Process automation

Compact Workstation

Fluid Lab ® PA

Handling description

Order no.:

Description: Fluid Lab ® PA for Compact Workstation

Designation: Handling description

Status: 02/2007

Author: Wolfgang Eckart, ADIRO Automatisierungstechnik GmbH

Graphics: Wolfgang Eckart, ADIRO Automatisierungstechnik GmbH

Layout: Festo Didactic GmbH & Co

Internet: www.festo.com/didactic http://www.festo.com/didactic/de/ProcessAutomation

e-mail: info@adiro.com

Table of Contents

Introduction

Introduction

The Festo Didactic learning system for process automation is designed to meet a number of different training and vocational requirements. The systems and stations of the learning system for process automation facilitate industry-orientated vocational and further training and the hardware consists of didactically suitable industrial components.

The Compact Workstation of the learning system for process automation provides you with an appropriate system for practice-orientated tuition of the following key qualifications

Social competence,
Technical competence and
Methodological competence

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

Training contents

Training contents covering the following subjects can be:

Process Engineering
- Reading and drawing of flow charts and technical documentation

Electrical technology
- Correct wiring of electrical components

Sensors
- Correct use of sensors
- Measuring of non-electrical, process and control variables

Closed-loop control technology
- basics of closed-loop control technology
- Extension of measuring chains into closed control loops
- Analyze a closed-loop system
- P, I, D-control
- Optimize a closed-loop system

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

Trouble Shooting
- Systematic trouble shooting on a process engineering system
- Maintenance of a process engineering system
- Operation and observation of a process

Important notes

The basic requirement for safe use and trouble-free operation of Fluid Lab®–PA is to observe the fundamental safety recommendations and regulations.

These operating instructions contain important notes concerning the safe operation of Fluid Lab®–PA.

The safety recommendations in particular must be observed by anyone working on Fluid Lab®–PA as well as for the used hardware.

Furthermore, the rules and regulations for the prevention of accidents applicable to the place of use must be observed.

Safety instructions

General

Participants must only work on the station under the supervision of an instructor. Observe the data in the data sheets for the individual components, in particular all notes on safety!

Electrics

Electrical connections and dis-connections are only allowed when when the power is disconnected! Use only low voltage of up to 24 V DC.

Pneumatics

If you use pneumatic components within your system, please do not exceed the permissible pressure of 8 bar (800 kPA). Do not switch on compressed air until you have established and secured all tubing connections. Do not disconnect air lines under pressure. Particular care is to be taken when switching on the compressed air. Cylinders may advance or retract as soon as the compressed air is switched on.

Mechanics

Securely mount all components on the plate. No manual intervention unless the system is in Stop mode. The pump can be mounted horizontally or vertically. If mounted, the output of the pump must point upwards. For further information please refer to the corresponding data sheet of the pump.

Process engineering

- Before filling the tanks with water, switch of the 24 VDC power supply and disconnect the 220 (230) VAC power from the socket
- 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 +50 °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 Fluid Lab®–PA by opening the manual hand valve V105

Fluid Lab®–PA general information

The Fluid Lab®–PA software in combination with the EasyPort digital/analog offers you the possibility to measure and analyze the signals of 8 digital and 4 analog inputs.

The electrical control interface (E/A Syslink and analog terminal) is the same like for MPS.

Three main functions are integrated in Process Lab:

M as in **m**easurement, for signal detection and analysis of 8 digital/4 analog input signals
C as in open loop **c**ontrol, for binary or continuous control of 8 digital/2 analog outputs
R as in **r**egulate a closed-loop system, free selectable closed-loop control elements for 2-point, P, I, PI and PID

With the Compact Workstation of the learning system for process automation you have the possibility to work with the following closed loop process:

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

By using the simulation environment with the continuous loop control you can simulate the following functions:

- level controlled system
- flow rate controlled system

Software Installation

1. Installation of Fluid Lab®–PA

Please insert the Fluid Lab®–PA CD in the drive and start the setup. Please follow the instructions on the screen to install the following software packages in different languages:

- Fluid Lab®–PA program files
- EzOCX driver (Third party distributor files)
- LabVIEW© Runtime environment (Version 7.1) (Third party distributor files)

The EcOCX driver

The EcOCX driver is needed for the communication between Fluid Lab®–PA software and EasyPort digital/analog via the serial interface RS 232.

During the installation process you are prompted whether to install EzOCX or not. If you choose “no”, you are able to run the installation process of EzOCX manually by opening the Setup.exe in EzOCX sub-folder.

LabVIEW© Runtime environment

Because Fluid Lab®–PA is developed with LabVIEW© of National Instruments© the software uses a runtime environment to be executed on your system.

During the installation process you are prompted whether to install the LabVIEW© Runtime Environment or not. If you choose “no”, you are able to run the installation process of LabVIEW© runtime environment manually by clicking the “LVRunTimeEng.exe” in “Runtime-Engine 71” sub-folder.

1.1 User name and license key

On the back side of the CD there is a sticker which mentiones the exact user name and license key which have to be inserted into the corresponding installation window.

Please make sure, that you put the exact phrase of the user name. For example the sticker looks like:

User name: XXXXXXXXXXXX
License key: YYYY

you must put the entire phrase of **XXXXXXXXXXXXXXXX** as the user name.

You are able to change the license status by editing the "FGB.ini" file manually with Notepad.exe e.g. after the successful installation of Fluid Lab®–PA. This file can be found in the main installation folder.

The file has to be layouted as follows:

First line: **License name + carriage return**
Second line: **License key**

and save the file.

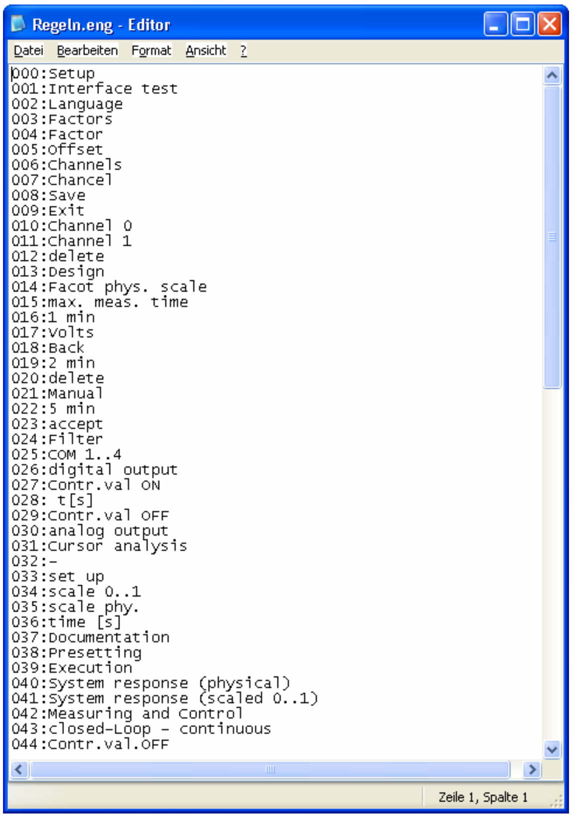
1.2 Change the text appearance

Fluid Lab®–PA is designed with multi language support. The displayed window and popup text are available in the languages mentioned below.

The text in the different Fluid Lab®–PA windows can be changed. Use an editor like Microsoft© Editor e.g. The relevant files are located in subdirectories of the Fluid Lab®–PA directory and differ by their suffix (file name extension):

German language text	...\German\ Regeln.GER
English language text	...\English\ Regeln.ENG
French language text	...\French\ Regeln.FRA
Spanish language text	...\Spanish\ Regeln.SPA
Chinese language text	...\Chinese\ Regeln.CHN

... other languages available upon request

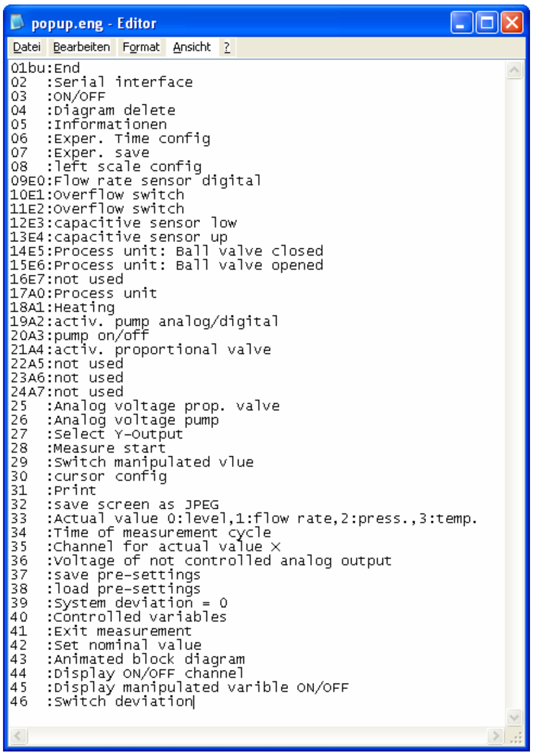

Regeln.eng - Editor
Datei Bearbeiten Format Ansicht ?

```
000:Setup
001:Interface test
002:Language
003:Factors
004:Factor
005:offset
006:Channels
007:Chancel
008:Save
009:Exit
010:Channel 0
011:Channel 1
012:delete
013:Design
014:Facot phys. scale
015:max. meas. time
016:1 min
017:Volts
018:Back
019:2 min
020:delete
021:Manual
022:5 min
023:accept
024:Filter
025:COM 1..4
026:digital output
027:Contr.val ON
028: t[s]
029:Contr.val OFF
030:analog output
031:Cursor analysis
032:-
033:set up
034:scale 0..1
035:scale phy.
036:time [s]
037:Documentation
038:Presetting
039:Execution
040:System response (physical)
041:System response (scaled 0..1)
042:Measuring and Control
043:closed-Loop - continuous
044:Contr.val.OFF
```

Zeile 1, Spalte 1

Every line starts with a number and a following text. It is recommended not to change the layout. only edit the text behind the colon. Please use short text only. Please note that the length of the text must not exceed about 54 signs. If the text is longer it will be cut off.

Fluid Lab®–PA provides a “Pop up” function, which helps you to orientate with every single component on the window. If you move the mouse over a component and leave it there a text will come up to give you information about the component. The pop up’s are collected in a text file which can be opened with Microsoft©Editor for example. The relevant files are located in the same subdirectories than the windows text mentioned one page before but have a different suffix (file name extension) - popup.eng for English language for example.


popup.eng - Editor

Datei Bearbeiten Format Ansicht ?

```
01bu:End
02  :Serial interface
03  :ON/OFF
04  :Diagram delete
05  :Informationen
06  :Exper. Time config
07  :Exper. save
08  :left scale config
09E0:Flow rate sensor digital
10E1:Overflow switch
11E2:Overflow switch
12E3:capacitive sensor low
13E4:capacitive sensor up
14E5:Process unit: Ball valve closed
15E6:Process unit: Ball valve opened
16E7:not used
17A0:Process unit
18A1:Heating
19A2:activ. pump analog/digital
20A3:pump on/off
21A4:activ. proportional valve
22A5:not used
23A6:not used
24A7:not used
25  :Analog voltage prop. valve
26  :Analog voltage pump
27  :Select Y-Output
28  :Measure start
29  :Switch manipulated vlue
30  :cursor config
31  :Print
32  :save screen as JPEG
33  :Actual value 0:level,1:flow rate,2:press.,3:temp.
34  :Time of measurement cycle
35  :Channel for actual value x
36  :Voltage of not controlled analog output
37  :save pre-settings
38  :load pre-settings
39  :System deviation = 0
40  :Controlled variables
41  :Exit measurement
42  :Set nominal value
43  :Animated block diagram
44  :Display ON/OFF channel
45  :Display manipulated varible ON/OFF
46  :Switch deviation
```

To change the text, please proceed like mentioned one page before for the windows text.

To change the text for the proportional valve for example please (see picture below) edit the line “21A4” in the popup text file.

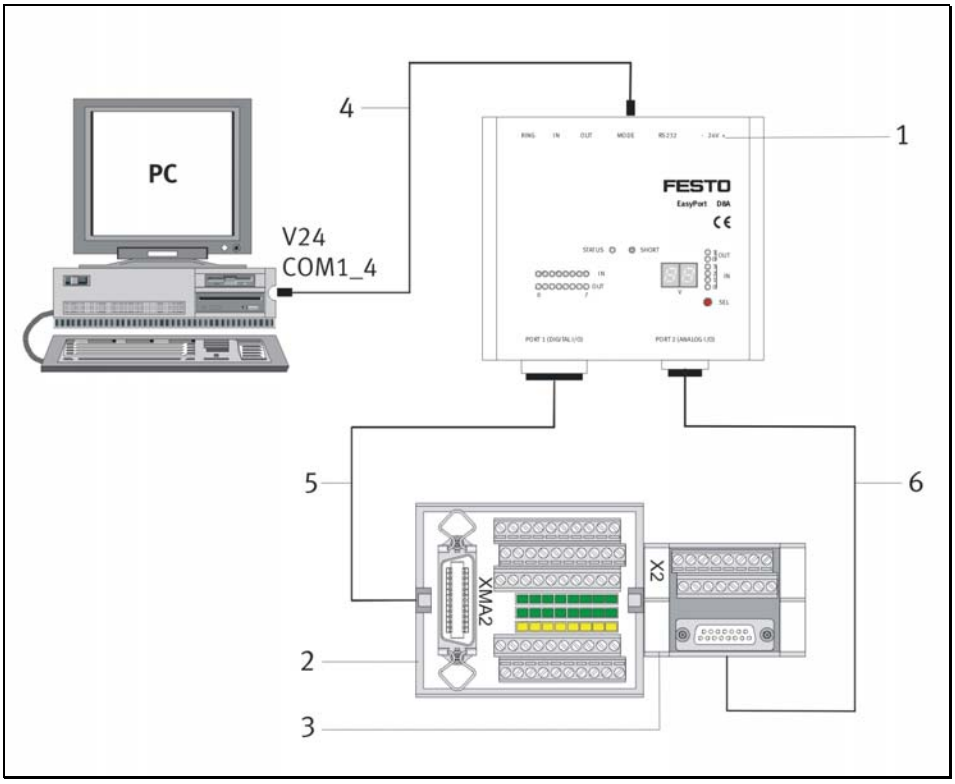
2. Preparation of the workstation

After unpacking the Compact Workstation, please proceed to set-up the system as follows:

2.1 Connection of the EasyPort DA

Required hardware:

- PC (minimum: Pentium 200MHz, 32MB RAM, 600x800 graphics) with serial interface (COM1...COM4)
- 24V power supply unit for the EasyPort DA
- EasyPort DA (interface)



1 EasyPort DA (interface)
2 I/O terminal SysLink (XMA2 is part of the workstation)
3 Analog terminal (X2 is part of the workstation)
4 PC data cable RS 232
5 SysLink cable
6 Analog cable, 15-pin parallel

The power supply 24 VDC has to be connected to the interface – 24V + at the EasyPort where the brown cable must be connected to + and the blue to -

2.2 Fill up the tank 101

After all cable connections have deen done, please fill the tank 101 with 300 mm of water. Please switch off the 24 VDC power supply and disconnect the 220 (230 VAC) power line from the socket during the filling process.

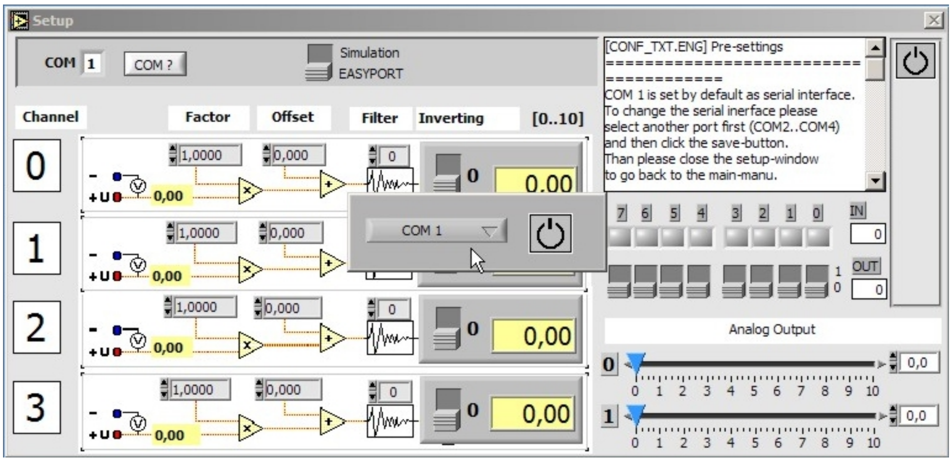
2.3 Close of the manual hand valves

Please close all manual hand valves within the system as shown within the picture.

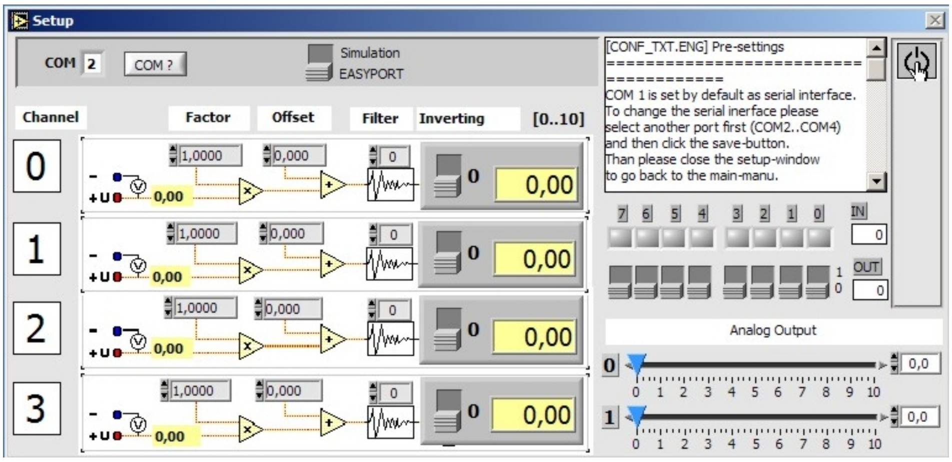
2.4 Start Fluid Lab®–PA and definition of the serial port

Please connect the 24 VDC power supply and switch it on and start the Fluid Lab®–PA software. The following window will appear (of course with a different user name).

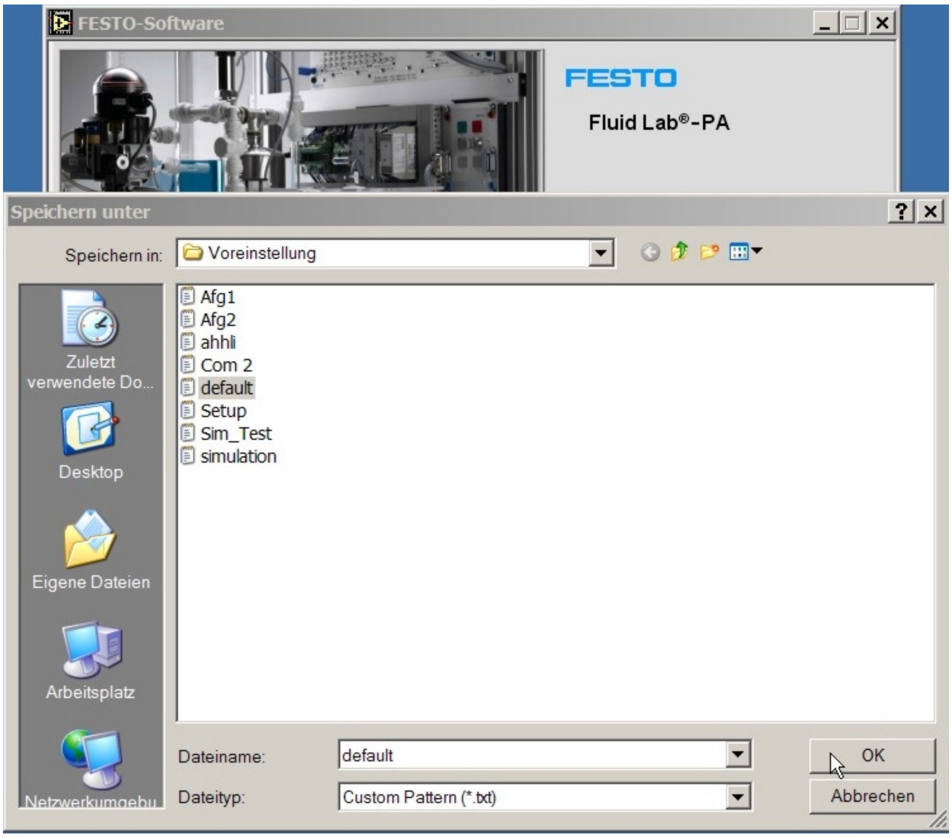
(If the message EASYPORT – no communication appears, please enter the Setup menu) **Setup**



(Check your COM port you are using at your computer – must corresponding to the COM port in the left upper corner. If you use another serial port than COM 1, please open the serial port menu, otherwise please proceed with the next screen shot on the next page) **COM ?** → (click on COM 1 to get the list of available serial ports) **COM 1** → (choose the correct COM port – for example COM 2)



(Close the Setup window)



(Click onto the symbol to save the setup) → (choose the name default) → **OK** → Close the Fluid Lab®–PA program window) **X**

(Restart Fluid Lab®–PA) → (if your COM port is correct, there will be a connection between the computer and the EasyPort and the message
EASYPORT – no communication
disappears and the Status LED on the EasyPort is blinking short time off and long time on).

3. Test the process with the Setup menu

Test the process means to activate the different actuators and check the reaction on the analog sensors (Channel 0 – 3). The following digital and analog in- and outputs will be used for this projects:

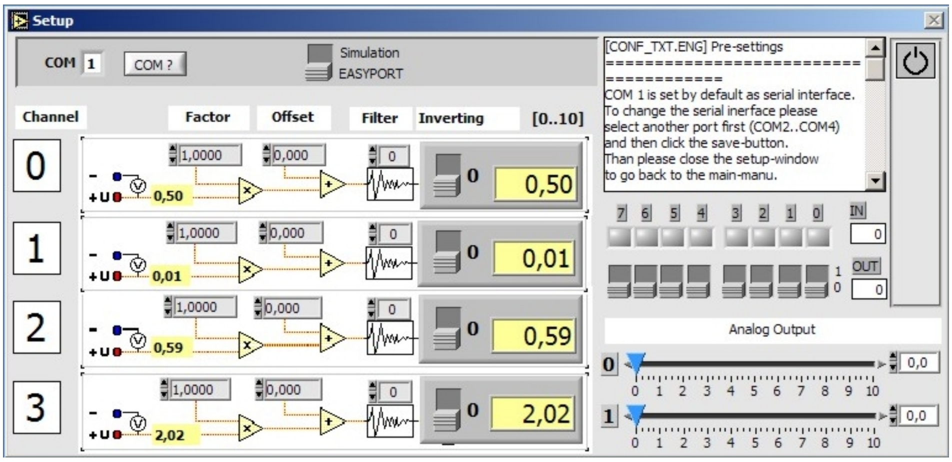
Output Bit	Description
1	Output 1 = 0 = Heating off, Output 1 = 1 = Heating on
2	Select manipulation of the pump digital or analog Output 2 = 0 = digital control of the pump Output 2 = 1 = analog control of the pump 0 – 10 V
3	Output 3 = 0 = digital activation of the pump, only when Output 2 = 0
4	Activate proportional valve 0 – 10 V

Input Channel	Description
0	Level sensor (ultrasonic sensor) with signal converter 0 – 10 V
1	Flow rate sensor with signal converter 0 – 10 V
2	Pressure sensor 0 -10 V
3	Temperature sensor PT100 with signal converter 0 – 10 V

Output Channel	Description
0	Analog control of the proportional valve. Works only if Output 4 = 1 The output voltage can be selected between 0 – 10 V
1	Analog control of the pump. Works only if Output 2 = 1 The output voltage can be selected between 0 – 10 V

Test the process

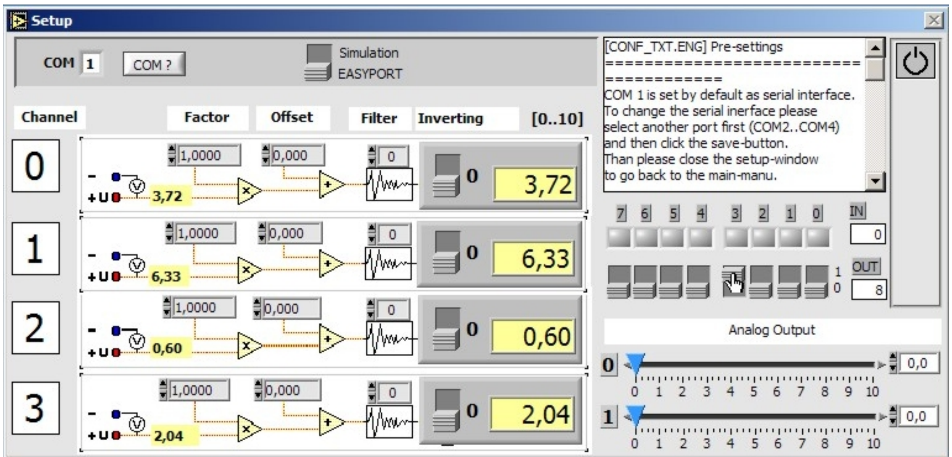
(If the connection between the computer and the EasyPort is ok, please enter the menu Setup again) **Setup**



(and the following window appears)

3.1 Test the level control process

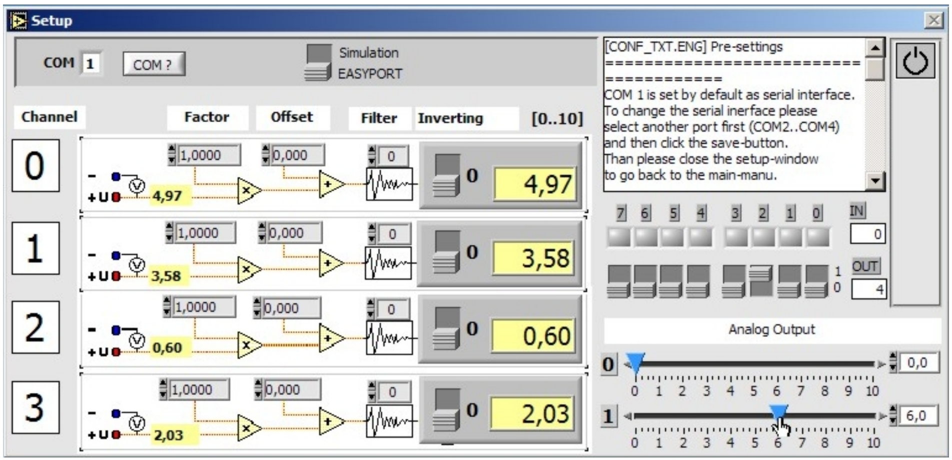
We are going to activate the pump digitally and pump water from tank 101 to tank 102 and watch if the analog sensor value changes (ultrasonic sensor Channel 0). To do so, we have to open the manual valve 101 as shown within the picture.



(Activate the pump digitally by switching the output 3 = 1 and watch the Channel 0 signal, which should increase as the water level increases) → (stop the pump by switching the output 3 = 0 if there are approximately 150 mm of water in the tank 102) → (wait until the tank 102 is empty again except the 20 mm rest of water and close the manual valve 101)

3.2 Test the flow control process

We are going to activate the pump analog and pump water from tank 101 to tank 101 (circulation) and watch if the analog sensor value changes (flow sensor Channel 1). Please open the manual valve 104 to proceed.

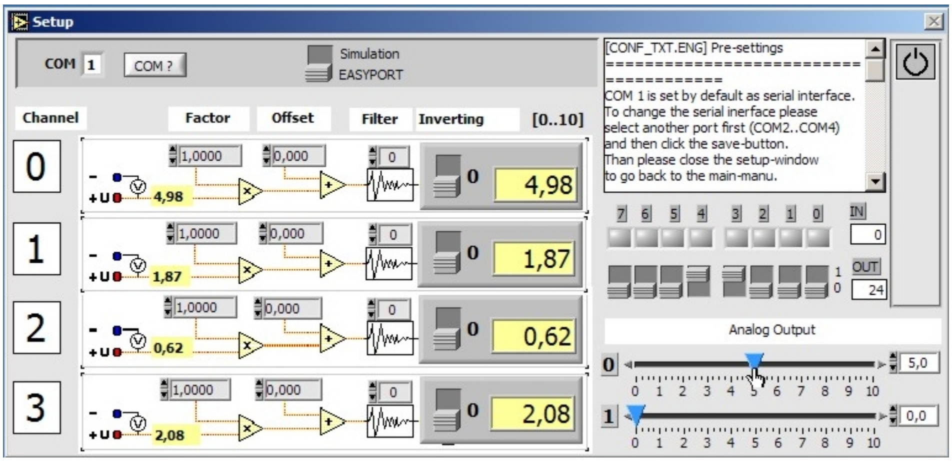


(Pre-select the output 2 = 1 to be able to activate the pump analog and set the analog value to the pump to 6,0 V - Analog Output 1. Watch the Channel 1 signal, which should increase as the output voltage to the pump increases. Please refer to the picture on the next page to see the water flow).

(After finish the test, please switch the analog output voltage to the pump to 0 Volt, deactivate the pump analog Output 2 = 0 and close the manual valve 104)

3.3 Test the flow control process via the proportional valve

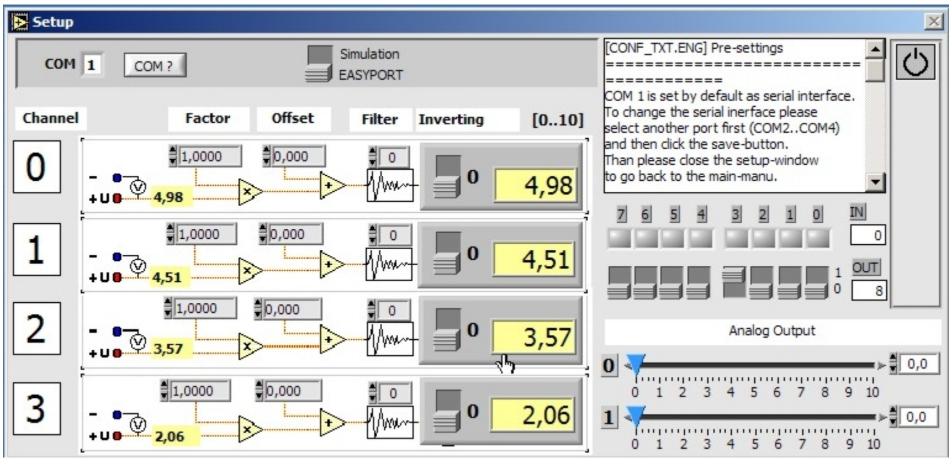
We are going to activate the pump digitally and the proportional valve analog and watch if the analog sensor value changes (flow sensor Channel 1). Please open the manual valve 109 to proceed.



(Pre-select the output 4 = 1 to be able to activate the proportional valve analog, set the analog signal to the proportional valve to 5,0 V - Analog Output 0 and activate the Output 3 = 1 to switch the pump on digitally and watch the Channel 1 signal, which should increase as the output voltage to the proportional valve increase. After the test is finished, please set analog signal to the proportional valve to 0 V, the Outputs 3 = 0 and Output 4 = 0 and close the valve 109).

3.4 Test the pressure control process

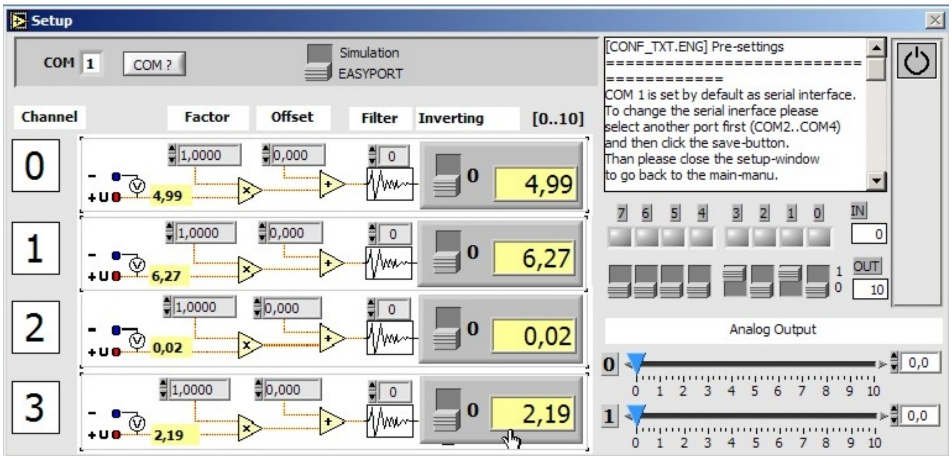
We are going to activate the pump digitally and watch if the analog sensor value changes (pressure sensor Channel 2). Please open the manual valves 103 and 108 to proceed.



(Activate the pump digitally by switching the Output 3 = 1 and watch the Channel 2 signal, which should increase immediately to the maximum pressure. After the test is finished, please set the Output 3 = 0 and close the valves 103 and 108).

3.5 Test the temperature control process

We are going to activate the pump and the heater digitally and watch if the analog sensor value increases (temperature sensor Channel 3). Please open the manual valves 103 and 109 to proceed.



(Activate the pump digitally by switching the Output 3 = 1 and switch on the heater with Output 1 = 1 and watch the Channel 3 signal, which should increase very slowly. After the test is finished, please set the Output 1 = 0, Output 3 = 0 and close the valves 103 and 109. Close the setup window and return to the main window).

4. **Test the control process with the Measuring and Control window**

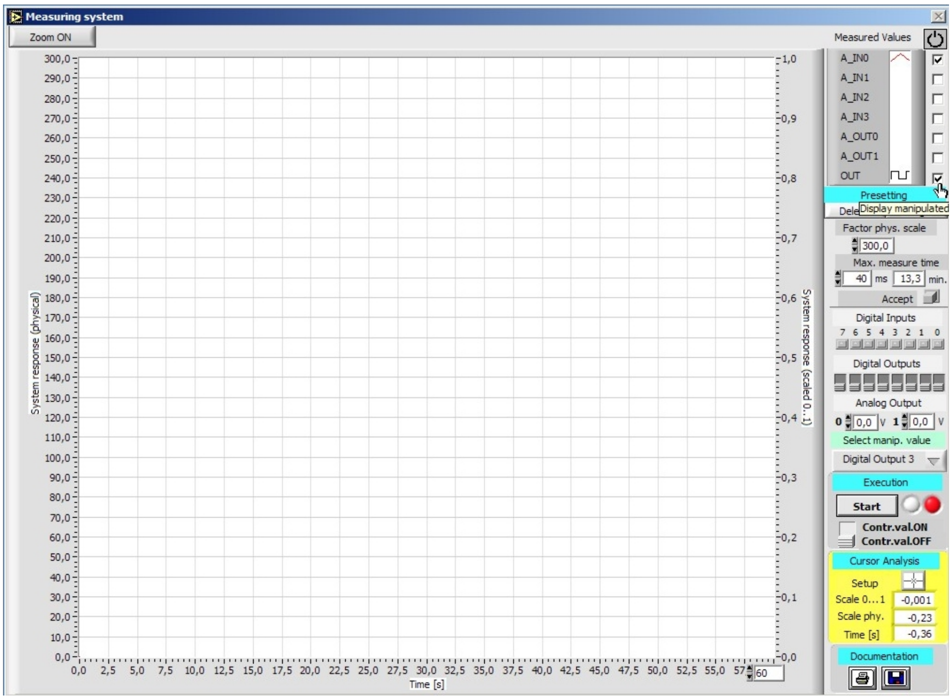
Instead of using the Setup window to test the different control process, we are going to use the window of Measuring and Control to proceed according to the exercises of 3.1 to 3.5.

Please activate the window Measuring and Control

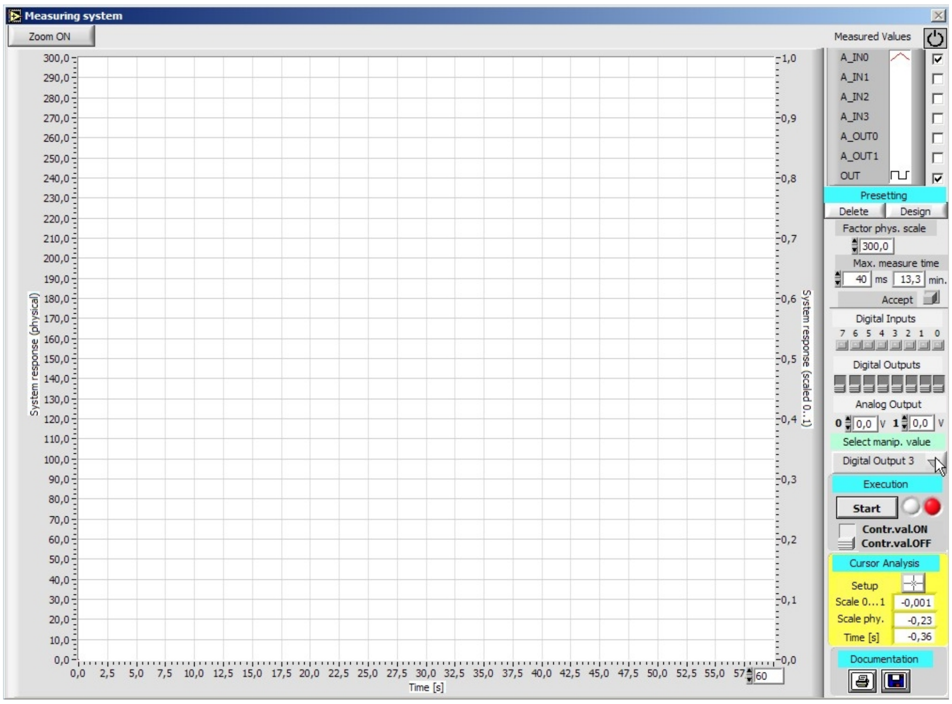
Measuring and Control

4.1 Test the level control process

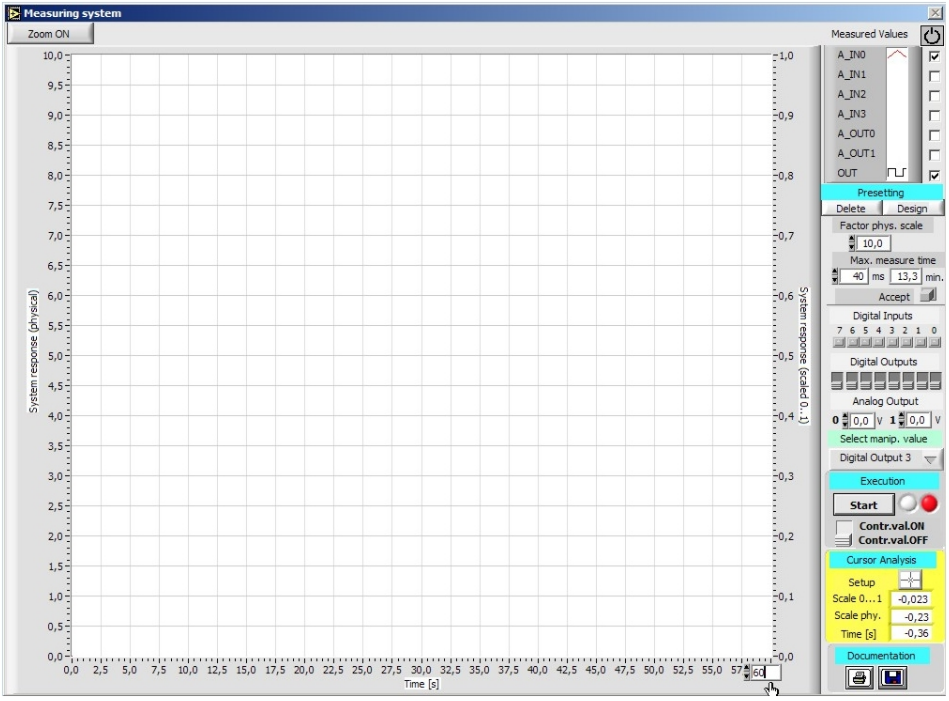
We are going to activate the pump digitally and pump water from tank 101 to tank 102 and watch if the analog sensor value changes (ultrasonic sensor Channel 0). To do so, we have to open the manual valve 101).



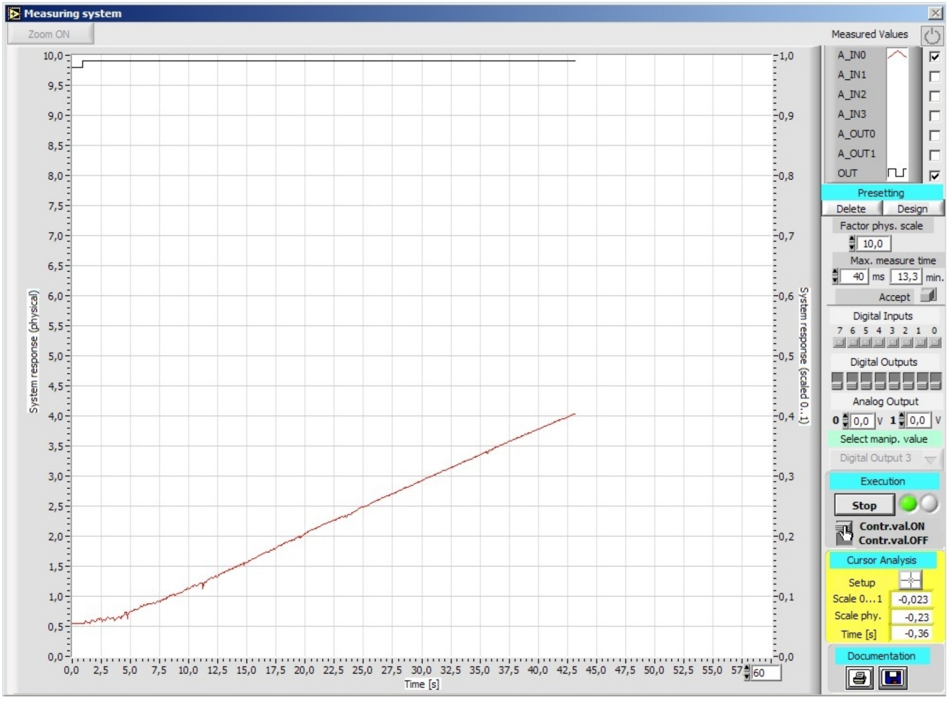
(Activate the Measured values of A_IN0 and OUT)



(Choose Digital Output 3 at the Selected manip. value)



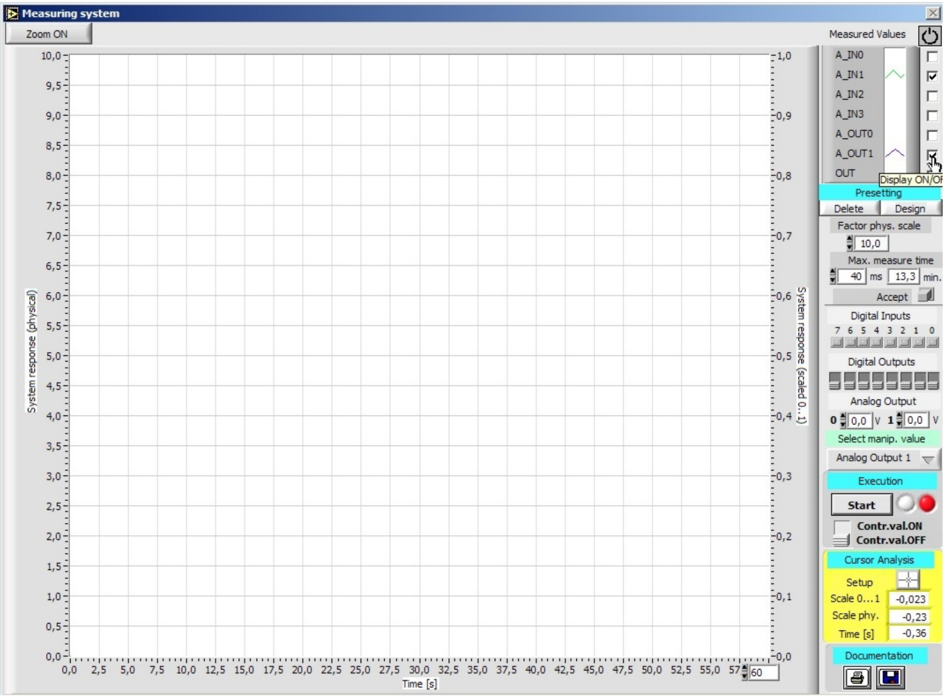
(Define the time on the x-axis – here 60 s)



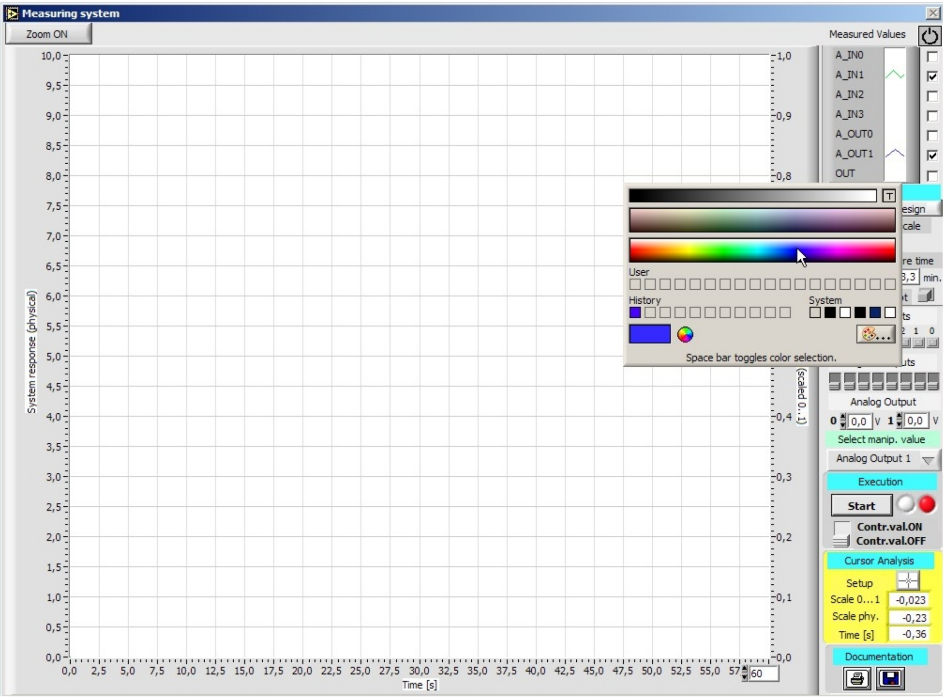
(Start the process) **Start** → (activate the manipulated value of the digital pump) **Contr.val.ON** → (watch the ultrasonic level sensor signal increases as the water increases inside tank 102) → (stop the process) **Contr.val.OFF** → **Stop** → (delete the actual screen) → **Delete** → (close the valve 101)

4.2 Test the flow control process

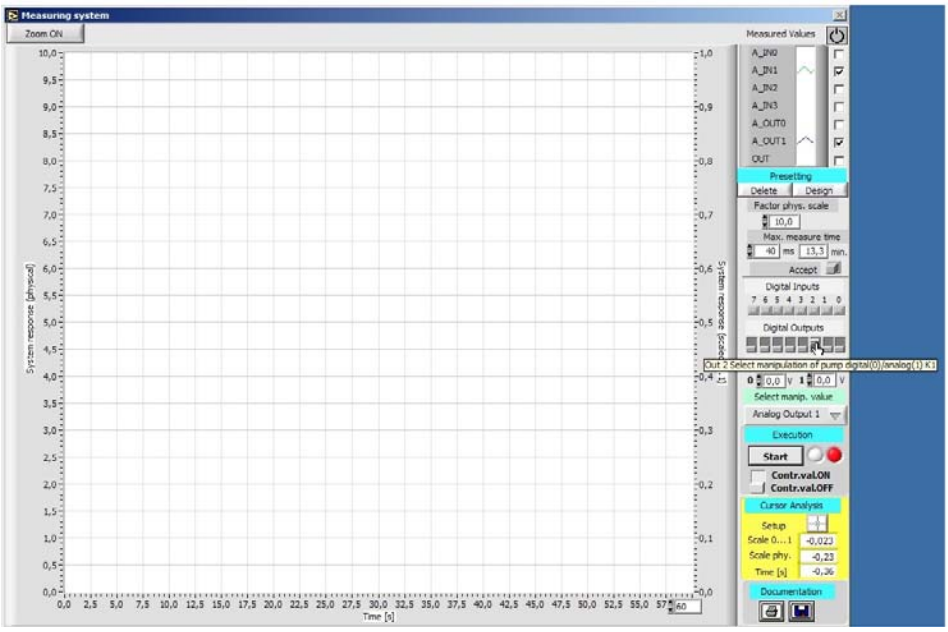
We are going to activate the pump analog and pump water from tank 101 to tank 101 (circulation) and watch if the analog sensor value changes (flow sensor Channel 1). Please open the manual valve 104 to proceed.



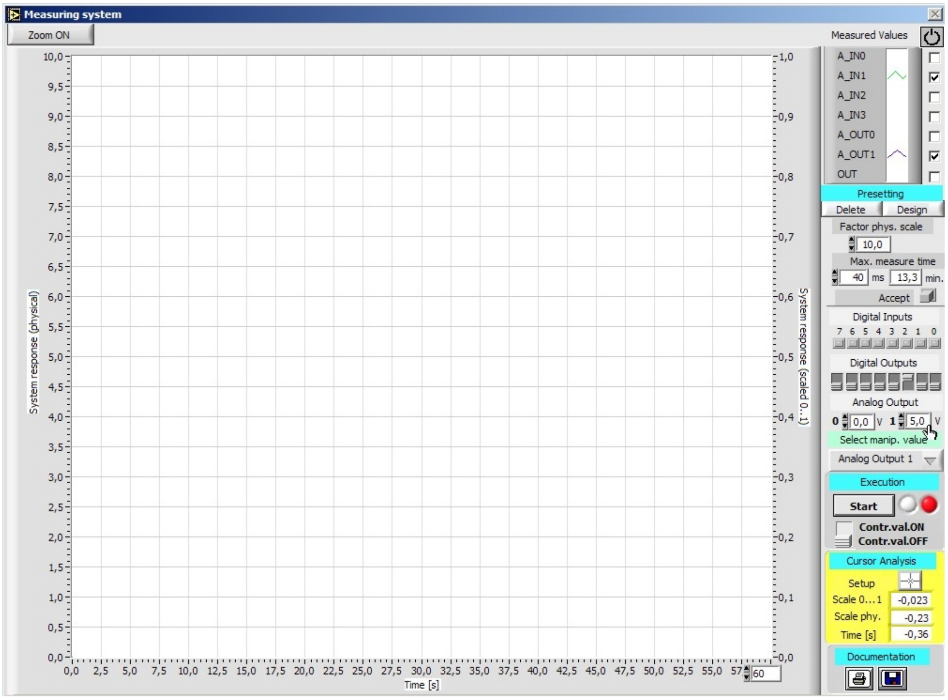
(Activate the Measured values of A_IN1 and A_OUT1)



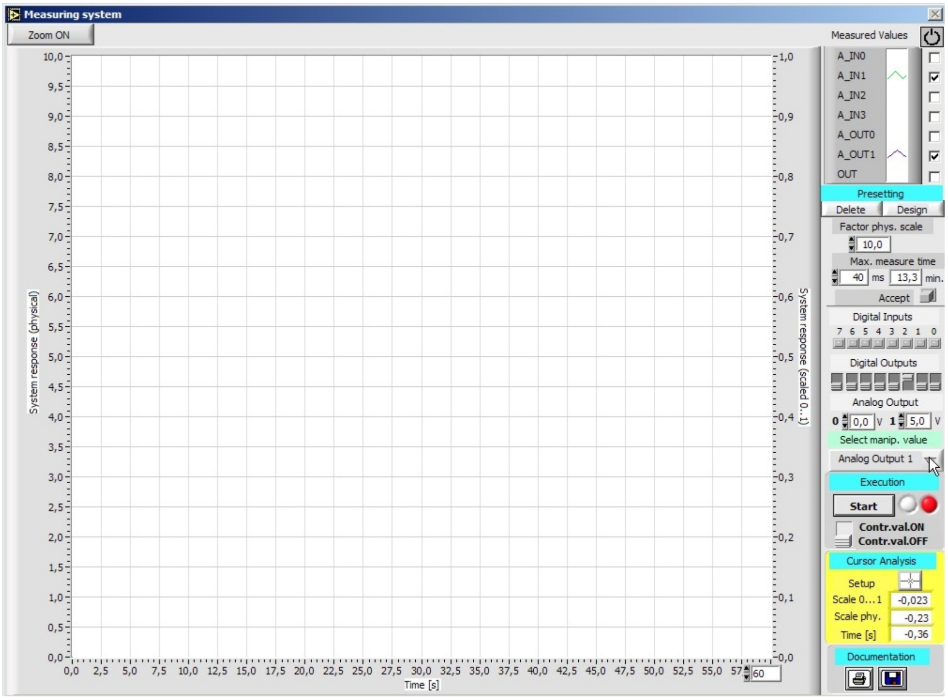
(For any measurement or continuous control process you can change the appearance of the graph in style and color, as shown within the screen shot. Click on the line you want to change and press the right mouse button. Choose the color you want by clicking on it)



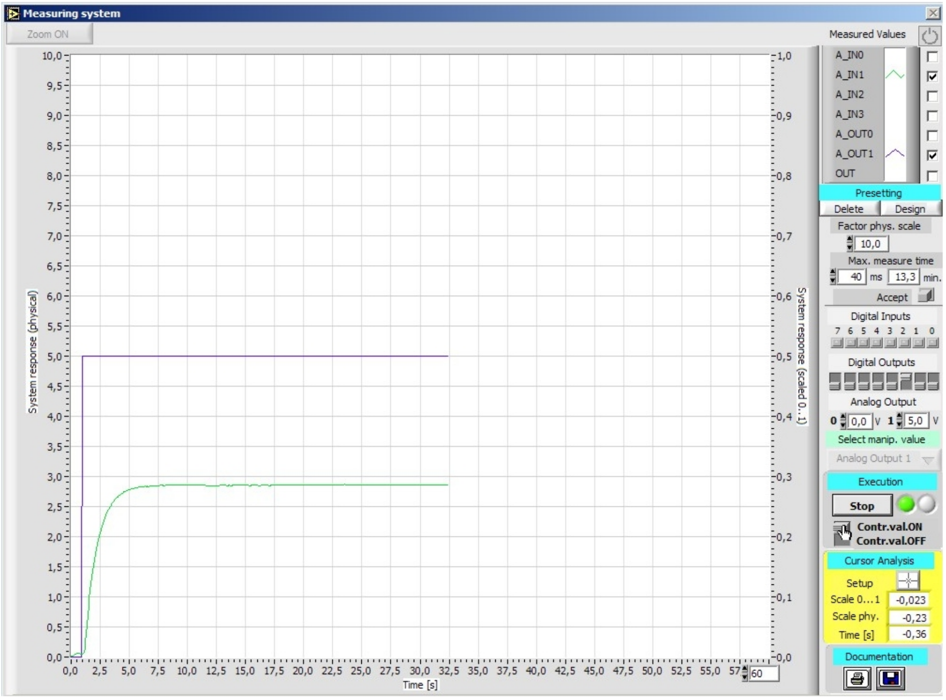
(Choose Digital Output 2 = 1 to pre-select the pump works analog)



(Pre-set the value to the pump to 5,0 V at the Analog Output 1)



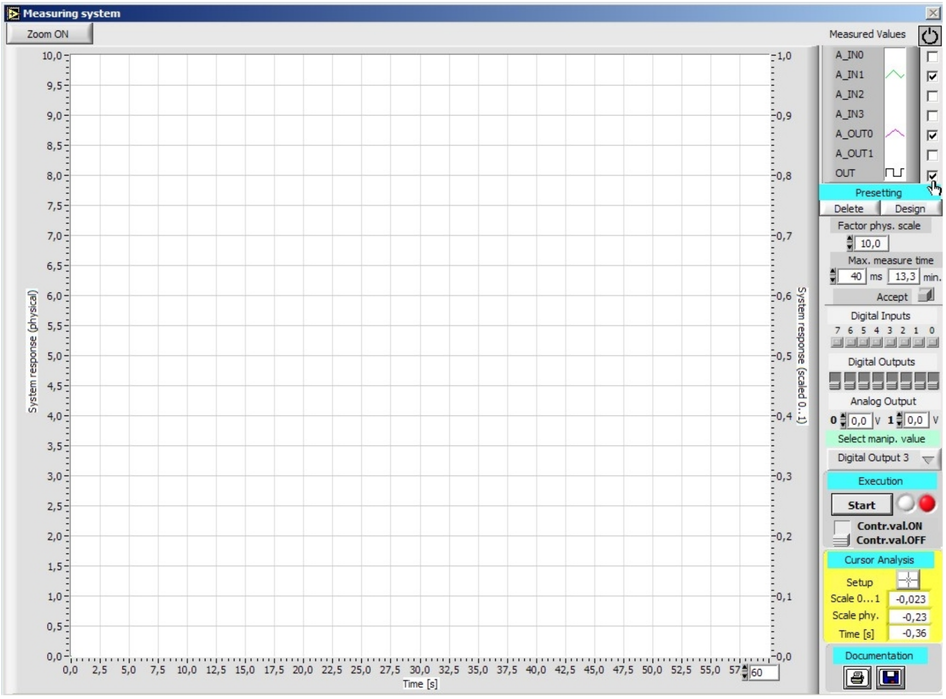
(Choose Analog Output 1 at the Selected manip. value)



(Start the process) **Start** → (activate the manipulated value of the analog pump) **Contr.val.ON** → (watch the flow sensor signal) → (stop the process) **Contr.val.OFF** → **Stop** → (delete the actual screen) → **Delete** → (close the valve 104)

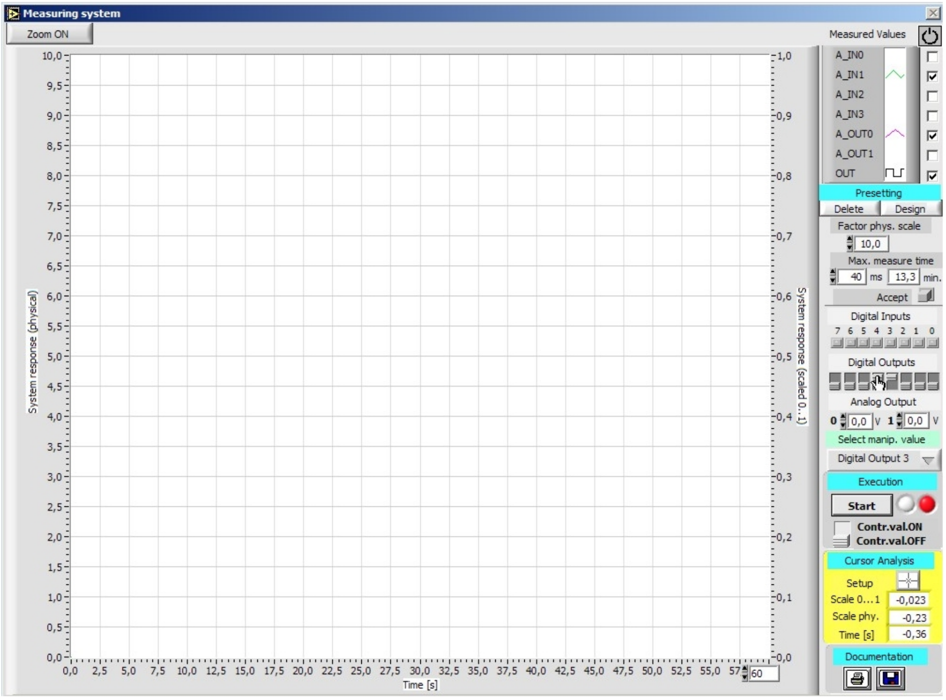
4.3 Test the flow control process via the proportional valve

We are going to activate the pump digitally and the proportional valve analog and watch if the analog sensor value changes (flow sensor Channel 1). Please open the manual valve 109 to proceed.

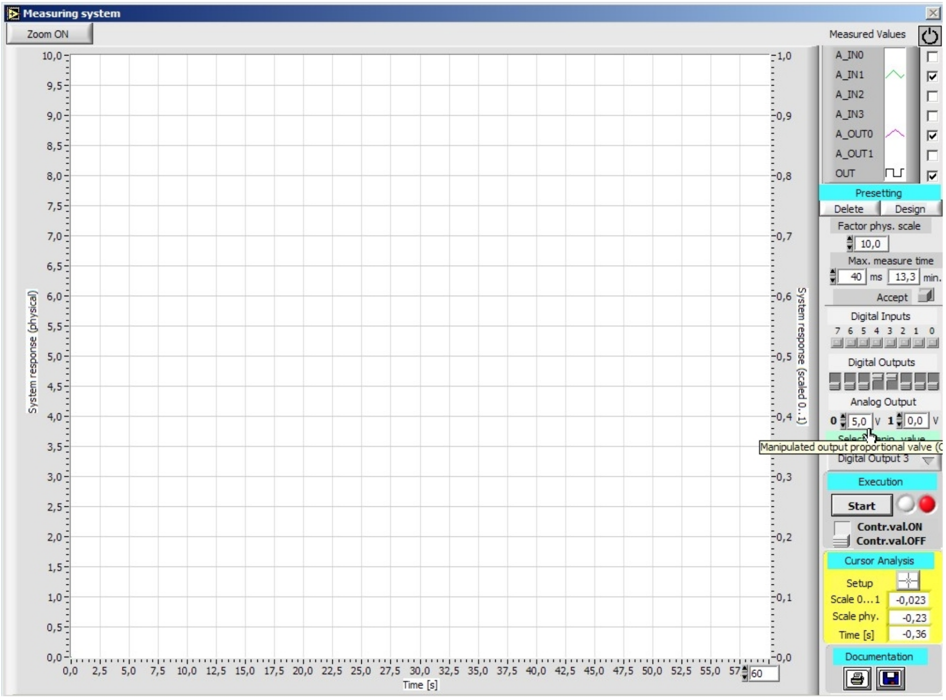


(Activate the Measured values of A_IN1, A_OUT0 and OUT)

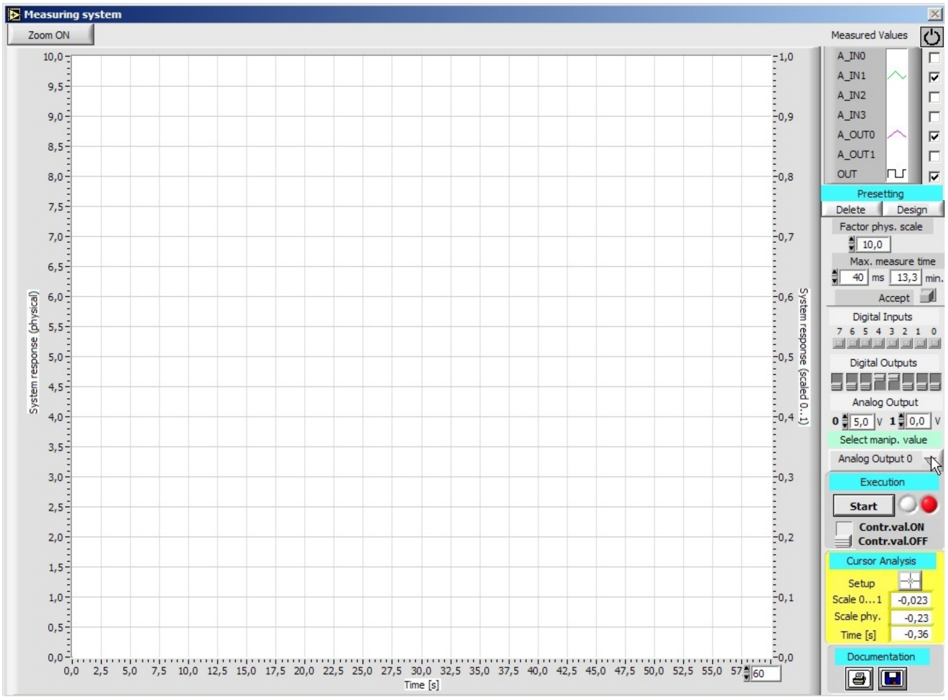
Test of the process



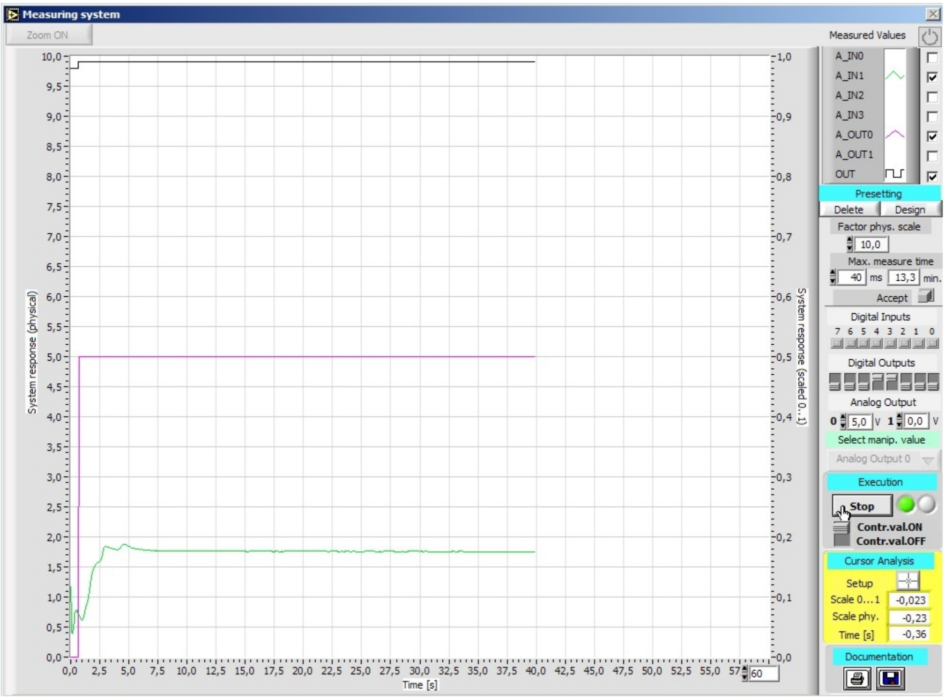
(Choose Digital Output 4 = 1 to activate the proportional valve and Output 3 = 1 to activate the pump digitally)



(Pre-set the value to the proportional valve to 5,0 V at the Analog Output 0)



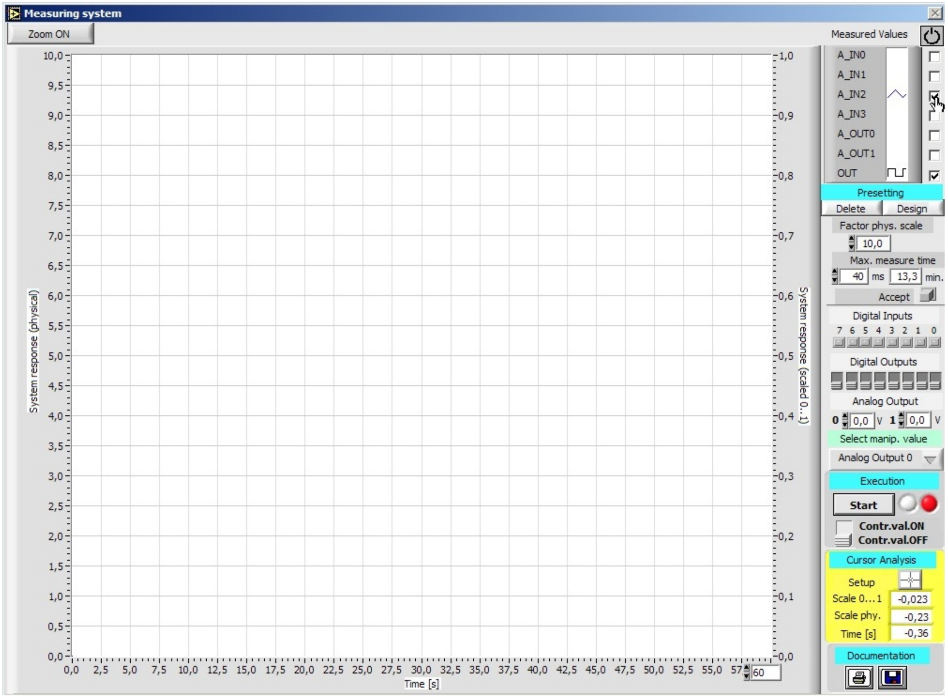
(Choose Analog Output 0 at the Selected manip. value)



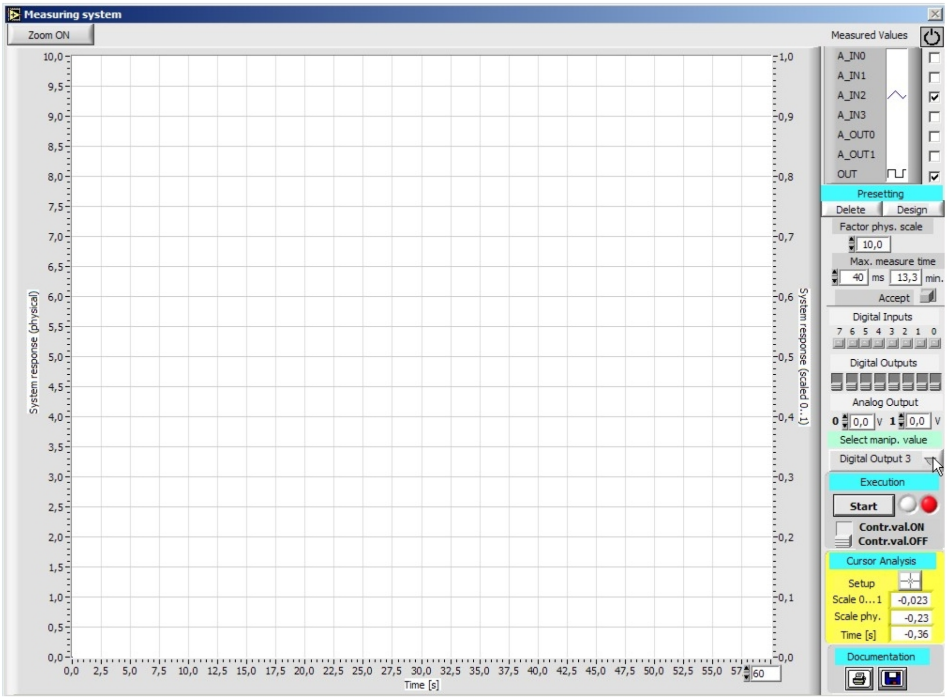
(Start the process) **Start** → (activate the manipulated value of the analog proportional valve) **Contr.val.ON** → (watch the flow sensor signal) → (stop the process) **Contr.val.OFF** → **Stop** → (delete the actual screen) → **Delete** → (close the valve 109)

4.4 Test the pressure control process

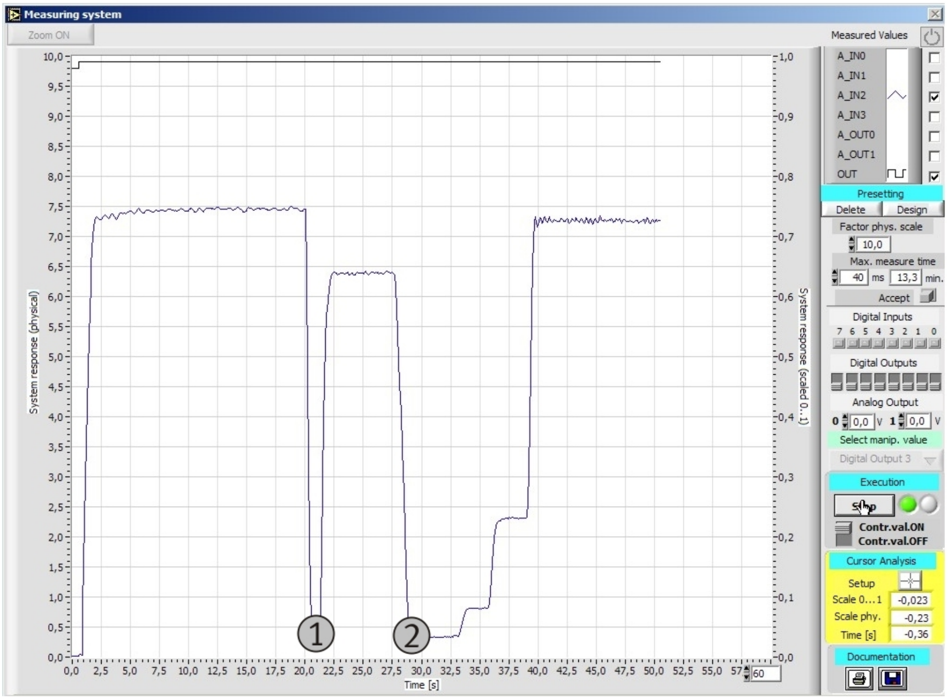
We are going to activate the pump digitally and watch if the analog sensor value changes (pressure sensor Channel 2). Please open the manual valves 103 and 108 to proceed.



(Activate the Measured values of A_IN2 and OUT)



(Choose Digital Output 3 at the Selected manip. value)

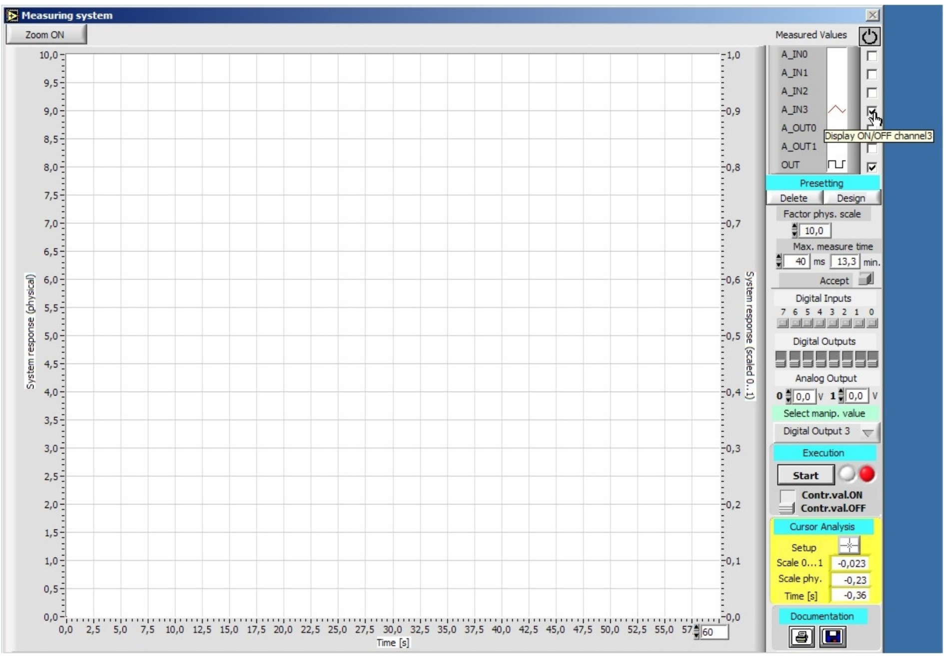


(Start the process) **Start** → (activate the manipulated value of the digital pump) **Contr.val.ON** → (watch the flow sensor signal) → (stop the process) **Contr.val.OFF** → **Stop** → (delete the actual screen) → **Delete** → (close the valves 103 and 108)

1 and 2 we openend the manual valve 112 to set a disturbance value

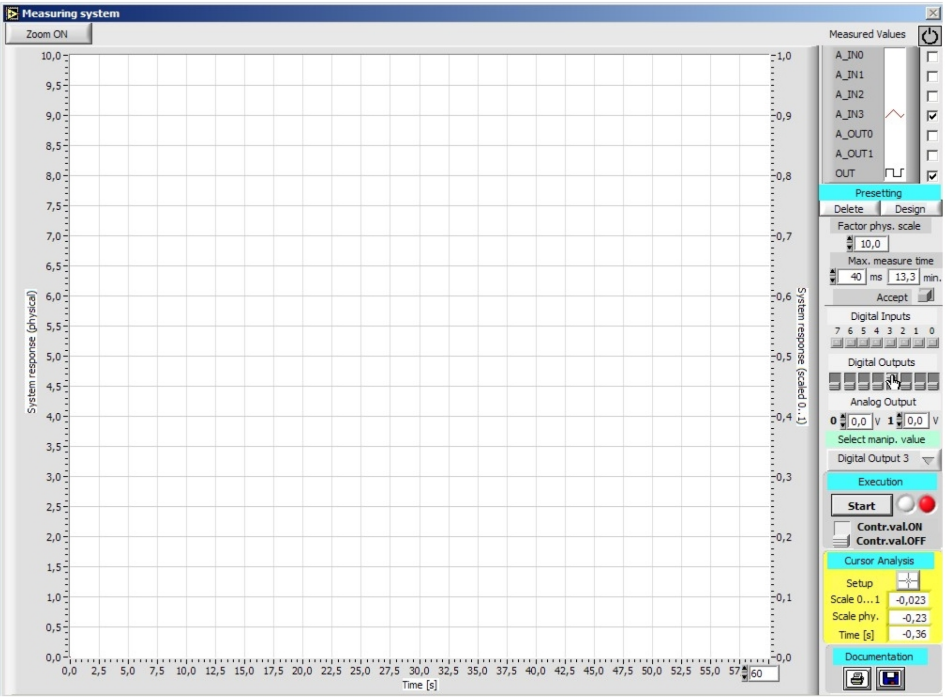
4.5 Test the temperature control process

We are going to activate the pump and the heater digitally and watch if the analog sensor value increases (temperature sensor Channel 3). Please open the manual valves 103 and 109 to proceed.

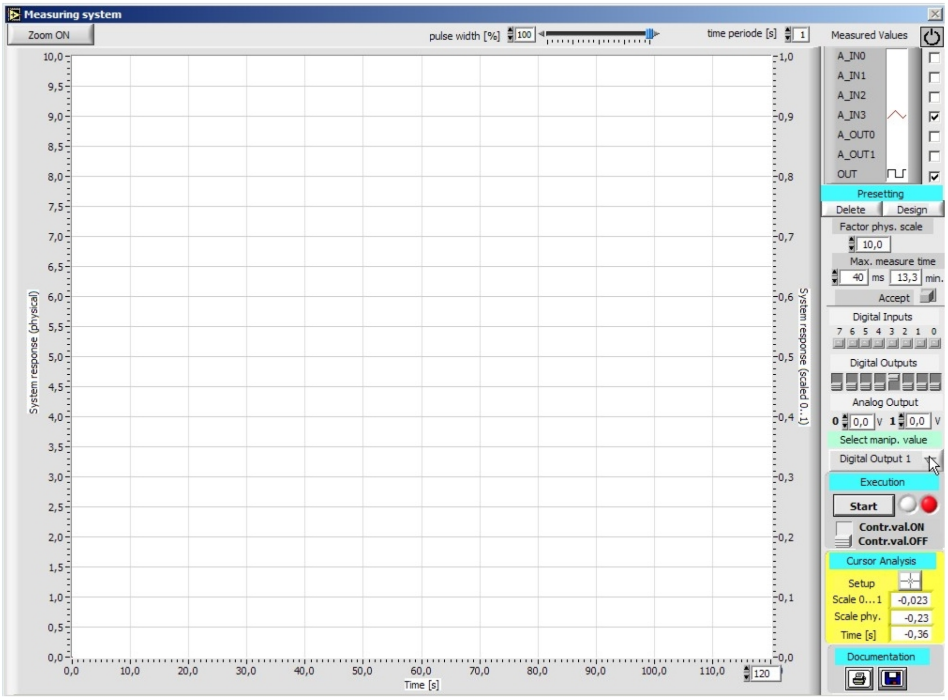


(Activate the Measured values of A_IN3 and OUT)

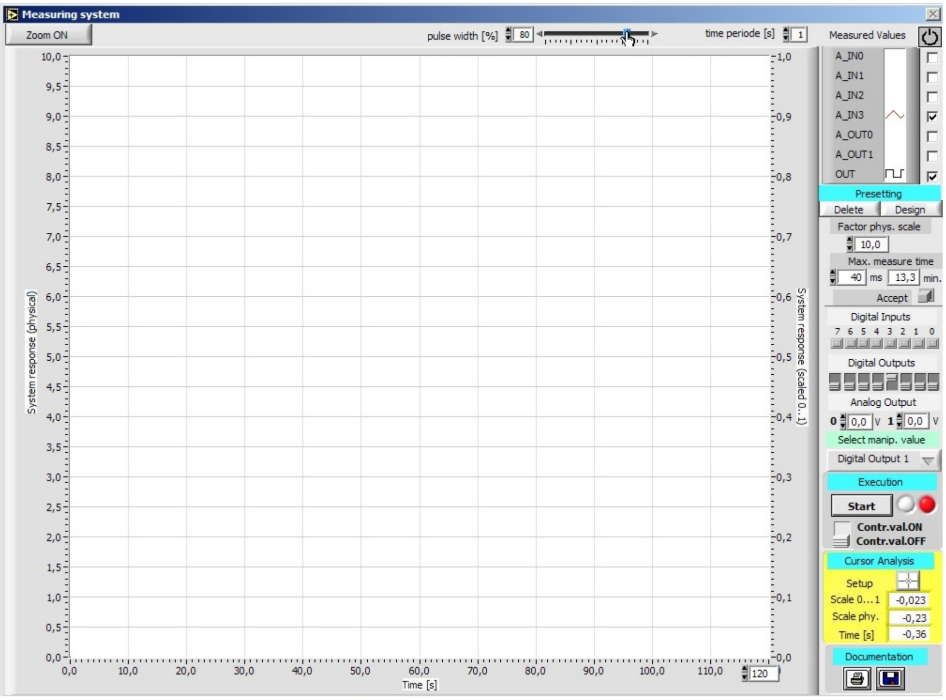
Test of the process



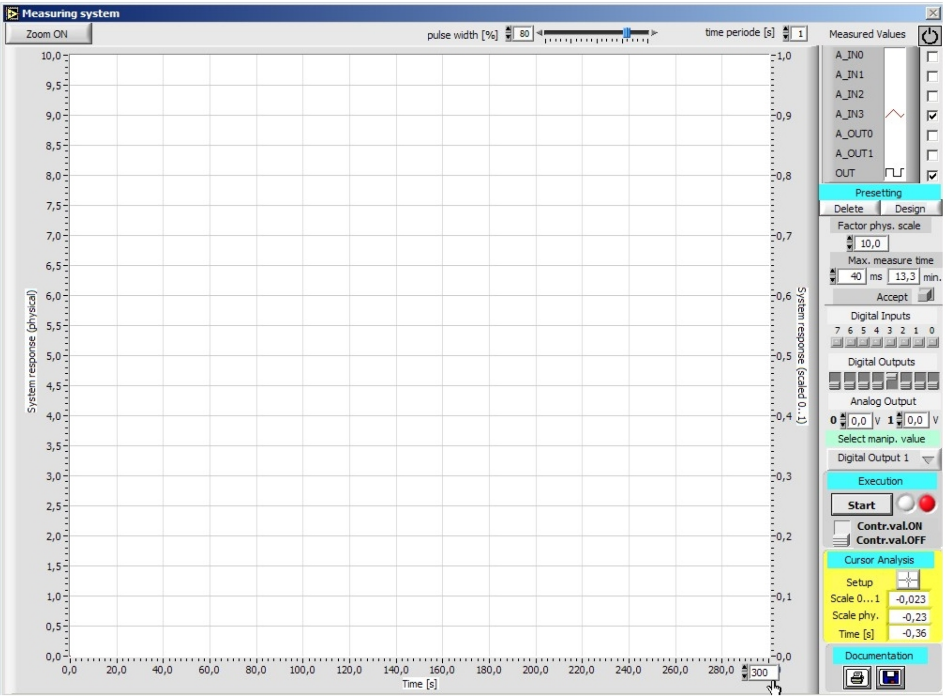
(Choose Digital Output 3 = 1 to activate the pump digitally)



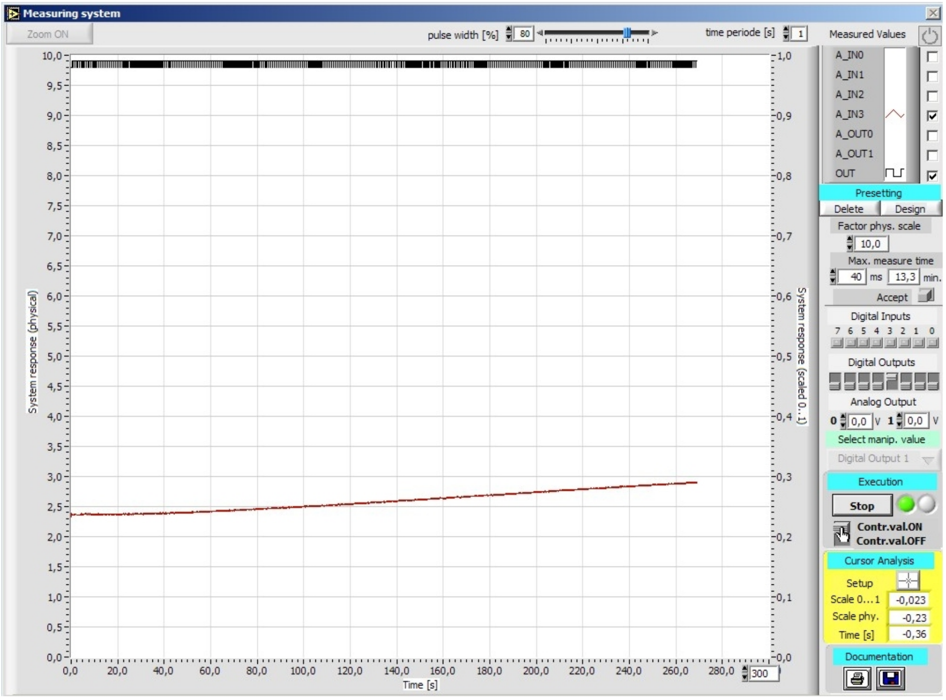
(Choose Digital Output 1 at the Selected manip. value)



(Pre-set the pulse width to the digital Output 1 of the heater to 80 %)



(Change the length of the time on the x-axis to 300 s)



(Start the process) **Start** → (activate the manipulated value of the heater) **Contr.val.ON** → (watch the temperature sensor signal) → (stop the process) **Contr.val.OFF** → **Stop** → (delete the actual screen) → **Delete** → (close the valves 103 and 109) → (close the Measuring and Control window)

5. **Definition of the factors for the process variables**

So far we have been working only with analog voltage signals of 0 – 10 V without focussing on the real process value like mm of water for the level control, or l/min for the flow or mbar for the pressure or °C for the temperature.

To do so, we have to calculate the relation between the analog voltage signals and the real process variable. We are going to do that using the Setup menu.

(Activate the Setup menu) **Setup**

We are going to use the following index:

$U_{max\ Process}$ represents the maximum analog sensor signal we can reach with the workstation

$X_{max\ Process}$ represents the maximum process variable we can reach with the workstation (later we need that information by using the industrial controller DR 19)

X_{max} represents the process value at a sensor signal of 10 V (later we need that information by using the industrial controller DR 19)

U_{max} 10 V

f Factor - represents the relation between the voltage signal and the process variable

5.1 Adjustment of the ultrasonic sensor

Using the level control, the relation of the voltage signal of the ultrasonic sensor and the process variable is defined by the process itself. We just have to make sure, that the ultrasonic sensor is adjusted according to the following values:

$U_{max\ Process}$ at the ultrasonic sensor = 10 V

$X_{max\ Process}$ 300 mm

X_{max} 300 mm

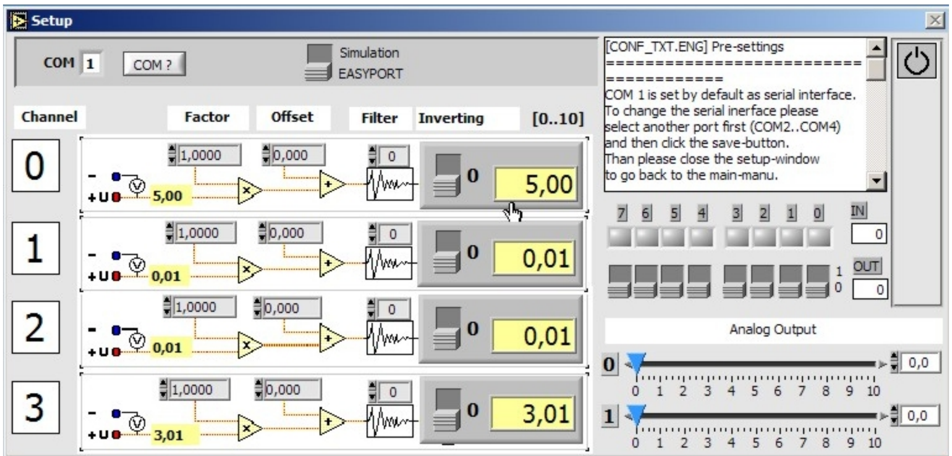
$f = X_{max\ Process} / U_{max\ Process}$

f = 300 mm / 10 V

f = 30 [mm/V]

To adjust the ultrasonic sensor, we will pump exactly 150 mm of water from tank 101 into the tank 102 and adjust the ultrasonic sensor to the corresponding value of exactly 5,00 V, because according to our definition, 150 mm of water is exactly the half of 300 mm and therefore the half of 10,00 V = 5,00 V.

After that, we are going to adjust the ultrasonic sensor (up or down) until the voltage signal at Channel 0 in the Setup menu is 5,00 V.



(Adjust the sensor until the voltage signal of Channel 0 is 5,00 V)

Now we are sure, that the voltage signal of the ultrasonic sensor, multiplied with the factor of 30 represents exactly the height of the water inside the tank 102. So we find the first relation of the following table already:

	$U_{max\ Process}$	$X_{max\ Process}$	X_{max}	**Factor**
Level control	10,00 V	300 mm	300 mm	30 mm / V
Flow control with pump				
Flow control with prop.valve				
Pressure control				
Temperature control				

5.2 Definition of the flow rate factor

Using the flow control, the relation of the voltage signal of the flow sensor and the process variable has to be defined by an experiment and calculated.

$U_{max\ Process}$ in [V] represents the flow sensor signal at Channel 1 using the maximum power of the pump (digital Output 3 = 1)

$X_{max\ Process}$ in [l / min] represents the maximum flow rate with the workstation which has to be defined by an experiment and calculated

U_{max} maximum value of the flow rate sensor = 10 V

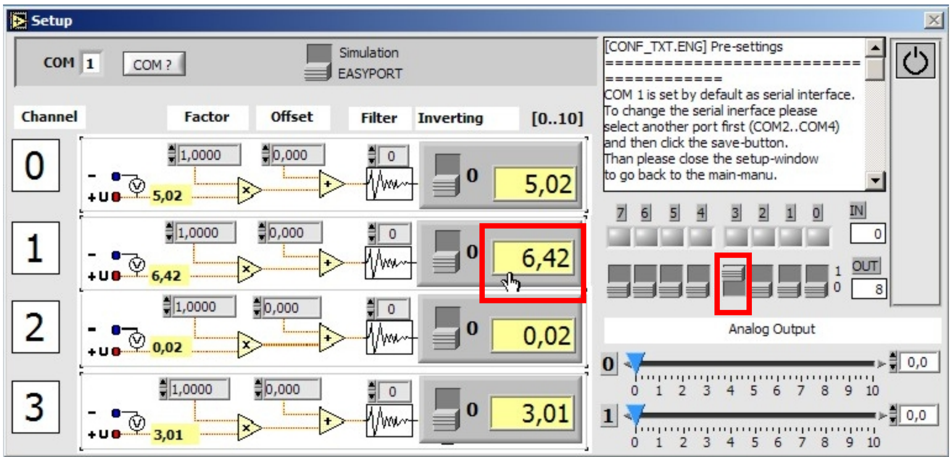
X_{max} in [l / min] represents the maximum flow rate if the flow rate sensor would have a 10 V signal

$X_{max} = f * U_{max}$

$f = X_{max\ Process} / U_{max\ Process}$

$X_{max} = X_{max\ Process} / U_{max\ Process} * U_{max}$

To do the experiment, we will pump water from tank 101 to tank 102 exactly one minute. We are going to check the maximum voltage signal of the flow rate sensor and check the height of the water reached within this minute.



The mathematical conditions are as follows:

$X_{max} = f * U_{max}$

$f = X_{max\ Process} / U_{max\ Process}$

$X_{max} = X_{max\ Process} / U_{max\ Process} * U_{max}$

We will calculate $X_{max\ Process}$ first with the following values:

l = 17,5 cm = 1,75 dm (length of the tank 102)

w = 19,0 cm = 1,9 dm (width of the tank 102)

$V = l * w$ / [dm^2]

m = 149 mm / min = 1,49 dm / min (measurement of the water height in 1 minute)

$X_{max\ Process} = V * m$

$X_{max\ Process} = l * w * m$

$X_{max\ Process}$ = 1,75 dm * 1,9 dm * 1,49 dm /min

$X_{max\ Process}$ = 4,95 l / min

The value for $U_{max\ Process}$ we found by the experiment (signal at Channel 1):

$U_{max\ Process}$ = 6,42 V

The maximum voltage is fixed to 10 V

U_{max} = 10 V

Now we can calculate the value of X_{max} and f:

$X_{max} = X_{max\ Process} / U_{max\ Process} * U_{max}$

X_{max} = 4,95 l / min / 6,42 V * 10 V

X_{max} = 7,7 l / min

f = 4,95 l / min / 6,42 V

f = 0,77 l / min / V

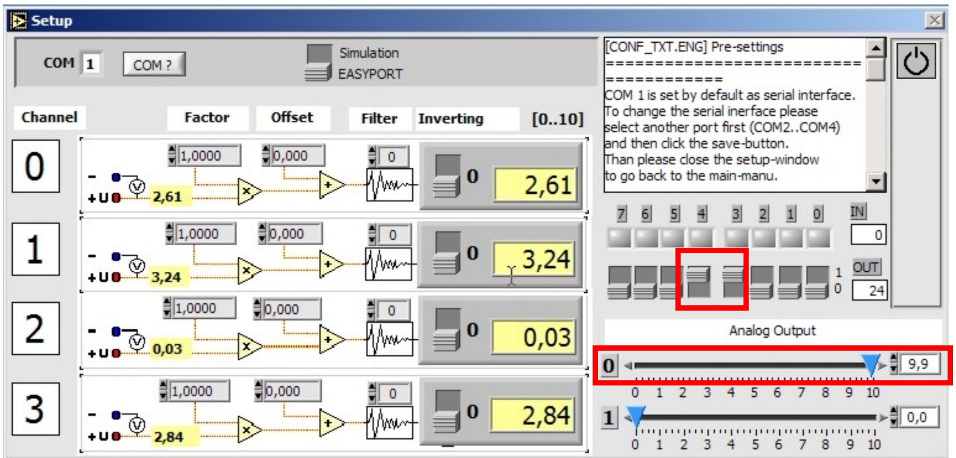
Now we can put the calculated values inside our table:

	$U_{max\ Process}$	$X_{max\ Process}$	X_{max}	**Factor**
Level control	10,00 V	300 mm	300 mm	30
Flow control with pump	6,42 V	4,95 l / min	7,7 l / min	0,77 l / min / V
Flow control with prop.valve				
Pressure control				
Temperature control				

5.3 Definition of the maximum flow rate using the proportional valve

This exercise is only important to find out the maximum flow rate by using the proportional valve activated with the maximum voltage of 10 V. The factor will be the same as for the flow rate done before of course, but if we are going to use the industrial controller DR 19, we need to know the maximum scale level we can reach.

Please do the following exercise and check the voltage level at the flow sensor. We are going to use the pump digitally and activate the proportional valve with 10 V.



As we can see, the maximum voltage level at the flow sensor is lower using the proportional valve. The reason for that is, that the diameter of the valve is smaller than the tubes.

The maximum value of 3,24 V is corresponding to the maximum flow rate of:

$X_{max\ Process} = U_{max\ Process} * f$

$X_{max\ Process} = 3{,}24\ V * 0{,}77\ l / min / V$

$\mathbf{X_{max\ Process} = 2{,}49\ l / min}$

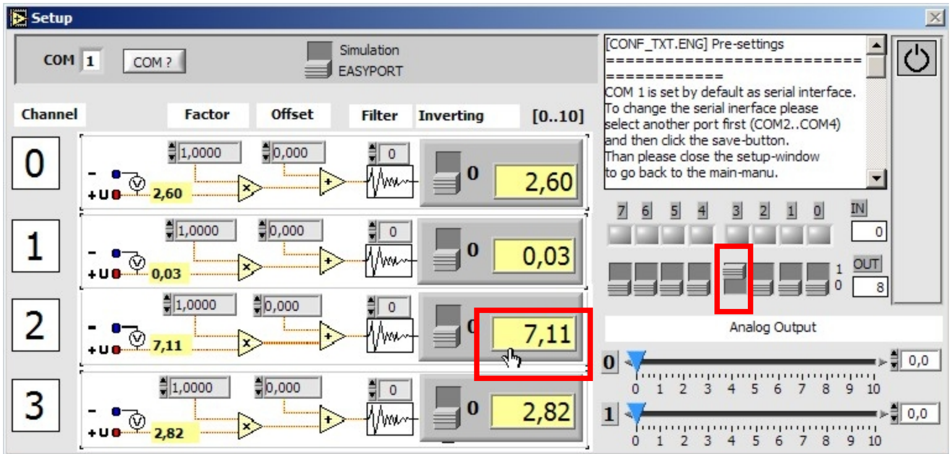
Now we can put the calculated value inside our table:

	$U_{max\ Process}$	$X_{max\ Process}$	X_{max}	**Factor**
Level control	10,00 V	300 mm	300 mm	30 mm / V
Flow control with pump	6,42 V	4,95 l / min	7,7 l / min	0,77 l / min / V
Flow control with prop.valve	3,42 V	2,49 l / min	----------	----------
Pressure control				
Temperature control				

5.4 Definition of the pressure rate factor

For this exercise, we will activate the pump digitally and check the maximum value of the pressure at the pressure measuring instrument.

We found out that the maximum pressure is 275 mbar which represents $X_{max\ Process}$



(The maximum voltage at Channel 2 is 7,11 V which represents $U_{max\ Process}$)

With that values we are able to calculate:

$X_{max} = f * U_{max}$

$f = X_{max\ Process\ /}\ U_{max\ Process}$

$X_{max} = X_{max\ Process\ /}\ U_{max\ Process} * U_{max}$

X_{max} = 275 mbar / 7,11 V* 10 V

X_{max} = 386,8 mbar

$f = X_{max\ Process\ /}\ U_{max\ Process}$

f = 275 mbar / 7,11 V

f = 38,7 mbar / V

Now we can put the calculated value inside our table:

	$U_{max\ Process}$	$X_{max\ Process}$	X_{max}	Factor
Level control	10,00 V	300 mm	300 mm	30 mm / V
Flow control with pump	6,42 V	4,95 l / min	7,7 l / min	0,77 l / min / V
Flow control with prop.valve	3,42 V	2,49 l / min	----------	----------
Pressure control	7,11 V	275 mbar	386,8 mbar	38,7 mbar / V
Temperature control				

5.5 Definition of the temperature factor

The easiest way to define the factor is the temperature process, because we are using a PT 100 sensor, normalized to 0 – 10 V which means 0 – 100 ° C.

The calculation of the factor is according to:

$f = X_{max\ Process} / U_{max\ Process}$

$f = 50\ °C / 5{,}0\ V$

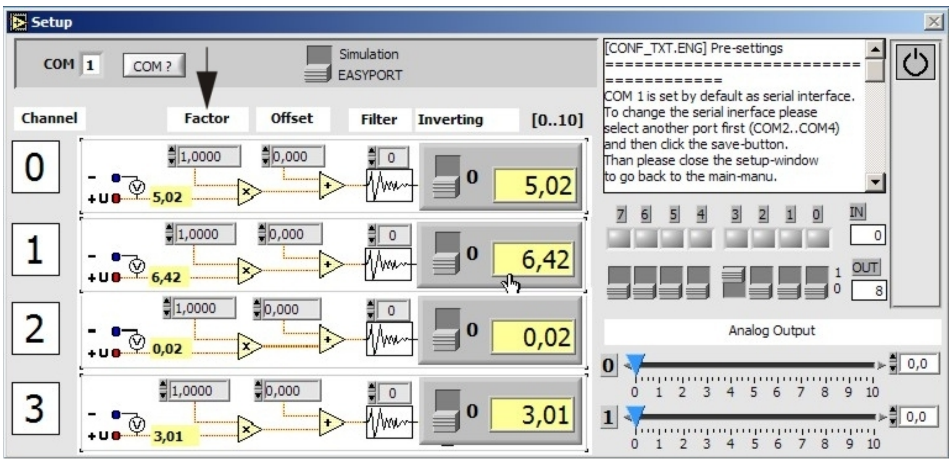
f = 10 ° C / V

Now we can complete our table:

	$U_{max\ Process}$	$X_{max\ Process}$	X_{max}	Factor
Level control	10,00 V	300 mm	300 mm	30 mm / V
Flow control with pump	6,42 V	4,95 l / min	7,7 l / min	0,77 l / min / V
Flow control with prop.valve	3,42 V	2,49 l / min	----------	----------
Pressure control	7,11 V	275 mbar	386,8 mbar	38,7 mbar / V
Temperature control	< 5,0 V *	50 ° C	100 ° C	10 °C / V

* The temperature inside the tank should not exceed 50 ° C which means 5,0 V

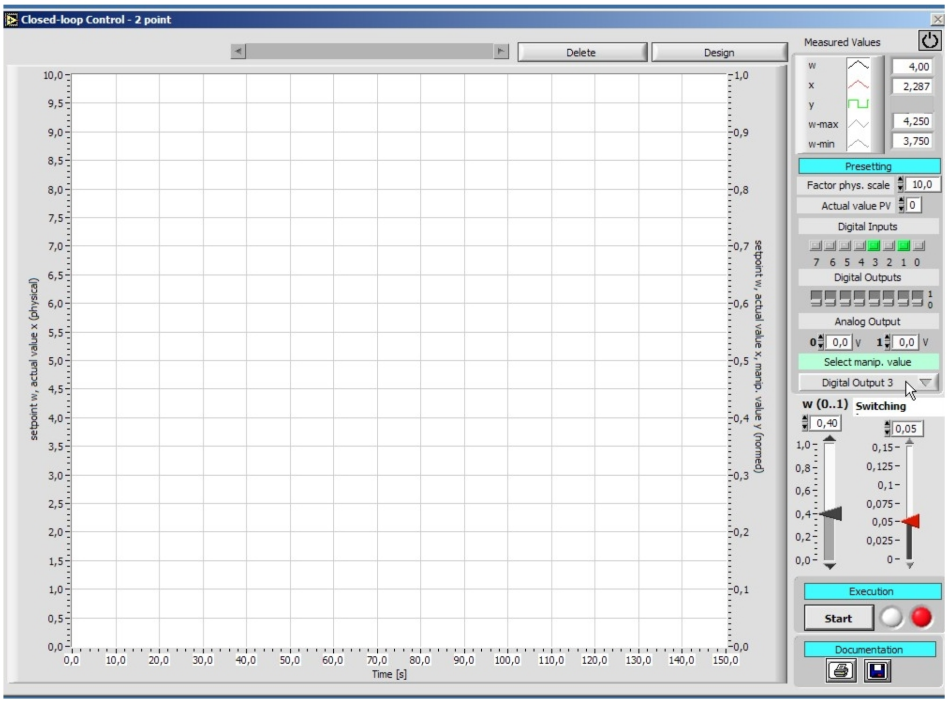
Now we can insert the above mentioned factors within the Setup menu and watch the voltage signals of Channel 0 to 3 in the real process variables.



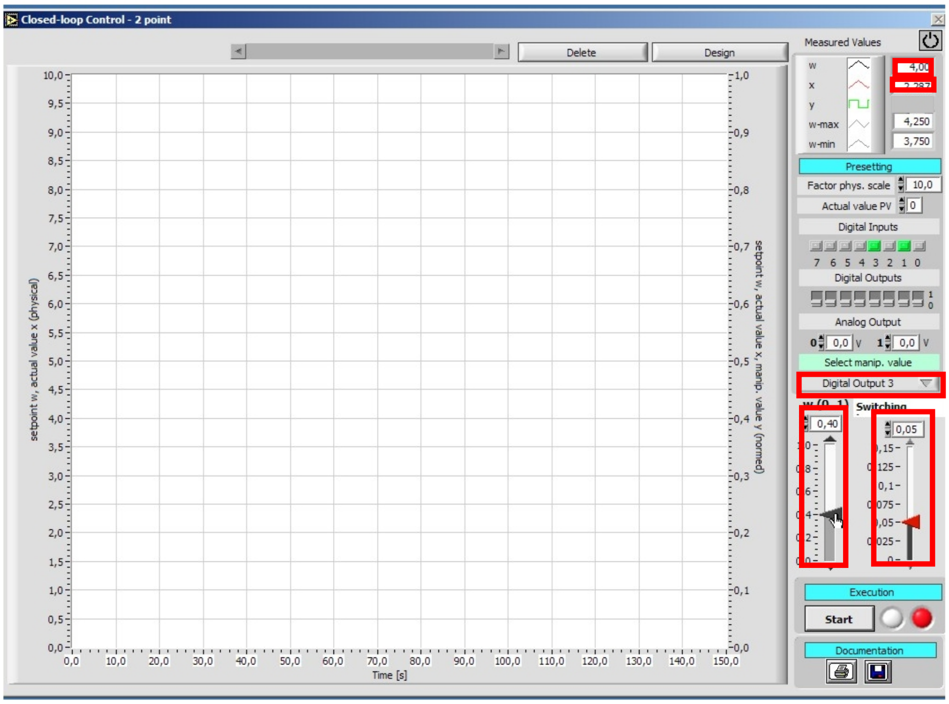
(Because we are going to use the voltage signals directly from 0 – 10 V to proceed with the 2-step controller as well as with the continuous control, please reset all factors to 1 again after the testing is finished. Close the Setup menu)

6. **Level control by a 2-step controller**

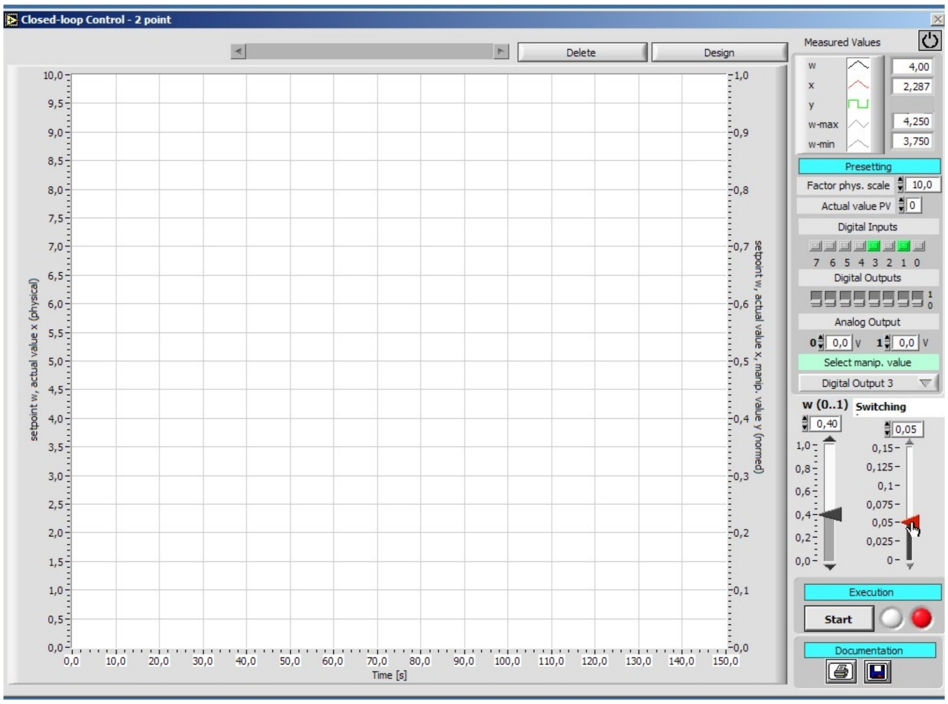
The 2-step controller represents the easiest way to control a process variable simply by digitally switching on the manipulated value when a minimum level is reached and switching it off when a maximum level is reached. For this exercise, we are going to activate the pump digitally and open the manual valve 101 totally and the valve 112 by 2/3 to realise a disturbance value. Open the window of
Closed loop Control – 2 point at the main menu and proceed as follows:



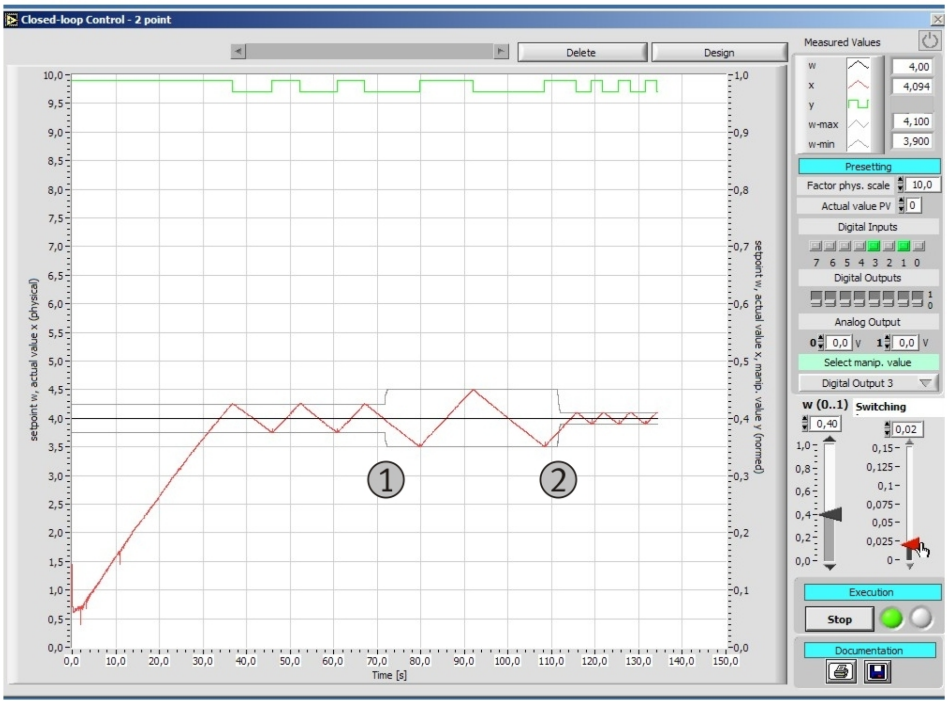
(Set the Select.manip. value to Digital Output 3 of the pump)



(Define the process value of 4 V = 0,4)



(Define the switching point for the process value between maximum and minimum to 0,5 V = 0,05 and start the process) **Start**



1 Change the switching points to +/- 1,0 V = 0,1

2 Change the switching points to +/- 0,2 V = 0,02

(After the test is finished, please stop the process) **Stop** → (close the window of the 2-step controller)

Continuous control

7. **Continuous control of level, flow and pressure process**

In the following projects we are going to realise continuous control for the level, the flow and the pressure process using different controller types. Please open the window of Closed loop Control – continuous in the main menu.

We are also going to change the values of the parameters during each process, mentioned by 1 – Start – Stop a.s.o. It is possible to start and stop the process at any time, change the parameters and start the process again.

These steps are marked with 1 a.s.o. within the chart and with 1 – Start – Stop a.s.o. within the table

The list of parameters for every project looks like:

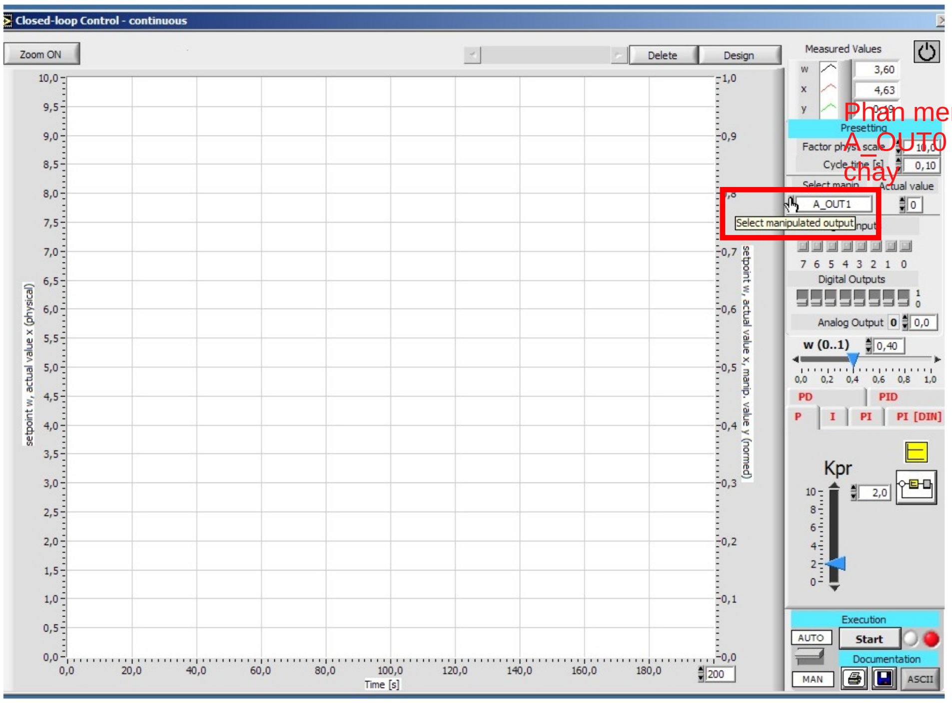
	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P		X	X		X	X		X	X		X	X		X	X
I	X		X	X		X	X		X	X		X	X		X
PI			X			X			X			X			X
PD		X			X			X			X			X	
PID															

For the continuous level control, we opened the manual valve 112 to 2/3 to realise a disturbance value.

We will not evaluate the results of the different continuous control results with the different controllers and parameters. It is part of this project, that you find the best control and parameters by yourself.

7.1 Continuous level control

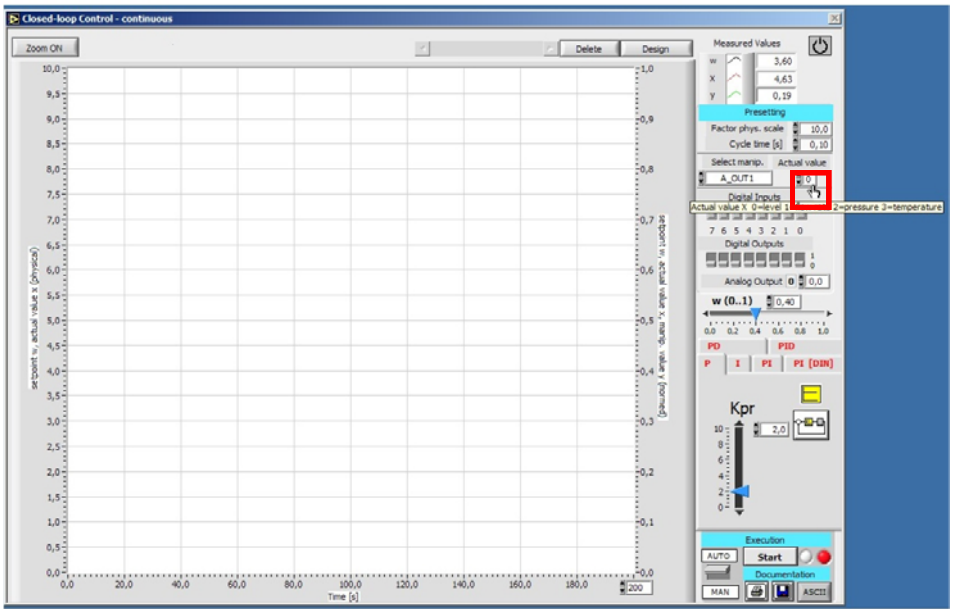
For the continuous level control, we opened the manual valve 112 to 2/3 to realise a disturbance value. Please proceed to prepare the continuous level control with different parameters as follows:



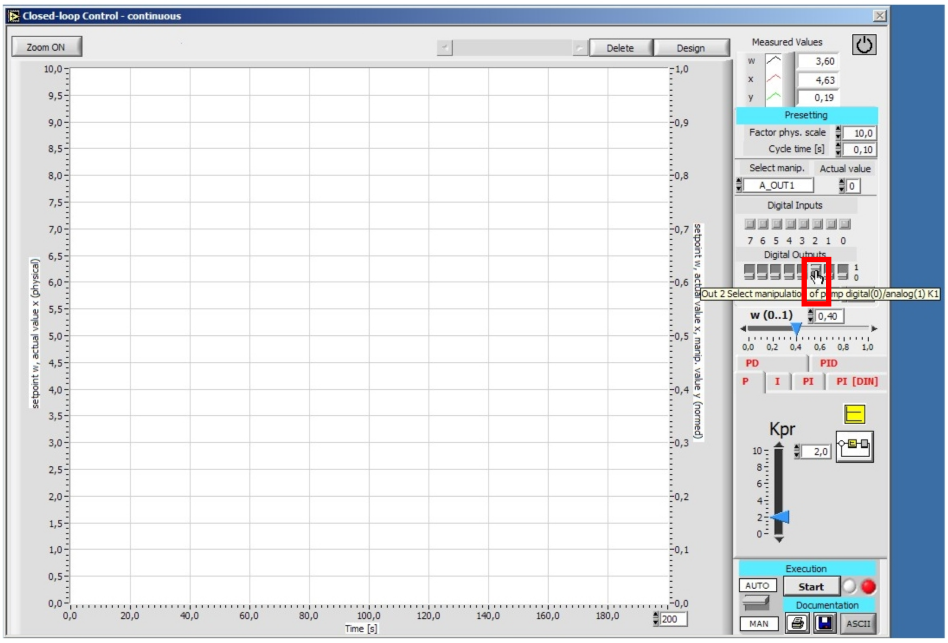
Phan mem cho A_OUT0 bang 0 moi chay

(Select manipu. (manipulated value) to A_OUT1 which represents the analog activation of the pump)

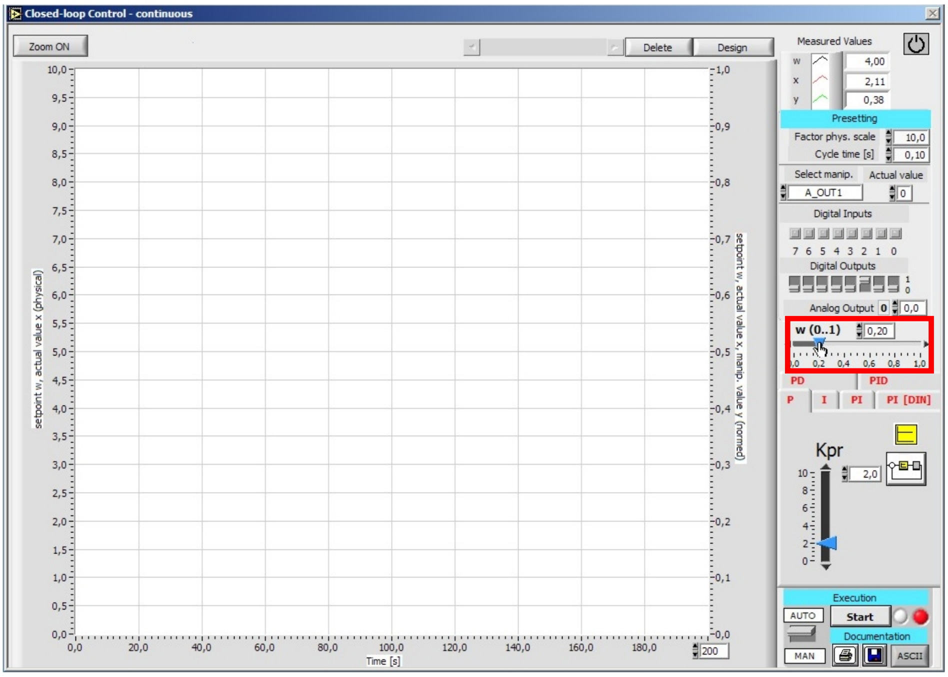
A_OUT0



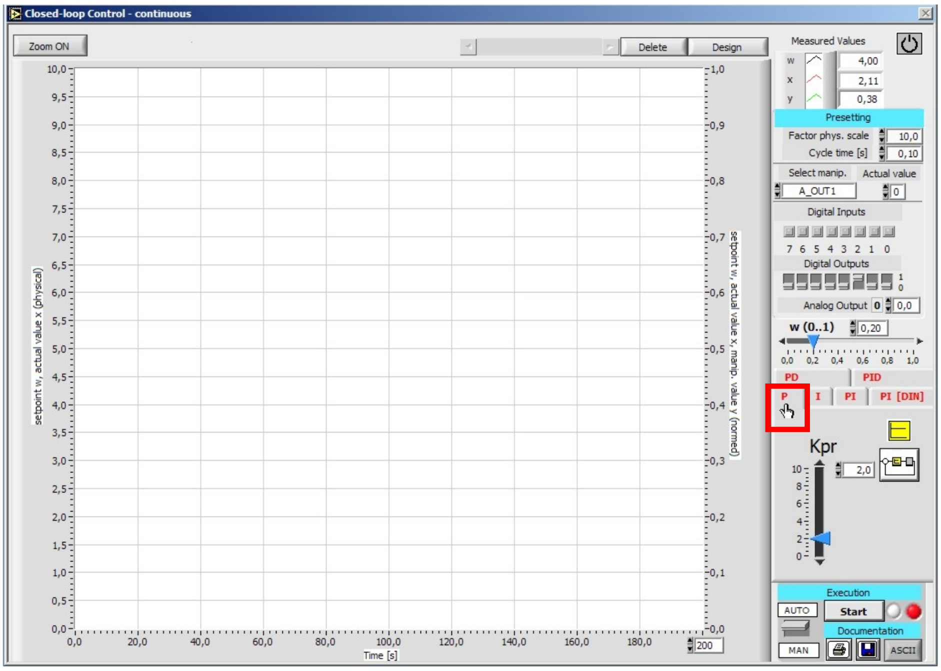
(Set the Actual value to 0 which represents the Channel 0 of the level sensor)



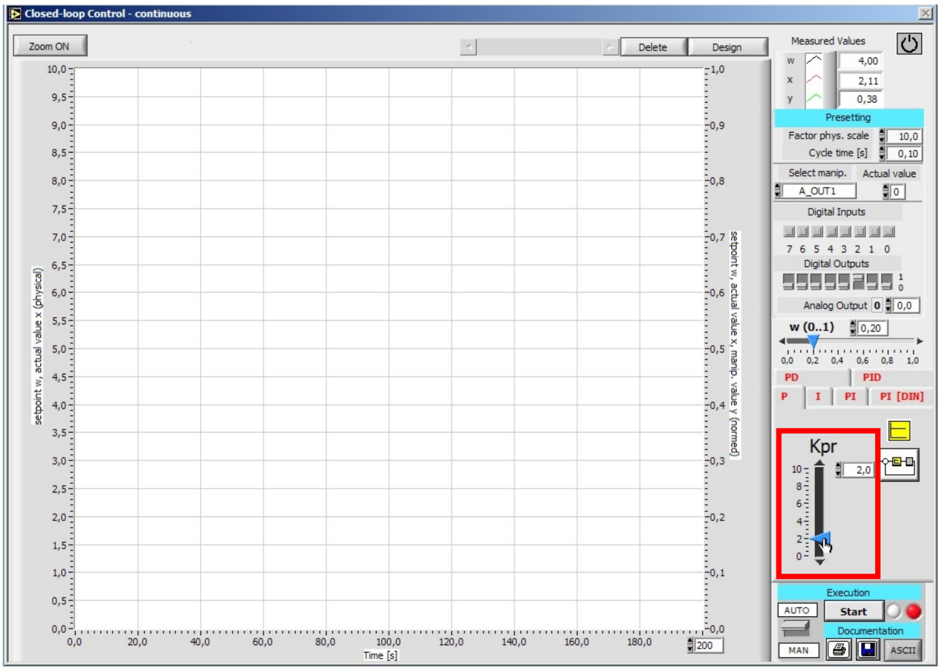
(Switch the Digital Output 2 = 1 to be able to activate the pump analog)



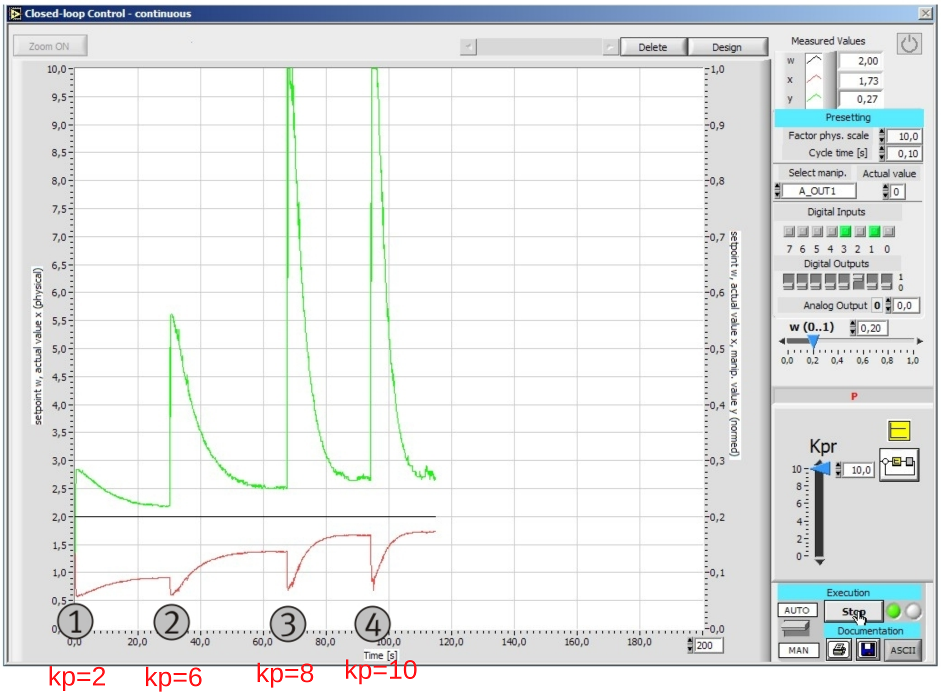
Pre-select the analog value of the level sensor to 2 V = 0,2, which represents a level of 60 mm)



(Choose the P-controller)



(Define the first k_{pr} parameter – here to 2,0)

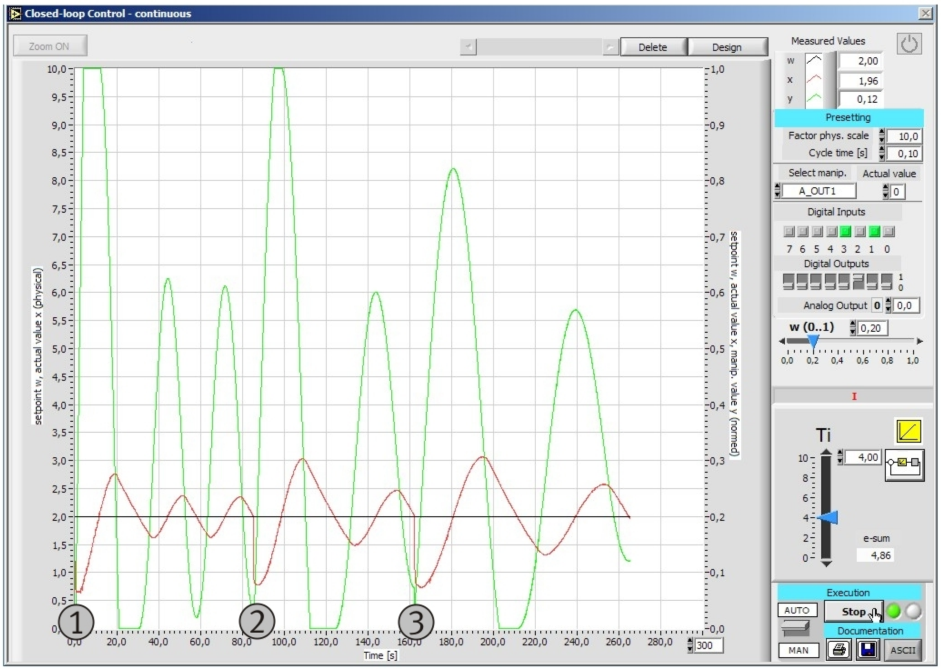


Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**
P	**2,0**	**X**	**X**	**4,0**	**X**	**X**	**8,0**	**X**	**X**	**10,0**	**X**	**X**	**n.u.**	**X**	**X**
I	X		X	X		X	X		X	X		X	X		X
PI			X			X			X			X			X
PD		X			X			X			X			X	
PID															

n.u. = not used, which means we interrupted the process there

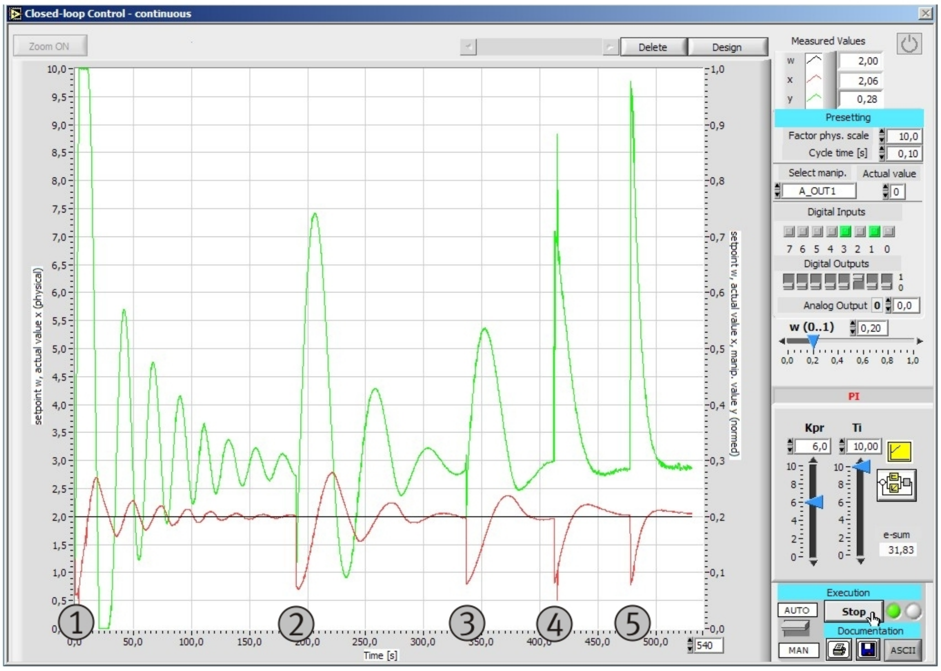


Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P		X	X		X	X		X	X		X	X		X	X
I	**X**	**1,0**	**X**	**X**	**2,0**	**X**	**X**	**4,0**	**X**	**X**	**n.u.**	**X**	**X**	**n.u.**	**X**
PI			X			X			X			X			X
PD		X			X			X			X			X	
PID															

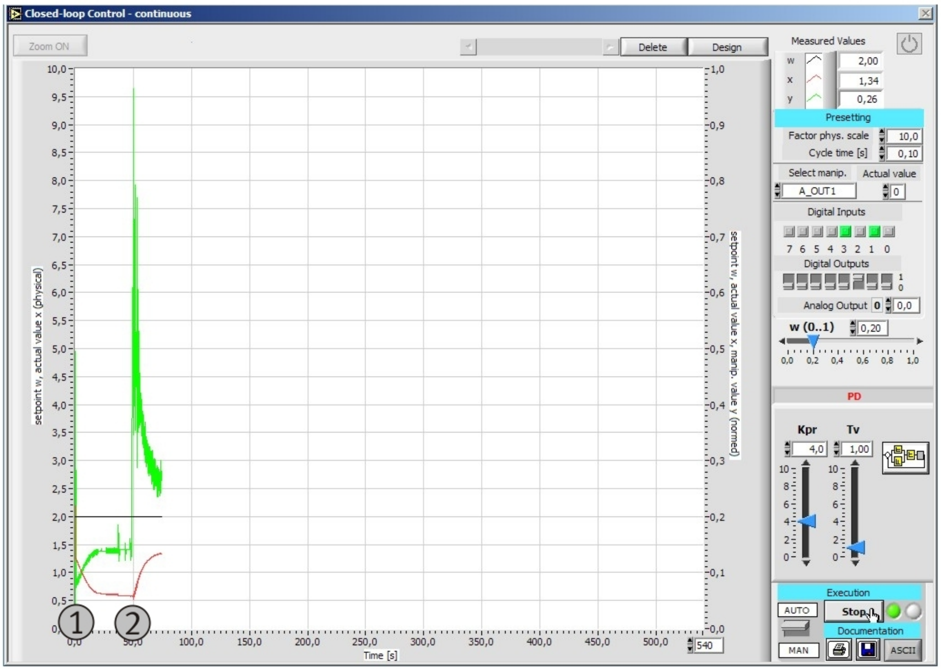
n.u. = not used, which means we interrupted the process there



Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P		X	X		X	X		X	X		X	X		X	X
I	X		X	X		X	X		X	X		X	X		X
PI	**1,0**	**1,0**	**X**	**1,0**	**4,0**	**X**	**2,0**	**6,0**	**X**	**4,0**	**8,0**	**X**	**6,0**	**8,0**	**X**
PD		X			X			X			X			X	
PID															

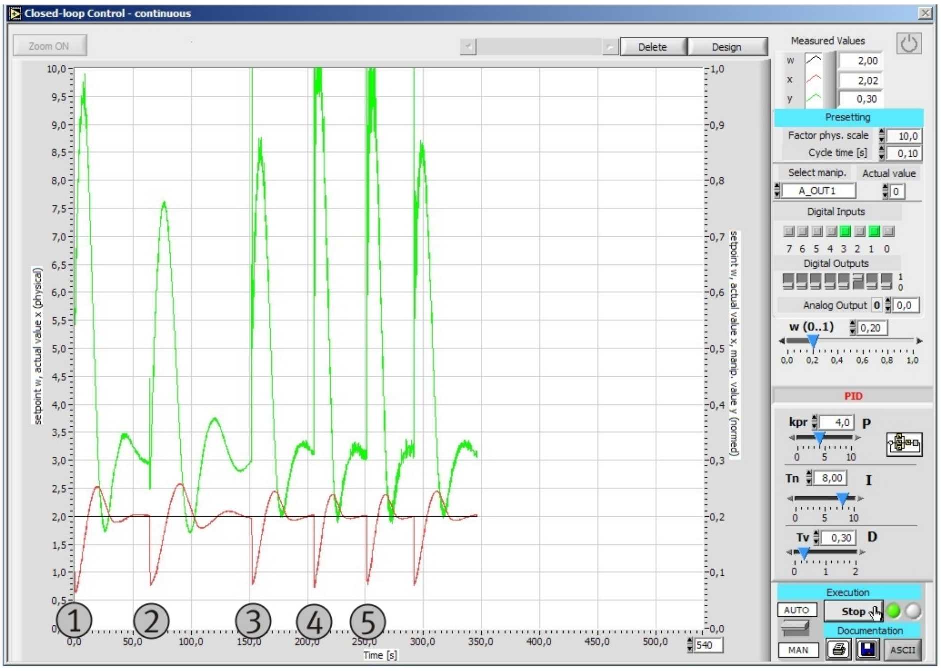


Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P		X	X		X	X		X	X		X	X		X	X
I	X		X	X		X	X		X	X		X	X		X
PI			X			X			X			X			X
PD	**1,0**	**X**	**1,0**	**4,0**	**X**	**1,0**	**n.u.**	**X**	**n.u.**	**n.u.**	**X**	**n.u.**	**n.u.**	**X**	**n.u.**
PID															

n.u. = not used, which means we interrupted the process there



Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			**2 - Start – Stop**			**3 - Start – Stop**			**4 - Start – Stop**			**5 - Start – Stop**		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P		X	X		X	X		X	X		X	X		X	X
I	X		X	X		X	X		X	X		X	X		X
PI			X			X			X			X			X
PD		X			X			X			X			X	
PID	**4,0**	**8,0**	**0,1**	**2,0**	**6,0**	**0,1**	**4,0**	**8,0**	**0,2**	**6,0**	**8,0**	**0,3**	**6,0**	**8,0**	**0,5**

The last two parameter settings, which are not mentioned within the table have been:

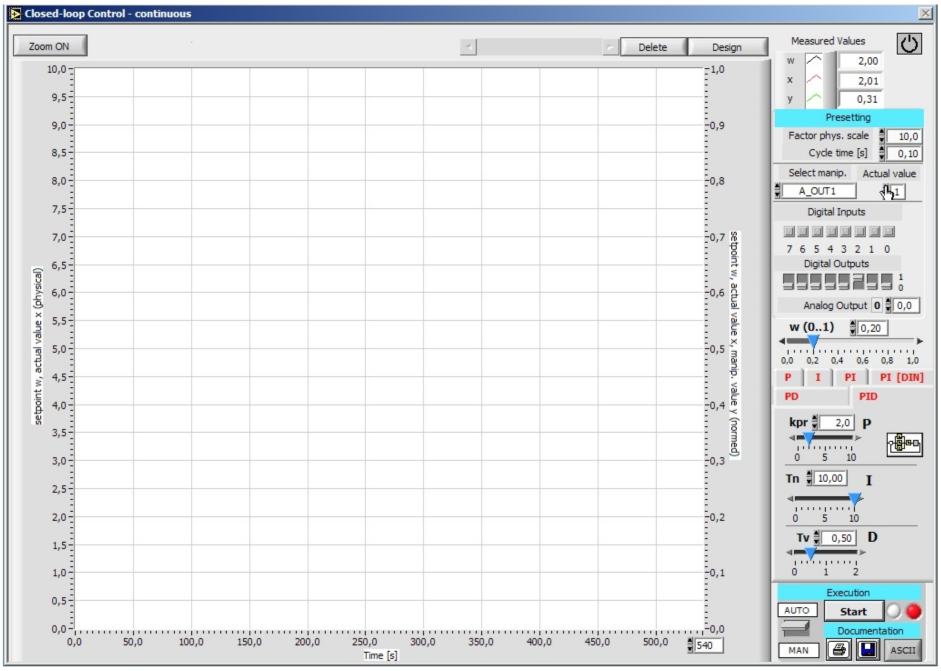
k_{pr} = 4,0 and 2,0

T_i = 8,0 and 8,0

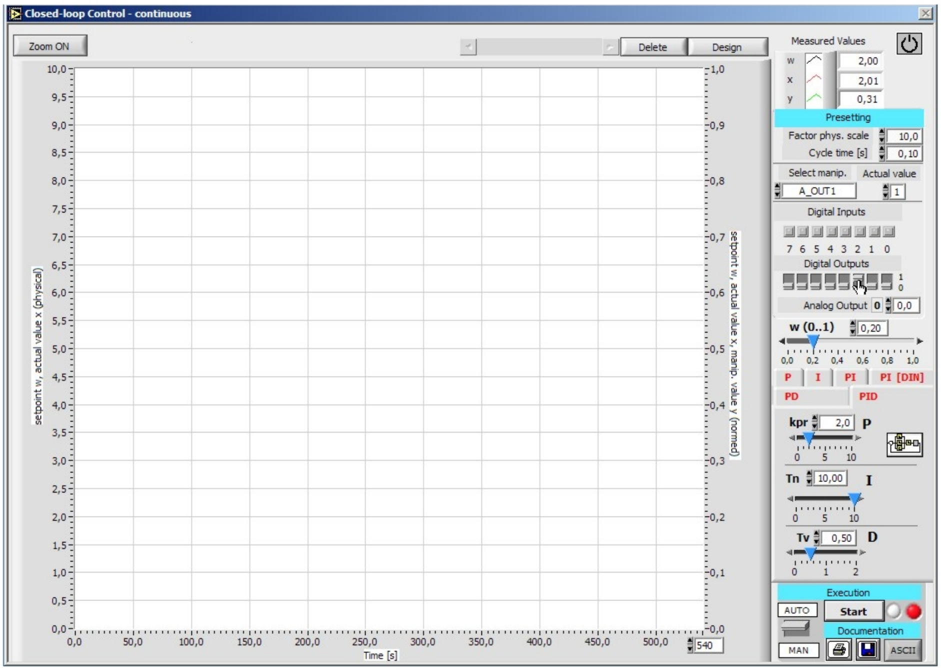
T_v = 0,3 and 0,3

7.2 Continuous flow control

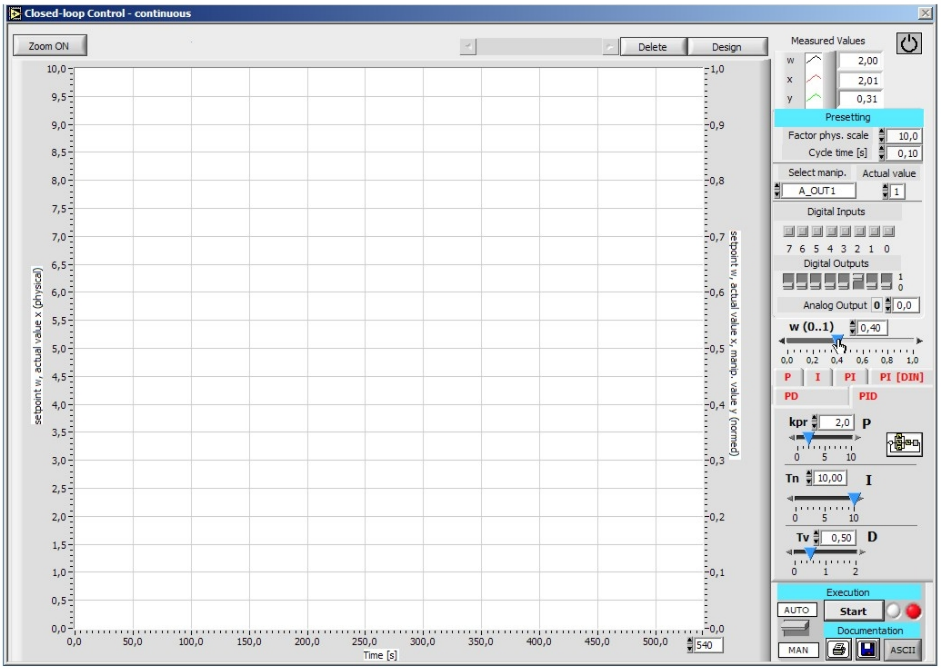
Please proceed to prepare the continuous flow control with different parameters as follows:



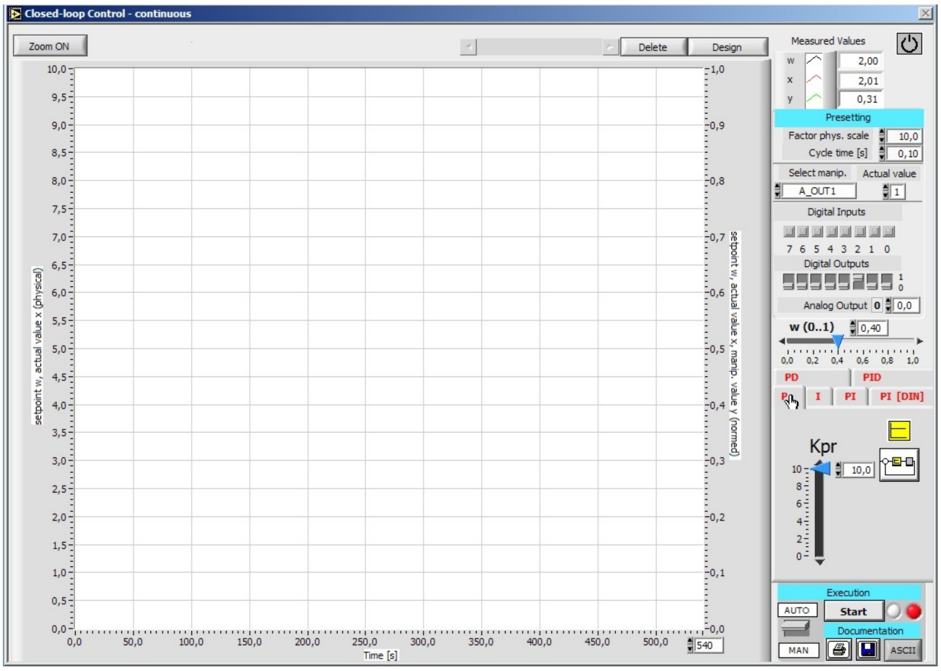
(Select manipu. (manipulated value) to A_OUT1 like it was before and change the Actual value to 1 which represents the flow sensor signal of Channel 1)



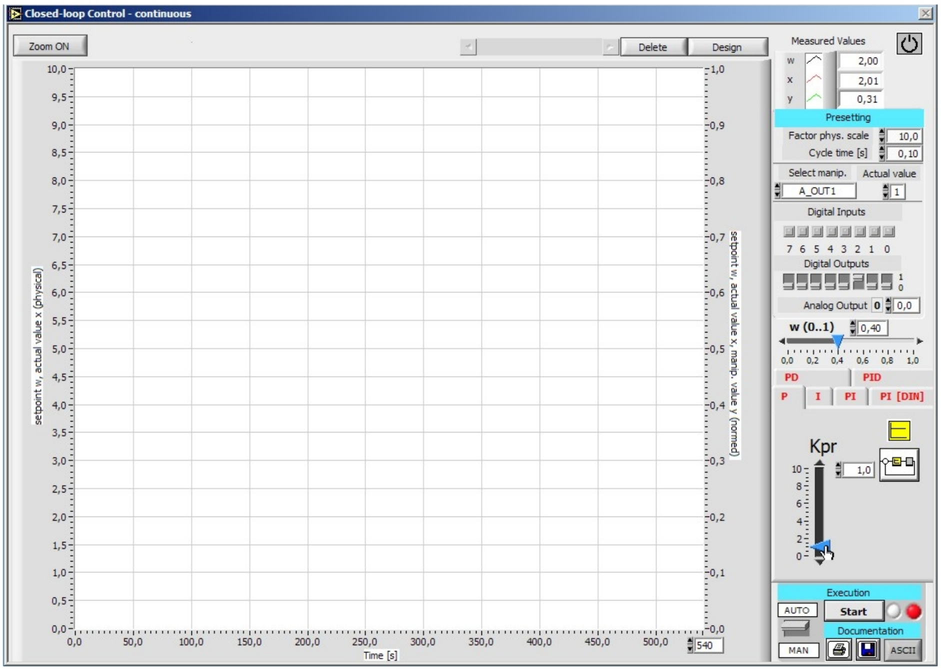
(Switch the Digital Output 2 = 1 to be able to activate the pump analog)



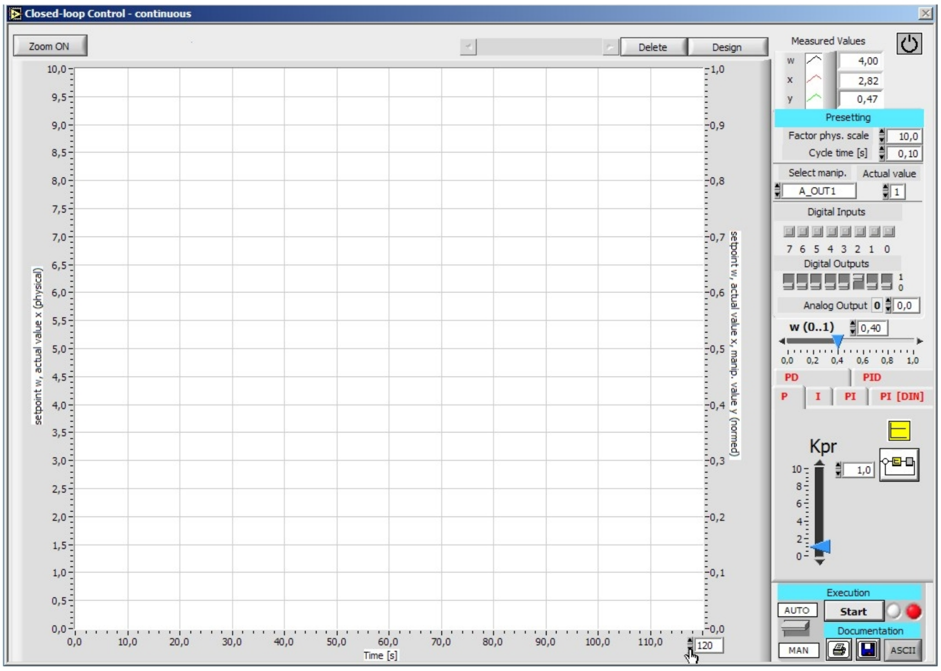
Pre-select the analog value of the flow sensor to 4 V = 0,4)



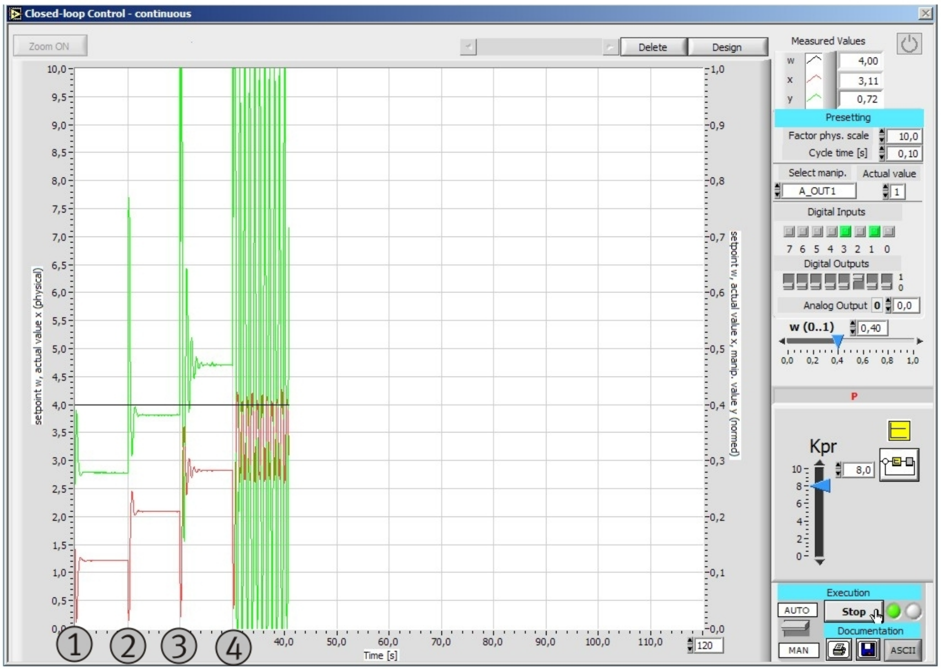
(Choose the P-controller)



(Define the first k_{pr} parameter – here to 1,0)



(Change the time on the x-axis to 120 s)

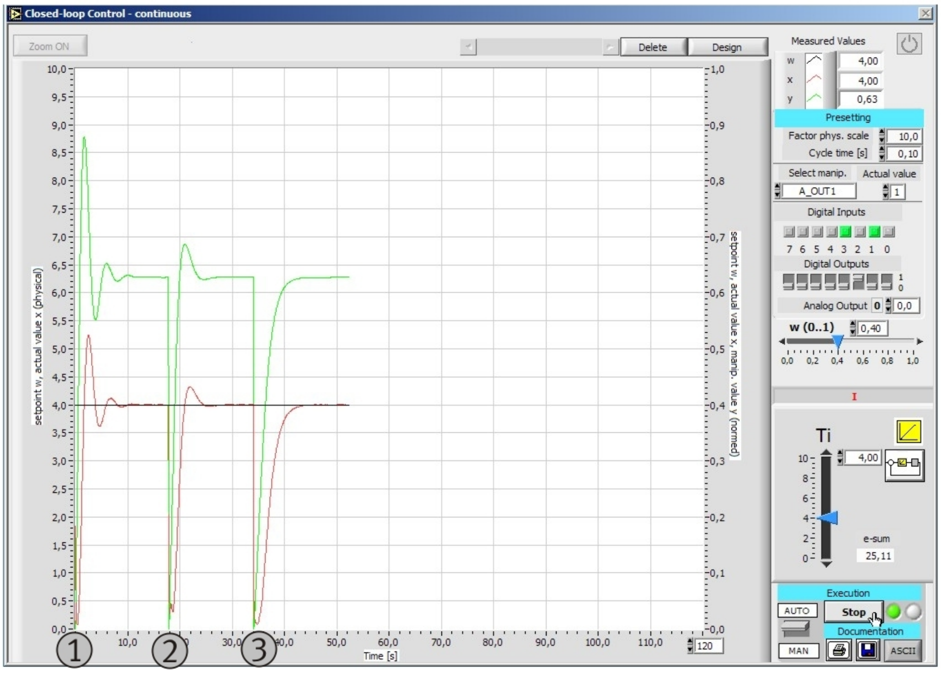


Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**
P	**1,0**	**X**	**X**	**2,0**	**X**	**X**	**4,0**	**X**	**X**	**8,0**	**X**	**X**	**n.u.**	**X**	**X**
I	X		X	X		X	X		X	X		X	X		X
PI			X			X			X			X			X
PD		X			X			X			X			X	
PID															

n.u. = not used, which means we interrupted the process there

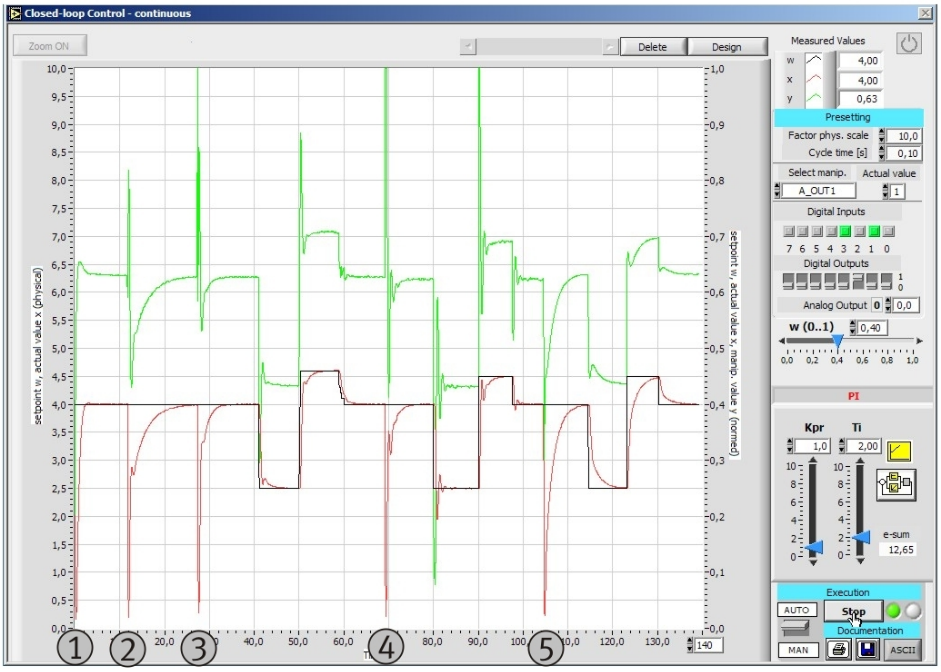


Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**
P		X	X		X	X		X	X		X	X		X	X
I	**X**	**1,0**	**X**	**X**	**2,0**	**X**	**X**	**4,0**	**X**	**X**	**8,0**	**X**	**X**	**n.u.**	**X**
PI			X			X			X			X			X
PD		X			X			X			X			X	
PID															

n.u. = not used, which means we interrupted the process there

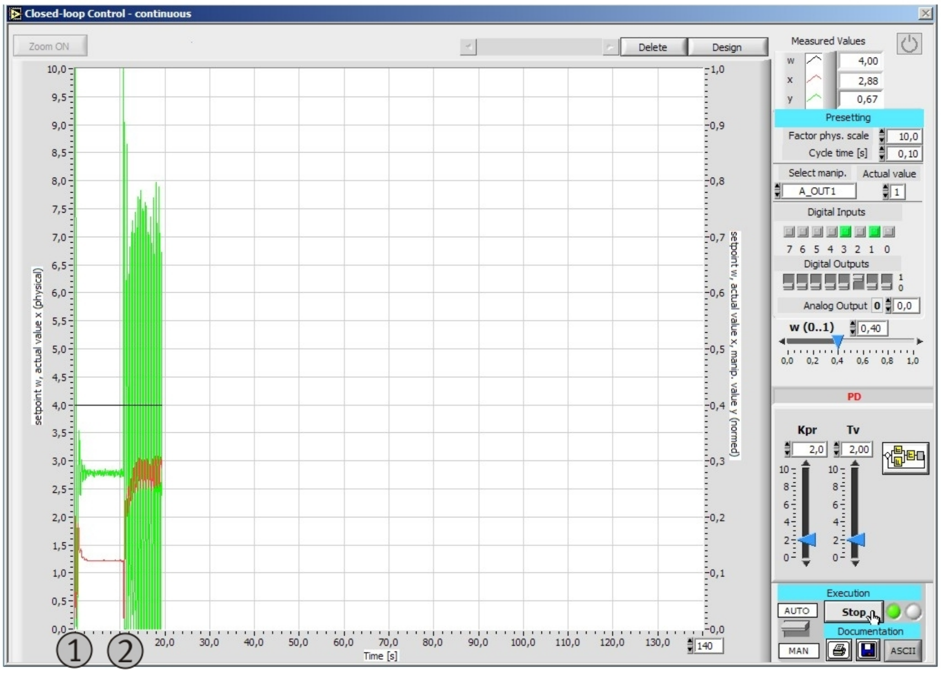


Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P		X	X		X	X		X	X		X	X		X	X
I	X		X	X		X	X		X	X		X	X		X
PI	1,0	1,0	X	2,0	2,0	X	2,0	1,0	X	3,0	0,7	X	1,0	2,0	X
PD		X			X			X			X			X	
PID															

From step 3 onwards, we also changed the setpoint down and up to see the reaction of the controller.

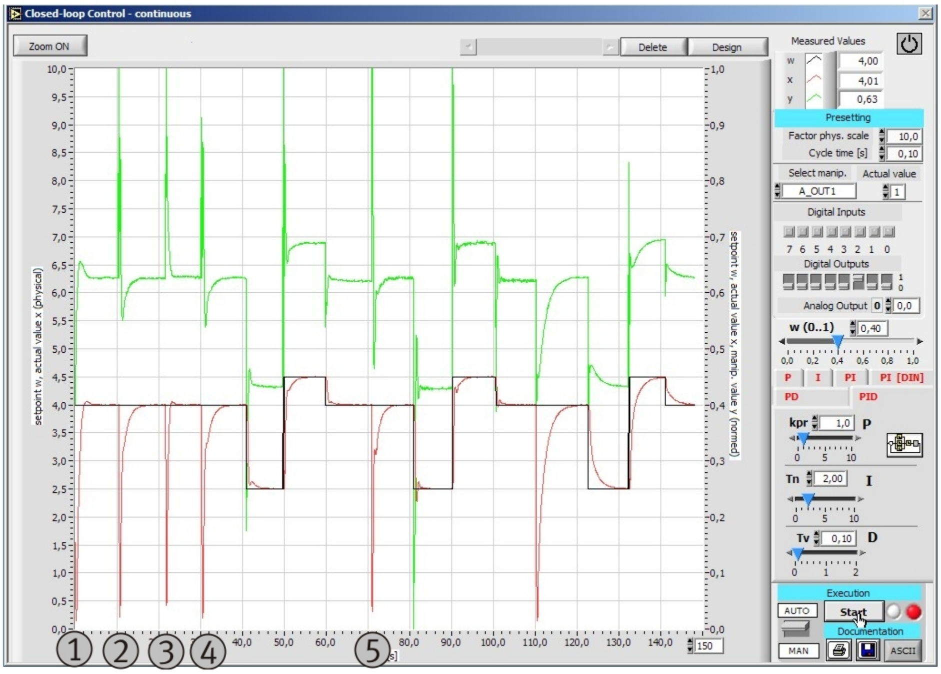


Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P		X	X		X	X		X	X		X	X		X	X
I	X		X	X		X	X		X	X		X	X		X
PI			X			X			X			X			X
PD	**1,0**	**X**	**1,0**	**2,0**	**X**	**2,0**	**n.u.**	**X**	**n.u.**	**n.u.**	**X**	**n.u.**	**n.u.**	**X**	**n.u.**
PID															

n.u. = not used, which means we interrupted the process there



Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P		X	X		X	X		X	X		X	X		X	X
I	X		X	X		X	X		X	X		X	X		X
PI			X			X			X			X			X
PD		X			X			X			X			X	
PID	**1,0**	**1,0**	**0,1**	**2,0**	**2,0**	**0,1**	**2,0**	**1,0**	**0,1**	**2,0**	**2,0**	**0,05**	**3,0**	**2,0**	**0,1**

From step 3 onwards, we also changed the setpoint down and up to see the reaction of the controller.The last parameter settings, which is not mentioned within the table have been:

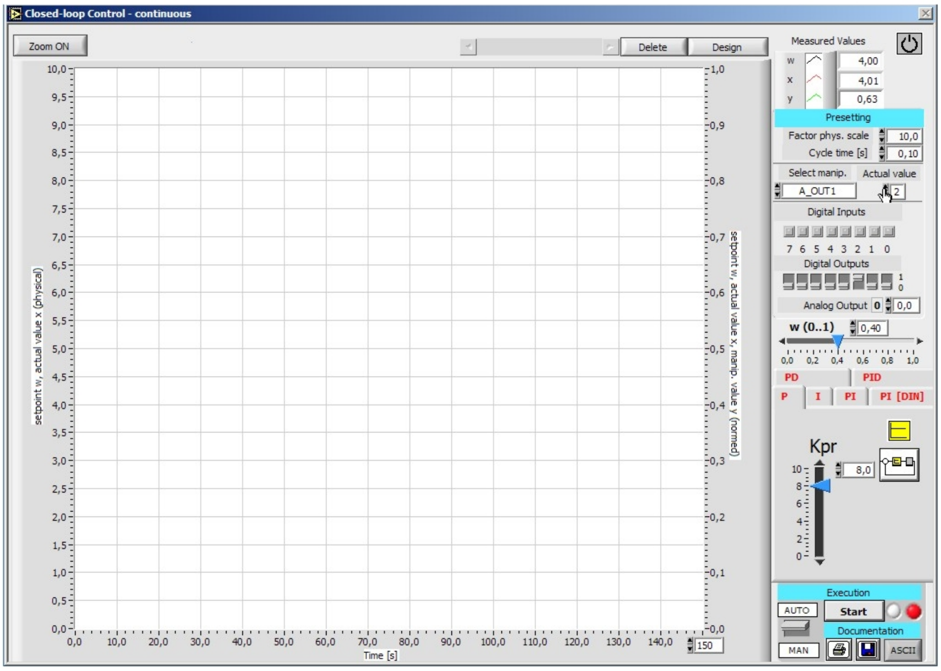
k_{pr} = 1,0

T_i = 2,0

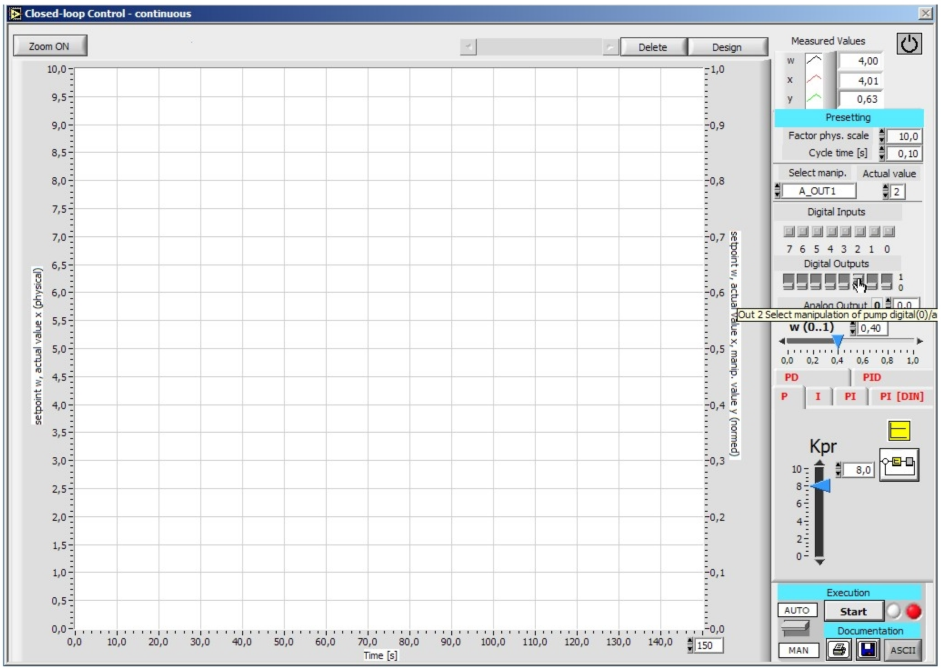
T_v = 0,1

7.3 Continuous pressure control

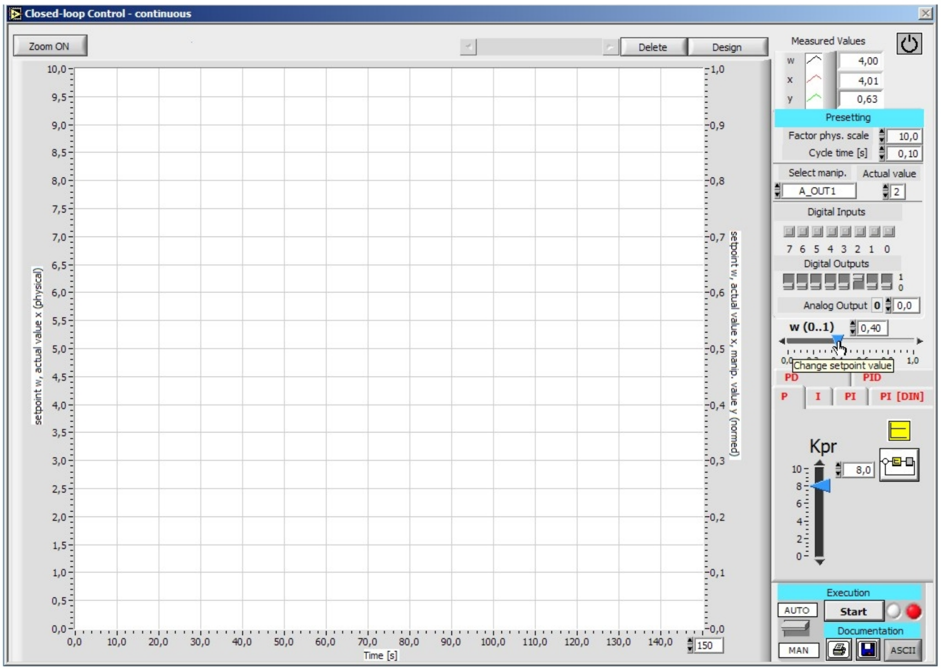
Please proceed to prepare the continuous pressure control with different parameters as follows:



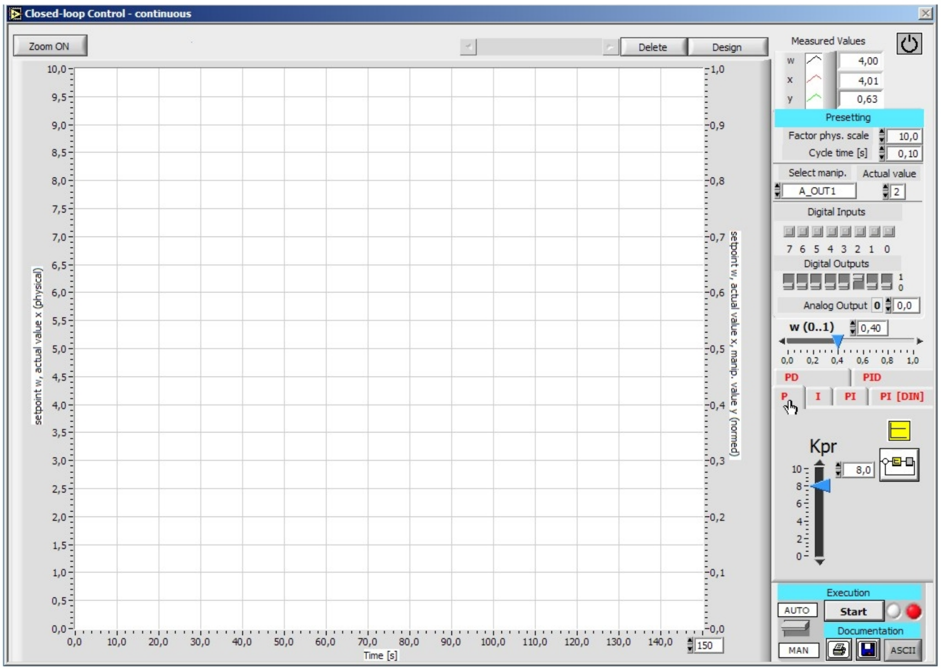
(Select manipu. (manipulated value) to A_OUT1 like it was before and change the Actual value to 2 which represents the pressure sensor signal of Channel 1)



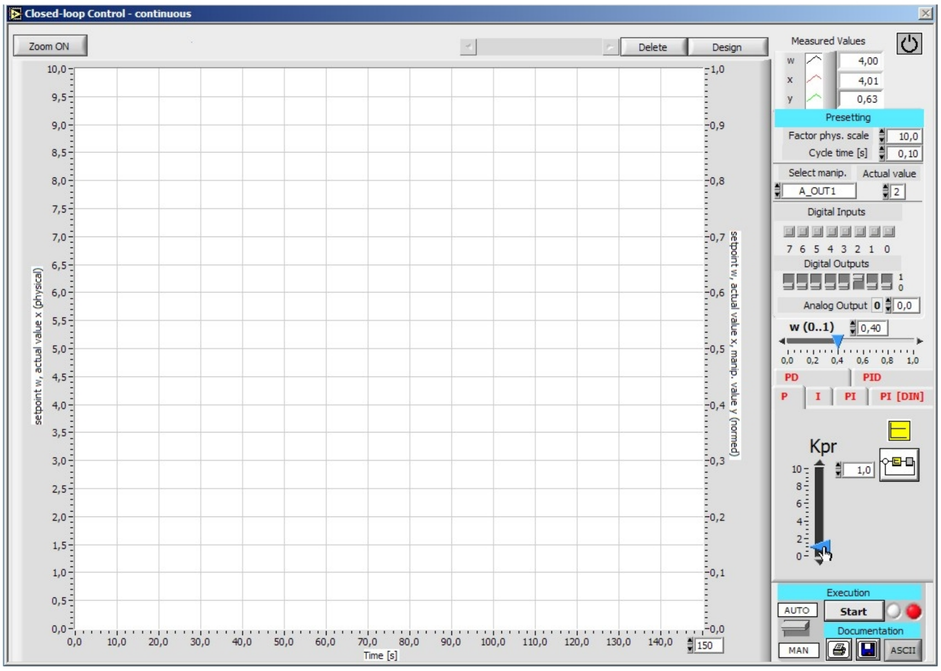
(Switch the Digital Output 2 = 1 to be able to activate the pump analog)



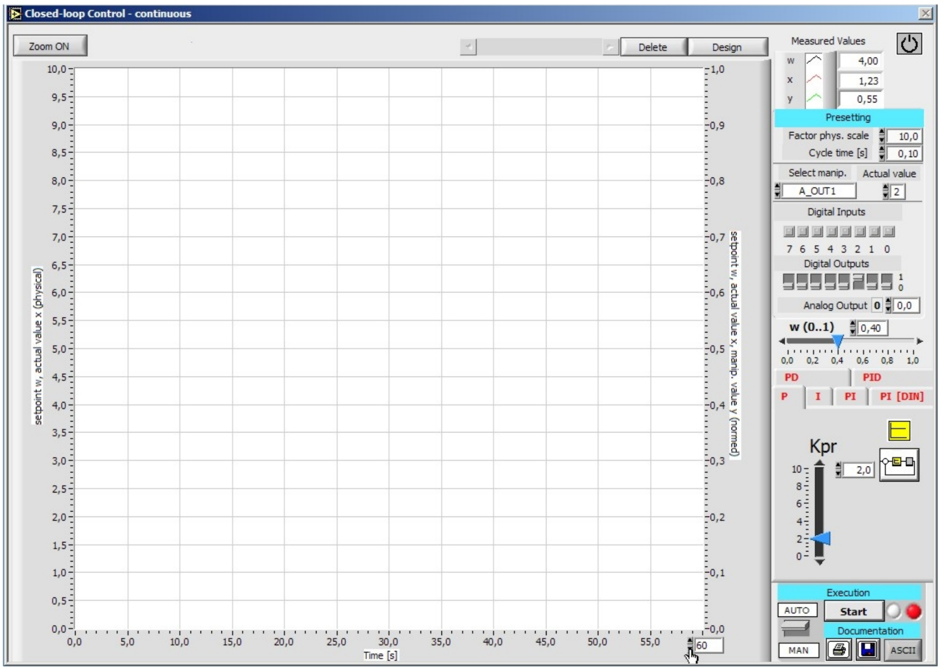
Pre-select the analog value of the pressure sensor to 4 V = 0,4)



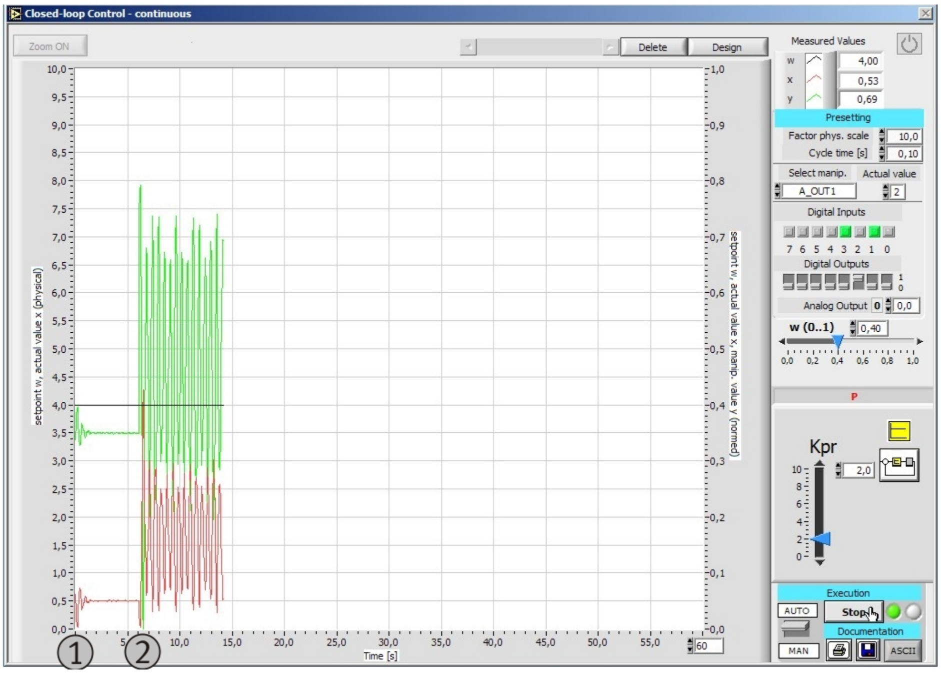
(Choose the P-controller)



(Define the first k_{pr} parameter – here to 1,0)



(Change the time on the x-axis to 60 s)

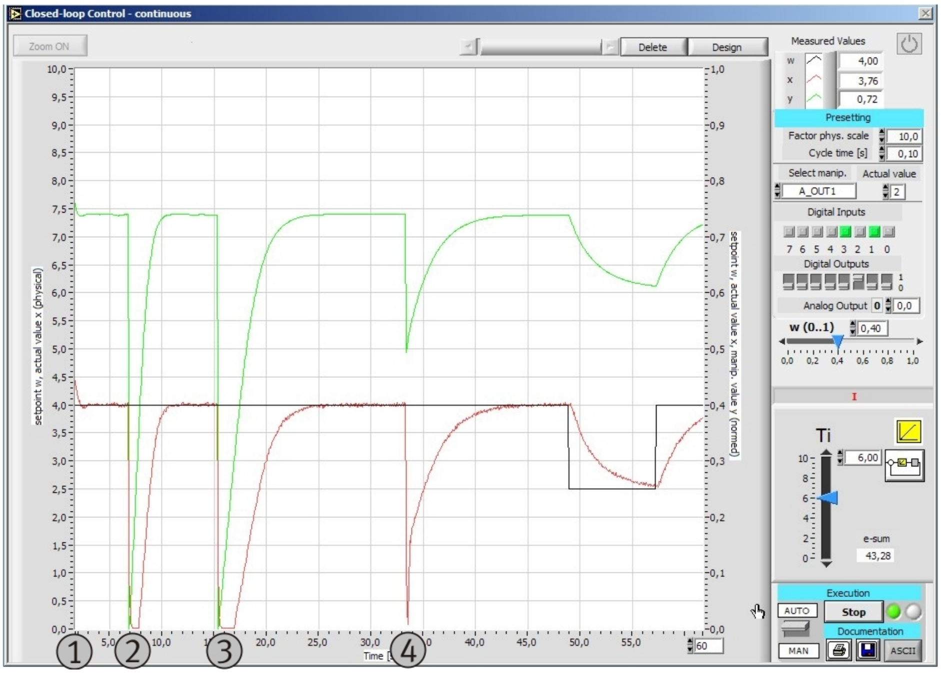


Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**
P	**1,0**	**X**	**X**	**2,0**	**X**	**X**	**n.u.**	**X**	**X**	**n.u.**	**X**	**X**	**n.u.**	**X**	**X**
I	X		X	X		X	X		X	X		X	X		X
PI			X			X			X			X			X
PD		X			X			X			X			X	
PID															

n.u. = not used, which means we interrupted the process there



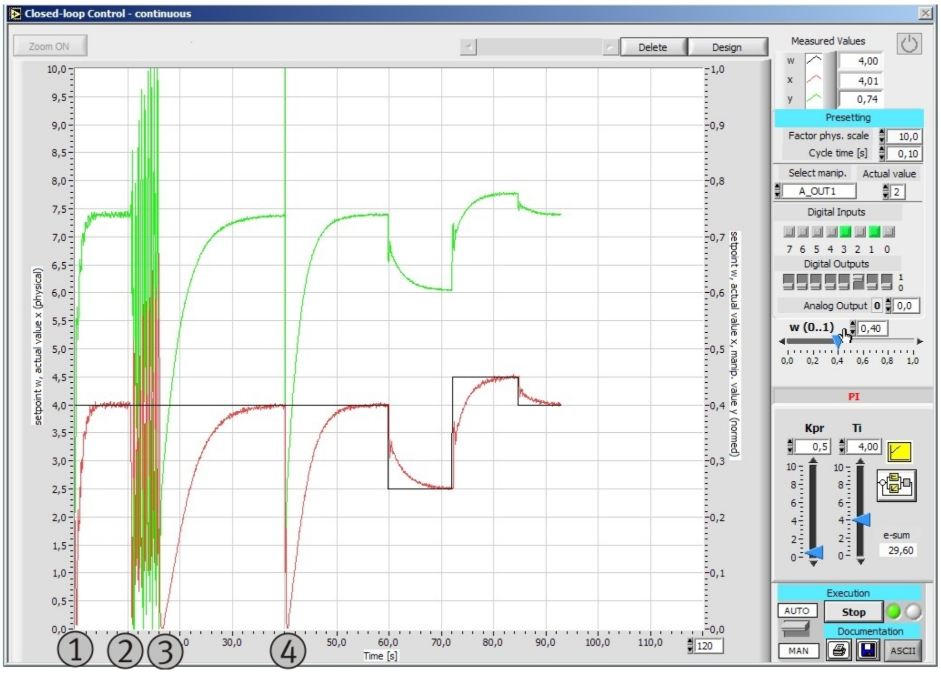
Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P		X	X		X	X		X	X		X	X		X	X
I	**X**	**1,0**	**X**	**X**	**2,0**	**X**	**X**	**4,0**	**X**	**X**	**6,0**	**X**	**X**	**n.u.**	**X**
PI			X			X			X			X			X
PD		X			X			X			X			X	
PID															

n.u. = not used, which means we interrupted the process there

From step 4 onwards we also changed the setpoint to see the reaction of the controller.



Please refer to the parameters we used for this project:

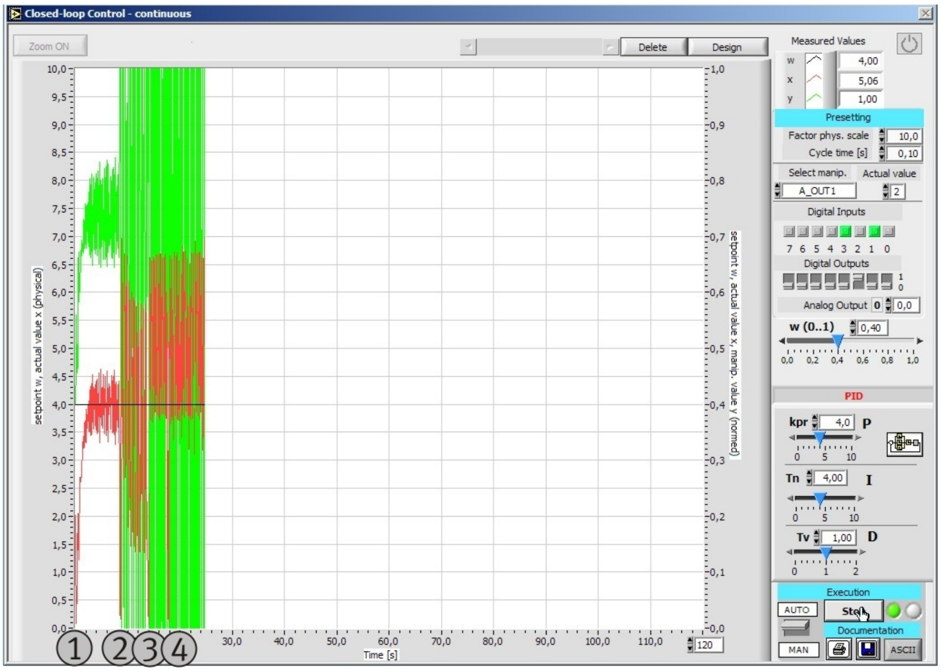
The list of parameters for every project looks like:

	1 - Start – Stop			**2 - Start – Stop**			**3 - Start – Stop**			**4 - Start – Stop**			**5 - Start – Stop**		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P		X	X		X	X		X	X		X	X		X	X
I	X		X	X		X	X		X	X		X	X		X
PI	**1,0**	**1,0**	**X**	**2,0**	**2,0**	**X**	**0,5**	**6,0**	**X**	**0,5**	**4,0**	**X**	**n.u.**	**n.u.**	**X**
PD		X			X			X			X			X	
PID															

n.u. = not used, which means we interrupted the process there

From step 4 onwards we also changed the setpoint to see the reaction of the controller.

The PD-control was not working at all for the pressure control process, that´s why we switched to PID-control, which was also not working as you can see.



Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			**2 - Start – Stop**			**3 - Start – Stop**			**4 - Start – Stop**			**5 - Start – Stop**		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P		X	X		X	X		X	X		X	X		X	X
I	X		X	X		X	X		X	X		X	X		X
PI			X			X			X			X			X
PD		X			X			X			X			X	
PID	**1,0**	**1,0**	**0,1**	**2,0**	**2,0**	**0,2**	**2,0**	**2,0**	**1,0**	**4,0**	**4,0**	**1,0**	**n.u.**	**n.u.**	**n.u.**

n.u. = not used, which means we interrupted the process there

7.4 Continuous control evaluation

After the optimisation of the different process, please fill-in the best results you got for each process within the following table:

The process evaluation defined the following optimised parameters and controllers:

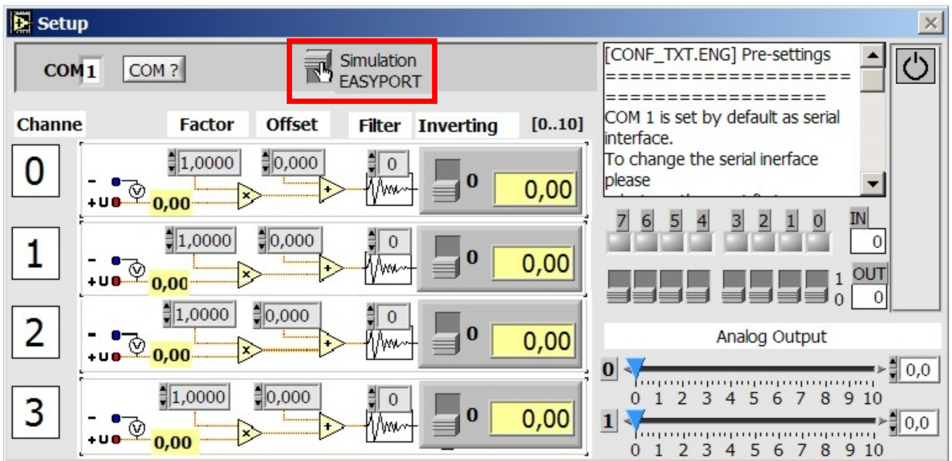
Process	Controller	k_{pr}	T_i	T_v
Level				
Flow				
Pressure				

After finishing the continuous control, please disconnect the Easyport from the computer and close the continuous control window to prepare for the simulation.

8. **Simulation**

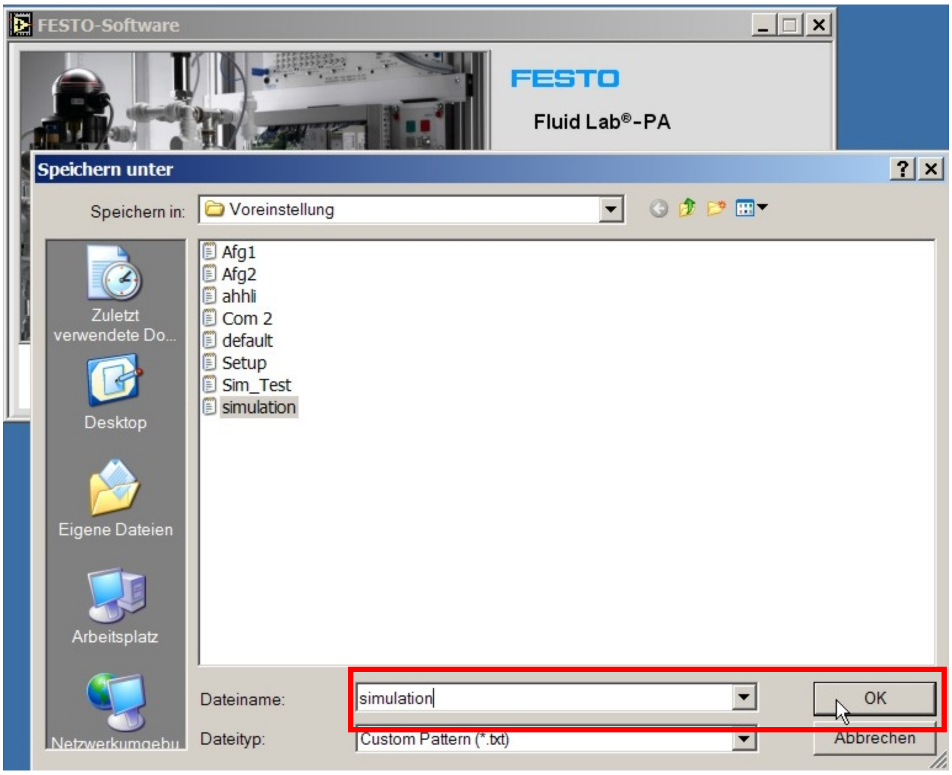
Besides the close loop control of the workstation process, you are also able to simulate several 2-step- and continuous controls. Please refer to the following page of how to proceed.

(Open disconnecting the Easyport from the computer, please open the Setup menu)
Setup



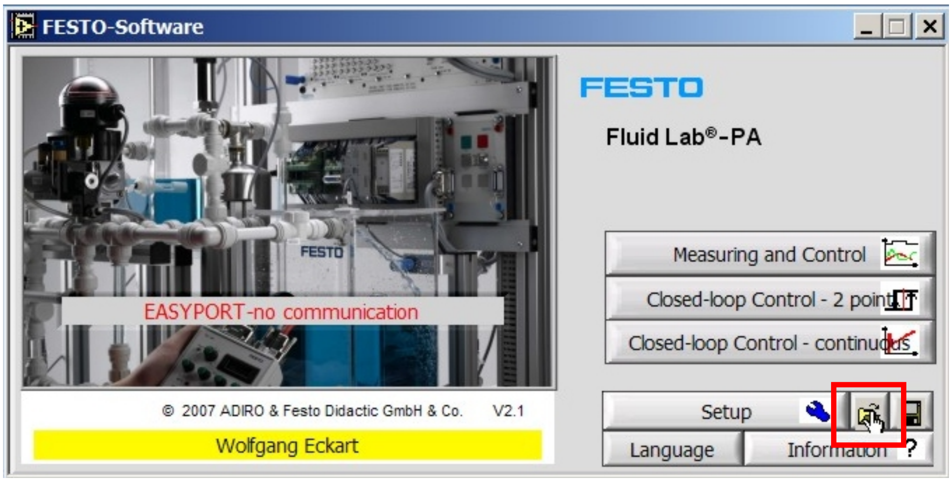
(Change from EASYPORT to Simulation and close the Setup window again)

(Save the configuration – click onto the save file symbol)

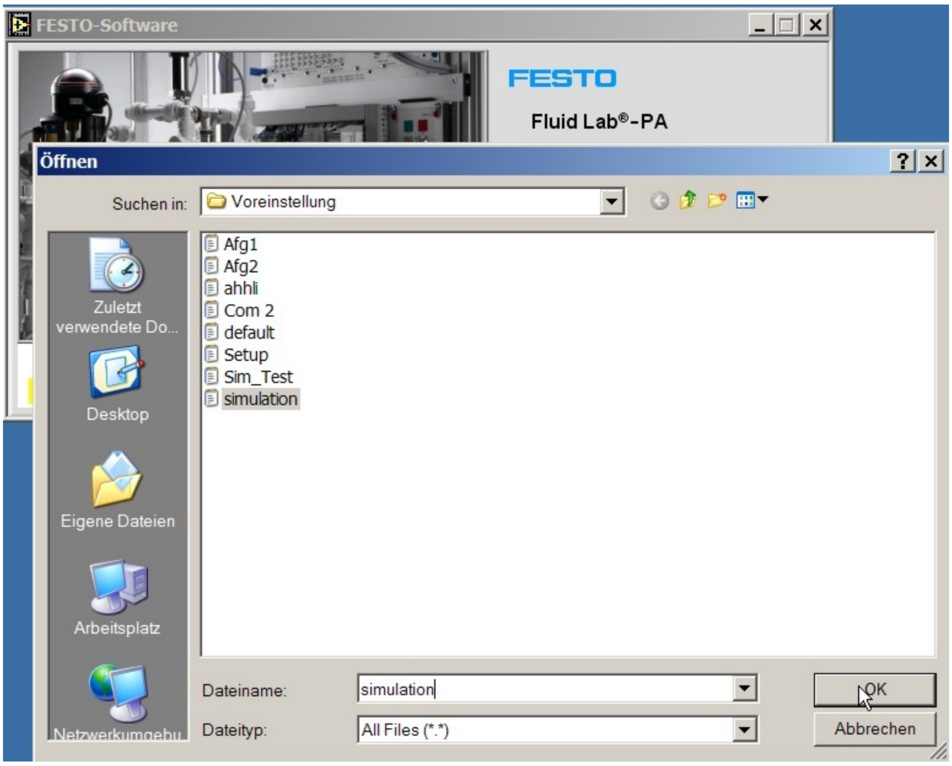


(Save the configuration with any name – here Simulation) → **OK**

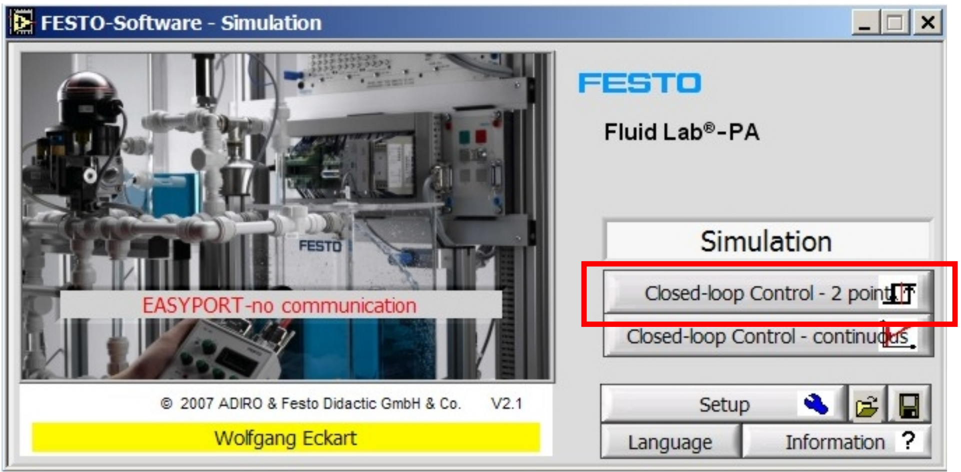
(Close the program) **X**



(Restart Fluid Lab ® - PA) → (click onto the load symbol)



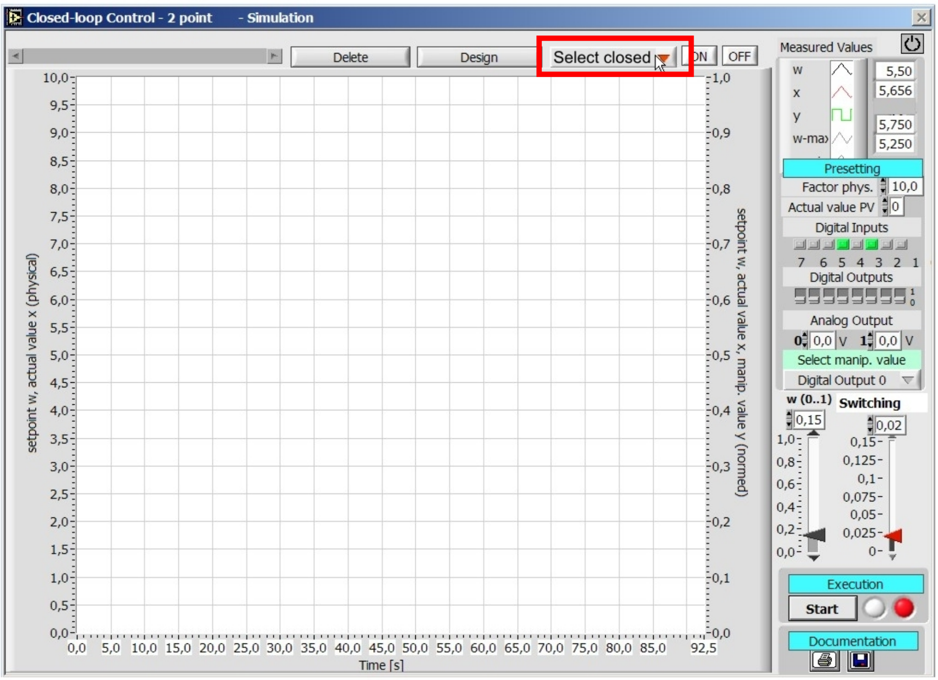
(Load your stored file – here Simulation) → **OK**



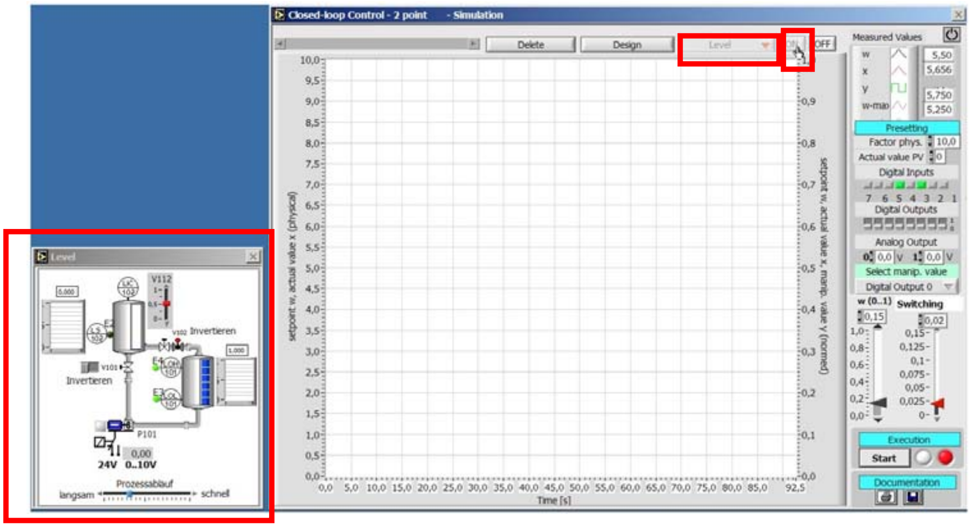
(Now the Simualtion mode is active) → (open the Closed-loop Control – 2 points menu) **Closed-loop Control – 2 points**

8.1 Simulation of the 2-step control

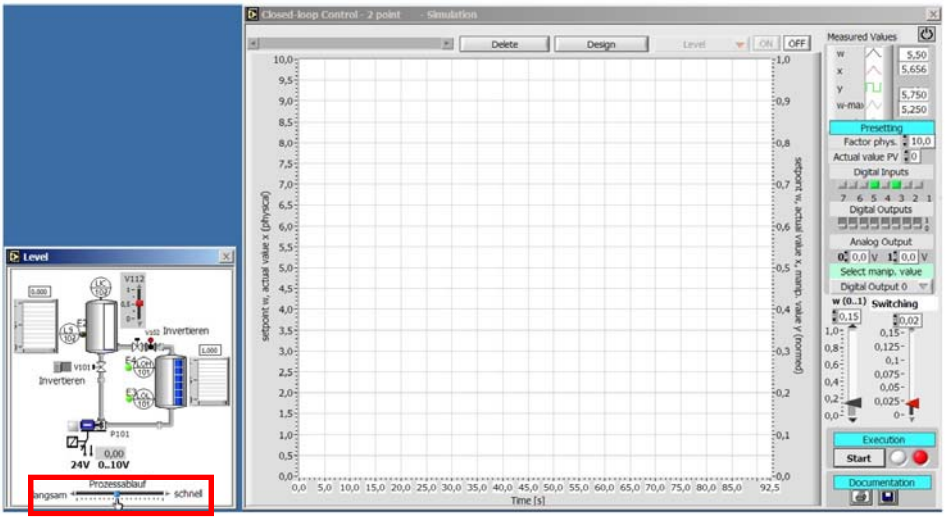
We are going to simulate the 2-step controller with the same parameters we did before and compare both results. Please proceed as follows:



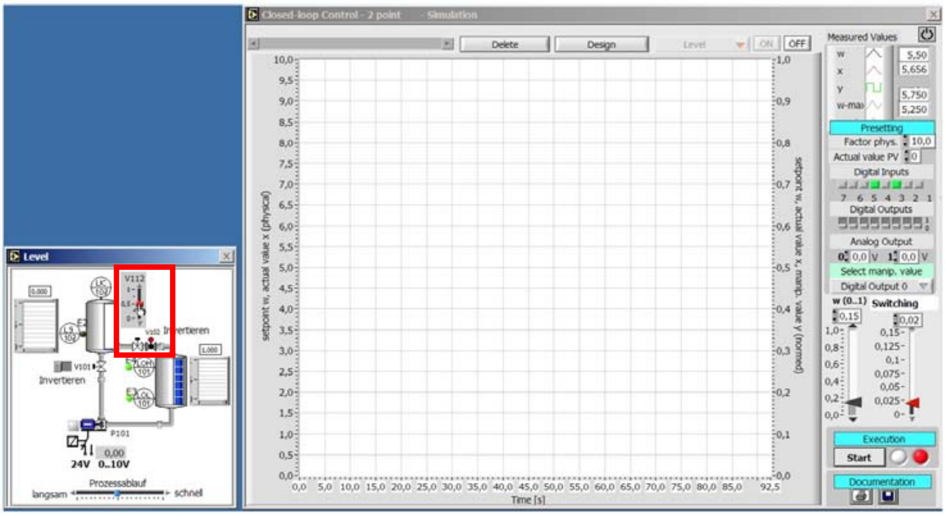
(Click on Select closed to selesct the process) **Select closed** → (select Level for level control) **Level**



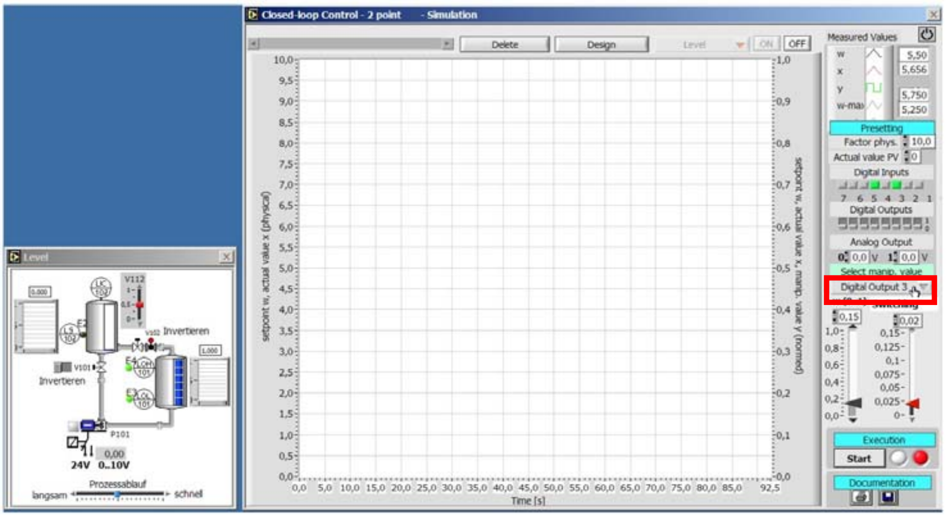
(Activate the simulated process) **ON** → arrange the windows like shown within the screen shot)



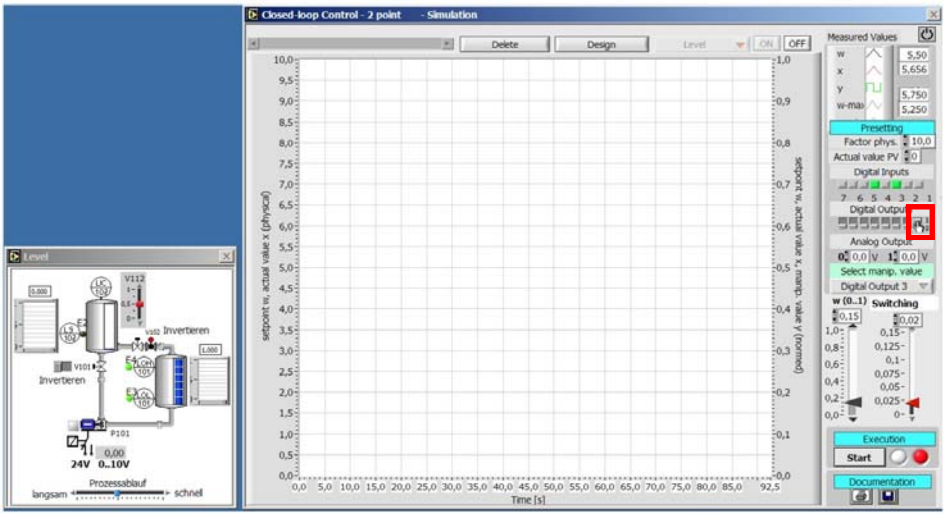
(Define the process speed to 50 %)



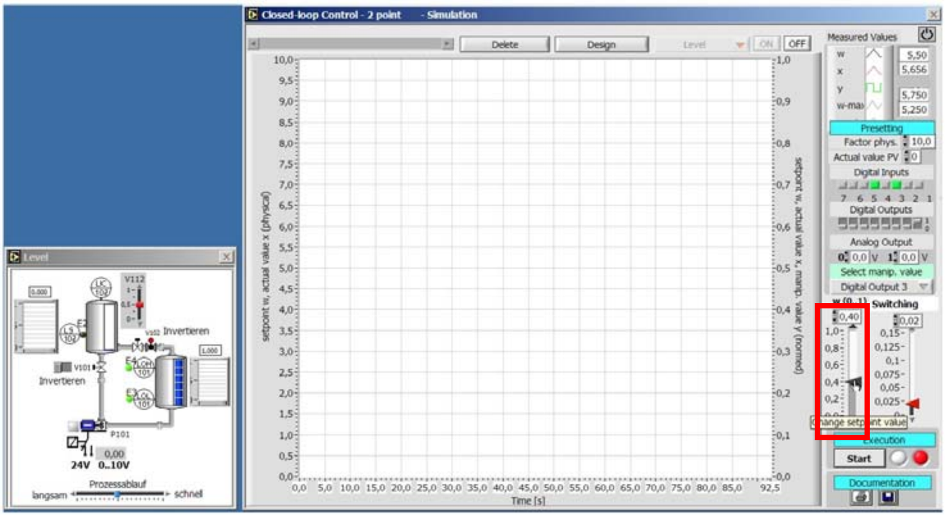
(Set the valve 112 to 50 % open)



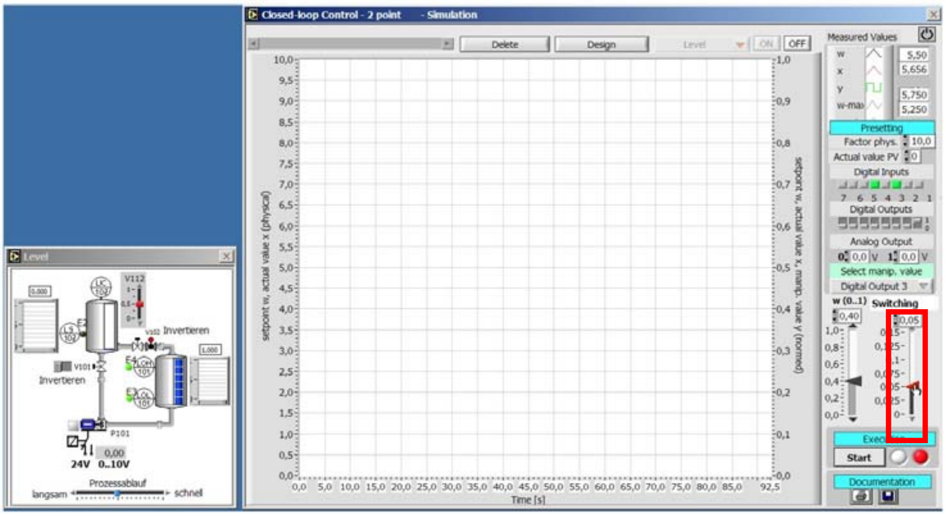
(Select Output 3 for the digital pump as the manipulated value)



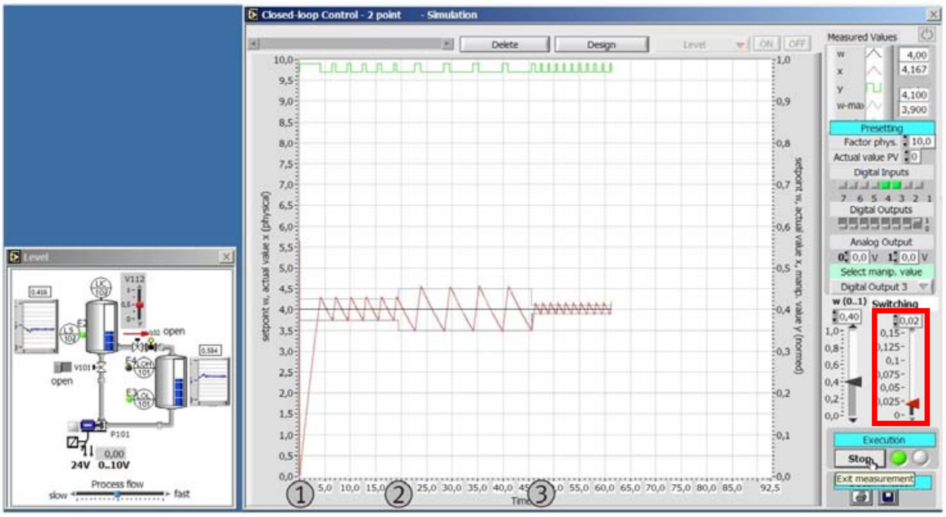
(Activate the simulation process by switching the Output 0= 1)



(Define the setpoint to 4 V = 0,4)



(Define the maximum and minimum range to 0,5 V = 0,05 and start the simulation)
Start



1 Change the switching points to +/- 1,0 V = 0,1

2 Change the switching points to +/- 0,2 V = 0,02

(After the test is finished, please stop the process) **Stop** → (close the window of the 2-step controller)

8.2 Simulation of the continuous control

We are going to show you the following examples of how to proceed to simulate a continuous control process:

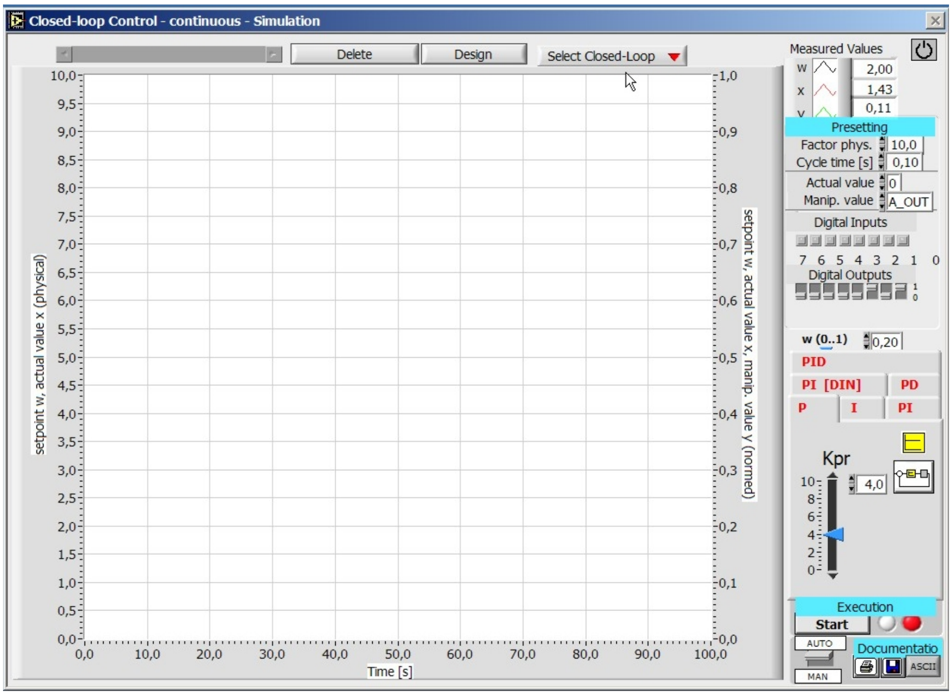
Level control	P-controller
Flow control	I-controller

with the same parameters than for the real continuous control with the workstation. Please continue this exercise with the other controllers and parameters by yourself as you did it for the process control of the workstation and compare the results.

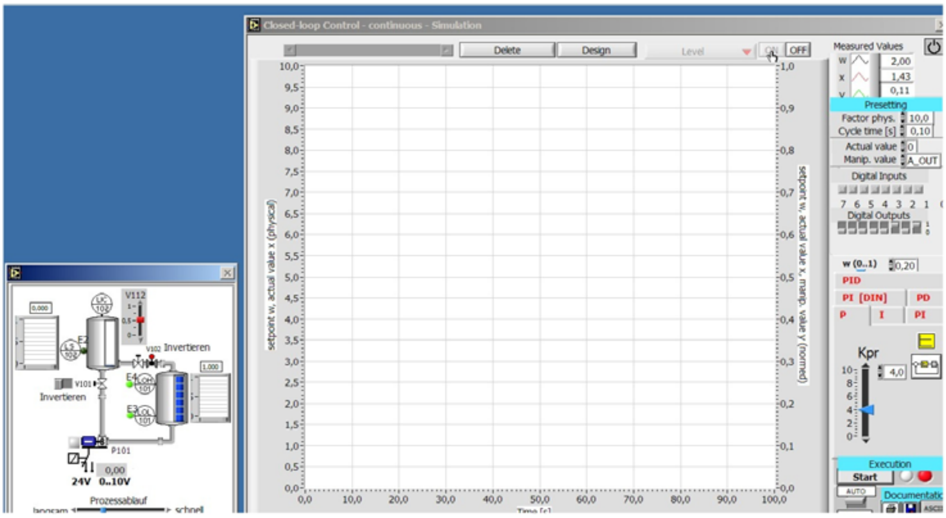
(Please open the window of the continuous control to proceed) **Closed loop Control – continuous**

8.2.1 Simulation of the continuous level control

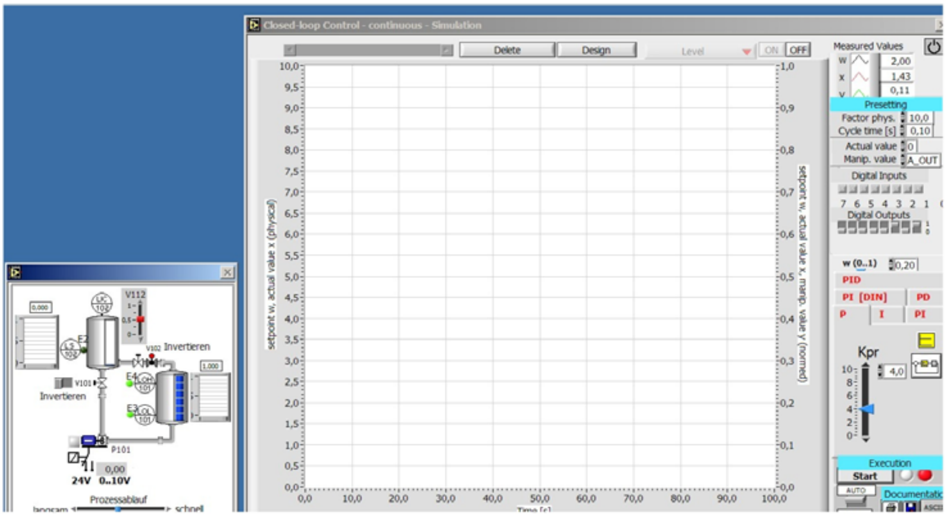
We are going to simulate the continuous level control process with the same parameters than for the real process. We will only show you how the P-control process have to be done. Please continue with the other controllers and parameters by yourself and compare each result with the real process.



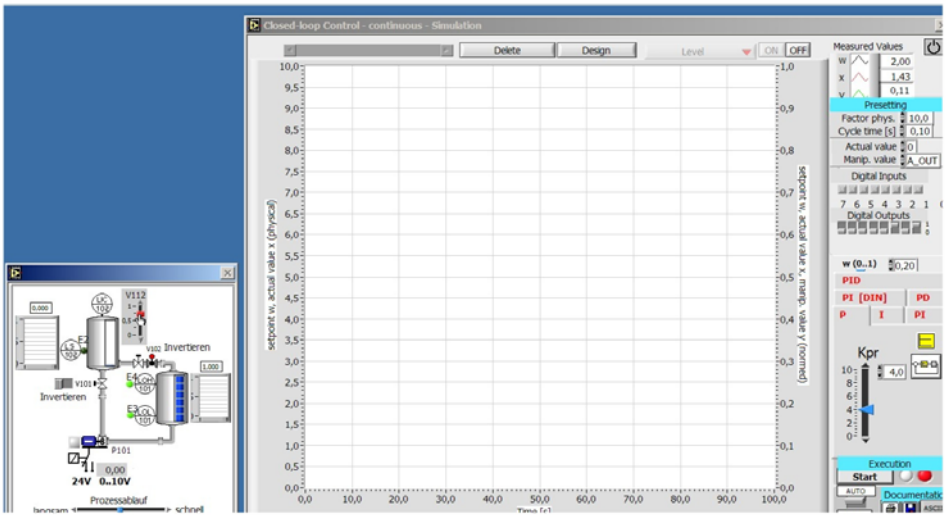
(Select the closed-loop process) **Select Closed Loop** → (select the level control) **Level**



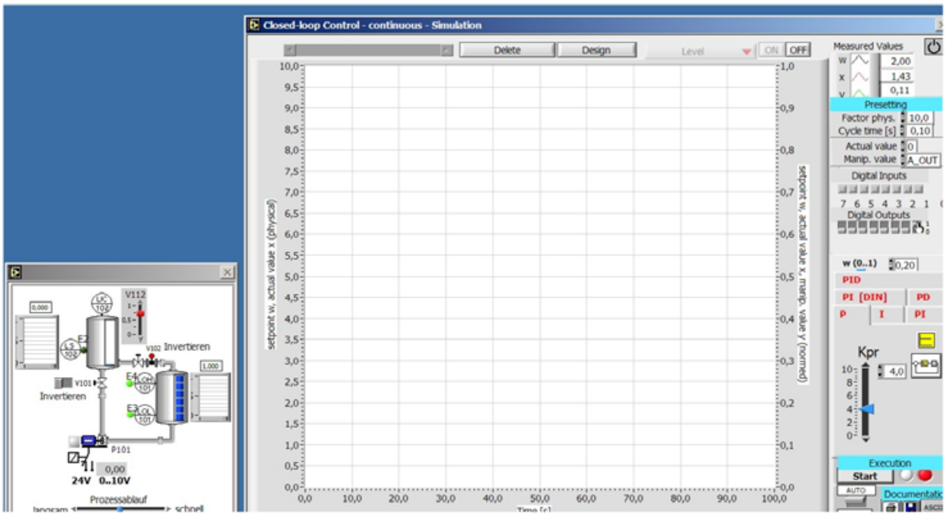
(Activate the process simulation) **ON**



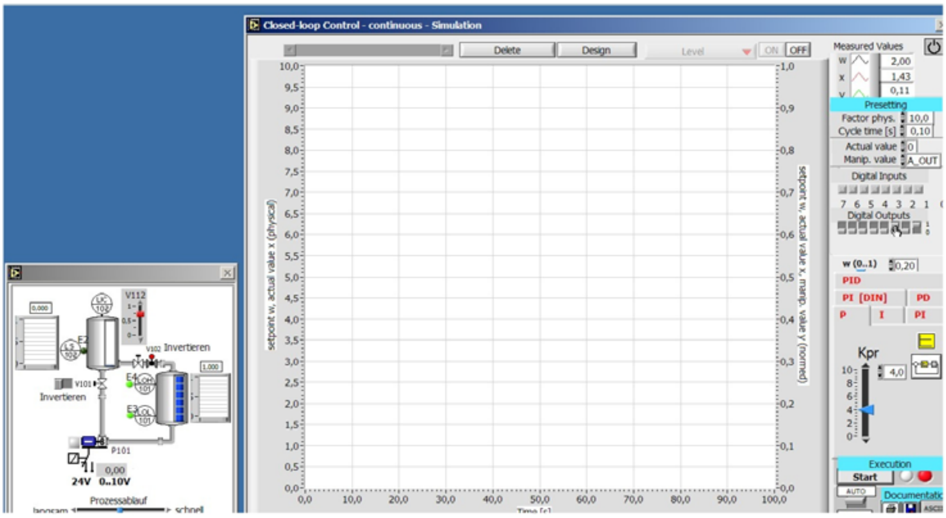
(Set the process speed to 50 %)



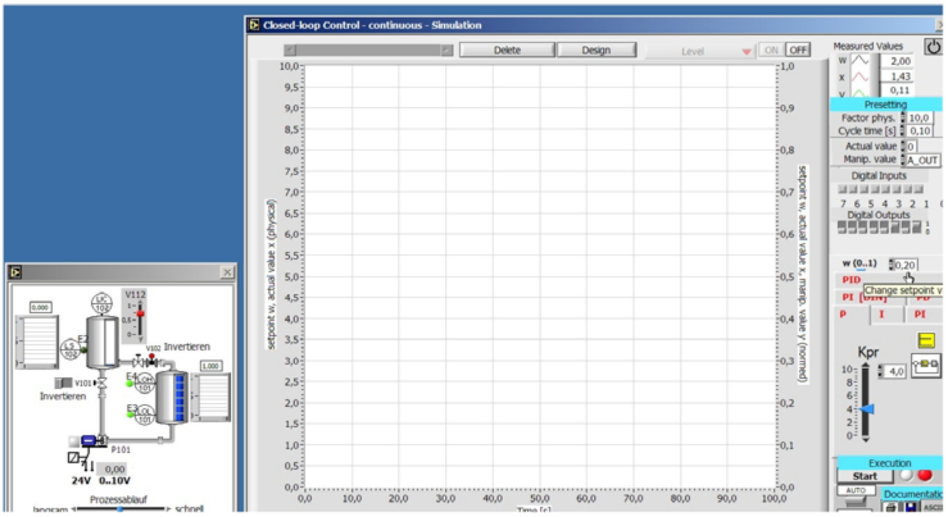
(Open the valve 112 approx. 75 %)



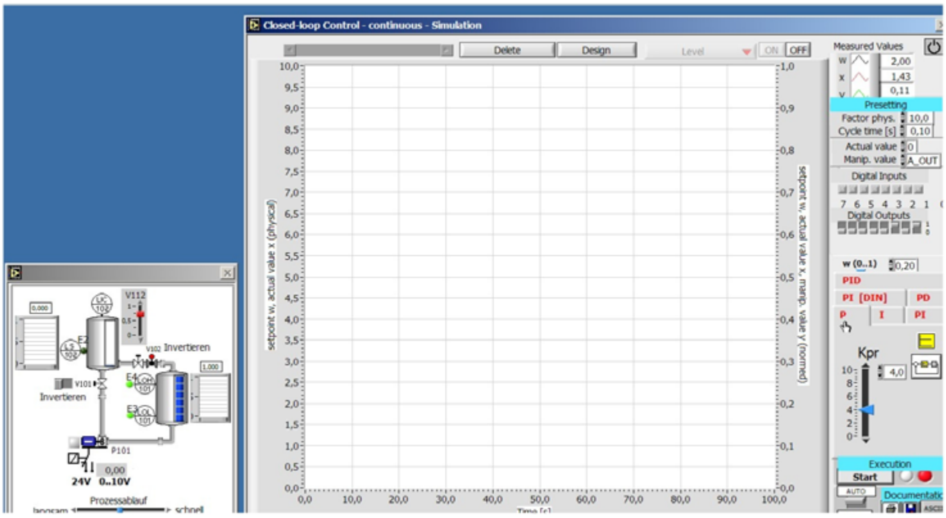
(Activate the simulation process by switching the Output 0= 1)



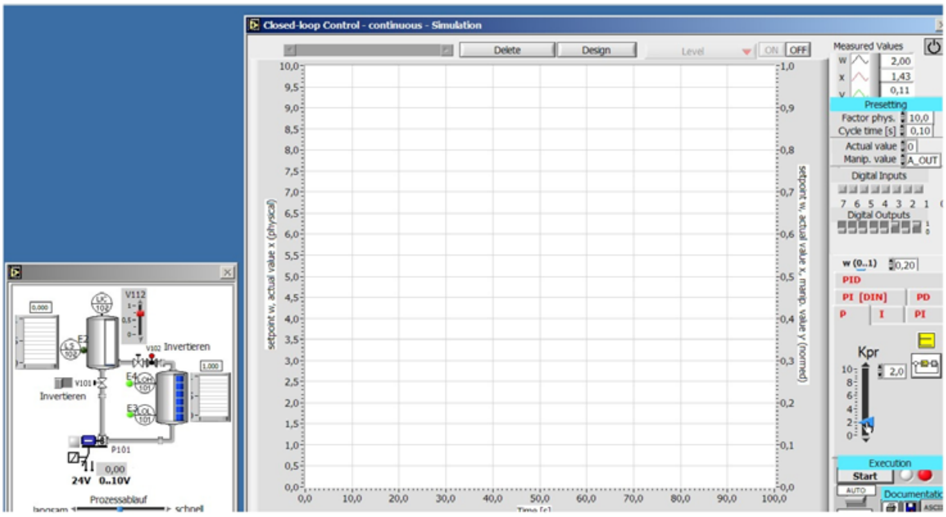
(Pre-select the Digital Output 2 = 1 to be able to activate the pump analog)



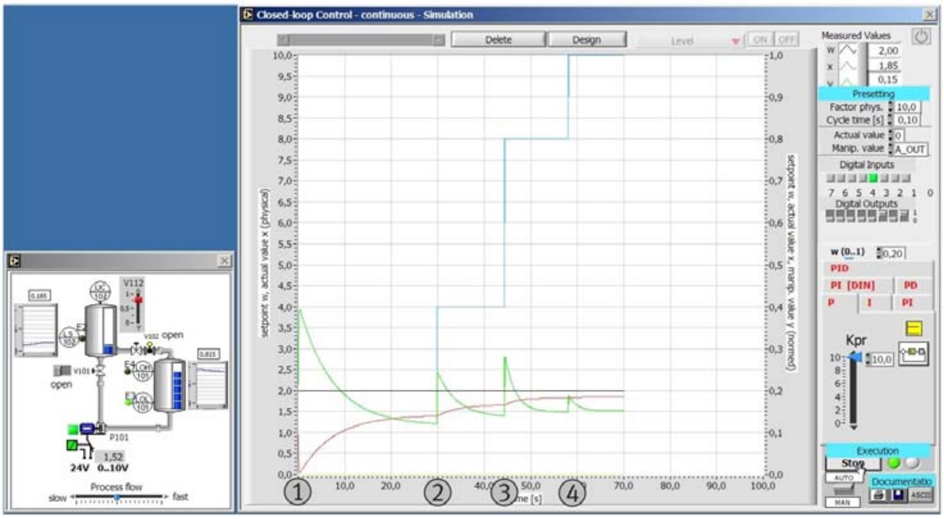
(Set the setpoint to 2 V = 0,2)



(Choose the P-controller)



(Set the first parameter to 2,0 and start the process) **Start**



Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**	**k_{pr}**	**T_i**	**T_v**
P	**2,0**	**X**	**X**	**4,0**	**X**	**X**	**8,0**	**X**	**X**	**10,0**	**X**	**X**	**n.u.**	**X**	**X**
I	X		X	X		X	X		X	X		X	X		X
PI			X			X			X			X			X
PD		X			X			X			X			X	
PID															

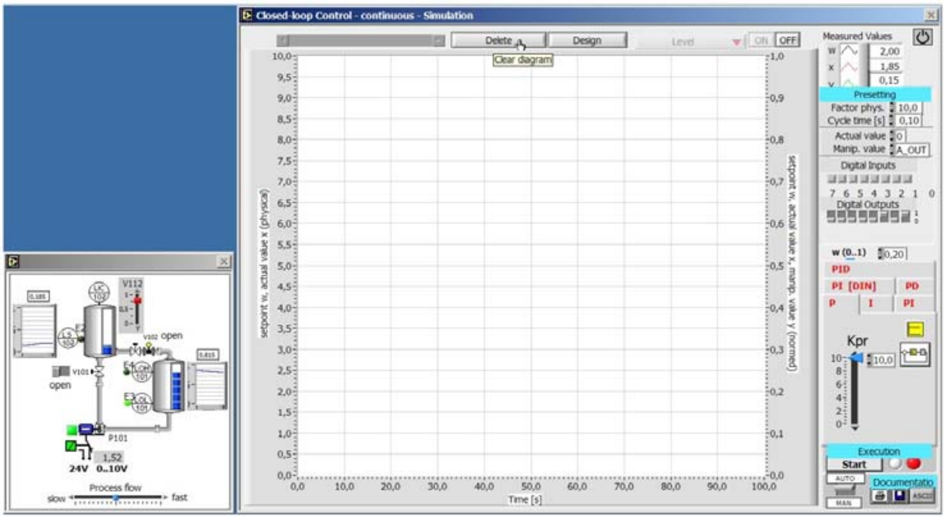
n.u. = not used, which means we interrupted the process there

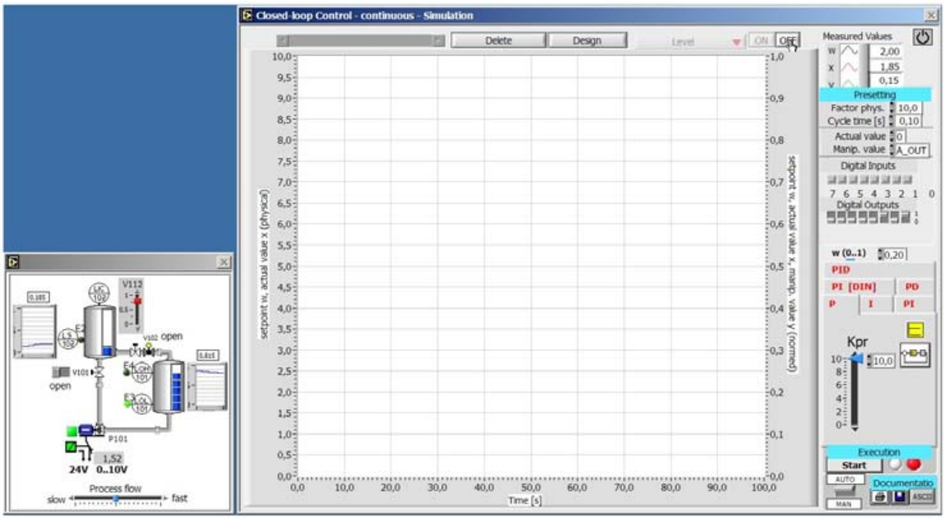
Please proceed with the other controls and parameters according to the following table:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P	2,0	X	X	4,0	X	X	8,0	X	X	10,0	X	X	n.u.	X	X
I	X	1,0	X	X	2,0	X	X	4,0	X	X	n.u.	X	X	n.u.	X
PI	1,0	1,0	X	1,0	4,0	X	2,0	6,0	X	4,0	8,0	X	6,0	8,0	X
PD	1,0	X	1,0	4,0	X	1,0	n.u.	X	n.u.	n.u.	X	n.u.	n.u.	X	n.u.
PID	4,0	8,0	0,1	2,0	6,0	0,1	4,0	8,0	0,2	6,0	8,0	0,3	6,0	8,0	0,5

n.u. = not used, which means we interrupted the process there

To start a new controller type, please delete the screen before:

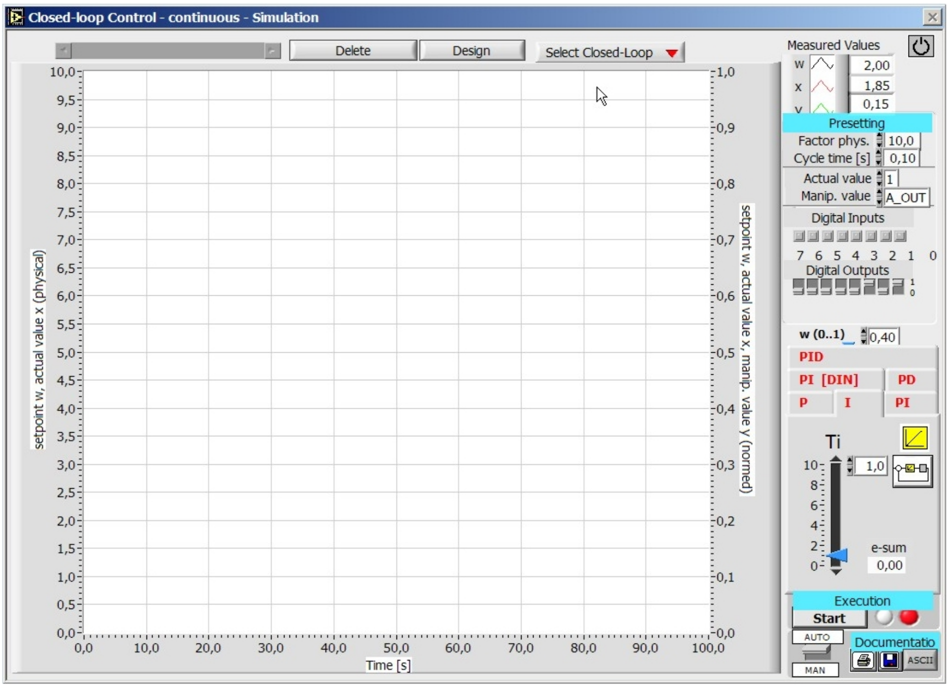




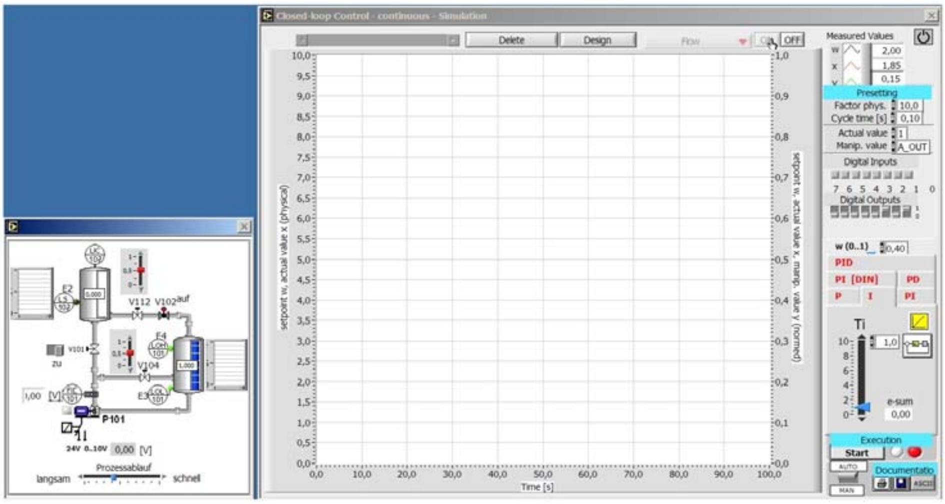
After finishing the entire project of level control, please switch off the level control simulation) **OFF**

8.2.2 Simulation of the continuous flow control

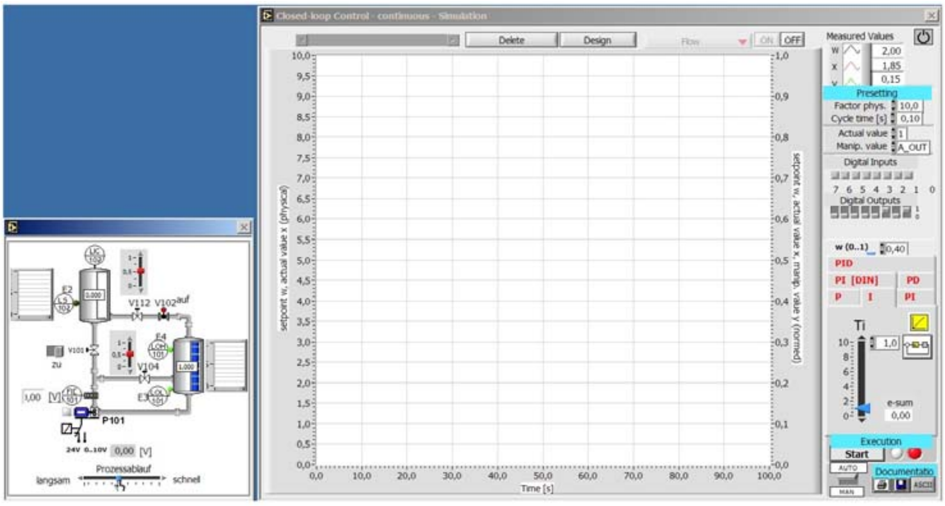
We are going to simulate the continuous flow control process with the same parameters than for the real process. We will only show you how the I-control process has to be done. Please continue with the other controllers and parameters by yourself and compare each result with the real process.



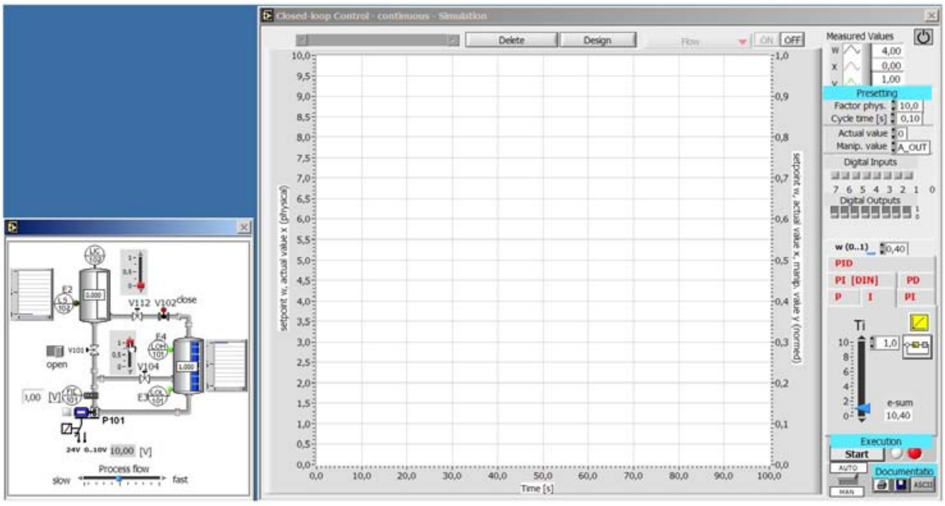
(Select the closed-loop process) **Select Closed Loop** → (select the flow control) **Flow**



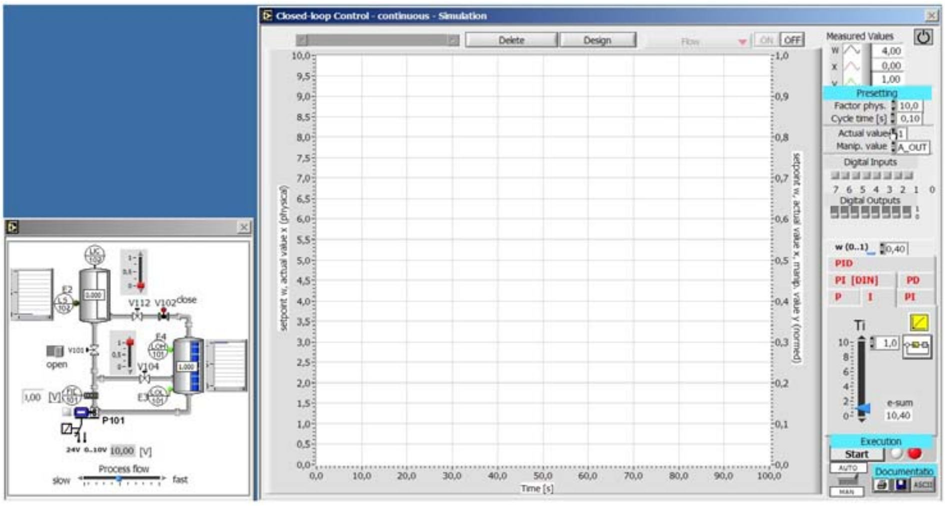
(Activate the process simulation) **ON**



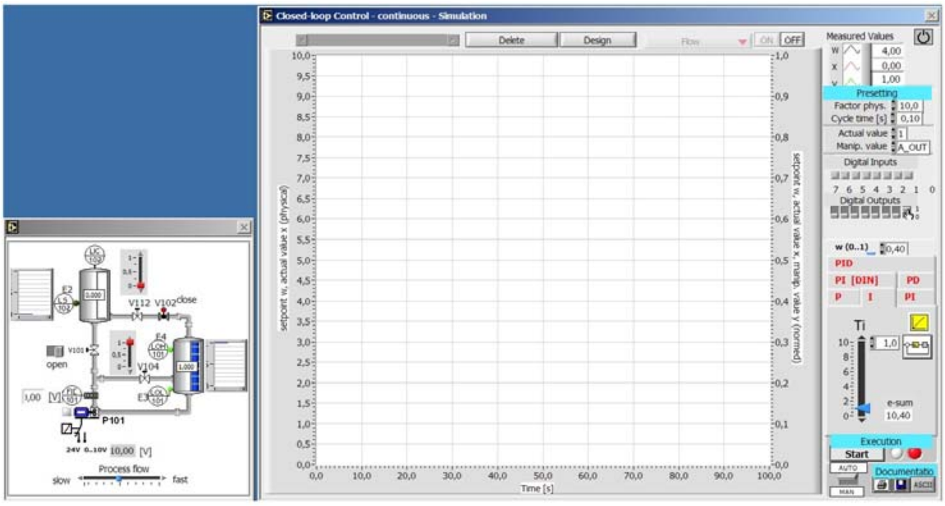
(Set the process speed to 50 %)



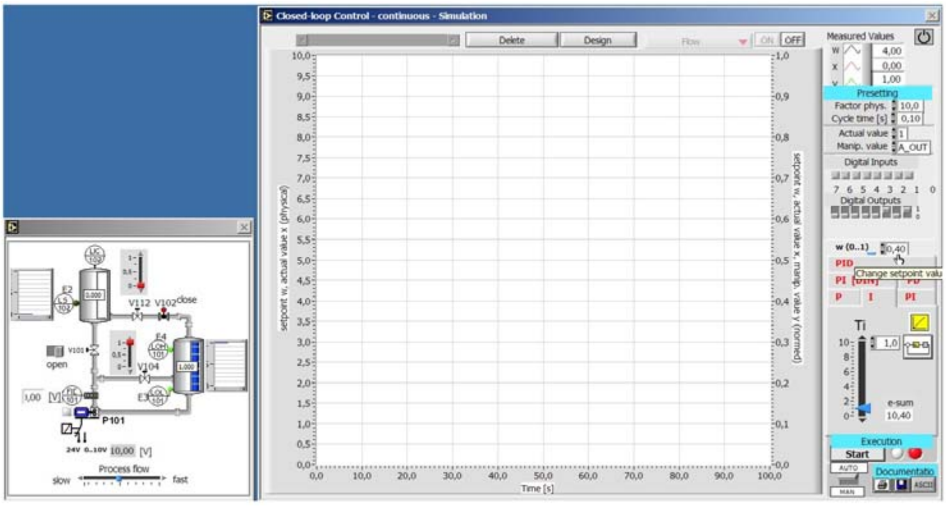
(Close the valve 112 = 0 %)



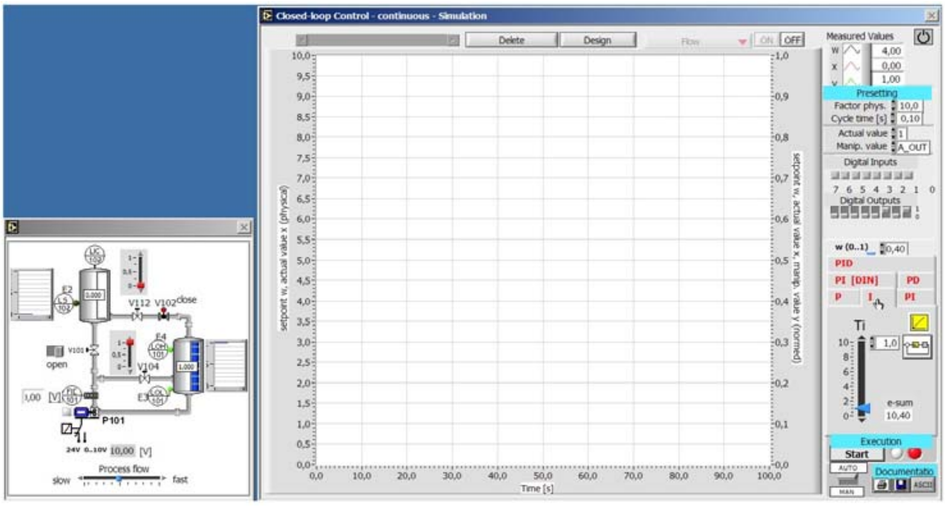
(Select the analog input signal to 1 for the flow sensor)



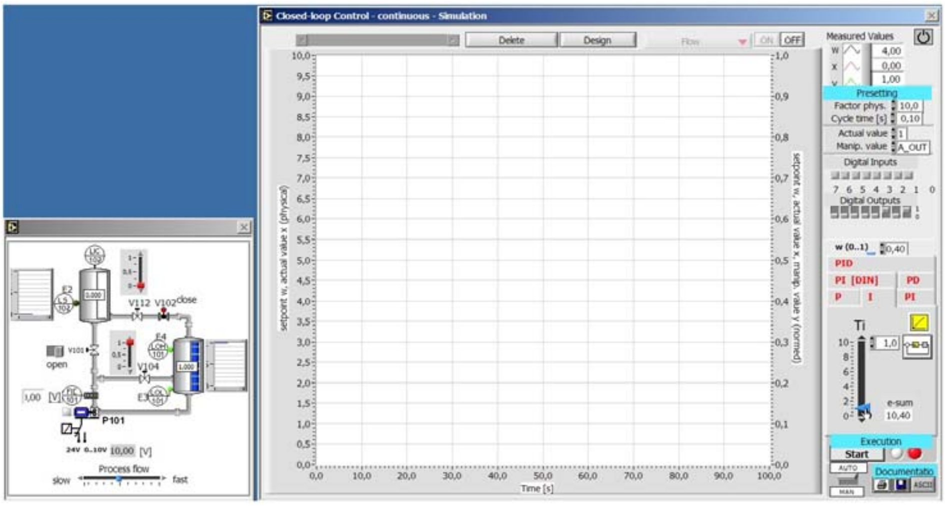
(Activate the simulation process by switching the Output 0= 1 and Output 2 = 1))



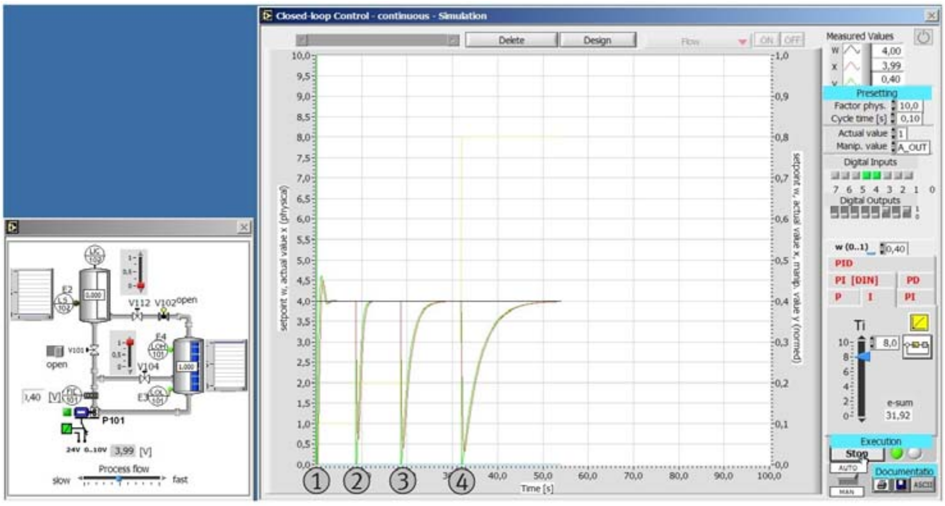
(Set the setpoint to 4 V = 0,4)



(Choose the I-controller)



(Set the first parameter to 1,0 and start the process) **Start**



Please refer to the parameters we used for this project:

The list of parameters for every project looks like:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P	**1,0**	**X**	**X**	**2,0**	**X**	**X**	**4,0**	**X**	**X**	**8,0**	**X**	**X**	**n.u.**	**X**	**X**
I	**X**	**1,0**	**X**	**X**	**2,0**	**X**	**X**	**4,0**	**X**	**X**	**8,0**	**X**	**X**	**n.u.**	**X**
I	X		X	X		X	X		X	X		X	X		X
PI			X			X			X			X			X
PD		X			X			X			X			X	
PID															

n.u. = not used, which means we interrupted the process there

Please proceed with the other controls and parameters according to the following table:

	1 - Start – Stop			2 - Start – Stop			3 - Start – Stop			4 - Start – Stop			5 - Start – Stop		
Contr	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v	k_{pr}	T_i	T_v
P	2,0	X	X	4,0	X	X	8,0	X	X	10,0	X	X	n.u.	X	X
I	X	1,0	X	X	2,0	X	X	4,0	X	X	n.u.	X	X	n.u.	X
PI	1,0	1,0	X	2,0	2,0	X	2,0	1,0	X	3,0	0,7	X	1,0	2,0	X
PD	1,0	X	1,0	2,0	X	2,0	n.u.	X	n.u.	n.u.	X	n.u.	n.u.	X	n.u.
PID	1,0	1,0	0,1	2,0	2,0	0,1	2,0	1,0	0,1	2,0	2,0	0,05	3,0	2,0	0,1

n.u. = not used, which means we interrupted the process there

After the entire project is finished, please close the window and close the program.