

Configuration example of AEL-TI with AEL-TI-07 application included

Key features:

- **Advanced Real-Time SCADA.**
- **Open Control + Multicontrol + Real-Time Control.**
- **Specialized EDIBON Control Software based on LabVIEW.**
- **Projector and/or electronic whiteboard compatibility allows the unit to be explained and demonstrated to an entire class at one time.**
- **Capable of doing applied research, real industrial simulation, training courses, etc.**
- **Remote operation and control by the user and remote control for EDIBON technical support, are always included.**
- **Totally safe, utilizing 4 safety systems (Mechanical, Electrical, Electronic & Software).**
- **Designed and manufactured under several quality standards.**
- **Optional ICAI software to create, edit and carry out practical exercises, tests, exams, calculations, etc. Apart from monitoring user's knowledge and progress reached.**
- **This unit has been designed for future expansion and integration. A common expansion is the EDIBON Scada-Net (ESN) System which enables multiple students to simultaneously operate many units in a network.**

**OPEN CONTROL
+
MULTICONTROL
+
REAL TIME CONTROL**



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↳ 40.- ELECTRICITY

For more information about Key Features, click here



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



European Union Certificate (total safety)



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



Certificate and Worlddidac Member

INTRODUCTION

Smart Grids are energy management sophisticated systems in which communications play an important role to know, in real time, network energy needed, as well as electricity production capacity. Smart Grids allows bidirectional communication to forecast the electricity production. In addition, renewable energies play an important role within Smart Grids. Wind and photovoltaic energy variations make difficult the energy balance, stability and reliability of the electrical system.

GENERAL DESCRIPTION

Power Transmission Application with Synchronous Generator, "AEL-TI-07", has been designed to study power generation systems based on synchronous generators. This application is designed to demonstrate the most important operations and maneuvers carried out in power generation substations. In addition, this application explains the working principles of control and regulation devices of real turbines and generators.

One advantage of this application is that it can be expanded with a conjunction of additional and recommended applications. On this way, a complete power system with generation, transmission, distribution and load consumption, can be studied.

Students and teachers can study and investigate the operation of a real Smart Grid, from the energy is generated until it is consumed, analyzing the problems and solutions in each part of the process or in conjunction.

The application "AEL-TI-07" includes a servomotor-generator group (turbine-generator). Generator is a three-phase synchronous machine used to study power generation. It is coupled to a servomotor-brushless whose velocity is controlled with a servodriver included in this application. Both servomotor speed and generator current excitation are controlled by cutting edge frequency/voltage controller. This controller monitors and controls in real time all turbine (servomotor) and generator parameters for keeping the generator frequency and voltage constants against load variations. In addition, the user can take the control of the turbine and generator in manual control mode, provoking frequency and voltage perturbations which will be corrected with the automatic frequency/voltage controller. In addition, this controller has the function of the synchronization and protection relay. The user can monitor speed and voltage PIDs to study the generator-motor stability.

In power generation systems it is very important to keep speed and voltage constants to avoid possible damages due to frequency and voltage oscillations. With this application students will learn the operation of a real frequency/voltage controller.

On the other hand, a series of additional modules are recommended to reach in this application its full operational potential:

- Analog instrumentation module. This module allows measuring active, reactive, frequency, current excitation and voltage.
- Analog synchronization module. This module allows to monitor the synchronization process.
- Resistive, inductive and capacitive loads for different energy consumptions.

The application "AEL-TI-07", includes a SCADA Control and Data Acquisition System which represents faithfully a power generation substation with a turbine-generator control center with network analyzers, circuit breakers, transmission line, as well as, resistive, capacitive and inductive loads. The SCADA is designed to control in real time of whole power substation, for instance, speed and voltage can be remotely controlled while the user observes the behavior of the operating system. On the other hand, it is possible to synchronize the generator with the national grid and take the control of the turbine and generator.

In addition, SCADA Control System acquires in real time many electrical parameters from the network analyzers. Power generation, power transmission and energy consumption waves can be monitored. After electrical data acquisition it is possible carry out data logging for future analysis.

The AEL-TI-07 application includes the following elements:

- N-VPS01. AC 3PH Variable Power Supply.
- N-PSUB2. Power Generation Substation Module 2.
- N-PPCM1. Control and Protection of Turbine-Generator Group Module 1.
- EMT6/1K. 1kW/1P Three-Phase Synchronous Generator.
- SERV01. AC Servomotor 1.
- N-EALD. Network Analyzer Module with Data Acquisition.
- AEL-TI-07/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Required element:

- AEL-PC. Touch screen and computer.

Recommended elements:

- N-PPIM1. Instrumentation Module 1.
- N-ASYB. Analog Synchronization Module.
- N-REFT/3C. 3x300 W Three-Phase Configurable Resistors Module.
- N-INDT/3C. 3x300 Var Three-Phase Configurable Inductances Module.
- N-CAR19T/3C. 3x300 Var Three-Phase Configurable Capacitors Module.



Generator-Motor Group detail

General Description

- AEL-TI-01. Analysis of Three-phase Power Lines Application.
<http://www.edibon.com/en/files/equipment/AEL-TI-01/catalog>
- AEL-TI-02. Distribution Transformer with Motor Regulation Application.
<http://www.edibon.com/en/files/equipment/AEL-TI-02/catalog>
- AEL-TI-03. Arc suppression Coil Application.
<http://www.edibon.com/en/files/equipment/AEL-TI-03/catalog>
- AEL-TI-04. Underground Transmission lines Application.
<http://www.edibon.com/en/files/equipment/AEL-TI-04/catalog>
- AEL-TI-05. Parallel and Series Transmission Lines Application.
<http://www.edibon.com/en/files/equipment/AEL-TI-05/catalog>
- AEL-TI-06. Analysis of flow power on Transmission Lines Application.
<http://www.edibon.com/en/files/equipment/AEL-TI-06/catalog>
- AEL-SST-01. Switching and Distribution Power Substations Application.
<http://www.edibon.com/en/files/equipment/AEL-SST-01/catalog>
- AEL-SST-02. Switching Substation Protection Application.
<http://www.edibon.com/en/files/equipment/AEL-SST-02/catalog>

The application AEL-TI-07 can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks.

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

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

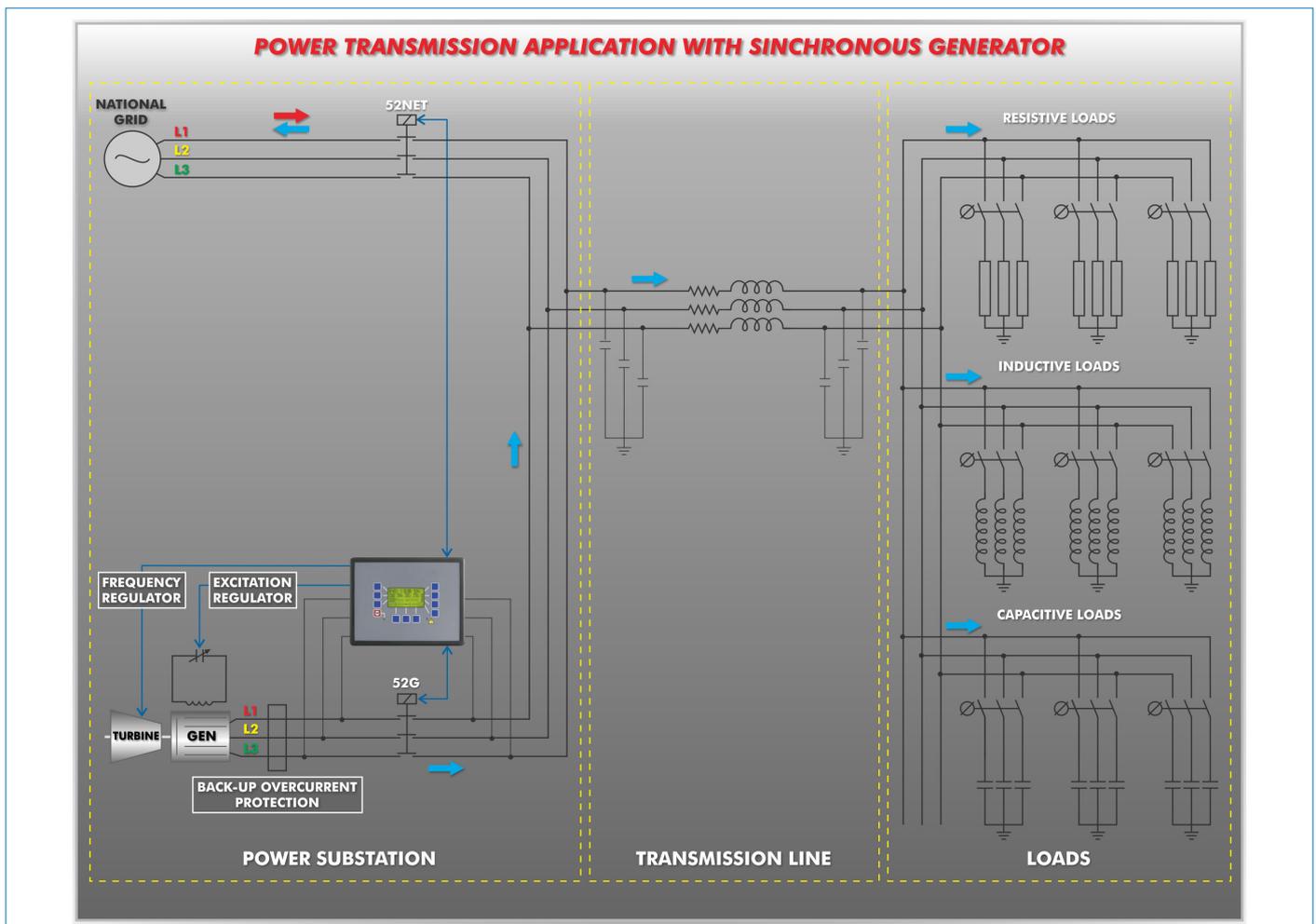
Option B:

This application can be mounted on rail.

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

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

PROCESS DIAGRAM AND UNIT ELEMENTS ALLOCATION



With this unit there are several options and possibilities:

- Main items: 1, 2, 3 and 4.
- Optional items: 5, 6 and 7.

Let us describe first the main items (1 to 4):

① **AEL-TI-07. Application.**

The AEL-TI-07 application includes the following elements:

- N-VPS01. **AC 3PH Variable Power Supply.**

- 3PH+N+GND male connector with cable.
- 200V DC fixed output terminals.
- 0-200V DC variable output terminals.
- 230/400V AC fixed output terminals.
- 0-230/400V AC variable output terminals.

Three positions voltage regulation commutator: this commutator allows to control the AC and DC output voltage terminals with a motorized autotransformer. Central position keep actual voltage. Right position increase slowly the output voltage. Left position reduce slowly the output voltage up to zero volts. By releasing the commutator, it will return to its initial position.

ON/OFF switch.

DC Ammeter.

DC Voltmeter.

AC Ammeter.

AC Voltmeter.

Adjustable three phase thermal protection.

Fuses.

GND terminal.



N-VPS01

- N-PSUB2. **Power Generation Substation Module 2.**

Supply voltage: 400V CA, 3PH+N+G

ON/OFF switch.

Power and signals connection:

- Auxiliary connection.

- Three-phase turbine supply hose with IP44 3PN+E 32A 400V connecting plug.

- Three-phase generator supply hose with IP44 3PN+E 32A 400V connecting plug.

Three switches to choose between the different modes:

- Local and remote control mode.

- Manual and automatic speed control.

- Manual and automatic excitation control

Three control switches to:

- Start and stop the turbine.

- Give permission to synchronize the generator with the grid.

- Give permission to close 52NET circuit breaker.

Two potentiometers to regulate:

- Turbine speed.

- Generator excitation.

Emergency stop button.

Two circuit breakers for synchronization and stand-alone operations.

Different terminals to measure.

Ethernet connection: RJ45 communication port for SCADA remote control.



N-PSUB2

• **N-PPCM1. Control and Protection of Turbine-Generator Group Module 1.**

Automatic speed and voltage controller (easygen):

Enables to connect up to 16 electric generators in parallel-island with distribution of active and reactive load and start/stop in function of the load demand.

Enables to connect a generator in parallel with the grid.

Enables different switches control modes, such as opening, closing and synchronization.

Analogical outputs to control voltage and frequency regulators.

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.

Six alarms:

Alarm 1: Reverse power.

Alarm 2: Overcurrent.

Alarm 3: Over/undervoltage.

Alarm 4: Inverse Time Overcurrent.

Alarm 5: Over/under frequency.

Alarm 6: Shutdown Alarms.

Four operation signals:

Ready for operation.

Start request.

Synchronization conditions.

Permission for synchronization.

Back-up protections:

Current relay.

Reverse Power relay.

Ethernet connection: RJ45 communication port.



N-PPCM1

• **EMT6/1K. 1kW/1P Three-Phase Synchronous Generator.**

Nominal power: 1000 VA.

Power factor: 0.8

Nominal output voltage: 3x 400V AC.

Frequency: 50/60 Hz.

Speed: 3000 r.p.m.

Nominal output current: 0.8 A.

Nominal excitation current: 5 A.



EMT6/1K

- **SERV01. AC Servomotor 1.**

Nominal power: 2000 W.
 Nominal voltage: 400V AC.
 Nominal speed: 3000 r.p.m.
 Nominal current: 5A.



SERV01

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

ON-OFF switch.
 Supply voltage: 400V AC.
 Input terminals: Input connection with the measurement point.
 Output terminals: Output connection with the measurement point.
 Digital outputs: Three digital outputs are used for pulses or alarms, or for combining both.
 RS-485 Communication port.
 Fuses: 3x10 A.
 Network Analyzer Display. It shows:
 Active, reactive and apparent power.
 Active, reactive and apparent energies.
 Lines and phase currents.
 Line and phase voltages.
 Frequencies.
 Power Factor.



N-EALD

Required element:

- **AEL-PC. Touch Screen and Computer.**

Touch Screen:
 Energy efficiency class: A.
 Screen diagonal: 68.6 cm (27 inch (s)).
 Power consumption (operating): 26 watts.
 Annual energy consumption: 38 kWh.
 Power consumption (standby / off) 0.49 watts.
 Screen resolution: 1920 x 1080 pixels.



AEL-PC

Computer:
 Processor Number: Intel Core i7-6600U Processor (4M Cache, up to 3,40 GHz).
 Cache: 4 MB Intel Smart Cache.
 Clock speed: 2.6 GHz.
 # Of Cores/# of Threads: 2/4.
 Max. TDP/Power: 15 W.
 Memory Types: DDR4-2133, LPDDR3-1866, DDR3L-1600.
 Graphics: Intel HD Graphics 530.
 Slot for PCI Express.

Recommended elements:

- **N-PPIM1. Instrumentation Module 1.**

Three-Phase wattmeter:
 Measured range: 0 - 1.5 KW.
 Three-Phase varmeter:
 Measured range: 0 - 1.5 Kvar.
 Voltmeter:
 Measured range: 0 - 500 V.
 Frequency meter:
 Measured range: 45 - 55 Hz.
 DC meter:
 Measured range: 0 - 10 A.



N-PPIM1

• **N-ASYB. Analog Synchronization Module.**

Input terminals: L1, L2, L3 and N generation input terminals.

Output terminals: L1, L2, L3 and N grid input terminals.

Synchronization switch: this switch allows close the synchronization switch. In addition, this switch has two 24V DC connections for remote close switch.

Analog voltmeter: it allows to measure the generation bus bar output voltage.

Digital synchroscope: it allows to monitor the synchronization process of the generator with the grid.

Double analog voltmeter: it allows to compare the voltages between generator and grid bus bars.

Double frequency meter: it allows to compare the frequencies between the generator and the grid.

400V AC lamps: it allows to realize the different synchronization procedures with the dark and light lamps method.

GND terminal.



N-ASYB

• **N-REFT/3C. 3x300 W Three-Phase Configurable Resistors Module.**

Configurable Star and Delta connections.

Three banks with three three-phase resistors of 1600 Ω.

Nominal voltage: 400V AC.

Nominal power: 3 x (3 x 300) W.



N-REFT/3C

• **N-INDT/3C. 3x300 VAR Three-Phase Configurable Inductances Module.**

Configurable Star and Delta connection.

Three banks with three three-phase inductances of 5 H.

Nominal voltage: 400V AC.

Nominal power: 3 x (3x300) VAR.



N-INDT/3C

• **N-CAR19T/3C. 3x300 VAR Three-Phase Configurable Capacitors Module.**

Configurable Star and Delta connection.

Three banks with three three-phase capacitors of 2 μF.

Nominal voltage: 400V AC.

Nominal power: 3 x (3 x 300) VAR.



N-CAR19T/3C

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

The complete application includes as well:

Advanced Real-Time SCADA.

Open Control + Multicontrol + Real-Time Control.

Specialized EDIBON Control Software based on LabVIEW.

Projector and/or electronic whiteboard compatibility allows the unit to be explained and demonstrated to an entire class at one time.

Capable of doing applied research, real industrial simulation, training courses, etc.

Remote operation and control by the user and remote control for EDIBON technical support, are always included.

Totally safe, utilizing 4 safety systems (Mechanical, Electrical, Electronic & Software).

Designed and manufactured under several quality standards.

Optional ICAI software to create, edit and carry out practical exercises, tests, exams, calculations, etc. Apart from monitoring user's knowledge and progress reached.

This unit has been designed for future expansion and integration. A common expansion is the EDIBON Scada-Net (ESN) System which enables multiple students to simultaneously operate many units in a network.

② **AEL-TI-07/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.

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.

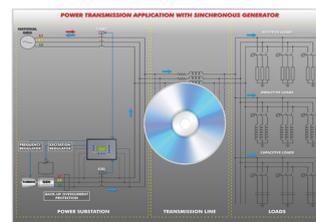
This unit allows the 30 students of the classroom to visualize simultaneously all the results and the manipulation of the unit, during the process, by using a projector or an electronic whiteboard.

③ **Cables and Accessories**, for normal operation.

④ **Manuals:**

This application is **supplied with 7 manuals:** Required Services, Assembly and Installation, Control Software, Starting-up, Safety, Maintenance & Practices Manuals.

*References 1 to 4 are the main items: AEL-TI-07 + AEL-TI-07/CCSOF + Cables and Accessories + Manuals are included in the minimum supply for enabling normal and full operation.



AEL-TI-07/CCSOF

EXERCISES AND PRACTICAL POSSIBILITIES TO BE DONE WITH THE MAIN ITEMS

- 1.- Basic concepts of Smart Grids.
- 2.- Manual control of voltage and frequency of the generator in a Stand-Alone Grid.
- 3.- Automatic control of voltage and frequency of the generator in a Smart Stand-Alone Grid.
- 4.- Study of energy requirements and energy generation in a Stand-Alone Grid.
- 5.- Smart Metering of the generated and transported energy
- 6.- Study of synchronous generator response when a resistive load variation occurs.
- 7.- Study of synchronous generator response when an inductive load variation occurs.
- 8.- Study of synchronous generator response when a capacitive load variation occurs.
- 9.- Synchronization operations with the synchronous generator and the grid.
- 10.- Representation of power generation waves through the Data Acquisition System.
- 11.- Visualization and comparison of the reactive load curves with and without power factor compensation.
- 12.- Display of measured values of the synchronous generator.
- 13.- Plotting of measured values vs time.
- 14.- Data processing, analyzing and exporting of generation, lines and load electrical parameters.

Other possibilities to be done with this Application:

- 15.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 16.- 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.
 - 17.- The Computer Control System with SCADA allows a real industrial simulation.
 - 18.- This application is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 19.- This application can be used for doing applied research.
 - 20.- This application can be used for giving training courses to Industries even to other Technical Education Institutions.
- Several other exercises can be done and designed by the user.

REQUIRED SERVICES

- Electrical supply: three-phase, 380V./50 Hz. or 208V./60 Hz., 3 Kw.
- Computer (PC).

DIMENSIONS AND WEIGHTS

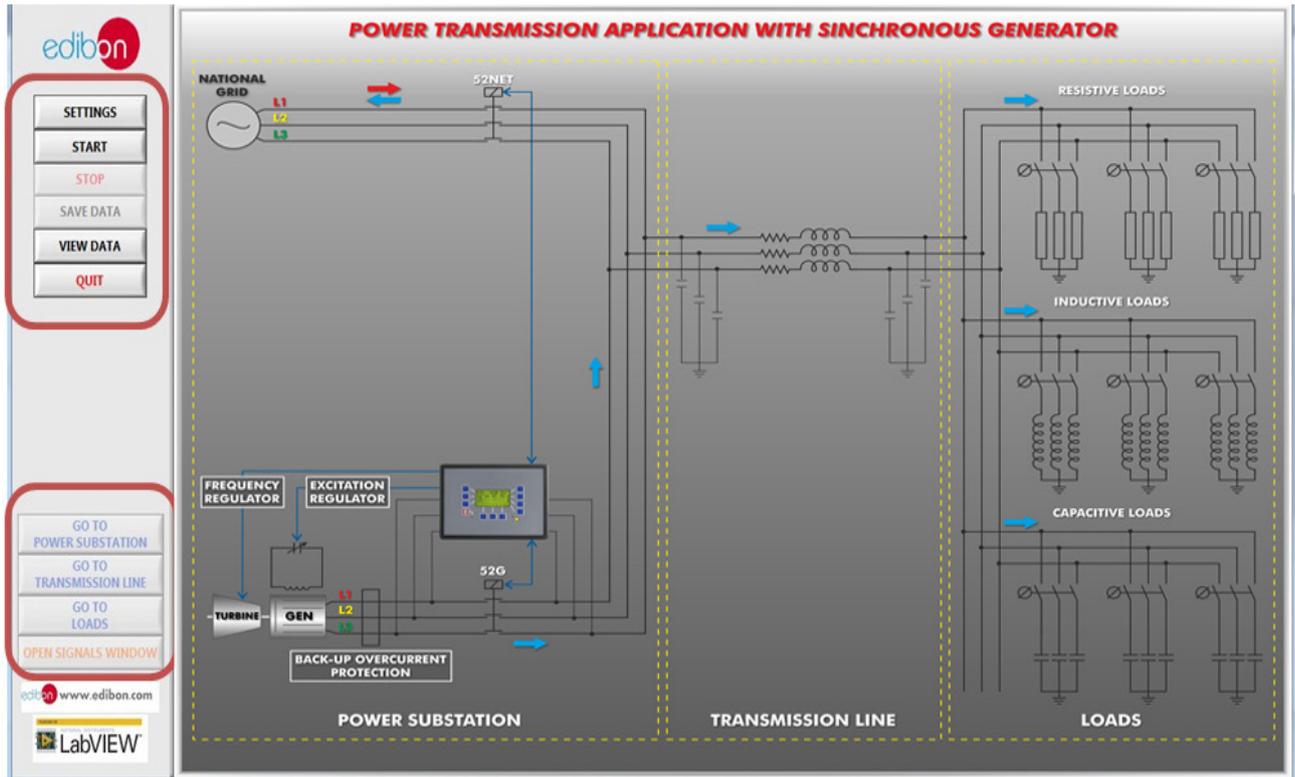
- AEL-TI-07:
- Dimensions: 1000 x 400 x 1600 mm approx.
(39.37 x 15.75 x 62.99 inches approx.)
 - Weight: 100 Kg. approx.
(220 pounds approx.)

AVAILABLE VERSIONS

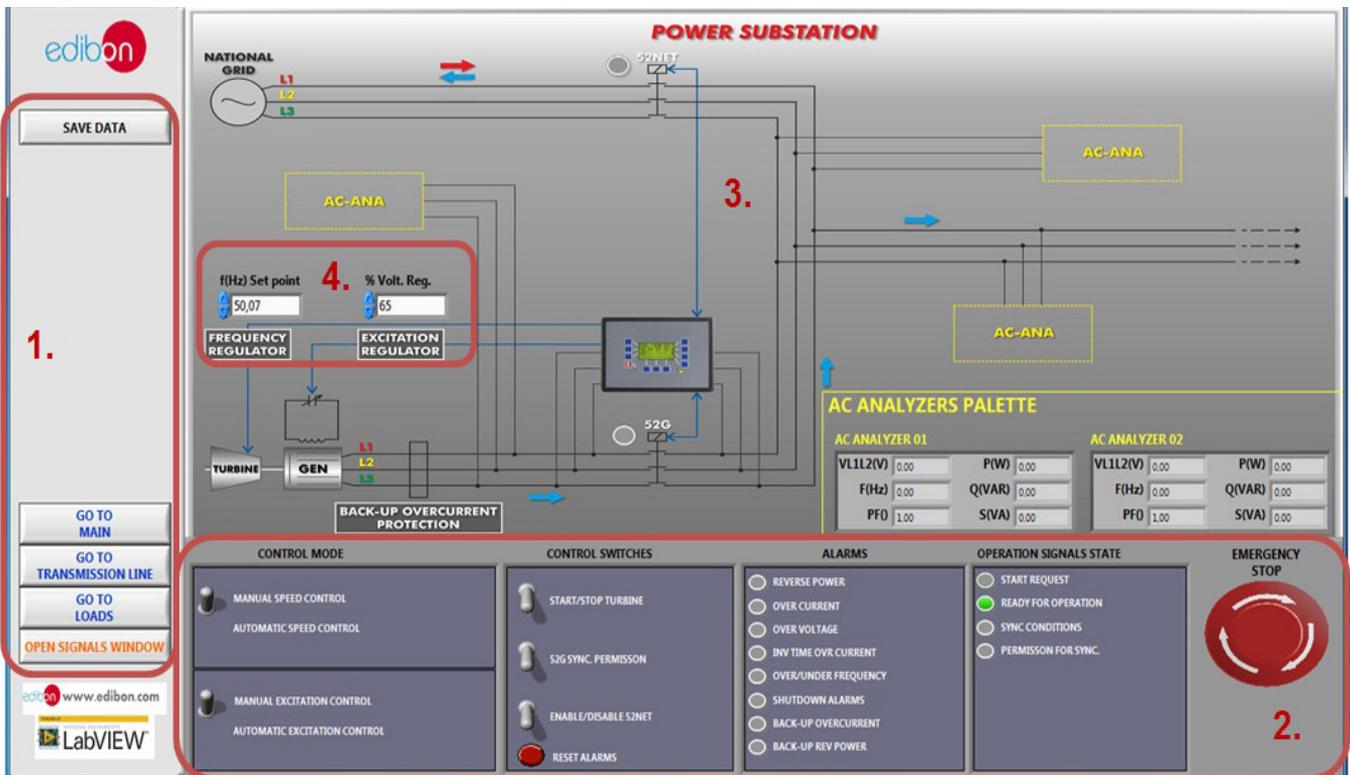
- Offered in this catalogue:
- AEL-TI-07. Transmission Application with Synchronous Generator.
- Offered in other catalogue:
- AEL-TI-01. Analysis of Three-phase Power Lines Application.
 - AEL-TI-02. Distribution Transformer with Motor Regulation Application.
 - AEL-TI-03. Arc suppression Coil Application.
 - AEL-TI-04. Underground Transmission lines Application.
 - AEL-TI-05. Parallel and Series Transmission Lines Application.
 - AEL-TI-06. Analysis of flow power on Transmission Lines Application.
 - AEL-SST-01. Switching and Distribution Power Substations Application.
 - AEL-SST-02. Switching Substation Protection Application.

SOFTWARE MAIN SCREENS

SCADA Main screen



- ① SCADA control menu. It contains the main commands of the system: alarms configuration, start and stop of the system, data saving and viewing saved data.
- ② Screen navigation menu. It is used to change between the specific screens of the system (power substation, transmission line and loads) and to visualize the signals measured in real time (open signals window).
- ③ Diagram of the application.



- ① Navigation menu and save data button.
- ② Power substation control panel: - Manual / Automatic Speed Control switch. - Manual / Automatic Excitation Control switch. - Control switches group: Start/Stop turbine, 52G synchronization permission, Enable/Disable 52NET and reset alarms. - Alarms monitoring: Revers power, over current, over voltage, inverse time over current, over frequency, shutdown alarms, back-up over current and back-up reverse power. - Operation signals state: start request, ready for operation, sync conditions, permission for sync. - Emergency stop.
- ③ Diagram of the power substation. In the right of the screen has an "AC analyzers palette" with the measures of the network analyzers. These analyzers can be moved to different positions.
- ④ Manual speed and voltage control regulators.

Transmission Line menu. This screen shows a three-phase diagram where the concentrated parameters of the transmission line can be visualized. The impedance of each phase line can be modified changing the resistances, inductances and capacitances values.

TRANSMISSION LINE

AC ANALYZERS PALETTE

AC ANALYZER 01		AC ANALYZER 02	
VL1L2(V)	0.00	P(W)	0.00
F(Hz)	50.00	Q(VAR)	0.00
PFO	1.00	S(VA)	0.00

	AC ANALYZER 1 (y1)	AC ANALYZER 2 (y2)	y1 - y2
VLL (V)	0,00	0,00	0,00
P (W)	0,00	0,00	0,00

- Navigation menu and save data button.
- AC analyzers palette and calculations. These tables show the measures taken by the analyzers and the different between them with the aim of obtain the line losses. The analyzers can be moved to the positions named as AC-ANA in the three-phase diagram.
- Diagram of the transmission line. It has two buttons to save the configuration of the transmission line and to reset them to the factory values.

Power distribution substation menu. This screen shows a power distribution system diagram with double bus bar topology. This menu allows carry out all maneuvers relating to these type of power substations, such as coupling bus bars, opening and closing logic of disconnectors and breakers, etc.

SWITCHING DISTRIBUTION SUBSTATION

AC ANALYZERS PALETTE

AC ANALYZER 01		AC ANALYZER 02	
VL1L2(V)	339.50	P1(W)	13.80
f1(Hz)	50.00	Q1(VAR)	12.70
PF10	0.74	S1(VA)	18.70

AC ANALYZER 02		AC ANALYZER 01	
VL1L2(V)	339.80	P2(W)	0.00
f2(Hz)	50.10	Q2(VAR)	0.00
PF20	1.00	S2(VA)	0.00

CONTROL PANEL

Phase	Component	OPEN	CLOSE
L1	89-1	●	●
	89-2	●	●
	52	●	●
L2	89-1	●	●
	89-2	●	●
	52	●	●
L3	89-1	●	●
	89-2	●	●
	52	●	●

- Navigation menu and save data button.
- AC analyzers palette for power distribution substation electrical measurements.
- Power distribution substation diagram. It has the conjunction of lamps which indicate the disconnectors and breakers state.
- Power distribution substation control panel. It has de function of opening and closing of controlling disconnectors and breakers.

Loads menu. This screen shows a three-phase diagram where the resistive, inductive and capacitive loads can be visualized.

LOADS

AC-ANA

L1 L2 L3 N

R(Ohm) x3 1600

L(H) x3 20

C(uF) x3 66

RESISTIVE LOADS INDUCTIVE LOADS CAPACITIVE LOADS

STAR CONNECTION STAR CONNECTION STAR CONNECTION

AC ANALYZERS PALETTE

AC ANALYZER 01		AC ANALYZER 02	
VL1L2(V)	0.00	P(W)	0.00
F(Hz)	50.00	Q(VAR)	0.00
PFO	1.00	S(VA)	0.00

SAVE DATA

GO TO MAIN

GO TO POWER SUBSTATION

GO TO TRANSMISSION LINE

OPEN SIGNALS WINDOW

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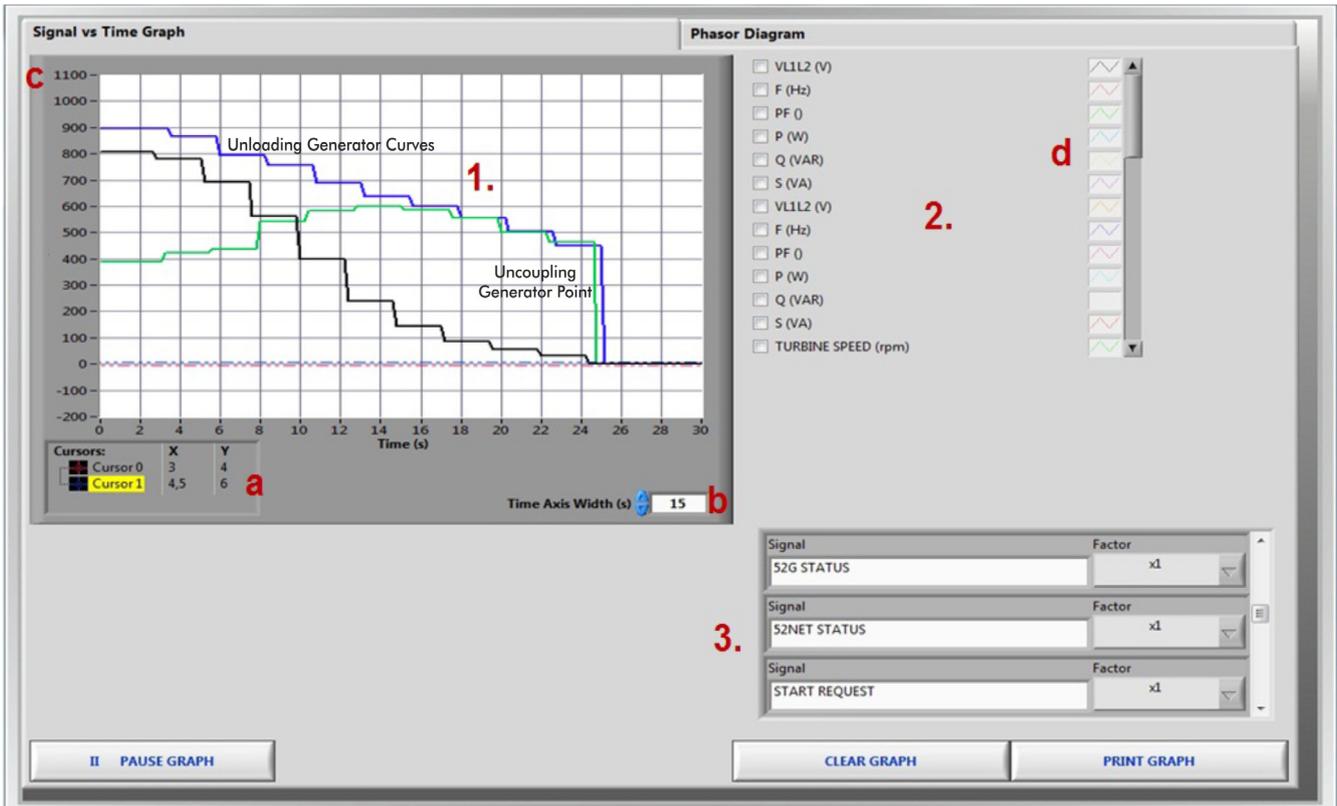
LabVIEW

SAVE CURRENT IMPEDANCE VALUES

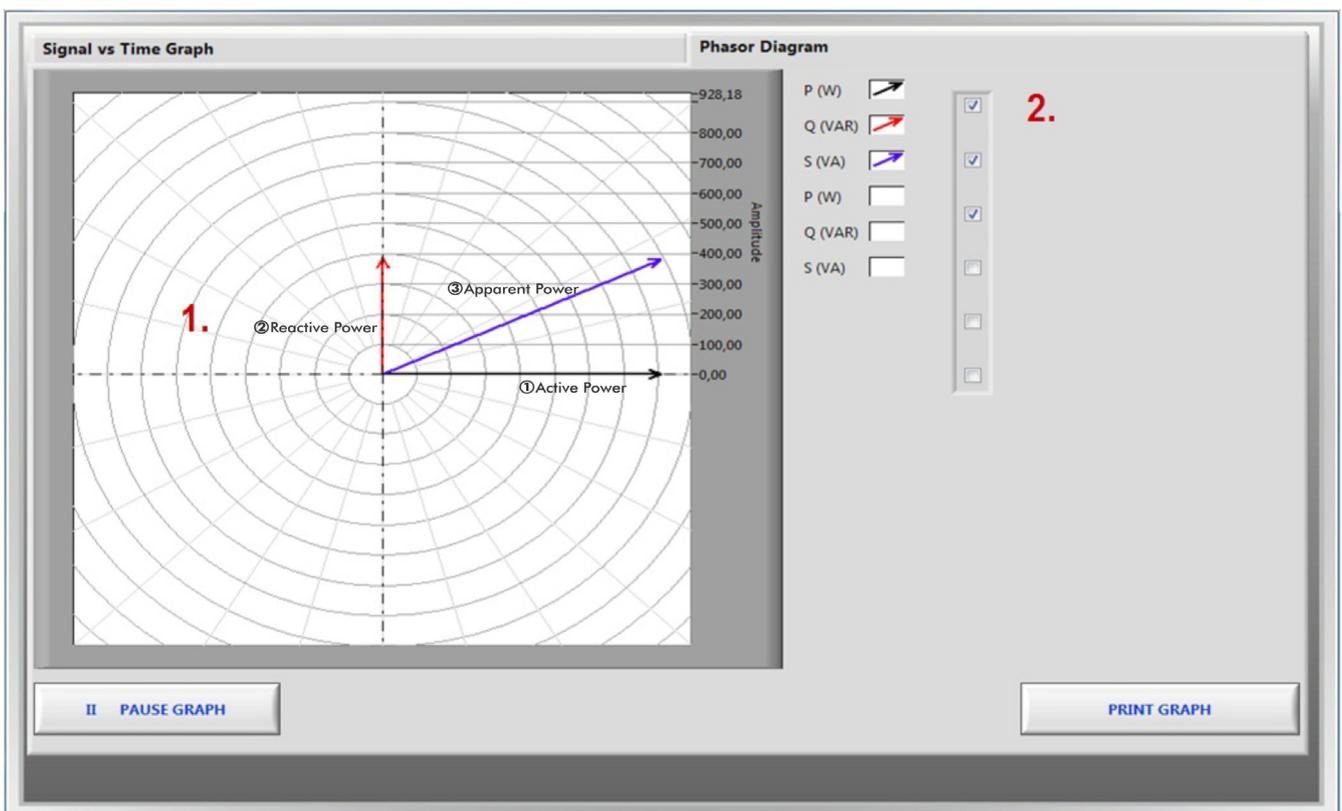
RESET TO FACTORY IMPEDANCE VALUES

- ① Navigation menu and save data button.
- ② AC analyzers palette. It shows the measures taken by the analyzers. The analyzers can be moved to the positions named as AC-ANA in the three-phase diagram.
- ③ Diagram of the loads.

SOME REAL RESULTS OBTAINED FROM THIS APPLICATION



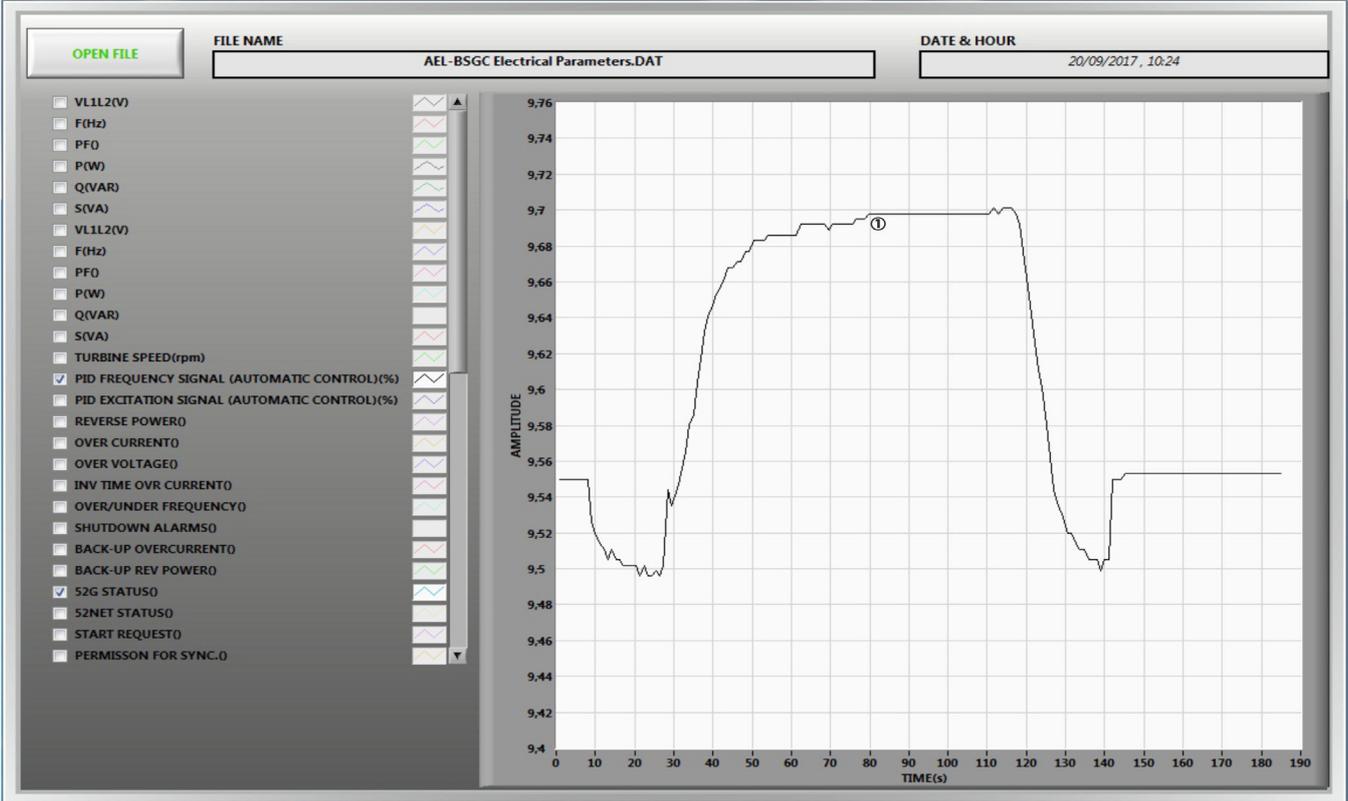
- ① **Real time graph.** It displays the variables selected and it is possible to take measures using two cursors (a) and modify the time (b) and the amplitude (c) scales. These three curves (apparent, active and reactive powers) represent uncoupling process of the generator and grid.
- ② **Variable selector.** In this section the variables showed in the real time graph are selected and configured.
- ③ **Multiplier of digital variables.**



- ① **Real time graph.** It displays the variables selected. This picture shows the phasors diagram of the active, reactive and apparent powers of the network analyzers.
- ② **Variable selector.** In this section the variables showed in the real time graph are selected.

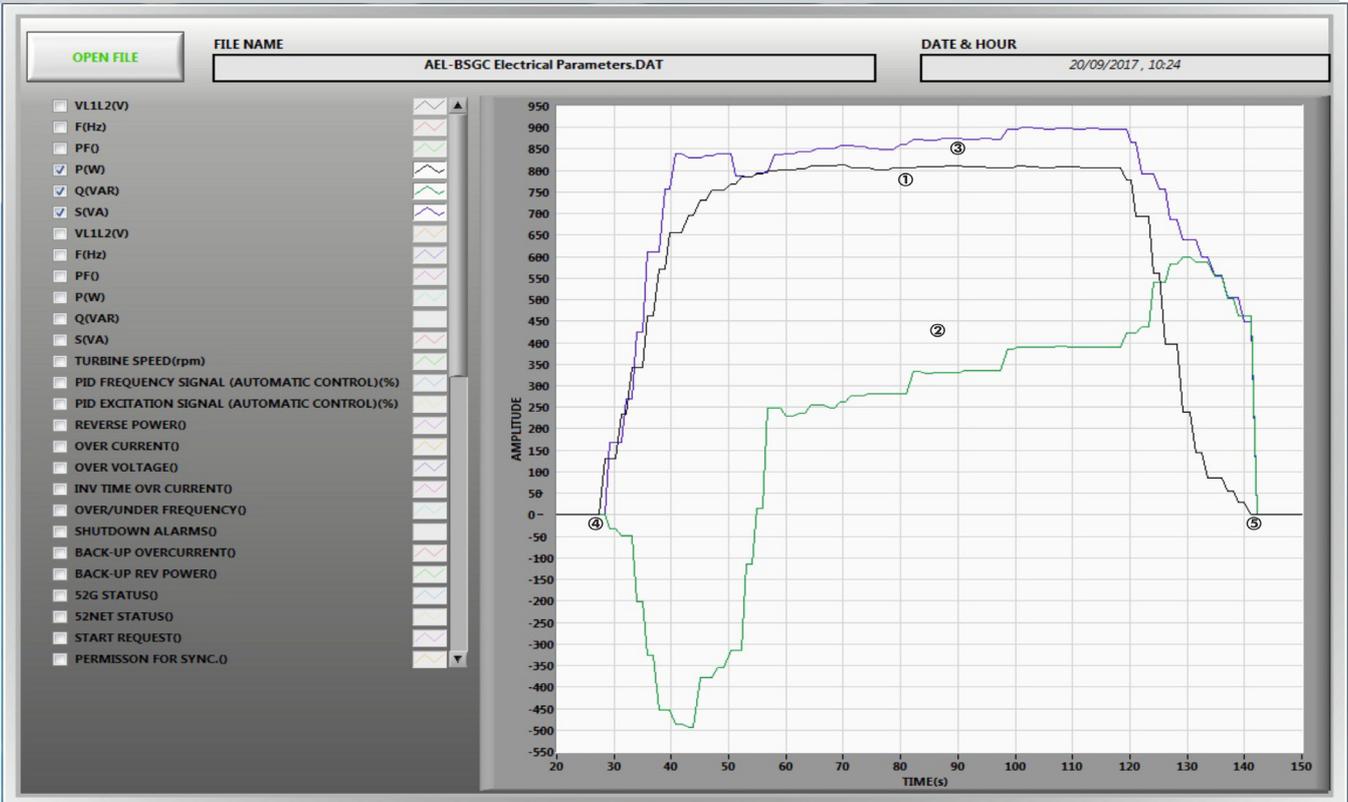
Some **real** results obtained from this Application

This picture shows a PID frequency signal report since the generator is synchronized with the grid till the generator is uncoupled of it.



① PID Frequency Signal Reported.

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



- ① Active power wave.
- ② Reactive power wave.
- ③ Apparent power wave.
- ④ Synchronization.
- ⑤ Uncoupling generator.

COMPLETE TECHNICAL SPECIFICATIONS (for optional items)

Additionally to the main items (1 to 4) described, we can offer, as optional, other items from 5 to 7.

All these items try to give more possibilities for:

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

a) Technical and Vocational Education configuration

5) AEL-TI-07/ICAI. Interactive Computer Aided Instruction Software System.

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

This software is optional and can be used additionally to items (1 to 4).

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

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

Innovative features:

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

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

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

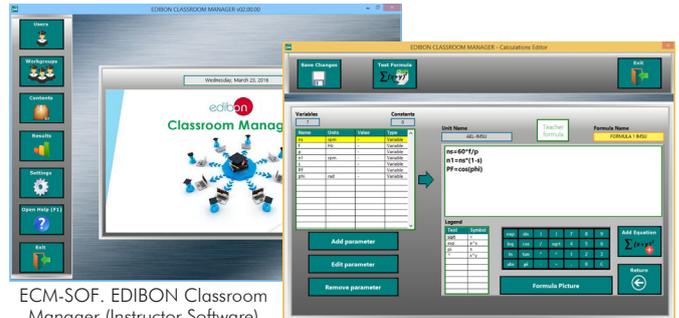
Innovative features:

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

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

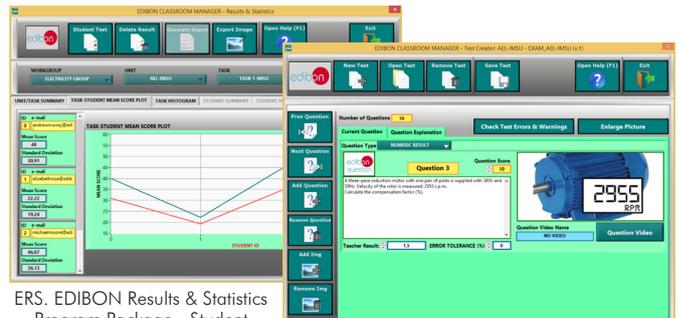
www.edibon.com/en/files/expansion/ICAI/catalog

Instructor Software



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

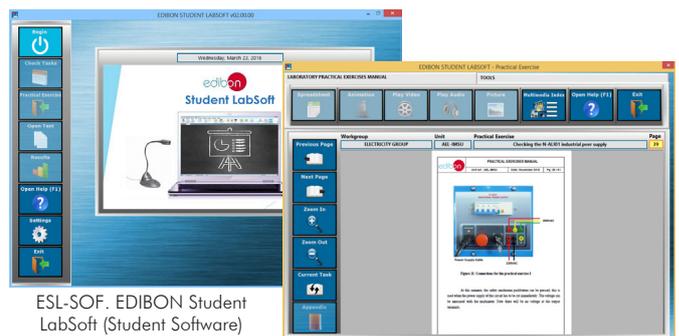
ECAL. EDIBON Calculations Program Package - Formula Editor Screen



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

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

Student Software



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

EPE. EDIBON Practical Exercise Program Package Main Screen



ERS. EDIBON Results & Statistics Program Package - Question Explanation

ECAL. EDIBON Calculations Program Package Main Screen

b) Multipost Expansions options

⑥ **MINI ESN. EDIBON Mini Scada-Net System for being used with EDIBON Teaching Units.**

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

The MINI ESN system consists of the adaptation of any EDIBON Computer Controlled Unit with SCADA integrated in a local network.

This system allows to view/control the unit remotely, from any computer integrated in the local net (in the classroom), through the main computer connected to the unit. Then, the number of possible users who can work with the same unit is higher than in an usual way of working (usually only one).

Main characteristics:

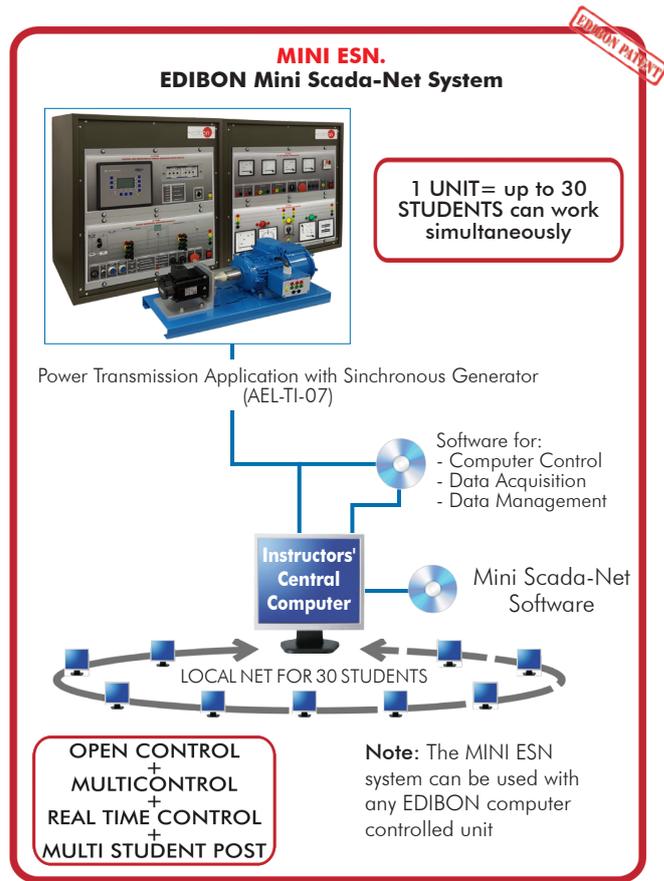
- It allows up to 30 students to work simultaneously with the EDIBON Computer Controlled Unit with SCADA, connected in a local net.
- Open Control + Multicontrol + Real Time Control + Multi Student Post.
- Instructor controls and explains to all students at the same time.
- Any user/student can work doing "real time" control/multicontrol and visualisation.
- Instructor can see in the computer what any user/student is doing in the unit.
- Continuous communication between the instructor and all the users/students connected.

Main advantages:

- It allows an easier and quicker understanding.
- This system allows you can save time and cost.
- Future expansions with more EDIBON Units.

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

www.edibon.com/en/files/expansion/MINI-ESN/catalog



⑦ **ESN. EDIBON Scada-Net Systems.**

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

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

www.edibon.com/en/files/expansion/ESN/catalog

ORDER INFORMATION

Main items (always included in the supply)

Minimum supply always includes:

- ① **Application: AEL-TI-07. Power Transmission Application with Synchronous Generator.**
- ② **AEL-TI-07/CCSOF. Computer Control + Data Acquisition + Data Management Software.**
- ③ **Cables and Accessories**, for normal operation.
- ④ **Manuals.**

*IMPORTANT: Under AEL-TI-07 we always supply all the elements for immediate running as 1, 2, 3 and 4.

Optional items (supplied under specific order)

a) Technical and Vocational Education configuration

- ⑤ AEL-TI-07/ICAL. Interactive Computer Aided Instruction Software System.

b) Multipost Expansions options

- ⑥ MINI ESN. EDIBON Mini Scada-Net System for being used with EDIBON Teaching Units.
- ⑦ ESN. EDIBON Scada-Net Systems.

① **AEL-TI-07. Application.**

The AEL-TI-07 application includes the following elements:

- N-VPS01. AC 3PH Variable Power Supply.
 - 3PH+N+GND male connector with cable.
 - 200V DC fixed output terminals.
 - 0-200V DC variable output terminals.
 - 230/400V AC fixed output terminals.
 - 0-230/400V AC variable output terminals.

Three positions voltage regulation commutator: this commutator allows to control the AC and DC output voltage terminals with a motorized autotransformer. Central position keep actual voltage. Right position increase slowly the output voltage. Left position reduce slowly the output voltage up to zero volts. By releasing the commutator, it will return to its initial position.

 - ON/OFF switch.
 - DC Ammeter.
 - DC Voltmeter.
 - AC Ammeter.
 - AC Voltmeter.
 - Adjustable three phase thermal protection.
 - Fuses.
 - GND terminal.
- N-PSUB2. Power Generation Substation Module 2.
 - Supply voltage: 400V AC, 3PH+N+G.
 - ON/OFF switch.
 - Power and signals connection:
 - Auxiliary connection.
 - Three-phase turbine supply hose with IP44 3PN+E 32A 400V connecting plug.
 - Three-phase generator supply hose with IP44 3PN+E 32A 400V connecting plug.
 - Three switches to choose between the different modes:
 - Local and remote control mode.
 - Manual and automatic speed control.
 - Manual and automatic excitation control
 - Three control switches to:
 - Start and stop the turbine.
 - Give permission to synchronize the generator with the grid.
 - Give permission to close 52NET circuit breaker.
 - Two potentiometers to regulate:
 - Turbine speed.
 - Generator excitation.
 - Emergency stop button.
 - Two circuit breakers for synchronization and stand-alone operations.
 - Different terminals to measure.
 - Ethernet connection: RJ45 communication port for SCADA remote control.
- N-PPCM1. Control and Protection of Turbine-Generator Group Module 1.
 - Automatic speed and voltage controller (easygen):
 - Enables to connect up to 16 electric generators in parallel-island with distribution of active and reactive load and start/stop in function of the load demand.
 - Enables to connect a generator in parallel with the grid.
 - Enables different switches control modes, such as opening, closing and synchronization.
 - Analogical outputs to control voltage and frequency regulators.
 - 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 (IC255), measured ground fault (50N/51N), phase rotation, switches faults.
 - Network:
 - Maximum/minimum voltage (59/27), maximum/minimum frequency (81O/U), vector jump, phase rotation.
 - Six alarms:
 - Alarm 1: Reverse power.
 - Alarm 2: Overcurrent.
 - Alarm 3: Over/undervoltage.
 - Alarm 4: Inverse Time Overcurrent.
 - Alarm 5: Over/under frequency.
 - Alarm 6: Shutdown Alarms.
 - Four operation signals:
 - Ready for operation.
 - Start request.
 - Synchronization conditions.
 - Permission for synchronization.
 - Back-up protections:
 - Current relay.
 - Reverse Power relay.
 - Ethernet connection: RJ45 communication port.
- EMT6/1K. 1kW/1P Three-Phase Synchronous Generator.
 - Nominal power: 1000 VA.
 - Power factor: 0.8
 - Nominal output voltage: 3x 400V AC.
 - Frequency: 50/60 Hz.
 - Speed: 3000 rpm.
 - Nominal output current: 0.8 A.
 - Nominal excitation current: 5 A.
- SERV01. AC Servomotor 1.
 - Nominal power: 2000 W.
 - Nominal voltage: 400V AC.
 - Nominal speed: 3000 rpm.
 - Nominal current: 5A.

Tender Specifications (for main items)

- N-EALD. Network Analyzer Module with Data Acquisition.
ON-OFF switch.
Supply voltage: 400V AC.
Input terminals: Input connection with the measurement point.
Output terminals: Output connection with the measurement point.
Digital outputs: Three digital outputs are used for pulses or alarms, or for combining both.
RS-485 Communication port.
Fuses: 3x10 A.
Network Analyzer Display. It shows:
Active, reactive and apparent power.
Active, reactive and apparent energies.
Lines and phase currents.
Line and phase voltages.
Frequencies.
Power Factor.

Required element:

- AEL-PC. Touch Screen and Computer.
Touch Screen:
Energy efficiency class: A.
Screen diagonal: 68.6 cm (27 inch (s)).
Power consumption (operating): 26 watts.
Annual energy consumption: 38 kWh.
Power consumption (standby / off) 0.49 watts.
Screen resolution: 1920 x 1080 pixels.
Computer:
Processor Number: Intel Core i7-6600U Processor (4M Cache, up to 3,40 GHz).
Cache: 4 MB Intel Smart Cache.
Clock speed: 2.6 GHz.
Of Cores/# of Threads: 2/4.
Max. TDP/Power: 15 W.
Memory Types: DDR4-2133, LPDDR3-1866, DDR3L-1600.
Graphics: Intel HD Graphics 530.

Recommended elements:

- N-PPIM1. Instrumentation Module 1.
Three-Phase wattmeter:
Measured range: 0 - 1.5 KW.
Three-Phase varmeter:
Measured range: 0 - 1.5 Kvar.
Voltmeter:
Measured range: 0 - 500 V.
Frequency meter:
Measured range: 45 - 55 Hz.
DC meter:
Measured range: 0 - 10 A.
- N-ASYB. Analog Synchronization Module.
Input terminals: L1, L2, L3 and N generation input terminals.
Output terminals: L1, L2, L3 and N grid input terminals.
Synchronization switch: this switch allows close the synchronization switch. In addition, this switch has two 24 VDC connections for remote close switch.
Analog voltmeter: it allows to measure the generation bus bar output voltage.
Digital synchronoscope: it allows to monitor the synchronization process of the generator with the grid.
Double analog voltmeter: it allows to compare the voltages between generator and grid bus bars.
Double frequency meter: it allows to compare the frequencies between the generator and the grid.
400V AC lamps: it allows to realize the different synchronization procedures with the dark and light lamps method.
GND terminal.
- N-REFT/3C. 3x300 W Three-Phase Configurable Resistors Module.
Configurable Star and Delta connections.
Three banks with three three-phase resistors of 1600 Ω .
Nominal voltage: 400V AC.
Nominal power: 3 x (3 x 300) W.
- N-INDT/3C. 3x300 VAR Three-Phase Configurable Inductances Module.
Configurable Star and Delta connection.
Three banks with three three-phase inductances of 5 H.
Nominal voltage: 400V AC.
Nominal power: 3 x (3x300) VAR.
- N-CAR19T/3C. 3x300 VAR Three-Phase Configurable Capacitors Module.
Configurable Star and Delta connection.
Three banks with three three-phase capacitors of 2 μ F.
Nominal voltage: 400V AC.
Nominal power: 3 x (3 x 300) VAR.
- All necessary cables to realize the practical exercises are included.

The complete application includes as well:

Advanced Real-Time SCADA.
Open Control + Multicontrol + Real-Time Control.
Specialized EDIBON Control Software based on LabVIEW.
Projector and/or electronic whiteboard compatibility allows the unit to be explained and demonstrated to an entire class at one time.
Capable of doing applied research, real industrial simulation, training courses, etc.
Remote operation and control by the user and remote control for EDIBON technical support, are always included.
Totally safe, utilizing 4 safety systems (Mechanical, Electrical, Electronic & Software).
Designed and manufactured under several quality standards.
Optional ICAI software to create, edit and carry out practical exercises, tests, exams, calculations, etc. Apart from monitoring user's knowledge and progress reached.
This unit has been designed for future expansion and integration. A common expansion is the EDIBON Scada-Net (ESN) System which enables multiple students to simultaneously operate many units in a network.

② AEL-TI-07/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.
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.

③ Cables and Accessories, for normal operation.

④ Manuals:

This application is supplied with 7 manuals: Required Services, Assembly and Installation, Control Software, Starting-up, Safety, Maintenance and Practices Manuals.

Exercises and Practical Possibilities to be done with the Main Items

- 1.- Basic concepts of Smart Grids.
- 2.- Manual control of voltage and frequency of the generator in a Stand-Alone Grid.
- 3.- Automatic control of voltage and frequency of the generator in a Stand-Alone Grid.
- 4.- Study of energy requirements and energy generation in a Stand-Alone Grid.
- 5.- Smart Metering of the generated and transported energy
- 6.- Study of synchronous generator response when a resistive load variation occurs.
- 7.- Study of synchronous generator response when an inductive load variation occurs.
- 8.- Study of synchronous generator response when a capacitive load variation occurs.
- 9.- Synchronization operations with the synchronous generator and the grid.
- 10.- Representation of power generation waves through the Data Acquisition System.
- 11.- Visualization and comparison of the reactive load curves with and without power factor compensation.
- 12.- Display of measured values of the synchronous generator.
- 13.- Plotting of measured values vs time.
- 14.- Data processing, analyzing and exporting of generation, lines and load electrical parameters.

Other possibilities to be done with this Application:

- 15.- Many students view results simultaneously.

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

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

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

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

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

- 19.- This application can be used for doing applied research.

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

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

TENDER SPECIFICATIONS (for optional items)

a) Technical and Vocational Education configuration

⑤ AEL-TI-07/ICAL. Interactive Computer Aided Instruction Software System.

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

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

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

Innovative features:

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

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Innovative features:

- Student Log-In & Self-Registration.
- Existing Tasks checking & Monitoring.
- Default contents & scheduled tasks available to be used from the first session.
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- Test self-correction.
- Calculations computing and plotting.
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- User Monitoring Learning & Printable Reports.
- Multimedia-Supported auxiliary resources.

b) Multipost Expansions options

⑥ MINI ESN. EDIBON Mini Scada-Net System for being used with EDIBON Teaching Units.

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The MINI ESN system consists of the adaptation of any EDIBON Computer Controlled Unit with SCADA integrated in a local network.

This system allows to view/control the unit remotely, from any computer integrated in the local net (in the classroom), through the main computer connected to the unit.

Main characteristics:

- It allows up to 30 students to work simultaneously with the EDIBON Computer Controlled Unit with SCADA, connected in a local net.
- Open Control + Multicontrol + Real Time Control + Multi Student Post.
- Instructor controls and explains to all students at the same time.
- Any user/student can work doing "real time" control/multicontrol and visualisation.
- Instructor can see in the computer what any user/student is doing in the unit.
- Continuous communication between the instructor and all the users/students connected.

Main advantages:

- It allows an easier and quicker understanding.
- This system allows you can save time and cost.
- Future expansions with more EDIBON Units.

The system basically will consist of:

This system is used with a Computer Controlled Unit.

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

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



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