Applications for Process Control

APC

Engineering and Technical Teaching Equipment

APC. Applications for Process Control

AVAILABLE ELEMENTS

SERVICE UNITS

- **Hydraulic** Supply
- **Chemical Substances** Supply
- **Electrical** Supply
- **Pneumatic** Supply

SENSORS, ACTUATORS, PLANTS AND OTHER AVAILABLE ELEMENTS

- **Flow Control** System
- **Level Control** System
- **Pressure Control** System
- **Temperature Control** System
- **pH Control** System

CONTROLLERS

- Control Software (**SCADA**)
- **Industrial** Controllers
- Programmable Logic Controllers (**PLC**)
- **CompactRIO**

Key features:

- **Advanced Real-Time SCADA.**
- **Open Control + Multicontrol + Real-Time Control.**
- **Specialized EDIBON Control Software based on LabVIEW.**
- **National Instruments Data Acquisition board (250 KS/s, kilo samples per second).**
- **Calibration exercises, which are included, teach the user how to calibrate a sensor and the importance of checking the accuracy of the sensors before taking measurements.**
- **Projector and/or electronic whiteboard compatibility allows the unit to be explained and demonstrated to an entire class at one time.**
- **Capable of doing applied research, real industrial simulation, training courses, etc.**

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PRODUCTS
10.-PROCESS CONTROL

For more information about Key Features, click here

ISO 9001: **Quality Management** (for Design, Manufacturing, Commercialization and After-sales service)

European Union Certificate (total safety)

Certificates ISO 14001 and ECO-Management and Audit Scheme (environmental management)

"Worlddidac Quality Charter" and Platinum Member of Worlddidac

INTRODUCTION

Today, control systems play an essential role in most industrial processes due to the significant improvements they can provide in terms of production quality, efficiency, costs and performance.

The Applications for Process Control, "APC", have been designed by EDIBON to study the fundamentals on which these systems are based, the behavior and configuration of the devices involved and the design of the control strategies that regulate them. With these applications, the user can study the complete automation process of a plant.

The modular design of the Applications for Process Control, "APC", makes it possible to choose the elements of each application and adapt it to the needs of the user. The result is a flexible and easily scalable application, which allows the study of the control theory applied to the desired type of devices and control loops.

The available modules are numerous and the applications that can be configured, countless. For this reason, the Applications for Process Control, "APC", is an ideal solution for any objective and learning level in the instrumentation and control field.

GENERAL DESCRIPTION

The Applications for Process Control, "APC", designed by EDIBON, allows the student to design, assemble and configure various control systems, apart from studying the fundamentals of the control engineering on which they are based.

These applications include from simple flow, level, pressure, temperature and pH control systems, to complex systems, resulting from the combination of several variables.

The following table shows the list of available applications. Nevertheless, at the end of this document, a table is provided with the available modules and the variables with which they are related to make other configurations.

AVAILABLE APPLICATIONS		
SIMPLE CONTROL LOOPS		
Flow	**Level**	**Pressure**
• APC-FSO. Computer Controlled Flow Regulation Application.	• APC-LSO. Computer Controlled Level Regulation Application.	• APC-PSOH. Computer Controlled Pressure Regulation Application in a Hydraulic Circuit.
• APC-FIC. Flow Regulation Application with Industrial Controller.	• APC-LICPR. Level Regulation Application with Industrial Controller and Proportional Valve.	• APC-PSOP. Computer Controlled Pressure Regulation Application in a Pneumatic Circuit.
	• APC-LICPN. Level Regulation Application with Industrial Controller and Pneumatic Valve.	• APC-PIC. Pressure Regulation Application with Industrial Controller.
Temperature		**pH**
• APC-TICPR. Temperature Regulation Application with Industrial Controller and Proportional Valve.		• APC-PHIC. PH Regulation Application with Industrial Controller.
• APC- TICFA. Temperature Regulation Application with Industrial Controller and Fan.		
CONTROL LOOPS WITH MULTIPLE VARIABLES		
• APC-FLIC. Flow and Level Regulation Application with Industrial Controller.	• APC-FLPSO. Computer Controlled Pressure, Level and Flow Regulation Application.	• APC-FLPTSO. Computer Controlled Temperature, Pressure, Level and Flow Regulation Application.
• APC-LPIC. Level and Pressure Regulation Application with Industrial Controller.	• APC-FLTIC. Temperature, Level and Flow Regulation Application with Industrial Controller.	• APC-FLPTIC. Temperature, Pressure, Level and Flow Regulation Application with Industrial Controller.

All the applications include the frame to mount the modules and the cables, hoses and accessories required for the correct operation of the application.

SPECIFICATIONS

FLOW

APC- FSO. Computer Controlled Flow Regulation Application.

In the "APC-FSO" application, a variable speed pump makes water flow from a supply tank through a proportional valve and two flow sensors. The control of the system is done through the "APC-SOF-SAC" software designed by EDIBON.

The elements included in the "APC-FSO" application are:

- **SU-H/S. Small Size Hydraulic Supply Unit.**

  Module designed to pump water to the other devices of the application. The variable speed pump included can be used as actuator of the system.

  The elements included in the "SU-H/S" module are:

  - Variable speed pump, 8 l/min approx.
  - Plastic tank, 4 l approx.
  - Manual valve.

- **N-ALI20. Power Supply.**
- **N-M-F-T/S. Turbine type sensor for low flow rates.**

  Maximun flow rate: 3 l/min approx.
- **N-P-F-WR/S. Rotameter for low flow hydraulic circuit.**

  Maximum flow rate: 4 l/min approx.
- **APC-SOF-KSAC. Simulation, acquisition and control software kit.**

  The elements included in the "APC-SOF-KSAC" kit are:

  - N-AC-USB. USB acquisition card.
  - APC- SOF-SAC. Simulation, acquisition and control software.

  The main functions of this software, based on LabVIEW, are:

  - Process signal visualization.
  - Data storage.
  - ON/OFF and PID controls via software.
  - Process simulation.
- **N-V-PR-W/S. Electromagnetic proportional valve for low flow hydraulic circuits.**

  Proportional valve that can be used to introduce disturbances in the system or as control device.

The elements recommended to extend the functionality of the "APC-FSO" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the flow control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-FSO" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a flow control system.
- Preparation of connection, circuits, wiring and terminals diagrams of a flow control system.
- Assembly of the hydraulic circuit of a flow control system.
- Wiring of the control and measurement signals and the power supply of a flow control system.

Analysis of the system and design of control strategies:

- Response of a flow control system to a step input.
- Simulation of a flow control system in open and closed loop.
- Effect of the parameters of a PID controller.
- PID control of a flow control system with the variable speed pump.
- PID control of a flow control system with the proportional valve.
- Response of the controlled system to disturbances and changes of the reference signal.
- Disturbance compensation through feedforward control.

APC-FIC. Flow Regulation Application with Industrial Controller.

In the "APC-FIC" application, a pump impels water through a hydraulic circuit consisting of a supply tank, a rotameter and a motorized valve. The control of the system is done through an industrial controller. In addition, a ball valve with scale is included to introduce disturbances.

The elements included in the "APC-FIC" application are:

- **SU-H. Hydraulic Supply Unit.**

  Module designed to pump water to the other devices of the application. It is recommended for simple control applications, with only one variable.

  The elements included in the "SU-H" module are:

  - Centrifugal pump, 80 l/min approx.
  - Stainless steel tank, 15 l approx.
  - Manual valve.
- **N-ALI20. Power Supply.**
- **N-M-F-P. Paddlewheel flow sensor.**

  Maximum flow rate: 50 l/min approx.
- **N-V-MO. Motorized control valve.**
- **N-P-F-WR. Hydraulic circuit rotameter.**

  The elements included in the "N-P-F-WR" module are:

  - Rotameter, 50 l/min.
  - Control valve.
- **N-IC. Industrial controller.**
- **N-V-H-S. Ball valve with scale.**

  Manual valve to introduce disturbances in the system.

The elements recommended to extend the functionality of the "APC-FIC" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the flow control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-FIC" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a flow control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a flow control system.
- Assembly of the hydraulic circuit of a flow control system.
- Wiring of the control and measurement signals and the power supply of a flow control system.

Configuration of the system devices:

- Configuration of an industrial controller.

Analysis of the system and design of control strategies:

- Manual control of the system with an industrial controller (open loop).
- Effect of the parameters of a PID controller.
- Obtaining the PID parameters automatically by auto-tuning.
- Adjustment and optimization of a PID controller.
- Response of the controlled system to disturbances and changes of the reference signal.

APC- LSO. Computer Controlled Level Regulation Application.

In the "APC-LSO" application, a variable speed pump impels water from a supply tank to an upper tank (process tank) where the level is measured. The application includes a control valve, which can be configured in different points of the hydraulic circuit to regulate the system or introduce disturbances. The control of the system is done through the "APC-SOF-SAC" software designed by EDIBON.

The elements included in the "APC-LSO" application are:

- **SU-H/S. Small Size Hydraulic Supply Unit.**
  Module designed to pump water to the other devices of the application. The variable speed pump included can be used as actuator of the system.
  The elements included in the "SU-H/S" module are:
  - Variable speed pump, 8 l/min approx.
  - Plastic tank, 4 l approx.
  - Manual valve.
- **N-ALI20. Power Supply.**
- **N-M-P-W/S. Pressure sensor for low water levels.**
  Maximum pressure: 30 mbar approx.
- **N-P-L-TT/S. Small size transparent tank.**
  Transparent tank with graduated scale.
  Maximum level: 250 mm approx.
- **APC-SOF-KSAC. Simulation, acquisition and control software kit.**
  The elements included in the "APC-SOF-KSAC" kit are:
  - N-AC-USB. USB acquisition card.
  - APC- SOF-SAC. Simulation, acquisition and control software.
    The main functions of this software, based on LabVIEW, are:
    - Process signal visualization.
    - Data storage.
    - ON/OFF and PID controls via software.
    - Process simulation.
- **N-V-PR-W/S. Electromagnetic proportional valve for low flow hydraulic circuits.**
  Proportional valve that can be used to introduce disturbances in the system or as control device.

The elements recommended to extend the functionality of the "APC-LSO" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the level control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-LSO" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a level control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a level control system.
- Assembly of the hydraulic circuit of a level control system.
- Wiring of the control and measurement signals and the power supply of a level control system.

Analysis of the system and design of control strategies:

- Response of a level control system to a step input.
- Simulation of a level control system in open and closed loop.
- Effect of the parameters of a PID controller.
- PID control of a level control system with the variable speed pump.
- PID control of a level control system with the proportional valve.
- Response of the controlled system to disturbances and changes of the reference signal.
- Disturbance compensation through feedforward control.

APC-LICPR. Level Regulation Application with Industrial Controller and Proportional Valve.

In the "APC-LICPR" application, a pump impels water through a hydraulic circuit consisting of a supply tank, a transparent tank with scale and a proportional valve. The control of the system is done through an industrial controller. In addition, a ball valve with scale is included to introduce disturbances.

The elements included in the "APC-LICPR" application are:

- **SU-H. Hydraulic Supply Unit.**

  Module designed to pump water to the other devices of the application. It is recommended for simple control applications, with only one variable.

  The elements included in the "SU-H" module are:

  - Centrifugal pump, 80 l/min approx.
  - Stainless steel tank, 15 l approx.
  - Manual valve.
- **N-ALI20. Power Supply.**
- **N-M-P-W. Level measurement pressure sensor.**

  Maximum pressure: 100 mbar approx.
- **N-V-PR-W. Electromagnetic proportional valve for hydraulic circuits.**
- **N-P-L-TT. Transparent tank.**

  Transparent tank with graduated scale.

  Maximum level: 600 mm approx.
- **N-IC. Industrial controller.**
- **N-V-H-S. Ball valve with scale.**

  Manual valve to introduce disturbances in the system.

The elements recommended to extend the functionality of the "APC-LICPR" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the level control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-LICPR" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a level control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a level control system.
- Assembly of the hydraulic circuit of a level control system.
- Wiring of the control and measurement signals and the power supply of a level control system.

Configuration of the system devices:

- Configuration of an industrial controller

Analysis of the system and design of control strategies:

- Manual control of the system with an industrial controller (open loop).
- Effect of the parameters of a PID controller.
- Obtaining the PID parameters automatically by auto-tuning.
- Adjustment and optimization of a PID controller.
- Response of the controlled system to disturbances and changes of the reference signal.

APC-LICPN. Level Regulation Application with Industrial Controller and Pneumatic Valve.

In the "APC-LICPN" application, a pump impels water through a hydraulic circuit consisting of a supply tank, a transparent tank with scale and a pneumatic valve. The control of the system is done through an industrial controller. In addition, a ball valve with scale is included to introduce disturbances and a signal recorder.

The elements included in the "APC-LICPN" application are:

- **SU-H. Hydraulic Supply Unit.**

  Module designed to pump water to the other devices of the application. It is recommended for simple control applications, with only one variable.

  The elements included in the "SU-H" module are:

  - Centrifugal pump, 80 l/min approx.
  - Stainless steel tank, 15 l approx.
  - Manual valve.
- **N-ALI20. Power Supply.**
- **N-M-P-W. Level measurement pressure sensor.**

  Maximum pressure: 100 mbar approx.
- **N-V-PN-W. Pneumatic valve for hydraulic circuits.**
- **N-P-L-TT. Transparent tank.**

  Transparent tank with graduated scale.

  Maximum level: 600 mm approx.
- **N-IC. Industrial controller.**
- **N-V-H-S. Ball valve with scale.**

  Manual valve to introduce disturbances in the system.
- **N-ATC01. Air filter and air pressure regulator pressure gauge.**

This application needs compressed air. The following accessory is recommended:

- **SU-P. Pneumatic supply unit.**

  Module to supply compressed air to the rest of devices of the application.

  The elements included in the "SU-P" module are:

  - Air compressor of 8 bar approx.

The elements recommended to extend the functionality of the "APC-LICPN" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the level control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-LICPN" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a level control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a level control system.
- Assembly of the hydraulic circuit of a level control system.
- Wiring of the control and measurement signals and the power supply of a level control system.

Configuration of the system devices:

- Configuration of an industrial controller.
- Configuration of a signal recorder.

Analysis of the system and design of control strategies:

- Manual control of the system with an industrial controller (open loop).
- Effect of the parameters of a PID controller.
- Obtaining the PID parameters automatically by auto-tuning.
- Adjustment and optimization of a PID controller.
- Response of the controlled system to disturbances and changes of the reference signal.

APC-PSOH. Computer Controlled Pressure Regulation Application in a Hydraulic Circuit.

In the "APC-PSOH" application, a variable speed pump impels water from a supply tank to a pressurized upper tank where the pressure is measured. The outlet of the process tank has a solenoid valve to regulate the system or introduce disturbances. The control of the system is done through the "APC-SOF-SAC" software designed by EDIBON.

The elements included in the "APC-PSOH" application are:

- **SU-H/S. Small Size Hydraulic Supply Unit.**
  Module designed to pump water to the other devices of the application. The variable speed pump included can be used as actuator of the system.
  The elements included in the "SU-H/S" module are:
  - Variable speed pump, 8 l/min approx.
  - Plastic tank, 4 l approx.
  - Manual valve.
- **N-ALI20. Power Supply.**
- **N-M-P-A/S. Compressed air low pressure sensor.**
  Maximum pressure: 1 bar approx.
- **N-P-L-PT/S. Small size pressurized transparent tank.**
  Pressurized transparent tank with graduated scale for level and pressure applications.
  Maximum level: 250 mm approx.
- **APC-SOF-KSAC. Simulation, acquisition and control software kit.**
  The elements included in the "APC-SOF-KSAC" kit are:
  - N-AC-USB. USB acquisition card.
  - APC-SOF-SAC. Simulation, acquisition and control software.
    The main functions of this software, based on LabVIEW, are:
    - Process signal visualization.
    - Data storage.
    - ON/OFF and PID controls via software.
    - Process simulation.
- **N-V-SO/S. Solenoid valve for low flow rates.**
  Solenoid valve that can be used to introduce disturbances in the system or as control device.

The elements recommended to extend the functionality of the "APC-PSOH" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the pressure control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-PSOH" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a pressure control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a pressure control system.
- Assembly of the hydraulic circuit of a pressure control system.
- Wiring of the control and measurement signals and the power supply of a pressure control system.

Analysis of the system and design of control strategies:

- Response of a pressure control system to a step input.
- Simulation of a pressure control system in open and closed loop.
- Effect of the parameters of a PID controller.
- ON/OFF control of a pressure control system with the solenoid valve.
- PID control of a pressure control system with the variable speed pump.
- Response of the controlled system to disturbances and changes of the reference signal.

APC-PSOP. Computer Controlled Pressure Regulation Application in a Pneumatic Circuit.

In the "APC-PSOP" application, a variable speed gas pump fills a tank with compressed air. The outlet of the tank has a valve to introduce disturbances. The control of the system is done through the "APC-SOF-SAC" software designed by EDIBON.
The elements included in the "APC-PSOP" application are:

- **N-ALI20. Power Supply.**
- **N-SU-P/S. Small size pneumatic supply unit.**
  Module designed to pump air to the other devices of the application. The variable speed pump included can be used as actuator of the system.
  The elements included in the "N-SU-P/S" module are:
  - Variable speed gas pump.
    Maximum flow: 3 l/min approx.
  - Manual valve.
- **N-M-P-A/S. Compressed air low pressure sensor.**
  Maximum pressure: 1 bar approx.
- **N-P-P/S. Small size air tank.**
  The elements included in the "N-P-P/S" module are:
  - Air tank of 400 ml approx.
  - Manometer of 1 bar approx.
  - 2x Relief valve.
- **APC-SOF-KSAC. Simulation, acquisition and control software kit.**
  The elements included in the "APC-SOF-KSAC" kit are:
  - N-AC-USB. USB acquisition card.
  - APC- SOF-SAC. Simulation, acquisition and control software.
    The main functions of this software, based on LabVIEW, are:
    - Process signal visualization.
    - Data storage.
    - ON/OFF and PID controls via software.
    - Process simulation.
- **N-V-SO/S. Solenoid valve for low flow rates.**
  Solenoid valve that can be used to introduce disturbances in the system or as control device.

The elements recommended to extend the functionality of the "APC-PSOP" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the pressure control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-PSOP" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a pressure control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a pressure control system.
- Assembly of the pneumatic circuit of a pressure control system.
- Wiring of the control and measurement signals and the power supply of a pressure control system.

Analysis of the system and design of control strategies:

- Response of a pressure control system to a step input.
- Simulation of a pressure control system in open and closed loop.
- Effect of the parameters of a PID controller.
- PID control of a pressure control system.
- Response of the controlled system to disturbances and changes of the reference signal.

APC-PIC. Pressure Regulation Application with Industrial Controller.

In the "APC-PIC" application, the main compressed air circuit consists of a pneumatic valve and two tanks. The control of the system is done through an industrial controller. In addition, a valve is included to introduce disturbances.
The elements included in the "APC-PIC" application are:

- N-ALI20. Power supply.
- N-M-P-A/L. Compressed air high pressure sensor.
  Maximum presure: 6 bar approx.
- N-V-PN-A. Pneumatic valve for pneumatic circuits.
- 2 x N-P-P/L. Large air tank.
  The elements included in the "N-P-P/L" module are:
  - Compressed air tank of 10 l approx.
  - Manometer of 12 bar approx.
  - Needle valve.
- N-IC. Industrial controller.
- 2 x N-ATC01. Air filter and air pressure regulator pressure gauge.

This application needs compressed air. The following accessory is recommended:

- SU-P. Pneumatic supply unit.
  Module to supply compressed air to the rest of devices of the application.
  The elements included in the "SU-P" module are:
  - Air compressor of 8 bar approx.

The elements recommended to extend the functionality of the "APC-PIC" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the pressure control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-PIC" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a pressure control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a pressure control system.
- Assembly of the pneumatic circuit of a pressure control system.
- Wiring of the control and measurement signals and the power supply of a pressure control system.

Configuration of the system devices:

- Configuration of an industrial controller.

Analysis of the system and design of control strategies:

- Manual control of the system with an industrial controller (open loop).
- Effect of the parameters of a PID controller.
- Obtaining the PID parameters automatically by auto-tuning.
- Adjustment and optimization of a PID controller.
- Response of the controlled system to disturbances and changes of the reference signal.

APC-TICPR. Temperature Regulation Application with Industrial Controller and Proportional Valve.

The "APC-TICPR" application consists of a hot water circuit, a cold water circuit and an exchanger that transfers the heat between both circuits. In the hot water circuit, a pump impels the water from the supply tank to the exchanger, passing through a heating element and a control valve. From the exchanger, the water returns to the supply tank, closing the circuit. Tap water is used as cold water source. Both circuits include rotameters and valves to adjust the flow rate.

The modular design of the "APC-TICPR" application makes it possible to measure and control the temperature in different points of the system. Besides, a valve with scale introduces disturbances.

The elements included in the "APC-TICPR" application are:

- **SU-H. Hydraulic Supply Unit.**
  Module designed to pump water to the other devices of the application. It is recommended for simple control applications, with only one variable.
  The elements included in the "SU-H" module are:
  - Centrifugal pump, 80 l/min approx.
  - Stainless steel tank, 15 l approx.
  - Manual valve.
- **N-ALI20. Power Supply.**
- **N-M-T-PT100. pt100 temperature sensor.**
  Range: fom -50 to 400 °C.
- **N-H. Heating element.**
  Heating element with thermostat for temperature control applications.
  Power: 2 kW.
- **N-P-T-WW. Water-water heat exchanger.**
  The elements included in the "N-P-T-WW" module are:
  - 2 x rotameter 6 l/min approx.
  - Plate heat exchanger.
  - 4 x needle thermometer of 80 °C approx.
  - Control valve.
- **N-IC. Industrial controller.**
- **N-V-H-S. Ball valve with scale.**
  Manual valve to introduce disturbances in the system.
- **N-V-PR-W. Electromagnetic proportional valve for hydraulic circuits.**

The elements recommended to extend the functionality of the "APC-TICPR" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the temperature control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-TICPR" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a temperature control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a temperature control system.
- Assembly of the hydraulic circuit of a temperature control system.
- Wiring of the control and measurement signals and the power supply of a temperature control system.

Configuration of the system devices:

- Configuration of an industrial controller.

Analysis of the system and design of control strategies:

- Manual control of the system with an industrial controller (open loop).
- Effect of the parameters of a PID controller.
- Obtaining the PID parameters automatically by auto-tuning.
- Adjustment and optimization of a PID controller.
- Response of the controlled system to disturbances and changes of the reference signal.

APC-TICFA. Temperature Regulation Application with Industrial Controller and Fan.

In the "APC-TICFA" application, a pump impels water through a hydraulic circuit consisting of a heating device, which heats water, and an air-water exchanger, which cools the fluid down with a fan. Both the fan and the heating element can be used to control the temperature.

The application includes three thermocouples to measure the temperature in various points of the circuit and a system of tubes to study delays. In addition, a valve with scale introduces disturbances.

The elements included in the "APC-TICFA" application are:

- **N-SU-H-HW. Hot water pumping unit.**

  Water pumping unit designed for temperature control applications.

  The elements included in the "N-SU-H-HW" module are:

  - Three-stage pump, 60 l/min approx.
  - Expansion vessel.
  - Manual valve.
- **N-ALI20. Power supply.**
- **N-M-T-JT. "J type" thermocouple.**

  Range: 0 – 200 °C.
- **N-H. Heating element.**

  Heating element with thermostat for temperature control applications.

  Power: 2 kW.
- **N-P-T-AW. Air-water heat exchanger.**

  The fan of the air-water exchanger included may be used as actuator of the system.

  The elements included in the "N-P-T-AW" module are:

  - Air-water heat exchanger with fan.
  - 2 x needle thermometer of 80 °C approx.
- **N-IC. Industrial controller.**
- **N-V-H-S. Ball valve with scale.**

  Manual valve to introduce disturbances in the system.
- **N-DELAY. Delay time module.**

The elements recommended to extend the functionality of the "APC-TICFA" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the temperature control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-TICFA" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a temperature control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a temperature control system.
- Assembly of the hydraulic circuit of a temperature control system.
- Wiring of the control and measurement signals and the power supply of a temperature control system.

Configuration of the system devices:

- Configuration of an industrial controller.
- Configuration of a signal recorder.

Analysis of the system and design of control strategies:

- Manual control of the system with an industrial controller (open loop).
- Effect of the parameters of a PID controller.
- Obtaining the PID parameters automatically by auto-tuning.
- Adjustment and optimization of a PID controller.
- Effect of the delay time.
- Response of the controlled system to disturbances and changes of the reference signal.

APC-PHIC. pH Regulation Application with Industrial Controller.

In the "APC-PHIC" application, an alkali is added to the tap water by a dosing pump and the pH is measured. Then, a second dosing pump adds an acid to the solution.

The control of the system is done through an industrial controller that acts on one of the pumps. Disturbances can be introduced into the system with the other pump or with a valve at the water inlet. In addition, a manual pH meter is included to remove the products and a signal recorder.

The elements included in the "APC-PHIC" application are:

- **2 x N-SU-C. Chemicals supply unit.**
  Module designed to pump reagents to the other devices of the application. The variable speed pump included can be used as actuator of the system.
  The elements included in the "N-SU-C" module are:
  - Dosing pump, 2 l/h approx.
  - Plastic tank, 5 l approx.
  - Manual valve.
- **N-ALI20. Power supply.**
- **2 x N-M-PH. pH sensor.**
  Range: 1 – 12.
- **N-P-PH. Tanks for pH measurement.**
  The elements included in the "N-P-PH" module are:
  - 2 x transparent tanks for pH measurement.
  - 2 x mixing nozzles.
  - Rotameter of 4 l/min.
  - Control valve.
  - Tank for chemicals.
- **N-IC. Industrial controller.**
- **N-SR-2. Two-channel signal recorder.**
- **2 x N-DD. Digital display.**
- **N-M-PH-HH. Handheld pH meter.**

Required consumables (not included):

- Caustic soda (NaOH) 45 %.
- Hydrochloric acid (HCl) 30 %.

The elements recommended to extend the functionality of the "APC-PHIC" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the pH control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-PHIC" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a pH control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a pH control system.
- Assembly of the hydraulic circuit of a pH control system.
- Wiring of the control and measurement signals and the power supply of a pH control system.

Configuration of the system devices:

- Configuration of an industrial controller.

Analysis of the system and design of control strategies:

- Manual control of the system with an industrial controller (open loop).
- Effect of the parameters of a PID controller.
- Obtaining the PID parameters automatically by auto-tuning.
- Adjustment and optimization of a PID controller.
- Response of the controlled system to disturbances and changes of the reference signal.

APC-FLIC. Flow and Level Regulation Application with Industrial Controller.

In the "APC-FLIC" application, a pump impels water through a hydraulic circuit consisting of a supply tank, a rotameter, a transparent tank and a proportional valve. The unit includes two industrial controllers that can be configured to control two independent control loops or as a cascade control system. Besides, two valves with scale introduce disturbances to the system.

The elements included in the "APC-FLIC" application are:

- **SU-H. Hydraulic supply unit.**
  Module designed to pump water to the other devices of the application. It is recommended for simple control applications, with only one variable.
  The elements included in the "SU-H" module are:
  - Centrifugal pump, 80 l/min approx.
  - Stainless steel tank, 15 l approx.
  - Manual valve.
- **N-ALI20. Power supply.**
- **N-M-F-E. Electromagnetic flow sensor.**
  Maximum flow rate: 50 l/min approx.
- **N-M-P-W. Level measurement pressure sensor.**
  Maximum pressure: 100 mbar approx.
- **N-V-PR-W. Electromagnetic proportional valve for hydraulic circuits.**
- **N-P-F-WR. Hydraulic circuit rotameter.**
  The elements included in the "N-P-F-WR" module are:
  - Rotameter: 50 l/min approx.
  - Control valve.
- **N-P-L-TT. Transparent tank.**
  Transparent tank with graduated scale.
  Maximum level: 600 mm approx.
- **2 x N-IC. Industrial controller.**
- **2 x N-V-H-S. Ball valve with scale.**
  Manual valve to introduce disturbances in the system.

The elements recommended to extend the functionality of the "APC-FLIC" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the pH control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-FLIC" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a flow and level control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a flow and level control system.
- Assembly of the hydraulic circuit of a flow and level control system.
- Wiring of the control and measurement signals and the power supply of a flow and level control system.

Configuration of the system devices:

- Configuration of an industrial controller.

Analysis of the system and design of control strategies:

- Manual control of the system with an industrial controller (open loop).
- Effect of the parameters of a PID controller.
- Obtaining the PID parameters automatically by auto-tuning.
- Adjustment and optimization of a PID controller to regulate flow.
- Adjustment and optimization of a PID controller to regulate a cascade flow and level system.
- Response of the controlled system to disturbances and changes of the reference signal.

APC-LPIC. Level and Pressure Regulation Application with Industrial Controller.

In the "APC-LPIC" application, a water jet pump generates vacuum in a pressurized tank, absorbing a mixture of water and air that, due to the generated depression, allows the extraction of gases dissolved in the water. To achieve this goal, the pressure and level in the pressurized tank must meet some specifications.

However, acting on any of these variables affects the control of the other.

With the Level and Pressure Regulation Application with Industrial Controller, "APC-LPIC", the student will check in a real system the interactions between different control loops and learn to uncouple them through multivariable control strategies.

The elements included in the "APC-LPIC" application are:

- **SU-H/L. Large hydraulic supply unit.**

  Module designed to pump water to the other devices of the application. It is recommended for multivariable control applications.

  The elements included in the "SU-H/L" module are:

  - Centrifugal pump, 90 l/min approx.
  - Stainless steel tank, 75 l approx.
  - Manual valve.
  - Connection to couple a refrigeration circuit.

- **SU-H-AP/L. Auxiliary high flow rate centrifugal pump.**

  Auxiliary pump designed for the study of the coupling of pumps in series and parallel or for complex control systems that require different pumps. This module is recommended for working together with the "SU-H/L" water supply unit.

  Maximum flow: 90 l/min approx.

- **N-ALI20. Power supply.**
- **N-M-L-C. Capacitive level sensor.**

  Maximum height: 480 mm approx.

- **N-M-P-V. Vacuum pressure sensor.**

  Range: from -1 to 600 mbar approx.

- **2 x N-V-PN-W. Pneumatic valve for hydraulic circuits.**
- **N-P-F-WR. Hydraulic circuit rotameter.**

  The elements included in the "N-P-F-WR" module are:

  - Rotameter, 50 l/min.
  - Control valve.

- **N-P-L-PT. Pressurized transparent tank.**

  Pressurized transparent tank with graduated scale for level and pressure applications.

  The elements included in the "N-P-L-PT" module are:

  - Pressurized transparent tank of 500 mm approx.
  - Manometer, 2.5 bar approx.
  - Safety valve.

- **2 x N-IC. Industrial controller.**
- **IC-KSS-SOF. Acquisition, control and controllers configuration software.**

  The main functions of this software, based on LabVIEW, are:

  - Process signal visualization.
  - Configuration of controllers.
  - Data storage.
  - ON/OFF and PID controls via software.

  Besides, if other applications with industrial controllers are connected, the "IC-KSS-SOF" software can supervise all applications connected, forming a distributed control system.

- **N-ATC01. Air filter and air pressure regulator pressure gauge.**
- **N-P-F-AR/S. Rotameter for low flow pneumatic circuit.**

  The elements included in the "N-P-F-AR/S" module are:

  - Rotameter, 6 l/min approx.
  - Control valve.

This application needs compressed air. The following accessory is recommended:

- **SU-P. Pneumatic supply unit.**

  Module to supply compressed air to the rest of devices of the application.

  The elements included in the "SU-P" module are:

  - Air compressor of 8 bar approx.

The elements recommended to extend the functionality of the "APC-LPIC" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the level and pressure control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-LPIC" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a level and pressure control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a level and pressure control system.
- Assembly of the hydraulic circuit of a level and pressure control system.
- Wiring of the control and measurement signals and the power supply of a level and pressure control system.

Configuration of the system devices:

- Configuration of an industrial controller.

Analysis of the system and design of control strategies:

- Manual control of the system with an industrial controller (open loop).
- Effect of the parameters of a PID controller.
- Obtaining the PID parameters automatically by auto-tuning.
- Adjustment and optimization of a PID controller to regulate a multivariable level and pressure system.
- Response of the controlled system to disturbances and changes of the reference signal.

SPECIFICATIONS

APC-FLPSO. Computer Controlled Pressure, Level and Flow Regulation Application.

In the "APC-FLPSO" application, a variable speed pump drives water from a supply tank into an upper pressurized tank, where pressure and water level are measured. The outlet of the process tank has a solenoid valve to regulate the system or introduce disturbances. The circuit also has several flow sensors to study its operation. The system is controlled through the "APC- SOF-SAC" software designed by EDIBON.

The elements included in the "APC-FLPSO" application are:

- **SU-H/S. Small Size Hydraulic Supply Unit.**
  Module designed to pump water to the other devices of the application. The variable speed pump included can be used as actuator of the system.
  The elements included in the "SU-H/S" module are:
  - Variable speed pump, 8 l/min approx.
  - Plastic tank, 4 l approx.
  - Manual valve.
- **N-ALI20. Power supply.**
- **N-M-F-P/S. Paddlewheel sensor for low flow rates.**
  Maximum flow rate: 3 l/min approx.
- **N-M-F-V/S. Venturi tube with differential pressure sensor to measure low flow rates.**
- **N-M-F-O/S. Orifice plate with differential pressure sensor to measure low flow rates.**
- N-M-P-W/S. Pressure sensor to measure low levels.
  Maximum pressure: 30 mbar approx.
- **N-M-P-A/S. Compressed air low pressure sensor.**
  Maximum pressure: 1 bar approx.
- **N-P-F-WR/S. Rotameter for low flow hydraulic circuit.**
  Maximum flow: 4 l/min approx.
- **N-P-L-PT/S. Small size pressurized transparent tank.**
  Pressurized transparent tank with graduated scale for level and pressure applications.
  Maximum level: 250 mm approx.
- **APC-SOF-KSAC. Simulation, acquisition and control software kit.**
  The elements included in the "APC-SOF-KSAC" kit are:
  - N-AC-USB. USB acquisition card.
  - APC- SOF-SAC. Simulation, acquisition and control software.
    The main functions of this software, based on LabVIEW, are:
    - Process signal visualization.
    - Data storage.
    - ON/OFF and PID controls via software.
    - Process simulation.
- **N-V-SO/S. Solenoid valve for low flow rates.**
  Solenoid valve that can be used to introduce disturbances in the system or as control device.
- **N-MED65. Digital multimeter.**
- **N-S-L. Float switch.**

The elements recommended to extend the functionality of the "APC-FLPSO" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the level and pressure control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-FLPSO" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a flow, level and pressure control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a flow, level and pressure control system.
- Assembly of the hydraulic circuit of different control system.
- Wiring of the control and measurement signals and the power supply of different control system.

Behavior of sensors and actuators:

- Flow measurement with different devices: rotameter, paddlewheel flow sensor, Venturi tube and orifice plate.

Analysis of the system and design of control strategies:

- Characterization of different control systems.
- Simulation of control systems in open and closed loop.
- Effect of the parameters of a PID controller.
- PID control of a flow control system.
- PID control of a level control system.
- PID control of a pressure control system.
- Cascade control of level and flow.
- Response of the controlled system to disturbances and changes of the reference signal.

APC-FLTIC. Temperature, Level and Flow Regulation Application with Industrial Controller.

The "APC-FLTIC" application consists of a hot water circuit, a cold water circuit and an exchanger that transfers the heat between both circuits. In the cold water circuit, a pump impels the water from the supply tank to the heat exchanger. A cooling circuit cools the water of the supply tank.

In the hot water circuit, a pump makes water flow through a heating device, a process tank with scale and the heat exchanger. The heating device can be used as an actuator for temperature control. In addition, this application includes a pneumatic valve that can be used to control the flow, level and temperature.

The controllers included in this application allow for the regulation of the system variables independently (flow, level and temperature) or by cascade control (flow-level and flow-temperature). The controllers can be configured through their own display or through the control and acquisition software included.

The elements included in the "APC-FLTIC" application are:

- **SU-H/L. Large hydraulic supply unit.**

  Module designed to pump water to the other devices of the application. It is recommended for multivariable control applications.

  The elements included in the "SU-H/L" module are:

  - Centrifugal pump, 90 l/min approx.
  - Stainless steel tank, 75 l approx.
  - Manual valve.
  - Connection to couple a refrigeration circuit.

- **N-SU-H-HW. Hot water pumping unit.**

  Water pumping unit designed for temperature control applications.

  The elements included in the "N-SU-H-HW" module are:

  - Three-stage pump, 60 l/min approx.
  - Expansion vessel.
  - Manual valve.

- **N-ALI20. Power supply.**
- **N-M-F-E. Electromagnetic flow sensor.**

  Maximum flow: 50 l/min approx.

- **N-M-P-W. Level measurement pressure sensor.**

  Maximum pressure: 100 mbar approx.

- **N-M-T-JT. "J type" thermocouple.**

  Range: 0 – 200 °C.

- **N-V-PN-W. Pneumatic valve for hydraulic circuits.**
- **N-H. Heating element.**

  Heating element with thermostat for temperature control applications.

  Power: 2 kW.

- **N-P-L-ST. Stirred tank.**

  Metal tank with stirrer for level and temperature applications.

  Maximum level: 500 mm approx.

- **N-P-T-WW. Water-water heat exchanger.**

  The elements included in the "N-P-T-WW" module are:

  - 2 x rotameter 6 l/min.
  - Plate heat exchanger.
  - 4 x needle thermometer of 80 °C.
  - Control valve.

- **2 x N-IC. Industrial controller.**
- **IC-KSS-SOF. Acquisition, control and controllers configuration software.**

  The main functions of this software, based on LabVIEW, are:

  - Process signal visualization.
  - Configuration of controllers.
  - Data storage.
  - ON/OFF and PID controls via software.

  Besides, if other applications with industrial controllers are connected, the "IC-KSS-SOF" software can supervise all applications connected, forming a distributed control system.

- AE-PLC-PAN-UB. PANASONIC PLC Base Unit.
- PLC-PAN-K2. PANASONIC Ethernet remote analog I/O module kit.
- CPU-PAN-SOF. PANASONIC PLC programming software.
- COOLC. Cooling circuit.
- PLC-PAN-K1. PANASONIC PLC test kit.
- N-ATC01. Air filter and air pressure regulator pressure gauge.
- 3 x N-DD. Digital display.

This application needs compressed air. The following accessory is recommended:

- SU-P. Pneumatic supply unit.

  Module to supply compressed air to the rest of devices of the application.

  The elements included in the "SU-P" module are:

  - Air compressor of 8 bar.

The elements recommended to extend the functionality of the "APC-FLTIC" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the level and pressure control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-FLTIC" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a flow, level and temperature control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a flow, level and temperature control system.
- Assembly of the hydraulic circuit of a flow, level and temperature control system.
- Wiring of the control and measurement signals and the power supply of a flow, level and temperature control system.

Configuration of the system devices:

- Configuration of an industrial controller.

Analysis of the system and design of control strategies:

- Manual control of the system with an industrial controller (open loop).
- Effect of the parameters of a PID controller.
- Obtaining the PID parameters automatically by auto-tuning.
- Adjustment and optimization of a PID controller to regulate flow.
- Adjustment and optimization of a PID controller to regulate level.
- Adjustment and optimization of a PID controller to regulate temperature.
- Response of the controlled system to disturbances and changes of the reference signal.

APC-FLPTSO. Computer Controlled Temperature, Pressure, Level and Flow Regulation Application.

In the "APC-FLPTSO" application, a variable speed pump impels water from a supply tank to a pressurized upper tank, where the pressure and the water level are measured. The outlet of the process tank has a solenoid valve to regulate the system or introduce disturbances. The circuit also has several flow sensors to study its operation. In addition, this application includes a heating element, a heat exchanger and several devices to measure temperature. The control of the system is done through the "APC-SOF-SAC" software designed by EDIBON.

The elements included in the "APC-FLPTSO" application are:

- **SU-H/S. Small Size Hydraulic Supply Unit.**

  Module designed to pump water to the other devices of the application. The variable speed pump included can be used as actuator of the system.

  The elements included in the "SU-H/S" module are:

  - Variable speed pump, 8 l/min approx.
  - Plastic tank, 4 l approx.
  - Manual valve.
- **N-ALI20. Power supply.**
- **N-M-F-P/S. Paddlewheel sensor for low flow rates.**

  Maximum flow rate: 3 l/min approx.
- **N-M-F-V/S. Venturi tube with differential pressure sensor to measure low flow rates.**
- **N-M-F-O/S. Orifice plate with differential pressure sensor to measure low flow rates.**
- **N-M-P-W/S. Pressure sensor to measure low levels.**

  Maximum pressure: 30 mbar approx.
- **N-M-P-A/S. Compressed air low pressure sensor.**

  Maximum pressure: 1 bar approx.
- **N-M-T-PT100. pt100 temperature sensor.**

  Range: from -50 to 400 °C.
- **N-M-T-JT. "J type" thermocouple.**

  Range: 0 – 200 °C.
- **N-H/S. Low power heating element.**

  Heating element with thermostat for temperature control applications.

  Power: 1.2 kW approx.
- **N-P-F-WR/S. Rotameter for low flow hydraulic circuit.**

  Maximum flow: 4 l/min approx.
- **N-P-L-PT/S. Small size pressurized transparent tank.**

  Pressurized transparent tank with graduated scale for level and pressure applications.

  Maximum level: 250 mm approx.
- **N-P-T-AW/S. Small size air-water exchanger.**

  The fan of the air-water exchanger included may be used as actuator of the system.

  The elements included in the "N-P-T-AW/S" module are:

  - Air-water exchanger.
  - Thermometer.
- **APC-SOF-KSAC. Simulation, acquisition and control software kit.**

  The elements included in the "APC-SOF-KSAC" kit are:

  - N-AC-USB. USB acquisition card.
  - APC- SOF-SAC. Simulation, acquisition and control software.

    The main functions of this software, based on LabVIEW, are:

    - Process signal visualization.
    - Data storage.
    - ON/OFF and PID controls via software.
    - Process simulation.
- **N-V-SO/S. Solenoid valve for low flow rates.**

  Solenoid valve that can be used to introduce disturbances in the system or as control device
- **N-MED65. Digital multimeter.**
- **N-S-L. Float switch.**

The elements recommended to extend the functionality of the "APC-FLPTSO" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the level and pressure control, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-FLPTSO" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of a flow, level, pressure and temperature control system.
- Preparation of circuits, wiring, terminals and connection diagrams of a flow, level, pressure and temperature control system.
- Assembly of the hydraulic circuit of different control systems.
- Wiring of the control and measurement signals and the power supply of different control systems.

Behavior of sensors and actuators:

- Flow measurement with different devices: rotameter, paddlewheel flow sensor, Venturi tube and orifice plate.
- Temperature measurement with different sensors: pt100 and "J type" thermocouple.

Analysis of the system and design of control strategies:

- Characterization of different control systems.
- Simulation of control systems in open and closed loop.
- Effect of the parameters of a PID controller.
- PID control of a flow control system.
- PID control of a level control system.
- PID control of a pressure control system.
- PID control of a temperature control system with different actuators.
- Cascade control of level and flow.
- Cascade control of temperature and flow.
- Response of the controlled system to disturbances and changes of the reference signal.

APC-FLPTIC. Temperature, Pressure, Level and Flow Regulation Application with Industrial Controller.

The "APC-FLPTIC" application consists of a hot water circuit, a cold water circuit and an exchanger that transfers the heat between both circuits. In the cold water circuit, a variable speed pump impels the water from the supply tank to an upper tank equipped with a valve at the top to make level control experiments with and without overpressure. Besides, the pressure and flow rate can be controlled in this circuit and the regulation can be carried out through the variable speed pump or through a pneumatic valve.

In the hot water circuit, a pump makes water flow through a heating device and the heat exchanger. The heating device can be used as an actuator for temperature control. In addition, the temperature of this circuit can also be regulated by controlling the flow that circulates through the cold water circuit.

The application includes several manual valves with scale to introduce disturbances to the system. Devices for direct visualization of all the process variables are also included.

The controller included in this application allows for the regulation of the system variables independently (flow, level, temperature and pressure) or by cascade control (flow-level and flow-temperature). The controller can be configured through its own screen or through the control and acquisition software included.

The elements included in the "APC-FLPTIC" application are:

- **N-SU-H-HW. Hot water pumping unit.**

  Water pumping unit designed for temperature control applications.

  The elements included in the "N-SU-H-HW" module are:

  - Three-stage pump, 60 l/min approx.
  - Expansion vessel.
  - Manual valve.

- **SU-H/L. Large hydraulic supply unit.**

  Module designed to pump water to the other devices of the application. It is recommended for multivariable control applications.

  The elements included in the "SU-H/L" module are:

  - Centrifugal pump, 90 l/min approx.
  - Stainless steel tank, 75 l approx.
  - Manual valve.
  - Connection to couple a refrigeration circuit.

- **N-ALI20. Power supply.**
- **N-M-F-E/L. Electromagnetic flow sensor for high flow rates.**

  Maximum flow: 70 l/min approx.

- **N-M-L-C/L. Capacitive sensor to measure high levels.**

  Maximum height: 700 mm approx.

- **N-M-P-A/L. Compressed air high pressure sensor.**

  Maximum pressure: 6 bar approx.

- **N-M-T-JT. "J type" thermocouple.**

  Range: 0 – 200 °C.

- **N-V-PN-W. Pneumatic valve for hydraulic circuits.**
- **N-ATC01. Air filter and air pressure regulator pressure gauge.**
- **N-H. Heating element.**

  Heating element with thermostat for temperature control applications.

  Power: 2 kW.

- **N-FI. Variable-frequency drive.**

  Module to control the turning speed of the pump.

- **N-P-L-PT/L. Large pressurized transparent tank.**

  Pressurized transparent tank with graduated scale for level and pressure applications.

  The elements included in the "N-P-L-PT/L" module are:

  - Pressurized transparent tank of 700 mm approx.
  - Manometer.
  - Safety valve.

- **N-P-T-WW. Water-water heat exchanger.**

  The elements included in the "N-P-T-WW" module are:

  - 2 x rotameter 6 l/min.
  - Plate heat exchanger.
  - 4 x needle thermometer of 80 °C.
  - Control valve.

- **N-IC. Industrial controller.**
- **IC-KSS-SOF. Acquisition, control and controllers configuration software.**

  The main functions of this software, based on LabVIEW, are:

  - Process signal visualization.
  - Configuration of controllers.
  - Data storage.
  - ON/OFF and PID controls via software.

  Besides, if other applications with industrial controllers are connected, the "IC-KSS-SOF" software can supervise all applications connected, forming a distributed control system.

- **3 x N-V-H-S. Ball valve with scale.**

  Manual valve to introduce disturbances in the system.

- **N-SR-3. Three-channel signal recorder.**
- **N-M-P-M/S. Low pressure manometer.**

  Maximum pressure: 1 bar approx.

This application needs compressed air. The following accessory is recommended:

- **SU-P. Pneumatic supply unit.**

  Module to supply compressed air to the rest of devices of the application.

  The elements included in the "SU-P" module are:

  - Air compressor of 8 bar approx.

The elements recommended to extend the functionality of the "APC-FLPTIC" application are indicated in the table of available modules found at the end of the document. In addition to the modules related to the control of flow, level, pressure and temperature, it is possible to add modules related to other variables to obtain multivariable control systems.

Some practical possibilities of the "APC-FLPTIC" application:

Design and assembly of the control system:

- Familiarization with the main components of a control system: sensor, actuator and controller.
- Preparation of the piping and instrumentation diagram (P&ID) of flow, level, pressure and temperature control systems.
- Preparation of circuits, wiring, terminals and connections diagrams of flow, level, pressure and temperature control systems.
- Assembly of the hydraulic circuit of different control systems.
- Wiring of the control and measurement signals and the power supply of different control systems.
- Disturbance compensation through feedforward control.

Analysis of the system and design of control strategies:

- Characterization of different control systems.
- Manual control of the system with an industrial controller (open loop).
- Effect of the parameters of a PID controller.
- On/off control of a temperature control system.
- PID control of a flow control system.
- PID control of a level control system.
- PID control of a pressure control system.
- PID control of a temperature control system with different actuators (heating element, variable speed pump, pneumatic valve).
- Cascade control of level and flow.
- Cascade control of temperature and flow.
- Response of the controlled system to disturbances and changes of the reference signal.

	Application	Service Units	Sensors	Actuators	Plants	Controllers	Other elements
FLOW	**APC-FSO.** Computer Controlled Flow Regulation Application	SU-H/S. Small Size Hydraulic Supply Unit N-ALI20. Power supply	N-M-F-T/S. Turbine type sensor for low flow rates	N-V-PR-W/S. Electromagnetic proportional valve for low flow hydraulic circuits	N-P-F-WR/S. Rotameter for low flow hydraulic circuit	APC-SOF-KSAC. Simulation, acquisition and control software kit	
	APC-FIC. Flow Regulation Application with Industrial Controller	SU-H. Hydraulic supply unit N-ALI20. Power supply	N-M-F-P. Paddlewheel flow sensor	N-V-MO. Motorized control valve	N-P-F-WR. Hydraulic circuit rotameter	N-IC. Industrial controller	N-V-H-S. Ball valve with scale
LEVEL	**APC-LSO.** Computer Controlled Level Regulation Application	SU-H/S. Small Size Hydraulic Supply Unit N-ALI20. Power supply	N-M-P-W/S. Pressure sensor to measure low levels	N-V-PR-W/S. Electromagnetic proportional valve for low flow hydraulic circuits	N-P-L-TT/S. Small size transparent tank	APC-SOF-KSAC. Simulation, acquisition and control software kit	
	APC-LICPR. Level Regulation Application with Industrial Controller and Proportional Valve	SU-H. Hydraulic supply unit N-ALI20. Power supply	N-M-P-W. Level measurement pressure sensor	N-V-PR-W. Electromagnetic proportional valve for hydraulic circuits	N-P-L-TT. Transparent tank	N-IC. Industrial controller	N-V-H-S. Ball valve with scale
	APC-LICPN. Level Regulation Application with Industrial Controller and Pneumatic Valve	SU-H. Hydraulic supply unit N-ALI20. Power supply	N-M-P-W. Level measurement pressure sensor	N-V-PN-W. Pneumatic valve for hydraulic circuits	N-P-L-TT. Transparent tank	N-IC. Industrial controller	N-V-H-S. Ball valve with scale N-ATC01. Air filter and pressure regulator pressure gauge
PRESSURE	**APC-PSOH.** Computer Controlled Pressure Regulation Application in a Hydraulic Circuit	SU-H/S. Small Size Hydraulic Supply Unit N-ALI20. Power supply	N-M-P-A/S. Compressed air low pressure sensor	N-V-SO/S. Solenoid valve for low flow rates	N-P-L-PT/S. Small size pressurized transparent tank	APC-SOF-KSAC. Simulation, acquisition and control software kit	
	APC-PSOP. Computer Controlled Pressure Regulation Application in a Pneumatic Circuit	N-ALI20. Power supply N-SU-P/S. Small size pneumatic supply unit	N-M-P-A/S. Compressed air low pressure sensor	N-V-SO/S. Solenoid valve for low flow rates	N-P-P/S. Small size air tank	APC-SOF-KSAC. Simulation, acquisition and control software kit	N-V-H-S. Ball valve with scale
	APC-PIC. Pressure Regulation Application with Industrial Controller	N-ALI20. Power supply	N-M-P-A/L. Compressed air high pressure sensor	N-V-PN-A. Pneumatic valve for pneumatic circuits	2x N-P-P/L. Large air tank	N-IC. Industrial controller	2x N-ATC01. Air filter and pressure regulator pressure gauge
TEMPERATURE	**APC-TICPR.** Temperature Regulation Application with Industrial Controller and Proportional Valve	SU-H. Hydraulic supply unit N-ALI20. Power supply	N-M-T-PT100. Pt100 temperature sensor	N-H. Heating element N-V-PR-W. Electromagnetic proportional valve for hydraulic circuits	N-P-T-WW. Water-water heat exchanger	N-IC. Industrial controller	N-V-H-S. Ball valve with scale
	APC-TICFA. Temperature Regulation Application with Industrial Controller and Fan	N-SU-H-HW. Hot water pumping unit N-ALI20. Power supply	N-M-T-JT. "J type" thermocouple	N-H. Heating element	N-P-T-AW. Air-water heat exchanger	N-IC. Industrial controller	N-V-H-S. Ball valve with scale N-DELAY. Delay time module
pH	**APC-PHIC.** PH Regulation Application with Industrial Controller	2x N-SU-C. Chemicals supply unit N-ALI20. Power supply	2x N-M-PH. pH sensor		N-P-PH. Tanks for pH measurement	N-IC. Industrial controller	N-SR-2. Two-channel signal recorder 2x N-DD. Digital display N-M-PH-HH. Hand-held pH meter
MULTIPLE VARIABLES	**APC-FLIC.** Flow and Level Regulation Application with Industrial Controller	SU-H. Hydraulic supply unit N-ALI20. Power supply	N-M-F-E. Electromagnetic flow sensor N-M-P-W. Level measurement pressure sensor	N-V-PR-W. Electromagnetic proportional valve for hydraulic circuits	N-P-F-WR. Hydraulic circuit rotameter N-P-L-TT. Transparent tank	2x N-IC. Industrial controller	2x N-V-H-S. Ball valve with scale
	APC-LPIC. Level and Pressure Regulation Application with Industrial Controller	SU-H/L. Large hydraulic supply unit SU-H-AP/L. Auxiliary high flow rate centrifugal pump N-ALI20. Power supply	N-M-L-C. Capacitive level sensor N-M-P-V. Vacuum pressure sensor	2x N-V-PN-W. Pneumatic valve for hydraulic circuits	N-P-F-WR. Hydraulic circuit rotameter N-P-F-AR/S. Rotameter for low flow pneumatic circuit N-P-L-PT. Pressurized transparent tank	2x N-IC. Industrial controller IC-KSS-SOF. Acquisition, control and controllers configuration software	N-ATC01. Air filter and pressure regulator pressure gauge

	Application	Service Units	Sensors	Actuators	Plants	Controllers	Other elements
MULTIPLE VARIABLES	**APC-FLPSO**. Computer Controlled Pressure, Level and Flow Regulation Application	SU-H/S. Small Size Hydraulic Supply Unit	N-M-F-P/S. Paddlewheel sensor for low flow rates	N-V-SO/S. Solenoid valve for low flow rates	N-P-F-WR/S. Rotameter for low flow hydraulic circuit	APC-SOF-KSAC. Simulation, acquisition and control software kit	N-MED65. Digital multimeter
		N-ALI20. Power supply	N-M-F-V/S. Venturi tube with differential pressure sensor to measure low flow rates				
			N-M-F-O/S. Orifice plate with differential pressure sensor to measure low flow rates		N-P-L-PT/S. Small size pressurized transparent tank		N-S-L. Float switch
			N-M-P-W/S. Pressure sensor to measure low levels				
			N-M-P-A/S. Compressed air low pressure sensor				
	APC-FLTIC. Temperature, Level and Flow Regulation Application with Industrial Controller	SU-H/L. Large hydraulic supply unit	N-M-F-E. Electromagnetic flow sensor	N-V-PN-W. Pneumatic valve for hydraulic circuits	N-P-L-ST. Stirred tank	2x N-IC. Industrial controller	COOLC. Cooling circuit
						IC-KSS-SOF. Acquisition, control and controllers configuration software	PLC-PAN-K1. PANASONIC PLC test kit
		N-SU-H-HW. Hot water pumping unit	N-M-P-W. Level measurement pressure sensor			AE-PLC-PAN-UB. PANASONIC PLC Base Unit	3x N-DD. Digital display
		N-ALI20. Power supply		N-H. Heating element	N-P-T-WW. Water-water heat exchanger	PLC-PAN-K2. PANASONIC Ethernet remote analog I/O module kit	N-ATC01. Air filter and pressure regulator pressure gauge
			N-M-T-JT. "J type" thermocouple			CPU-PAN-SOF. PANASONIC PLC programming software	
	APC-FLPTSO. Computer Controlled Temperature, Pressure, Level and Flow Regulation Application	SU-H/S. Small Size Hydraulic Supply Unit	N-M-F-P/S. Paddlewheel sensor for low flow rates	N-H/S. Low power heating element	N-P-F-WR/S. Rotameter for low flow hydraulic circuit	APC-SOF-KSAC. Simulation, acquisition and control software kit	N-MED65. Digital multimeter
			N-M-F-V/S. Venturi tube with differential pressure sensor to measure low flow rates				
			N-M-F-O/S. Orifice plate with differential pressure sensor to measure low flow rates		N-P-L-PT/S. Small size pressurized transparent tank		
		N-ALI20. Power supply	N-M-P-W/S. Pressure sensor to measure low levels	N-V-SO/S. Solenoid valve for low flow rates			N-S-L. Float switch
			N-M-P-A/S. Compressed air low pressure sensor				
			N-M-T-PT100. Pt100 temperature sensor		N-P-T-AW/S. Small size air-water exchanger		
			N-M-T-JT. "J type" thermocouple				
	APC-FLPTIC. Temperature, Pressure, Level and Flow Regulation Application with Industrial Controller	N-SU-H-HW. Hot water pumping unit	N-M-F-E/L. Electromagnetic flow sensor for high flow rates	N-V-PN-W. Pneumatic valve for hydraulic circuits	N-P-L-PT/L. Large pressurized transparent tank	N-IC. Industrial controller	3x N-V-H-S. Ball valve with scale
			N-M-L-C/L. Capacitive sensor to measure high levels				N-SR-3. Three-channel signal recorder
		SU-H/L. Large hydraulic supply unit	N-M-P-A/L. Compressed air high pressure sensor	N-H. Heating element	N-P-T-WW. Water-water heat exchanger	IC-KSS-SOF. Acquisition, control and controllers configuration software	N-ATC01. Air filter and pressure regulator pressure gauge
		N-ALI20. Power supply	N-M-T-JT. "J type" thermocouple	N-FI. Frequency inverter			N-M-P-M/S. Low Pressure Manometer

AVAILABLE MODULES

The following table shows the available elements and the variables with which they are related:

AVAILABLE ELEMENTS				AVAILABLE CONTROL VARIABLES				
Group	**Subgroup**	**Reference**	**Description**	**F**	**L**	**P**	**T**	**pH**
SERVICE UNITS	Hydraulic Supply	SU-H/S	Small Size Hydraulic Supply Unit	▲	▲	▲	▲	△
		SU-H	Hydraulic supply unit	▲	▲	▲	▲	△
		N-SU-H-HW	Hot water pumping unit			▲	▲	
		SU-H/L	Large hydraulic supply unit	▲	▲	▲	▲	
		SU-H-AP/L	Auxiliary high flow rate centrifugal pump	△	△	△	△	△
	Chemical Substances Supply	N-SU-C/S	Small size chemicals supply unit					▲
		N-SU-C	Chemicals supply unit					▲
	Electrical Supply	N-ALI20	Power supply	▼	▼	▼	▼	▼
	Pneumatic Supply	N-SU-P/S	Small size pneumatic supply unit			▲		
		SU-P	Pneumatic supply unit	▲		▲		
SENSORS	Flow Sensors	N-M-F-T/S	Turbine type sensor for low flow rates	▲				
		N-M-F-P/S	Paddlewheel sensor for low flow rates	▲				
		N-M-F-V/S	Venturi tube with differential pressure sensor to measure low flow rates	▲				
		N-M-F-O/S	Orifice plate with differential pressure sensor to measure low flow rates	▲				
		N-M-F-P	Paddlewheel flow sensor	▲				
		N-M-F-E	Electromagnetic flow sensor	▲				
		N-M-F-E/L	Electromagnetic flow sensor for high flow rates	▲				
		N-M-F-O	Orifice plate with differential pressure sensor	▲				
	Level Sensors	N-M-L-U/S	Ultrasonic sensor to measure low levels		▲			
		N-M-L-C	Capacitive level sensor		▲			
		N-M-L-C/L	Capacitive sensor to measure high levels		▲			
	Pressure Sensors	N-M-P-W/S	Pressure sensor to measure low levels		▲			
		N-M-P-A/S	Compressed air low pressure sensor			▲		
		N-M-P-W	Level measurement pressure sensor		▲			
		N-M-P-A	Compressed air pressure sensor			▲		
		N-M-P-A/L	Compressed air high pressure sensor			▲		
		N-M-P-V	Vacuum pressure sensor			▲		
	Temperature Sensors	N-M-T-PT100	Pt100 temperature sensor				▲	
		N-M-T-JT	"J type" thermocouple				▲	
	pH Sensors	N-M-PH	pH sensor					▼
ACTUATORS	Valves	N-V-PR-W/S	Electromagnetic proportional valve for low flow hydraulic circuits	△	△	△	△	△
		N-V-PR-A/S	Electromagnetic proportional valve for low flow pneumatic circuits			△		
		N-V-SO/S	Solenoid valve for low flow rates	△	△	△	△	△
		N-V-MO	Motorized control valve	△	△	△	△	△
		N-V-PN-W	Pneumatic valve for hydraulic circuits	△	△	△	△	△
		N-V-PR-W	Electromagnetic proportional valve for hydraulic circuits	△	△	△	△	△
		N-V-PN-A	Pneumatic valve for pneumatic circuits			△		
		N-V-PR-A	Electromagnetic proportional valve for pneumatic circuits			△		
		N-V-SO/L	Solenoid valve for high flow rates	△	△	△	△	△
	Heating Elements	N-H/S	Low power heating element				▲	
		N-H	Heating element				▲	
	Frecuency Variators	N-FI	Frequency inverter	△	△	△	△	

AVAILABLE ELEMENTS				AVAILABLE CONTROL VARIABLES				
Group	**Subgroup**	**Reference**	**Description**	**F**	**L**	**P**	**T**	**pH**
PLANTS	Flow Plants	N-P-F-WR/S	Rotameter for low flow hydraulic circuit	▲				
		N-P-F-WR	Hydraulic circuit rotameter	▲				
		N-P-F-AR/S	Rotameter for low flow pneumatic circuit	▲				
	Level Plants	N-P-L-TT/S	Small size transparent tank		▲			
		N-P-L-TT	Transparent tank		▲			
		N-P-L-PT/S	Small size pressurized transparent tank		▲	▲		
		N-P-L-PT	Pressurized transparent tank		▲	▲		
		N-P-L-PT/L	Large pressurized transparent tank		▲	▲		
		N-P-L-ST	Stirred tank		▲		▲	
	Pressure Plants	N-P-P/S	Small size air tank			▲		
		N-P-P	Air tank			▲		
		N-P-P/L	Large air tank			▲		
	Temperature Plants	N-P-T-AW/S	Small size air-water exchanger				▲	
		N-P-T-WW	Water-water heat exchanger				▲	
		N-P-T-AW	Air-water heat exchanger				▲	
	pH Plants	N-P-PH/S	Small size tank for pH measurement					▲
		N-P-PH	Tanks for pH measurement					▲
CONTROLLERS	Control Software (SCADA)	APC-SOF-KSAC	Simulation, acquisition and control software kit	▲	▲	▲	▲	▲
		APC-SOF-KAC	Acquisition and control software kit	▲	▲	▲	▲	▲
	Industrial Controllers	N-IC	Industrial controller	▲	▲	▲	▲	▲
		IC-KSS-SOF	Acquisition, control and controllers configuration software	▲	▲	▲	▲	▲
		IC-KMS-SOF	Controllers configuration software	▲	▲	▲	▲	▲
	Programmable Logic Controllers (PLC)	AE-PLC-PAN-UB PLC-PAN-K2 CPU-PAN-SOF	PANASONIC PLC Base Unit PANASONIC Ethernet remote analog I/O module kit PANASONIC PLC programming software	▲	▲	▲	▲	▲
		AE-PLC-SIE-UB PLC-SIE-K2 CPU-SIE-SOF	SIEMENS PLC Base Unit SIEMENS Ethernet remote analog I/O module kit SIEMENS PLC programming software	▲	▲	▲	▲	▲
		AE-PLC-OMR-UB PLC-OMR-K2 CPU-OMR-SOF	OMRON PLC Base Unit OMRON Ethernet remote analog I/O module kit OMRON PLC programming software	▲	▲	▲	▲	▲
		AE-PLC-MIT-UB PLC-MIT-K2 CPU-MIT-SOF	MITSUBISHI PLC Base Unit MITSUBISHI Ethernet remote analog I/O module kit MITSUBISHI PLC programming software	▲	▲	▲	▲	▲
		AE-PLC-AB-UB PLC-AB-K2 CPU-AB-SOF	ALLEN BRADLEY PLC Base Unit ALLEN BRADLEY Ethernet remote analog I/O module kit ALLEN BRANDLEYPLC programming software	▲	▲	▲	▲	▲
		AE-PLC-SCH-UB PLC-SCH-K2 CPU-SCH-SOF	SCHNEIDER PLC Base Unit SCHNEIDER Ethernet remote analog I/O module kit SCHNEIDER PLC programming software	▲	▲	▲	▲	▲
	CompactRIO	N-CR	CompactRIO	▲	▲	▲	▲	▲

AVAILABLE ELEMENTS				AVAILABLE CONTROL VARIABLES				
Group	**Subgroup**	**Reference**	**Description**	**F**	**L**	**P**	**T**	**pH**
OTHER AVAILABLE ELEMENTS	Measurement and Display Devices	N-MED65	Digital multimeter	△	△	△	△	△
		N-M-P-M/S	Low pressure manometer			△		
		N-M-P-M	Manometer			△		
		N-M-P-M/L	High pressure manometer			△		
		N-M-T-M	Thermometer				△	
		N-M-PH-HH	Hand-held pH meter					△
		N-SR-2	Two-channel signal recorder	△	△	△	△	△
		N-SR-3	Three-channel signal recorder	△	△	△	△	△
		N-DD	Digital display	△	△	△	△	△
	Manual Actuators	N-V-H-S	Ball valve with scale	△	△	△	△	△
		N-V-H-3	Three-way manual valve			△		
		N-ATC01	Air filter and pressure regulator pressure gauge			△		
	Human-Machine Interface (HMI)	PLC-PAN-K3 HMIB-PAN-SOF	PANASONIC HMI device kit Programming software of the small PANASONIC HMI interface	△	△	△	△	△
		PLC-PAN-K4 HMIA-PAN-SOF	PANASONIC HMI device with web server kit Programming software of the large PANASONIC HMI interface	△	△	△	△	△
		PLC-SIE-K3 HMIB-SIE-SOF	SIEMENS HMI device kit Programming software of the small SIEMENS HMI interface	△	△	△	△	△
		PLC-SIE-K4 HMIA-SIE-SOF	SIEMENS HMI device with web server kit Programming software of the large SIEMENS HMI interface	△	△	△	△	△
		PLC-OMR-K3 HMIB-OMR-SOF	OMRON HMI device kit Programming software of the small OMRON HMI interface	△	△	△	△	△
		PLC-OMR-K4 HMIA-OMR-SOF	OMRON HMI device with web server kit Programming software of the large OMRON HMI interface	△	△	△	△	△
		PLC-MIT-K3 HMIB-MIT-SOF	MITSUBISHI HMI device kit Programming software of the small MITSUBISHI HMI interface	△	△	△	△	△
		PLC-MIT-K4 HMIA-MIT-SOF	MITSUBISHI HMI device with web server kit Programming software of the large MITSUBISHI HMI interface	△	△	△	△	△
		PLC-AB-K3 HMIB-AB-SOF	ALLEN BRADLEY HMI device kit Programming software of the small ALLEN BRANDLEYHMI	△	△	△	△	△
		PLC-AB-K4 HMIA-AB-SOF	ALLEN BRADLEY HMI device with web server kit Programming software of the large ALLEN BRANDLEYHMI interface	△	△	△	△	△
		PLC-SCH-K3 HMIB-SCH-SOF	SCHNEIDER HMI device kit Programming software of the small SCHNEIDER HMI interface	△	△	△	△	△
		PLC-SCH-K4 HMIA-SCH-SOF	SCHNEIDER HMI device with web server kit Programming software of the large SCHNEIDER HMI interface	△	△	△	△	△
	PLCs Test Modules	PLC-PAN-K1	PANASONIC PLC test kit	△	△	△	△	△
		PLC-SIE-K1	SIEMENS PLC test kit	△	△	△	△	△
		PLC-OMR-K1	OMRON PLC test kit	△	△	△	△	△
		PLC-MIT-K1	MITSUBISHI PLC test kit	△	△	△	△	△
		PLC-AB-K1	ALLEN BRADLEY PLC test kit	△	△	△	△	△
		PLC-SCH-K1	SCHNEIDER PLC test kit	△	△	△	△	△
	Switches	N-S-L	Float switch	△	△	△	△	△
		N-S-P	Pressure switch	△	△	△	△	△
	Others	N-DELAY	Delay time module	△	△	△	△	△
		COOLC	Cooling circuit	△	△	△	△	△
		PLC-K5	Intranet WLAN kit	△	△	△	△	△

Table 1. Available elements

The symbols used in the table indicate:

▲: Within a group, at least one of the elements marked with this symbol is required.

▼: All items marked with this symbol are required.

△: It is recommended to buy the element marked with this symbol.

SPECIFICATIONS

Service units

The modules responsible for supplying water, compressed air, chemical products and electricity to the rest of modules are included in the group of service units.

Hydraulic supply

- **SU-H/S. Small Size Hydraulic Supply Unit.**

  Module designed to pump water to the other devices of the application. The variable speed pump included can be used as actuator of the system.

  The elements included in the "SU-H/S" module are:

  - Variable speed pump, 8 l/min approx.
  - Plastic tank, 4 l approx.
  - Manual valve.

- **SU-H. Hydraulic supply unit.**

  Module designed to pump water to the other devices of the application. It is recommended for simple control applications, with only one variable.

  The elements included in the "SU-H" module are:

  - Centrifugal pump, 80 l/min approx.
  - Stainless steel tank, 15 l approx.
  - Manual valve

- **N-SU-H-HW. Hot water pumping unit.**

  Water pumping unit designed for temperature control applications.

  The elements included in the "N-SU-H-HW" module are:

  - Three-stage pump, 60 l/min approx.
  - Expansion vessel.
  - Manual valve.

- **SU-H/L. Large hydraulic supply unit.**

  Module designed to pump water to the other devices of the application. It is recommended for multivariable control applications.

  The elements included in the "SU-H/L" module are:

  - Centrifugal pump, 90 l/min approx.
  - Stainless steel tank, 75 l approx.
  - Manual valve.
  - Connection to couple a refrigeration circuit.

- **SU-H-AP/L. Auxiliary high flow rate centrifugal pump.**

  Auxiliary pump designed for the study of the coupling of pumps in series and parallel or for complex control systems that require different pumps. This module is recommended for working together with the "SU-H/L" water supply unit.

  Maximum flow: 90 l/min approx.

Chemicals supply:

- **N-SU-C/S. Small size chemicals supply unit.**

  Module designed to pump reagents to the other devices of the application. The variable speed pump included can be used as actuator of the system.

  The elements included in the "N-SU-C/S" module are:

  - Dosing pump, 2 l/h approx.
  - Plastic tank, 2 l approx.
  - Manual valve.

  This module requires the following consumables (not included):

  - Caustic soda 45% (NaOH).
  - Hydrochloric acid 30% (HCl).

- **N-SU-C. Chemicals supply unit.**

  Module designed to pump reagents to the other devices of the application. The variable speed pump included can be used as actuator of the system.

  The elements included in the "N-SU-C" module are:

  - Dosing pump, 2 l/h approx.
  - Plastic tank, 5 l approx.
  - Manual valve.

  This module requires the following consumables (not included):

  - Caustic soda 45% (NaOH).
  - Hydrochloric acid 30% (HCl).

SPECIFICATIONS

Power supply:

- N-ALI20. Power supply.

Pneumatic supply:

- N-SU-P/S. Small size pneumatic supply unit.

  Module designed to pump air to the other devices of the application. The variable speed pump included can be used as actuator of the system.

  The elements included in the "N-SU-P/S" module are:

  - Variable speed gas diaphragm pump

    Maximum flow: 3 l/min approx.
  - Manual valve.
- SU-P. Pneumatic supply unit.

  Module designed to supply air to the other devices of the application.

  The elements included in the "SU-P" module are:

  - Air compressor, 8 bar approx.

Sensors

The group of sensors includes the measuring devices used to provide feedback to the control loop.

Flow sensors:

- N-M-F-T/S. Turbine type sensor for low flow rates.
  Maximun flow rate: 3 l/min approx.
- N-M-F-P/S. Paddlewheel sensor for low flow rates.
  Maximum flow rate: 3 l/min approx.
- N-M-F-V/S. Venturi tube with differential pressure sensor to measure low flow rates.
- N-M-F-O/S. Orifice plate with differential pressure sensor to measure low flow rates.
- N-M-F-P. Paddlewheel flow sensor.
  Maximum flow rate: 50 l/min approx.
- N-M-F-E. Electromagnetic flow sensor.
  Maximum flow rate: 50 l/min approx.
- N-M-F-E/L. Electromagnetic flow sensor for high flow rates.
  Maximum flow rate: 70 l/min approx.
- N-M-F-O. Orifice plate with differential pressure sensor.

Level sensors:

- N-M-L-U/S. Ultrasonic sensor to measure low levels.
- N-M-L-C. Capacitive level sensor.
  Maximum height: 480 mm approx.
- N-M-L-C/L. Capacitive sensor to measure high levels.
  Maximum height: 700 mm approx.

Pressure sensors:

- N-M-P-W/S. Pressure sensor to measure low levels.
  Maximum pressure: 30 mbar approx.
- N-M-P-A/S. Compressed air low pressure sensor.
  Maximum pressure: 1 bar approx.
- N-M-P-W. Level measurement pressure sensor.
  Maximum pressure: 100 mbar approx.
- N-M-P-A. Compressed air pressure sensor.
  Maximum pressure: 2 bar approx.
- N-M-P-A/L. Compressed air high pressure sensor.
  Maximum pressure: 6 bar approx.
- N-M-P-V. Vacuum pressure sensor.
  Range: from -1 to 600 mbar approx.

Temperature sensors:

- N-M-T-PT100. pt100 temperature sensor.
  Range: from -50 to 400 °C.
- N-M-T-JT. "J type" thermocouple.
  Range: 0 – 200 °C.

pH sensors:

- N-M-PH. pH sensor.
  Range: 1–12.

Actuators

The group of actuators includes the devices used to control the system.

Valves:

- **N-V-PR-W/S. Electromagnetic proportional valve for low flow hydraulic circuits.**
  Proportional valve that can be used to introduce disturbances in the system or as control device.
- **N-V-PR-A/S. Electromagnetic proportional valve for low flow pneumatic circuits.**
  Proportional valve that can be used to introduce disturbances in the system or as control device.
- **N-V-SO/S. Solenoid valve for low flow rates.**
  Solenoid valve that can be used to introduce disturbances in the system or as control device.
- **N-V-MO. Motorized control valve.**
- **N-V-PN-W. Pneumatic valve for hydraulic circuits.**
  This module needs compressed air. The following accessories are recommended:
  - N-ATC01. Air filter and air pressure regulator pressure gauge.
  - SU-P. Pneumatic supply unit.
    Module to supply compressed air to the rest of devices of the application.
    The elements included in the "SU-P" module are:
    - Air compressor, 8 bar approx.
- **N-V-PR-W. Electromagnetic proportional valve for hydraulic circuits.**
- **N-V-PN-A. Pneumatic valve for pneumatic circuits.**
  This module needs compressed air. The following accessories are recommended:
  - N-ATC01. Air filter and air pressure regulator pressure gauge.
  - SU-P. Pneumatic supply unit.
    Module to supply compressed air to the rest of devices of the application.
    The elements included in the "SU-P" module are:
    - Air compressor, 8 bar approx.
- **N-V-PR-A. Electromagnetic proportional valve for pneumatic circuits.**
- **N-V-SO/L. Solenoid valve for high flow rates.**
  Solenoid valve that can be used to introduce disturbances in the system or as control device.

Heating elements:

- **N-H/S. Low power heating element.**
  Heating element with thermostat for temperature control applications.
  Power: 1.2 kW approx.
- **N-H. Heating element.**
  Heating element with thermostat for temperature control applications.
  Power: 2 kW.

Variable-frequency drives:

- **N-FI. Variable-frequency drive.**
  Module to control the turning speed of the pump.

Plants

The plant modules include the characteristic elements of each control system that are not included in other groups. For example, some of the characteristic elements of these modules are a tank with scale for level control or a heat exchanger for temperature control.

Flow plant:

- **N-P-F-WR/S. Rotameter for low flow hydraulic circuit.**
  Maximum flow rate: 4 l/min approx.
- **N-P-F-WR. Hydraulic circuit rotameter.**
  The elements included in the "N-P-F-WR" module are:
  - Rotameter, 50 l/min approx.
  - Control valve.
- **N-P-F-AR/S. Rotameter for low flow pneumatic circuit.**
  The elements included in the "N-P-F-AR/S" module are:
  - Rotameter, 6 l/min approx.
  - Control valve.

Level plants:

- **N-P-L-TT/S. Small size transparent tank.**
  Transparent tank with graduated scale.
  Maximum level: 250 mm approx.
- **N-P-L-TT. Transparent tank.**
  Transparent tank with graduated scale.
  Maximum level: 600 mm approx.
- **N-P-L-PT/S. Small size pressurized transparent tank.**
  Pressurized transparent tank with graduated scale for level and pressure applications.
  Maximum level: 250 mm approx.
- **N-P-L-PT. Pressurized transparent tank.**
  Pressurized transparent tank with graduated scale for level and pressure applications.
  The elements included in the "N-P-L-PT" module are:
  - Pressurized transparent tank of 500 mm approx.
  - Manometer, 2.5 bar approx.
  - Safety valve.
- **N-P-L-PT/L. Large pressurized transparent tank.**
  Pressurized transparent tank with graduated scale for level and pressure applications.
  The elements included in the "N-P-L-PT/L" module are:
  - Pressurized transparent tank of 700 mm approx.
  - Manometer.
  - Safety valve.
- **N-P-L-ST. Stirred tank.**
  Metal tank with stirrer for level and temperature applications.
  Maximum level: 500 mm approx.

Pressure plants:

- **N-P-P/S. Small size air tank.**
  The elements included in the "N-P-P/S" module are:
  - Air tank of 400 ml approx.
  - Manometer of 1 bar approx.
  - 2x Relief valve.
- **N-P-P. Air tank.**
  The elements included in the "N-P-P" module are:
  - Compressed air tank of 3 l approx.
  - Manometer of 12 bar approx.
  - Needle valve.
  - Overpressure valve.

  This module needs compressed air. The following accessories are recommended:
  - SU-P. Pneumatic supply unit
    Module to supply compressed air to the rest of devices of the application.
    The elements included in the "SU-P" module are:
    - Air compressor of 8 bar approx.
- **N-P-P/L. Large air tank.**
  The elements included in the "N-P-P/L" module are:
  - Compressed air tank of 10 l approx.
  - Manometer of 12 bar approx.
  - Needle valve.

  This module needs compressed air. The following accessories are recommended:
  - SU-P. Pneumatic supply unit.
    Module to supply compressed air to the rest of devices of the application.
    The elements included in the "SU-P" module are:
    - Air compressor of 8 bar approx.

Temperature plant:

- **N-P-T-AW/S. Small size air-water exchanger.**
  The fan of the air-water exchanger included may be used as actuator of the system.
  The elements included in the "N-P-T-AW/S" module are:
  - Air-water exchanger.
  - Thermometer.
- **N-P-T-WW. Water-water heat exchanger.**
  The elements included in the "N-P-T-WW" module are:
  - 2 x rotameter 6 l/min.
  - Plate heat exchanger.
  - 4 x needle thermometer of 80 °C approx.
  - Control valve.
- **N-P-T-AW. Air-water heat exchanger.**
  The fan of the air-water exchanger included may be used as actuator of the system.
  The elements included in the "N-P-T-AW" module are:
  - Air-water heat exchanger with fan.
  - 2 x needle thermometer of 80 °C approx.

pH plants:

- **N-P-PH/S. Small size tank for pH measurement.**
  The elements included in the "N-P-PH/S" module are:
  - Transparent tank for pH measurement.
  - Tank for chemicals.
- **N-P-PH. Tanks for pH measurement.**
  The elements included in the "N-P-PH" module are:
  - 2 x transparent tanks for pH measurement.
  - 2 x mixing nozzles.
  - Rotameter of 4 l/min.
  - Control valve.
  - Tank for chemicals.

Controllers

Control software (SCADA):

- **APC-SOF-KSAC. Simulation, acquisition and control software kit.**
  The elements included in the "APC-SOF-KSAC" kit are:
  - N-AC-USB. USB acquisition card.
  - APC- SOF-SAC. Simulation, acquisition and control software.
    The main functions of this software, based on LabVIEW, are:
    - Process signal visualization.
    - Data storage.
    - ON/OFF and PID controls via software.
    - Process simulation.
- **APC-SOF-KAC. Acquisition and control software kit.**
  The elements included in the "APC-SOF-KAC" kit are:
  - N-AC-USB. USB acquisition card.
  - APC- SOF-AC. Acquisition and control software.
    The main functions of this software, based on LabVIEW, are:
    - Process signal visualization.
    - Data storage.
    - Study of the response of the system to a step input.
    - ON/OFF and PID controls via software.

Industrial controllers:

- **N-IC. Industrial controller.**
- **IC-KMS-SOF. Controllers configuration software.**

  Controller manufacturer software to configure the device from the PC.
- **IC-KSS-SOF. Acquisition, control and controllers configuration software.**

  The main functions of this software, based on LabVIEW, are:
  - Process signal visualization.
  - Configuration of controllers.
  - Data storage.
  - ON/OFF and PID controls via software.

  Besides, if other applications with industrial controllers are connected, the "IC-KSS-SOF" software can supervise all applications connected, forming a distributed control system.

Programmable Logic Controllers (PLC):

- **PANASONIC PLC:**
  - AE-PLC-PAN-UB. PANASONIC PLC Base Unit.
  - PLC-PAN-K2. PANASONIC Ethernet remote analog I/O module kit.
  - CPU-PAN-SOF. PANASONIC PLC programming software.
- **SIEMENS PLC:**
  - AE-PLC-SIE-UB. SIEMENS PLC Base Unit.
  - PLC-SIE-K2. SIEMENS Ethernet remote analog I/O module kit.
  - CPU-SIE-SOF. SIEMENS PLC programming software.
- **OMRON PLC:**
  - AE-PLC-OMR-UB. OMRON PLC Base Unit.
  - PLC- OMR-K2. OMRON Ethernet remote analog I/O module kit.
  - CPU-OMR-SOF. OMRON PLC programming software.
- **MITSUBISHI PLC:**
  - AE-PLC-MIT-UB. MITSUBISHI PLC Base Unit.
  - PLC- MIT-K2. MITSUBISHI Ethernet remote analog I/O module kit.
  - CPU-MIT-SOF. MITSUBISHI PLC programming software.
- **ALLEN BRANDLEYPLC:**
  - AE-PLC-AB-UB. ALLEN BRANDLEYPLC Base Unit.
  - PLC-AB-K2. ALLEN BRANDLEYEthernet remote analog I/O module kit.
  - CPU-AB-SOF. ALLEN BRANDLEYPLC programming software.
- **Shneider PLC:**
  - AE-PLC-SCH-UB. SHNEIDER PLC Base Unit.
  - PLC-SCH-K2. SHNEIDER Ethernet remote analog I/O module kit.
  - CPU-SCH-SOF. SHNEIDER PLC programming software.

CompactRIO:

- **N-CR. CompactRIO.**

Other available elements

Measuring and display devices:

- **N-MED65. Digital multimeter.**
- **N-M-P-M/S. Low pressure manometer.**
  Maximum pressure: 1 bar approx.
- **N-M-P-M. Manometer.**
  Maximum pressure: 6 bar approx.
- **N-M-P-M/L. High pressure manometer.**
  Maximum pressure: 10 bar approx.
- **N-M-T-M. Thermometer.**
  Maximum temperature: 100 ºC approx.
- **N-M-PH-HH. Handheld pH meter.**
- **N-SR-2. Two-channel signal recorder.**
- **N-SR-3. Three-channel signal recorder.**
- **N-DD. Digital display.**

Manual actuators:
- **N-V-H-S. Ball valve with scale.**
  Manual valve to introduce disturbances in the system.
- **N-V-H-3. Three-way manual valve.**
- **N-ATC01. Air filter and air pressure regulator pressure gauge.**

Human-Machine Interface (HMI):
- **PANASONIC small HMI:**
  - PLC-PAN-K3. PANASONIC HMI device kit.
  - HMIB-PAN-SOF. Programming software of the small PANASONIC HMI interface.
- **PANASONIC large HMI:**
  - PLC-PAN-K4. PANASONIC HMI device with web server kit.
  - HMIA-PAN-SOF. Programming software of the large PANASONIC HMI interface.
- **SIEMENS small HMI:**
  - PLC-SIE-K3. SIEMENS HMI device kit.
  - HMIB-SIE-SOF. Programming software of the small SIEMENS HMI interface.
- **SIEMENS large HMI:**
  - PLC-SIE-K4. SIEMENS HMI device with web server kit.
  - HMIA-SIE-SOF. Programming software of the large SIEMENS HMI interface.
- **OMRON small HMI:**
  - PLC-OMR-K3. OMRON HMI device kit.
  - HMIB-OMR-SOF. Programming software of the small OMRON HMI interface.
- **OMRON large HMI:**
  - PLC-OMR-K4. OMRON HMI device with web server kit.
  - HMIA-OMR-SOF. Programming software of the large OMRON HMI interface.
- **MITSUBISHI small HMI:**
  - PLC-MIT-K3. MITSUBISHI HMI device kit.
  - HMIB-MIT-SOF. Programming software of the small MITSUBISHI HMI interface.
- **MITSUBISHI large HMI:**
  - PLC-MIT-K4. MITSUBISHI HMI device with web server kit.
  - HMIA-MIT-SOF. Programming software of the large MITSUBISHI HMI interface.
- **ALLEN BRANDLEYsmall HMI:**
  - PLC-AB-K3. ALLEN BRANDLEYHMI device kit.
  - HMIB-AB-SOF. Programming software of the small ALLEN BRANDLEYHMI interface.
- **ALLEN BRANDLEYlarge HMI:**
  - PLC-AB-K4. ALLEN BRANDLEYHMI device with web server kit.
  - HMIA-AB-SOF. Programming software of the large ALLEN BRANDLEYHMI interface.
- **SCHNEIDER small HMI:**
  - PLC-SCH-K3. SCHNEIDER HMI device kit.
  - HMIB-SCH-SOF. Programming software of the small SCHNEIDER HMI interface.
- **SCHNEIDER large HMI:**
  - PLC-SCH-K4. SCHNEIDER HMI device with web server kit.
  - HMIA-SCH-SOF. Programming software of the large SCHNEIDER HMI interface.

PLC test modules:
- **PLC-PAN-K1. PANASONIC PLC test kit.**
- **PLC-SIE-K1. SIEMENS PLC test kit.**
- **PLC-OMR-K1. OMRON PLC test kit.**
- **PLC-MIT-K1. MITSUBISHI PLC test kit.**
- **PLC-AB-K1. ALLEN BRANDLEYPLC test kit.**
- **PLC-SCH-K1. SCHNEIDER PLC test kit.**

Switches:
- **N-S-L. Float switch.**
- **N-S-P. Pressure switch.**

Others:
- **N-DELAY. Delay time module.**
- **COOLC. Cooling circuit.**
- **PLC-K5. Intranet WLAN kit.**

Additionally to the main items described, we can offer, as optional, APC/ICAI. Interactive Computer Aided Instruction Software System.

This item try to give more possibilities for:

a) Technical and Vocational Education configuration. (ICAI)

a) Technical and Vocational Education configuration

APC/ICAI. Interactive Computer Aided Instruction Software System.
This complete software package consists of an Instructor Software (EDIBON Classroom Manager - ECM-SOF) totally integrated with the Student Software (EDIBON Student Labsoft - ESL-SOF). Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students.
This software is optional and can be used additionally to main items.

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).

ECM-SOF is the application that allows the Instructor to register students, manage and assign tasks for workgroups, create own content to carry out Practical Exercises, choose one of the evaluation methods to check the Student knowledge and monitor the progression related to the planned tasks for individual students, workgroups, units, etc... so the teacher can know in real time the level of understanding of any student in the classroom.

Innovative features:

- **User Data Base Management.**
- **Administration and assignment of Workgroup, Task and Training sessions.**
- **Creation and Integration of Practical Exercises and Multimedia Resources.**
- **Custom Design of Evaluation Methods.**
- **Creation and assignment of Formulas & Equations.**
- **Equation System Solver Engine.**
- **Updatable Contents.**
- **Report generation, User Progression Monitoring and Statistics.**

- ESL-SOF. EDIBON Student Labsoft (Student Software).

ESL-SOF is the application addressed to the Students that helps them to understand theoretical concepts by means of practical exercises and to prove their knowledge and progression by performing tests and calculations in addition to Multimedia Resources. Default planned tasks and an Open workgroup are provided by EDIBON to allow the students start working from the first session. Reports and statistics are available to know their progression at any time, as well as explanations for every exercise to reinforce the theoretically acquired technical knowledge.

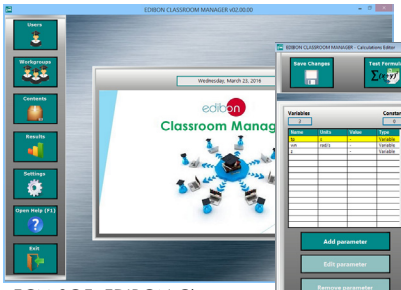
Innovative features:

- **Student Log-In & Self-Registration.**
- **Existing Tasks checking & Monitoring.**
- **Default contents & scheduled tasks available to be used from the first session.**
- **Practical Exercises accomplishment by following the Manual provided by EDIBON.**
- **Evaluation Methods to prove your knowledge and progression.**
- **Test self-correction.**
- **Calculations computing and plotting.**
- **Equation System Solver Engine.**
- **User Monitoring Learning & Printable Reports.**
- **Multimedia-Supported auxiliary resources.**

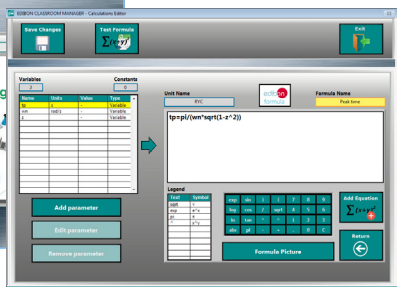
For more information see **ICAI** catalogue. Click on the following link:

www.edibon.com/en/files/expansion/ICAI/catalog

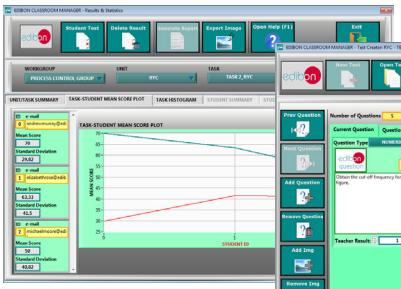
Instructor Software



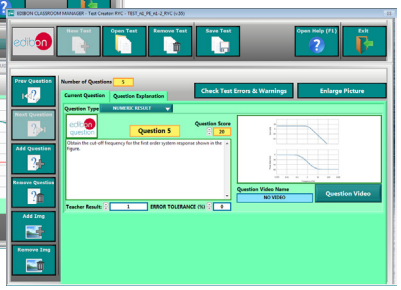
ECM-SOF. EDIBON Classroom Manager (Instructor Software) Application Main Screen



ECAL. EDIBON Calculations Program Package - Formula Editor Screen

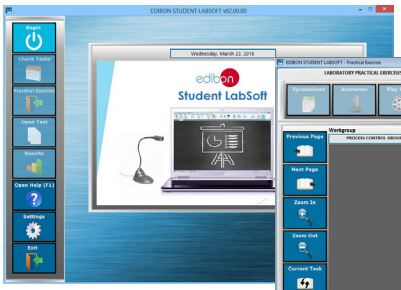


ERS. EDIBON Results & Statistics Program Package - Student Scores Histogram

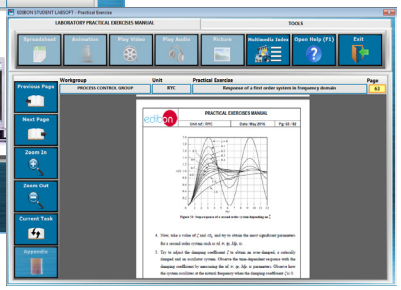


ETTE. EDIBON Training Test & Exam Program Package - Main Screen with Numeric Result Question

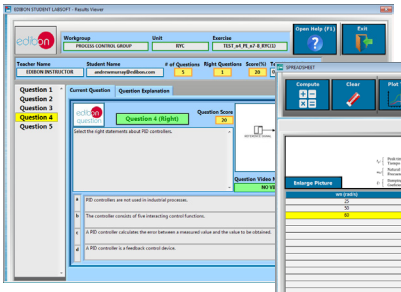
Student Software



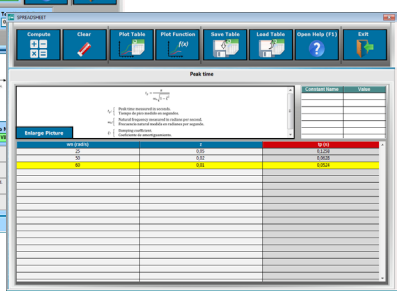
ESL-SOF. EDIBON Student LabSoft (Student Software) Application Main Screen



EPE. EDIBON Practical Exercise Program Package Main Screen



ERS. EDIBON Results & Statistics Program Package - Question Explanation



ECAL. EDIBON Calculations Program Package Main Screen

✱ Specifications subject to change without previous notice, due to the convenience of improvement of the product.

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