EDIBON PATENT

Teaching Technique used

EDIBON **SCADA** System and **PID Control** included

② Control Interface Box

③ Data Acquisition Board

④ Software for:
- Computer Control
- Data Acquisition
- Data Management

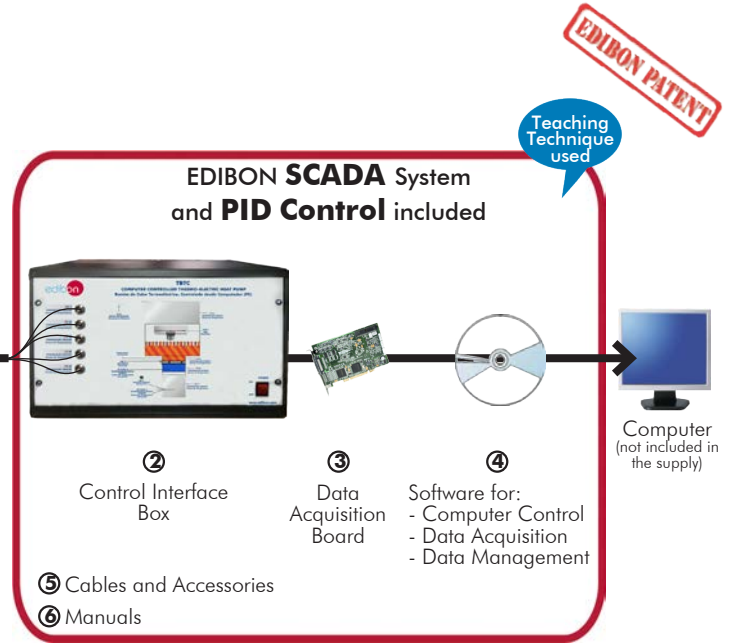Computer (not included in the supply)

⑤ Cables and Accessories

⑥ Manuals

① Unit: TBTC. Computer Controlled Thermo-Electric Heat Pump

* 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

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INTRODUCTION

Thermoelectricity is considered a branch of thermodynamics and the electricity which studies the phenomena involving heat and electricity. The best known phenomenon is that of the electricity generated by the application of heat to the junction of two different materials. This effect is known as the Seebeck effect.

When a current passes through a circuit composed of different materials whose junctions are at the same temperature, the inverse effect takes place. In this case, heat is absorbed in one junction and is given off in the other one. This phenomenon is known as the Peltier effect (nowadays, this application is becoming more important; the reason is that it enables the use of semiconductors systems based on the Peltier effect as refrigerators in numerous applications).

The Computer Controlled Thermo-Electric Heat Pump "TBTC" consists of a thermoelectric heat pump completely equipped to demonstrate the Seebeck effect, the Peltier effect and Thomson or Lenz effect.

GENERAL DESCRIPTION

The Computer Controlled Thermo-Electric Heat Pump "TBTC" allows the study of different phenomena in which heat and electricity take place (Thermoelectricity). Some of them are the Peltier effect, the Thomson or Lenz effect and the Seebeck effect. The application of the Peltier effect as a refrigeration method can also be studied.

We will be able to carry out with this unit the study and use of a Peltier element as a heat pump and for the refrigeration.

This thermoelectric heat pump consists of a thermoelectric cell or module mounted over two sides. There is a heating element, computer controlled, covered by a thermally insulated conductor made of stainless steel, over the cold side of the module. A heatsink is located in the hot side of the module; it is composed of a heat exchanger and a fan placed inside an insulated box.

Different experimental configurations of the unit can be easily established through the activation of different switches.

The thermoelectric module is composed of two small semiconductor pieces, A and B, one of them of the n-type and the other one of the p-type. They are joined by one of their ends through a metallic joint or weld. If this joint is subjected to a heat source, keeping it at a high temperature meanwhile the rest is kept at a lower temperature, a small electromotive force is generated that produces an electric current in the circuit.

In a similar way, due to Peltier's effect, if a current passes through the semiconductor joints circuit p-n and n-p, some of them heat up and other cool down, generating a temperature gradient among the plates.

The thermoelectric element consists of a variable number of joints placed electrically in series, but thermally in parallel.
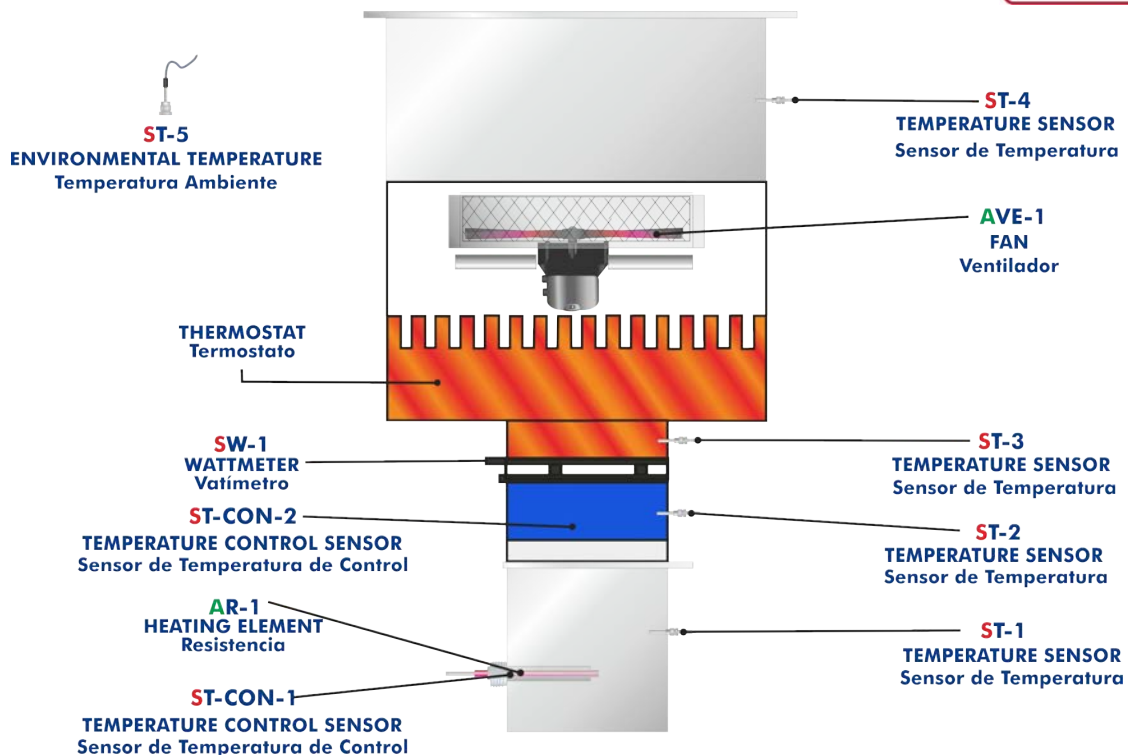
The unit includes two temperature control sensors, situated in the heating element and in one side of the module.

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

4 actuators and 8 sensors controlled from any computer, and working simultaneously

OPEN CONTROL
+
MULTICONTROL
+
REAL TIME CONTROL

ST-5
ENVIRONMENTAL TEMPERATURE
Temperatura Ambiente

ST-4
TEMPERATURE SENSOR
Sensor de Temperatura

AVE-1
FAN
Ventilador

THERMOSTAT
Termostato

ST-3
TEMPERATURE SENSOR
Sensor de Temperatura

SW-1
WATTMETER
Vatímetro

ST-CON-2
TEMPERATURE CONTROL SENSOR
Sensor de Temperatura de Control

ST-2
TEMPERATURE SENSOR
Sensor de Temperatura

AR-1
HEATING ELEMENT
Resistencia

ST-1
TEMPERATURE SENSOR
Sensor de Temperatura

ST-CON-1
TEMPERATURE CONTROL SENSOR
Sensor de Temperatura de Control

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 TBTC. Unit:

Bench-top unit.

Anodized aluminum structure and panels of painted steel.

Main metallic elements of stainless steel.

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

Thermoelectric module-Peltier device mounted over two sides.

There is a heating element on the cold side of the module, covered by a thermally insulated conductor made of stainless steel.

There is a heatsink and a fan on the hot side of the module, they are placed inside an insulated box with a gate.

Heat transfer rate up to 89 W.

Heating element (75 W, 230 V), computer controlled, through a temperature sensor (PID control).

Fan, computer controlled (air flow of 50 m³/h). Air flow regulation.

Heatsink.

Energy/power supply to the thermoelectric module, computer controlled. Mounted internally (Power supply of 24 V).

Unit: TBTC

Polarity reverser.

5 Temperature sensors ("J" type) at different points, to measure the temperature in the hot side, in the cold side and the environmental temperature.

Sensors to measure voltage, current and power related to the power supply to the thermoelectric module.

Measurement of the voltage generated by the thermoelectric module.

A thermostat situated in the thermoelectric cell that cuts when the temperature is 80°C, approximately.

Two temperature control sensors, situated in the heating element and in one side of the module.

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 **TBTC/CIB. Control Interface Box:**

The Control Interface Box is part of the SCADA system.

<u>Control interface box with process diagram in the front panel</u> 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 PID and on/off 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.
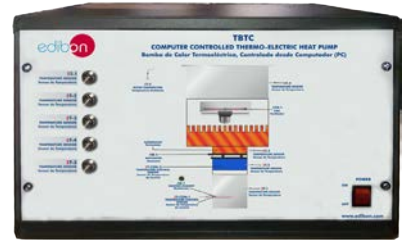
TBTC/CIB

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: <u>250 KS/s (kilo samples per second)</u>.

Input range (V)=±10 V. Data transfers=DMA, interrupts, programmed I/0. 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/0.

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 **TBTC/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 <u>250 KS/s (kilo samples per second)</u>.

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.
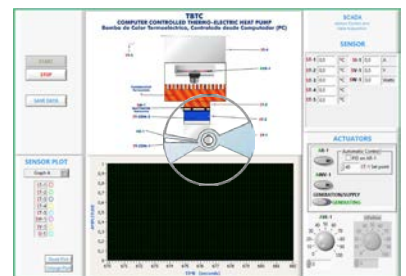
TBTC/CCSOF

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: TBTC + TBTC/CIB + DAB + TBTC/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 THE MAIN ITEMS

1.- Investigation of the effects upon the surface temperature of either face of the module with increasing power supply (Peltier Effect).

2.- Investigation of the effect upon heat transfer of reversing the polarity of the power supply (Thomson or Lenz Effect).

3.- Investigation of the variation in open circuit voltage across the module due to the variation in surface temperature difference (Seebeck Effect).

4.- Estimation of the module's efficiency coefficient acting as refrigerator (COP).

Additional practical possibilities:

5.- Sensors calibration.

6.- Energy balance.

Other possibilities to be done with this Unit:

7.- Many students view results simultaneously.

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

8.- 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.

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

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

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

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

13.-Control of the TBTC unit process through the control interface box without the computer.

14.-Visualization of all the sensors values used in the TBTC 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./50 Hz or 110V./60 Hz.

- Computer.

DIMENSIONS AND WEIGHTS
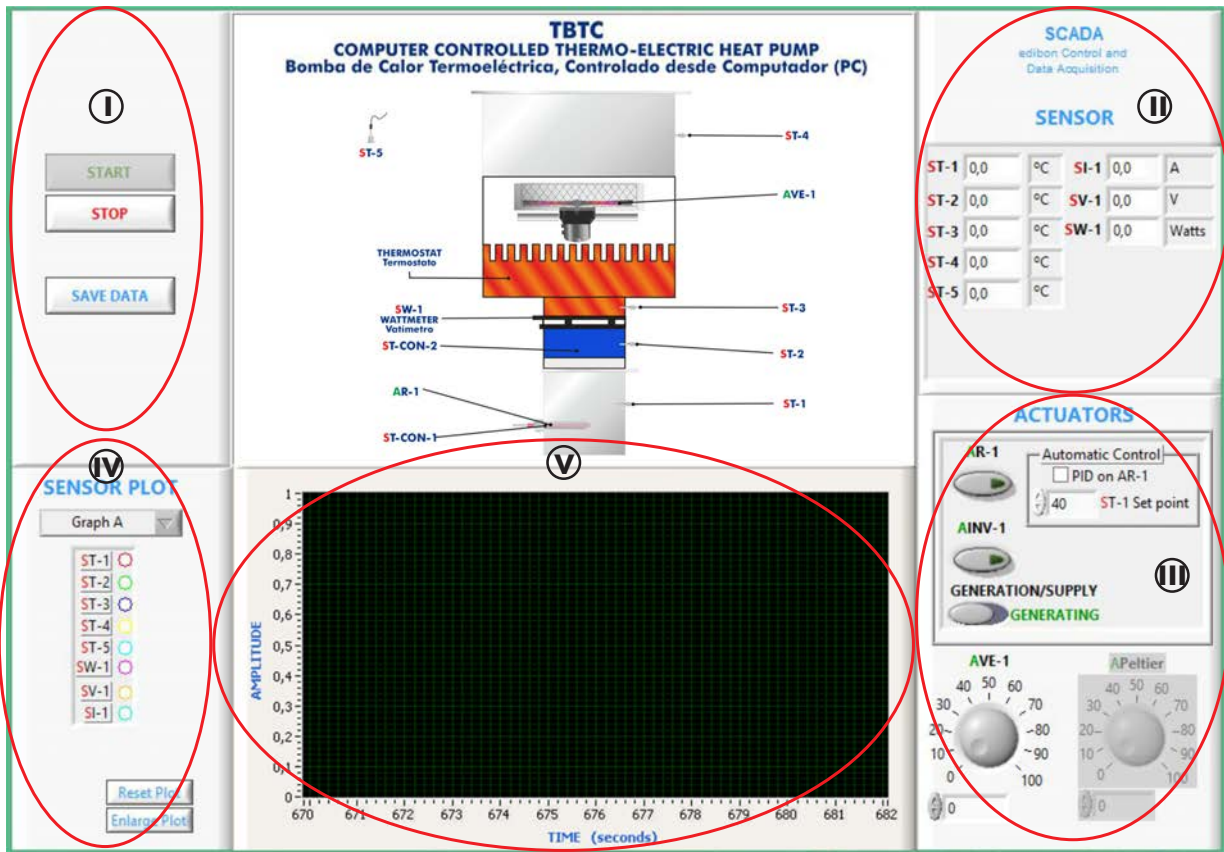
TBTC:

  Unit:

     -Dimensions: 500 x 400 x 550 mm. approx.

               (19.7 x 15.75 x 21.65 inches approx.)

     -Weight: 20 Kg. approx.

               (44 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.).

<u>SCADA and PID Control</u>
<u>Main screen</u>

Ⓘ Main software operation possibilities.

Ⓘ Sensors displays, real time values, and extra output parameters. **Sensors:** ST=Temperature sensor.   SW=Power sensor.   SV=Voltage sensor.   SI=Current sensor.

Ⓘ Actuators controls. **Actuators:** AR=Heating element.   AINV=Polarity inverter.   AVE=Fan.   APeltier= Peltier.

Ⓥ Channel selection and other plot parameters.

Ⓥ Real time graphics displays.

<u>Software for Sensors Calibration</u>
Example of screen
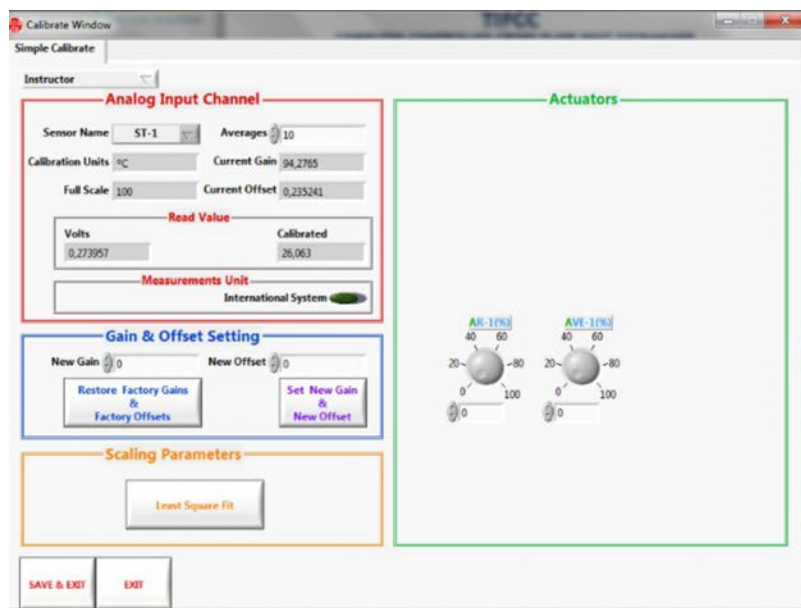
By using a free of charge code, the teacher and the students can calibrate the unit. The teacher can recover his/her own calibration by using the EDIBON code that we give free of charge.

Peltier effect: This plot shows the effects produced on the temperature of the module's sides surface when increasing the power supplied. It is demonstrated that the temperature of the hot side (ST-3 sensor) increases (yellow curve) and the temperature of the cold side (ST-2 sensor) decreases with time (green curve).
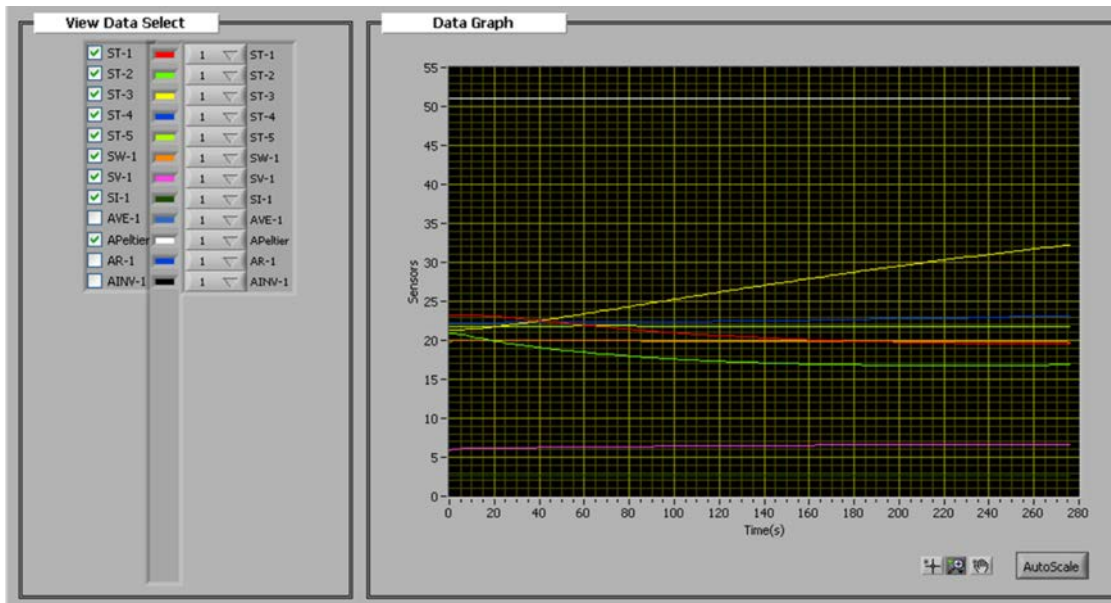
Thomson effect: we observe in this screen how the temperature of the hot side (ST-3 sensor) is lower than the temperature of the cold side (ST-2 sensor) when the polarity of the module changes (AINV-1 is on).

We can verify in this results plot that the temperature of the hot side is decreasing (yellow curve), meanwhile the temperature of the cold side is increasing (green curve).

www.edibon.com

Some **real** results obtained from this Unit

Estimation of the module's efficiency coefficient acting as refrigerator: It can be observed how heat is introduced by means of the heating element (AR-1 is on) and power is applied in the module through the Apeltier actuator.
Under these conditions, the temperature of the cold side of the module remains at room temperature. It can be assumed that heat is not absorbed by the atmosphere, and that all the heat supplied by the heating element is absorbed by the module working in refrigerator mode. This can be checked by means of the ST-3 sensor and ST-4 sensor, observing that the temperature is much more lower.

Some **real** results obtained from this Unit

Seebeck effect: in this practical exercise we study the variation of the voltage, generated in open circuit by the module due to the variation of the temperatures difference between the surface of both sides of the module.

It can be observed in the graph how when the heating element and the fan are on, which corresponds with a temperature increase of the cold side (ST-2 sensor, green curve) and a temperature decrease of the hot side (ST-3 sensor, yellow curve), a voltage is generated in the module, which is measured with SV-1 (pink curve).

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. (CAI and FSS)

  c) Higher Education and/or Technical and Vocational Education configuration. (CAL)

  d) Multipost Expansions options. (Mini ESN and ESN)

<u>a) Industrial configuration</u>

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 μsec. 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.

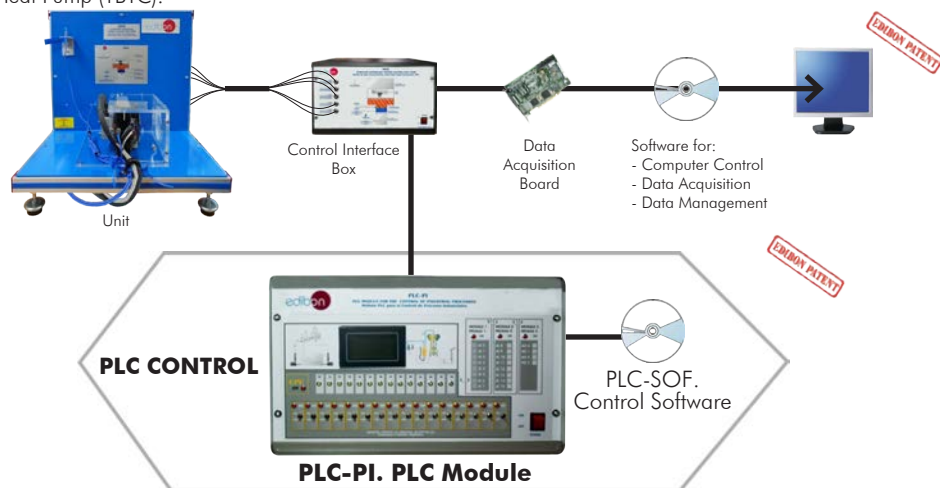 Digital inputs/outputs and analog inputs/outputs Panasonic modules.

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.).

-TBTC/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 Thermo-Electric Heat Pump (TBTC).

Unit

Control Interface Box

Data Acquisition Board

Software for:
- Computer Control
- Data Acquisition
- Data Management

PLC CONTROL

PLC-SOF. Control Software

PLC-PI. PLC Module

Practices to be done with PLC-PI:

1.- Control of a specific unit process through the control interface box without the computer.

2.- Visualization of all the sensors values used in a specific unit process.

3.- Calibration of all sensors included in a specific unit process.

4.- Hand on of all the actuators involved in a specific unit process.

5.- Realization of different experiments, in automatic way, without having in front a specific unit. (This experiment can be previously decided).

6.- Simulation of outside actions, in the cases do not exist hardware elements. (Example: test of complementary tanks, complementary industrial environment to the process to be studied, etc).

7.- PLC general use.

8.- PLC process application for a specific unit.

9.- PLC structure.

10.-PLC inputs and outputs configuration.

11.-PLC configuration possibilities.

12.-PLC program languages.

13.-PLC different programming standard languages (ladder diagram (LD), structured text (ST), instructions list (IL), sequential function chart (SFC), function block diagram (FBD)).

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 a specific unit process.

17.-Possibility of creating new process in relation with a specific unit.

18.-PLC Programming Exercises.

19.-Own PLC applications in accordance with teacher and student requirements.

<u>b) Technical and Vocational Education configuration</u>

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

This complete software package includes two Softwares: the INS/SOF. Classroom Management Software (Instructor Software) and the TBTC/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 (TBTC/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

TBTC/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.

Student Software

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

www.edibon.com/products/catalogues/en/CAI.pdf

⑨ **TBTC/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 in 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:
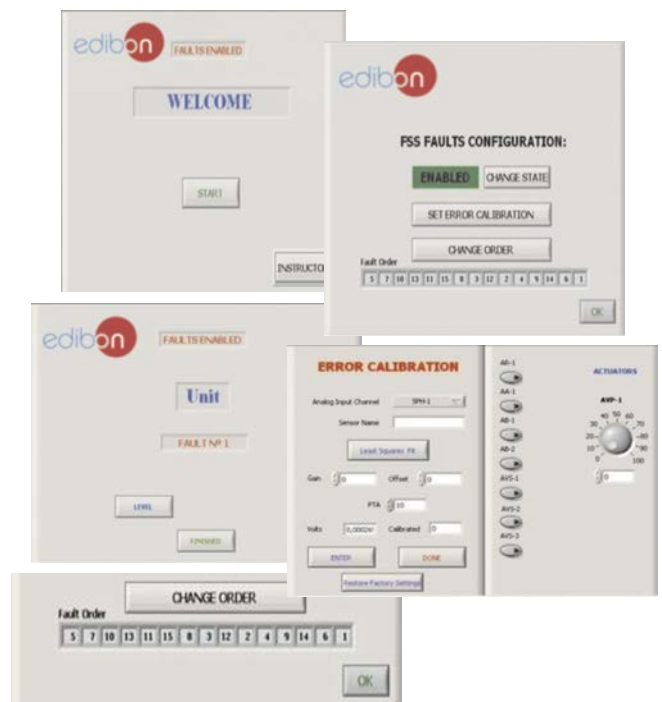
    - Inversion of the performance in ON/OFF controls.

    - 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.

Example of some screens

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

www.edibon.com/products/catalogues/en/FSS.pdf

Complete Technical Specifications (for optional items)

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

⑩ **TBTC/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.
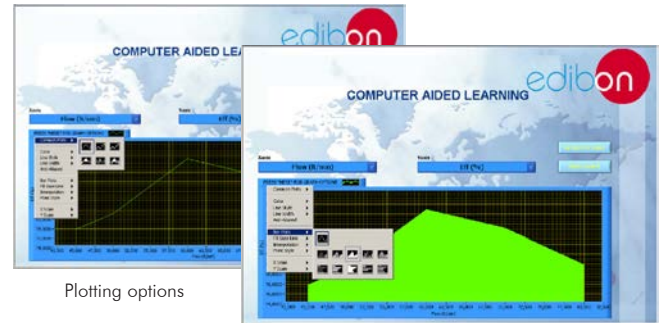
For more information see **CAL** catalogue. Click on the following link:
www.edibon.com/products/catalogues/en/CAL.pdf
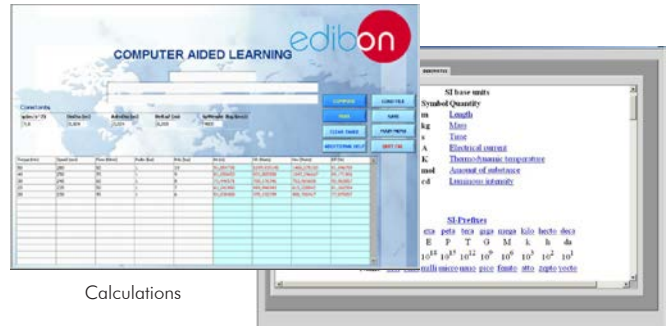
Calculations

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 of 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

Mini ESN.
EDIBON Mini Scada-Net System

EDIBON PATENT

1 UNIT= up to 30 STUDENTS can work simultaneously

Computer Controlled Thermo-Electric Heat Pump (TBTC)

Control Interface Box

Software for:
- Computer Control
- Data Acquisition
- Data Management

Instructors' Central Computer

Mini Scada-Net Software

LOCAL NET FOR 30 STUDENTS

OPEN CONTROL
+
MULTICONTROL
+
REAL TIME CONTROL
+
MULTI STUDENT POST

Note: The Mini ESN system can be used with any EDIBON computer controlled unit

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
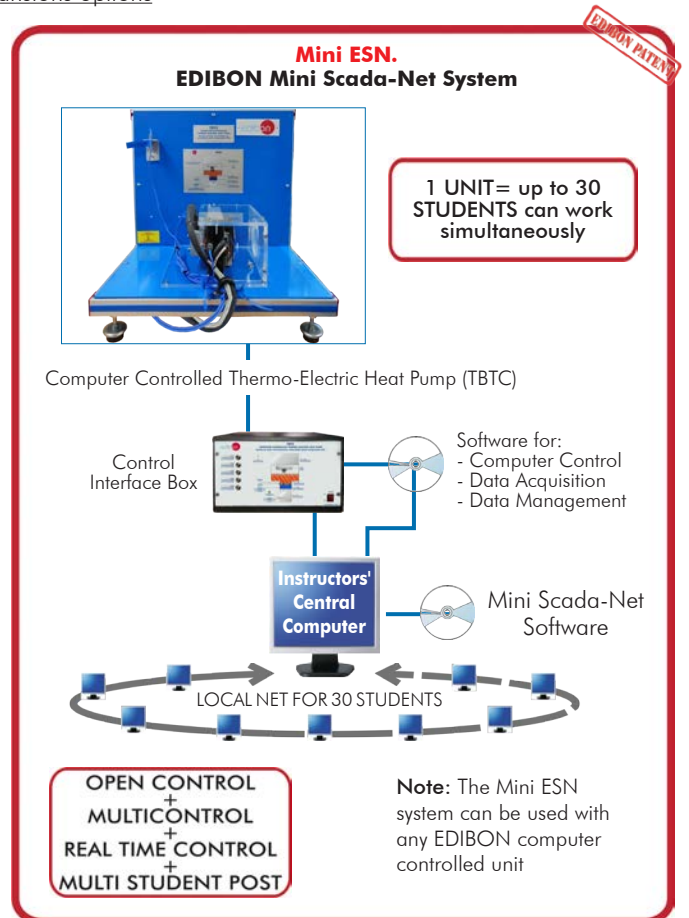
Main items (always included in the supply)

Minimum supply always includes:

① Unit: TBTC. Computer Controlled Thermo-Electric Heat Pump.

② TBTC/CIB. Control Interface Box.

③ DAB. Data Acquisition Board.

④ TBTC/CCSOF. PID Computer Control + Data Acquisition + Data Management Software.

⑤ Cables and Accessories, for normal operation.

⑥ Manuals.

*IMPORTANT: Under TBTC 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.

   - TBTC/PLC-SOF. PLC Control Software.

b) Technical and Vocational configuration

⑧ TBTC/CAI. Computer Aided Instruction Software System.

⑨ TBTC/FSS. Faults Simulation System.

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

⑩ TBTC/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 TBTC. Unit:

Bench-top unit.

Anodized aluminum structure and panels of painted steel.

Main metallic elements of stainless steel.

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

Thermoelectric module-Peltier device mounted over two sides.

There is a heating element on the cold side of the module, covered by a thermally insulated conductor made of stainless steel.

There is a heatsink and a fan on the hot side of the module, they are placed inside an insulated box with a gate.

Heat transfer rate up to 89 W.

Heating element (75 W, 230 V), computer controlled, through a temperature sensor (PID control).

Fan, computer controlled (air flow of 50 m³/h). Air flow regulation.

Heatsink.

Energy/power supply to the thermoelectric module, computer controlled. Mounted internally (Power supply of 24 V).

Polarity reverser.

5 Temperature sensors ("J" type) at different points, to measure the temperature in the hot side, in the cold side and the environmental temperature.

Sensors to measure voltage, current and power related to the power supply to the thermoelectric module.

Measurement of the voltage generated by the thermoelectric module.

A thermostat situated in the thermoelectric cell that cuts when the temperature is 80°C, approximately.

Two temperature control sensors, situated in the heating element and in one side of the module.

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 TBTC/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 TBTC/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 the Main Items

1.- Investigation of the effects upon the surface temperature of either face of the module with increasing power supply (Peltier Effect).

2.- Investigation of the effect upon heat transfer of reversing the polarity of the power supply (Thomson or Lenz Effect).

3.- Investigation of the variation in open circuit voltage across the module due to the variation in surface temperature difference (Seebeck Effect).

4.- Estimation of the module's efficiency coefficient acting as refrigerator (COP).

Additional practical possibilities:

5.- Sensors calibration.

6.- Energy balance.

Other possibilities to be done with this Unit:

7.- Many students view results simultaneously.

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

8.- 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.

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

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

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

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

13.-Control of the TBTC unit process through the control interface box without the computer.

14.-Visualization of all the sensors values used in the TBTC unit process.

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

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

<u>a) Industrial configuration</u>

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

-TBTC/PLC-SOF. PLC Control Software:
For this particular unit, always included with PLC supply.

<div align="center">Practices to be done with PLC-PI:</div>

1.- Control of a specific unit process through the control interface box without the computer.
2.- Visualization of all the sensors values used in a specific unit process.
3.- Calibration of all sensors included in a specific unit process.
4.- Hand on of all the actuators involved in a specific unit process.
5.- Realization of different experiments, in automatic way, without having in front a specific unit. (This experiment can be previously decided).
6.- Simulation of outside actions, in the cases do not exist hardware elements. (Example: test of complementary tanks, complementary industrial environment to the process to be studied, etc).
7.- PLC general use.
8.- PLC process application for a specific unit.
9.- PLC structure.
10.-PLC inputs and outputs configuration.
11.-PLC configuration possibilities.
12.-PLC program languages.
13.-PLC different programming standard languages (ladder diagram (LD), structured text (ST), instructions list (IL), sequential function chart (SFC), function block diagram (FBD)).
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 a specific unit process.
17.-Possibility of creating new process in relation with a specific unit.
18.-PLC Programming Exercises.
19.-Own PLC applications in accordance with teacher and student requirements.

<div align="center"><u>b) Technical and Vocational Education configuration</u></div>

⑧ **TBTC/CAI. Computer Aided Instruction Software System.**
This complete software package consists of an Instructor Software (INS/SOF) totally integrated with the Student Software (TBTC/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.
- TBTC/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 **TBTC/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 in 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.

<u>c) Higher Education and/or Technical and Vocational Education configuration</u>

⑩ **TBTC/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.

<u>d) Multipost Expansions options</u>

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 of 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 improvement of the product.