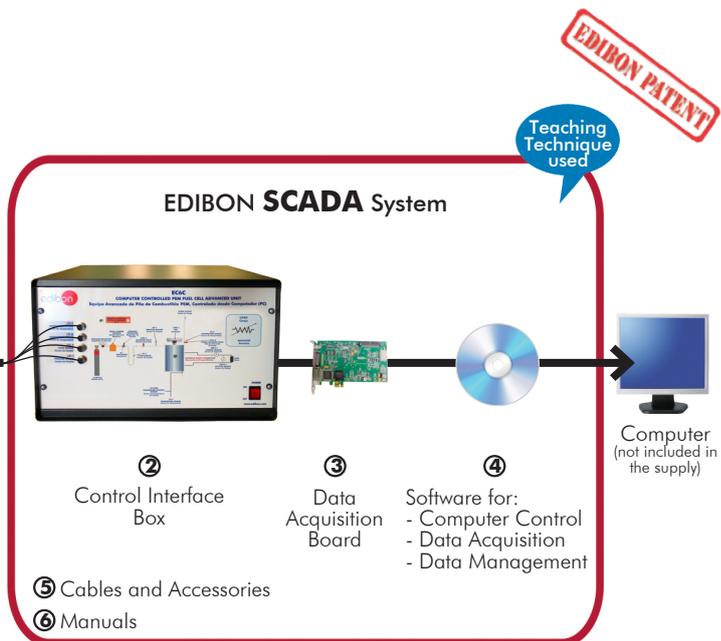




① Unit: EC6C. Computer Controlled PEM Fuel Cell Advanced Unit



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

Key features:

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

For more information about Key Features, click here



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



European Union Certificate (total safety)



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



"Worlddidac Quality Charter" and Platinum Member of Worlddidac

## INTRODUCTION

The current energetic situation is based on an unsustainable model from the economic and environmental points of view. Fuel cells technology offers the possibility of having energy in an efficient, clean and abundant manner, since hydrogen used for their operation is obtained from different sources. A fuel cell is an electrochemical device that transforms chemical energy from a reaction directly into electrical energy.

Although there are several types of fuel cells, each one with advantages, disadvantages and ideal applications, the PEM fuel cell is nowadays the one which offers the best characteristics for portable and automobile applications. This type of device can generate electricity from hydrogen coming from different sources and oxygen from the atmosphere, generating only heat and water as a residue.

## GENERAL DESCRIPTION

The Computer Controlled PEM Fuel Cell Advanced Unit, "EC6C", has been designed to allow the students to understand the fuel cells technology; especially that of a proton exchange membrane fuel cell (PEM). It also enables to calculate 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 cells (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.

Hydrogen storage represents one of the essential points regarding the hydrogen economy. For that purpose, a cylinder of metal hydride (2000 NL) is included. Thanks to the absorption of the hydrogen inside, hydrogen is stored in a safe and certified way. Since the discharge pressure of the metal hydride cylinder is 15 – 20 bars, the "EC6C" unit also includes two pressure regulators: one of them is prepared to be installed in the H<sub>2</sub> cylinder in order to regulate the outlet pressure; the other is placed at the inlet of the metal hydride cylinder in order to regulate the inlet pressure to the stack.

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 (30 A) and low voltage shut down (36 V).

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<sub>2</sub>.

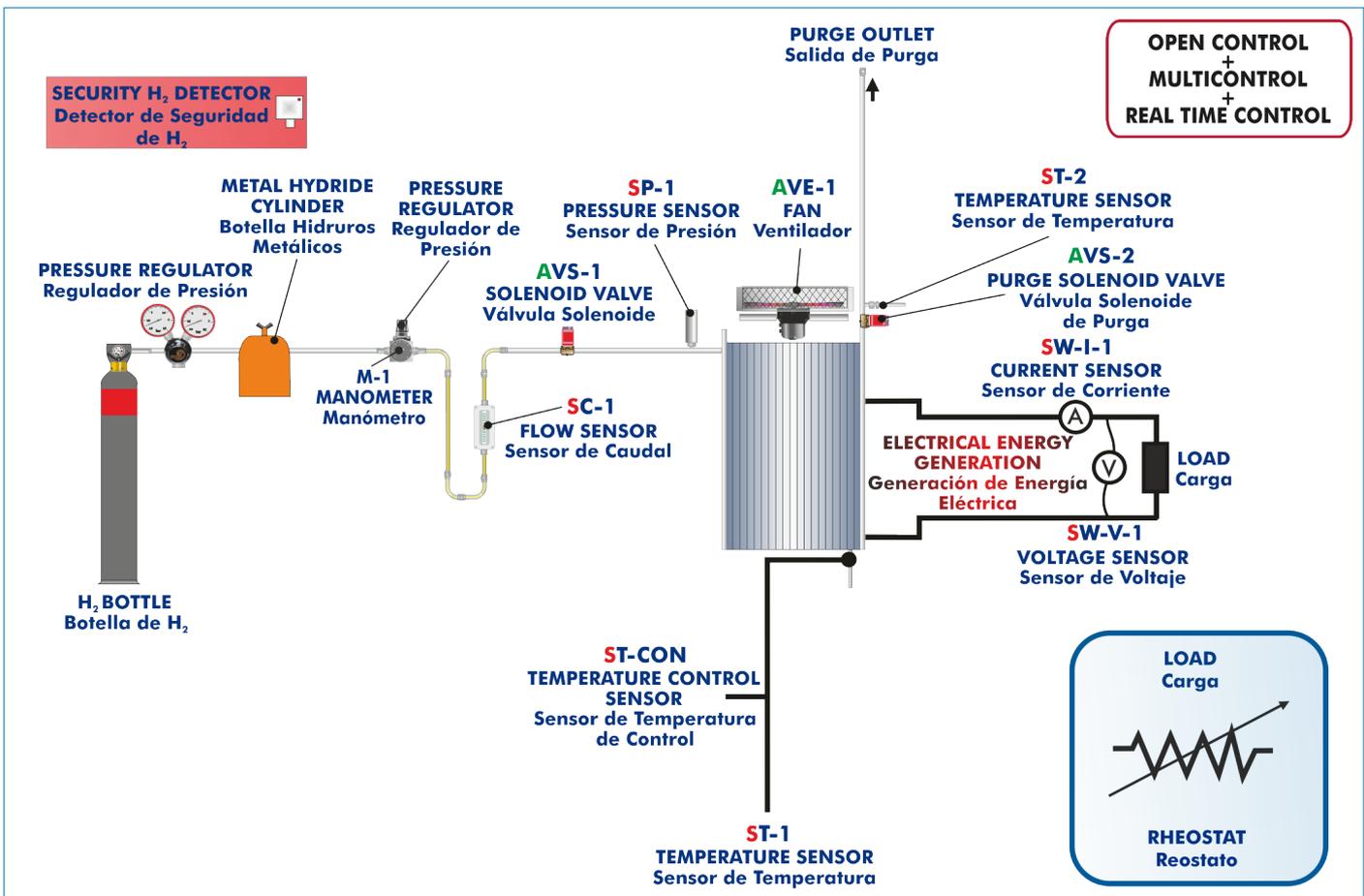
It includes a hydrogen leak detector with a detection range from 0 to 2% Vol. and from 0 to 100% L.E.L. (Lower Explosive Limit) respectively.

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



EC6C detail

## 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 and 10.

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

① **EC6C. Unit:**

Bench-top unit.

Anodized aluminum frame and panels made of painted steel.

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

Metal hydride cylinder with a capacity of 2000 NL for the storage of H<sub>2</sub>.

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

Fan incorporated in the stack.

Solenoid valve to supply H<sub>2</sub>.

Purge solenoid valve.

Pressure regulator for the H<sub>2</sub> 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 hose for use with H<sub>2</sub> with a high safety factor: up to 210 bars.

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

Hydrogen leakage detector (4 – 20 mA; IP65) and software warning.

Battery and charger (12 V).

Failure protection with solenoid valve at the stack inlet:

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

Flow sensor to measure the inlet H<sub>2</sub> 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<sub>2</sub> 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 ICAI software to create, edit and carry out practical exercises, tests, exams, calculations, etc. Apart from monitoring user's knowledge and progress reached.**

**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.**



Unit: EC6C



Detail of the pressure regulator of the H<sub>2</sub> bottle and hose

**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** 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.**

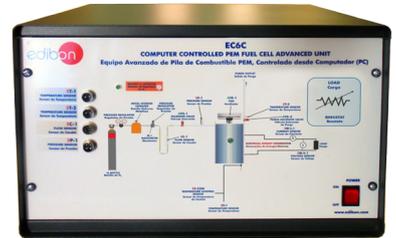
**Real time computer control with flexibility of modifications from the computer keyboard of the parameters, at any moment during the process.**

Real time computer control for pumps, compressors, heating elements, 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.**



EC6C/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 EC6C/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.

**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).**

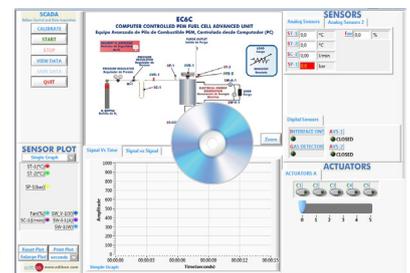
**Calibration system for the sensors involved in the process.**

**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.**



EC6C/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: 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 THE MAIN ITEMS

- 1.- Study of the main principles of a proton exchange fuel cell (PEM) operation.
  - 2.- Study of the structure and main principles of a metal hydride cylinder.
  - 3.- Calculation of the efficiency of a PEM fuel cell.
  - 4.- Study of the influence of air consumption and hydrogen consumption in the efficiency of a PEM fuel cell.
  - 5.- Study of the power density of a PEM fuel cell.
  - 6.- Representation of the polarization curve of a PEM fuel cell.
  - 7.- Determination of the voltage and current density characteristics of a PEM fuel cell.
  - 8.- Influence of hydrogen consumption in the electric power generation.
  - 9.- Study of the influence of the generated power in the efficiency of a PEM fuel cell.
  - 10.-Study of the influence of the reagents' flows in the generation of electrical power.
  - 11.-Study of the use of reagents and transport phenomena.
- Additional practical possibilities:
- 12.-Sensors calibration.
- Other possibilities to be done with this Unit:
- 13.-Many students view results simultaneously.  
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
  - 14.-Open Control, Multicontrol and Real Time Control.  
This unit allows intrinsically and/or extrinsically to change the span, gains; proportional, integral, derivative parameters; etc, in real time.
- 15.-The Computer Control System with SCADA allows a real industrial simulation.
  - 16.-This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
  - 17.-This unit can be used for doing applied research.
  - 18.-This unit can be used for giving training courses to Industries even to other Technical Education Institutions.
  - 19.-Control of the EC6C unit process through the control interface box without the computer.
  - 20.-Visualization of all the sensors values used in the EC6C unit process.
- Several other exercises can be done and designed by the user.

### REQUIRED SERVICES

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

### RECOMMENDED ACCESSORIES (Not included)

- EDILAB-ELEC2. Electrolyzer (60 NI/h).

### REQUIRED CONSUMABLES (Not included)

- Bottle of compressed hydrogen of degree 4.0 (purity of 99.995%) at a pressure of 150 – 200 bars.

### DIMENSIONS AND 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 450 x 470 mm approx.  
(19.29 x 17.71 x 18.50 inches approx.)
- Weight: 12 Kg approx.  
(26.4 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 catalog:

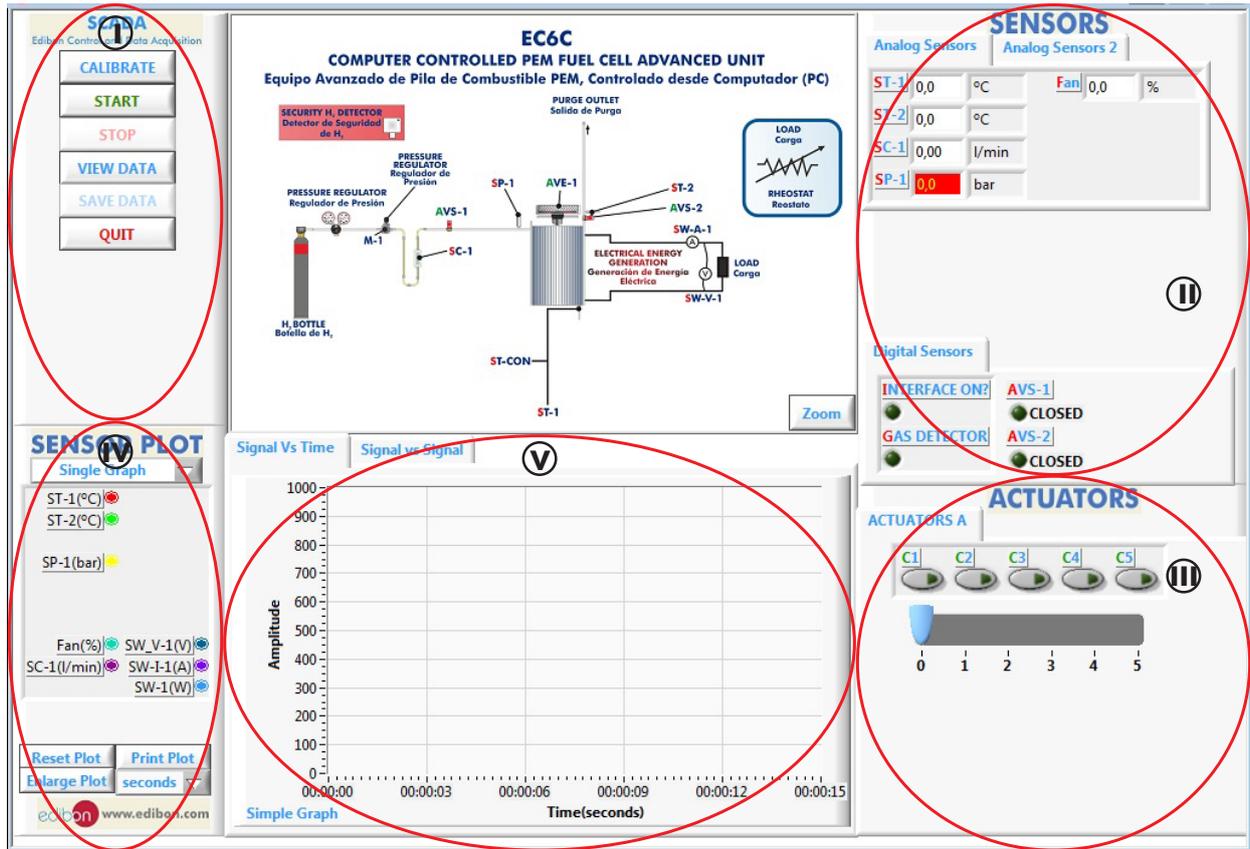
- EC6C. Computer Controlled PEM Fuel Cell Advanced Unit.

#### Offered in other catalog:

- EC6B. PEM Fuel Cell Advanced Unit.

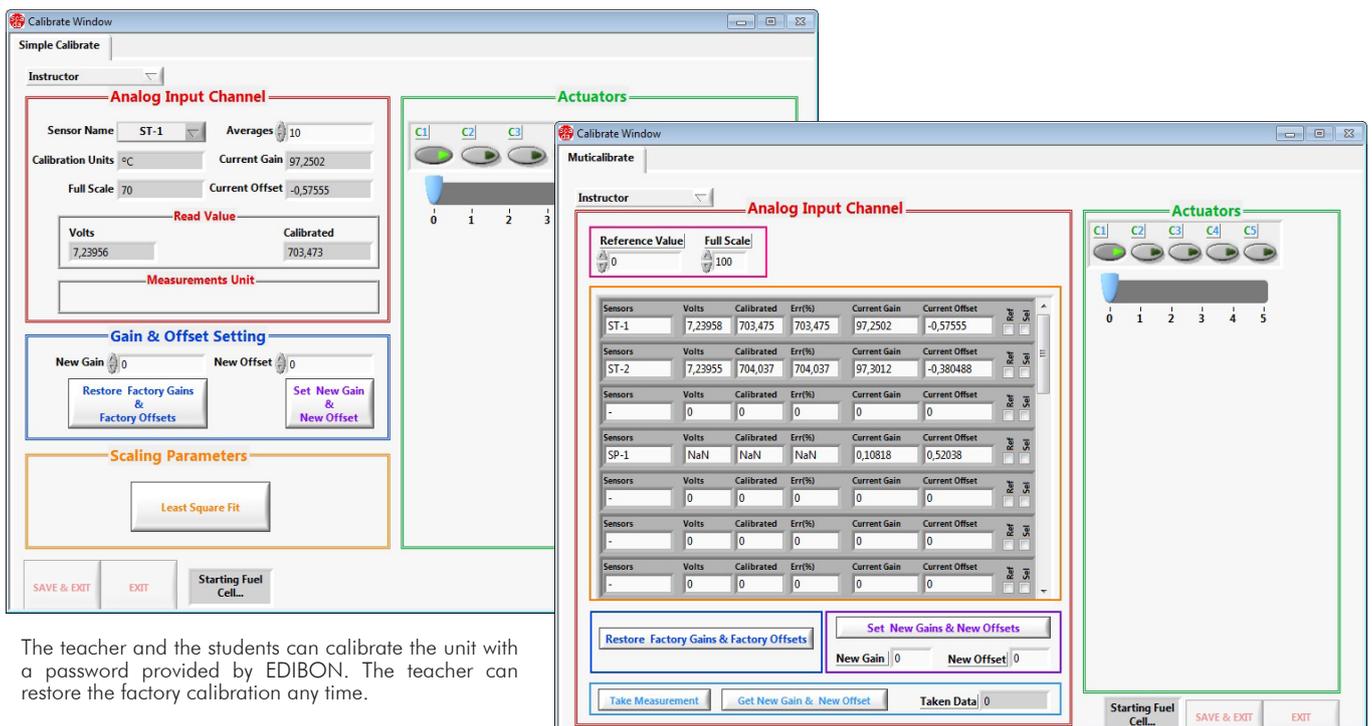
# SOFTWARE MAIN SCREENS

## SCADA Main screen



- ❶ Main software operation possibilities.
- ❷ Sensors displays, real time values, and extra output parameters. Sensors: ST=Temperature sensor. SC=Flow sensor. SP=Pressure sensor. FAN=Porcentaje de air supplied by the fan. SW=Power sensor. SW-V=Voltage sensor. SW-I=Current sensor.
- ❸ Actuators controls. Actuators: C1-C5=Load regulation.
- ❹ Channel selection and other plot parameters.
- ❺ Real time graphics displays.

## Software for Sensors Calibration Example of screens



The teacher and the students can calibrate the unit with a password provided by EDIBON. The teacher can restore the factory calibration any time.

## SOME REAL RESULTS OBTAINED FROM THIS UNIT

Chart representing signal vs signal of the measured variables. Power vs current.

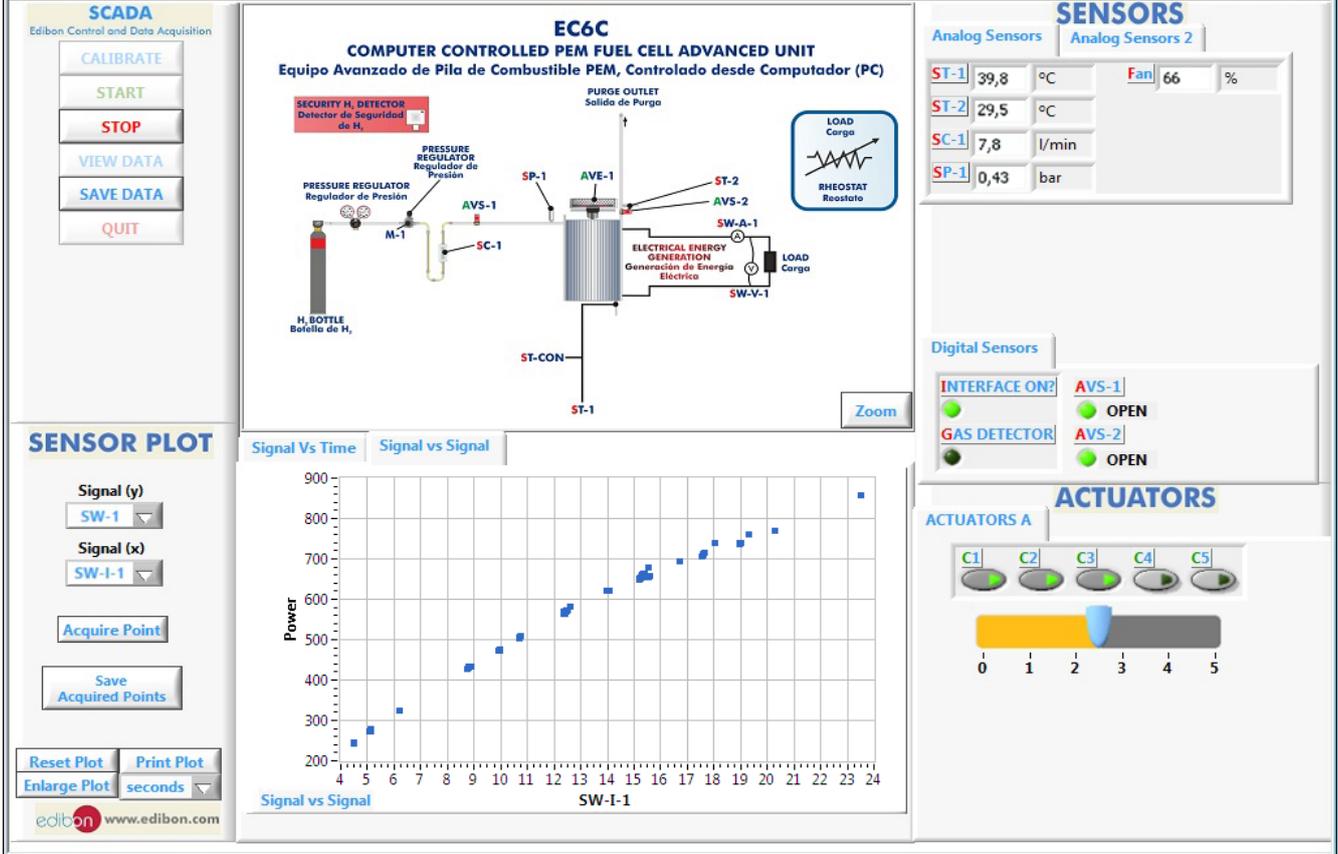
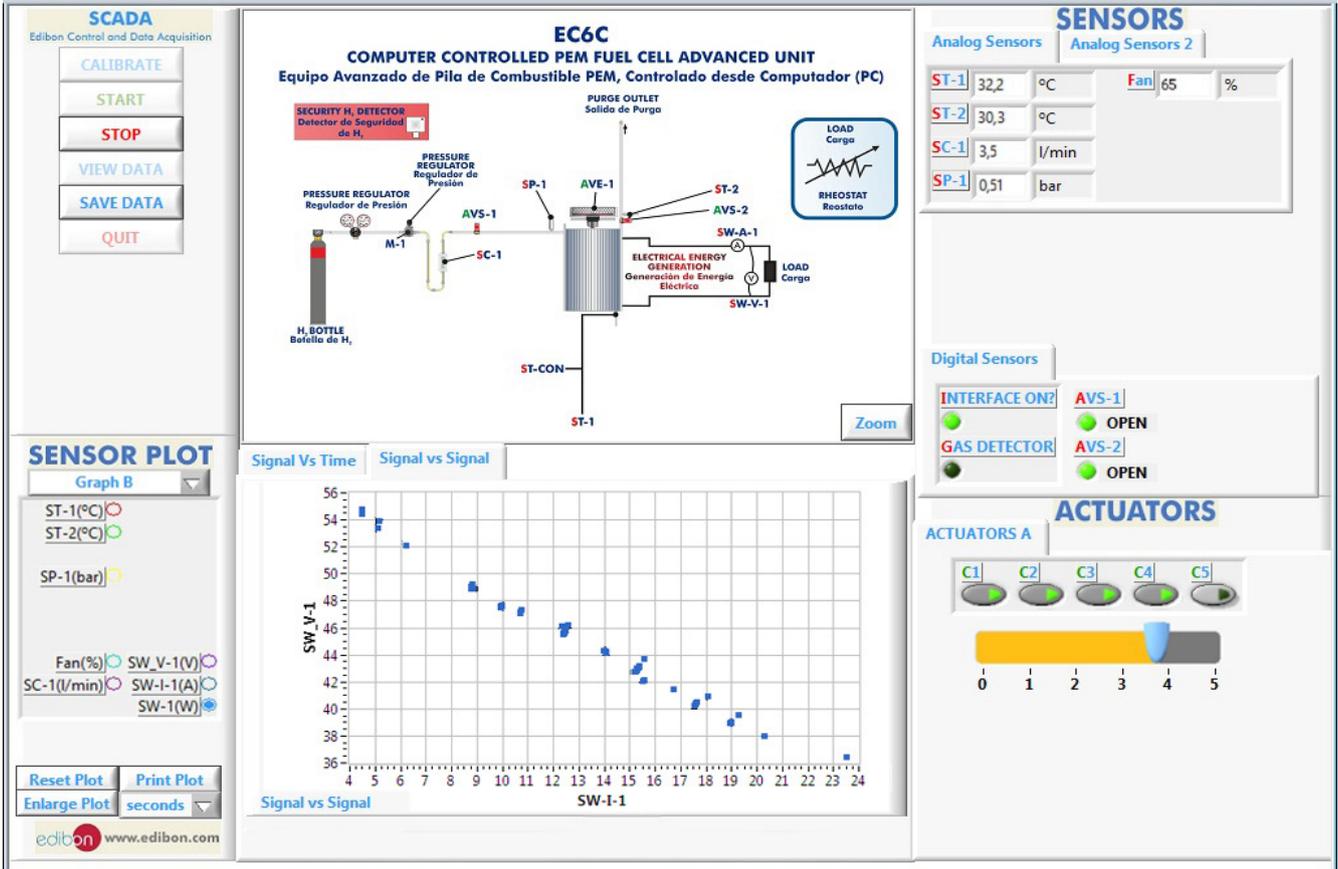


Chart representing signal vs signal of the measured variables. Voltage vs current.



Representation in real time of the measured magnitudes. Two charts to display the H<sub>2</sub> flow and the power and voltage generated.

**SCADA**  
Edibon Control and Data Acquisition

CALIBRATE

START

STOP

VIEW DATA

SAVE DATA

QUIT

**EC6C**  
**COMPUTER CONTROLLED PEM FUEL CELL ADVANCED UNIT**  
Equipo Avanzado de Pila de Combustible PEM, Controlado desde Computador (PC)

Zoom

**SENSORS**

Analog Sensors | Analog Sensors 2

ST-1	42,0	°C	Fan	65	%
ST-2	29,2	°C			
SC-1	6,7	l/min			
SP-1	0,44	bar			

Digital Sensors

INTERFACE ON?	AVS-1
GAS DETECTOR	AVS-2

**ACTUATORS**

ACTUATORS A

C1 C2 C3 C4 C5

0 1 2 3 4 5

**SENSOR PLOT**

Graph B

ST-1(°C) ST-2(°C)

SP-1(bar)

Fan(%) SW\_V-1(V)

SC-1(l/min) SW-I-1(A)

SW-1(W)

Reset Plot Print Plot

Enlarge Plot seconds

edibon www.edibon.com

Signal Vs Time | Signal vs Signal

Graph A

Graph B

Solenoid valves status indication.

**SCADA**  
Edibon Control and Data Acquisition

CALIBRATE

START

STOP

VIEW DATA

SAVE DATA

QUIT

**EC6C**  
**COMPUTER CONTROLLED PEM FUEL CELL ADVANCED UNIT**  
Equipo Avanzado de Pila de Combustible PEM, Controlado desde Computador (PC)

Zoom

**SENSORS**

Analog Sensors | Analog Sensors 2

SW_V-1	42,00	V
SW-I-1	15,70	A
SW-1	660	W

Digital Sensors

INTERFACE ON?	AVS-1
GAS DETECTOR	AVS-2

**ACTUATORS**

ACTUATORS A

C1 C2 C3 C4 C5

0 1 2 3 4 5

**SENSOR PLOT**

Single Graph

ST-1(°C) ST-2(°C)

SP-1(bar)

Fan(%) SW\_V-1(V)

SC-1(l/min) SW-I-1(A)

SW-1(W)

Reset Plot Print Plot

Enlarge Plot seconds

edibon www.edibon.com

Signal Vs Time | Signal vs Signal

Simple Graph

## 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 10.

All these items try to give more possibilities for:

- a) Technical and Vocational Education configuration. (ICAI and FSS)
- b) Multipost Expansions options. (MINI ESN and ESN)

### a) Technical and Vocational Education configuration

#### ⑦ EC6C/ICAI. Interactive Computer Aided Instruction Software System.

This complete software package consists of an Instructor Software (EDIBON Classroom Manager - ECM-SOF) totally integrated with the Student Software (EDIBON Student Labsoft - ESL-SOF). Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students.

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

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

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

Innovative features:

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

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

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

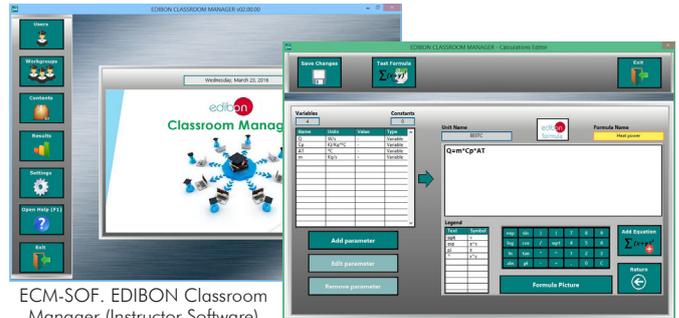
Innovative features:

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

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

[www.edibon.com/en/files/expansion/ICAI/catalog](http://www.edibon.com/en/files/expansion/ICAI/catalog)

### Instructor Software



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

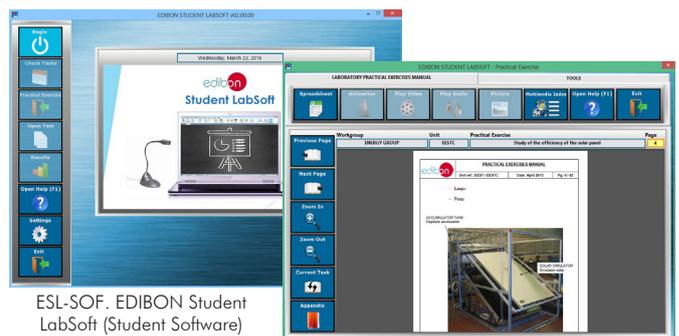
ECAL. EDIBON Calculations Program Package - Formula Editor Screen



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

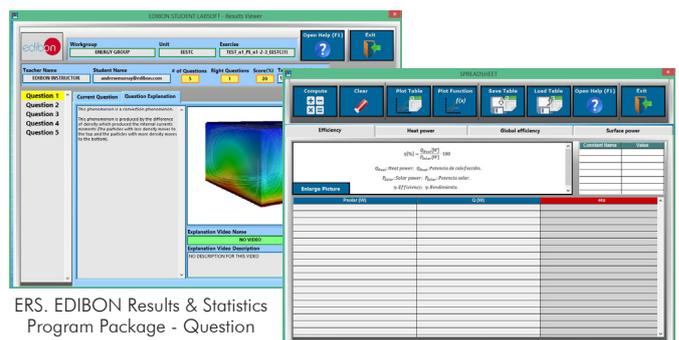
ETTE. EDIBON Training Test & Exam Program Package - Main Screen with Numeric Result Question

### Student Software



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

EPE. EDIBON Practical Exercise Program Package Main Screen



ERS. EDIBON Results & Statistics Program Package - Question Explanation

ECAL. EDIBON Calculations Program Package Main Screen

**⑧ 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.

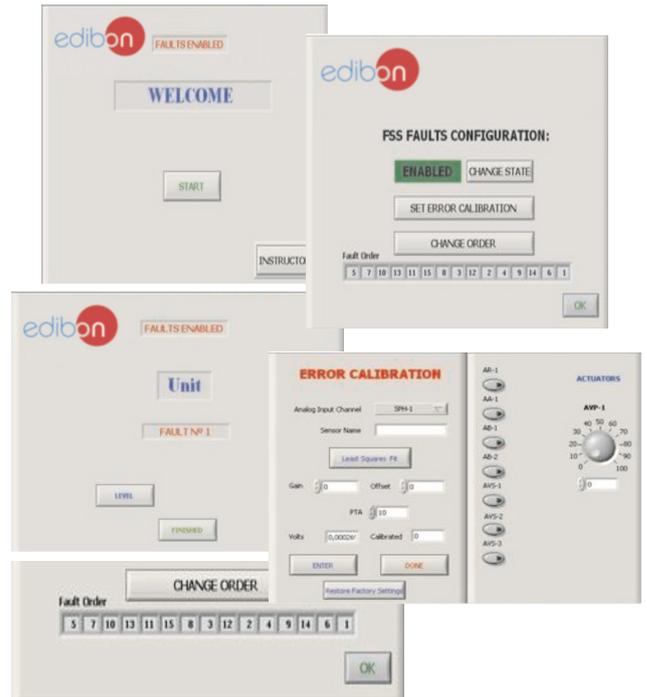
The "FAULTS" mode consists in causing several faults in the unit normal operation. The student must find them and solve them. There are several kinds of faults that can be grouped in the following sections:

- 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.

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

[www.edibon.com/en/files/expansion/FSS/catalog](http://www.edibon.com/en/files/expansion/FSS/catalog)

Example of some screens



b) Multipost Expansions options

**⑨ MINI ESN. EDIBON Mini Scada-Net System for being used with EDIBON Teaching Units.**

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 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 save time and cost.
- Future expansions with more EDIBON Units.

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

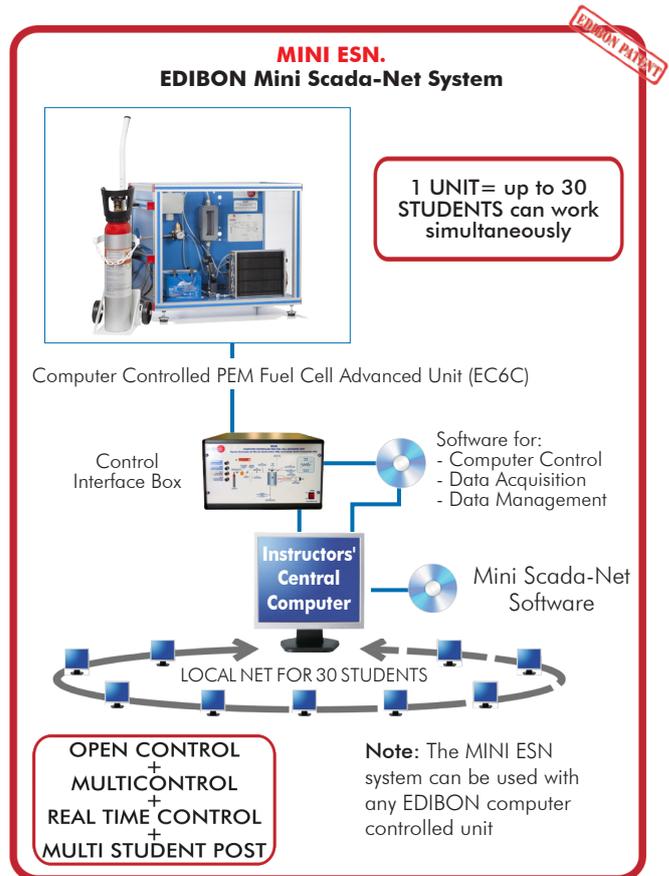
[www.edibon.com/en/files/expansion/MINI-ESN/catalog](http://www.edibon.com/en/files/expansion/MINI-ESN/catalog)

**⑩ ESN. EDIBON Scada-Net Systems.**

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/en/files/expansion/ESN/catalog](http://www.edibon.com/en/files/expansion/ESN/catalog)



## ORDER INFORMATION

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

Minimum supply always includes:

- ① **Unit: EC6C. Computer Controlled 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) Technical and Vocational Education configuration

- ⑦ EC6C/ICAI. Interactive Computer Aided Instruction Software System.
- ⑧ EC6C/FSS. Faults Simulation System.

#### b) Multipost Expansions options

- ⑨ MINI ESN. EDIBON Mini Scada-Net System for being used with EDIBON Teaching Units.
- ⑩ ESN. EDIBON Scada-Net Systems.

**① EC6C. Unit:**

Bench-top unit.  
 Anodized aluminum frame and panels made of painted steel.  
 Diagram in the front panel with distribution of the elements similar to the real one.  
 Metal hydride cylinder with a capacity of 2000 NL for the storage of H<sub>2</sub>.  
 Fuel cell stack with 72 cells and a rated power of 1000 W. Cells are self-humidifying and do not require any type of external humidification.  
 Fan incorporated in the stack.  
 Solenoid valve to supply H<sub>2</sub>.  
 Purge solenoid valve.  
 Pressure regulator for the H<sub>2</sub> 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 hose for use with H<sub>2</sub> with a high safety factor: up to 210 bars.  
 Load module: Rheostat (22 R – 760 W) + four wirewound resistors (10 R – 300 W).  
 Hydrogen leakage detector (4 – 20 mA; IP65) and software warning.  
 Battery and charger (12 V).  
 Failure protection with solenoid valve at the stack inlet:  
     Over current shut down (30 A).  
     Low voltage shut down (36 V).  
     Over temperature shut down in the stack.  
 Flow sensor to measure the inlet H<sub>2</sub> 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<sub>2</sub> 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 ICAI software to create, edit and carry out practical exercises, tests, exams, calculations, etc. Apart from monitoring user's knowledge and progress reached.  
     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 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 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 the Main Items

- 1.- Study of the main principles of a proton exchange fuel cell (PEM) operation.
- 2.- Study of the structure and main principles of a metal hydride cylinder.
- 3.- Calculation of the efficiency of a PEM fuel cell.
- 4.- Study of the influence of air consumption and hydrogen consumption in the efficiency of a PEM fuel cell.
- 5.- Study of the power density of a PEM fuel cell.
- 6.- Representation of the polarization curve of a PEM fuel cell.
- 7.- Determination of the voltage and current density characteristics of a PEM fuel cell.
- 8.- Influence of hydrogen consumption in the electric power generation.
- 9.- Study of the influence of the generated power in the efficiency of a PEM fuel cell.
- 10.-Study of the influence of the reagents' flows in the generation of electrical power.
- 11.-Study of the use of reagents and transport phenomena.

Additional practical possibilities:

- 12.-Sensors calibration.

Other possibilities to be done with this Unit:

- 13.-Many students view results simultaneously.

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

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

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

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

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

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

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

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

- 20.-Visualization of all the sensors values used in the EC6C unit process.

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

### a) Technical and Vocational Education configuration

#### ⑦ EC6C/ICAI. Interactive Computer Aided Instruction Software System.

This complete software package consists of an Instructor Software (EDIBON Classroom Manager - ECM-SOF) totally integrated with the Student Software (EDIBON Student Labsoft - ESL-SOF). Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students.

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

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

Innovative features:

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

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

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

Innovative features:

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

#### ⑧ EC6C/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.

b) Multipost Expansions options

Ⓢ **MINI ESN. EDIBON Mini Scada-Net System for being used with EDIBON Teaching Units.**

MINI ESN. 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 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 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.



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