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Engineering and Technical Teaching Equipment

Microgrid Power Systems

AEL-MGP

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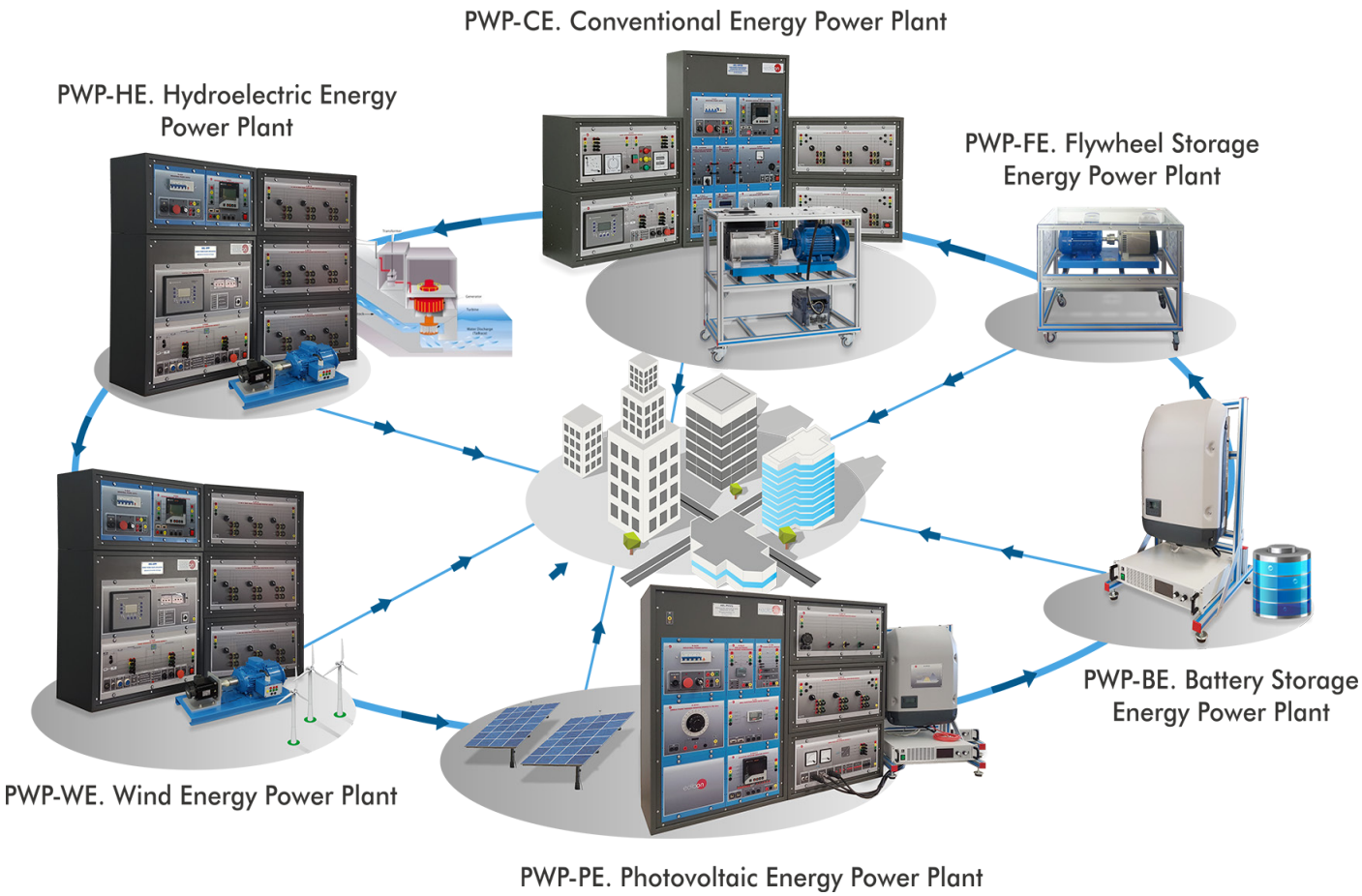
↳5.- ENERGY



Configuration example of AEL-MGP application

INTRODUCTION

The current electrical system shows a mainly centralized topology for energy production. That is to say, most of the electrical energy generation comes from large power plants interconnected through power transmission lines. This huge structure is contingent upon the main energy companies, being the energy sector one of the biggest monopolies in the world. However, this coarse and inefficient electrical system is progressively overshadowed by the expansion of renewable energies.

The current energy scenario is mostly based on conventional power generation plants and large-sized transmission systems. Due to this, the need of searching for new and better ways to obtain and manage the available energy resources has arisen. The implementation of systems which include little generators based on renewable energies and placed close to the consumption points, has resulted in Microgrids. A microrgrid is defined as an interconnected group of load and preferably renewable distributed generation resources (DERs, Distributed Energy Resources), which has definite surroundings and acts as a single element able to operate disconnected or connected to the national grid.

This energy paradigm is almost a fact thanks to the latest advances in telecommunications and power electronics, the implementation of new control algorithms and the greater knowledge about the potential of renewable energies and its feasible coexistence.

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

GENERAL DESCRIPTION

The Microgrid Power System, "AEL-MGP", has been designed for the theoretical-practical training on microgrid power systems. This system allows studying the architecture, management and the main control maneuvers carried out in a hybrid context based on renewable energies. This is power system which stands for the set of renewable resources (photovoltaic, wind and hydroelectric) integrated into an isolated grid for power production. Moreover, the design of this system has been done with actual scaled industrial elements with the aim of gaining the maximum experience with the management of a microgrid.

Generator-Motor Group detail

The "AEL-MGP" Microgrid Power System is constituted by a set of applications recommended to study the different scenarios that can occur in a micro grid. Due to the diversity of micro grids Edibon recommends a set of applications with the purpose of the user selecting those based on the situations he wants to study. The recommended applications are as follows: Conventional Energy Power Plants, Hydroelectric Power Power Plants, Wind Power Plants, Energy Storage Power Plants with Batteries and Energy Storage Power Plants with Flywheel.

- **PWP-CE. Conventional Energy Power Plant.**

This power plant is required to work with any other power plant offered in this catalog. Its purpose is, as in a real Micro Grid, to create the basis of the structure of the micro grid and determine the frequency and voltage parameters of the latter. The rest of the power plants will be synchronized to this thanks to the stability produced. In addition, this application acts as a base generation in the micro grid, providing constant power. As in real micro grids, this application represents diesel or gas power plants, normally used in islands or other systems based on micro grids.

Generator Excitation Circuit Detail

It is essential that this application is complemented with some of the renewable energy applications recommended in this catalog in order to create a complete micro grid.

This application includes a turbine-generator group consisting of an electric motor (turbine) coupled to a three-phase synchronous generator for generating electricity. For the control of the turbine-generator group, a digital multifunction controller (AVR and ASC) is included, which will allow an optimal regulation of all its electrical and mechanical parameters. The most relevant control parameters are the turbine speed, the generator frequency, the excitation current, the voltage and the P, Q and S powers of the generator. In addition, this control module is also an advanced protection of generators and turbines. It complies with the ANSI standard regarding the protection parameters of generators and turbines (ANSI 81O, ANSI 81U, ANSI 59, ANSI 27, ANSI 50/51, ANSI 32R / F, ANSI IOP 32, ANSI MOP 32, ANSI 46 , Voltage Asymmetry, Generator Ground Fault, Phase Rotation, ANSI IEC 255, Generator Lagging Power Factor, among others).

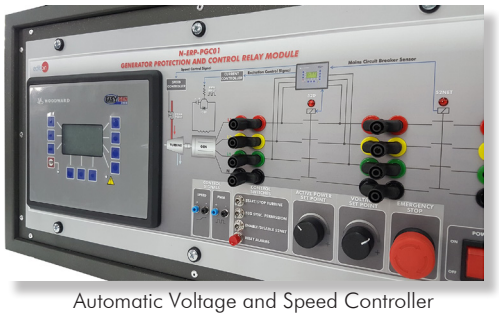
On the other hand, this application also includes a dynamic load control module as a point of power consumption in the micro grid. This programmable module allows to elaborate real demand curves, programming the maximum and minimum power consumption as well as the times of valley consumption This process of generating demand profiles allows to study the different management and control maneuvers carried out in the micro grid by the electric operator (user). The application also includes the network analyzers necessary for the measurement of the electrical parameters of the micro grid such as the energy generated and the energy consumed by the dynamic load. These analyzers meet the standards of "Smart Metering" by having two-way communication with the other elements of the network for optimal management of it.

- **PWP-HE. Hydroelectric Power Plants.**

  The purpose of this application is the study of hydroelectric power plants in the context of micro grids. Hydroelectric power plants have a great capacity to supply energy at certain times of maximum demand due to their rapid response. Therefore, this application consists of a turbine-generator group whose purpose is to provide energy to the micro grid, making an intelligent energy distribution based on the decisions of the operator (user). The application includes a network analyzer to measure in real time the energy produced by the hydroelectric power plant. For the control of the turbine-generator group, a digital multifunction controller (AVR and ASC) is included, which will allow an optimal regulation of all its electrical and mechanical parameters. Among many of the parameters, it is possible to control the "set point" of the generator's active power to automatically control how much active power we want to inject into the micro grid. The multifunction controller is of vital importance, since it is the one in charge of managing the distribution of power between the different generators present in the micro grid.

- **PWP-WE. Wind Power Plants.**

  The purpose of this application is the study of wind power plants in the context of micro grids. It consists of an induction turbine-generator group whose purpose is to provide energy to the micro grid by making an intelligent energy distribution based on the decisions of the operator (user). For this, the application includes a network analyzer to measure in real time the energy produced by the wind power plant. For the control of the turbine-generator group, a digital multifunction controller (AVR and ASC) is included, which will allow an optimal regulation of all its electrical and mechanical parameters. Among many parameters, it is possible to control the "set point" of active power to automatically select how much power we want to inject into the micro grid. The multifunction controller is of vital importance, since it is the one in charge of managing the distribution of power between the different energy sources.



Automatic Voltage and Speed Controller (AVR, ASC) detail

- **PWP-PE. Phototvoltaic Power Plants.**

  The purpose of this application is the study of photovoltaic power plants in the context of micro grids. It consists of a three-phase inverter fed with a photovoltaic panel array simulator. The user will be able to set the generation parameters and functions for the photovoltaic simulator according to the scernarios and conditions meant to be studied. At the same time, the user will be able to study significant concepts about photovoltaic installations such as the MPPT characteristic (maximum power point tracking), the limitation of the inverter power (derating), the efficiency of the inverter or the reactive energy generation. This application includes a network analyzer to measure in real time the energy produced by the photovoltaic power plant.

- **PWP-BE. Batteries Energy Storage Power Plant.**

  The purpose of this application is to demonstrate the importance of energy storage in isolated environments. There are cases in which due to the absence of wind or photovoltaic energy we have no other option than to resort to the storage of chemical energy by means of batteries. This application consists of a bidirectional inverter whose purpose is to store energy in a battery, also included, and in moments when demand requires it to quickly supply said energy. The advantage of this type of applications is that, since they are power electronics, they have a high response speed. In this way, power plants such as hydroelectric or wind power have enough time to react to sudden changes in demand. In periods of over energy production, batteries use that surplus to store it.

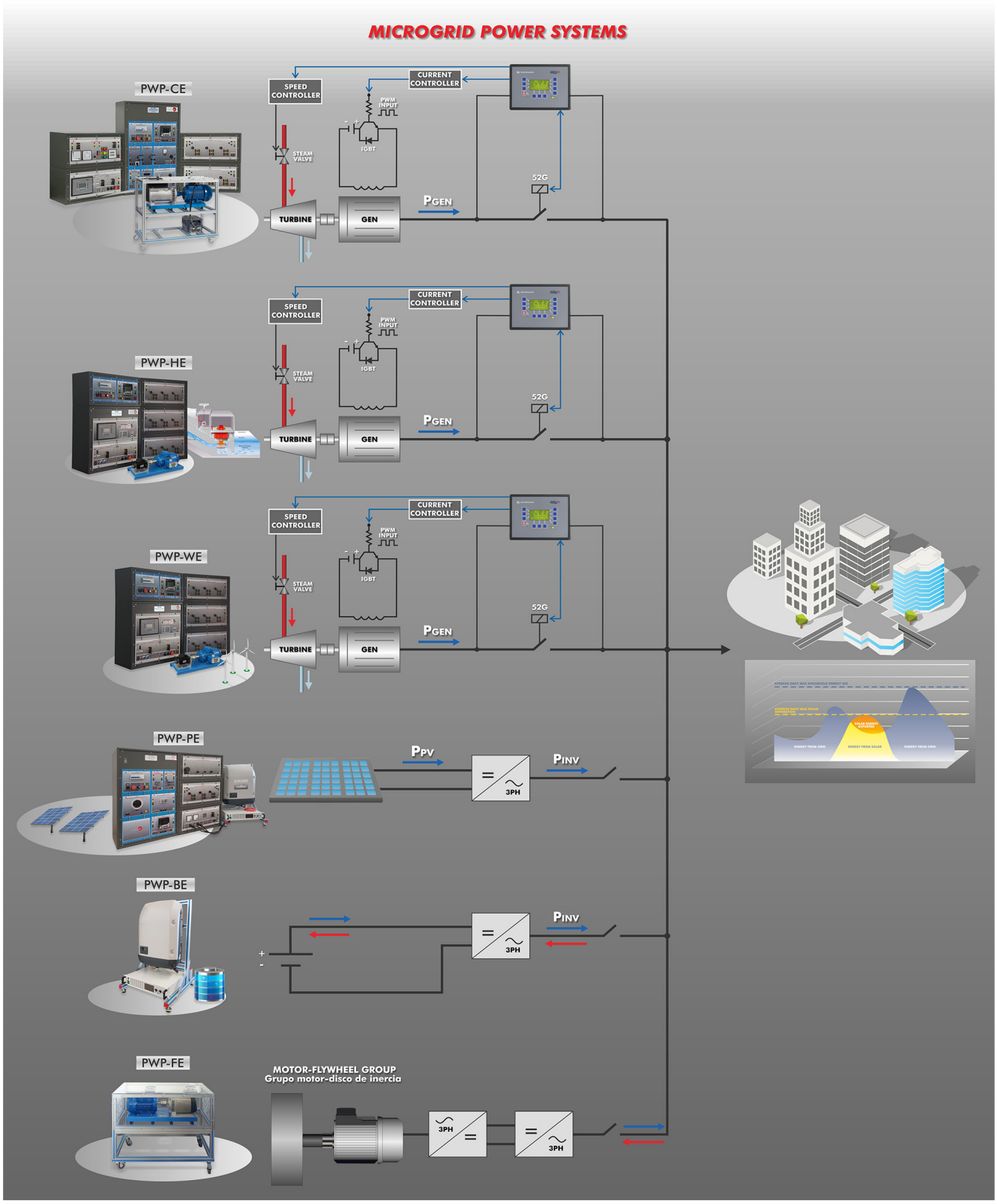
- **PWP-FE. Flywheel Storage Power Plant.**

  The purpose of this application is to demonstrate the importance of energy storage in isolated environments. In this case, it is a sophisticated application in charge of storing kinetic energy through a flywheel. It has a bidirectional inverter that allows you to take energy from the micro grid and then return it in specific moments of need. The advantage of this type of applications is that, since they are power electronics (bidirectional inverter), they have a high response speed. In this way, power plants such as hydroelectric or wind have enough time to react to sudden changes in demand.

In addition, it is also offered the possibility to acquire a kit for the study of faults in microgrids, consisting of an advanced protection relay with configurable numerical programming which allows showing the features of feeder protection relays, one power switch module as interrupting device and a fault injection module for the injection of single-phase, two-phase or three-phase, to earth, faults.

It is also recommended to acquire the control and data acquisition software, EMG-SCADA (Energy Manager and Data Acquisition Software), which stands for the operation and control center of a microgrid (MGCC, Microgrid Control Center). From this software, the user will be able to plan the wind, photovoltaic and hydroelectrical resources. On the basis of this predefined planning, the renewable energy generation sources will inject the available energy into the microgrid in order to meet the demand requirements. Meanwhile, the user will be able to visualize the power curves resulting from the conventional, wind, photovoltaic and hydroelectric generators. All this energy production will keep a delicate balance with the energy consumption determined by the dynamic load.

Diagram of the complet AEL-MGP Power System



Power plants can be acquired in two ways:

- As a complete power system, under the reference “AEL-MGP”, which includes all “PWP- ” power plants, the Fault Injection Kit 1, “FIJ-K1” and the Energy Manager and Data Acquisition Software, “EMG-SCADA”.
- Acquiring them individually according to the technical requirements of the user. This option always requires at least the reference Conventional Power Plant, “PWP-CE”.

The “AEL-MGP” includes the following elements:

- PWP-CE. Conventional Energy Power Plant.
    - N-ALI01. Industrial Main Power Supply Module.
    - GMG4.5K3PH. 4,5 kVA Generator-Motor group.
    - N-EALD. Network Analyzer Module with Oscilloscope and Data Acquisition. (2 units).
    - N-ERP-PGC01. Generator Protection and Control Relay Module.
    - N-PSM. Power Switch Module.
    - GEC-KIT-1. Generator Excitation Circuit Kit 1.
        - N-AVR/P. Automatic Voltage Regulator.
        - N-TRANS04. Single-Phase Transformer 230 VAC/2x35 VAC, 300 VA.
        - N-SPAD01. Single-Phase AC/DC Converter 1.
    - SVC-K3. Dynamic Load Kit 1.
        - EMT7/1K. 3 PH Squirrel Cage Motor, 1 kW.
        - FRENP. Magnetic Powder Brake.
        - N-DLC01. Dynamic Load Controller 1.
- PWP-WE. Wind Energy Power Plant.
    - EMT7/1K. 3 PH Squirrel Cage Motor, 1 kW. (2 units).
    - N-EALD. Network Analyzer Module with Oscilloscope and Data Acquisition.
    - N-VVCA2K. 2 kW Motor Speed Controller.
    - N-CAR19T3. Three-Phase Bank of Commutable Capacitors Module.
    - N-ERP-PGC01. Generator Protection and Control Relay Module.
- PWP-PE. Photovoltaic Energy Power Plant.
    - PSPS/A. Advanced Panel Simulator Power Supply.
    - N-INV02. Grid Three-Phase Inverter Module 1.
    - N-EALD. Network Analyzer Module with Oscilloscope and Data Acquisition.
- PWP-HE. Hydroelectric Energy Power Plant.
    - EMT7/1K. 3 PH Squirrel Cage Motor, 1 kW.
    - EMT6/1K. Independent Excitation 3 PH Synchronous Motor-Generator, 1 kW.
    - N-EALD. Network Analyzer Module with Oscilloscope and Data Acquisition.

- N-VVCA2K. 2 kW Motor Speed Controller.
- N-ERP-PGC01. Generator Protection and Control Relay Module.
- GEC-KIT-1. Generator Excitation Circuit Kit 1.
    - N-AVR/P. Automatic Voltage Regulator.
    - N-TRANS04. Single-Phase Transformer 230 VAC/2x35 VAC, 300 VA.
    - N-SPAD01. Single-Phase AC/DC Converter 1.
- HYDP-K1. Hydroelectric Pumping Kit 1.
    - EMT7. 3 PH Squirrel Cage Motor.
    - FRENP. Magnetic Powder Brake.
    - N-EALD. Network Analyzer Module with Oscilloscope and Data Acquisition.

- PWP-BE. Battery Energy Storage Power Plant.
    - N-INV/HY. Hybrid Inverter Module.
    - BAT3. Lithium-Iron Phosphate Battery.
    - N-EALD. Network Analyzer Module with Oscilloscope and Data Acquisition.
- PWP-FE. Flywheel Storage Energy Power Plant.
    - N-EALD. Network Analyzer Module with Oscilloscope and Data Acquisition.
    - N-VVCA7K. 5.5 kW AC Motor Control Module.
    - FMG/5K. 5 kW Flywheel-Motor Group.
    - N-ERC. Electrical Regeneration Control Module.
- FIJ-K1. Faults injection Kit 1.
    - N-ERP-MA01. Feeder Management Protection Relay.
    - N-PSM. Power Switch Module.
    - N-ERP-MF01. Digital Fault Simulator Module.
- EMG-SCADA. Energy Manager and Data Acquisition Software.

The application "AEL-MGP" can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks:

- N-RACK-A (2 units).
- N-RACK-B (2 units).

Optionally the AEL-WBR. Electrical Workbench (Rack) can be supplied to place the rack/s.

Option B:

This application can be mounted on rail.

Optionally the AEL-WBC. Electrical Workbench (Rail) can be supplied to mount the modules.

SPECIFICATIONS

- N-ALI01. **Industrial Main Power Supply Module.**

N-ALI01

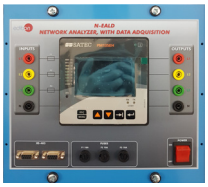
Voltage supply: 400 VAC, 3PH+N+G.
ON-OFF removable key.
Emergency stop push-button.
Output voltage connections:
Three-Phase + Neutral: 400 VAC.
Single-Phase: 230 VAC.
Three-Phase supply wire with IP44 3PN+E 32A 400V connecting plug.
Differential magnetothermal, 4 poles, 25A, 300mA AC 6KA.

- GMG4.5K3PH. **4.5 kWA Generator-Motor Group.**

GMG4.5K3PH

Motor-generator group coupled in an aluminum frame with wheels.
Generator nominal power: 4.5 kVA.
Generator nominal speed: 3000 rpm.
Generator nominal output current: 6.5 A.
Generator nominal excitation current: 4 A.
Generator power factor: 0.8.
Generator nominal output voltage: 3x 400 VAC.
Frequency: 50/60 Hz.
Motor nominal power: 5 kVA.
Motor nominal current: 7.2 A.
Motor nominal speed: 3000 rpm.

- N-EALD. **Network Analyzer Module with Oscilloscope and Data Acquisition.**



N-EALD

The network analyzer module allows fulfilling measurements, displaying and analyzing all the arameters of the AC electrical networks. It has a LCD screen and push-buttons for the navigation through the different menus. It includes specific software for monitoring current and voltage curves, harmonics display, tariffs programming and electrical parameters storage.

Features:

Multifunctional three-phase power meter:
Single and three-phase voltage. Up to 690 VAC L-L.
Phase and line current. Current range up to 200%. Measurement from 0 - 10 A.
Active, reactive and apparent power.
Suitable frequencies: 25 Hz, 50 Hz, 60 Hz y 400 Hz.
Display of the V-I vector diagram.
Supply voltage: 85 - 265 VAC.
Energy quality control:
Current and voltage individual harmonics measurement. Up to the 40 th harmonic.
THD voltage and current, TDD and K-factor.
Maximums and minimums display.
Waveforms display, 128 samples/sec.
Events and data storage.
Harmonics analyzer:
THD voltage and current, TDD current and K-factor, up to the 40 th harmonic.
Current and voltage harmonic spectrum and angles.
Tariff programming:
Class 0.5S IEC 62053 - 22, active and reactive power in four quadrants.
Measurement of the total and per phase three-phase active, reactive and apparent powers.
Usage time, 4 energy/demand records of total tariffs.
8 tariffs, 4 seasons, 4 types of days.
Automatic daily report of energy consumption maximums and minimums.
Communications:
Modbus TCP communication protocol with Ethernet interface.

- N-ERP-PGC01. **Generator Protection and Control Relay Module.**

N-ERP-PGC01

Automatic Speed and Voltage Controller: It enables to connect up to 16 electric generators in parallel-island with active and reactive power distribution and start/stop depending on the load demand.

Enables to connect a generator in parallel with the grid.

It allows different switch control modes, such as opening, closing and synchronization.

Three-phase measurement of the grid and the generator voltage.

Three-phase measurement of the generator intensity and power.

Single-phase measurement of the grid intensity.

Protection system:

Generator: Maximum/minimum voltage (59/27), maximum/minimum frequency (81O/U), voltage asymmetry, detection of dead busbars, overvoltage (32), load unbalance (46), negative sequence power/reduced power (32R/F), overcurrent by defined curve (50/51), inverse time overcurrent (IEC255), measured ground fault (50N/51N), phase rotation, switches faults.

Network: Maximum/minimum voltage (59/27), maximum/minimum frequency (81O/U), vector jump, phase rotation.

Measurement terminals.

Output terminals for the connection to the lab grid.

2 mm terminals to monitor the PWM for the excitation circuit and speed signals.

Three control switches to:

Start and stop the turbine.

Give permission to synchronize the generator with the grid.

Give permission to synchronize the generator with the national grid.

Two potentiometers to:

Adjust the set point for the generated active power.

Adjust the set point for the voltage.

Emergency stop push button:

Two circuit breakers for synchronization and island mode operations with state indicator lamps.

- N-PSM. **Power Switch Module.**

N-PSM

Power terminals:

Four input terminals (3PH+N).

Four output terminals (3PH+N).

Auxiliary contacts:

One NO contact.

One NC contact.

Two push-buttons to open/close the power switch and the auxiliary contacts.

Two 24 VDC control inputs.

Two 24 VDC voltage outputs.

- N-AVR/P. **Automatic Voltage Regulator.**

N-AVR/P

Input voltage: 0 - 100 VDC.

Input for voltage regulation signal through PWM control.

Terminals for PWM signals monitoring.

Output voltage: 0 - 100 VDC.

DC ammeter for output current measurement, 0 - 4 A.

3-pin female connector for connection to the excitation input of a generator.

Fuse 5 A.

- N-TRANS04. **Single-Phase Transformer 230 VAC/2x35 VAC, 300 VA.**

N-TRANS04

230 VAC single-phase input terminals.

Terminals for a 70 VAC single-phase output.

Terminals for two 35 VAC single-phase outputs.

0 (Opened)/1(Closed) selector switch.

Fuses:

Primary side: 5 A.

Secondary side: 2.5 A.

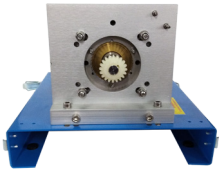
- N-SPAD01. **Single-Phase AC/DC Converter 1.**
  - 0 - 230 VAC single-phase input terminals.
  - AC/DC rectifier.
  - DC output terminals.
  - Filter capacitor for voltage ripple reduction.
  - Bypass terminals for filter capacitor connection.
  - 5 A fuse.


N-SPAD01

- EMT7/1K. **3 PH Squirrel Cage Motor, 1 kVA.**
  - Nominal power: 1100 W.
  - Nominal voltage: 3 x 230/400 VAC Δ/Y.
  - Frequency: 50/60 Hz.
  - Number of poles: 2.
  - Nominal speed: 2730 rpm.
  - Nominal current: 2.52 / 1.45 A.


EMT7/1K

- FRENP. **Magnetic Powder Brake.**
  - Nominal Torque: 5 Nm.
  - Maximum Power Dissipation: 100 W.
  - Maximum output current adjustment.
  - Operating modes “freewheel “ and “blocking”.
  - Nominal voltage: 24 VAC/VDC.
  - Maximum Output Current: 2 A.
  - Output Load (Resistor): 4 to 20 Ohms.
  - Maximum power consumed: 70 W.
  - Remote voltage control: 0 to 10 VDC.
  - Weight: 4 Kg.


FRENP

- N-DLC01. **Dynamic Load Controller 1.**
  - Supply voltage: 230 VAC.
  - LCD Display.
  - Setting of maximum, minimum and valley braking signal times to simulate real daily energy consumption.
  - Manual and automatic braking torque.
  - GND terminal.


N-DLC01

- N-VVCA2K. **2 kW Motor Speed Controller Module.**
  - ON/OFF switch.
  - Micro connector of 8 pins.
  - Supply terminals:
    - Supply: 400 VAC.
    - Supply terminals L1, L2, L3 and N from the module to the frequency variator.
  - Output connector.
  - Motor speed potentiometer.
  - Red switch.


N-VVCA2K

- N-CAR19T3. **Three-Phase Bank of Commutable Capacitors Module.**
  - ON/OFF switch.
  - Supply terminals:
    - Supply voltage 230 VAC.
  - Open/close switches.
  - Three indicating LEDs.
  - Three input/output power terminals.


N-CAR19T3

- PSPS/A. **Advanced Panel Simulator Power Supply.**

  This power source allows carry out the programming of characteristics curves of photovoltaic panels.

  Open-circuit voltage: 500 V.

  Closed-circuit current: 10 A.

  Power output: 1500 W.

PSPS/A

- N-INV02. **Three-Phase Grid Inverter Module 2.**

  DC circuit breaker.

  Overload voltage protection for photovoltaic and bus terminals.

  DC input voltage range: 0 - 500 VDC.

  Output voltage: 3x 400 V/ 50/60 Hz.

  Power output: 3000 W.

N-INV02

- EMT6/1K. **Independent Excitation 3PH Synchronous Motor-gnerator,1 kVA.**

  Nominal power: 1000 VA.

  Power factor: 0.8

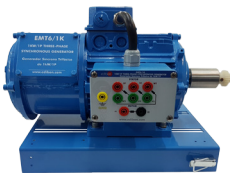
  Nominal output voltage: 3x 400 VAC.

  Frequency: 50/60 Hz.

  Speed: 3000 rpm.

  Nominal output current: 0.8 A.

  Nominal excitation current: 5 A.



EMT6/1K

- EMT7. **3PH Squirrel-Cage Motor.**

  Nominal power: 370 W.

  Nominal voltage: 3x 230/400 VAC Δ/Y

  Frequency: 50/60 Hz.

  Poles number: 2.

  RPM: 2730 rpm.

  Shaft height: 71 mm.

EMT7

- N-INV/HY. **Hybrid Inverter Module.**

  Three-phase inverter.

  Three-phase energy injection to the grid with battery charge control.

  Terminals:

    One DC input.

    One AC three-phase ouput.

  Nominal power: 2000 W.

  Output voltage: 400 VAC.

  Frequency: 50 Hz.

N-INV/HY

- BAT3. **Lithium - Iron Phosphate Battery.**

  Long lifespan battery.

  Battery capacity: 2000 Wh.

BAT3

- N-VVCA7K. **5.5 kW AC Motor Control Module.**

  Supply voltage: 400 VAC.

  Nominal power: 7 kW.

  PWM output voltage connections: Three-phases, 230 VAC.

  Digital inputs control panel.

  Analog inputs control panel.

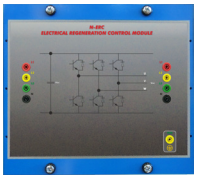
  Setting and visualization display of the machine parameters.

N-VVCA7K

- FMG/5K. **5 kW Flywheel-Motor Group.**
  Flywheel:
    Weight: 30 kg.
    Maximum recommended speed: 4000 rpm.
  Three-phase squirrel cage motor:
    Nominal power: 5 kW.
    Nominal voltage: 3x 230/400 VAC Δ/Y.
    Frequency: 50/60 Hz.
    Number of poles: 2.
    RPM: 2730 rpm.


FMG/5K

- N-ERC. **Electrical Regeneration Control Module.**
  Module for electric regeneration.
  Input and regenerative power with sinusoidal ands square current.
  Adjustable input and regenerative power control.
  Configurable control terminals.


N-ERC

- N-ERP-MA01. **Feeder Management Relay Module.**
  This protection relay is used to test different short circuits in any point of the power system. This protection relay allows investigations into protection and monitoring of overhead lines, underground cables and feeders.
  The connections are via safety sockets.
  The main functions:
    Four levels of Phase Instantaneous Overcurrent Element (50P).
    Four levels of Negative-Sequence Overcurrent Element (50Q).
    Four levels of Residual Overcurrent Element (50G).
    Four levels of Neutral Overcurrent Element (50G).
    Two levels of Phase Time-Overcurrent Element (51P).
    Two levels of Residual Time-Overcurrent Element (51G).
    Two levels of Ground Time-Overcurrent Element (51G).
    One level of Negative-Sequence Time-Overcurrent Element (51Q).
    Phase to Ground Overvoltage (59G).
    Phase to Phase Overvoltage (59P).
    Negative-Sequence Overvoltage (59Q).
    Residual Overvoltage (59G).
    Phase to Ground Undervoltage (27G).
    Phase to Phase Undervoltage (27P).
    Six levels of Secure Overfrequency (81O).
    Six levels of Secure Underfrequency (81U).
    Two levels of Negative Power Flow with Definite Time Delay (32).
    Two levels of Positive Power Flow with Definite Time Delay (32).
    Station Battery Monitor.
    Breaker Wear Monitoring.
    Synchrophasor Protocol.
    Peak Demand and Demand Metering.
    Auto-Reclosing.
    Creating fault and disturbance records.
  The connection to the experimental circuit is via current transformers with ratio to suit the inputs of the relay.
  It allows an effective demonstration of the effect of current and voltage transformer ratio, connection and rating on protective relays.
  Accuracy: +- 10%. Current: 5 A (A. C.). Frequency: 50 or 60 Hz.
  Operating time: typically 10 ms to 25 ms.


N-ERP-MA01

- N-ERP-MF01. **Digital Fault Simulator Module.**
  Enables injecting one, two or three pole different faults at the desired location through fault and line terminals.
  Trip time potentiometer.
  Ethernet connection: Two communication ports for SCADA remote control.


N-ERP-MF01

- **All necessary cables to realize the practical exercises are included.**

Cables and accessories, for normal operation.

Manuals:

This unit **is supplied with the following manuals:** Required Services, Assembly and Installation, Starting-up, Safety, Maintenance & Practices Manuals.

EXERCISES AND PRACTICAL POSSIBILITIES

Some practical exercises with the included base unit "PWP-CE":

1.- Basic concepts of isolated, stand-alone grids.

2.- Automatic control of voltage and frequency of the generator in a stand-alone grid.

3.- Study of energy requirements and energy generation in stand-alone grids.

4.- Smart Metering of the generated energy.

5.- Study of synchronous generator response to a change in the load.

6.- Synchronization operations with the synchronous generator and the grid.

Some practical exercises with the Wind Energy Power Plant, "PWP-WE":

7.- Automatic control of the turbine-generator group speed.

8.- Startup of the three-phase induction generator.

9.- Automatic synchronization of the three-phase induction generator with the grid.

10.- Monitoring the electrical parameters of the three-phase induction generator in synchronism with the grid.

11.- Adjustable automatic control of the active power delivered to the grid.

12.- Influence of speed variation on the active power and analysis of the feasible solutions to automate the power factor regulation.

13.- Compensation of the reactive power consumed by the three-phase induction generator by means of capacitor banks.

Some practical exercises with the Photovoltaic Energy Power Plant "PWP-PE":

14.- Installation of photovoltaic power plants.

15.- Grid-connection of photovoltaic plants.

16.- Setting the P-V curves for power generation.

17.- Monitoring the power injection into the grid.

18.- Maximum power point tracking (MPPT).

19.- Limiting the inverter power (derating).

20.- Determining the inverter efficiency.

Some practical exercises with Hydroelectric Energy Power Plant, "PWP-HE":

21.- Study of hydroelectric resources and power production with synchronous generators.

22.- Study of active power production from synchronous generator in synchronism with other generators.

23.- Determination of threshold power load for active power injection from the hydroelectric power plant.

24.- Real time active power control.

25.- Study of synchronous generator power factor regulation in hydroelectric power plants

Some practical exercises with the Hydroelectric Pumping Kit 1, "HYDP-K1":

26.- Study of pumping power stations.

27.- Control of pumping power with the dynamic brake and energy consumption measurement.

28.- Study of energy balance between power production and power consumption.

29.- Demonstration the working principles of mechanism of pumping power stations.

Some practical exercises with the Battery Storage Energy Power Plant, "PWP-BE":

30.- Installation process of energy accumulation systems based on the combination of batteries with the charge controller inverter.

31.- Interaction among the photovoltaic system and the battery.

32.- Energy storage in the generation surplus scenario of the microgrid.

33.- Discharge of the battery in the lack of generation scenario of the microgrid.

Some practical exercises with the Flywheel Storage Energy Power Plant, "PWP-FE":

34.- Study of the different components of the flywheel energy storage system.

35.- Setting of the frequency regulator, acceleration curves of the induction motor and inertia disk.

36.- Measurement of power consumption during inertia disc loading.

37.- Setting of the energy regeneration module.

38.- Measurement of the energy regenerated by the inertia disk.

39.- Relationship between the electrical and mechanical parameters of the inertia disk.

40.- Calculation of the performance of the flywheel regeneration system.

41.- Display of the power consumption curves of the flywheel.

42.- Display of the energy regeneration curves injected into the grid

Exercises and practical possibilities

Some practical exercises with the Study of Faults in Generators Kit 1, "FIJ-K1":

43.- Feeder management protection relay setting.

44.- Study of different protection schemes in Micro Grids.

45.- Study of single-phase, two-phase, three-phase, to earth, with and without impedance faults in different points of the Micro grid.

46.- Study and configuration of over frequency protection events.

47.- Study and configuration of under frequency protection events.

48.- Study and configuration of over voltage protection events.

49.- Study and configuration of under voltage protection events.

50.- Study and configuration of over current protection events.

51.- Transient analysis of fault injection by means of the differential relay manufacturer's software.

Some practical exercises with the Energy Manager and Data Acquisition Software, EMG-SCADA:

52.- Remote control of voltage and power set points of the synchronous generator in the microgrid.

53.- Real time measurement of the synchronous generator electrical parameters.

54.- Remote synchronization operation with synchronous generator and grid.

55.- Remote control maneuvers for the different sources of renewable generation.

56.- Customized configuration of the wind speed curves.

57.- Automatic simulation of the pre-configured wind speed curves for a wind turbine with three-phase induction generator.

58.- Visualization of the power curve for the pre-configured wind speed values.

59.- Customized configuration of the solar irradiation curves.

60.- Automatic simulation of the pre-configured irradiation solar curves for the photovoltaic power generation.

61.- Visualization of the power curve for the pre-configured solar irradiation values.

62.- Visualization of the power curve for the hydroelectric generation.

63.- Visualization of the remaining capacity of the hydroelectric resource as the generated power is progressively delivered.

64.- Analysis of the efficiency and stability provided to the microgrid by the storage system during the simulation of a demand profile.

65.- Visualization of the demand and total generation curves to analyze the management of the different renewable resources during the simulated scenarios.

66.- Real time monitoring of frequency, current and voltage values and waveforms.

67.- Real time monitoring of the active, reactive and apparent powers generated.

68.- Visualization of the phasor diagrams of the system electrical parameters.

69.- Real time monitoring of the obtained results

70.- Data saving and storage.

71.- Comparison of the obtained results.

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

REQUIRED SERVICES

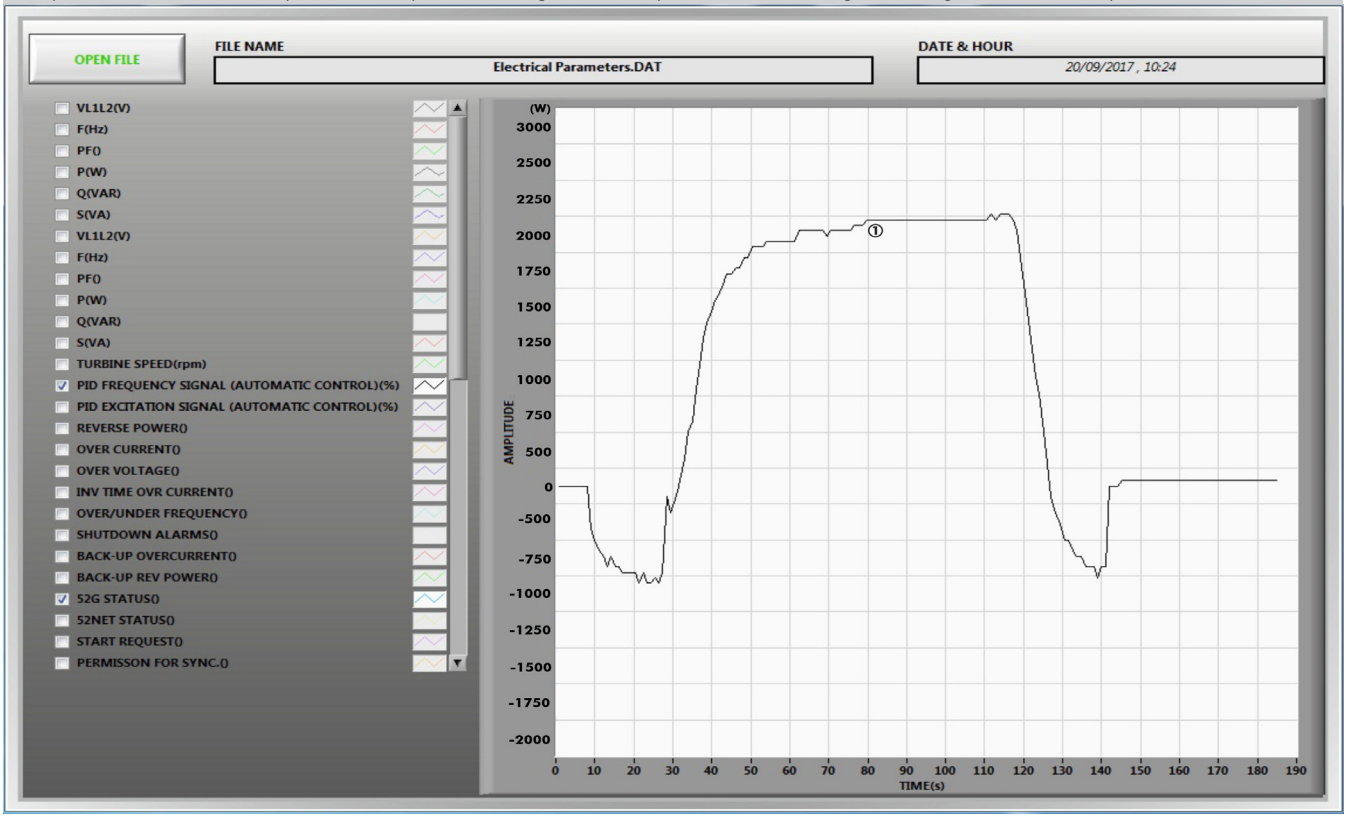
- Electrical supply: three phase, 380 VAC- 415 VAC/50 Hz or 190 VAC-240/60 Hz, 5 kW.

DIMENSIONS AND WEIGHTS

AEL-MGP:

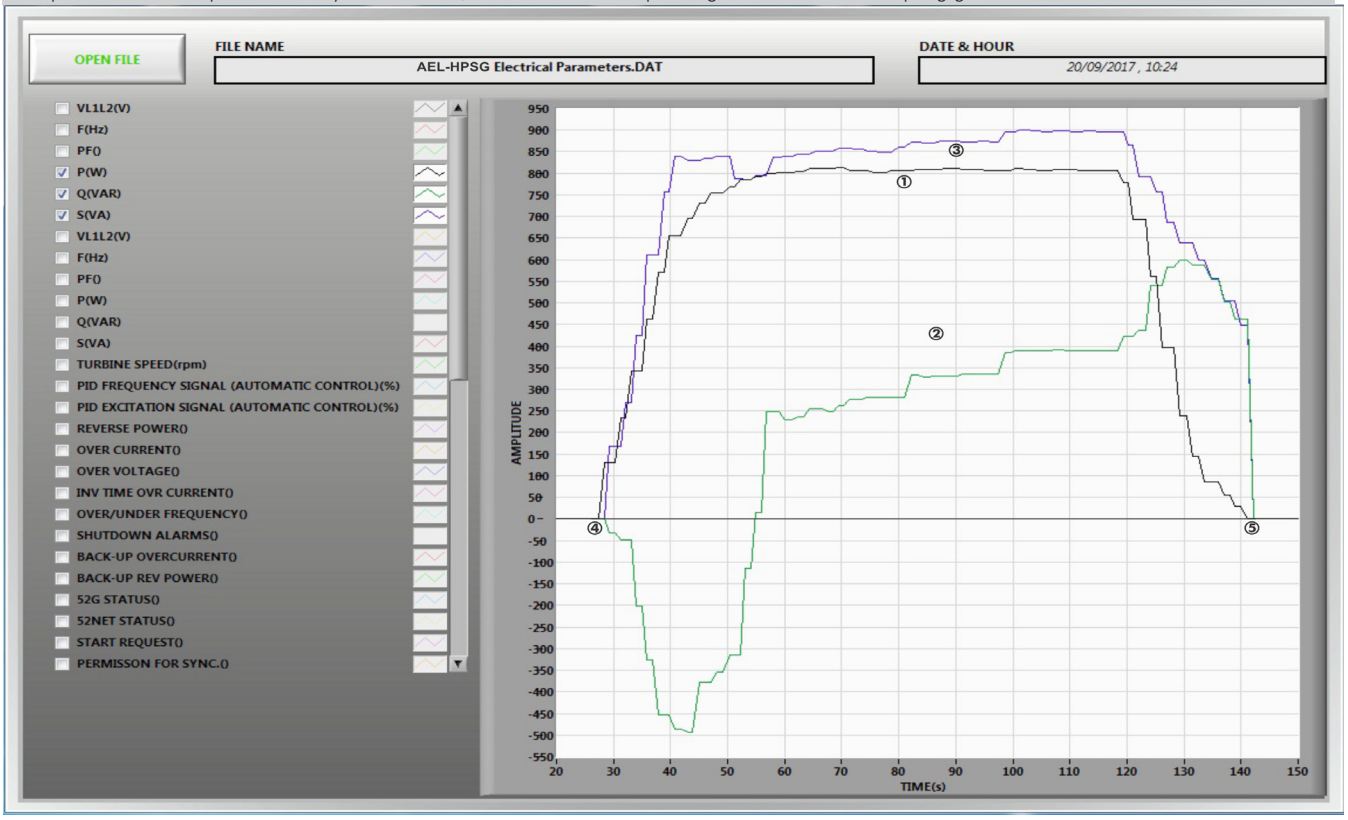
- Dimensions: 2000 x 320 x 920 mm approx.
  (78.73x12.59x36.22 inches approx.)
- Weight: 150 Kg approx.
  (330 pounds approx.)

This picture shows a the active power curvereport since the generator is synchronized with the grid till the generator is uncoupled of it.



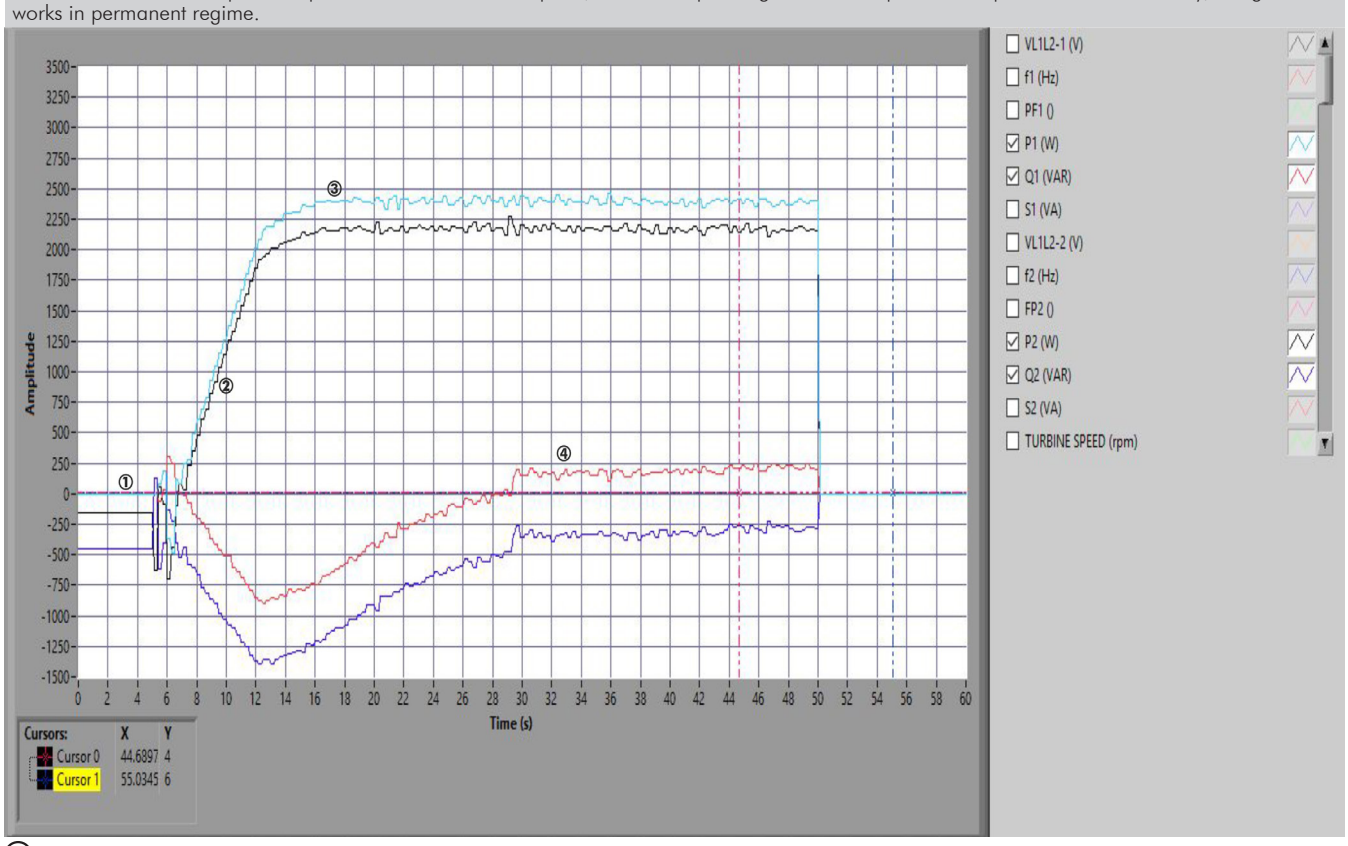
① Active power curve Reported.

This picture shows the processes of synchronization, active and reactive power generation and uncoupling generator.



① Generator Active Power Wave.
② Generator Reactive Power Wave.
③ Generator Apparent Power Wave.
④ Synchronization.
⑤ Uncoupling generator.

This picture shows the synchronization process between the generator and the grid. In the first stage, the turbine is unstable (0 - 6 sec.) and there are fluctuations in P and Q powers up to 6 seconds. After this point, the active power generator ramp is linear up to 18 seconds. Finaly, the generator works in permanent regime.



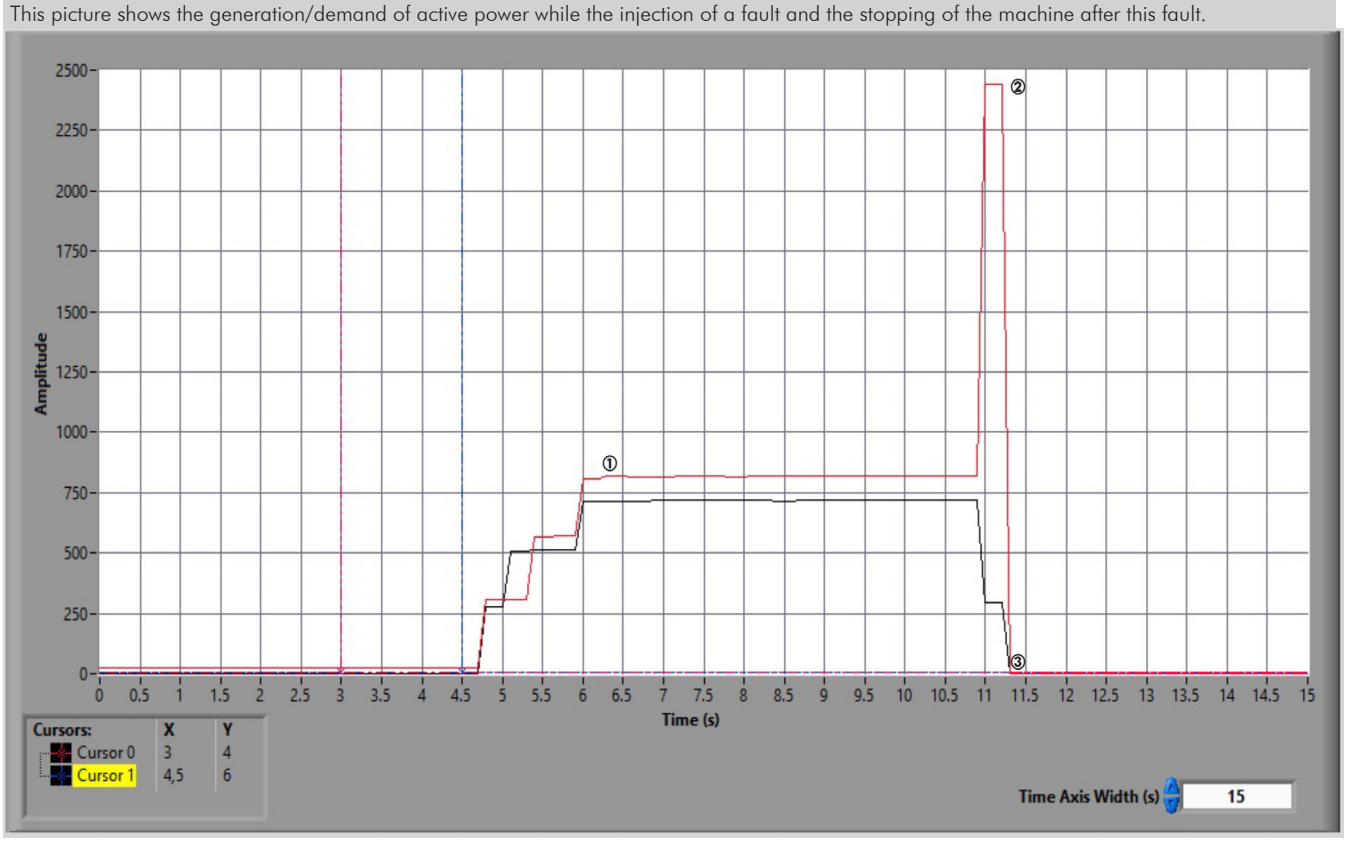
① Generation of active power in permanent regimen in parallel with the grid.

② Generator loading ramp.

③ Reactive power wave during synchronization and loading of generator.

④ Coupling of the generator with the grid.

This picture shows the generation/demand of active power while the injection of a fault and the stopping of the machine after this fault.

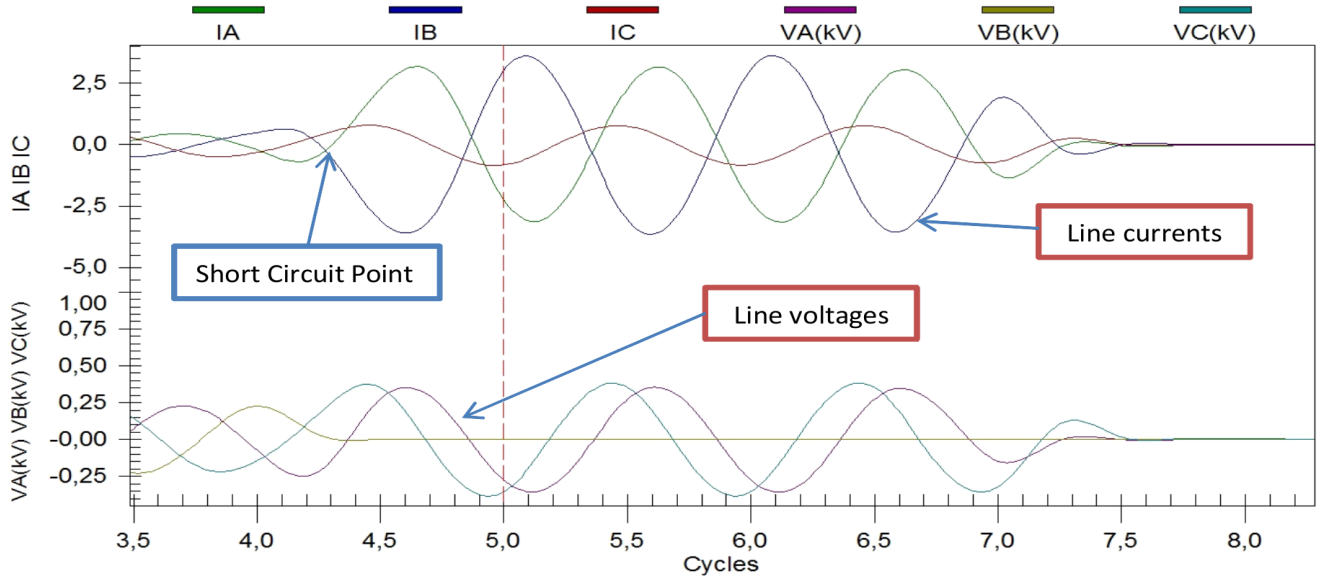


① Active power consumption.

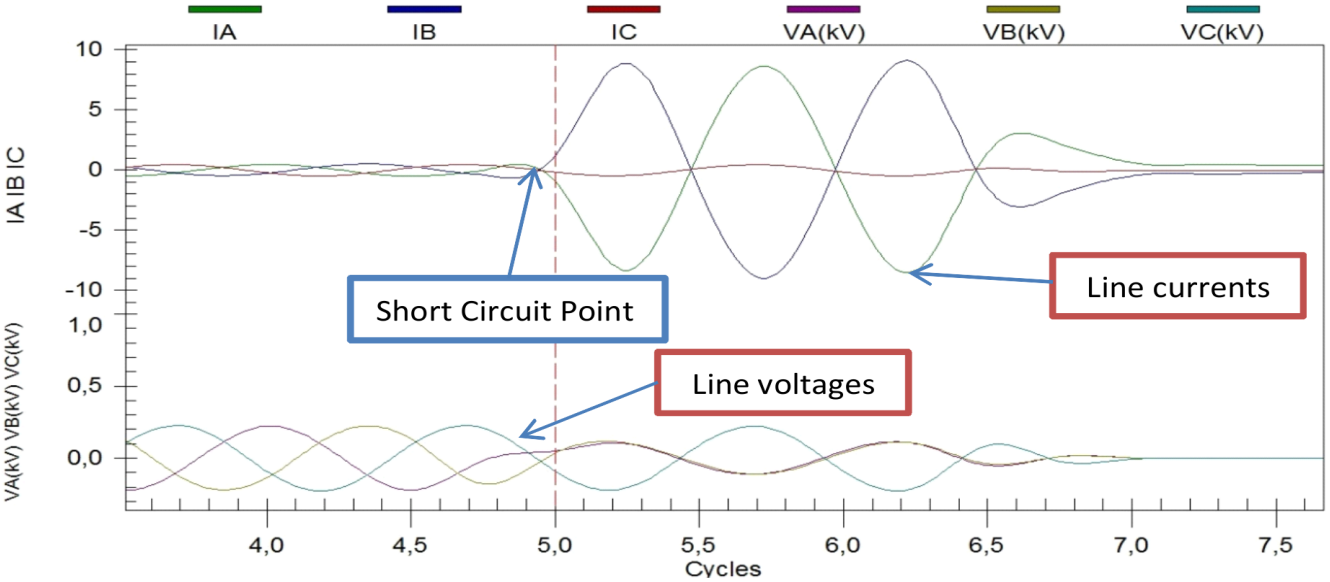
② Fault overcurrent.

③ Turning off the generator.

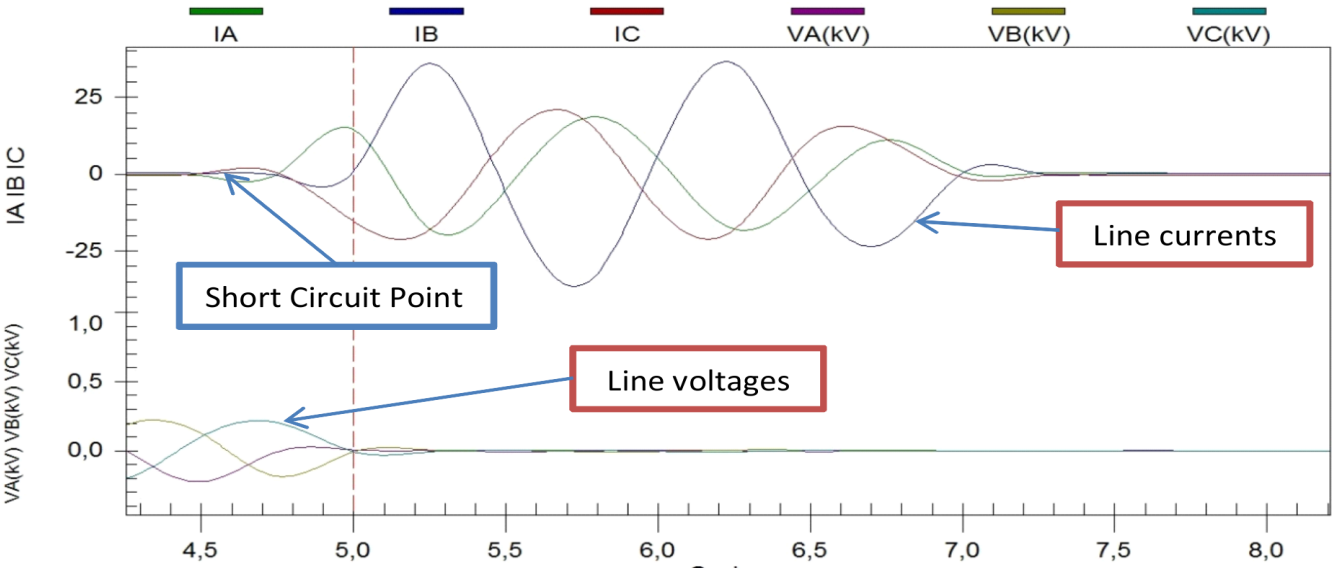
Some **real** results obtained from this unit with the software EMG-SCADA



Two-Pole Short Circuit with fault impedance screen

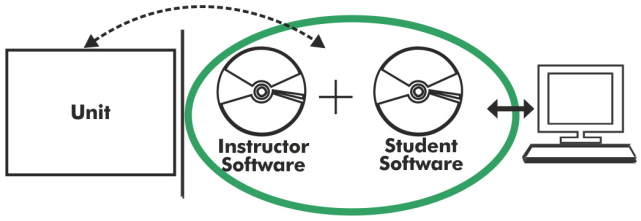


Two-Pole Short Circuit screen



Three-Pole Short Circuit screen

AEL-MGP/ICAI. Interactive Computer Aided Instruction Software System:



With no physical connection between unit and computer, **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.

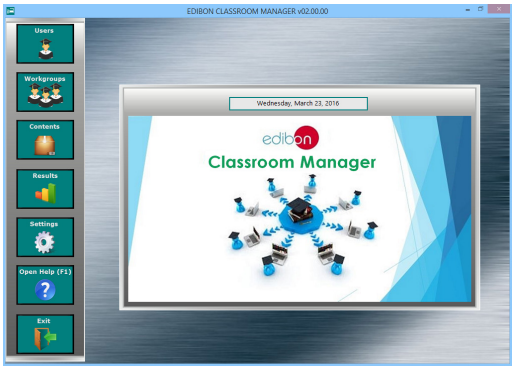
Instructor Software

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

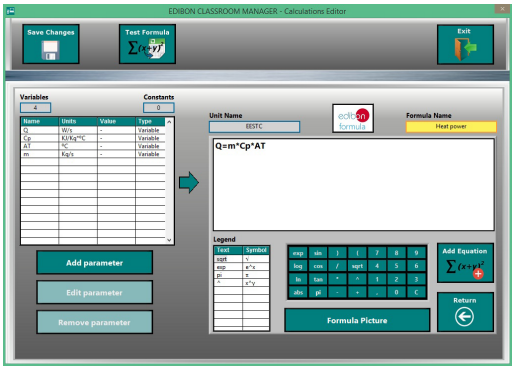
ECM-SOF is the application that allows the Instructor to register students, manage and assign tasks for workgroups, create own content to carry out Practical Exercises, choose one of the evaluation methods to check the Student knowledge and monitor the progression related to the planned tasks for individual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

Innovative features:

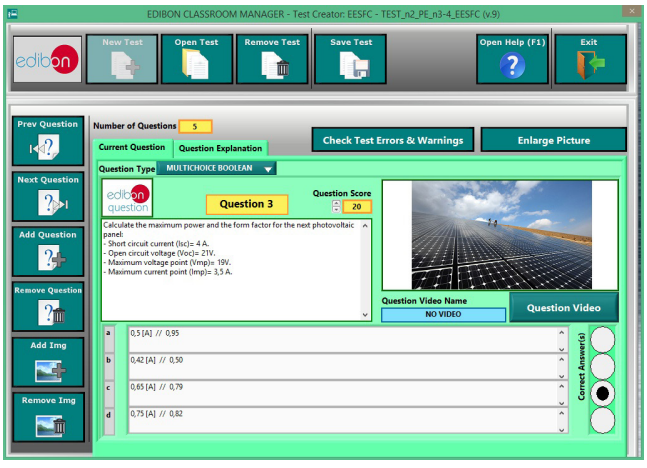
- User Data Base Management.
- Administration and assignment of Workgroup, Task and Training sessions.
- Creation and Integration of Practical Exercises and Multimedia Resources.
- Custom Design of Evaluation Methods.
- Creation and assignment of Formulas & Equations.
- Equation System Solver Engine.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



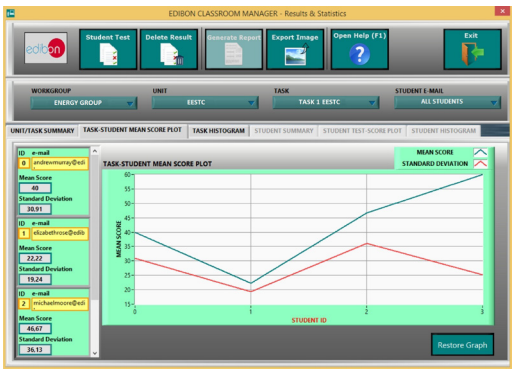
ECM-SOF. EDIBON Classroom Manager (Instructor Software) Application Main Screen



ECAL. EDIBON Calculations Program Package - Formula Editor Screen



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



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

Optional

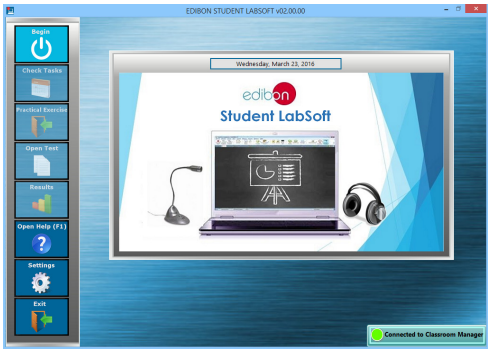
Student Software

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

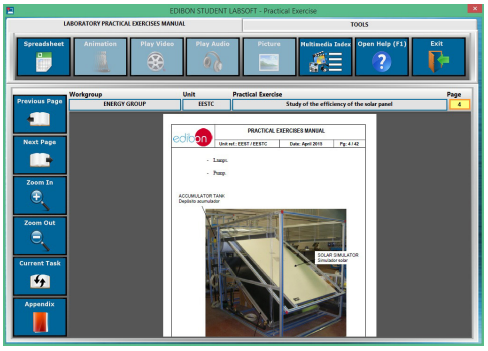
ESL-SOF is the application addressed to the Students that helps them to understand theoretical concepts by means of practical exercises and to prove their knowledge and progression by performing tests and calculations in addition to Multimedia Resources. Default planned tasks and an Open workgroup are 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.**

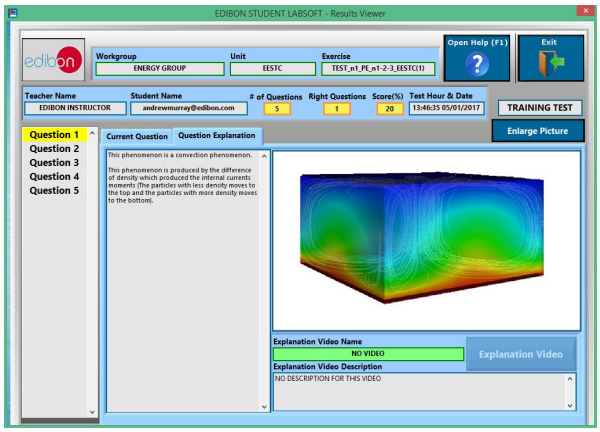


ESL-SOF. EDIBON Student LabSoft (Student Software) Application Main Screen

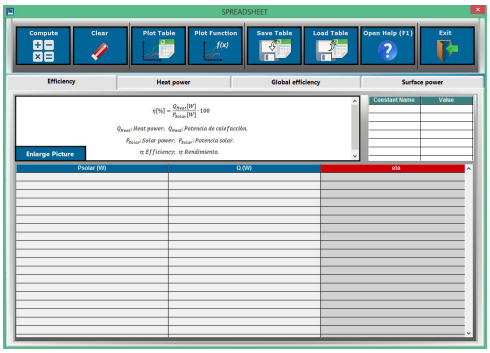


EPE. EDIBON Practical Exercise Program Package Main Screen

For more information see **ICAI** catalogue. Click on the following link:
www.edibon.com/en/files/expansion/ICAI/catalog



ERS. EDIBON Results & Statistics Program Package - Question Explanation



ECAL. EDIBON Calculations Program Package Main Screen

✱ Specifications subject to change without previous notice, due to the convenience of improvement of the product.

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REPRESENTATIVE: