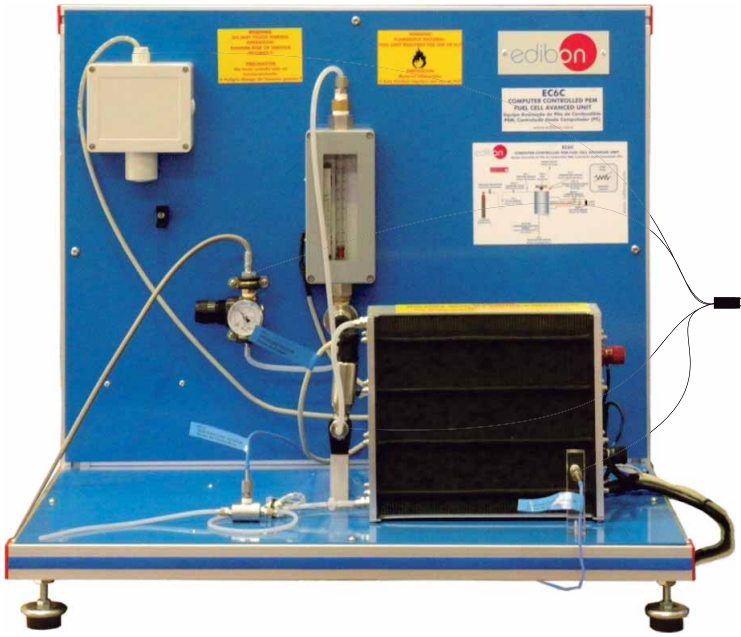
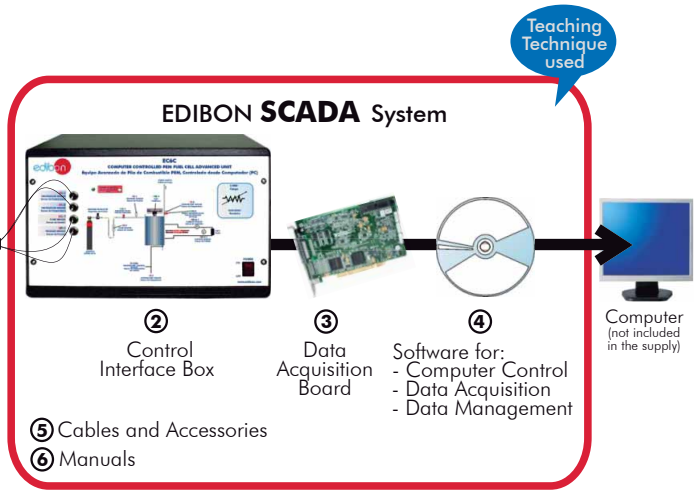
edibon
Technical Teaching Equipment

Computer Controlled **PEM Fuel Cell Advanced Unit,** with SCADA

EC6C

EDIBON PATENT





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

①Unit: EC6C. PEM Fuel Cell Advanced Unit

Key features:

OPEN CONTROL + MULTICONTROL + REAL TIME CONTROL

- **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.**
- **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.**

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Products
Products range
Units
5.- Energy

For more information about Key Features, click here:

ISO 9000: Quality Management
(for Design, Manufacturing, Commercialization and After-sales service)

European Union Certificate
(total safety)

Certificates ISO 14000 and **ECO-Management and Audit Scheme**
(environmental management)

Worlddidac Quality Charter Certificate
(Worlddidac Member)

GENERAL DESCRIPTION

This unit has been designed to allow the students to understand the fuel cells technology; especially that of a proton exchange membrane fuel cell (PEM).

The main operation principles of a PEM fuel cell can be studied with this unit. It also enables the calculation of several fundamental parameters of a PEM type fuel cell, such as power density, polarization curves, efficiency, etc., and the variation of some of these parameters in function of the consumption of reagents and the developed power.

The unit is supplied with a stack of proton exchange membrane fuel cell (PEM) with a rated power of 1000 W. The stack is composed of 72 cells with channelled plate shape that allow the air flow through the membrane. The membrane facilitates the hydrogen flow, generating the electrons release. There are separate plates which conduct electricity, allowing that electrons flow, between each pair of cells.

Cells are self-humidifying and do not require any type of external humidification.

The stack has an integrated fan that is able to provide the required air for proper operation and to maintain a suitable temperature.

Besides, the EC6C unit includes two pressure regulators: one for the H_2 cylinder, to regulate its outlet pressure, and the other for the stack inlet, to regulate the inlet pressure.

In addition, the unit includes two solenoid valves. One of them is located before the stack and controls the hydrogen inlet, and when the unit is switched off, the valve is closed to avoid any possible hydrogen leakage. This valve is automatically shutted when the temperature of the stack exceeds 65°C. The other valve, placed at the stack outlet, purges the excess of water and Hydrogen outside for a proper operation.

The unit also has a load regulation system. It enables the study of the generated electrical energy, the representation of the characteristic operation curves and their comparison with the theoretical curves.

The whole electrical circuit of the stack is protected by a short circuit unit in case of an overcurrent (30A) and low voltage shut down (36V). In the event of one of these problems, the hydrogen inlet solenoid valve is automatically closed.

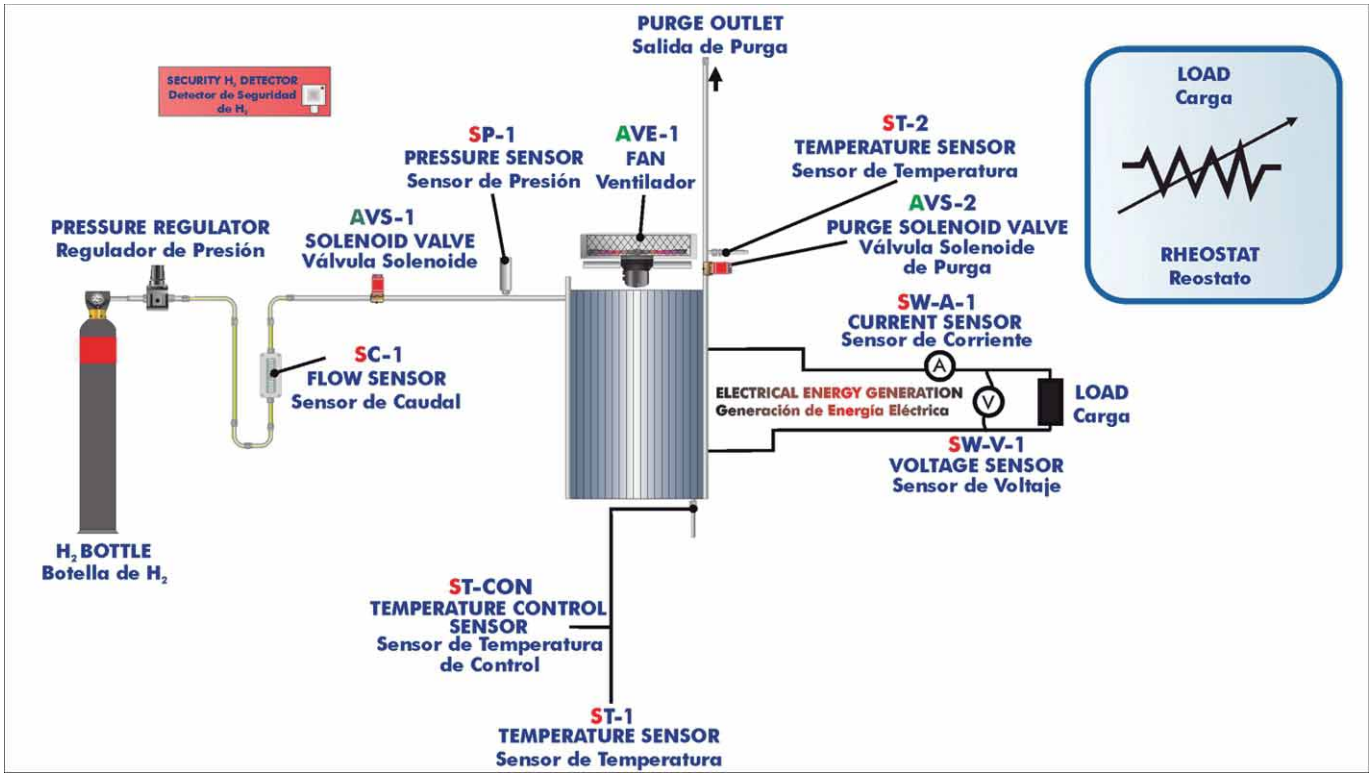
The unit's connections and hoses are made of materials which are suitable for their use with H_2.

It includes a hydrogen leak detector with a detection range from 0 to 2% Vol. and from 0 to 100% L.I.E. respectively.

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 and Data Acquisition Software Packages, for controlling the process and all parameters involved in the process.

PROCESS DIAGRAM AND UNIT ELEMENTS ALLOCATION

OPEN CONTROL
+
MULTICONTROL
+
REAL TIME 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 EC6C. Unit:

Bench-top unit.

Anodized aluminium structure and panels in painted steel.

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

Fuel cell stack with 72 cells and a rated power of 1000W. Cells are self-humidifying and do not require any type of external humidification.

Fan incorporated in the stack.

Solenoid valve to supply H_2.

Pressure regulator for the H_2 bottle. Inlet at 200 bars and outlet at 5-50 bars.

Pressure regulator for the hydrogen inlet at the PEM fuel cell, range: 0-1 bar.

Suitable tubes and hose for use with H_2 with a high safety factor: up to 210 bar.

Purge solenoid valve.

Load module: Rheostat (22R 760W) + 4 wirewound resistors (10R-300W).

Hydrogen leakage detector (4-20 mA; Ip65) and software warning.

Failure protection with solenoid valve at the stack inlet:

- Over current shut down. (30A).
- Low voltage shut down. (36V).
- Over temperature shut down in the stack.

Flow sensor to measure the inlet H_2 flow to the stack, range: 1-15 l./min.

Control temperature sensor placed between two bipolar plates of the cell.

Temperature sensor for the purging flow.

Pressure sensor to measure the H_2 pressure at the stack inlet, range: 0-1 bar.

Current, voltage and power sensors.

EC6C. Unit

Detail of the pressure regulator of the H_2 bottle and hose

The complete unit includes as well:

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.

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.

②EC6C/CIB. Control Interface Box:

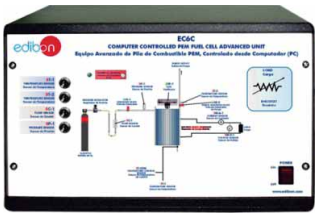
The Control Interface Box is part of the SCADA system.

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.



EC6C/CIB

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 computer control with flexibility of modifications from the computer keyboard of the parameters, at any moment during the process.

Real time computer control for pumps, compressors, resistances, control valves, etc.

Real time computer control for parameters involved in the process simultaneously.

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.

③DAB. Data Acquisition Board:

The Data Acquisition board is part of the SCADA system.

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

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/0. DMA channels=6.

DAB

Analog output:

Number of **channels=2**. **Resolution=16 bits**, 1 in 65536. Maximum output rate up to: 833 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 1 MHz.

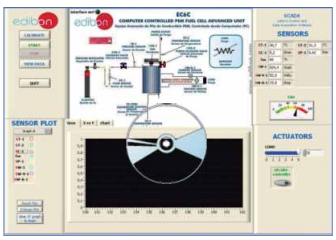
Timing: Number of **Counter/timers=2**. Resolution: Counter/timers: 32 bits.

④EC6C/CCSOF. 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.



EC6C/CCSOF

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

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.

⑤Cables and Accessories, for normal operation.

⑥Manuals: 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: EC6C + EC6C/CIB + DAB + EC6C/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.- Study of the main principles of a proton exchange fuel cell (PEM) operation.

2.- Calculation of the efficiency of a PEM fuel cell.

3.- Study of the influence of air consumption and hydrogen consumption in the efficiency of a PEM fuel cell.

4.- Study of the power density of a PEM fuel cell.

5.- Representation of the polarization curve of a PEM fuel cell.

6.- Determination of the voltage and current density characteristics of a PEM fuel cell.

7.- Influence of hydrogen consumption in the electric power generation.

8.- Study of the influence of the generated power in the efficiency of PEM a fuel cell.

9.- Study of the influence of the reagents' flows in the generation of electrical power.

10.- Study of the use of reagents and transport phenomena.

Additional practical possibilities:

11.- Sensors calibration.

Other possibilities to be done with this Unit:

12.- Many students view results simultaneously.

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

13.- 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.

14.- The Computer Control System with SCADA allows a real industrial simulation.

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

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

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

18.- Control of the EC6C unit process through the control interface box without the computer.

19.- Visualization of all the sensors values used in the EC6C 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 110 V./60 Hz.

-Computer (PC).

CONSUMABLES REQUIRED

-Bottle of compressed hydrogen of degree 4.0 (purity of 99,995%) at a pressure of 150-200 bar.

RECOMMENDED ACCESSORIES

-Edilab-Elec 2: Electrolyzer with a hydrogen production of 100 NL/h.

DIMENSIONS & WEIGHTS

EC6C:

Unit:	-Dimensions:	700 x 400 x 550 mm. approx. (27.55 x 15.75 x 21.65 inches approx.)
	-Weight:	25 Kg. approx. (55 pounds approx.)
Load module:	-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.)
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:

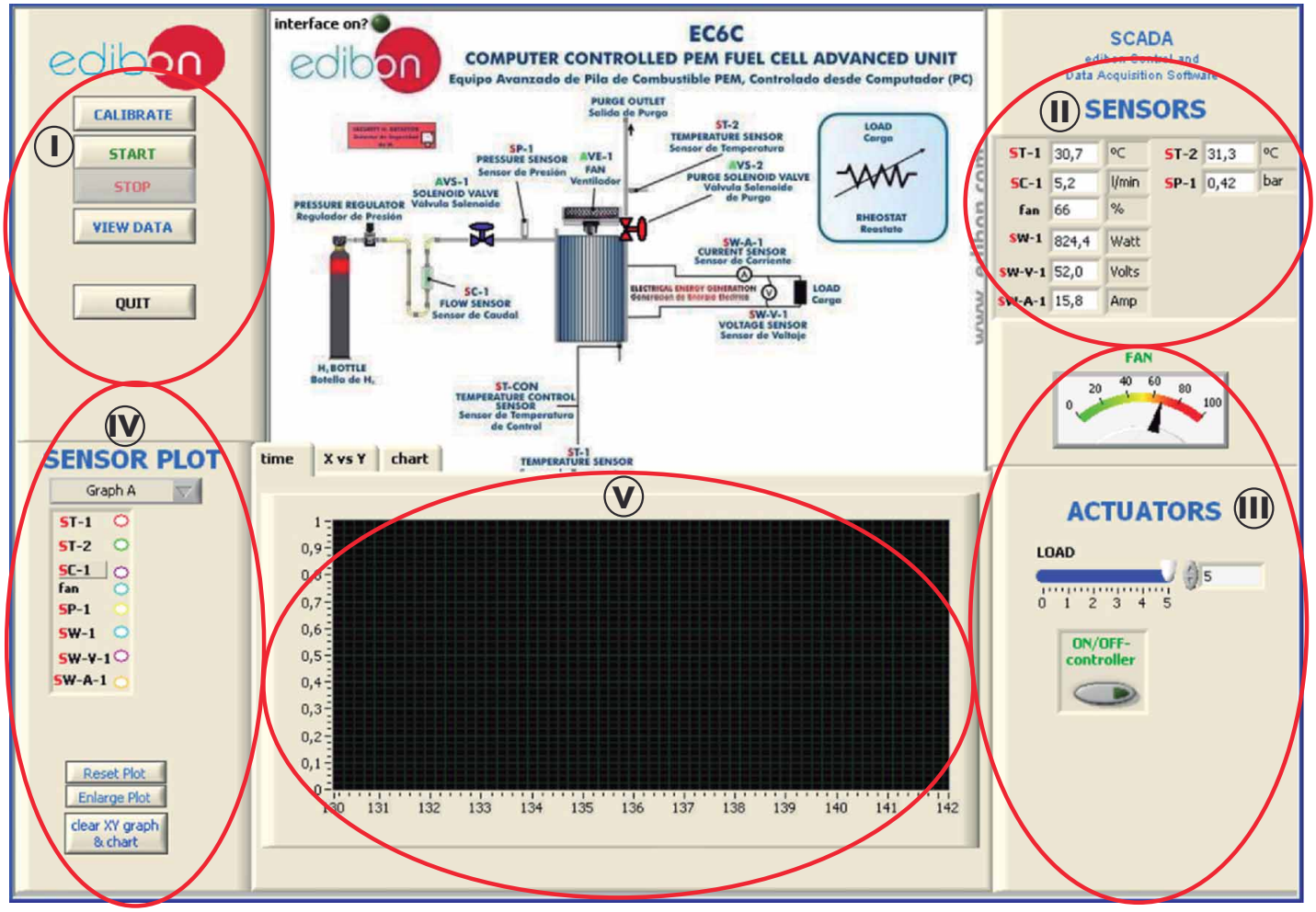
-EC6C. Computer Controlled PEM Fuel Cell Advanced Unit.

Offered in other catalogue:

-EC6B. PEM Fuel Cell Advanced Unit.

SCADA

Main screen



(I) Main software operation possibilities.

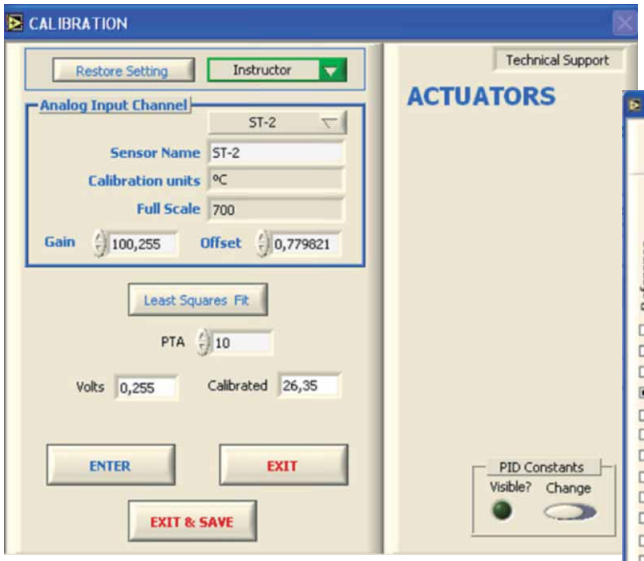
(II) Sensors displays, real time values, and extra output parameters. **Sensors:** ST=Temperature sensor. SC=Flow sensor. SP=Pressure sensor. SW=Power sensor. SW-V-1=Voltage sensor. SW-A-1=Current sensor.

(III) Actuators controls. **Actuators:** Load= Load control. AVS= Solenoid valve open/close visualization. FAN=Fan speed visualization.

(IV) Channel selection and other plot parameters.

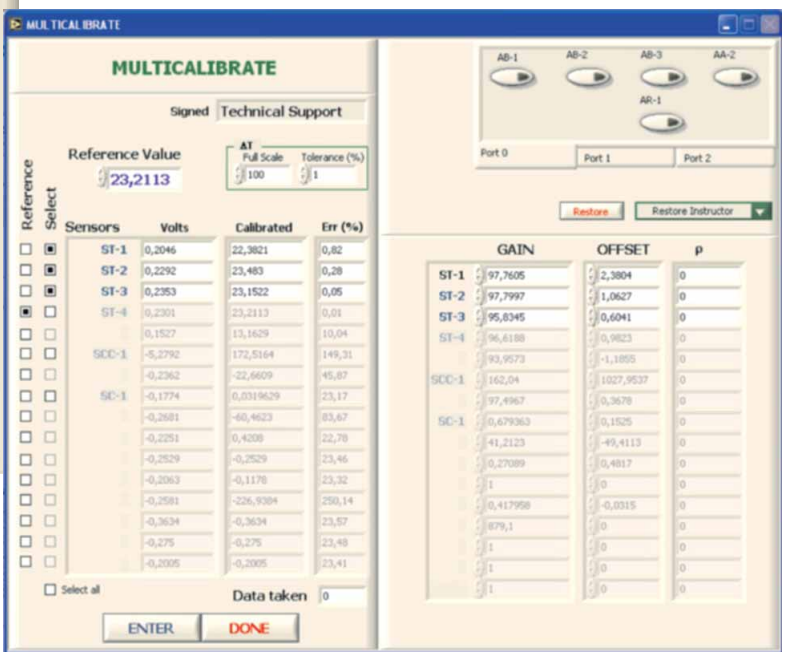
(V) Real time graphics and tables displays.

Software for Sensors Calibration



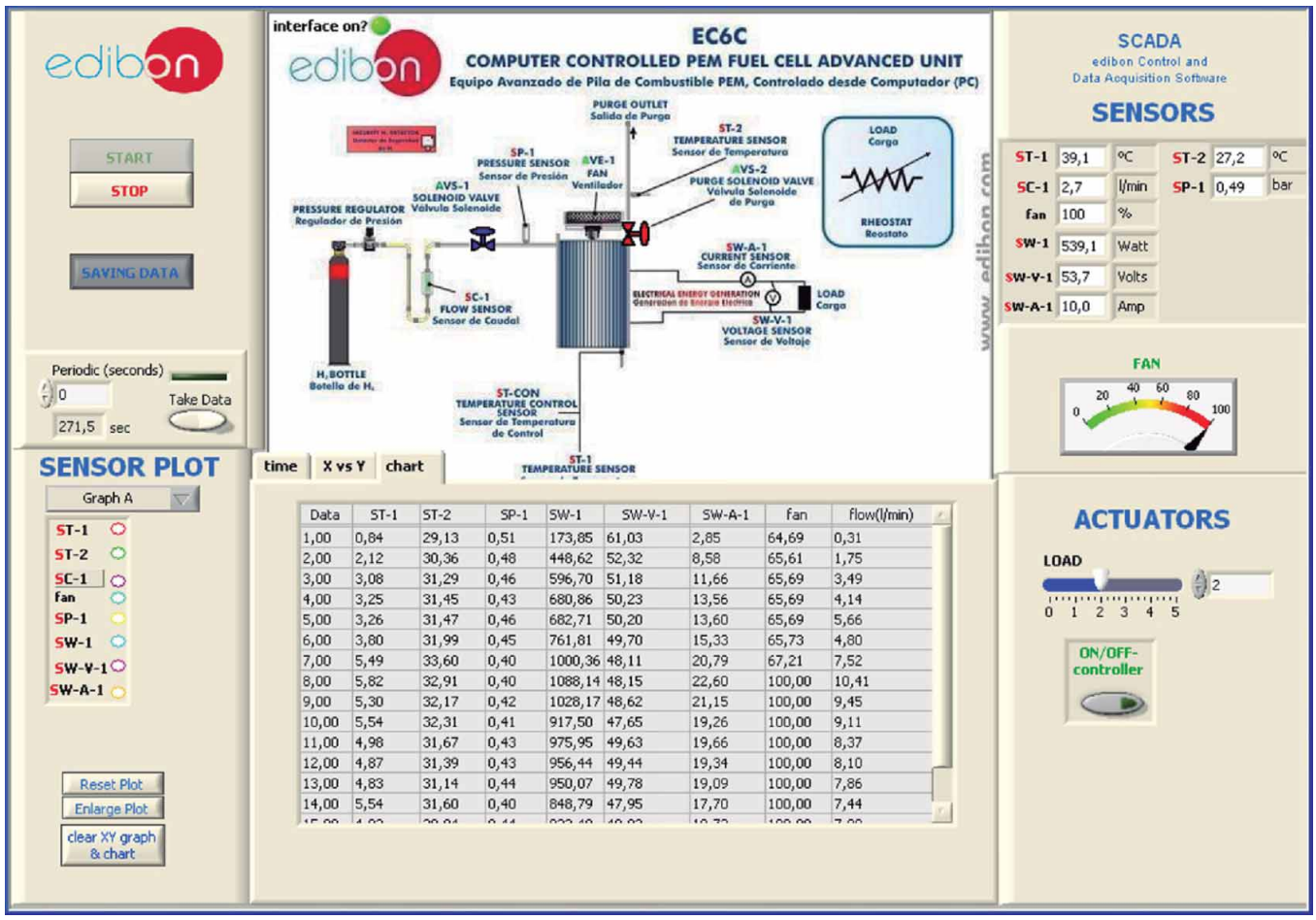
By using a free of charge code, the teacher and the students can calibrate the unit.

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



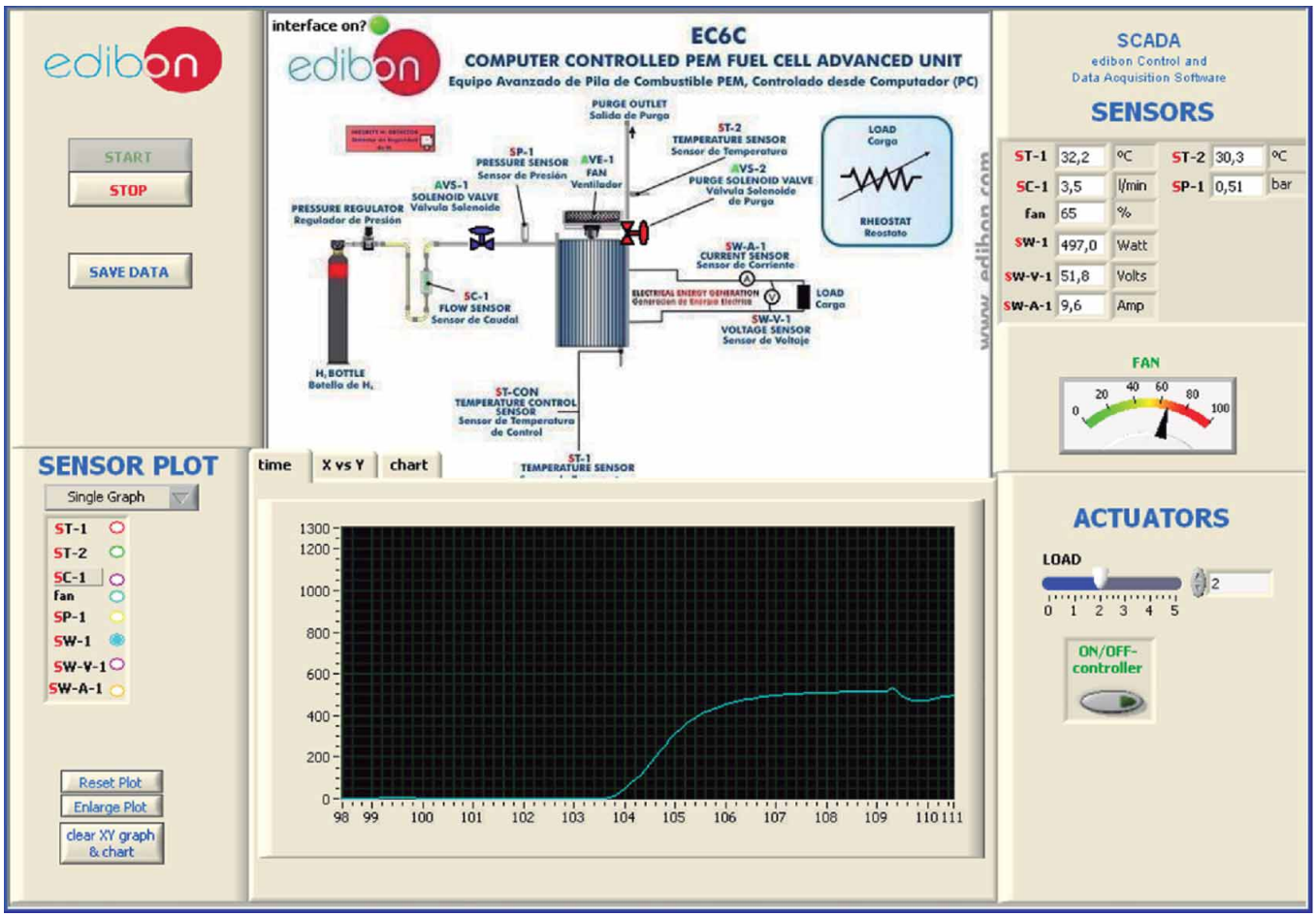
SOME TYPICAL RESULTS

The software enables to visualize either the data obtained during a chosen period of time or the specific required datum on a simple table.

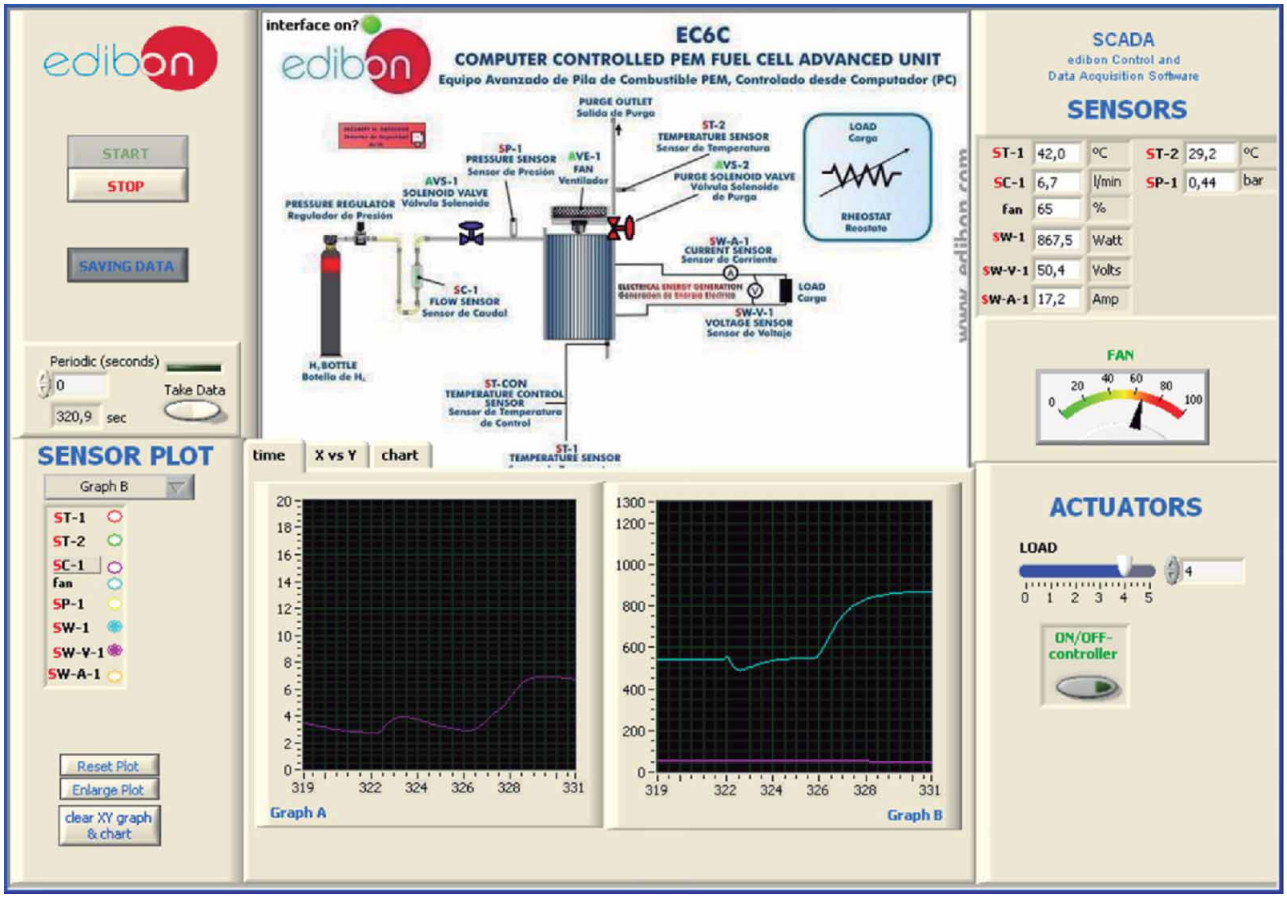


Data	ST-1	ST-2	SP-1	SW-1	SW-V-1	SW-A-1	fan	flow(l/min)
1,00	0,84	29,13	0,51	173,85	61,03	2,85	64,69	0,31
2,00	2,12	30,36	0,48	448,62	52,32	8,58	65,61	1,75
3,00	3,08	31,29	0,46	596,70	51,18	11,66	65,69	3,49
4,00	3,25	31,45	0,43	680,86	50,23	13,56	65,69	4,14
5,00	3,26	31,47	0,46	682,71	50,20	13,60	65,69	5,66
6,00	3,80	31,99	0,45	761,81	49,70	15,33	65,73	4,80
7,00	5,49	33,60	0,40	1000,36	48,11	20,79	67,21	7,52
8,00	5,82	32,91	0,40	1088,14	48,15	22,60	100,00	10,41
9,00	5,30	32,17	0,42	1028,17	48,62	21,15	100,00	9,45
10,00	5,54	32,31	0,41	917,50	47,65	19,26	100,00	9,11
11,00	4,98	31,67	0,43	975,95	49,63	19,66	100,00	8,37
12,00	4,87	31,39	0,43	956,44	49,44	19,34	100,00	8,10
13,00	4,83	31,14	0,44	950,07	49,78	19,09	100,00	7,86
14,00	5,54	31,60	0,40	848,79	47,95	17,70	100,00	7,44

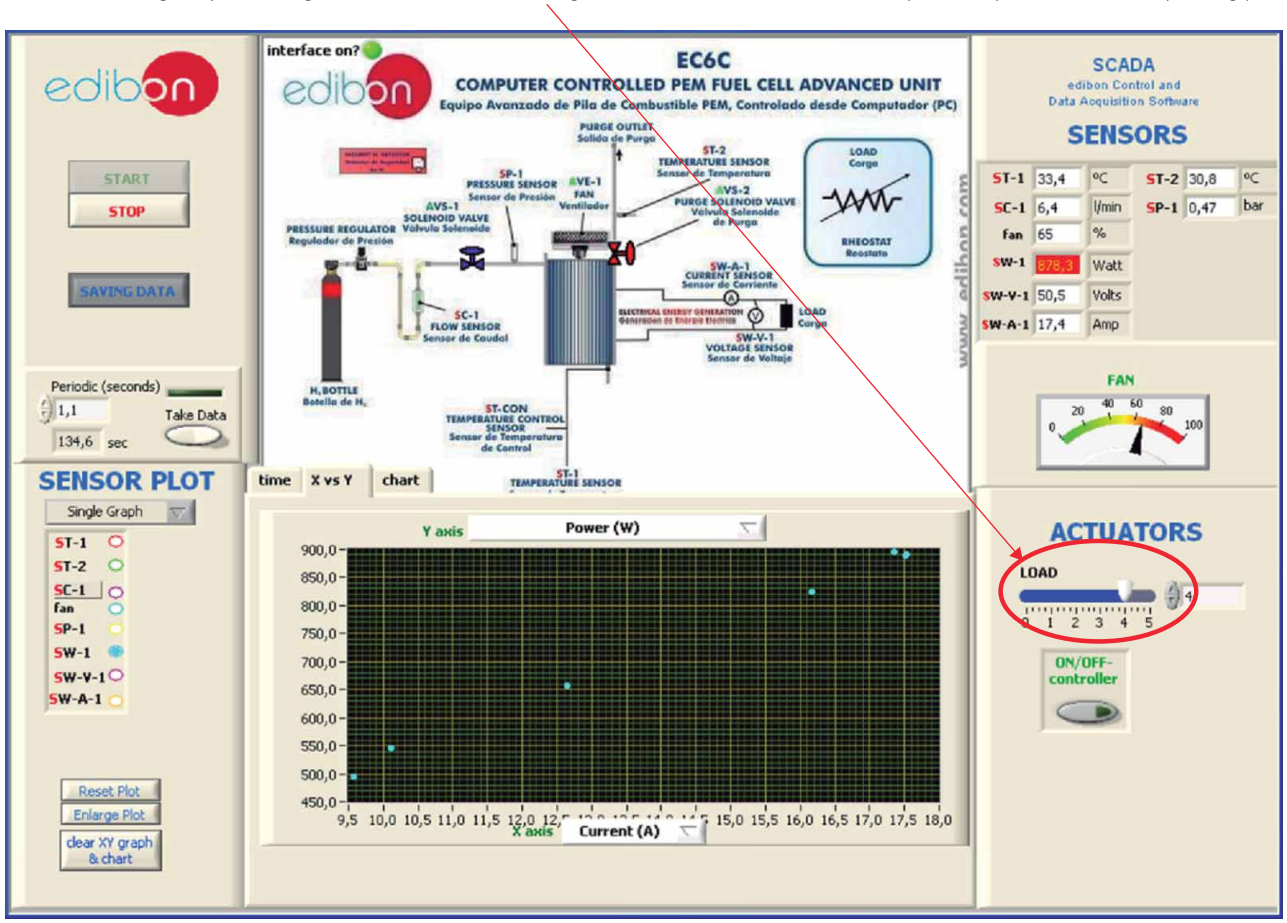
Data collected by the sensors can be represented vs. time. The evolution of the PEM type fuel cell power (SW-1 sensor) vs. time is observed in this graph.

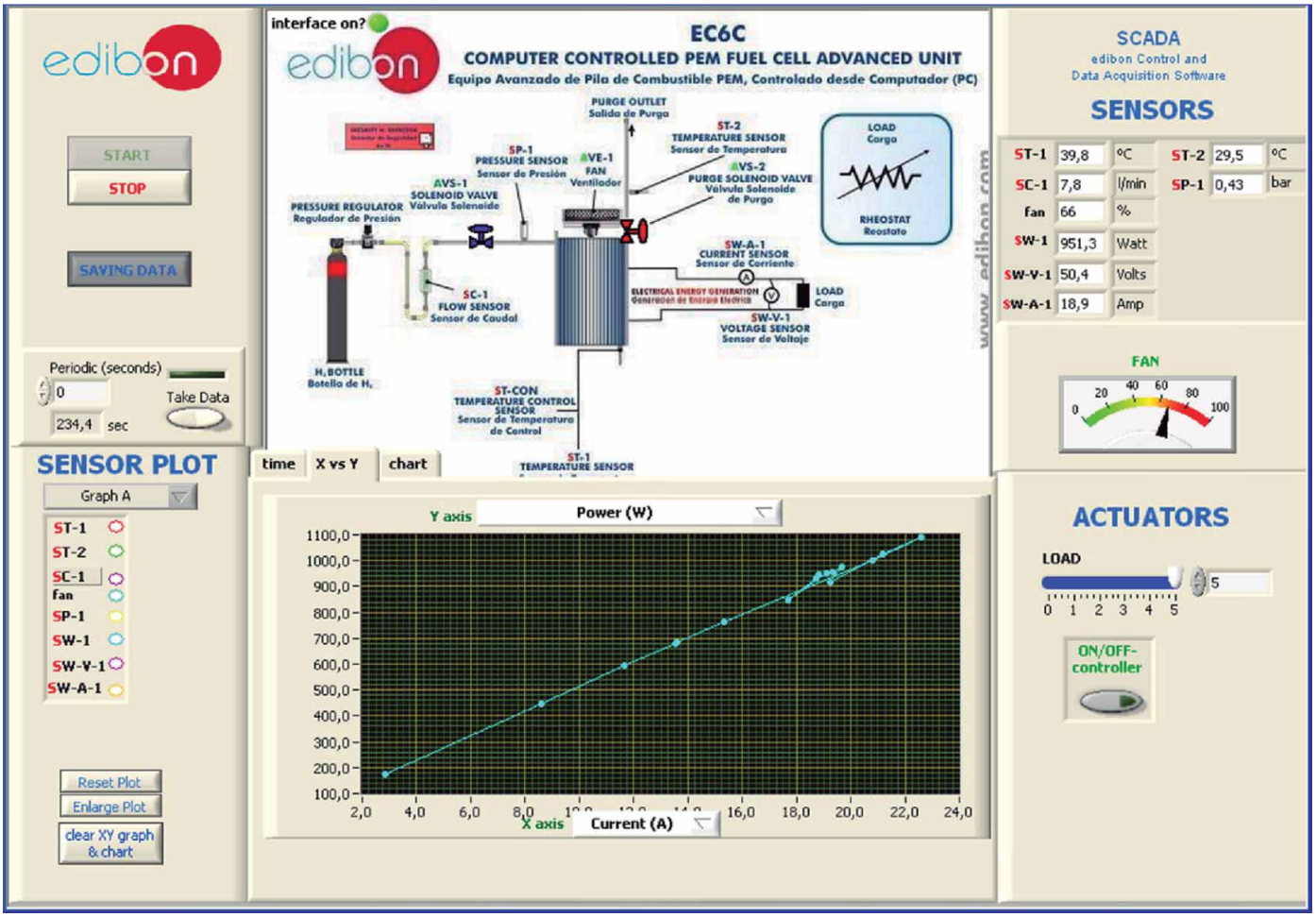


The right side graph shows the evolution of power and voltage vs. time, and the left side graph shows the evolution of the required hydrogen flow vs. time depending on the consumed load. Thus, the influence of various parameters can be easily studied.



Using the software, the PEM fuel cell characteristic curves can be plotted and compared with the theoretical working curves.
The points which determine the power (SW-1 sensor) vs. current (SW-A-1 sensor) characteristic curve can be observed in such representation.
Current is changed by increasing the resistance with a load regulator and the software enables to represent a point with its corresponding power.




edibon
START
STOP
SAVING DATA
Periodic (seconds)
0
Take Data
234,4 sec
SENSOR PLOT
Graph A
ST-1
ST-2
SC-1
fan
SP-1
SW-1
SW-V-1
SW-A-1
Reset Plot
Enlarge Plot
clear XY graph & chart
interface on?
EC6C
COMPUTER CONTROLLED PEM FUEL CELL ADVANCED UNIT
Equipo Avanzado de Pila de Combustible PEM, Controlado desde Computador (PC)
PURGE OUTLET
Salida de Purga
ST-2
TEMPERATURE SENSOR
Sensor de Temperatura
SP-1
PRESSURE SENSOR
Sensor de Presión
AVE-1
FAN
Ventilador
AVS-1
SOLENOID VALVE
Válvula Solenoide
AVS-2
PURGE SOLENOID VALVE
Válvula Solenoide de Purga
PRESSURE REGULATOR
Regulador de Presión
LOAD
Carga
RHEOSTAT
Reostato
SW-A-1
CURRENT SENSOR
Sensor de Corriente
ELECTRICAL ENERGY GENERATION
LOAD
Carga
SC-1
FLOW SENSOR
Sensor de Caudal
SW-V-1
VOLTAGE SENSOR
Sensor de Voltaje
H2 BOTTLE
Botella de H2
ST-CON
TEMPERATURE CONTROL SENSOR
Sensor de Temperatura de Control
ST-1
TEMPERATURE SENSOR
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time
X vs Y
chart
Y axis
Power (W)
1100,0
1000,0
900,0
800,0
700,0
600,0
500,0
400,0
300,0
200,0
100,0
2,0
4,0
6,0
8,0
16,0
18,0
20,0
22,0
24,0
X axis
Current (A)
SCADA
edibon Control and Data Acquisition Software
SENSORS
ST-1 39,8 °C
ST-2 29,5 °C
SC-1 7,8 l/min
SP-1 0,43 bar
fan 66 %
SW-1 951,3 Watt
SW-V-1 50,4 Volts
SW-A-1 18,9 Amp
FAN
0
20
40
60
80
100
ACTUATORS
LOAD
0 1 2 3 4 5
5
ON/OFF-controller

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:

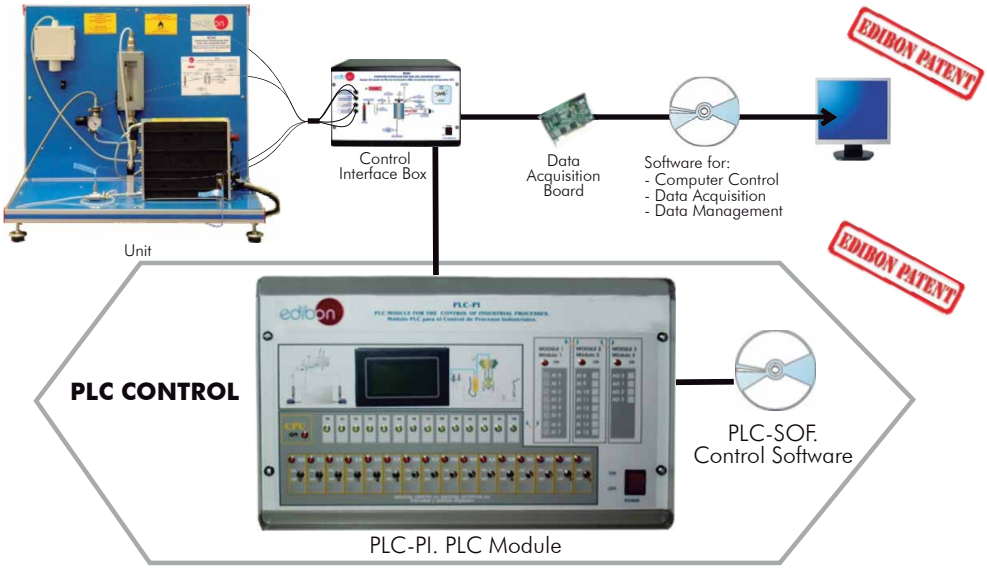
a) Industrial configuration. (PLC)
b) Technical and Vocational Education configuration. (CAI and FSS)
c) Higher Education and/or Technical and Vocational Education configuration. (CAL)
d) Multipost Expansions options. (Mini ESN and ESN)

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 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.).

-**EC6C/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 PEM Fuel Cell Advanced Unit (EC6C).



Practices to be done with PLC-PI:

1.- Control of the EC6C unit process through the control interface box without the computer.
2.- Visualization of all the sensors values used in the EC6C unit process.
3.- Calibration of all sensors included in the EC6C unit process.
4.- Hand on of all the actuators involved in the EC6C 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 EC6C 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 EC6C unit process.
17.- Possibility of creating new process in relation with the EC6C unit.
18.- PLC Programming exercises.
19.- Own PLC applications in accordance with teacher and student requirements.

b) Technical and Vocational Education configuration

⑧ EC6C/CAI. Computer Aided Instruction Software System.

This complete package includes two Softwares: the INS/SOF. Classroom Management Software (Instructor Software) and the EC6C/SOF. Computer Aided Instruction Software (Student Software).

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

This complete package consists on an Instructor Software (INS/SOF) totally integrated with the Student Software (EC6C/SOF). Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students. These, on the other hand, get a virtual instructor who helps them to deal with all the information on the subject of study.

- 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.

Print reports.

Develop own examinations.

Detect student's progress and difficulties.

...and many other facilities.

Instructor Software

- EC6C/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 EC6C/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.**

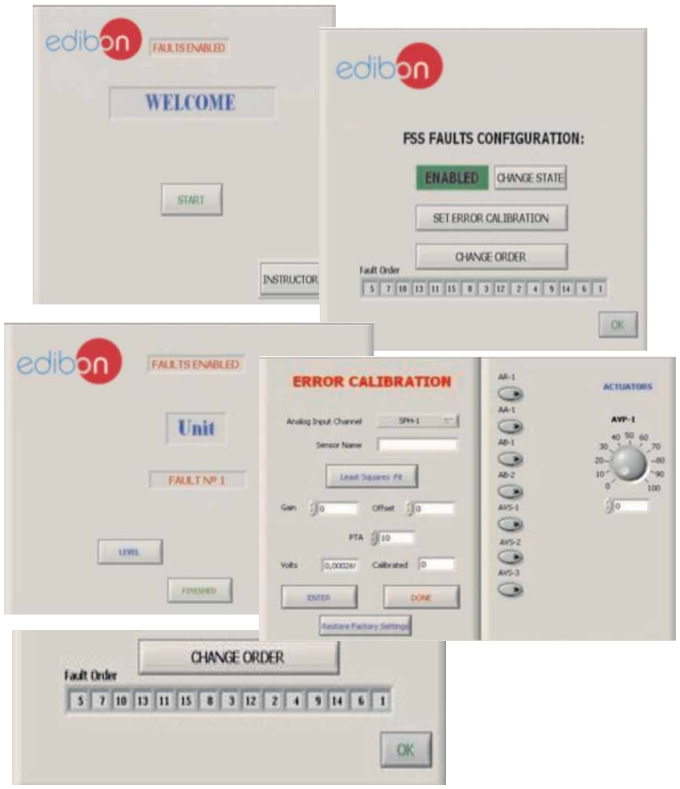
Faults in the controls execution:

- **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.**

Example of some screens



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

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

⑩ EC6C/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 making the necessary calculations to extract the right conclusions from data obtained during the experimental practices.

CAL will perform the calculations.

CAL computes the value of all the variables involved.

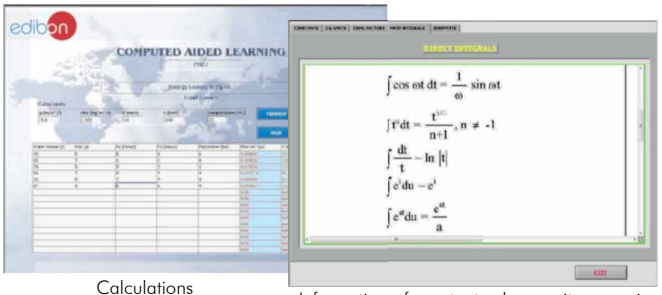
It allows to plot and print the results. Between the plotting options, any variable can be represented against any other.

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 on the adaptation of any EDIBON Computer Controlled Unit with SCADA 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:

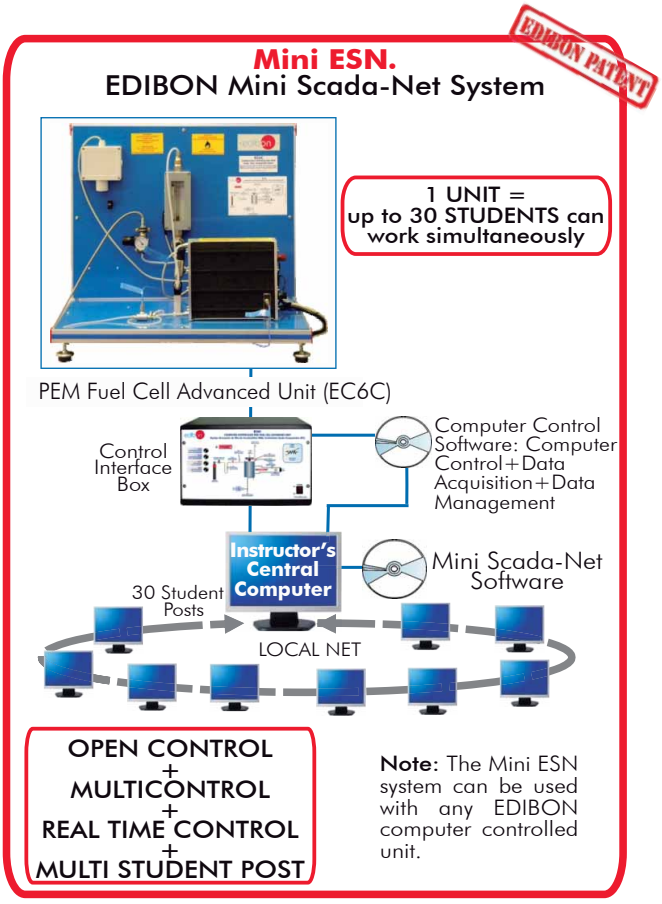
- **It allows up to 30 students to work simultaneously with the EDIBON Computer Controlled Unit with SCADA, connected in a local net.**
- **Open Control + Multicontrol + Real Time Control + Multi Student Post.**
- **Instructor controls and explains to all students at the same time.**
- **Any user/student 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 safe 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



⑫ ESN. EDIBON Scada-Net System.

This unit can be integrated, in future, in 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/energy/esn-alternativeenergies/ESN-ALTERNATIVE_ENERGIES.pdf

ORDER INFORMATION

Main items (always included in the supply)

Minimum supply always includes:

① **Unit: EC6C. PEM Fuel Cell Advanced Unit.**

② **EC6C/CIB. Control Interface Box.**

③ **DAB. Data Acquisition Board.**

④ **EC6C/CCSOF. Computer Control + Data Acquisition + Data Management Software.**

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

⑥ **Manuals.**

* IMPORTANT: Under EC6C 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.
- EC6C/PLC-SOF. PLC Control Software.

b) Technical and Vocational configuration

⑧ EC6C/CAI. Computer Aided Instruction Software System.

⑨ EC6C/FSS. Faults Simulation System.

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

⑩ EC6C/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 EC6C. Unit:

Bench-top unit.
Anodized aluminium structure and panels in painted steel.
Diagram in the front panel with similar distribution to the elements in the real unit.
Fuel cell stack with 72 cells and a rated power of 1000W. Cells are self-humidifying and do not require any type of external humidification.
Fan incorporated in the stack.
Solenoid valve to supply H_2.
Pressure regulator for the H_2 bottle. Inlet at 200 bars and outlet at 5-50 bars.
Pressure regulator for the hydrogen inlet at the PEM fuel cell, range: 0-1 bar.
Suitable tubes and hose for use with H_2 with a high safety factor: up to 210 bar.
Purge solenoid valve.
Load module: Rheostat (22R 760W) + 4 wirewound resistors (10R-300W).
Hydrogen leakage detector (4-20 mA; Ip65), and software warning.
Failure protection with solenoid valve at the stack inlet:
- Over current shut down. (30A).
- Low voltage shut down. (36V).
- Over temperature shut down in the stack.

Flow sensor to measure the inlet H_2 flow to the stack, range: 1-15 l./min.
Control temperature sensor placed between two bipolar plates of the cell.
Temperature sensor for the purging flow.
Pressure sensor to measure the H_2 pressure at the stack inlet, range: 0-1 bar.
Current, voltage and power sensors.
The complete unit includes as well:
- 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.
- 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 EC6C/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 computer control with flexibility of modifications from the computer keyboard of the parameters, at any moment during the process.
Real time computer control for parameters involved in the process simultaneously.
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 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 EC6C/CCSOF. 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.
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.- Study of the main principles of a proton exchange fuel cell (PEM) operation.

2.- Calculation of the efficiency of a PEM fuel cell.

3.- Study of the influence of air consumption and hydrogen consumption in the efficiency of a PEM fuel cell.

4.- Study of the power density of a PEM fuel cell.

5.- Representation of the polarization curve of a PEM fuel cell.

6.- Determination of the voltage and current density characteristics of a PEM fuel cell.

7.- Influence of hydrogen consumption in the electric power generation.

8.- Study of the influence of the generated power in the efficiency of PEM a fuel cell.

9.- Study of the influence of the reagents' flows in the generation of electrical power.

10.- Study of the use of reagents and transport phenomena.

Additional practical possibilities:

11.- Sensors calibration.

Other possibilities to be done with this Unit:

12.- Many students view results simultaneously.

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

13.- 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.

14.- The Computer Control System with SCADA allows a real industrial simulation.

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

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

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

18.- Control of the EC6C unit process through the control interface box without the computer.

19.- Visualization of all the sensors values used in the EC6C 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 μsec. Program capacity of 32 Ksteps. High-speed counter. Multi-point PID control.
Digital inputs/outputs and analog inputs/outputs Panasonic modules.

-**EC6C/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 EC6C unit process through the control interface box without the computer.
2.- Visualization of all the sensors values used in the EC6C unit process.
3.- Calibration of all sensors included in the EC6C unit process.
4.- Hand on of all the actuators involved in the EC6C 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 EC6C 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 EC6C unit process.
17.- Possibility of creating new process in relation with the EC6C unit.
18.- PLC Programming exercises.
19.- Own PLC applications in accordance with teacher and student requirements.

b) Technical and Vocational Education configuration

⑧ EC6C/CAI. Computer Aided Instruction Software System.

This complete package consists on an Instructor Software (INS/ SOF) totally integrated with the Student Software (EC6C/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.
Print reports.
Develop own examinations.
Detect student's progress and difficulties.
-EC6C/SOF. Computer Aided Instruction Software (Student Software):
It explains how to use the unit, run the experiments and what to do at any moment.
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Theory.
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- Inversion of the performance in ON/OFF controls.
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On/off faults:
- Several on/off faults can be included.

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

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CAL is a class assistant that helps in making the necessary calculations to extract the right conclusions from data obtained during the experimental practices.
CAL will perform the calculations.
CAL computes the value of all the variables involved.
It allows to plot and print the results. Between 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 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, 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 safe 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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