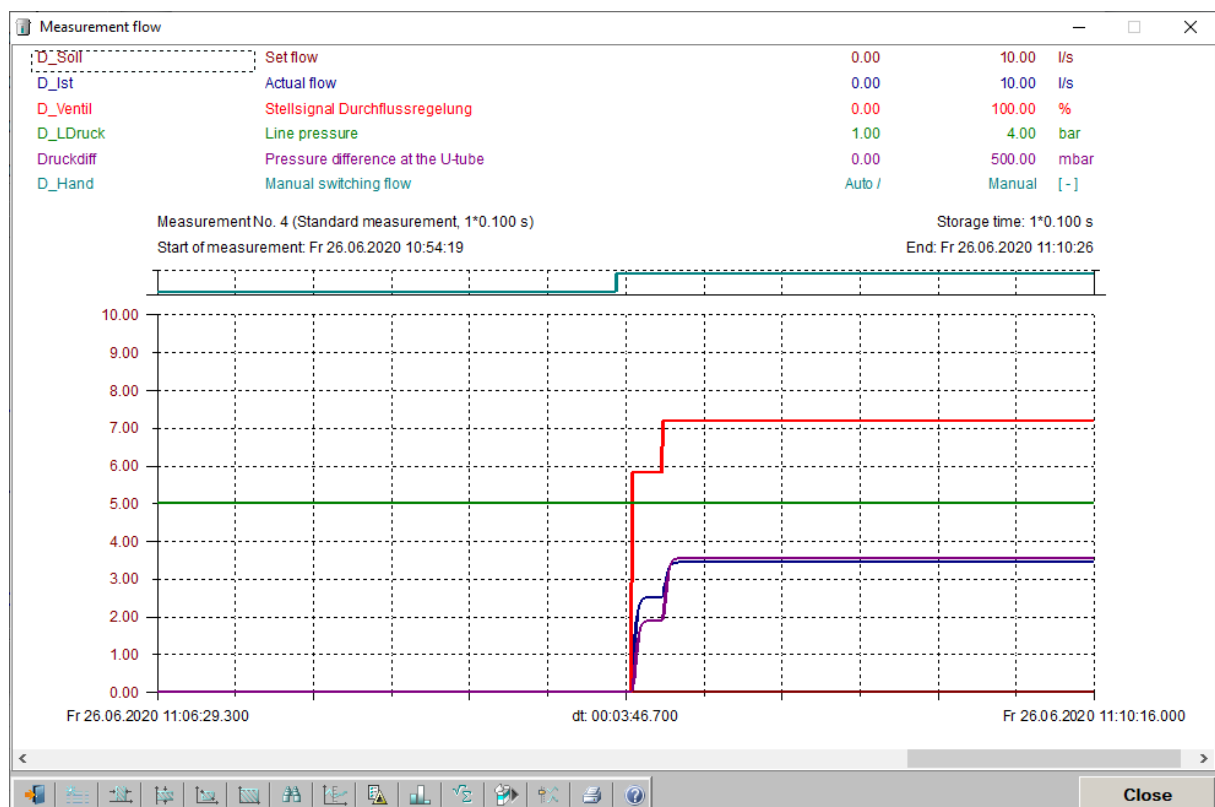


Figure 12: Measured signal of flow rate system

The button „reset“ resets the simulation to it's initial values.

With „<< previous“ and „next >>“ you switch to according process views.

Level, Analogue Control

A container with inlet and outlet will be simulated as a controlled system. The size of the inlet or outlet can be adjusted with valves (by adjusting the shift buttons). The exercise on control engineering is to control the liquid level by closing or opening the valve, so that the level corresponds to a certain setpoint value. Therefore, the inlet constitutes the input variable, and the liquid level the output variable of the system. The inlet acts as a disturbance.

The valve is controlled with an engine which runs with a three-position controller. The valve can open, close or stay in the same position. The three-position controller gives the orders "open" and "close". The setpoint valve position is the setpoint of the three-position controller. The actual valve position follows the setpoint with a time delay, when opening or closing the valve.

In the initial state the valve is closed and the inlet is 0. To change the liquid level, the inlet must be set to value greater than 0.

Inflow and valve position are inputs of the system. Liquid level is the output. The inflow is a disturbance. The outflow depends on valve position and level.

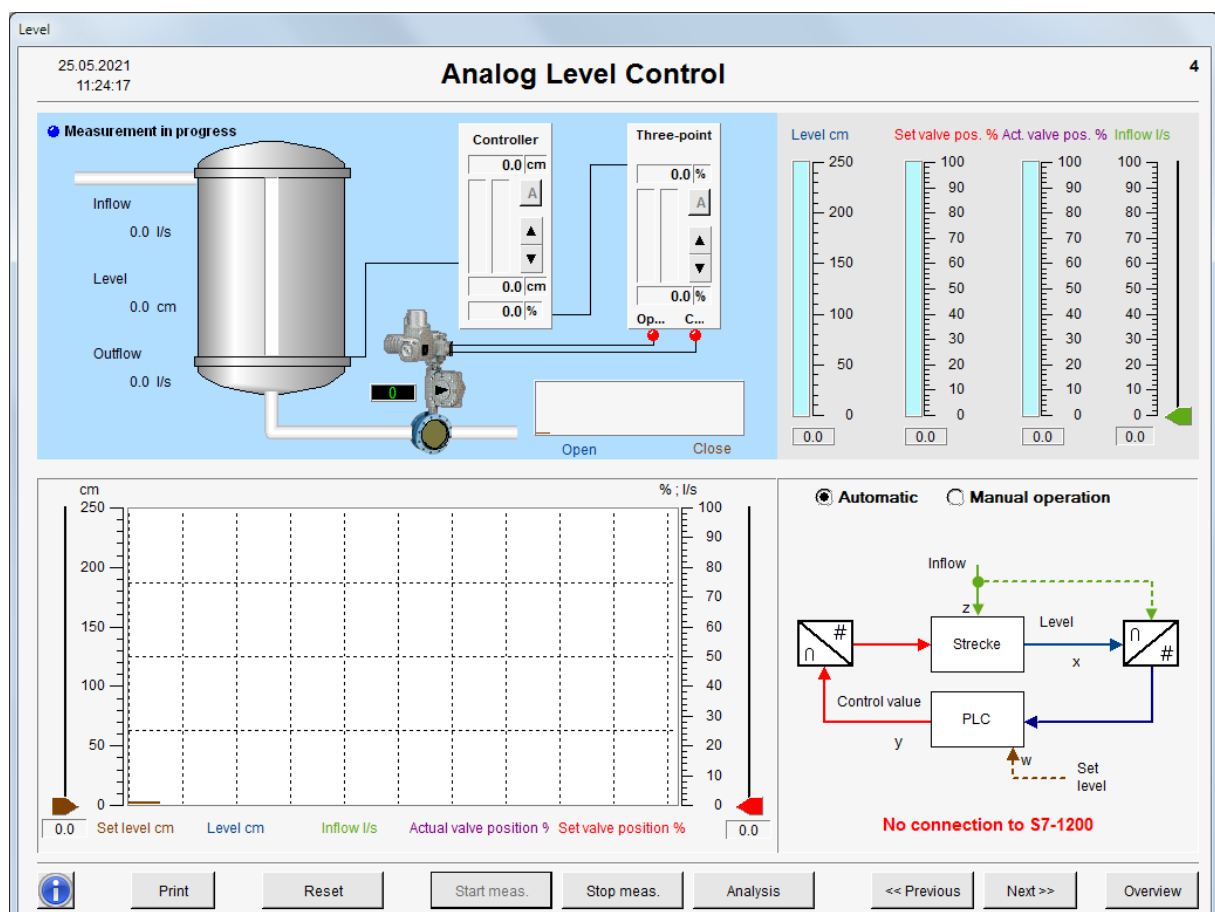


Figure 13: Process view of analogue level control

Following signals can be monitored:

- Set point level (command variable), range: 0 – 250 cm, Name: F_{Sol}
- Actual level (control variable), range: 0 – 250 cm, Name: F_{lst}
- Corrective signal valve (actuator), range: 0 – 100 %, Name: F_Y

- Inflow (disturbance), range: 0 – 100 l/s, Name: F_Zulauf
- Manual operation, Name, Name: F_Hand

The signals are assigned to following data words:

Table 4: Signal assignment for level system

Signal name	Description	Range	Type	for S7	Flag	Type	Address in driver
F_Hand	Manual control level	0	binary	In	101	Bit	M101.5
F_Ist	Actual level	0 - 250	analogue	In	48	DWord	MD48.IEEE
F_Zulauf	inflow	0 - 100	analogue	In	52	DWord	MD52.IEEE
F_Soll	Setpoint level	0 - 250	analogue	In	76	DWord	MD76.IEEE
F_Y	Actuator level	0 - 100	analogue	Out	96	DWord	MD96.IEEE

All signals can be transferred into real values (float) and vice versa using range and format of “address in driver”.

The set point is adjusted with slide control or numerically in the window below slide control. The set point is an input signal for the PLC.

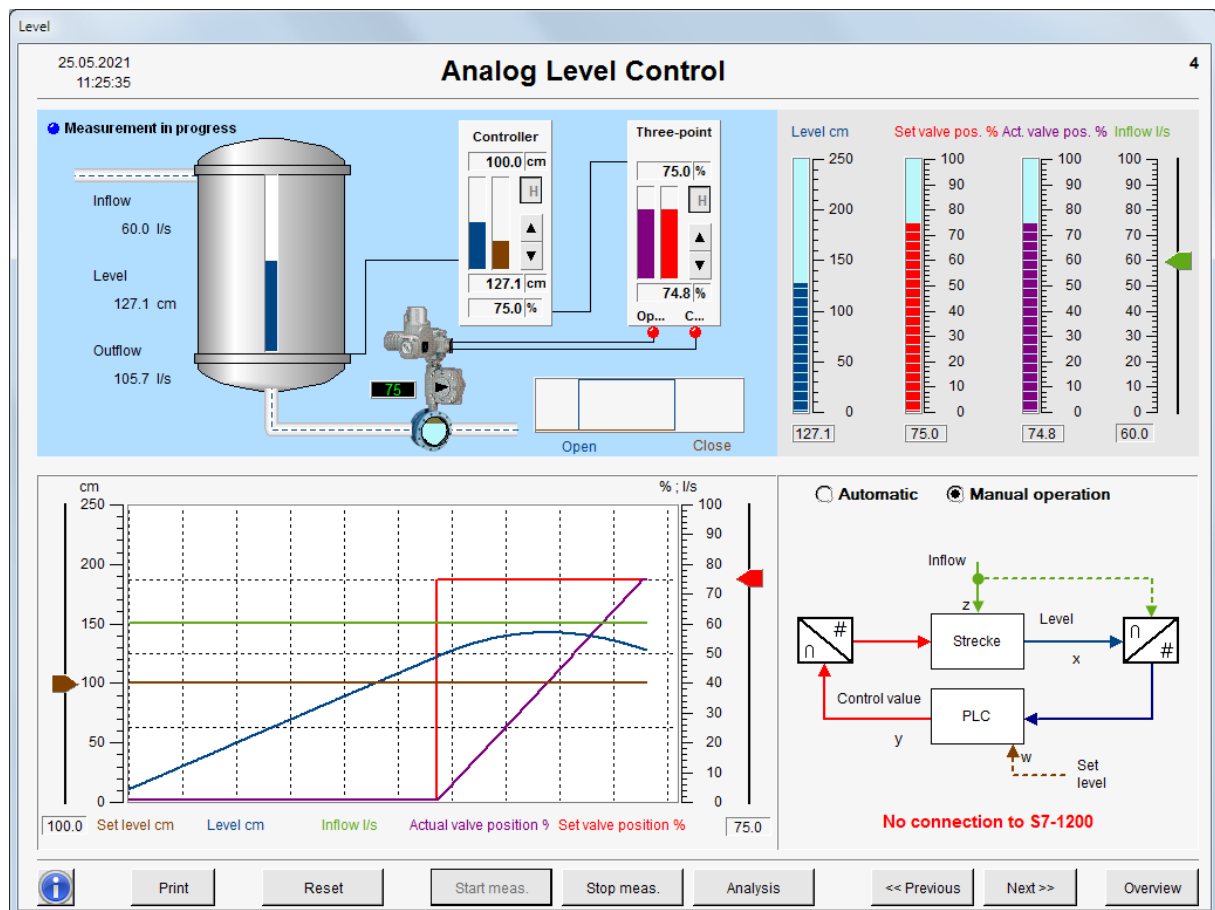


Figure 14: Manual control of liquid level

All disturbance variable (inflow) are adjusted likewise, using slide control or numerically in the window below slide control. The disturbance variables are inputs for the PLC.

The corrective signal (valve position) is an output of the PLC. In manual operation the corrective signal is adjusted via slide control or numerically in the window below slide control. Thereby you have the opportunity to analyse the system without using the PLC.

In automatic operation the corrective signal is calculated in the PLC and displayed in the process view. It effects the control system and influences the room temperature.

The signal D_Hand provides the PLC with the information if manual operation is on or off.

In the displayed process (Figure 14) window manual control is switched on and the corrective signal is increased.

With “Start meas.” And “Stop meas.” Buttons a measurement is started or stopped.

The button analysis is only active with running measurement. When clicking analysis a sub window is opened, displaying all data of running measurement in a time diagram. The scale is adjusted when clicking on the corresponding signal. When clicking on signal curves the value of the active signal is displayed. With click and drag you see value and time differences and the gradient. In the bottom line is a menu bar with analysis tools zoom, change time range, change value range, ruler, export signals to text file and statistical evaluation (Figure 15).

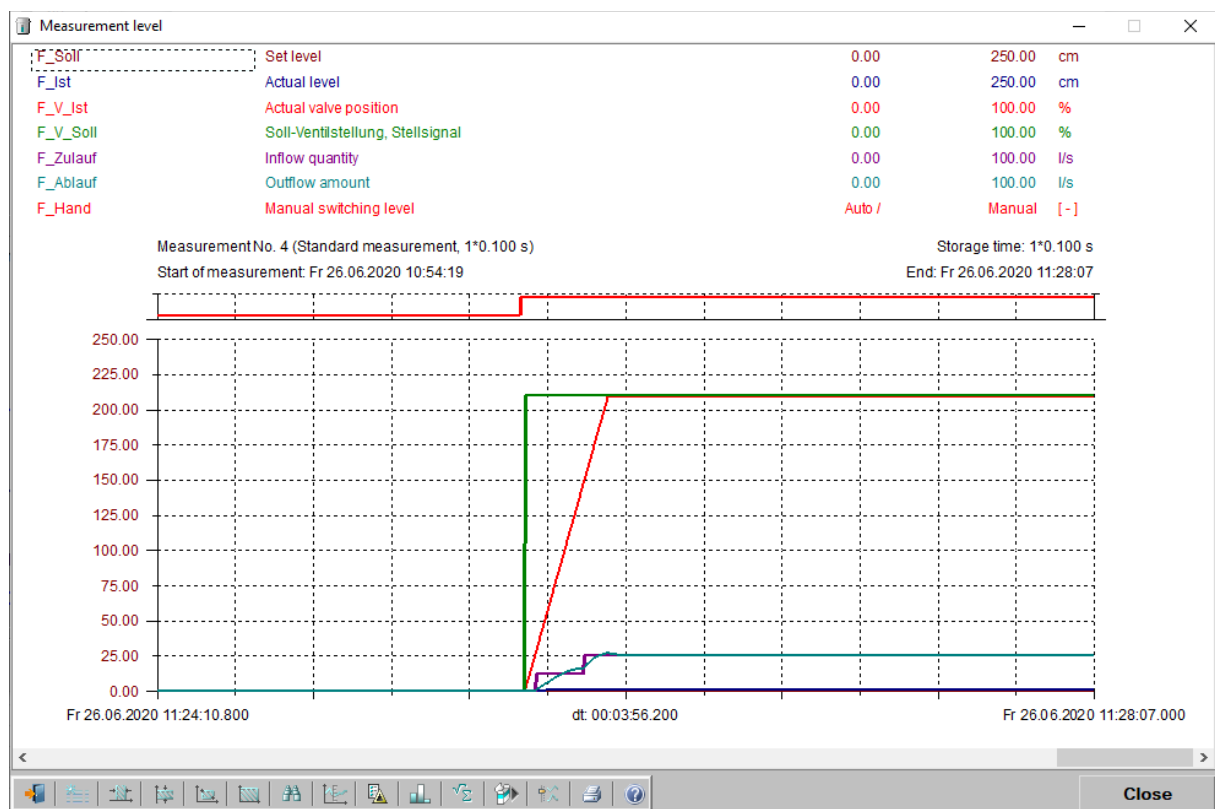


Figure 15: Measured signals of manual liquid level control

A detailed description of analysis tools opens when clicking the question mark.

The button „reset“ resets the simulation to it’s initial values.

With „<< previous“ and „next >>“ you switch to according process views.

Level, Three-Point Control

Figure 16 displays the liquid level system with 3-position controller. Contrary to the previous analogue controller, here the functioning of a 3-position controller shall be analysed.

A container with inlet and outlet will be simulated as a controlled system. The size of the inlet or outlet can be adjusted with valves (by adjusting the shift buttons). The exercise on control engineering is to control the liquid level by closing or opening the valve, so that the level corresponds to a certain setpoint value.

The 3-position controller gives two binary commands open and close

In the initial state the valve is closed and the inlet is 0. To change the liquid level, the inlet must be set to value greater than 0.

Inflow and valve position are inputs of the system. Liquid level is the output. The inflow is a disturbance. The outflow depends on valve position and level.

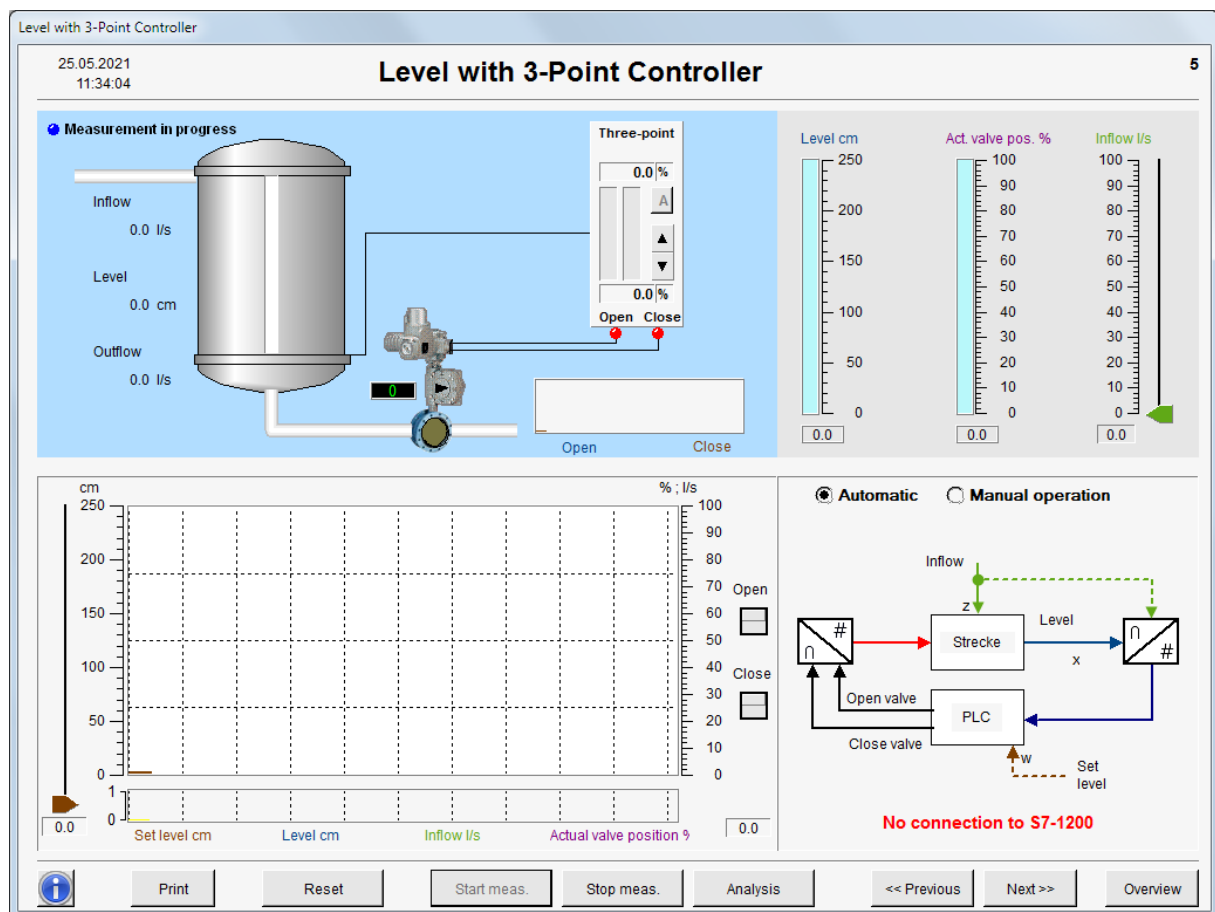


Figure 16: Process view of level system with 3-point controller

Following signals can be monitored:

- Set point level (command variable), range: 0 – 250 cm, Name: *F_Soll*
- Actual level (control variable), range: 0 – 250 cm, Name: *F_Ist*
- Corrective signal through binary signals *F_VentilAuf* und *F_VentilZu*
- Inflow (disturbance), range: 0 – 100 l/s, Name: *F_Zulauf*

- Manual operation, Name, Name: F_Hand

The signals are assigned to following data words:

Table 5: Signal assignment of level system with 3-position controller

Signal name	Description	Range	Type	for S7	Flag	Type	Address in driver
F_Hand	Manual control level	0	binary	In	101	Bit	M101.5
F_Ist	Actual level	0 - 250	analogue	In	48	DWord	MD48.IEEE
F-VentilAuf	Valve control direction open	0	binary	Out	100	Bit	M100.2
F_VentilZu	Valve control direction close	0	binary	Out	100	Bit	M100.3
F_Zulauf	inflow	0 - 100	analogue	In	52	DWord	MD52.IEEE
F_Soll	Setpoint level	0 - 250	analogue	In	76	DWord	MD76.IEEE
F_Y	Actuator level	0 - 100	analogue	Out	96	DWord	MD96.IEEE

All signals can be transferred into real values (float) and vice versa using range and format of “address in driver”.

The set point is adjusted with slide control or numerically in the window below slide control. The set point is an input signal for the PLC.

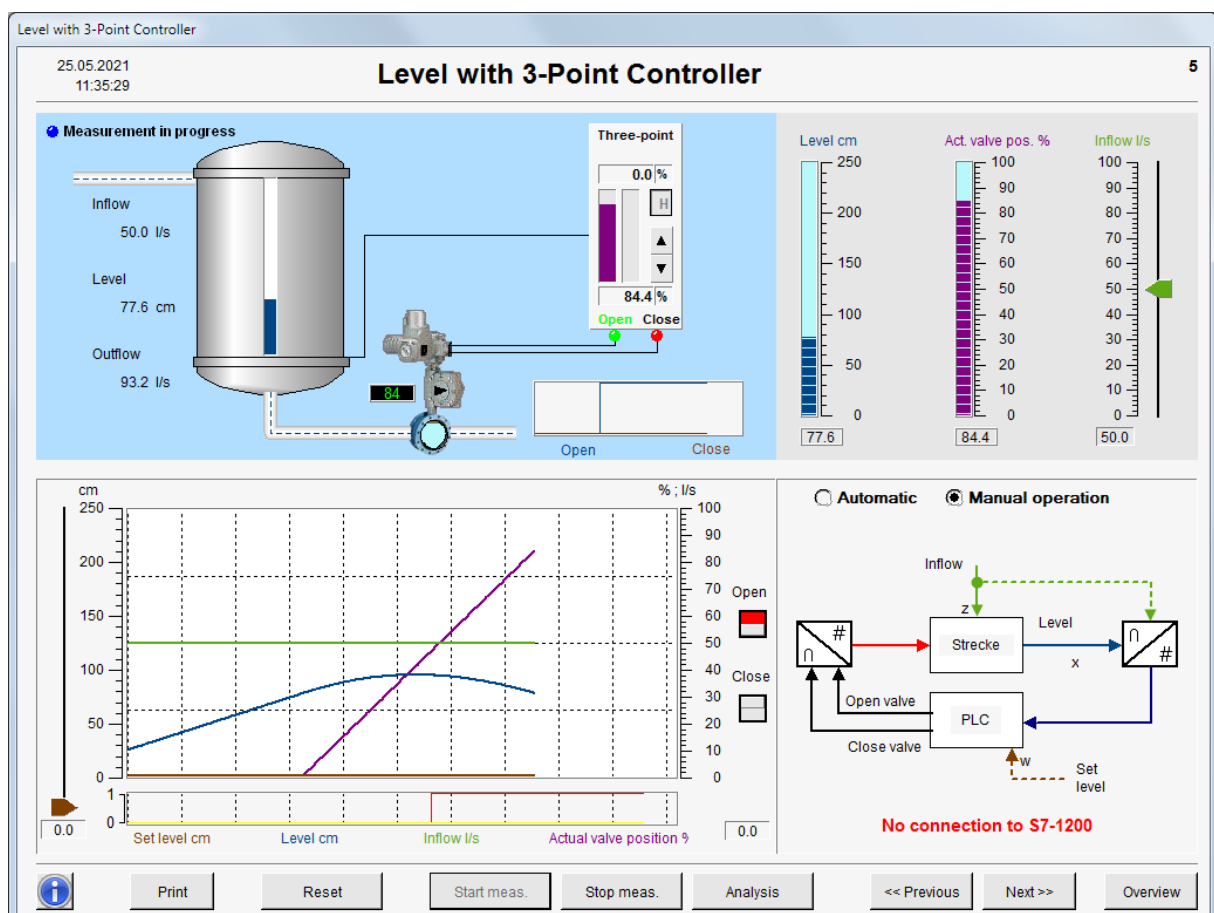


Figure 17: Manual control of level with 3-position controller

All disturbance variable (inflow) are adjusted likewise, using slide control or numerically in the window below slide control. The disturbance variables are inputs for the PLC.

The corrective signal (valve position) is an output of the PLC. In manual operation the corrective signal is adjusted via slide control or numerically in the window below slide control. Thereby you have the opportunity to analyse the system without using the PLC.

In automatic operation the setting or resetting of the binary corrective signal is displayed. It effects the control system and influences the valve position and liquid level.

The signal F_Hand provides the PLC with the information if manual operation is on or off.

In the displayed process (Figure 15) window manual control is switched on and binary open signal is set.

With “Start meas.” And “Stop meas.” Buttons a measurement is started or stopped.

The button analysis is only active with running measurement. When clicking analysis a sub window is opened, displaying all data of running measurement in a time diagram. The scale is adjusted when clicking on the corresponding signal. When clicking on signal curves the value of the active signal is displayed. With click and drag you see value and time differences and the gradient. In the bottom line is a menu bar with analysis tools zoom, change time range, change value range, ruler, export signals to text file and statistical evaluation (Figure 18).

The binary actuating signals for level are outputs of the PLC. In manual operation you may set the signals with according button to analyse the system without PLC.

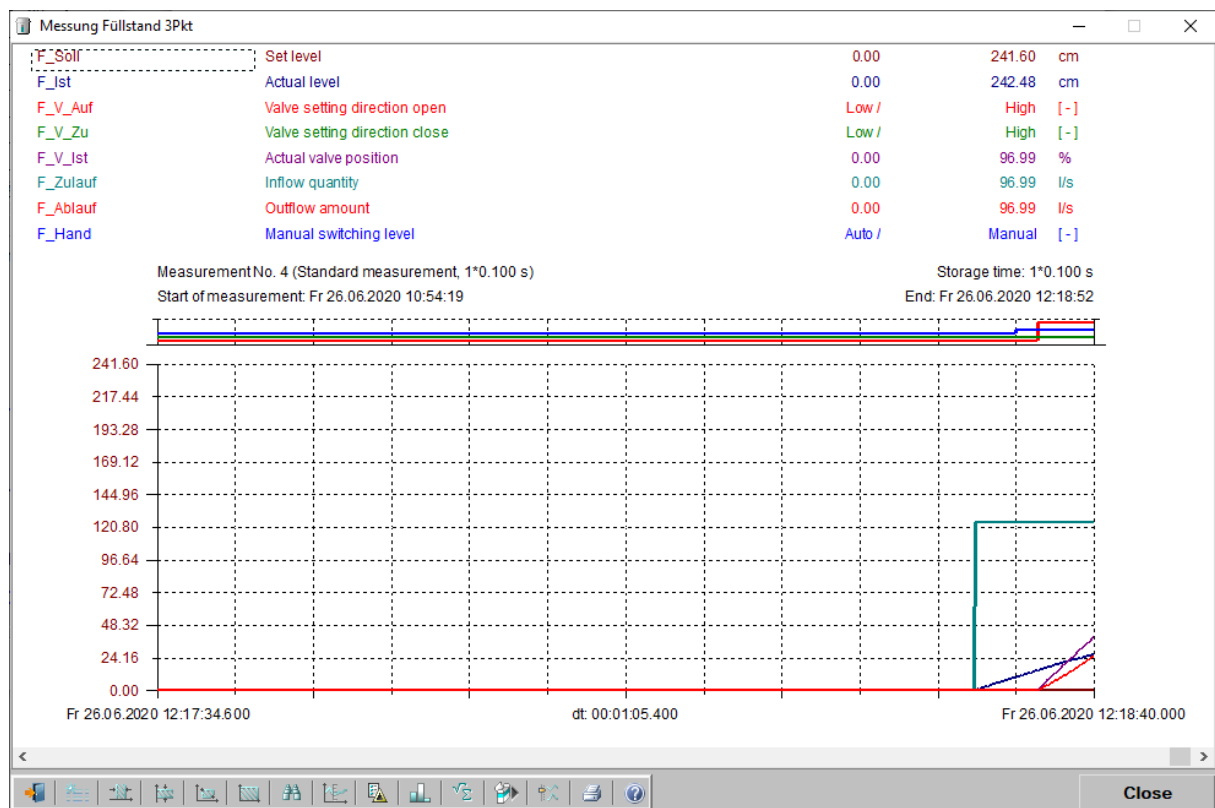


Figure 18: Measured signals of level system with 3-position controller

In Figure 17 manual operation is activated, inflow is set and the binary signal „open“ is set.

A detailed description of analysis tools opens when clicking the question mark.

The button „reset“ resets the simulation to it's initial values.

With „<< previous“ and „next >>“ you switch to according process views.

Cold Room System

Figure 19 displays the process view of the cold room.

This process contains a cooling chamber in which the temperature is influenced with cold or warm supply air. The exercise on control engineering is to control the temperature by closing or opening the valves to the heat exchanger, so that it corresponds to a certain setpoint value. Therefore, the inlet air temperature constitutes the input variable, and the temperature in the chamber is the output variable of the system. The inlet air temperature acts as a disturbance.

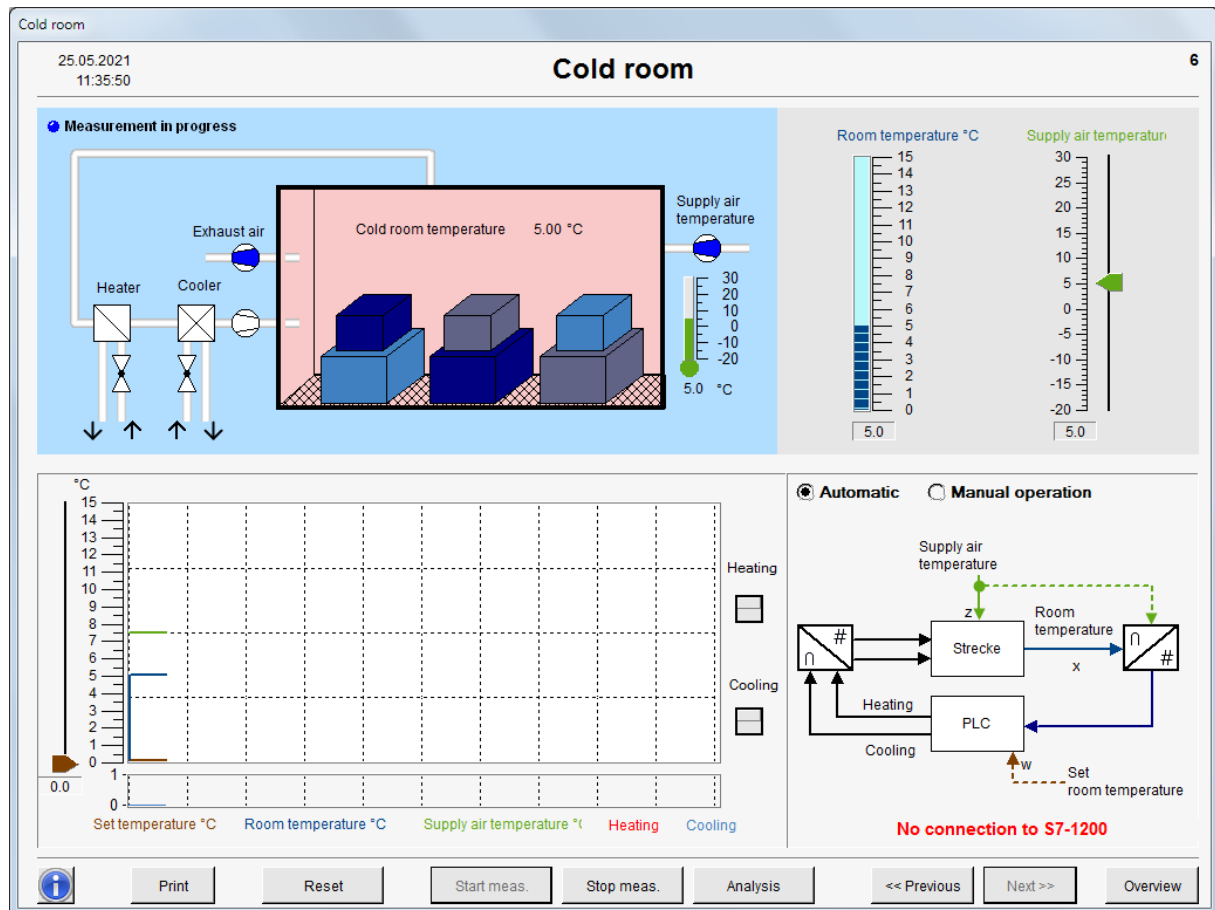


Figure 19: Process view of cold room

The simulated cold room was developed for realisation of a 3-position control. Therefore there is no analogue actuating signal. The temperature is influenced by turning on and off a heater or a cooler. These binary signals are K_Heater and K_Cooler .

Following signals can be monitored:

- Set point temperature (command variable), range: 0 – 15 °C, Name: K_Soll
- Actual temperature (control variable), range: 0 – 15 °C, Name: K_Ist
- Corrective signal through binary signals K_Heater and K_Cooler
- Supply air temperature (disturbance), range: -20 – 30 °C, Name: K_Zuluft
- Manual operation, Name: KT_Hand

The signals are assigned to following data words:

Table 6: Signal assignment for cold room

Signal name	Description	Range	Type	for S7	Flag	Type	Address in driver
K_Heater	Switches on heater of cold room	0	binary	Out	100	Bit	M100.0
K_Cooler	Switches on cooler of cold room	0	binary	Out	100	Bit	M100.1
K_Hand	Manual control cold room	0	binary	In	101	Bit	M101.6
K_Ist	actual temperature cold room	0 - 15	analogue	In	56	DWord	MD56.IEEE
K_Zuluft	Supply air temperature cold room	-30 - 30	analogue	In	60	DWord	MD60.IEEE
K_Soll	Setpoint cold room temperature	0 - 15	analogue	In	80	DWord	MD80.IEEE

All signals can be transferred into real values (float) and vice versa using range and format of “address in driver”.

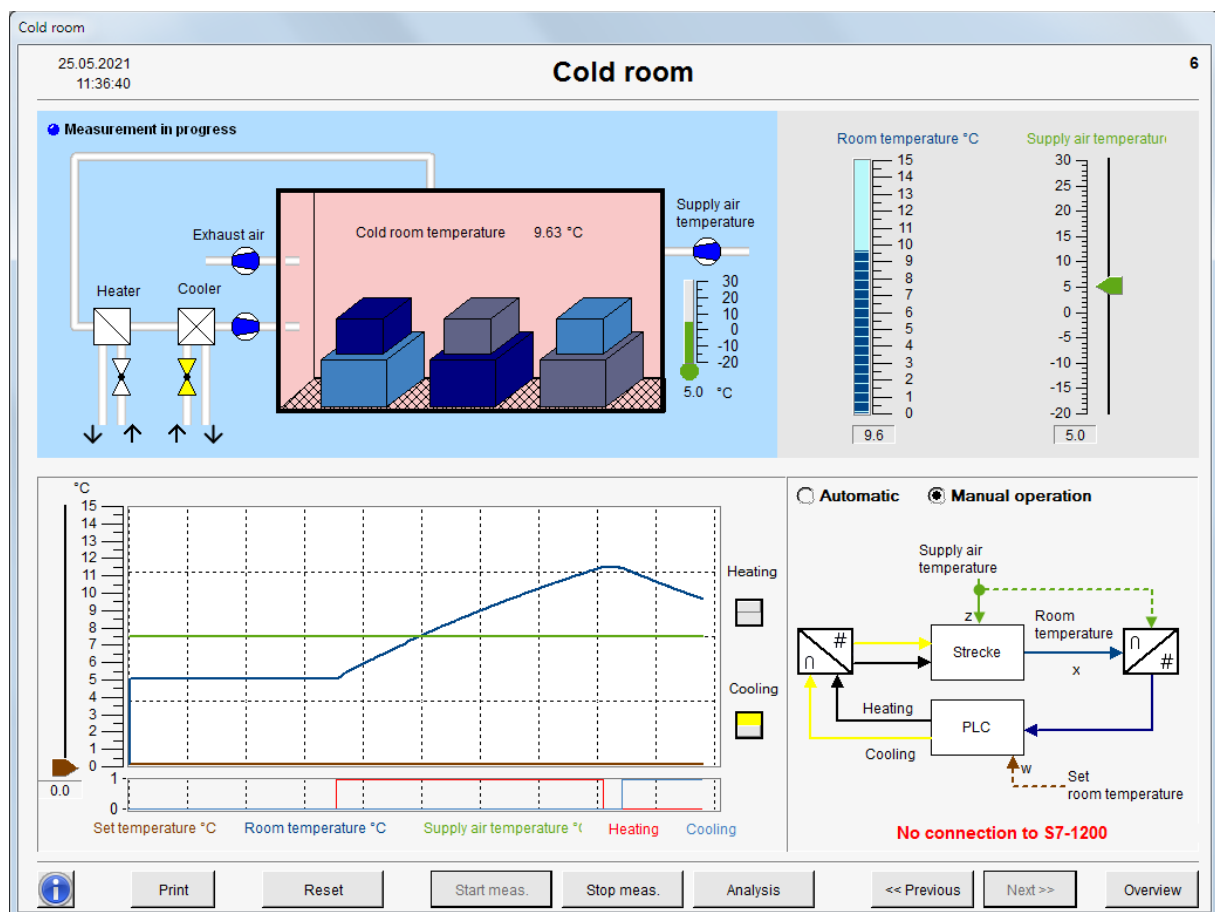


Figure 20: heating and cooling in manual operation of cold room

The set point is adjusted with slide control or numerically in the window below slide control. The set point is an input signal for the PLC.

All disturbance variable (supply air temperature) are adjusted likewise, using slide control or numerically in the window below slide control. The disturbance variables are inputs for the PLC.

The corrective signal (valve position) is an output of the PLC. In manual operation the corrective signal is adjusted via slide control or numerically in the window below slide control. Thereby you have the opportunity to analyse the system without using the PLC.

In automatic operation the setting or resetting of the binary corrective signal is displayed. It effects the control system and influences cold room temperature.

The signal K_Hand provides the PLC with the information if manual operation is on or off.

In the displayed process (Figure 20) window manual control is switched on and first binary heating signal and later binary cooling signal are set.

With "Start meas." And "Stop meas." Buttons a measurement is started or stopped.

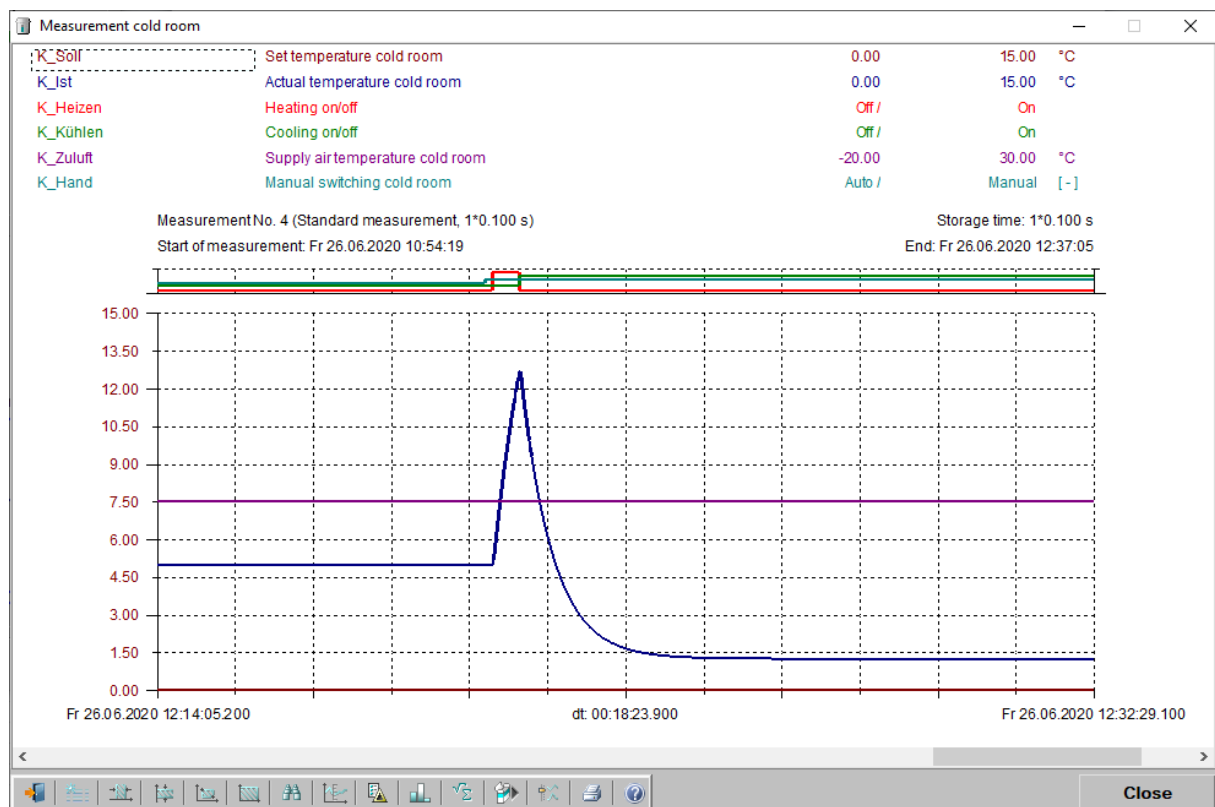


Figure 21: Measured signals of cold room system

The button analysis is only active with running measurement. When clicking analysis a sub window is opened, displaying all data of running measurement in a time diagram. The scale is adjusted when clicking on the corresponding signal. When clicking on signal curves the value of the active signal is displayed. With click and drag you see value and time differences and the gradient. In the bottom line is a menu bar with analysis tools zoom, change time range, change value range, ruler, export signals to text file and statistical evaluation (Figure 21).

The binary actuating signals for level are outputs of the PLC. In manual operation you may set the signals with according button to analyse the system without PLC.

A detailed description of analysis tools opens when clicking the question mark.

The button „reset“ resets the simulation to it's initial values.

With „<< previous“ and „next >>“ you switch to according process views.