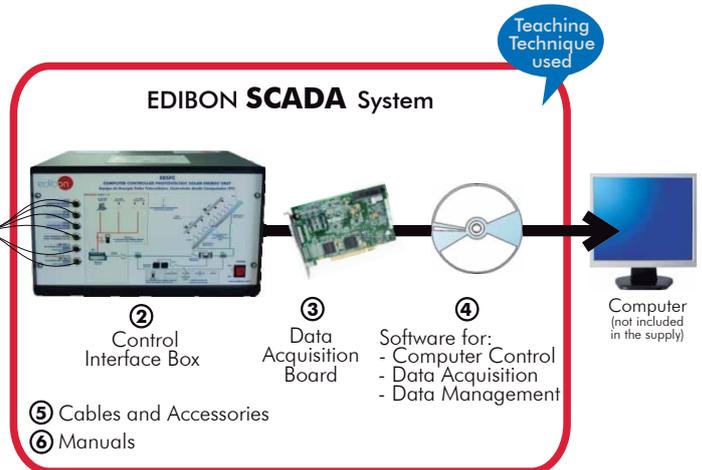




① Unit: EESFC. Photovoltaic Solar Energy Unit



\* 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 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**

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)



## INTRODUCTION

The sun provides a wide spectrum of solar power. With the exception of the light we see around us every day, the rest of the solar power is invisible. Other parts of the spectrum consist of cosmic beams, gamma rays, x-rays, ultraviolet light, infrared light, radio waves and heat.

Solar radiation is a form of energy that can be transformed into other types of usable energy: electric, calorific, etc. The systems that carry out this transformation belong to a set of new clean technologies, which do not harm the environment. The direct conversion of light energy into electrical energy is known as photovoltaic effect.

## GENERAL DESCRIPTION

The Computer Controlled Photovoltaic Solar Energy Unit (EESFC) includes equipment that uses the photo-conversion law for the direct conversion of solar radiation into electricity. The absorbed energy is provided by simulated solar radiation, which in our case is supplied by a panel with powerful light sources (solar lamps).

The unit contains:

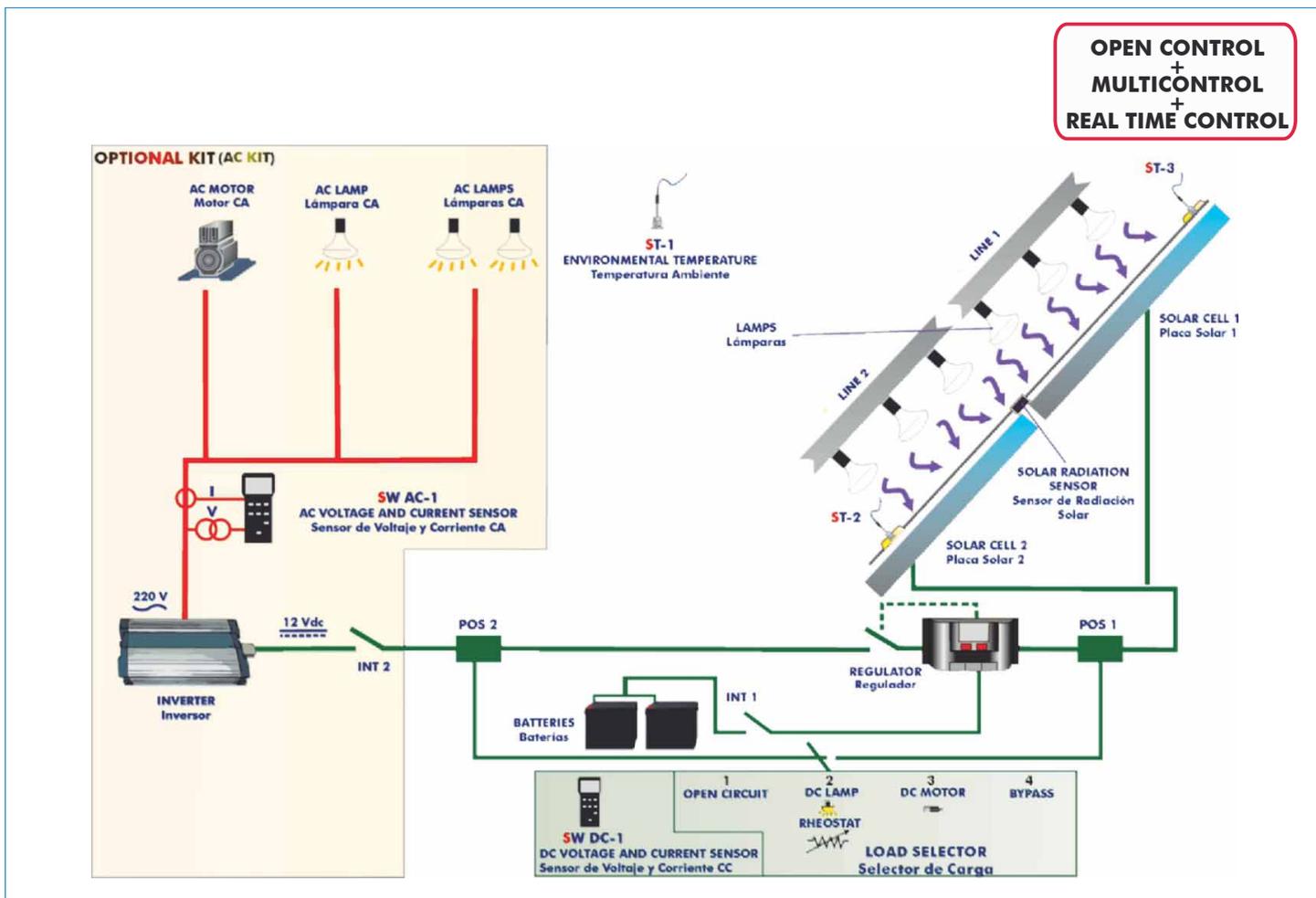
- Photovoltaic solar panels.
- Solar simulator composed of solar lamps.
- Ventilation system.
- DC load and battery charger regulator.
- Auxiliary battery charger.
- Battery.
- DC Loads module.
- Sensors (temperature, light radiation, DC current and DC voltage).

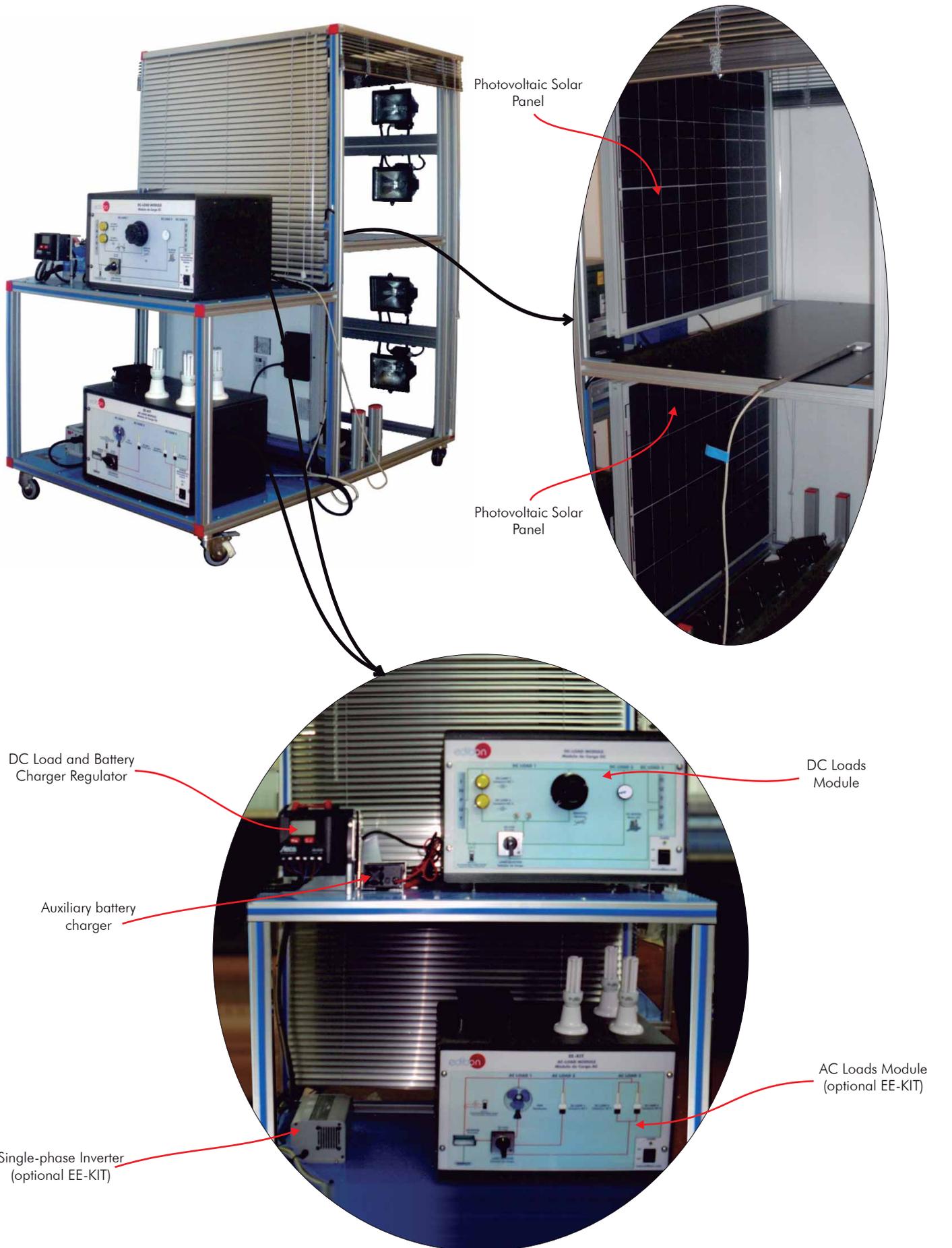
This Computer Controlled Unit is supplied with the EDIBON Computer Control System (SCADA), and includes: The unit itself + a Control Interface Box + a Data Acquisition Board + Computer Control, Data Acquisition and Management Software Packages, for controlling the process and all parameters involved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

Optional (NOT included in the minimum supply):

- EE-KIT. Kit of Conversion and Consumption Simulation (AC):
  - Single-phase inverter.
  - AC Loads Module:
    - 3 Lamps, 1 axial compact fan with plastic guards and 4 positions selector.
  - AC voltage and current sensors.
- EE-KIT2. Grid Connection Inverter Kit:
  - Grid Connection Inverter.
  - Grid Simulator (ESR).

## PROCESS DIAGRAM AND UNIT ELEMENTS ALLOCATION





With this unit there are several options and possibilities:

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

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

**① EESFC. Unit:**

The "EESFC" unit is a computer controlled unit for the study of the conversion of solar energy into electric energy.

Anodized aluminum structure and panels in painted steel.

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

This unit includes wheels for its mobility.

The unit includes:

Two photovoltaic solar panels (polycrystalline):

Tempered glass modules with high level of transmissivity.

Encapsulating material: modified ethylene-vinyl acetate.

Output nominal power: 66W.

Area of the panel: 0.51 m<sup>2</sup>.

Max. current: 3.76 A. Max. voltage: 17.53 V.

36 cells, 156 x 156 mm each.

Solar simulator composed of:

Aluminum frame.

8 Halogen lamps of 400W each one, distributed into two independent voltage regulated circuits.

Electrically safe.

Ventilation system, computer controlled, that allows to analyze the temperature influence on the unit operation, formed by:

4 Axial compact fans with plastic guards.

DC load and battery charger regulator:

It regulates how power generated in the photovoltaic solar panels is distributed to and from the auxiliary battery and to the load. A display informs about the state of the charge, operating parameters and fault messages. The functions of the electronic protection are:

Overvoltage disconnection, short circuit protection of load and module, overvoltage protection at module input, over-temperature and overload protection, and battery overvoltage shutdown.

Auxiliary battery charger:

It carefully assesses the battery and then delivers the optimum charge required.

Battery.

Nominal voltage: 12V. Rated capacity (20 hours rate): 24A/H.

DC loads module:

Metallic box with diagram on the front panel.

2 Lamps of 24V.

One DC motor: voltage: 36V, power: 5W.

Rheostat of 500W.

Independent connection for every load with the help of the 4 positions selector:

Solar panels work at open-circuit.

Rheostat and lamps are connected directly to the solar panels. These loads can be connected individually or in parallel with the aid of manual switches.

The DC motor is directly connected to the solar panels.

The DC load is disconnected and the solar panels are directly connected to the charge regulator.

Sensors:

Solar radiation sensor to study the behaviour of solar photovoltaic panels.

3 "J" type temperature sensors to measure the environmental temperature, the temperature in the solar panel no. 1 and the temperature in the solar panel no. 2.

DC current sensor and DC voltage sensor. The value of DC power can be visualized with the software.

The connection of solar panels in parallel or series, the measurement of the voltage and the current before or after the regulator and the regulation of the light intensity of lamps of the two independent circuits are computer controlled.

The unit includes four blinds to reduce a direct visual contact with the halogen lamps and to reduce the direct contact with the photovoltaic solar panels when the unit is working.

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.**



EESFC. Unit

Optional (NOT included with the minimum supply): See the "Optional" section on page 6.

- EE-KIT. Kit of Conversion and Consumption Simulation (AC):

Single-phase inverter.

AC Loads module:

3 lamps, 1 axial compact fan with plastic guards and 4 positions selector.

AC voltage and current sensors.

- EE-KIT2. Grid Connection Inverter Kit:

Grid Connection Inverter.

Grid Simulator (ESR).

② **EESFC/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, 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.**



EESFC/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 **EESFC/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).**

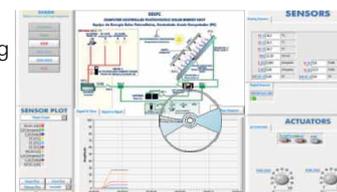
**Calibration system for the sensors involved in the process.**

**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.**



EESFC/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: EESFC + EESFC/CIB + DAB + EESFC/CCSOF + Cables and Accessories + Manuals are included in the minimum supply for enabling normal and full operation.

**EE-KIT. Kit of Conversion and Consumption Simulation (AC):**

• Single-phase inverter:

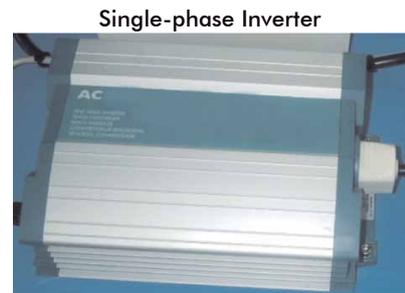
- Single-phase.
- 25 kHz switch mode technology.
- Start-up power of 200%.
- Short-circuit protection.
- High temperature protection.
- Overcharge protection.
- Operation state indicating LED.
- Rear connection/disconnection switch.

• AC Loads Module:

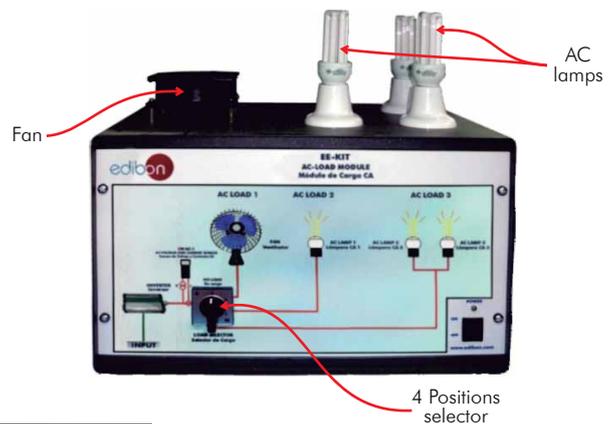
- Metallic box.
- Diagram in the front panel.
- Axial compact fan of 230V with plastic guards.
- 3 Lamps of 220V - 240V, power: 11W.
- Independent connection for every load with the help of the 4 positions selector:

  - Inverter operation with no load.
  - Fan motor connected.
  - One AC lamp connected.
  - Two AC lamps connected in parallel.

• AC voltage and current sensor: The value of AC power can be visualized with the software.



Single-phase Inverter



AC Loads Module

**EE-KIT2. Grid Connection Inverter Kit:**

Inverter used for the conversion and injection to the grid of the power generated by a simulated source of renewable energy. The simulated source is a simulator used to obtain a variable power to be injected to the grid.

The operation mode is displayed by means of an indicating LED at the front side of the housing.

It is equipped with extensive safety measures to ensure that it is immediately switched off as soon as the AC plug is removed from the wall socket or the operation of the public grid fails.

The inverter can be connected to a computer (PC) through a RS232 communication to display some parameters, such as voltage and current inputs, mains voltage and frequency, maximum AC power, Kwh, etc.

• Grid Connection Inverter:

- Input (DC):
  - Nominal power @ 25°C: 150 W.
  - Maximum power @ 25°C: 220 W.
  - MPP voltage: 45-125V DC.
  - Maximum voltage: 155V DC.
  - Nominal current: 3A.
- Output (AC):
  - Voltage: 230V (207 - 253 V).
  - Maximum power, fuse: 2.25 A.
  - Frequency: 50 Hz (49.8 ~ 50.2 Hz).

This unit is supplied with the Grid Simulator (ESR), which simulates a low power grid to inject the power generated by the inverter.

• Grid Simulator (ESR):

ESR is designed to create an isolated low power grid. The unit uses a battery as voltage source and generates a sine signal of 220V/50Hz. The main features of the ESR are:

- Inlet voltage source: battery of 12Vdc.
- Output: 220V/50Hz.
- Isolation transformer.
- Battery charger included.
- Protection fuses.

The user can work with this module safely. The devices included in the EE-KIT2 can be used worldwide.



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

- 1.- Identification and familiarization with all components of the unit and how they are associated with its operation.
- 2.- Determination of the solar panel characteristic parameters.
- 3.- Study of the materials that make up the solar cell.
- 4.- Study of the p and n sides of a solar cell.
- 5.- Study of the I-V and P-V curves.
- 6.- Study of the inverse current or the saturation current.
- 7.- Study of V, I and W according to different loads.
- 8.- Measurement of the open-circuit voltage and the short-circuit current for a solar panel with load.
- 9.- Measurement of the maximum power for a solar panel with load.
- 10.- Study of the relationship between power generated and solar radiation power.
- 11.- Study of the solar panel maximum power.
- 12.- Study of the influence of temperature on the solar panel open-circuit voltage.
- 13.- Determination of the photo-conversion efficiency.
- 14.- Study of the efficiency of the solar panels connected in parallel.
- 15.- Study of the efficiency of the solar panels connected in series.
- 16.- Study of the efficiency, depending on the temperature, of the photovoltaic system connected in parallel.
- 17.- Study of the operation of the photovoltaic generation system supplying power to different DC loads without an auxiliary battery.
- 18.- Study of the photovoltaic power generation system operation with an auxiliary battery and supplying different DC/AC loads.
- 19.- Study of the operation of the photovoltaic system in series/parallel with connection of different loads and without the support of the storage battery.
- 20.- Study of the operation of the photovoltaic system in series/parallel with connection of different loads DC and with the support of the storage battery.

Additional practical possibilities:

- 21.- Sensors calibration.
- 22.- Lamps illumination profile study.
- 23.- Determination of the resistance of a solar cell connected in series and in parallel.

- 24.- Study of the parameters that define the quality of a solar cell.
- 25.- Study of the dependence of the voltage of open circuit ( $V_{\infty}$ ) on the lumens.

Practices to be done with the OPTIONAL KIT "EE-KIT":

- 26.- Study of the operation of the photovoltaic system in series/parallel with connection of different loads and without the support of the storage battery.
- 27.- Study of the operation of the photovoltaic system in series/parallel with connection of different AC loads and with the support of the storage battery.
- 28.- Study of the connection of loads to an alternating voltage of 220V.

Practices to be done with the OPTIONAL KIT "EE-KIT2":

- 29.- Study of the inverter connected to the grid simulator.

Other possibilities to be done with this Unit:

- 30.- Many students view results simultaneously.  
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
- 31.- 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.
- 32.- The Computer Control System with SCADA allows a real industrial simulation.
- 33.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 34.- This unit can be used for doing applied research.
- 35.- This unit can be used for giving training courses to Industries even to other Technical Education Institutions.
- 36.- Control of the EESFC unit process through the control interface box without the computer.
- 37.- Visualization of all the sensors values used in the EESFC 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: three phase, 380V/50Hz, 220V/60Hz, and minimum power 5 kVA.
- Computer (PC).

### DIMENSIONS & WEIGHTS

EESFC:	
Unit:	-Dimensions: 2200 x 1200 x 2005mm. approx. (86.61 x 47.24 x 78.93 inches approx.)
	-Weight: 300 Kg. approx. (661 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.)

### OPTIONAL

- EE-KIT. Kit of Conversion and Consumption Simulation (AC):  
Single-phase inverter.  
AC Loads Module:  
3 Lamps, 1 axial compact fan with plastic guards and 4 positions selector.  
AC voltage and current sensors.
- EE-KIT2. Grid Connection Inverter Kit:  
Grid Connection Inverter.  
Grid Simulator (ESR).
- PSA/PC. Polycrystalline photovoltaic solar panel. (2 units)
- PSA/MC. Monocrystalline photovoltaic solar panel. (2 units)
- PSA/AM. Amorphous photovoltaic solar panel. (2 units)

### AVAILABLE VERSIONS

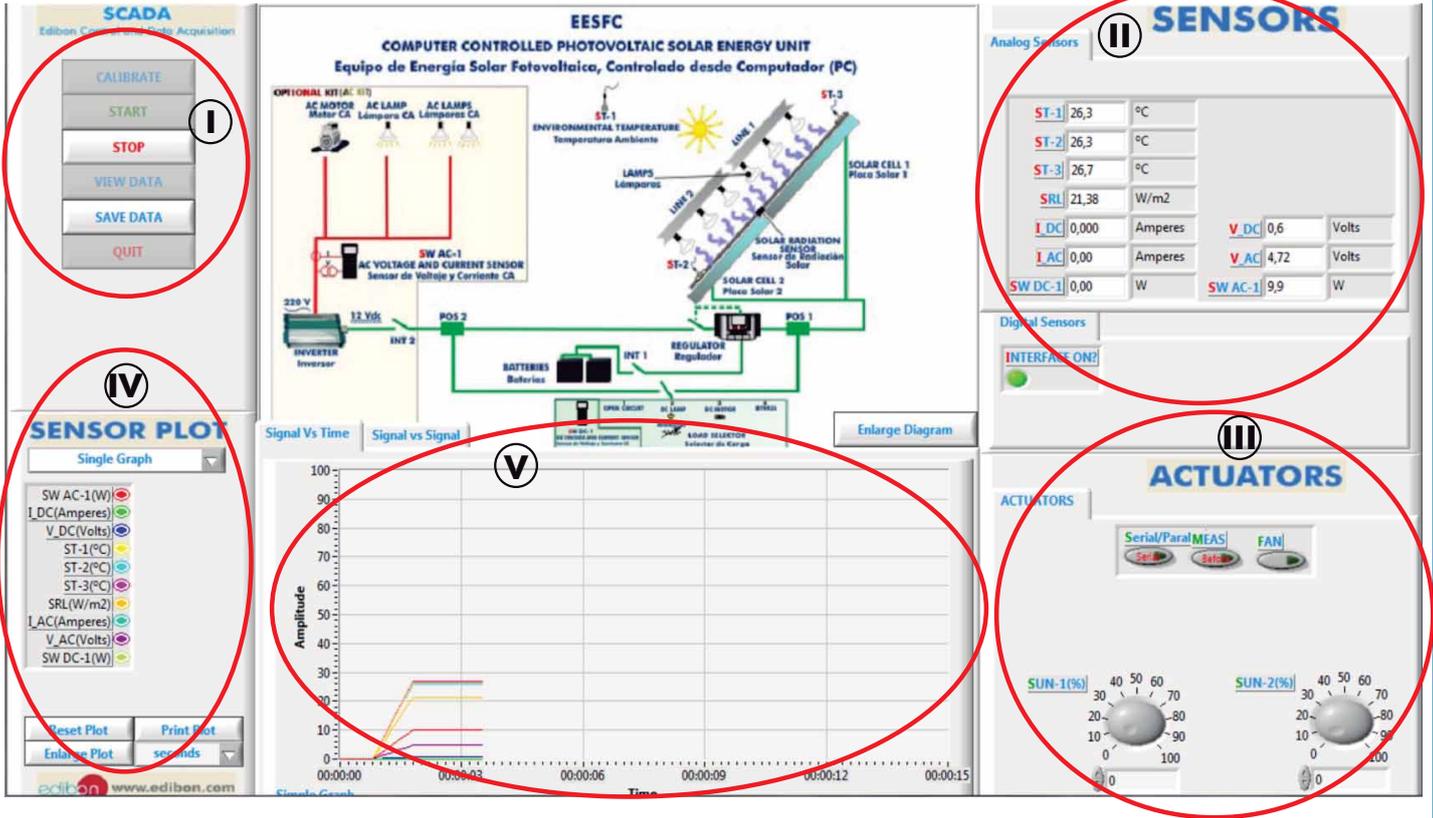
Offered in this catalogue:

- EESFC. Computer Controlled Photovoltaic Solar Energy Unit.

Offered in other catalogues:

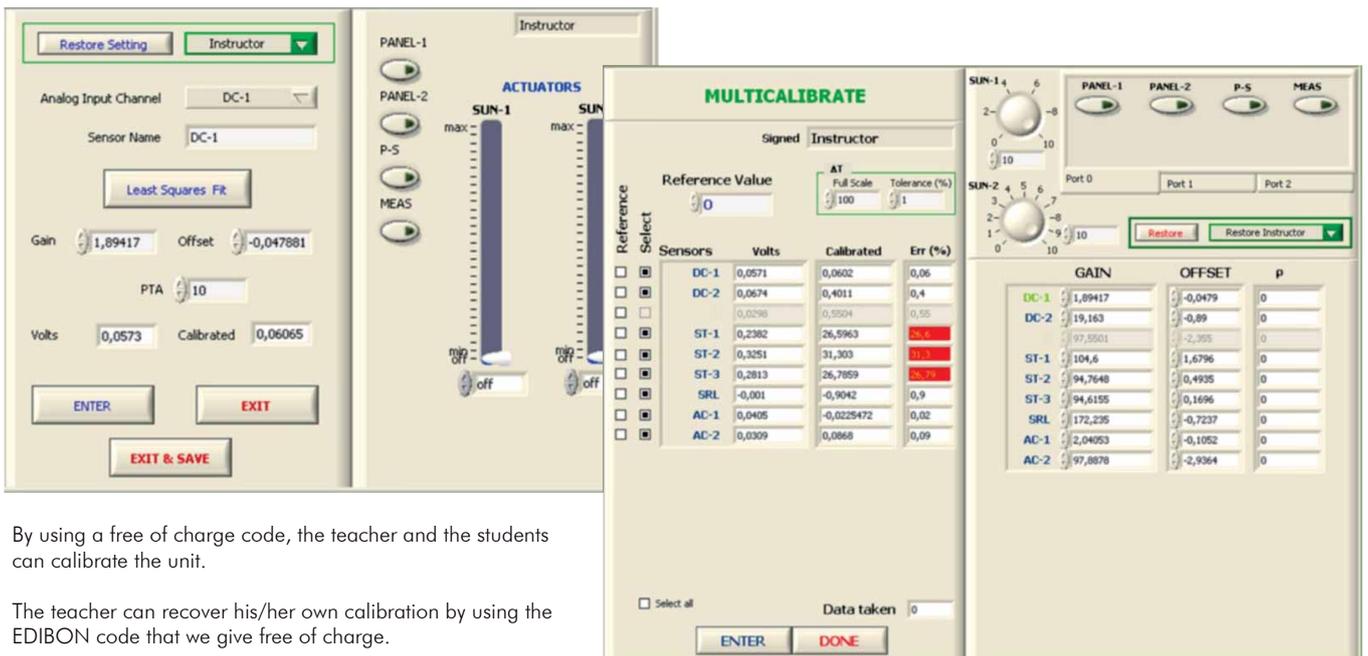
- EESFB. Photovoltaic Solar Energy Unit.
- MINI-EESF. Photovoltaic Solar Energy Modular Trainer.

SCADA  
Main screen



- I Main software operation possibilities.
- II Sensors displays, real time values, and extra output parameters. Sensors: ST= Temperature sensor. SRL= Radiation sensor. I\_DC= DC current sensor. V\_DC= DC voltage sensor. SW DC-1= DC power measurement. With optional EE-KIT: I\_AC= AC current sensor. V\_AC= AC voltage sensor. SW AC-1=AC power measurement.
- III Actuators controls. Actuators: Serial/Paral= Selector for the connection of photovoltaic solar panels in series or in parallel. MEAS= Selector for the measurement of the voltage and the current before or after the regulator. FAN= Ventilation system On/off. SUN-1= Light intensity regulator (lamps of the circuit no. 1). SUN-2= Light intensity regulator (lamps of the circuit no. 2).
- IV Channel selection and other plot parameters.
- V Real time graphics 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

This screen shows the different values of DC voltage versus the values of DC current of the electricity obtained with the two photovoltaic solar panels connected in parallel.

### SCADA

Edibon Control and Data Acquisition

CALIBRATE

START

STOP

VIEW DATA

SAVE DATA

QUIT

### EESFC

#### COMPUTER CONTROLLED PHOTOVOLTAIC SOLAR ENERGY UNIT

Equipo de Energía Solar Fotovoltaica, Controlado desde Computador (PC)

OPTIONAL KIT (AC KIT)  
AC MOTOR Motor CA, AC LAMP Lámpara CA, AC LAMPS Lámparas CA

ENVIRONMENTAL TEMPERATURE Temperatura Ambiente (ST-1)

LAMPS Lámparas

SOLAR CELL 1 Placa Solar 1 (ST-2)

SOLAR CELL 2 Placa Solar 2 (ST-3)

SOLAR RADIATION SENSORS Sensor de Radiación Solar (SRI)

REGULATOR Regulador

BATTERIES Baterías (INT 1)

INVERTER Inversor

SW AC-1 AC VOLTAGE AND CURRENT SENSOR Sensor de Voltaje y Corriente CA

220 V, 12 Ydc, POS 2, POS 1

OPEN CIRCUIT DE CARGA, DE CARGA, DE CARGA, DE CARGA

ADAP. SELECTOR Selector de Carga

Enlarge Diagram

### SENSORS

Analog Sensors

ST-1	27,1	°C
ST-2	27,1	°C
ST-3	27,4	°C
SRI	4,87	W/m2
I_DC	0,138	Amperes
I_AC	0,00	Amperes
SW DC-1	2,83	W
SW AC-1	0,0	W
V_DC	20,5	Volts
V_AC	226	Volts

Digital Sensors

INTERFACE ON!

### SENSOR PLOT

Signal (x) Signal (y)

I\_DC V\_DC

Acquire Point

Save Acquired Points

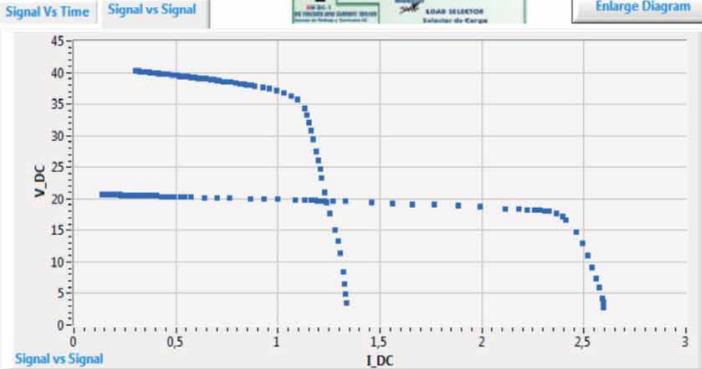
Reset Plot Print Plot

Enlarge Plot seconds

### ACTUATORS

Serial/Parallel/MEAS FAN

SUN-1(%) SUN-2(%)



## 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** (-10V. to +10V.) (through SCSI connector).

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

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

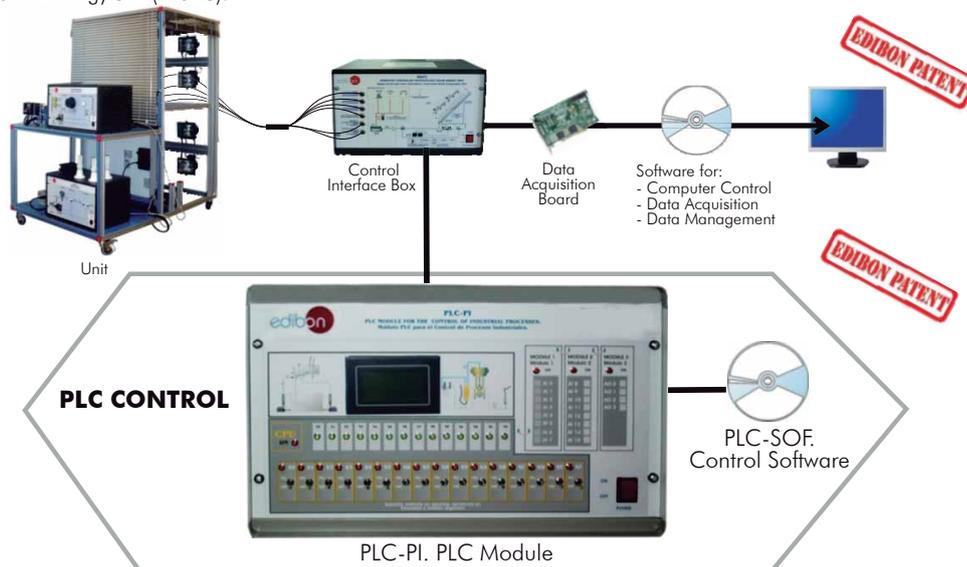
Communication RS232 wire to computer (PC).

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.).

##### **-EESFC/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 Photovoltaic Solar Energy Unit (EESFC).



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

- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>1.- Control of the EESFC unit process through the control interface box without the computer.</li> <li>2.- Visualization of all the sensors values used in the EESFC unit process.</li> <li>3.- Calibration of all sensors included in the EESFC unit process.</li> <li>4.- Hand on of all the actuators involved in the EESFC unit process.</li> <li>5.- Realization of different experiments, in automatic way, without having in front the unit. (This experiment can be decided previously).</li> <li>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).</li> <li>7.- PLC hardware general use and manipulation.</li> <li>8.- PLC process application for EESFC unit.</li> <li>9.- PLC structure.</li> </ul> | <ul style="list-style-type: none"> <li>10.- PLC inputs and outputs configuration.</li> <li>11.- PLC configuration possibilities.</li> <li>12.- PLC programming languages.</li> <li>13.- PLC different programming standard languages.</li> <li>14.- New configuration and development of new process.</li> <li>15.- Hand on an established process.</li> <li>16.- To visualize and see the results and to make comparisons with the EESFC unit process.</li> <li>17.- Possibility of creating new process in relation with the EESFC unit.</li> <li>18.- PLC Programming exercises.</li> <li>19.- Own PLC applications in accordance with teacher and student requirements.</li> </ul> |
|--|--|

b) Technical and Vocational Education configuration

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

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

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

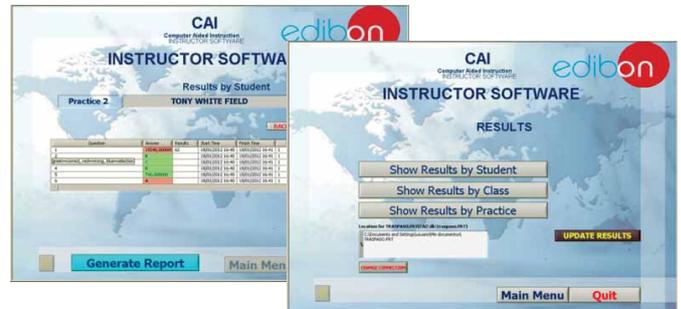
This complete software package consists on an Instructor Software (INS/SOF) totally integrated with the Student Software (EESFC/SOF). Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students.

- 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



- EESFC/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.
- Exam.
- View Instructor/Sonal Videos.
- Save Results.

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

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

Student Software



⑨ **EESFC/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.

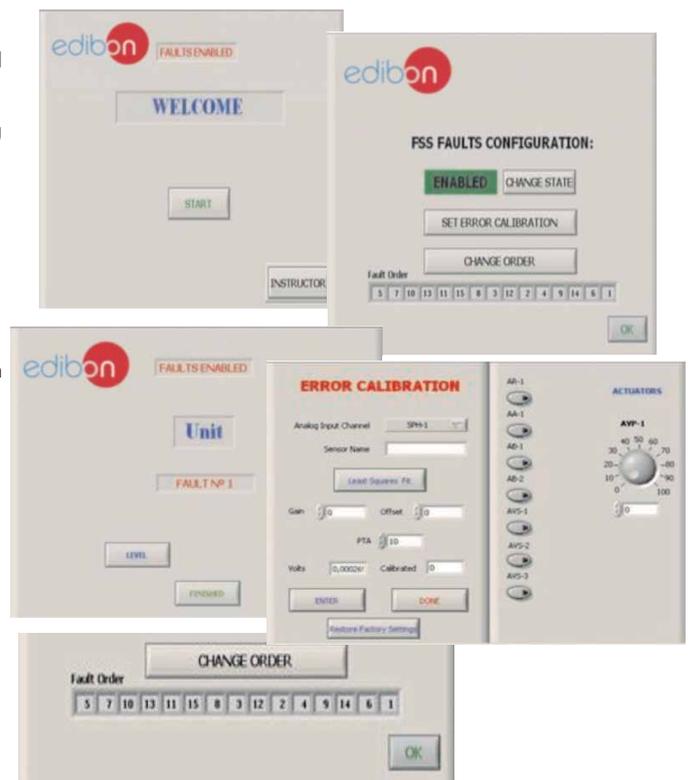
Faults in the controls execution:

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

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

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

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

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

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

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

Different plotting displays.

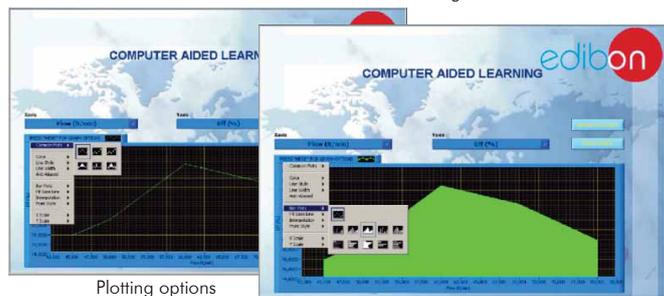
It has a wide range of information, such as constant values, unit conversion factors and integral and derivative tables.

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



Calculations

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



Plotting options

d) Multipost Expansions options

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

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

The Mini ESN system consists on the adaptation of any EDIBON Computer Controlled Unit with SCADA 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).

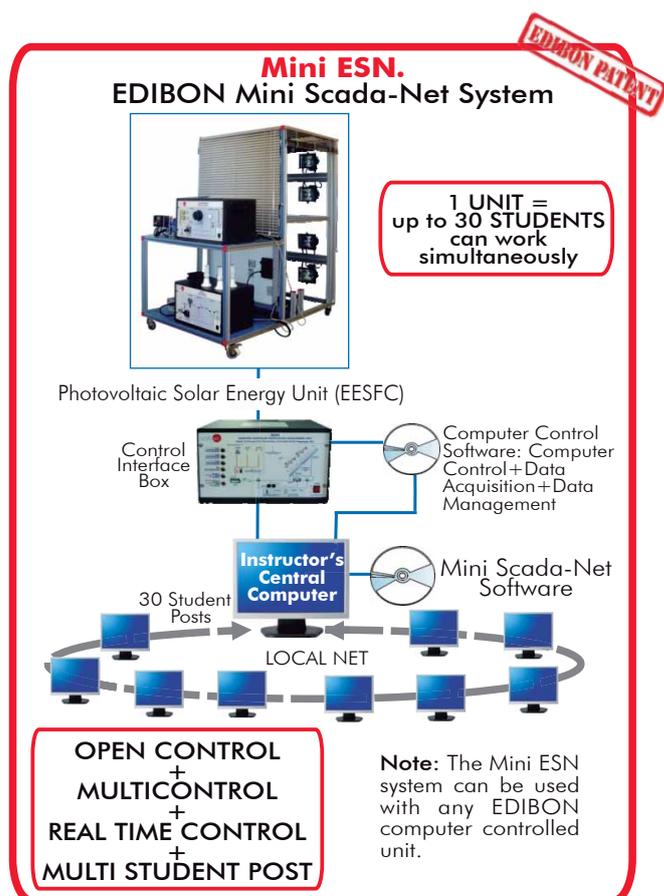
Main characteristics:

- 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/products/catalogues/en/Mini-ESN.pdf](http://www.edibon.com/products/catalogues/en/Mini-ESN.pdf)



⑫ **ESN. EDIBON Scada-Net System.**

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

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

[www.edibon.com/products/catalogues/en/units/energy/esn-alternativeenergies/ESN-ALTERNATIVE\\_ENERGIES.pdf](http://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: EESFC. Photovoltaic Solar Energy Unit.**
- ② **EESFC/CIB. Control Interface Box.**
- ③ **DAB. Data Acquisition Board.**
- ④ **EESFC/CCSOF. Computer Control + Data Acquisition + Data Management Software.**
- ⑤ **Cables and Accessories**, for normal operation.
- ⑥ **Manuals.**

\* **IMPORTANT:** Under EESFC 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.
  - EESFC/PLC-SOF. PLC Control Software.

#### b) Technical and Vocational configuration

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

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

- ⑩ EESFC/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 EESFC. Unit:**

The "EESFC" unit is a computer controlled unit for the study of the conversion of solar energy into electric energy.

Anodized aluminum structure and panels in painted steel.

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

This unit includes wheels for its mobility.

The unit includes:

Two photovoltaic solar panels (polycrystalline):

Tempered glass modules with high level of transmissivity.

Encapsulating material: modified ethylene-vinyl acetate.

Output nominal power: 66W.

Area of the panel: 0,51 m<sup>2</sup>.

Max. current: 3.76 A. Max. voltage: 17.53 V.

36 cells, 156 x 156 mm each.

Solar simulator composed of solar lamps:

Aluminum frame.

8 Halogen lamps of 400W each one, distributed into two independent voltage regulated circuits.

Electrically safe.

Ventilation system, computer controlled, that allows to analyze the temperature influence on the unit operation, formed by:

4 Axial compact fans with plastic guards.

DC load and battery charger regulator:

It regulates how power generated in the photovoltaic solar panels is distributed to and from the auxiliary battery and to the load. A display informs about the state of the charge, operating parameters and fault messages. The functions of the electronic protection are:

Overvoltage disconnection, short circuit protection of load and module, overvoltage protection at module input, over-temperature and overload protection, and battery overvoltage shutdown.

Auxiliary battery charger:

It carefully assesses the battery and then delivers the optimum charge required.

Battery.

Nominal voltage: 12V. Rated capacity (20 hours rate): 24A/H.

DC loads module:

Metallic box with diagram on the front panel.

2 Lamps of 24V.

One DC motor: voltage: 36V, power: 5W.

Rheostat of 500W.

Independent connection for every load with the help of the 4 positions selector:

Solar panels work at open-circuit.

Rheostat and lamps are connected directly to the solar panels. These loads can be connected individually or in parallel with the aid of manual switches.

The DC motor is directly connected to the solar panels.

The DC load is disconnected and the solar panels are directly connected to the charge regulator.

Sensors:

Solar radiation sensor to study the behaviour of solar photovoltaic panels.

3 "J" type temperature sensors to measure the environmental temperature, the temperature in the solar panel no. 1 and the temperature in the solar panel no. 2.

DC current sensor and DC voltage sensor. The value of DC power can be visualized with the software.

The connection of solar panels in parallel or series, the measurement of the voltage and the current before or after the regulator and the regulation of the light intensity of lamps of the two independent circuits are computer controlled.

The unit includes four blinds to reduce a direct visual contact with the halogen lamps and to reduce the direct contact with the photovoltaic solar panels when the unit is working.

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.

Optional (NOT included with the minimum supply):

-EE-KIT. Kit of Conversion and Consumption Simulation (AC):

Single-phase inverter.

AC Loads module:

3 lamps, 1 axial compact fan with plastic guards and 4 positions selector.

AC voltage and current sensors.

-EE-KIT2. Grid Connection Inverter Kit:

Grid Connection Inverter.

Grid Simulator (ESR).

**② EESFC/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 EESFC/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.- Identification and familiarization with all components of the unit and how they are associated with its operation.
- 2.- Determination of the solar panel characteristic parameters.
- 3.- Study of the materials that make up the solar cell.
- 4.- Study of the p and n sides of a solar cell.
- 5.- Study of the I-V and P-V curves.
- 6.- Study of the inverse current or the saturation current.
- 7.- Study of V, I and W according to different loads.
- 8.- Measurement of the open-circuit voltage and the short-circuit current for a solar panel with load.
- 9.- Measurement of the maximum power for a solar panel with load.
- 10.- Study of the relationship between power generated and solar radiation power.
- 11.- Study of the solar panel maximum power.
- 12.- Study of the influence of temperature on the solar panel open-circuit voltage.
- 13.- Determination of the photo-conversion efficiency.
- 14.- Study of the efficiency of the solar panels connected in parallel.
- 15.- Study of the efficiency of the solar panels connected in series.
- 16.- Study of the efficiency, depending on the temperature, of the photovoltaic system connected in parallel.
- 17.- Study of the operation of the photovoltaic generation system supplying power to different DC loads without an auxiliary battery.
- 18.- Study of the photovoltaic power generation system operation with an auxiliary battery and supplying different DC/AC loads.
- 19.- Study of the operation of the photovoltaic system in series/parallel with connection of different loads and without the support of the storage battery.
- 20.- Study of the operation of the photovoltaic system in series/parallel with connection of different loads DC and with the support of the storage battery.

Additional practical possibilities:

- 21.- Sensors calibration.
- 22.- Lamps illumination profile study
- 23.- Determination of the resistance of a solar cell connected in series and in parallel.
- 24.- Study of the parameters that define the quality of a solar cell.
- 25.- Study of the dependence of the voltage of open circuit ( $V_{\infty}$ ) on the lumens.

Practices to be done with the OPTIONAL KIT "EE-KIT":

- 26.- Study of the operation of the photovoltaic system in series/parallel with connection of different loads and without the support of the storage battery.
- 27.- Study of the operation of the photovoltaic system in series/parallel with connection of different AC loads and with the support of the storage battery.
- 28.- Study of the connection of loads to an alternating voltage of 220V.

Practices to be done with the OPTIONAL KIT "EE-KIT2":

- 29.- Study of the inverter connected to the grid simulator.

Other possibilities to be done with this Unit:

- 30.- Many students view results simultaneously.  
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
- 31.- 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.
- 32.- The Computer Control System with SCADA allows a real industrial simulation.
- 33.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 34.- This unit can be used for doing applied research.
- 35.- This unit can be used for giving training courses to Industries even to other Technical Education Institutions.
- 36.- Control of the EESFC unit process through the control interface box without the computer.
- 37.- Visualization of all the sensors values used in the EESFC 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.

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

b) Technical and Vocational Education configuration

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

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

-EESFC/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 EESFC/FSS. Faults Simulation System.**

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

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- Response reduction of an actuator.

Faults in the controls execution:

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

On/off faults:

- Several on/off faults can be included.

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

⑩ **EESFC/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.

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

d) Multipost Expansions options

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

The system basically will consist of:

This system is used with a Computer Controlled Unit.

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

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



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REPRESENTATIVE:

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