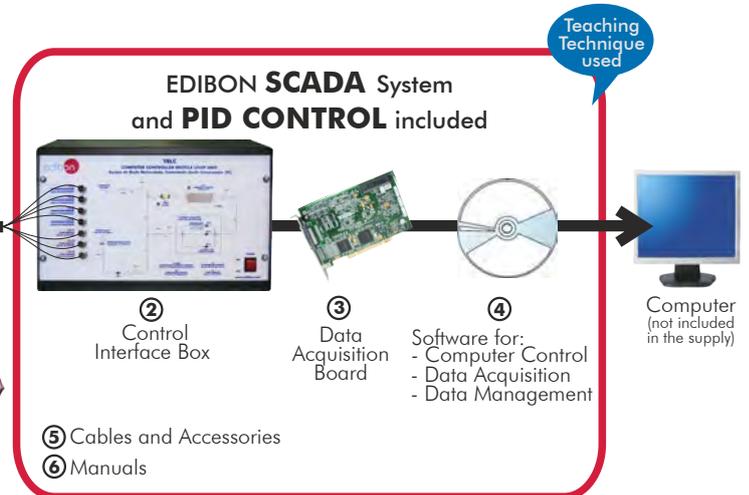


EDIBON PATENT



① Unit: TRLC. Recycle Loops Unit



\* Minimum supply always includes: 1 + 2 + 3 + 4 + 5 + 6  
(Computer not included in the supply)

Key features:

- ▶ **Advanced Real-Time SCADA and PID Control.**
- ▶ **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.**
- ▶ **Remote operation and control by the user and remote control for EDIBON technical support, are always included.**
- ▶ **Totally safe, utilizing 4 safety systems (Mechanical, Electrical, Electronic & Software).**
- ▶ **Designed and manufactured under several quality standards.**
- ▶ **Optional CAL software helps the user perform calculations and comprehend the results.**
- ▶ **This unit has been designed for future expansion and integration. A common expansion is the EDIBON Scada-Net (ESN) System which enables multiple students to simultaneously operate many units in a network.**

**OPEN CONTROL  
+  
MULTICONTROL  
+  
REAL TIME CONTROL**

**www.edibon.com**

- ↳ Products
- ↳ Products range
- ↳ Units
- ↳ 9.- Thermodynamics & Thermotechnics

For more information about Key Features, click here:



## INTRODUCTION

The kinetic chemistry treats the chemical reactors calculation and study, based on experimental kinetic models and on the energy and mass balance equations. Basically, it consists in determining the operation size and time to get the final product desired quantities. So, one of the parameters to take into account will be the residence time, which is the requirement for a fluid to complete its input cycle, permanence and output from a system.

The Computer Controlled Recycle Loops Unit "TRLC" is developed by the EDIBON technical team to demonstrate the principles of the recycle loops basic operation. In addition, several practices are developed for the thermodynamic analysis of the parameters that affect the system.

In the "TRLC" unit an input water flow rate is thermally conditioned by a recycle loop to get an output water flow rate in the desired terms. The hot water recycle loop is a type of application used in several chemical and industrial installations with the purpose of controlling the outlet temperature with changes inside the loop.

The recycle loop consists of a heating element mounted in a pipe to carry out the heating of the water that goes through it.

## GENERAL DESCRIPTION

The Computer Controlled Recycle Loops Unit "TRLC" has been designed to demonstrate, both visually and experimentally, what a recycle loop is and how it works. It has many teaching applications, among them the performance of mass and energy balances under stable and unstable state conditions.

In this unit an inlet water flow is thermally conditioned in a recycle loop to obtain an outlet water flow that fits the desired conditions.

The unit consists of a tube that carries water from the cold water supply to a drain and a loop connected between the supply and the drain connections. This recycle loop includes a pump and a heating element to increase the water temperature inside the loop.

Different volumes of the recycle loop can be selected by just opening the corresponding valve.

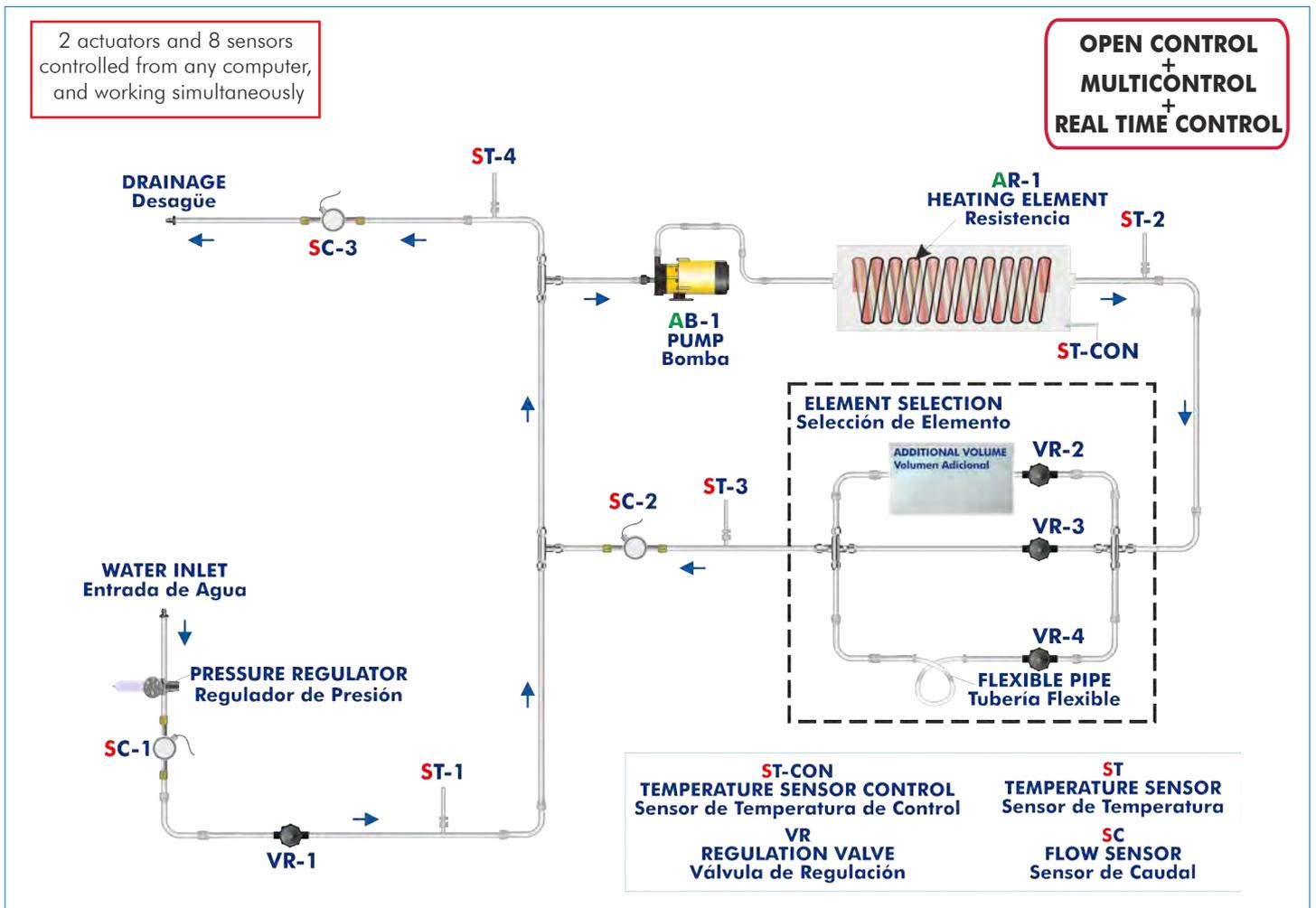
The residence time of each configuration can be studied. The loop flow variation has important didactic properties. The recycle loop is regulated through that variation.

The water temperature at the inlet, outlet and inside the loop are measured with temperature sensors. The water flows in the corresponding points are measured with flow sensors.

Mass and energy balances in different points of the circuit can be determined with the data obtained. The experimental results are compared with the theoretical one using the software.

This Computer Controlled Unit is supplied with the EDIBON Computer Control System (SCADA), and includes: The unit itself + a Control Interface Box + a Data Acquisition Board + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

## PROCESS DIAGRAM AND UNIT ELEMENTS ALLOCATION



With this unit there are several options and possibilities:

- Main items: 1, 2, 3, 4, 5 and 6.
- Optional items: 7, 8, 9, 10, 11 and 12.

Let us describe first the main items (1 to 6):

① **TRLC. Unit:**

Bench-top unit.

Anodized aluminum structure and panel of painted steel.

Main metallic elements of stainless steel.

Diagram in the panel with similar distribution to the elements in the real unit.

Water inlet tube, including:

- A "J" type temperature sensor.
- A flow sensor (range: 0.25-6.5 l./min).
- A valve to regulate the water inlet flow to the circuit (0-3 bars) to avoid overpressures along the circuit.
- A regulation valve.



TRLC. Unit

Recycle loop, where the water that flows through the periphery of the test tube is heated. It consists of:

- Computer controlled hot water impulsion pump.
- Heating element of 2000 W. Its operation is controlled via PID control on a control temperature sensor from the computer. It includes a protection thermostat.
- Three water regulation valves to select the recycle loop and regulate the water flow.
- Three different volumes of recycle loop: additional volume, rigid pipe and flexible pipe.
- Two "J" type temperature sensors.
- One flow sensor (range: 0.25-6.5 l./min.).

Water outlet pipe, including:

- A "J" type temperature sensor.
- A flow sensor (range: 0.25-6.5 l./min.).

The complete unit includes as well:

- Advanced Real-Time SCADA and PID Control.**
- 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.**
- Remote operation and control by the user and remote control for EDIBON technical support, are always included.**
- Totally safe, utilizing 4 safety systems (Mechanical, Electrical, Electronic & Software).**
- Designed and manufactured under several quality standards.**
- Optional CAL software helps the user perform calculations and comprehend the results.**
- This unit has been designed for future expansion and integration. A common expansion is the EDIBON Scada-Net (ESN) System which enables multiple students to simultaneously operate many units in a network.**

② **TRLC/CIB. Control Interface Box:**

The Control Interface Box is part of the SCADA system.

**Control interface box with process diagram in the front panel** and with the same distribution that the different elements located in the unit, for an easy understanding by the student.

All sensors, with their respective signals, are properly manipulated from -10V. to +10V. computer output. Sensors connectors in the interface have different pines numbers (from 2 to 16), to avoid connection errors.

Single cable between the control interface box and computer.

**The unit control elements are permanently computer controlled**, without necessity of changes or connections during the whole process test procedure.

**Simultaneous visualization in the computer of all parameters involved in the process.**

**Calibration of all sensors involved in the process.**

**Real time curves representation about system responses.**

Storage of all the process data and results in a file.

Graphic representation, in real time, of all the process/system responses.

**All the actuators' values can be changed at any time from the keyboard** allowing the analysis about curves and responses of the whole process. All the actuators and sensors values and their responses are displayed on only one screen in the computer.

**Shield and filtered signals to avoid external interferences.**

**Real time PID control with flexibility of modifications from the computer keyboard of the PID parameters, at any moment during the process.** Real time computer control for pumps, compressors, heating elements, control valves, etc. **Real time PID control for parameters involved in the process simultaneously. Proportional control, integral control and derivative control, based on the real PID mathematical formula, by changing the values, at any time, of the three control constants (proportional, integral and derivative constants).**

**Open control** allowing modifications, at any moment and in real time, of parameters involved in the process simultaneously.

Possibility of automatization of the actuators involved in the process.

**Three safety levels, one mechanical in the unit, another electronic in the control interface and the third one in the control software.**



TRLC/CIB

③ **DAB. Data Acquisition Board:**

The Data Acquisition board is part of the SCADA system.

PCI Express Data acquisition board (National Instruments) to be placed in a computer slot. Bus PCI Express.

**Analog input:**

Number of channels= 16 single-ended or 8 differential. Resolution= 16 bits, 1 in 65536.

**Sampling rate up to: 250 KS/s (kilo samples per second).**

Input range (V)= 10 V. Data transfers=DMA, interrupts, programmed I/O. DMA channels=6.

**Analog output:**

Number of channels=2. Resolution= 16 bits, 1 in 65536. Maximum output rate up to: 900 KS/s.

Output range(V)= 10 V. Data transfers=DMA, interrupts, programmed I/O.

**Digital Input/Output:**

Number of channels=24 inputs/outputs. D0 or DI Sample Clock frequency: 0 to 100 MHz.

Timing: Number of Counter/timers=4. Resolution: Counter/timers: 32 bits.



DAB

④ **TRLC/CCSOF. PID Computer Control + Data Acquisition + Data Management Software:**

The three softwares are part of the SCADA system.

Compatible with actual Windows operating systems. Graphic and intuitive simulation of the process in screen. **Compatible with the industry standards.**

Registration and visualization of all process variables in an automatic and simultaneous way.

**Flexible, open and multicontrol software**, developed with actual windows graphic systems, acting simultaneously on all process parameters.

**Analog and digital PID control.**

**PID menu and set point selection required in the whole work range.**

**Management, processing, comparison and storage of data.**

**Sampling velocity up to 250 KS/s (kilo samples per second).**

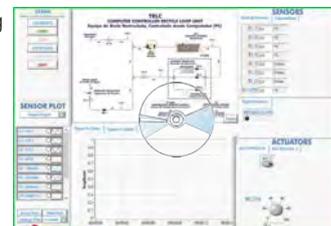
**Calibration system for the sensors involved in the process.**

**It allows the registration of the alarms state and the graphic representation in real time.**

Comparative analysis of the obtained data, after the process and modification of the conditions during the process.

**Open software, allowing the teacher to modify texts, instructions. Teacher's and student's passwords** to facilitate the teacher's control on the student, and allowing the access to different work levels.

**This unit allows the 30 students of the classroom to visualize simultaneously all the results and the manipulation of the unit, during the process, by using a projector or an electronic whiteboard.**



TRLC/CCSOF

⑤ **Cables and Accessories**, for normal operation.

⑥ **Manuals:**

This unit is **supplied with 8 manuals:** Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

\* References 1 to 6 are the main items: TRLC + TRLC/CIB + DAB + TRLC/CCSOF + Cables and Accessories + Manuals are included in the minimum supply for enabling normal and full operation.

## EXERCISES AND PRACTICAL POSSIBILITIES TO BE DONE WITH MAIN ITEMS

1.- Understanding the meaning of Water Recycle Loop.

Mass balances of steady state:

2.- Mass balance in the recycle loop in stationary regime with different water proportion in recirculation and different loops.

Heat balances of unsteady state:

3.- Determination of the recycle loop system response faced, when the heating element is switched on, at different flow rates and different loops.

4.- Determination of the recycle loop system response faced, when the heating element is switched off, at different flow rates and different loops.

Heat balances of steady state:

5.- Thermal balance in the recycle loop in stationary regime with different water proportions in recirculation and different loops.

Additional practical possibilities:

6.- Sensors calibration.

Mass balances of steady state:

7.- Demonstrating that whatever the recycle rate, the inlet flow rate equals the outlet flow rate.

Heat balances of unsteady state:

8.- Study of the effect of change the inlet flow.

9.- Study of the effect of recycle with no through flow.

Heat balances of steady state:

10.- Checking the variation of the outlet temperature, with the heating element switched on and a fixed water flow at the inlet, caused by different recycled flow.

11.- Determination of the heat quantity absorbed in the recycle loop.

12.- Use of the steady flow energy equation for the overall system.

13.- Use of the steady flow energy equation for different points of the system.

14.- Study of the system response when the recycle flow is changed.

15.- Study of the system response when the inlet-outlet flow is changed.

16.- Study of the system response when the recycle volume is changed.

17.- Study of the system response when the heating element power is changed.

Other possibilities to be done with this Unit:

18.- Many students view results simultaneously.

To view all results in real time in the classroom by means of a projector or an electronic whiteboard.

19.- Open Control, Multicontrol and Real Time Control.

This unit allows intrinsically and/or extrinsically to change the span, gains; proportional, integral, derivate parameters; etc, in real time.

20.- The Computer Control System with SCADA and PID Control allow a real industrial simulation.

21.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.

22.- This unit can be used for doing applied research.

23.- This unit can be used for giving training courses to Industries even to other Technical Education Institutions.

24.- Control of the TRLC unit process through the control interface box without the computer.

25.- Visualization of all the sensors values used in the TRLC unit process.

- By using PLC-PI additional 19 more exercises can be done.

- Several other exercises can be done and designed by the user.

### REQUIRED SERVICES

Electrical supply: single-phase, 220V./50Hz or 110V./60Hz.

Water supply and drainage.

Computer.

### DIMENSIONS & WEIGHTS

TRLC:

Unit: -Dimensions: 1110 x 630 x 300 mm. approx.  
(43.70 x 24.80 x 11.81 inches approx.).

-Weight: 40 Kg. approx.  
(88 pounds approx.).

Control Interface Box: -Dimensions: 490 x 330 x 310 mm. approx.  
(19.29 x 12.99 x 12.20 inches approx.).

-Weight: 10 Kg. approx.  
(22 pounds approx.).

### AVAILABLE VERSIONS

Offered in this catalogue:

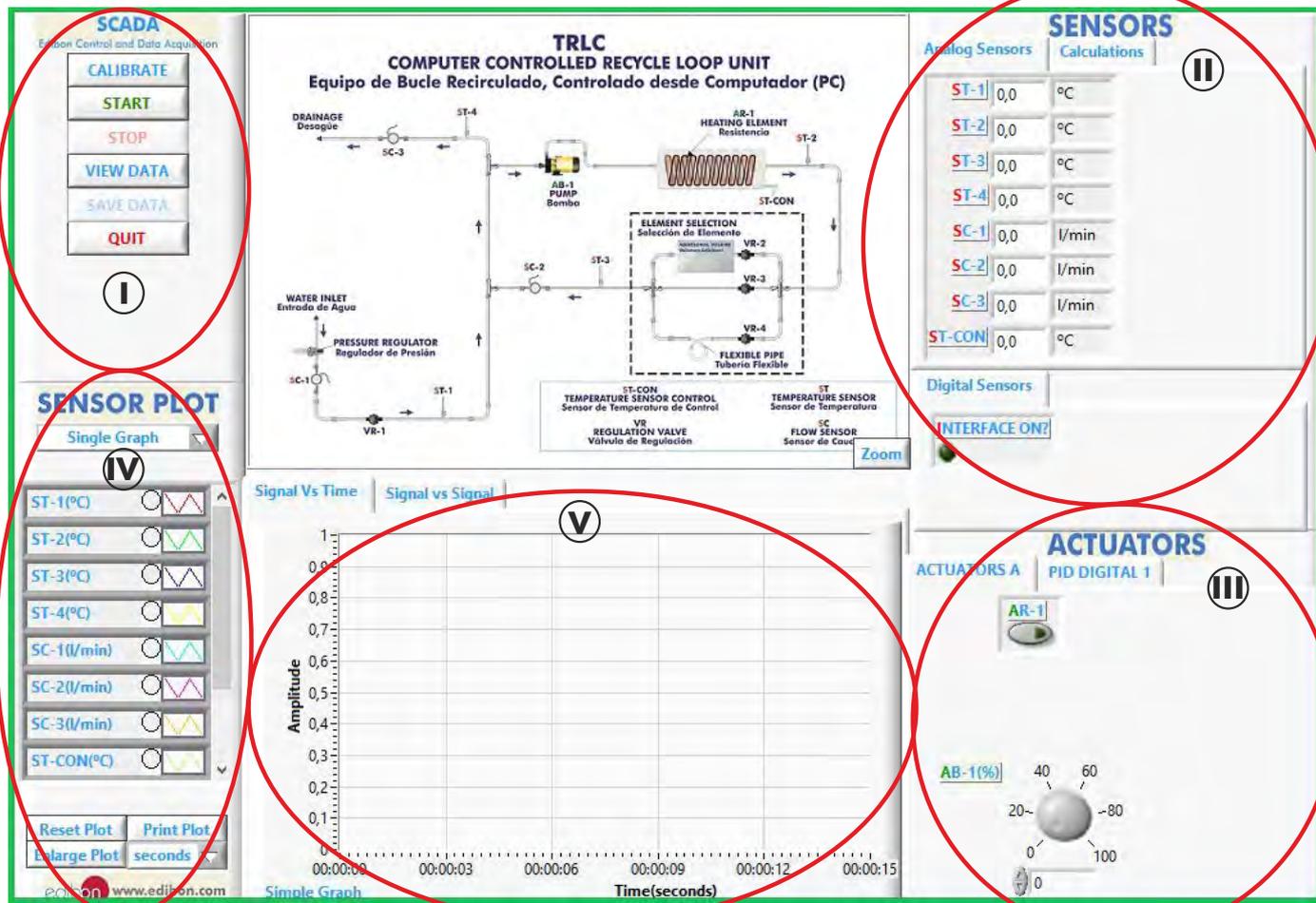
- TRLC. Computer Controlled Recycle Loops Unit.

Offered in other catalogue:

- TRLB. Recycle Loops Unit.

SCADA and PID Control

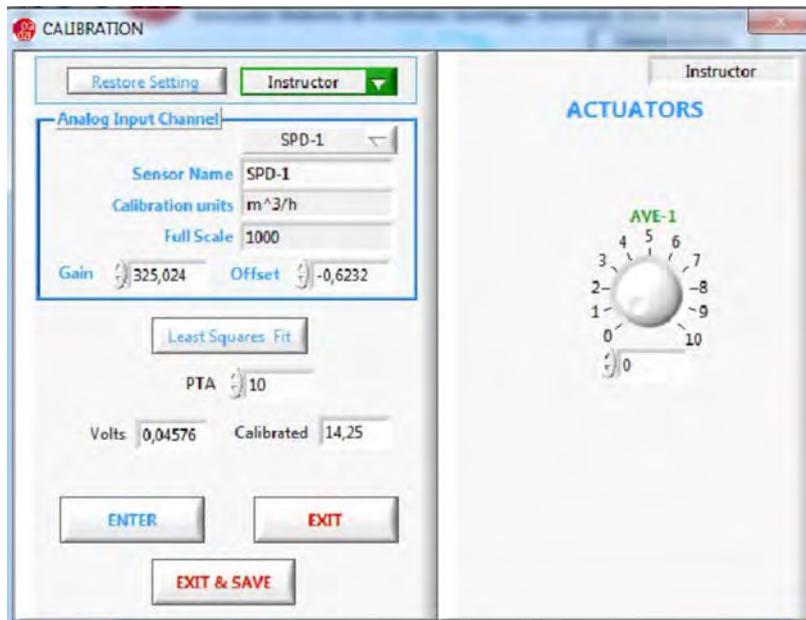
Main screen



- I Main software operation possibilities.
- II Sensors displays, real time values, and extra output parameters. Sensors: ST= Temperature sensor. SC= Flow sensor. ST-CON= Temperature sensor control.
- III Actuators controls. Actuators: AR= Heating element. AB= Pump.
- IV Channel selection and other plot parameters.
- V Real time graphics displays.

Software for Sensors Calibration

Example of screen



By using a free of charge code, the teacher and the students can calibrate the unit.

The teacher can recover his/her own calibration by using the EDIBON code that we give free of charge.

Main screen of TRLC unit software including the PID of the AR-1 on ST-CON and calculations section. In real time the software calculates General Energy Balance and Energy Balance in Nodes.

**SCADA**  
Edibon Control and Data Acquisition

CALIBRATE

START

STOP

VIEW DATA

SAVE DATA

QUIT

**TRLC**  
**COMPUTER CONTROLLED RECYCLE LOOP UNIT**  
Equipo de Bucle Recirculado, Controlado desde Computador (PC)

ST-CON TEMPERATURE SENSOR CONTROL  
Sensor de Temperatura de Control

ST TEMPERATURE SENSOR  
Sensor de Temperatura

VR REGULATION VALVE  
Válvula de Regulación

SC FLOW SENSOR  
Sensor de Caudal

**SENSORS**

Analog Sensors | Calculations

Q(Heat) 0,0 W

T4 0,0 °C

Digital Sensors

INTERFACE ON?

**SENSOR PLOT**

Single Graph

- ST-1(°C)
- ST-2(°C)
- ST-3(°C)
- ST-4(°C)
- SC-1(l/min)
- SC-2(l/min)
- SC-3(l/min)
- ST-CON(°C)

Reset Plot | Print Plot

Enlarge Plot | seconds

edibon www.edibon.com

Signal Vs Time | Signal vs Signal

Simple Graph

**ACTUATORS**

ACTUATORS A | PID DIGITAL 1

Automatic Control 1 D

AR-1 on ST-CON

SP ST-CON  0

SP ST-CON

Output(%)

ST-CON

## COMPLETE TECHNICAL SPECIFICATIONS (for optional items)

Additionally to the main items (1 to 6) described, we can offer, as optional, other items from 7 to 12.

All these items try to give more possibilities for:

- a) Industrial configuration. (PLC)
- b) Technical and Vocational Education configuration. (CAL and FSS)
- c) Higher Education and/or Technical and Vocational Education configuration. (CAL)
- d) Multipost Expansions options. (Mini ESN and ESN)

### a) Industrial configuration

#### ⑦ **PLC. Industrial Control using PLC** (it includes PLC-PI Module plus PLC-SOF Control Software):

##### **-PLC-PI. PLC Module:**

**Metallic box.**

**Circuit diagram in the module front panel.**

Front panel:

##### **Digital inputs(X) and Digital outputs (Y) block:**

**16 Digital inputs**, activated by switches and 16 LEDs for confirmation (red).

**14 Digital outputs** (through SCSI connector) with 14 LEDs for message (green).

##### **Analog inputs block:**

**16 Analog inputs** (-10 V. to + 10 V.) (through SCSI connector).

##### **Analog outputs block:**

**4 Analog outputs** (-10 V. to + 10 V.) (through SCSI connector).

##### **Touch screen:**

High visibility and multiple functions. Display of a highly visible status. Recipe function. Bar graph function. Flow display function. Alarm list.

Multi language function. True type fonts.

Back panel:

Power supply connector. Fuse 2A. RS-232 connector to PC. USB 2.0 connector to PC.

Inside:

Power supply outputs: 24 Vdc, 12 Vdc, -12 Vdc, 12 Vdc variable.

##### **Panasonic PLC:**

**High-speed scan of 0.32 sec.** for a basic instruction.

**Program capacity of 32 Ksteps**, with a sufficient comment area.

Power supply input (100 to 240 V AC).

DC input: 16 (24 V DC).

Relay output: 14.

**High-speed counter.**

**Multi-point PID control.**

**Digital inputs/outputs and analog inputs/outputs Panasonic modules.**

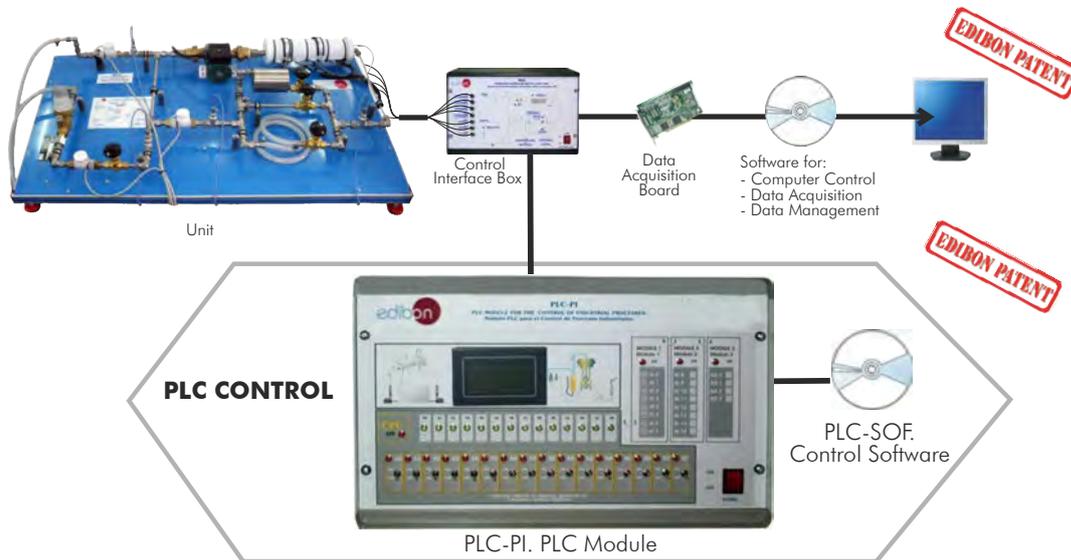
Communication RS232 wire to computer (PC).

Dimensions: 490 x 330 x 310 mm. approx. (19.29 x 12.99 x 12.20 inches approx.). Weight: 30 Kg. approx. (66 pounds approx.).

##### **-TRLC/PLC-SOF. PLC Control Software:**

**For this particular unit, always included with PLC supply.**

The software has been designed using Labview and it follows the unit operation procedure and linked with the Control Interface Box used in the Computer Controlled Recycle Loops Unit (TRLC).



#### **Practices to be done with PLC-PI:**

- 1.- Control of the TRLC unit process through the control interface box without the computer.
- 2.- Visualization of all the sensors values used in the TRLC unit process.
- 3.- Calibration of all sensors included in the TRLC unit process.
- 4.- Hand on of all the actuators involved in the TRLC unit process.
- 5.- Realization of different experiments, in automatic way, without having in front the unit. (This experiment can be decided previously).
- 6.- Simulation of outside actions, in the cases hardware elements do not exist. (Example: test of complementary tanks, complementary industrial environment to the process to be studied, etc).
- 7.- PLC hardware general use and manipulation.
- 8.- PLC process application for TRLC unit.
- 9.- PLC structure.
- 10.- PLC inputs and outputs configuration.
- 11.- PLC configuration possibilities.
- 12.- PLC programming languages.
- 13.- PLC different programming standard languages.
- 14.- New configuration and development of new process.
- 15.- Hand on an established process.
- 16.- To visualize and see the results and to make comparisons with the TRLC unit process.
- 17.- Possibility of creating new process in relation with the TRLC unit.
- 18.- PLC Programming exercises.
- 19.- Own PLC applications in accordance with teacher and student requirements.

b) Technical and Vocational Education configuration

⑧ **TRLC/CAI. Computer Aided Instruction Software System.**

This complete software package includes two Softwares: the INS/SOF. Classroom Management Software (Instructor Software) and the TRLC/SOF. Computer Aided Instruction Software (Student Software).

This software is optional and can be used additionally to items (1 to 6).

**This complete software package consists of an Instructor Software (INS/SOF) totally integrated with the Student Software (TRLC/SOF).** Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students.

- **INS/SOF. Classroom Management Software (Instructor Software):**

The Instructor can:

- Organize Students by Classes and Groups.
- Create easily new entries or delete them.
- Create data bases with student information.
- Analyze results and make statistical comparisons.
- Generate and print reports.
- Detect student's progress and difficulties.
- ...and many other facilities.

**Instructor Software**



- **TRLC/SOF. Computer Aided Instruction Software (Student Software):**

It explains how to use the unit, run the experiments and what to do at any moment.

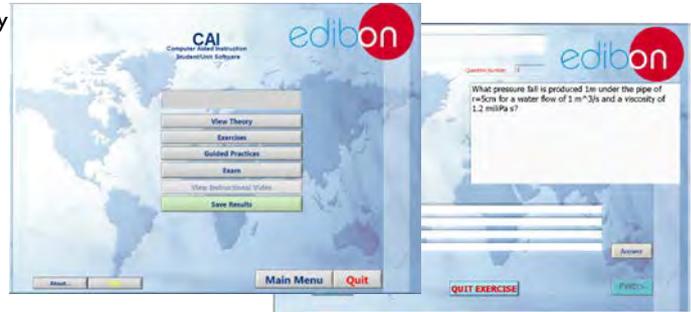
This Software contains:

- Theory.
- Exercises.
- Guided Practices.
- Exams.

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

[www.edibon.com/products/catalogues/en/CAI.pdf](http://www.edibon.com/products/catalogues/en/CAI.pdf)

**Student Software**



⑨ **TRLC/FSS. Faults Simulation System.**

Faults Simulation System (FSS) is a Software package that simulates several faults in any EDIBON Computer Controlled Unit. It is useful for Technical and Vocational level.

The "FAULTS" mode consists on causing several faults in the unit normal operation. The student must find them and solve them.

There are several kinds of faults that can be grouped in the following sections:

Faults affecting the sensors measurement:

- An incorrect calibration is applied to them.
- Non-linearity.

Faults affecting the actuators:

- Actuators channels interchange at any time during the program execution.
- Response reduction of an actuator.

Faults in the controls execution:

- Inversion of the performance in ON/OFF controls.
- Reduction or increase of the calculated total response.
- The action of some controls is annulled.

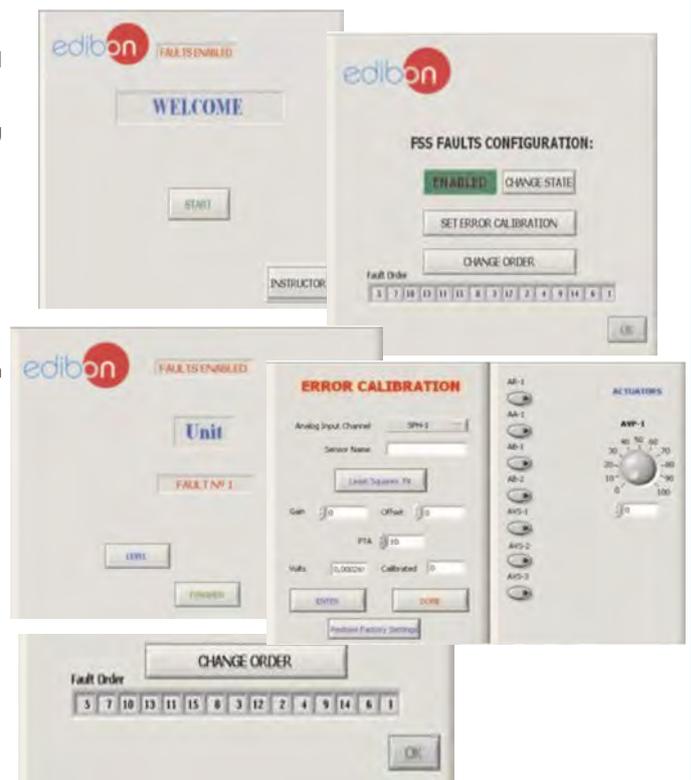
On/off faults:

- Several on/off faults can be included.

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

[www.edibon.com/products/catalogues/en/FSS.pdf](http://www.edibon.com/products/catalogues/en/FSS.pdf)

Example of some screens



c) Higher Education and/or Technical and Vocational Education configuration

10) **TRLC/CAL. Computer Aided Learning Software (Results Calculation and Analysis).**

This Computer Aided Learning Software (CAL) is a Windows based software, simple and very easy to use, specifically developed by EDIBON. It is very useful for Higher Education level.

CAL is a class assistant that helps in doing the necessary calculations to extract the right conclusions from data obtained during the experimental practices.

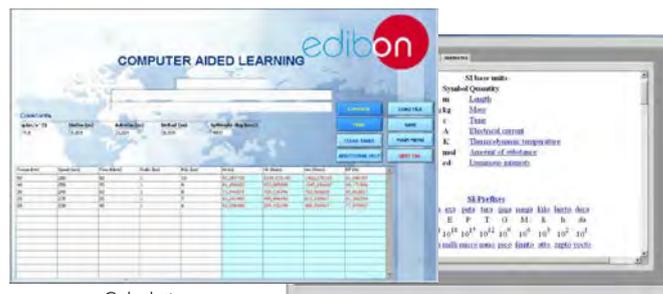
CAL computes the value of all the variables involved and performs the calculations.

It allows to plot and print the results. Within the plotting options, any variable can be represented against any other.

Different plotting displays.

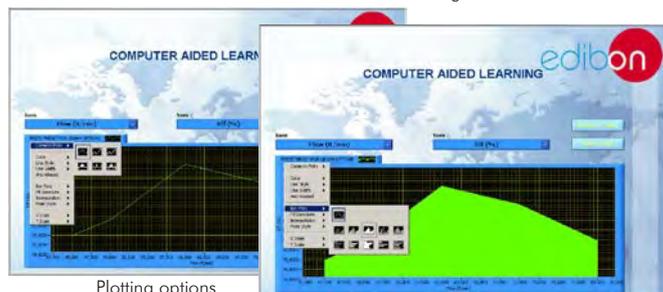
It has a wide range of information, such as constant values, unit conversion factors and integral and derivative tables.

For more information see **CAL** catalogue. Click on the following link:  
[www.edibon.com/products/catalogues/en/CAL.pdf](http://www.edibon.com/products/catalogues/en/CAL.pdf)



Calculations

Information of constant values, unit conversion factors and integral and derivative tables



Plotting options

d) Multipost Expansions options

11) **Mini ESN. EDIBON Mini Scada-Net System.**

Mini ESN. EDIBON Mini Scada-Net System allows up to 30 students to work with a Teaching Unit in any laboratory, simultaneously. It is useful for both, Higher Education and/or Technical and Vocational Education.

The Mini ESN system consists on the adaptation of any EDIBON Computer Controlled Unit with SCADA and PID Control integrated in a local network.

This system allows to view/control the unit remotely, from any computer integrated in the local net (in the classroom), through the main computer connected to the unit. Then, the number of possible users who can work with the same unit is higher than in an usual way of working (usually only one).

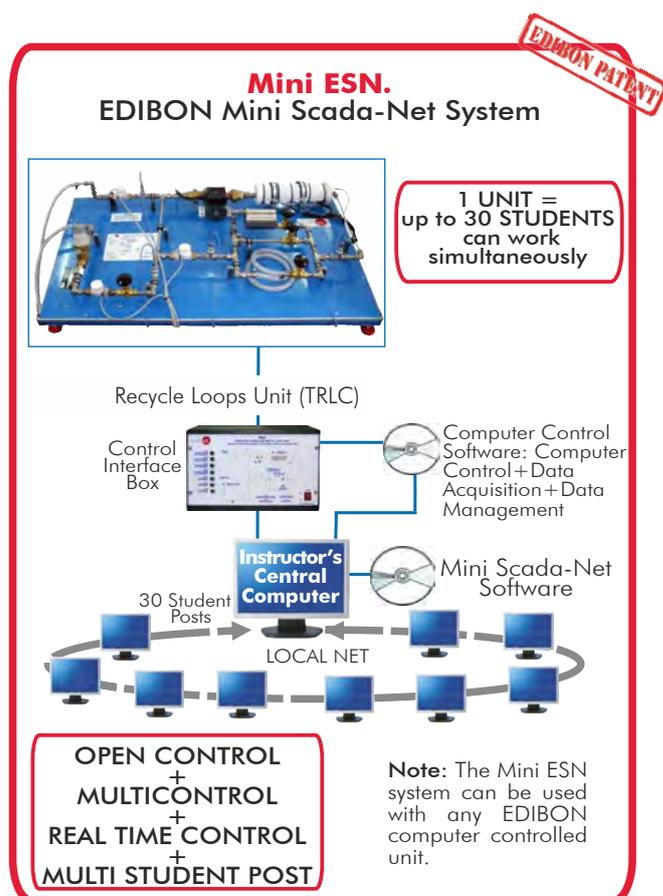
Main characteristics:

- It allows up to 30 students to work simultaneously with the EDIBON Computer Controlled Unit with SCADA and PID Control, connected in a local net.
- Open Control + Multicontrol + Real Time Control + Multi Student Post.
- Instructor controls and explains to all students at the same time.
- Any user/student can work doing "real time" control/multicontrol and visualisation.
- Instructor can see in the computer what any user/student is doing in the unit.
- Continuous communication between the instructor and all the users/students connected.

Main advantages:

- It allows an easier and quicker understanding.
- This system allows you can save time and cost.
- Future expansions with more EDIBON Units.

For more information see **Mini ESN** catalogue. Click on the following link:  
[www.edibon.com/products/catalogues/en/Mini-ESN.pdf](http://www.edibon.com/products/catalogues/en/Mini-ESN.pdf)



12) **ESN. EDIBON Scada-Net System.**

This unit can be integrated, in the future, into a Complete Laboratory with many Units and many Students.

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

[www.edibon.com/products/catalogues/en/units/thermodynamicsthermotechnics/esn-thermodynamics/ESN-THERMODYNAMICS.pdf](http://www.edibon.com/products/catalogues/en/units/thermodynamicsthermotechnics/esn-thermodynamics/ESN-THERMODYNAMICS.pdf)

## ORDER INFORMATION

### **Main items** (always included in the supply)

Minimum supply always includes:

- ① **Unit: TRLC. Recycle Loops Unit.**
- ② **TRLC/CIB. Control Interface Box.**
- ③ **DAB. Data Acquisition Board.**
- ④ **TRLC/CCSOF. PID Computer Control + Data Acquisition + Data Management Software.**
- ⑤ **Cables and Accessories**, for normal operation.
- ⑥ **Manuals.**

\* **IMPORTANT:** Under TRLC we always supply all the elements for immediate running as 1, 2, 3, 4, 5 and 6.

### **Optional items** (supplied under specific order)

#### a) Industrial configuration

- ⑦ PLC. Industrial Control using PLC (it includes PLC-PI Module plus PLC-SOF Control Software):
  - PCL-PI. PLC Module.
  - TRLC/PLC-SOF. PLC Control Software.

#### b) Technical and Vocational configuration

- ⑧ TRLC/CAI. Computer Aided Instruction Software System.
- ⑨ TRLC/FSS. Faults Simulation System.

#### c) Higher Education and/or Technical and Vocational Education configuration

- ⑩ TRLC/CAL. Computer Aided Learning Software (Results Calculation and Analysis).

#### d) Multipost Expansions options

- ⑪ Mini ESN. EDIBON Mini Scada-Net System.
- ⑫ ESN. EDIBON Scada-Net System.

**① TRLC. Unit:**

Bench-top unit.

Anodized aluminum structure and panel of painted steel.

Main metallic elements of stainless steel.

Diagram in the panel with similar distribution to the elements in the real unit.

Water inlet tube, including:

A "J" type temperature sensor.

A flow sensor (range: 0.25-6.5 l./min).

A valve to regulate the water inlet flow to the circuit (0-3 bars) to avoid overpressures along the circuit.

A regulation valve.

Recycle loop, where the water that flows through the periphery of the test tube is heated. It consists of:

Computer controlled hot water impulsion pump.

Heating element of 2000 W. Its operation is controlled via PID control on a control temperature sensor from the computer. It includes a protection thermostat.

Three water regulation valves to select the recycle loop and regulate the water flow.

Three different volumes of recycle loop: additional volume, rigid pipe and flexible pipe.

Two "J" type temperature sensors.

One flow sensor (range: 0.25-6.5 l./min.).

Water outlet pipe, including:

A "J" type temperature sensor.

A flow sensor (range: 0.25-6.5 l./min.).

The complete unit includes as well:

Advanced Real-Time SCADA and PID Control.

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.

Remote operation and control by the user and remote control for EDIBON technical support, are always included.

Totally safe, utilizing 4 safety systems (Mechanical, Electrical, Electronic & Software).

Designed and manufactured under several quality standards.

Optional CAL software helps the user perform calculations and comprehend the results.

This unit has been designed for future expansion and integration. A common expansion is the EDIBON Scada-Net (ESN) System which enables multiple students to simultaneously operate many units in a network.

**② TRLC/CIB. Control Interface Box:**

The Control Interface Box is part of the SCADA system.

Control interface box with process diagram in the front panel.

The unit control elements are permanently computer controlled.

Simultaneous visualization in the computer of all parameters involved in the process.

Calibration of all sensors involved in the process.

Real time curves representation about system responses.

All the actuators' values can be changed at any time from the keyboard allowing the analysis about curves and responses of the whole process.

Shield and filtered signals to avoid external interferences.

Real time PID control with flexibility of modifications from the computer keyboard of the PID parameters, at any moment during the process. Real time PID control for parameters involved in the process simultaneously. Proportional control, integral control and derivative control, based on the real PID mathematical formula, by changing the values, at any time, of the three control constants (proportional, integral and derivative constants).

Open control allowing modifications, at any moment and in real time, of parameters involved in the process simultaneously.

Three safety levels, one mechanical in the unit, another electronic in the control interface and the third one in the control software.

**③ DAB. Data Acquisition Board:**

The Data Acquisition board is part of the SCADA system.

PCI Express Data acquisition board (National Instruments) to be placed in a computer slot.

Analog input: Channels= 16 single-ended or 8 differential. Resolution= 16 bits, 1 in 65536. Sampling rate up to: 250 KS/s (kilo samples per second).

Analog output: Channels=2. Resolution= 16 bits, 1 in 65536.

Digital Input/Output: Channels=24 inputs/outputs.

**④ TRLC/CCSOF. PID Computer Control + Data Acquisition + Data Management Software:**

The three softwares are part of the SCADA system.

Compatible with the industry standards.

Flexible, open and multicontrol software, developed with actual windows graphic systems, acting simultaneously on all process parameters.

Analog and digital PID control. PID menu and set point selection required in the whole work range.

Management, processing, comparison and storage of data.

Sampling velocity up to 250 KS/s (kilo samples per second).

Calibration system for the sensors involved in the process.

It allows the registration of the alarms state and the graphic representation in real time.

Open software, allowing the teacher to modify texts, instructions. Teacher's and student's passwords to facilitate the teacher's control on the student, and allowing the access to different work levels.

This unit allows the 30 students of the classroom to visualize simultaneously all the results and the manipulation of the unit, during the process, by using a projector or an electronic whiteboard.

**⑤ Cables and Accessories, for normal operation.****⑥ Manuals:** This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

**Exercises and Practical Possibilities to be done with Main Items**

1.- Understanding the meaning of Water Recycle Loop.

Mass balances of steady state:

2.- Mass balance in the recycle loop in stationary regime with different water proportion in recirculation and different loops.

Heat balances of unsteady state:

3.- Determination of the recycle loop system response faced, when the heating element is switched on, at different flow rates and different loops.

4.- Determination of the recycle loop system response faced, when the heating element is switched off, at different flow rates and different loops.

Heat balances of steady state:

5.- Thermal balance in the recycle loop in stationary regime with different water proportions in recirculation and different loops.

Additional practical possibilities:

6.- Sensors calibration.

Mass balances of steady state:

7.- Demonstrating that whatever the recycle rate, the inlet flow rate equals the outlet flow rate.

Heat balances of unsteady state:

8.- Study of the effect of change the inlet flow.

9.- Study of the effect of recycle with no through flow.

Heat balances of steady state:

10.- Checking the variation of the outlet temperature, with the heating element switched on and a fixed water flow at the inlet, caused by different recycled flow.

11.- Determination of the heat quantity absorbed in the recycle loop.

12.- Use of the steady flow energy equation for the overall system.

13.- Use of the steady flow energy equation for different points of the system.

14.- Study of the system response when the recycle flow is changed.

15.- Study of the system response when the inlet-outlet flow is changed.

16.- Study of the system response when the recycle volume is changed.

17.- Study of the system response when the heating element power is changed.

Other possibilities to be done with this Unit:

18.- Many students view results simultaneously.

To view all results in real time in the classroom by means of a projector or an electronic whiteboard.

19.- Open Control, Multicontrol and Real Time Control.

This unit allows intrinsically and/or extrinsically to change the span, gains; proportional, integral, derivate parameters; etc, in real time.

20.- The Computer Control System with SCADA and PID Control allow a real industrial simulation.

21.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.

22.- This unit can be used for doing applied research.

23.- This unit can be used for giving training courses to Industries even to other Technical Education Institutions.

24.- Control of the TRLC unit process through the control interface box without the computer.

25.- Visualization of all the sensors values used in the TRLC unit process.

- By using PLC-PI additional 19 more exercises can be done.

- Several other exercises can be done and designed by the user.

a) Industrial configuration

**⑦ PLC. Industrial Control using PLC** (it includes PLC-PI Module plus PLC-SOF Control Software):

**-PLC-PI. PLC Module:**

- Metallic box.
- Circuit diagram in the module front panel.
- Digital inputs(X) and Digital outputs (Y) block: 16 Digital inputs. 14 Digital outputs.
- Analog inputs block: 16 Analog inputs.
- Analog outputs block: 4 Analog outputs.
- Touch screen.
- Panasonic PLC:

High-speed scan of 0.32 sec. Program capacity of 32 Ksteps. High-speed counter. Multi-point PID control.  
Digital inputs/outputs and analog inputs/outputs Panasonic modules.

**-TRLC/PLC-SOF. PLC Control Software:**

For this particular unit, always included with PLC supply.

**Practices to be done with PLC-PI:**

- 1.- Control of the TRLC unit process through the control interface box without the computer.
- 2.- Visualization of all the sensors values used in the TRLC unit process.
- 3.- Calibration of all sensors included in the TRLC unit process.
- 4.- Hand on of all the actuators involved in the TRLC unit process.
- 5.- Realization of different experiments, in automatic way, without having in front the unit. (This experiment can be decided previously).
- 6.- Simulation of outside actions, in the cases hardware elements do not exist. (Example: test of complementary tanks, complementary industrial environment to the process to be studied, etc).
- 7.- PLC hardware general use and manipulation.
- 8.- PLC process application for TRLC unit.
- 9.- PLC structure.
- 10.- PLC inputs and outputs configuration.
- 11.- PLC configuration possibilities.
- 12.- PLC programming languages.
- 13.- PLC different programming standard languages.
- 14.- New configuration and development of new process.
- 15.- Hand on an established process.
- 16.- To visualize and see the results and to make comparisons with the TRLC unit process.
- 17.- Possibility of creating new process in relation with the TRLC unit.
- 18.- PLC Programming exercises.
- 19.- Own PLC applications in accordance with teacher and student requirements.

b) Technical and Vocational Education configuration

**⑧ TRLC/CAI. Computer Aided Instruction Software System.**

This complete software package consists of an Instructor Software (INS/SOF) totally integrated with the Student Software (TRLC/SOF).

**-INS/SOF. Classroom Management Software (Instructor Software):**

The Instructor can:

- Organize Students by Classes and Groups.
- Create easily new entries or delete them.
- Create data bases with student information.
- Analyze results and make statistical comparisons.
- Generate and print reports.
- Detect student's progress and difficulties.

**-TRLC/SOF. Computer Aided Instruction Software (Student Software):**

It explains how to use the unit, run the experiments and what to do at any moment.

This Software contains:

- Theory.
- Exercises.
- Guided Practices.
- Exams.

**⑨ TRLC/FSS. Faults Simulation System.**

Faults Simulation System (FSS) is a Software package that simulates several faults in any EDIBON Computer Controlled Unit.

The "FAULTS" mode consists on causing several faults in the unit normal operation. The student must find them and solve them.

There are several kinds of faults that can be grouped in the following sections:

Faults affecting the sensors measurement:

- An incorrect calibration is applied to them.
- Non-linearity.

Faults affecting the actuators:

- Actuators channels interchange at any time during the program execution.
- Response reduction of an actuator.

Faults in the controls execution:

- Inversion of the performance in ON/OFF controls.
- Reduction or increase of the calculated total response.
- The action of some controls is annulled.

On/off faults:

- Several on/off faults can be included.

c) Higher Education and/or Technical and Vocational Education configuration

⑩ **TRLC/CAL. Computer Aided Learning Software (Results Calculation and Analysis).**

This Computer Aided Learning Software (CAL) is a Windows based software, simple and very easy to use.

CAL is a class assistant that helps in doing the necessary calculations to extract the right conclusions from data obtained during the experimental practices.

CAL computes the value of all the variables involved and performs the calculations.

It allows to plot and print the results. Within the plotting options, any variable can be represented against any other.

Different plotting displays.

It has a wide range of information, such as constant values, unit conversion factors and integral and derivative tables.

d) Multipost Expansions options

⑪ **Mini ESN. EDIBON Mini Scada-Net System.**

EDIBON Mini Scada-Net System allows up to 30 students to work with a Teaching Unit in any laboratory, simultaneously.

The Mini ESN system consists on the adaptation of any EDIBON Computer Controlled Unit with SCADA and PID Control integrated in a local network.

This system allows to view/control the unit remotely, from any computer integrated in the local net (in the classroom), through the main computer connected to the unit.

Main characteristics:

- It allows up to 30 students to work simultaneously with the EDIBON Computer Controlled Unit with SCADA and PID Control, connected in a local net.
- Open Control + Multicontrol + Real Time Control + Multi Student Post.
- Instructor controls and explains to all students at the same time.
- Any user/student can work doing "real time" control/multicontrol and visualisation.
- Instructor can see in the computer what any user/student is doing in the unit.
- Continuous communication between the instructor and all the users/students connected.

Main advantages:

- It allows an easier and quicker understanding.
- This system allows you can save time and cost.
- Future expansions with more EDIBON Units.

The system basically will consist of:

This system is used with a Computer Controlled Unit.

- Instructor's computer.
- Students' computers.
- Local Network.
- Unit-Control Interface adaptation.
- Unit Software adaptation.
- Webcam.
- Mini ESN Software to control the whole system.
- Cables and accessories required for a normal operation.

\*Specifications subject to change without previous notice, due to the convenience of improvements of the product.



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