

# SMARTSIM

DL VPC-LAB 4.0

VIRTUAL PROCESS CONTROL



DE LORENZO

# SMART SIMULATOR FOR PROCESS CONTROL TRAINING

The DL VPC-LAB 4.0 is a software that has been developed to teach process control techniques in a unique and effective way.

With this software, students can improve their individual experience on studying process control in practice.

Students will be able to carry out several experiments dealing with the following topics:

- ✔ **Control systems, open and closed loop system;**
- ✔ **Sensors, transducers and actuators;**
- ✔ **Input and power signal conditioning;**
- ✔ **Level, flow, pressure, temperature;**
- ✔ **Error, offset, calibration, response time, ON-OFF control, hysteresis, PID controller, Proportional control (P), Proportional-Integral control (PI), Proportional-Integral-Derivative control (PID).**

This software will be able to reproduce the features and behaviours of the DE LORENZO Process Control Trainer – DL 2314. This system can work with or without a PLC. Students can easily implement the controllers using the virtual control modules or connecting the plant to a real PLC or to a SoftPLC, such as Siemens S7-1200/1500, PL-CSIM and Codesys.


With this type of software developed by DE LORENZO, students can learn in their own rhythm and teachers have more time to support the class, manage and improve the process because - unlike any other simple simulator - it grants the following benefits:

**INDUSTRIAL TOOLS**

**POWERFUL 3D SIMULATOR**

**PROFESSIONAL  
LEARNING**



**INDUSTRIAL REALISTIC  
ENVIRONMENTS**

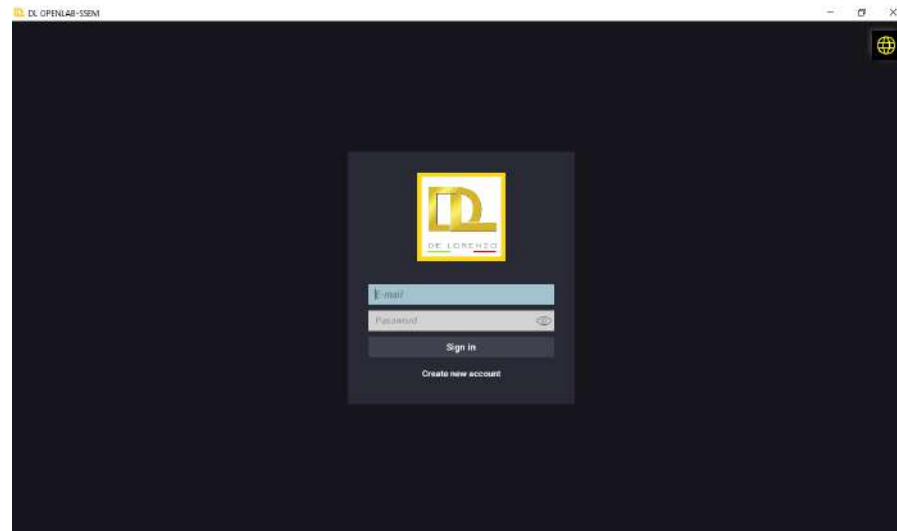
  

**PROFESSIONAL EXPERIENCE**

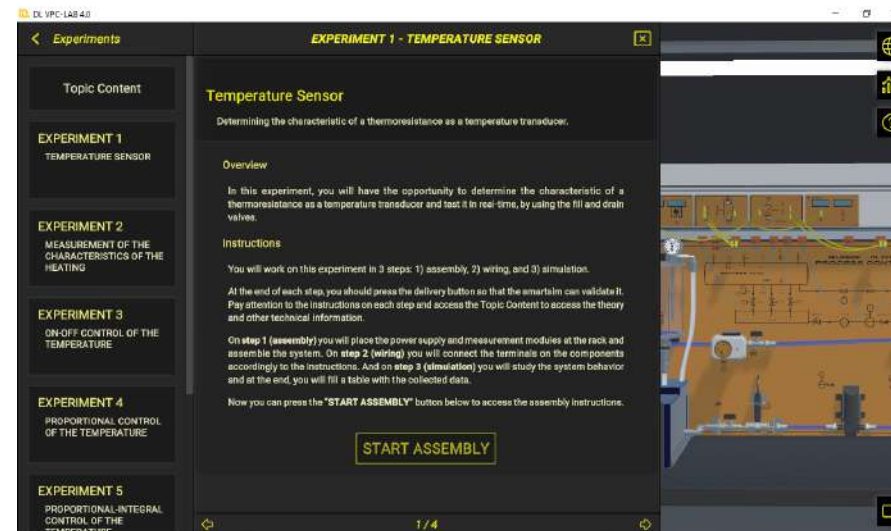
**REAL-LIFE SITUATIONS**

## 1. EFFECTIVE GUIDE FOR STUDENT

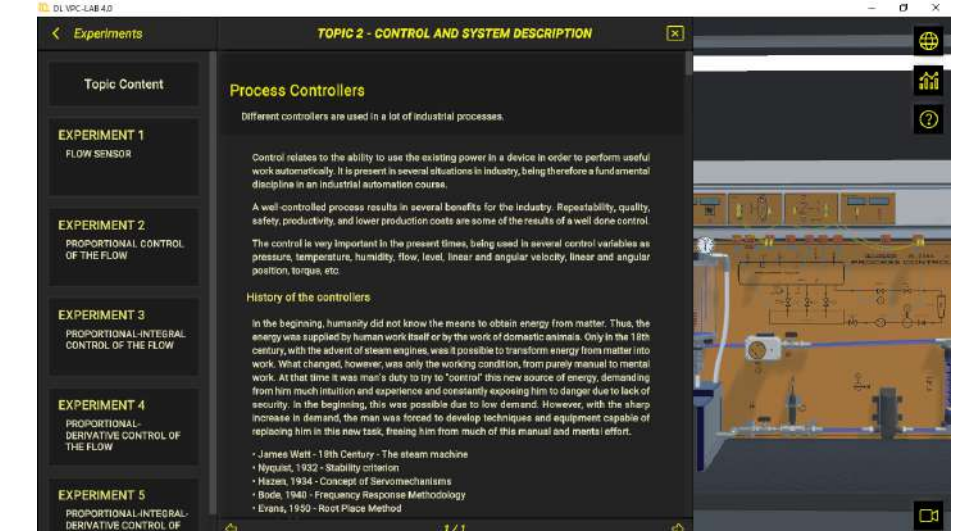
Possibility to access learning topics, with theory, instructions and experiment proposals. The software includes a virtual version of the DL 2314



Student logs in, so his progress can be tracked.



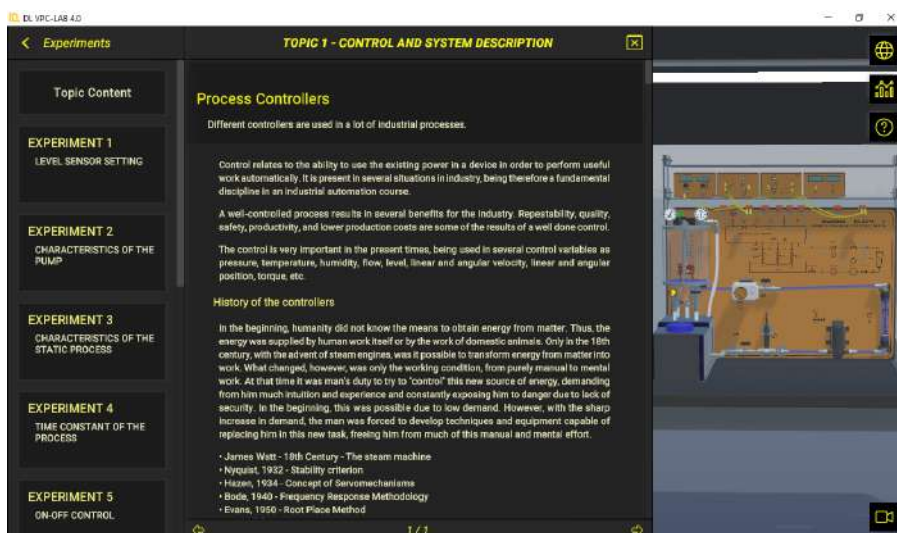
...choose one of the learning topics



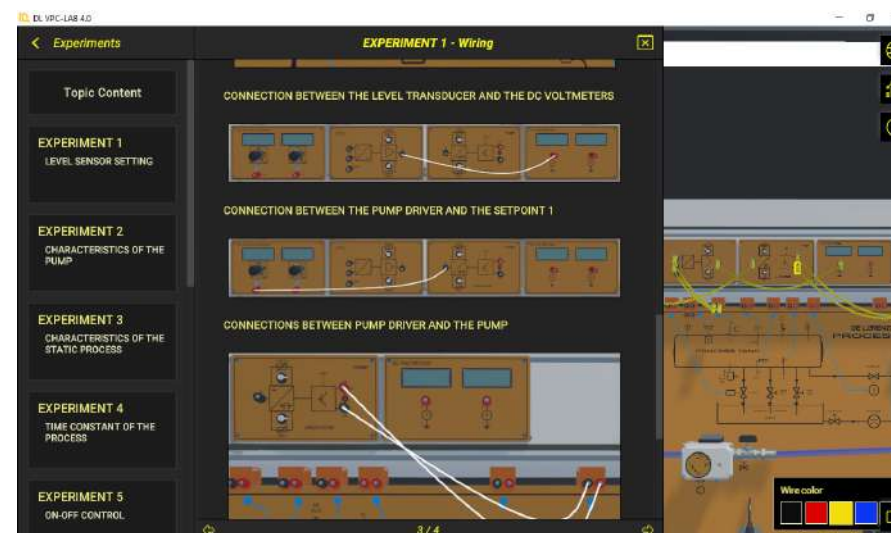
...accesses theory, experiments proposals and instructions.

## 2. AUTOMATIC VALIDATION OF STUDENTS' TASKS

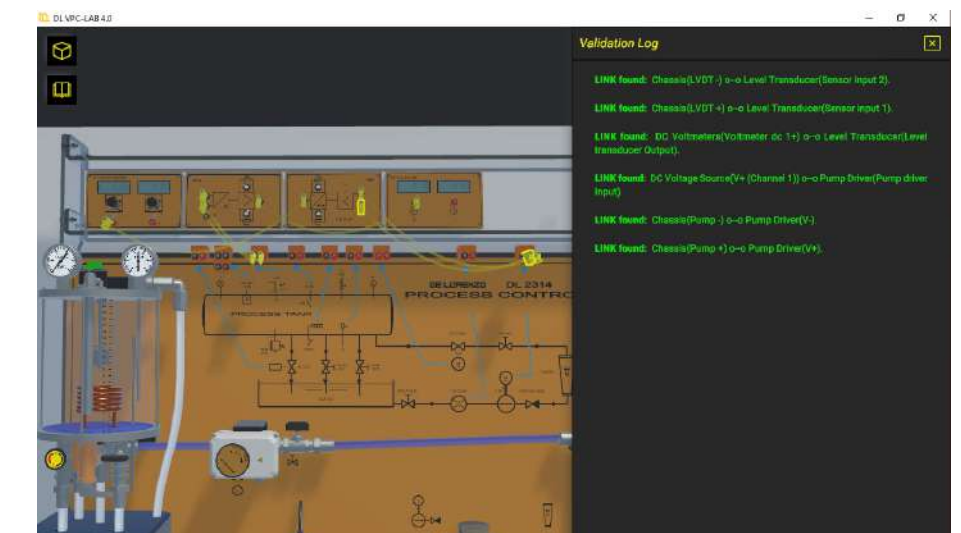
The software automatically verifies if the student completed successfully each task in order to allow him/her to go ahead with the next one;



Student works on the assembly of the signal and control modules



...then makes the electrical connections



...and with all that correctly done, runs the experiment.

# 3D INDUSTRIAL ENVIRONMENT TO PROVIDE REAL PRACTICAL EXPERIENCE TO STUDENTS

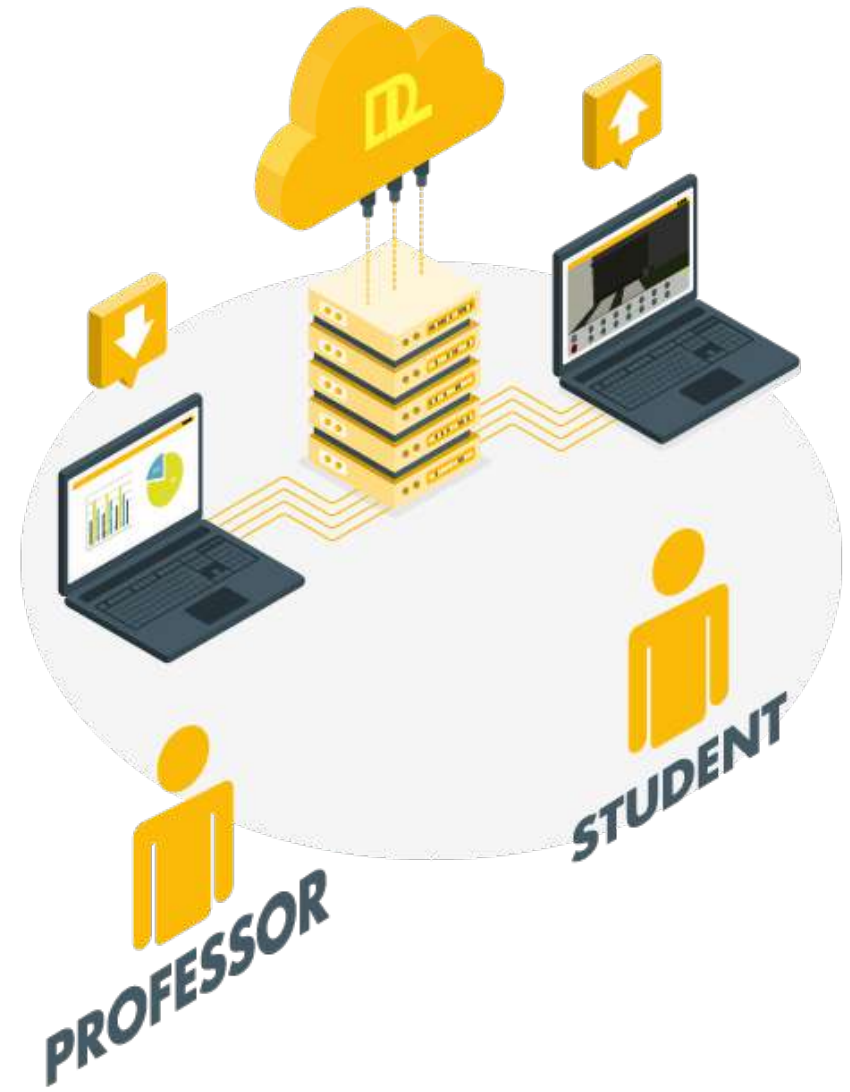


# WHY IS IT A SMARTSIM?

**IT CONNECTS PROFESSOR, STUDENT AND SCHOOL**

De Lorenzo's cloud server receives students activities and provides reports and analytics to professors and institutions. Besides, a student can start working at school and continue at home or vice-versa.

That means that the professors can monitor the students and based on the report that De Lorenzo's cloud provides, the professors can give the support that a specific student might be needing.



**COMPATIBLE WITH THE DL SMART-DASHBOARD (SOLD SEPARATELY)**

**PROFESSORS CAN FOLLOW STUDENTS PROGRESS**

The professor can do and access everything the student can. Besides, he/she can also access the dashboard's portal. It includes interesting reports and analytics that help the professor to monitor the group in real time, as well as to identify students who are doing very well, as well as those who need help, who are not working at all and who seem to be "cheating".

**Tasks report**

This is an important tool since it provides evidence of the activities a student worked on. That means the school has evidence of the practical activities the distance learner has done with detailed information about it.

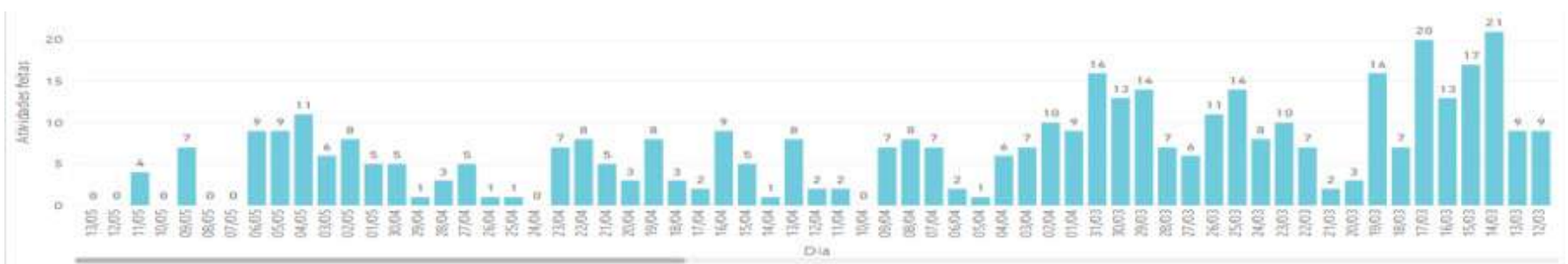
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Scripts	1.1 - Abrindo uma tela modal	3/9/2020 6:33:37 PM	False
Desenvolvimento de sistemas supervisórios	2.5 - Implementar Gráficos	11/22/2019 7:14:00 PM	False
Desenvolvimento de sistemas supervisórios	2.5 - Montar interface principal	11/18/2019 5:04:15 PM	True
Desenvolvimento de sistemas supervisórios	2.4 - Construindo os objetos da aplicação	11/18/2019 4:28:54 PM	True
Desenvolvimento de sistemas supervisórios	2.3 - Explorando Recursos	11/15/2019 5:35:44 PM	True
Desenvolvimento de sistemas supervisórios	2.2 - Conhecendo o Elipse E3	11/15/2019 5:10:00 PM	True
Desenvolvimento de sistemas supervisórios	2.1 - Comunicação OPC	11/14/2019 12:57:42 PM	True
Desenvolvimento de sistemas supervisórios	1.8 - Comandos pelo supervisorio	11/14/2019 11:25:14 AM	True

**PROFESSOR CAN SEE WHICH STUDENTS ARE ON SCHEDULE**

With this interface, the professor may choose which groups he/she wants to monitor, to verify who is on schedule, who is pending and so on. It is possible to define the expected progress percentage in relation to the tasks available in the course.

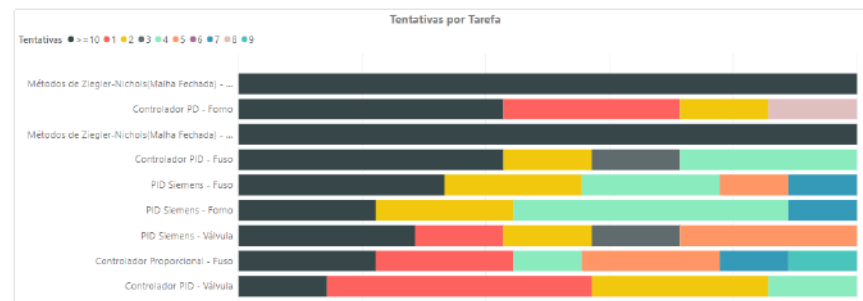
**RHYTHM**

This other dashboard shows the number of activities the students did daily and weekly. The professor may decide to verify it regarding a whole group/class or a specific student.



**TRIALS PER TASK**

This chart helps the teacher to understand which task may be the most difficult and which one may be the easiest in order to adjust the deadlines.

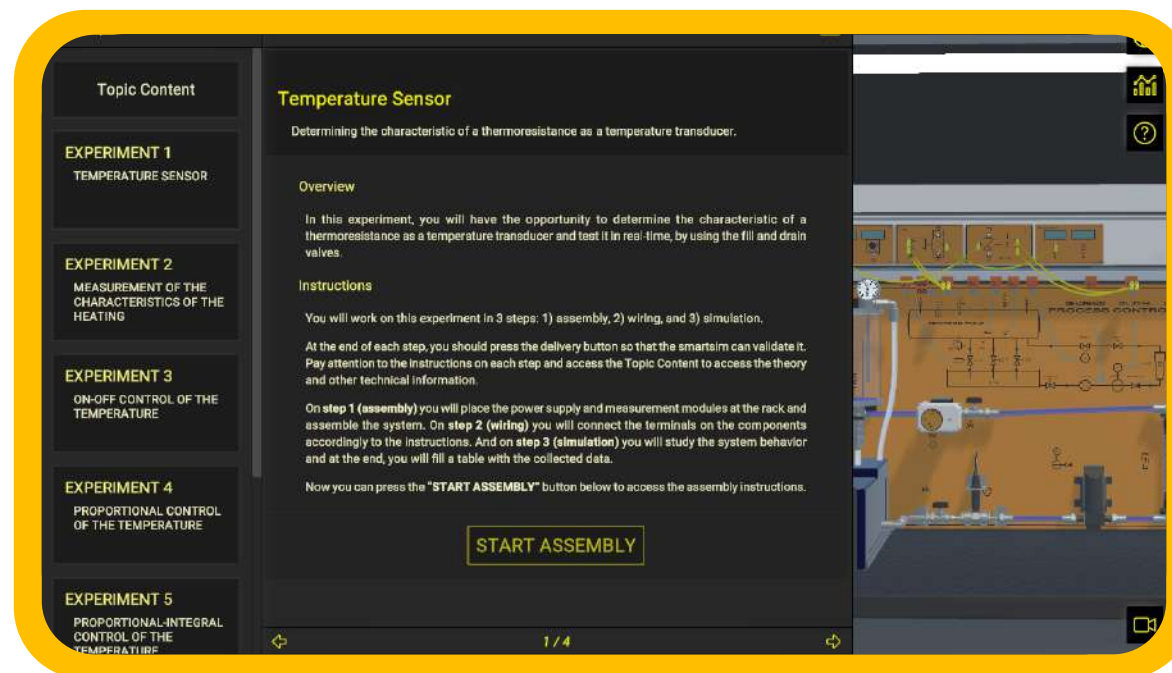


# SUMMARY OF FEATURES

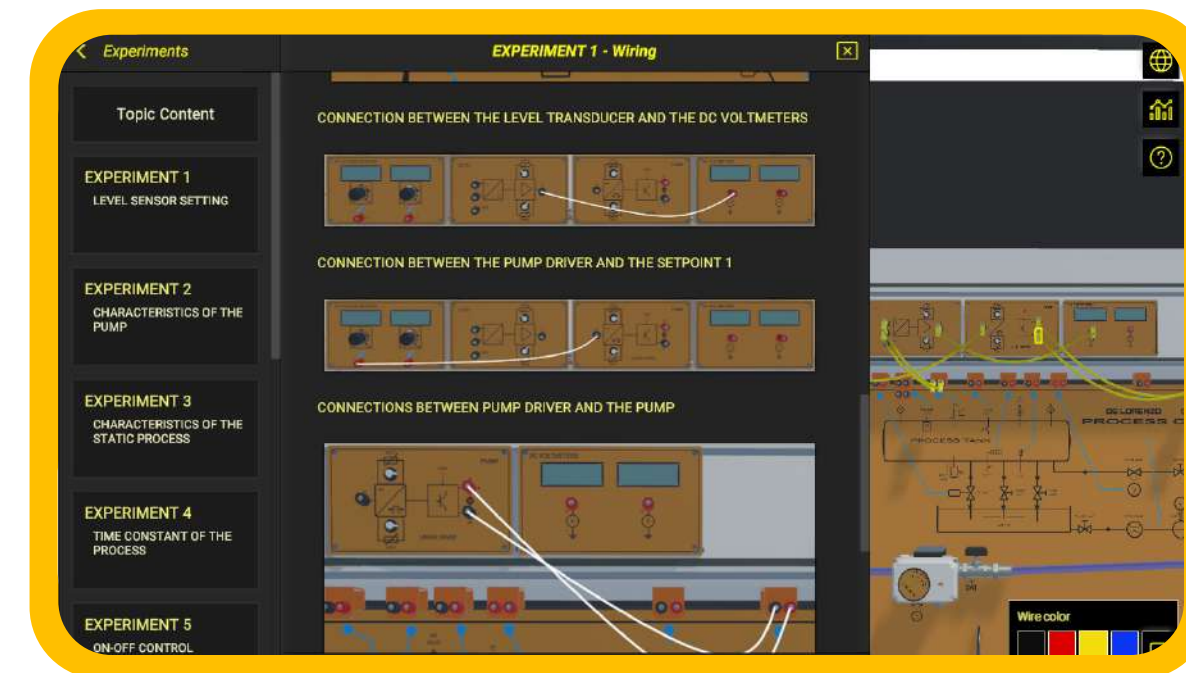
IT'S A 3D SIMULATOR



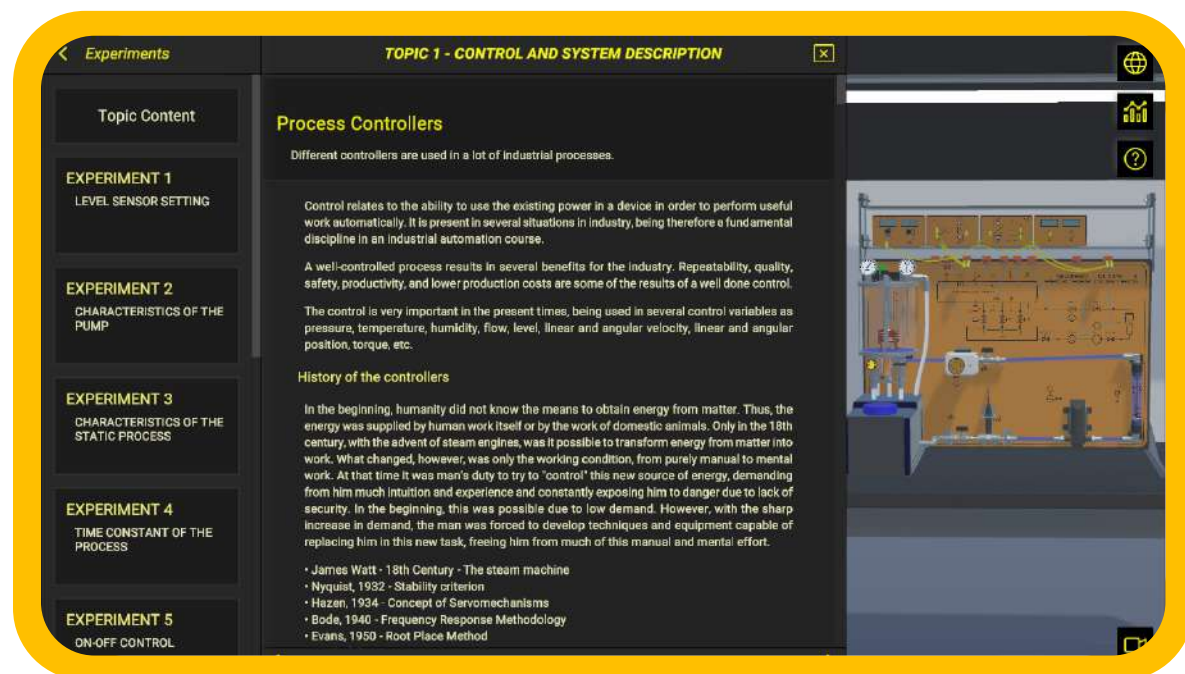
IT HAS BUILT-IN PROJECTS



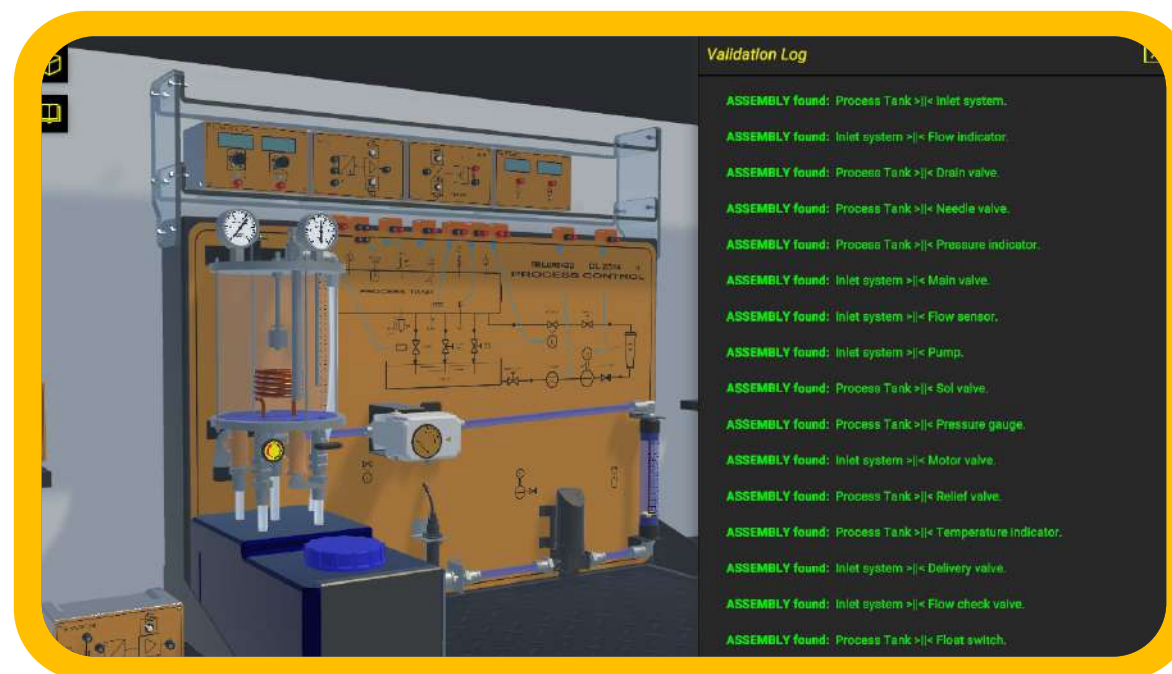
THE PROJECTS INCLUDE GUIDANCE



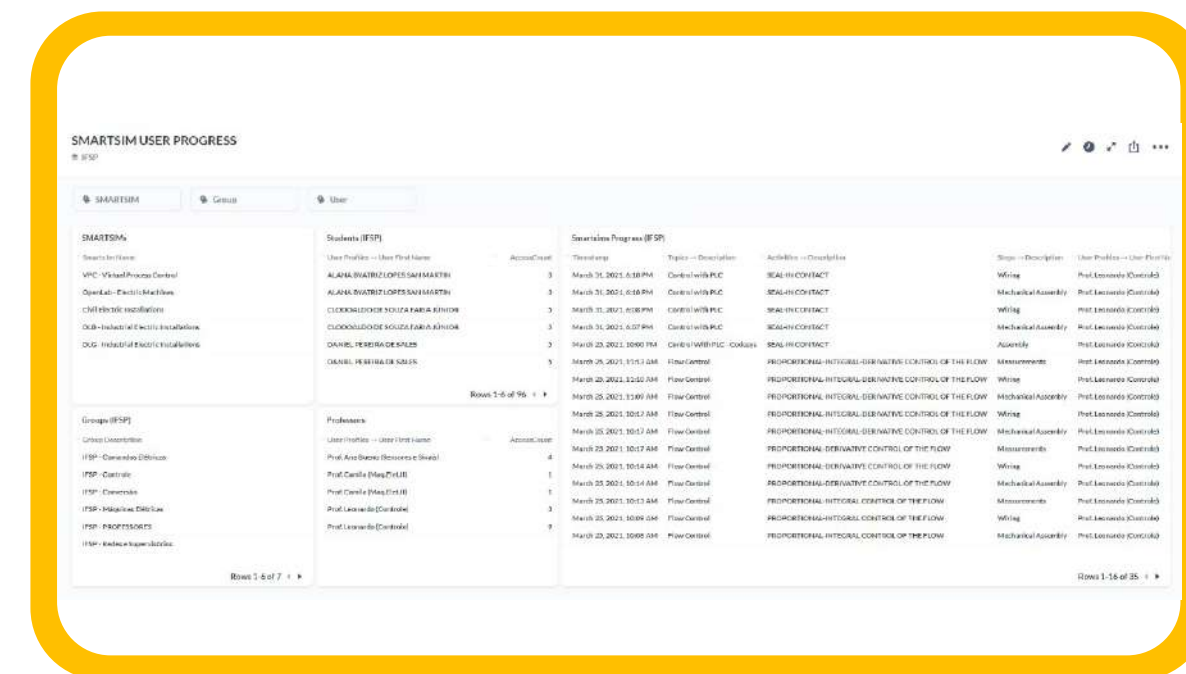
+ CONTENTS AND SUPPORT MATERIALS, SO THEY CAN LEARN BY THEMSELVES



IT AUTOMATICALLY CHECKS STUDENT ACTIVITIES TO LET THEM MOVE ON, LIKE IN GAME

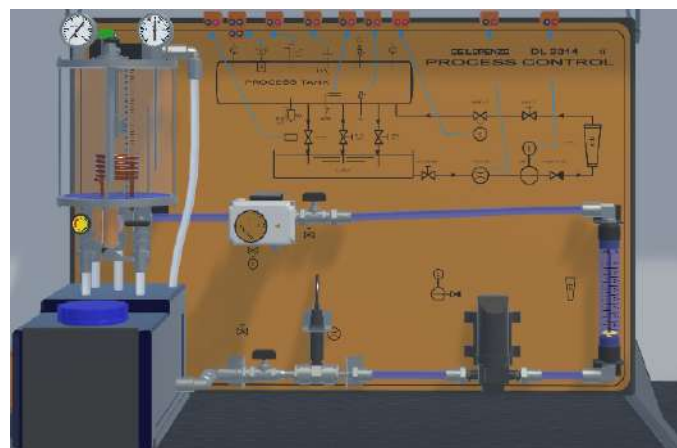


PROFESSORS CAN MONITOR STUDENTS AND VERIFY WHICH POINT THEY NEED HELP (Option available with the Dashboard)



# SOFTWARE DESCRIPTION

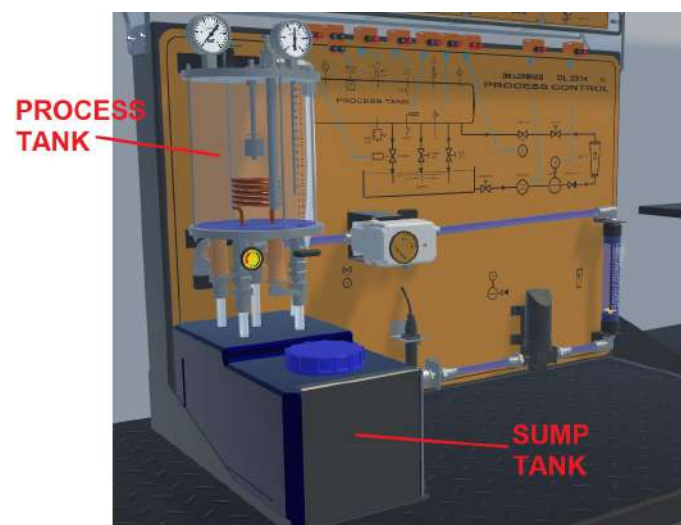
This software reproduces a process plant and signal, power, control and PLC modules.



**PROCESS PLANT**



**SIGNAL, POWER AND CONTROL AND PLC MODULES**



**PROCESS PLANT DESCRIPTION**

The process control laboratory is composed of two main sections: the process tank and the sump tank.

The **PROCESS PLANT** is designed to teach the process control principles.

The **SUMP TANK** includes pipelines to process water supply and to drain water out from the process plant.

The **PROCESS TANK (pressurized vessel)** includes the following components:

- A level sensor and a metric scale suitable for measuring the water level (cm or mm).
- A float switch suitable for detecting the level of water within the pressurized tank.
- A heating element.
- A temperature sensor (PT100) and a thermometer suitable for measuring the temperature inside the process tank (°C or °F).
- A pressure sensor and a pressure gauge suitable for measuring the pressure (bar or psi).
- Four types of valves (three manually operated and a controlled one).

The **SUMP TANK (water tank)** and the pipelines include the following components:

- A delivery valve (the main water supply valve).
- A flow meter turbine (volumetric measuring turbine).
- A motor pump with thermal protection.
- A visual flowmeter (indicator for flow rate).
- A manually operated valve to reduce the water flow.
- A motor valve suitable for controlling the water flow.

## INSTRUMENTATION AND CONTROL SECTION

The **CONTROL MODULES** include interface signal conditioners for sensors, power drivers for actuators and basic control logic that behaves as either a regulating device or a state-oriented device:

### INPUT

- Level transducer
- Flow transducer
- Temperature transducer
- Pressure transducer

### CONTROLLERS

- ON-OFF
- ON-OFF with hysteresis
- PID (P; P-I; P-D; P-I-D)

### OUTPUT

- Linear driver for PUMP
- Driver for MOTOR VALVE
- PWM driver for HEATER
- ON-OFF driver for SOL VALVE

## CHARACTERISTICS OF THE SIGNAL, POWER AND CONTROL MODULES

The process plant has an associated panel that shows the entire process diagram using standard symbols. This is very useful for students to understand the basic concepts of process control.

The software is supplied with a detailed on line educational guide. Following the experiments, students will be guided step by step to learn the following activities:

- Calibration of a sensor,
- Obtaining the characteristic of a static process and time constant,
- Control of a process by ON-OFF, Proportional, Proportional-Integral and Proportional-Integral-Derivative.

Through this software, teachers will be able to easily guide students in studying the principles of process control. The main objective of a basic course in process control is to make students able to solve practical and real control problems. The didactic advantage of this trainer is the possibility to investigate the behavior of each process (level, flow, temperature or pressure) or any possible relevant combination.

The software guarantees a complete experience in the field of process control. Students can approach this topic starting from the basic concepts of control systems up to designing and tuning controllers for the main four control variables in industries (level, temperature, pressure and flow).

Each experiment is presented to students with its goals and the theoretical concepts necessary to understand the next steps to be taken. After that, students run the experiment in three steps, as shown in the image below. DL VPC-LAB4.0 represents closely the main features of a process plant, so that it will be like having a real process control laboratory for each student.

### • STEP 1: ASSEMBLY

The student chooses the signal, control and power modules.

### • STEP 2: WIRING

The student works on the electrical connections.

### • STEP 3: TUNING, TESTING AND MEASUREMENTS

The student works on signal adjustments, controller tuning and response analysis.

# CONTROL OPTIONS: PLC, SOFTPLC AND BUILT-IN-CONTROL MODULES

The process plant represented by the software can be controlled using:

- The built-in control modules, such as On-OFF, Proportional and PID.
- An external PLC such as S7-1200/1500.
- A SoftPLC, such as PLCSIM and Codesys Control.

When working with a PLC or SoftPLC, students still need to work on signal and power conditioning in the virtual environment, but instead of using control modules, students will connect the input and output normalized signals to a PLC MODULE and the PLC MODULE will handle the interface with the respective external PLC or SoftPLC.

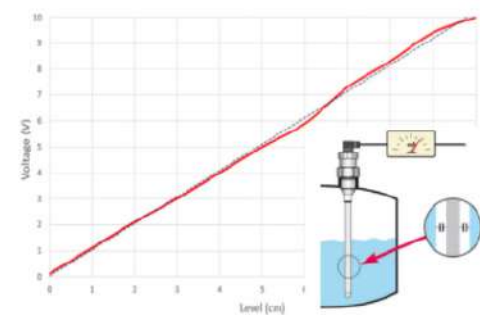
## LIST OF EXPERIMENTS

- Level sensor settings
- Characteristics of the pump
- Characteristics of the static process
- Time constant of the process
- ON - OFF control of the level
- ON - OFF control of the level with "Sol Valve"
- ON - OFF control of the level with "Float Switch"
- Closed loop control of the LEVEL
  - › Closed loop Proportional control of the level
  - › Closed loop Proportional-Integral control of the level
  - › Closed loop Proportional-Derivative control of the level
  - › Closed loop Proportional-Integral-Derivative control of the level
- Flow sensor
- Closed loop control of the FLOW
  - › Closed loop Proportional control of the flow
  - › Closed loop Proportional-Integral control of the flow
  - › Closed loop Proportional-Derivative control of the flow
  - › Closed loop Proportional-Integral-Derivative control of the flow

- Temperature sensor
- Measurement of the characteristics of the heating
- ON - OFF control of the TEMPERATURE
- Closed loop control of the TEMPERATURE
  - › Closed loop Proportional control of the temperature
  - › Closed loop Proportional-Integral control of the temperature
  - › Closed loop Proportional-Derivative control of the temperature
  - › Closed loop Proportional-Integral-Derivative control of the temperature
- Pressure sensor
- Pressure sensor as a level sensor
- ON - OFF control of the level through the pressure sensor

## DESCRIPTION OF PERFORMABLE EXPERIMENTS

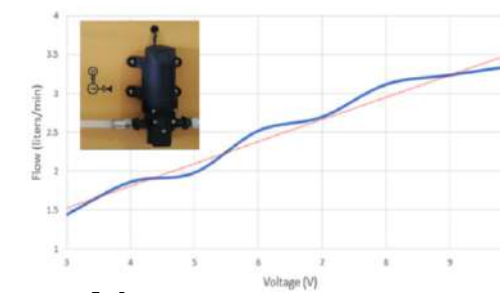
This software grants the possibility to perform 27 practical experiments with progressive difficulties levels. Here follows a short description of some of the performable experiments:



### Level sensor settings

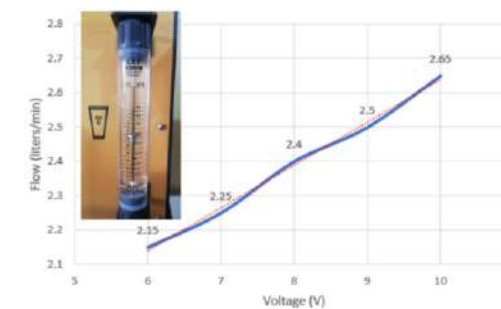
From the beginning of the experiments, students will learn about different types of sensors. Students can learn how to calibrate and use a capacitive fluid level sensor in order to measure the water level and to determine the sensor characteristics.

The level transducer (L/U) is used to calibrate the level sensor for a correspondence of 1 V to 1 cm.



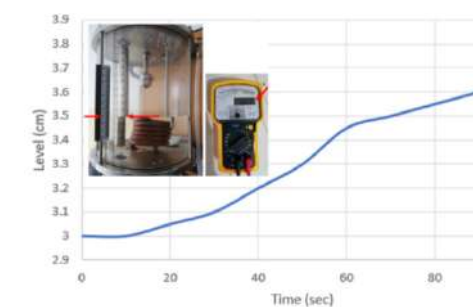
### Characteristics of the pump

After running this experiment, students will understand the working principle of a diaphragm pump. They will learn how to compute the flow and how to measure it using the flowmeter in order to draw the characteristic curve of the flow.



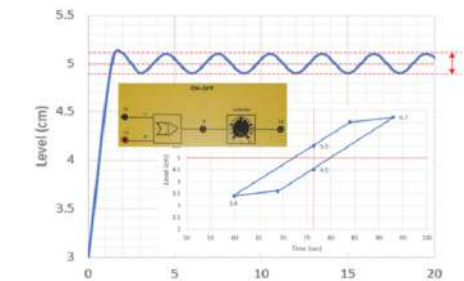
### Characteristics of the static process

The main objective of this experiment is to understand how the flow will influence the rising time of the fluid level rate in a level control process. The flow transducer (f/U) is used to calibrate the flow sensor for a correspondence of 1 V output to 0.5 liters per minute.



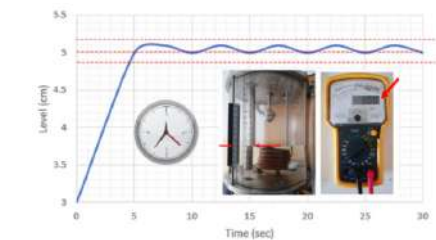
### Time constant of the process

What is the time constant of a process? How do I calculate it? Students can answer these questions by performing this experiment. The time constant estimation of the water flow in the tank is made as a ratio between the input flow and the draining flow rate. This process is an example of parameter identification.



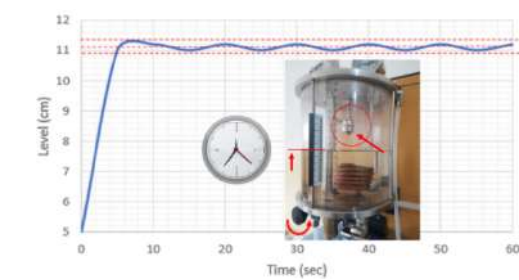
### ON - OFF control of the level

What are the effects of the hysteresis on the level control? Students will find out while learning how to measure the dynamic response of the process. Students will use the capacitive level sensor to measure the water level in the process tank. This knowledge is very important because, in practical situations, one of the most widely used types of control is the ON/OFF control.



### ON - OFF control of the level with the "Sol Valve"

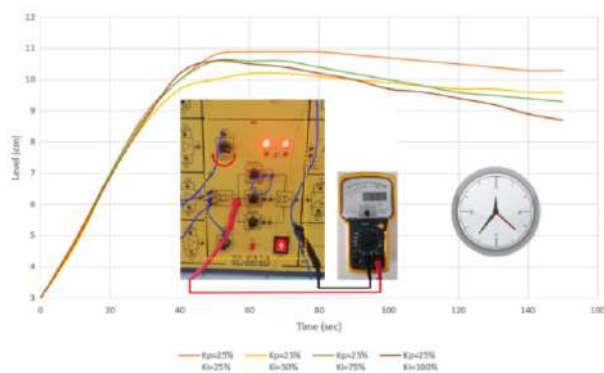
In this experiment, students will use the knowledge acquired so far regarding the hysteresis on level control. They will measure the up and down times of the level between start and stop of the electro-valve with a hysteresis of 0%, 15% and 30%.



### ON - OFF control of the level with the "Float Switch"

Students will perform a practical study to maintain constant the level in the tank using an ON-OFF level sensor and the electro valve sol valve. They will learn how to measure the water level variation in time. In order to determine the hysteresis curve for on - off control of the level, students will use the engraved mobile scale or the level sensor and float switch.



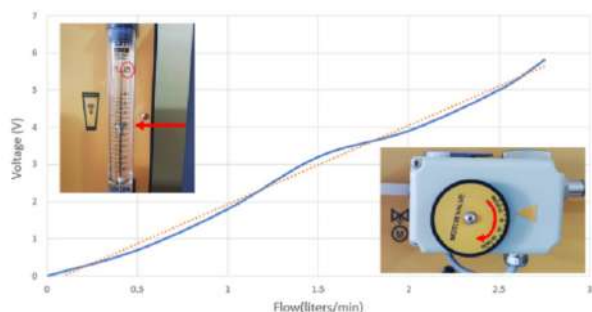


### Closed loop control of the LEVEL

- › Closed loop Proportional control of the level
- › Closed loop Proportional-Integral control of the level
- › Closed loop Proportional-Derivative control of the level
- › Closed loop Proportional-Integral-Derivative control of the level

In order to study the closed loop control, students need to check first the effects of the gain on the dynamic response of the system. It is very interesting to observe the output characteristic of the PID controller for different  $K_p$ ,  $K_d$  and  $K_i$  constant values.

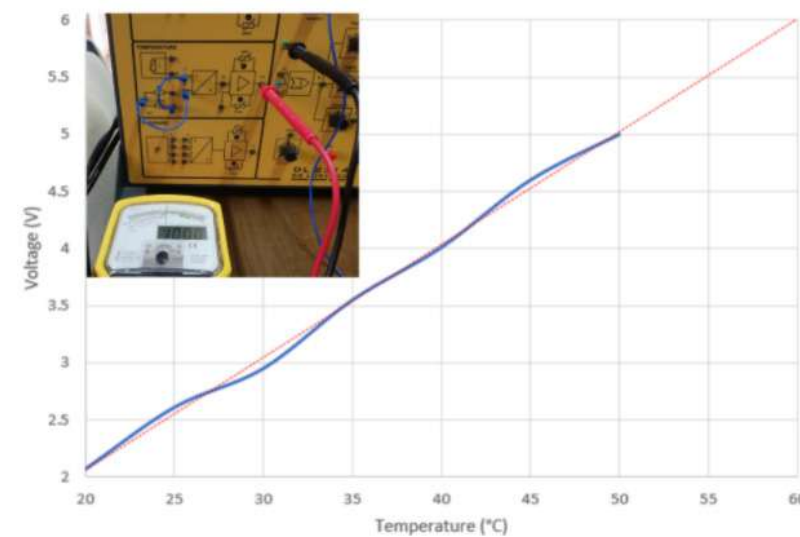
Ziegler-Nichols tuning method is used in tuning of PID controller. The student learn how to determine the PID parameters in order to obtain the controlled level.



### Closed loop control of the FLOW

- › Flow sensor
- › Closed loop Proportional control of the flow
- › Closed loop Proportional-Integral control of the flow
- › Closed loop Proportional-Derivative control of the flow
- › Closed loop Proportional-Integral-Derivative control of flow

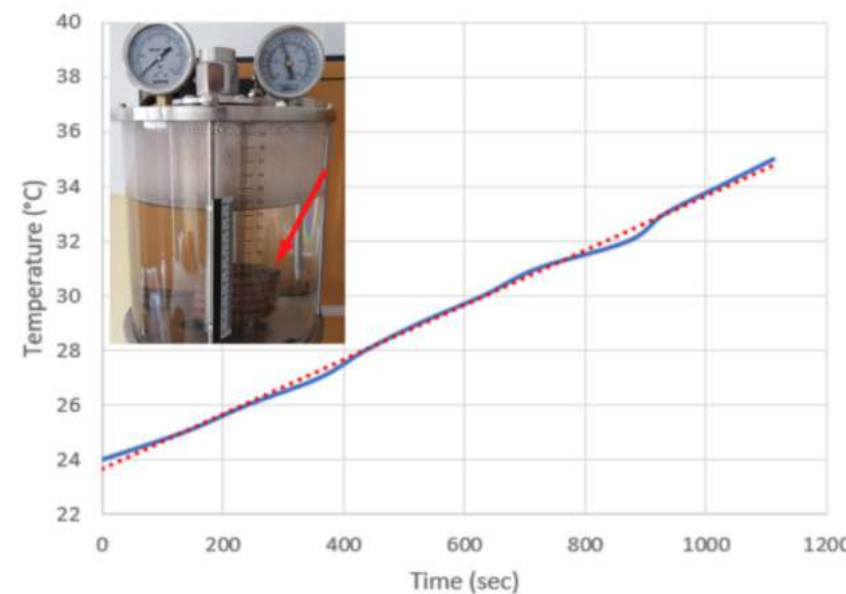
During this experiment, students learn how to measure the water flow rate by using the engraved scale of the direct flow meter or the turbine flow sensor. After analyzing the results in this experiment, students will be able to implement the tuning of the PID control of the system with optimum stability.



### Temperature sensor

Students can learn how to measure the temperature variation in time (using the engraved thermometer scale or the temperature sensor), in order to determine and compute the characteristic curve of the PT100 sensor (RDT).

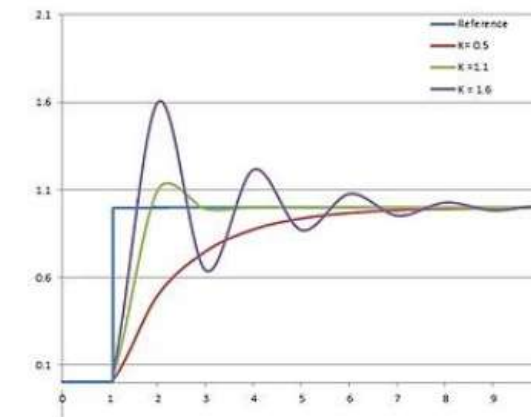
The temperature transducer ( $u/U$ ) is used to calibrate the temperature sensor for a correspondence of 1 V to 10 degrees Celsius.



### Measurement of the characteristics of the heating

In this experiment (similar to the previous one), students will understand the working principle of a resistive temperature sensor in order to measure the temperature in the industrial process tank.

Using a classical oscilloscope, students can analyze the wave form of the PWM for the heating element.



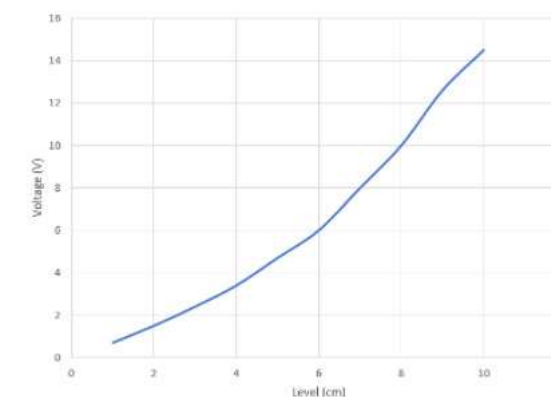
### Closed loop control of the TEMPERATURE

- › ON - OFF control of the temperature
- › Closed loop Proportional control of the temperature
- › Closed loop Proportional-Integral control of the temperature
- › Closed loop Proportional-Derivative control of the temperature
- › Closed loop Proportional-Integral-Derivative control of the temperature

Students will learn that a temperature controller is an instrument used to control temperatures.

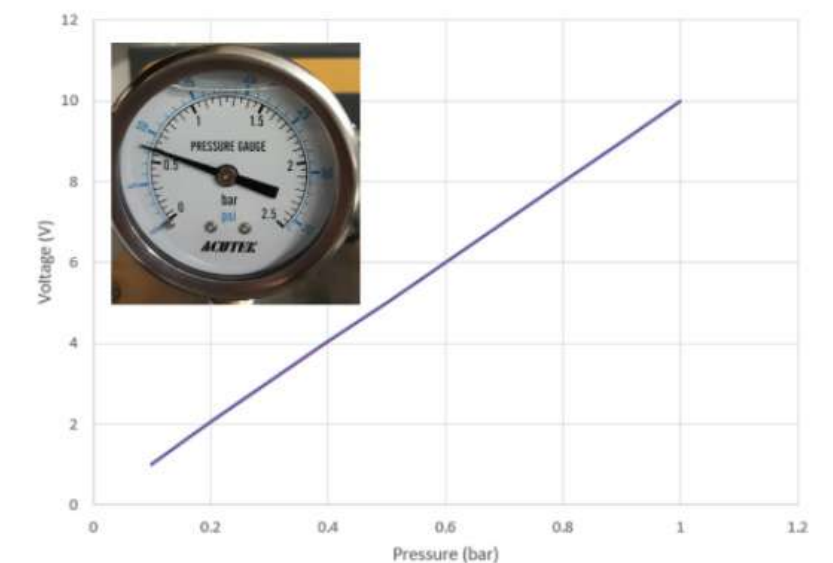
In the temperature controller system, the controller accepts a temperature sensor as an input (such as an RTD or thermocouple) and compares the actual temperature with the required control temperature or set point. The output is then provided to a control element.

After analyzing the results in this experiment, students will be able to tune properly the PID control of the system.



### Pressure sensor as a level sensor

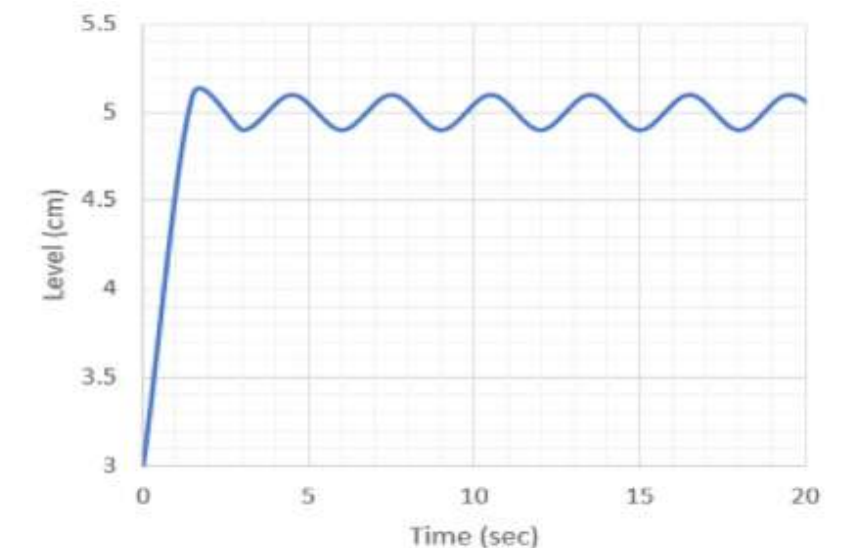
The main objective of this experiment is to measure the pressure, using the electronic pressure sensor or pressure gauge scale, in order to determine the characteristic curve of the level vs. pressure response.



### Pressure sensor

Students will learn how to measure the pressure, using the electronic pressure sensor or pressure gauge scale, in order to determine and compute the characteristic curve of the pressure sensor.

The pressure transducer ( $P/U$ ) is used to calibrate the pressure sensor for a correspondence of 1 V to 0.1 bar. The characteristic of a pressure transducer will be determined.



### ON - OFF control of the level through the pressure sensor

In this experiment, students will perform the operation of a closed loop ON-OFF control system using the pressure sensor as a level sensor.

Thanks to the knowledge acquired so far about the effects of the hysteresis on the control, students will be able to control the pressure.

# SYSTEM REQUIREMENTS

## ORDER CODES

### DL VPC-LAB4.0-C

VIRTUAL PROCESS CONTROL SIMULATOR FOR CODESYS

### DL VPC-LAB4.0-T

VIRTUAL PROCESS CONTROL SIMULATOR FOR TIA PORTAL

## IMPORTANT NOTE:

THESE PRODUCTS DO NOT INCLUDE ANY THIRD PARTY SOFTWARES SUCH AS TIA PORTAL, PLCSIM, CODESYS OR CODESYS CONTROL WIN SL.

TO OUR KNOWLEDGE, CODESYS DEVELOPMENT SYSTEM CAN BE DOWNLOADED FOR FREE AT CODESYS STORE.

TIA PORTAL STEP7 + PLCSIM HAVE TRIAL VERSIONS ON SIEMENS WEBSITE. AND AN EDUCATIONAL VERSION CAN BE PURCHASED BY SIEMENS.

## MINIMUM REQUIREMENTS

### OPERATIONAL SYSTEM

64-BIT WINDOWS 10

### DIRECTX VERSION

DIRECTX 11

### PROCESSOR

INTEL i5 9400F OR AMD RYZEN 5 3600

### MEMORY

8GB

### GRAPHIC CARD

### STORAGE

HDD (1GB)

## RECOMMENDED REQUIREMENTS

### OPERATIONAL SYSTEM

64-BIT WINDOWS 10 PRO

### DIRECTX VERSION

DIRECTX 12

### PROCESSOR

INTEL i7 9700 OR AMD RYZEN 7 3700X

### MEMORY

16 GB

### GRAPHIC CARD

NVIDIA GTX 1050 TI 4GB OR RX 550 4GB

### STORAGE

HDD (1GB)